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International Review of Frameworks for Standard Setting & Labeling Development

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Framework for Standards & Labeling Setting and Development

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Executive Summary

As appliance energy efficiency standards and labeling (S&L) programs reach a broader geographic and product scope, a series of sophisticated and complex technical and economic analyses have been adopted by different countries in the world to support and enhance these growing S&L programs. The initial supporting techno-economic and impact analyses for S&L development make up a defined framework and process for setting and developing appropriate appliance efficiency standards and labeling programs. This report reviews in-depth the existing framework for standards setting and label development in the well-established programs of the U.S., Australia and the EU to identify and evaluate major trends in how and why key analyses are undertaken and to understand major similarities and differences between each of the frameworks.

The in-depth review of the existing framework for standards and label development and supporting analyses and tools used in the U.S., Australia and the EU reveal several overarching trends. First, each country or region's regulatory context for standard-setting has significantly influenced the specific processes and analyses that are conducted when setting or revising efficiency standard levels. Whereas the specific sets of 15 analyses were developed to meet regulatory mandated criteria for standard-setting in the U.S., Australia's principle of adopting existing world-best regulatory target and reliance on international trade data is the result of its import-dependent appliance market. The EU Ecodesign preparatory study framework and accompanying seven tasks of analyses traces directly back to the directive's unique scope of evaluating life-cycle environmental impacts and costs. These region-specific trends suggest that there is not necessarily a "one size fits all" framework for standards setting and label development but rather, the framework should be developed based on region-specific conditions such as market factors, purpose and goals of standards and labeling programs and data availability.

Another overarching trend illustrated by the three regional frameworks examined is that there are considerable variations in the rigor and scope of core techno-economic analyses, despite similarities in a common approach of using stock accounting model and scenario analysis to conduct shipments, national impacts and energy and environmental analyses. The U.S. engineering and life-cycle cost analyses are distinguished by unique approaches of estimating manufacturer cost for separate components by "tearing down" actual products and using statistically representative samples to evaluate cross-section of consumer impacts, respectively. Australia, on the other hand, is limited by data availability to statistical analysis and engineering simulations for its engineering analysis, but conducts more detailed cost-benefit analysis that distinguishes the costs to consumers, government and industry.

The EU Ecodesign process is distinct in defining both a standard base case and a real-life base case that adjusts for variations in consumer behavior and loads for its environmental and life-cycle cost assessments and also considers Best Not Yet Available Technology in its technical analysis. In support of each region's strengths in conducting specialized techno-economic analysis, specific tools such as the U.S. life-cycle cost model with Crystal Ball, the Australian Business Cost Calculator and the EU EcoReport tool for life-cycle environmental assessment have been developed and make up important components of each framework for standards and labeling development.

In sum, while similar types of analyses are embodied in the standard-setting and label development framework of the U.S., Australia, and the EU, there are distinct features in each of the three frameworks that are shaped by the regulatory context and conditions of that region. Each of the frameworks in turn has distinguished itself by incorporating more rigor into specific areas of analysis ranging from engineering and life-cycle subgroup impact analysis to cost-benefit and environmental impact analysis in order to meet specific regulatory goals or policy scopes. At the same time, these regions have also developed the necessary supporting tools and data inputs to conduct the more rigorous analyses, making it possible for the standards setting and label development framework to be fully implemented.

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1. Introduction

As appliance energy efficiency standards and labeling (S&L) programs reach a broader geographic and product scope, a series of sophisticated and complex technical and economic analyses are being adopted by different countries in the world to support and enhance these S&L programs. There are two main types of analyses related to S&L programs: technical and economic analyses undertaken prior to the implementation of standards and labeling. These initial supporting analyses for S&L development are aimed at illuminating and assessing the impact of the proposed policy on industry, consumers, the national economy, trade, and other areas. This set of analyses and tools in turn make up a defined framework and process for setting and developing appropriate appliance efficiency standards and labeling programs.

Appliance S&L programs have been in use internationally for over thirty years, but few programs have consistently followed a comprehensive and well-defined framework in setting and revising efficiency standards and labeling thresholds. The notable exceptions are three developed regions that have had a relatively long history of S&L programs: the United States (U.S.), Australia and the European Union (EU). In each of these regions, a set of pre-determined analyses are carried out and the process and results are documented when standards and/or labeling thresholds have to be set or revised. In order for the comprehensive analyses to be conducted in a timely and effective manner to inform standard-setting and label development, supporting data sources and tools are also developed as part of the national framework. This report thus reviews the set of initial analyses that compose the underlying framework for standards and labeling setting and development in the U.S., Australia and EU in order to identify and evaluate major components and trends.

The report provides in-depth overview of the framework for standards and labeling setting and development in the U.S., Australia the EU. Within each chapter, specific details are first provided on each country's regulatory framework as context for understanding the influence that existing policy framework has on standards and labeling setting processes. Then, the standard-setting process and the underlying analyses and tools used in the process of each selected region are reviewed in-depth to understand the purpose and contributions of each analysis to the framework, as well as the underlying data requirements and tools for conducting the analysis. This report ends with a short discussion of key findings and conclusions drawn from similarities and differences observed in the frameworks of all three regions.

2. Overview of United States MEPS and ENERGY STAR Framework

The United States has had a mandatory labeling and minimum energy performance standards program under the Department of Energy (DOE) since 1978. In 1992, the U.S. Environmental Protection Agency and the Department of Energy jointly launched the Energy Star voluntary endorsement labeling program.

2.1 MEPS Regulatory Process Overview

The U.S. regulatory process for standard-setting is shaped largely by legislation which initially created the MEPS. As outlined in the legislation, the U.S. guiding principle for setting the threshold for MEPS is to achieve the maximum efficiency that is technologically feasible and economically justified, thus maximizing energy savings. The Secretary of Energy has discretion in weighing the benefits and burdens of selecting the final stringency level of the standard for a given product class, where product class is defined by differences in a given product's utility functions to consumers. In doing so, the Secretary of Energy must consider seven statutory criteria, including:

1. The economic impact of the standard on consumers and manufacturers
2. Lifetime operating cost savings resulting from the standard
3. Total projected energy savings resulting from the standard
4. Impact of the standard on utility or performance of products
5. Impact of any lessening of competition likely to result from the standard
6. Need for national energy conservation
7. Other factors the Secretary considers relevant

From a procedural perspective, the U.S. has followed a rulemaking process for setting its MEPS since the National Appliance Energy Conservation Act of 1987. DOE has authority to change the process, restructured the standard setting process in a formal Process Rule in 1996, and continues to adapt the process to current circumstances, including using consensus-building methods. In 2006, DOE initiated the process used in recent rulemakings by the authority of a planned multi-year schedule of approximate rule initiation and final action dates. The current schedule of appliance standards development was updated in a semi-annual report to Congress (February, 2012)[1], based on the consent decree of 2006, the Energy Independence and Security Act (EISA) of 2007, and the status of recent rulemakings. DOE is responsible for standards for 24 residential products[2] and 18 commercial products[3]. DOE may add additional products (e.g., miscellaneous electronics products[4]) if they meet the criteria specified in the Energy Policy Conservation Act (EPCA).

Normally, the energy standards process begins with a test procedure rulemaking, then a standards rulemaking. Test procedure rulemakings typically involve a proposed and final rule, while standards rulemakings typically involve a framework, preliminary analysis, proposed rule and final rule. (For some

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[1] http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/report_to_congress_february_2012.pdf
[2] http://www1.eere.energy.gov/buildings/appliance_standards/residential_products.html
[3] http://www1.eere.energy.gov/buildings/appliance_standards/commercial_products.html
[4] Including possibly audio-video equipment, computer systems, household cleaning equipment, imaging equipment, network equipment, personal space heating equipment, thermal household equipment, thermal kitchen equipment, uninterruptible power supplies (UPS), and vertical transport equipment.

products specified by legislation, the energy standards rulemaking process begins with the publication of a Notice of Determination in the Federal Register to determine if a new or revised standard is needed. This is followed by a 30 calendar day comment period for the public to provide input to DOE regarding the Notice of Determination. If a Determination concludes that standards are warranted, then the normal test procedure and standards rulemakings are initiated for these products.

In a typical standards rulemaking, a Framework Document is drafted by DOE and its contractors (usually Lawrence Berkeley National Laboratory, Pacific Northwest National Laboratory, and Navigant Consulting). This Framework Document describes DOE's plans for conducting the supporting analyses for the rulemaking and is published with a Notice of Availability that seeks further comments or data input from the public. After a public meeting is held for further public participation, DOE and its contractors perform a variety of economic and technical analyses. The typical duration of time from the Framework Document to completion of the Preliminary Analysis is 18 months.

After the Preliminary Analysis is completed, the results are published in a Notice of Data Availability, and a 30 to 45 calendar day comment period begins with a public meeting held for further comments. After this comment period, additional analyses are conducted and revisions may be made based on comments. DOE then reviews all comments and addresses them in the Notice of Proposed Rulemaking in the Federal Register. This period typically takes 11 months.

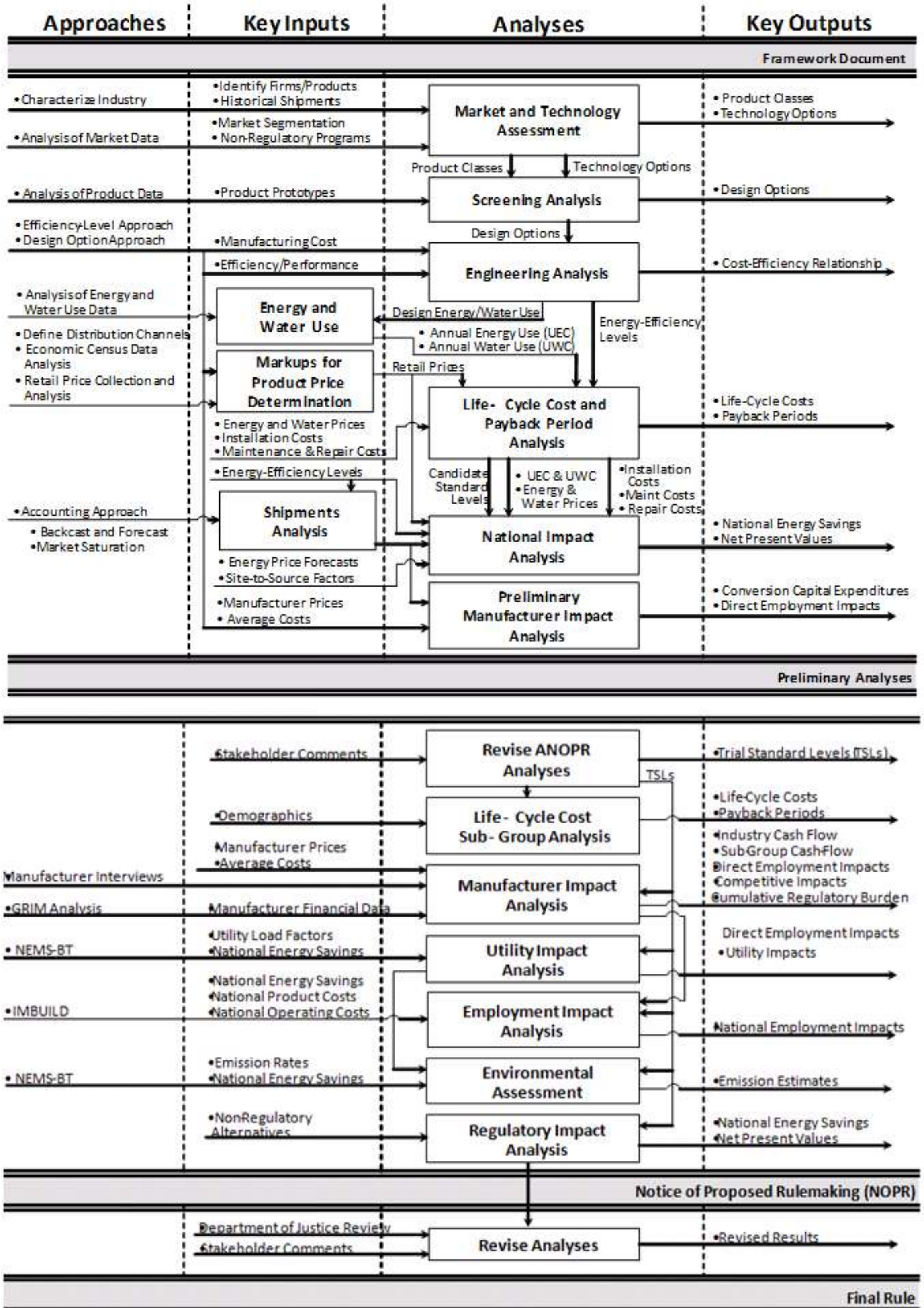
Finally, a 60 calendar day comment period follows the published Notice of Proposed Rulemaking and final revisions can be made to the analysis if necessary, based on the comments received. Within a six month timeframe, DOE publishes the Final Rule announcing the energy efficiency standards and their effective dates.

2.2 Supporting Analyses and Tools

In support of the DOE MEPS rulemaking, a comprehensive framework involving fourteen different analytical approaches, sets of key inputs and supporting analyses has been developed in the U.S. to provide key outputs that are used to evaluate proposed MEPS thresholds and to justify the choice of the final threshold.

The framework for the U.S. MEPS rulemaking is illustrated in Figure 1.

Figure 1. U.S. DOE MEPS Rulemaking Flow Diagram



Source: Rosenquist 2010.

Market and Technology Assessment and Screening Analysis

One of the first initial analyses conducted by DOE under its standards rulemaking is a market and technology assessment used to identify product design options or efficiency levels that will be evaluated in the rulemaking. The market and technology assessment help develop a qualitative and quantitative characterization of the industry and market structure for a particular product type. The market assessment addresses manufacturer characteristics and market shares, existing regulatory and non-regulatory efficiency improvement initiatives, equipment classes and trends in market and equipment characteristics. For example, the market assessment may involve producing projections of future shipments based on demographic projections, ownership trends, changing market shares and product lifetime. The technology assessment in turn develops a preliminary list of technologies that could improve the efficiency of a specific product which is then used in the screening analysis.

The purpose of the screening analysis is to evaluate the technologies that improve equipment efficiency in order to determine which technologies to consider further and which to screen out. This analysis identifies technology options that are viable for mass production in three to five years by using manufacturer websites, literature review and discussions with industry and independent technical experts.

The screening analysis evaluates a set of four criteria in determining the feasible design options or efficiency levels that warrant further consideration:

- Technological feasibility: technologies incorporated in commercial equipment or working prototypes are considered technologically feasible
- Practicality to manufacture, install and service: mass production of a technology and reliable installation and servicing of that technology must be able to reach the scale necessary to serve the market by the effective date of the standard
- Adverse impacts on product functions or availability: technology is screened out if it is determined to have adverse impacts on the equipment’s functionality for significant subgroups of customers or result in unavailability of any covered equipment type that are currently generally available
- Adverse impacts on health or safety: technology is screened out if it has significant adverse impacts on health or safety (DOE, 2006).

Engineering Analysis and Mark-Up Analysis

Engineering Analysis

The technologically feasible design options or efficiency levels that survive the screening analysis are further evaluated in the engineering analysis, typically conducted by Navigant Consulting. This analysis is used to determine a cost-efficiency relationship which helps evaluate which design changes or efficiency levels could save energy and to what degree. In particular, steps in the engineering analysis include (McMahon 2004):

- Determining the maximum technologically achievable efficiency
- Identifying potential technologies or design options or efficiency levels
- Using computer simulation models or spreadsheets to quantify energy savings

This analysis often involves purchasing models of different efficiency levels and dismantling them to itemize parts and costs, along with developing a model that accounts for investment costs outside of the cost for parts and labor (Rosenquist 2010). Manufacturing costs are then determined by cross-checking costs determined through the "tearing down" or dismantling of existing products and input from manufacturers about expected manufacturing costs and used in the subsequent Mark-up Analysis.

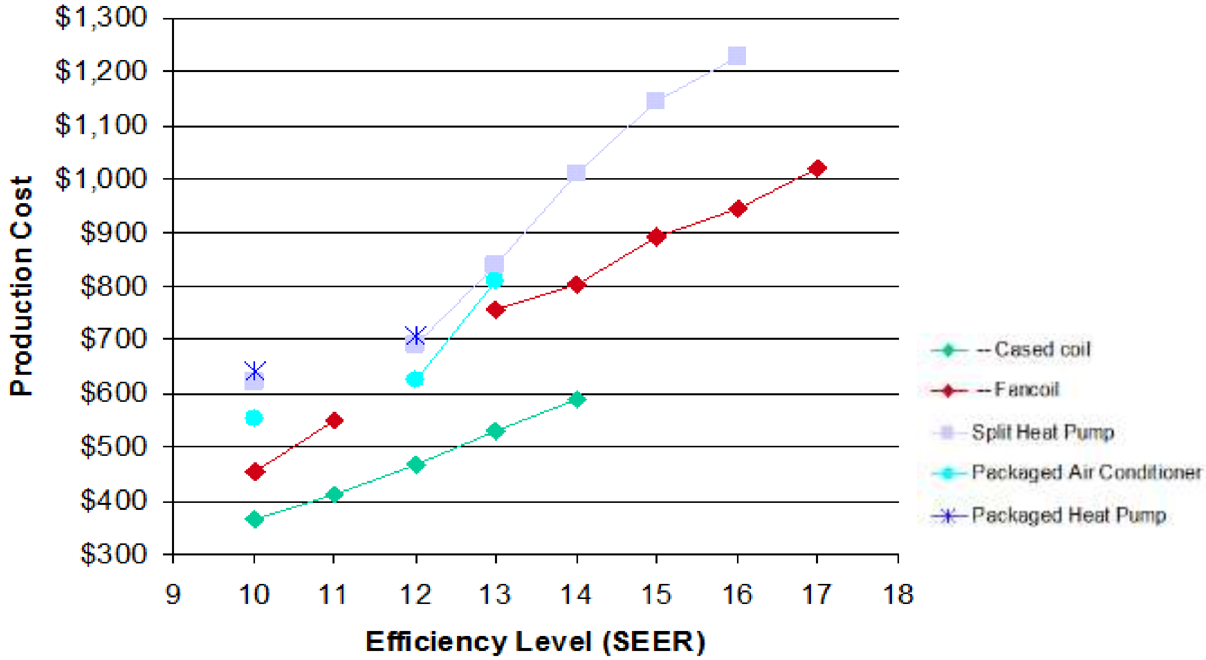
Following the engineering analysis, a mark-up analysis is conducted to determine the expected cost-efficiency relationship.

Mark-ups for Product Price Determination

An increase in manufacturing cost of appliances as a result of new standards is expected to result in incremental change in consumer price associated with the rise in manufacturer price, an "incremental mark-up" (McMahon 2003). The incremental mark-up is dependent on how products are distributed and may include mark-ups by wholesalers, distributors and for some products, contractors. The mark-up analysis is used to determine the mark-up and sales tax associated with converting to a consumer price from an estimated manufacturer price based on census data and profit data from publicly traded companies. Specifically, analysis is conducted to determine the relationship between consumer prices and manufacturer costs and develop scaling factors that can be used to convert from the change in manufacturer costs required to increase efficiency to the resulting change expected in consumer prices (McMahon 2004).

An example of a cost-efficiency relationship for unitary air conditioners as identified through engineering analysis is shown in Figure 2.

Figure 2. Unitary Air Conditioner Example of Cost-Efficiency Relationship



Source: Rosenquist 2010

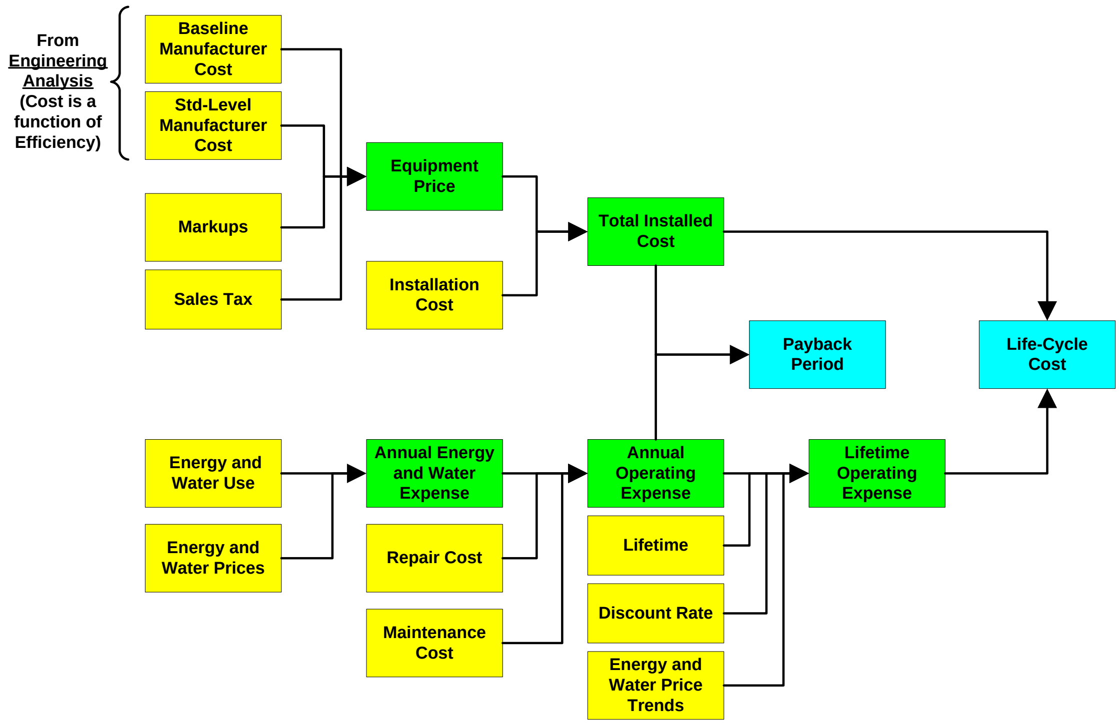
Energy and Water Use Analysis

For each design option or efficiency level, the operational energy and water use is estimated based on usage patterns taken from a sample of household data from the latest Residential Energy Consumption Survey or other data.

Life-cycle Cost (LCC) and Payback Analysis

Since the economic impact of a standard on consumers is a major factor in the MEPS formulation process, the LCC and Payback analysis evaluates the life-cycle economic impacts of potential standard levels on consumers or end-users. In the U.S., life-cycle costs are calculated to be statistically representative of a cross-section of consumer impacts and thus differ from a single estimate of estimated national benefits and costs. Using inputs from the mark-up analysis; technical product data such as equipment lifetime, energy consumption, installation, maintenance and repair costs and estimates of future product and energy prices, an LCC and payback model is developed to calculate savings in operational costs over the product's life-cycle relative to any price increase related to adoption of a standard. In recent years, marginal energy prices have been developed for peak end-uses such as air conditioners in order to account for the value of energy savings that differs depending on when energy is used (i.e., peak versus non-peak loads) (Rosenquist 2012). Figure 3 shows the necessary inputs to the LCC analysis.

Figure 3. Data Inputs to U.S. MEPS Life-cycle Cost Analysis



Source: Rosenquist 2010.

Sensitivity analyses of discount rates and future energy price forecasts are also included in the analysis. To account for variability and uncertainty, the LCC and Payback Analysis is conducted for a statistical sample of expected applications. More specifically, this analysis is conducted using the Monte Carlo probabilistic approach using nationally representative samples for different variables (energy prices, income, household size) from the Residential Energy Consumption Survey (more details in McMahon and Liu, 2000). Microsoft Excel spreadsheet models with the add-on software, Crystal Ball ®, are used to perform the Monte Carlo simulation analysis.

Shipment Analysis

The shipment analysis collects industry data on current shares of shipments by efficiency to feed into the National Impacts Analysis. A national stock accounting model is used to estimate annual shipments, taking into consideration historical shipments data, specific market segments, retirement function and distribution of in-service product stocks. Specific data inputs for model calibration include historical shipments and market factors (e.g., demand for replacement units, secondary units).

National Impacts Analysis

This analysis is used to evaluate the potential energy and economic impacts associated with each design option or efficiency level at the national level. A spreadsheet-based accounting model of stock turnover analysis and forecasting models of U.S. residential and commercial energy use serves as the main tools for calculating annual and net present values of total consumer costs and savings, and national energy and water savings, in energy and economic units.

More specifically, the stock accounting model uses historical shipments data to develop two sets of projected shipments through 2035: a base case without new standards and a standards case. Shipments for the standards case are forecasted by using purchase price elasticity to take into account the impact of standards on future shipments (Rosenquist 2012). The purchase price elasticity are developed using market data and help model consumer choices under new standards. For both cases, shipments are used to derive annual energy consumption and cumulative energy consumption, with the difference between base case and standards case taken as the cumulative site energy savings. Site-to-source energy conversions then help convert site energy savings into national energy savings, and economic parameters such as future energy prices and discount rates can be used to calculate future economic savings. In 2010, the U.S. began using forecasted product prices that are determined using experience curves rather than constant product prices in the National Impacts Analysis. The forecasted product prices reflect the more realistic expectation that future prices will change over time as a function of cumulative shipments rather than remain constant (Rosenquist 2012).

Under this analysis, a rebound effect is considered for energy use, but not economic analysis (since rebound implies benefits at least as high as the value of direct energy savings). The value of future primary energy savings is discounted. Results from the national impacts analysis serve as inputs for employment and environmental assessments.

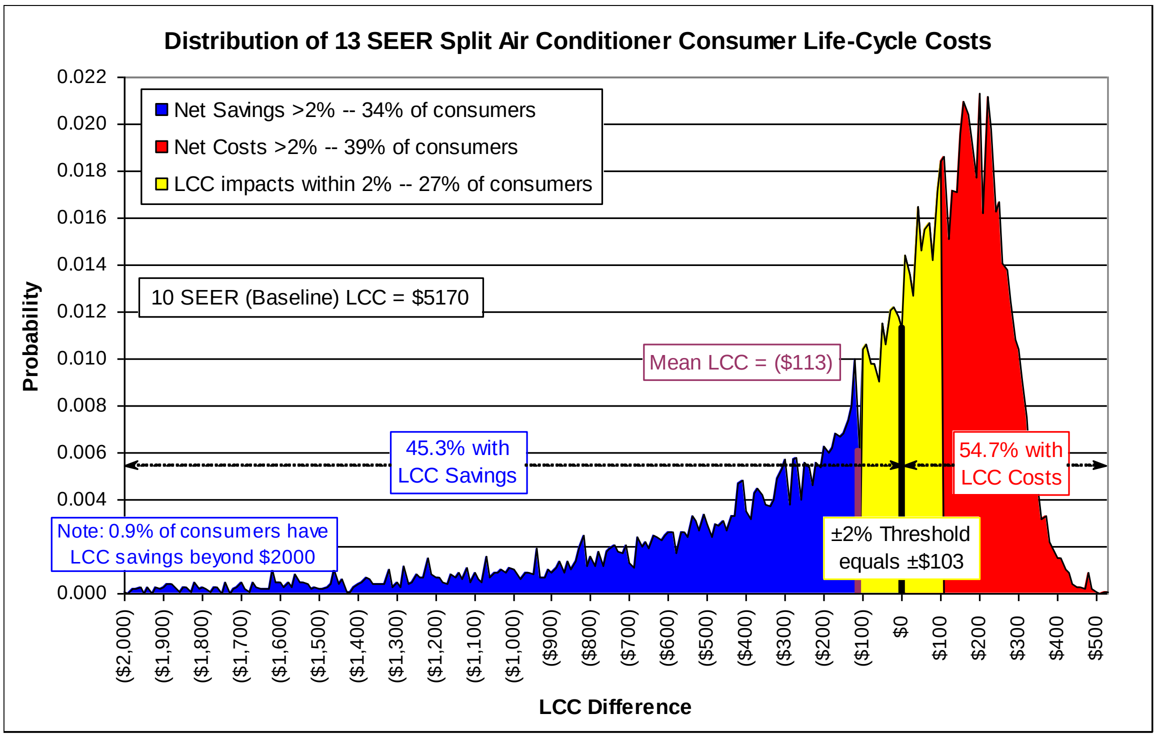
Manufacturer Impact Analysis

A qualitative analysis of identified proposed standards' impact on manufacturers is conducted by consulting companies in three phases. First, an industry profile is created to characterize the industry with preliminary interviews with manufacturers to identify areas of concern. Second, manufacturers are interviewed with questionnaires to formulate the Government Regulatory Impact Model (GRIM) that helps assess industry and subgroup cash flow impacts and industry net present values. The GRIM model uses spreadsheet models to estimate the financial impact of MEPS for individual manufacturers, which are then aggregated to produce industry impacts and net present values. The specific data inputs needed for the industry cash flow analysis include additional investment needs, changes to production costs and revenue effects (e.g., from higher prices and lower sales) (McMahon 2004). Based on the interviews and GRIM model, the impacts on competition, manufacturing capacity, employment and regulatory burden can be assessed and the results are used by the U.S. Attorney General to determine if the proposed MEPS could have potential impact on lessening competition.

LCC Subgroup Analysis

This analysis evaluates whether the proposed standards' impacts on consumers vary by region, demographic groups, or income levels in order to ensure that the standard does not disproportionately affect a certain subgroup of consumers or end-users. In this analysis, a distribution of values is defined rather than a single average value for each input parameter. The distribution is used to represent the range of possible values in a consumer sample and each value's corresponding probability to account for variability from household to household and for uncertainty (McMahon, 2003). The consumer sample is based on consumers who utilize the appliance, based on statistically representative survey data from the Residential Energy Consumption Survey (RECS) for residential products and Commercial Building Energy Consumption Survey (CBECS) for commercial products. Monte Carlo simulation is used to draw a value from each input distribution by random sampling and a range of LCC results through 10,000 iterations are produced to reflect the fraction of population having particular results (Rosenquist 2010). An example of the results of the LCC subgroup analysis for residential central air conditioners is shown in Figure 4.

Figure 4. Residential Central AC LCC Subgroup Analysis Results



Source: Rosenquist 2010.

Employment Impact Analysis

This analysis evaluates the net jobs created or eliminated nationally amongst manufacturers, related service industries, energy suppliers and the economy in general by the proposed standards. This analysis is conducted using a national, 187-sector economic input/output econometric model called ImSET 3.1.1 developed by the Pacific Northwest National Laboratory. This model provides estimates of the change in national output for each sector based on data collected on initial investments, energy savings and economic activity associated with spending the savings resulting from standards.

Utility Impact Analysis

This analysis considers the impacts of potential standards on national electricity and gas suppliers using estimates of reduced energy sales, peak load and deferred power plant construction due to proposed efficiency standards. This analysis is conducted using a version of the EIA National Energy Modeling System (NEMS) tool, with annual energy savings from the National Impact Analysis as the model input. Each proposed standard level is compared to the Annual Energy Outlook's Reference Case to evaluate the amount of energy saved and its impact on utilities.

Regulatory Impact Analysis

This analysis evaluates and compares the national impacts of non-regulatory alternatives, such as information, incentives or tax credits, compared with proposed mandatory MEPS standards. The NEMS tool is also used to evaluate and compare the impact of non-regulatory alternatives to proposed MEPS standards.

Environmental Assessment

This assessment is conducted to determine potential reductions in the emissions of carbon dioxide and air pollutants of sulfur dioxide and nitrogen oxides associated with energy savings from the proposed standard levels. This analysis uses the same inputs and modeling tool as the Utility Impact Analysis, but with carbon and NO_x emissions as the key outputs of the analysis. Estimated power plant emission factors are taken from the NEMS model while the value of CO_2 savings are also modeled using different approaches, e.g. social cost of carbon, market price or estimated impact on energy prices from CO_2 cap and trade legislation (Rosenquist 2010). For some products, additional environmental factors are considered, such as ozone-depleting potential for such products as refrigerators, air conditioners, and water heaters.

2.3 ENERGY STAR Process Overview

Unlike the U.S. MEPS, there is no specific regulatory timeline for revising ENERGY STAR product specifications, but rather the revisions are initiated in response to changing market shares for efficient products. A general principle for considering revisions of a product specification has historically been if the market share of ENERGY STAR qualified products in a particular category reaches 50% or higher. However, other considerations for undertaking specification revisions include changes in federal MEPS, technological changes and advancements that allow revised specifications to capture additional savings, product availability, significant issues with consumers realizing expected savings, performance or quality issues and issues with test procedures. In March 2011, the U.S. EPA and DOE signed a memorandum of understanding outlining a workplan for the ENERGY STAR program which set a goal of maintaining relevance and value by regularly reviewing and updating product performance specifications (U.S. EPA 2011). For rapidly evolving product categories, a review of the specifications to determine if revisions are needed will be undertaken every two years. For other product categories, specification review will be undertaken every three years or when the market share reaches 35%.

For the ENERGY STAR program, energy efficiency requirements are set in the product specifications and typically represent approximately the top 20% efficient products on the market. Additional guiding principles for setting the ENERGY STAR specifications include significant nationwide energy savings, provide features and performance demanded by consumers, reasonable payback period for higher incremental cost of more efficient unit, broadly available and non-proprietary technologies by more than one manufacturer, and verifiable energy consumption and performance. The specific processes in the specification development cycle are shown in Figure 5 below. Because the specification development and revision cycle is much shorter than the MEPS rulemaking process at only six to nine months per specification, the EPA references relevant technical analyses conducted for the DOE MEPS rulemaking process and generally adopt the same efficiency indicators and performance requirements as the MEPS program. As part of the specification development process, EPA also interviews manufacturers about cutting-edge technology to understand the future development trajectories of different product technologies.

Figure5: Steps in ENERGY STAR Specification Development Cycle

Source: http://www.ENERGY STAR.gov/index.cfm?c=prod_development.prod_development_spec_rev

In May 2011, the ENERGY STAR program also launched a new pilot program element to designate the most efficient or top tier efficiency models for selected product categories including clothes washers, refrigerators, televisions and heating and cooling equipment. The Most Efficient designation is intended to recognize truly exceptional, inspirational or leading edge efficiency performance and targets in a very small proportion of highly efficient models such as the top 5% efficient TV models on the market.

3. Overview of Australia MEPS and Energy Label Framework

In Australia, a mandatory energy labeling program was first created unilaterally by three states in the late 1980s after negotiations between jurisdictions and manufacturers failed to establish a national-scale labeling program. Concerns about piece-meal development of S&L policies led to the creation of a national committee on appliance and equipment efficiency to coordinate national MEPS program and other S&L activities in Australia in 1992. By 1999, all jurisdictions had implemented state and territory regulations for mandatory energy labeling and MEPS with all S&L activities managed and coordinated by the Equipment Energy Efficiency (E3) Committee.

Australia is also unique in that most of the products in its appliance market are imported, rather than produced domestically. This has important implications for its MEPS setting process, as the country tends to have less access to detailed and comprehensive data and have to rely predominantly on import and customs data. The import-heavy appliance market in Australia has also influenced its general goal of setting MEPS at levels that are at least the equivalent of existing world-best regulatory target.

Because a key goal of Australia's MEPS program is to reduce greenhouse gas emissions, there is a broader set of secondary criteria for setting MEPS levels with less direct emphasis on energy savings. The secondary criteria for setting acceptable MEPS levels include (McMahon 2004):

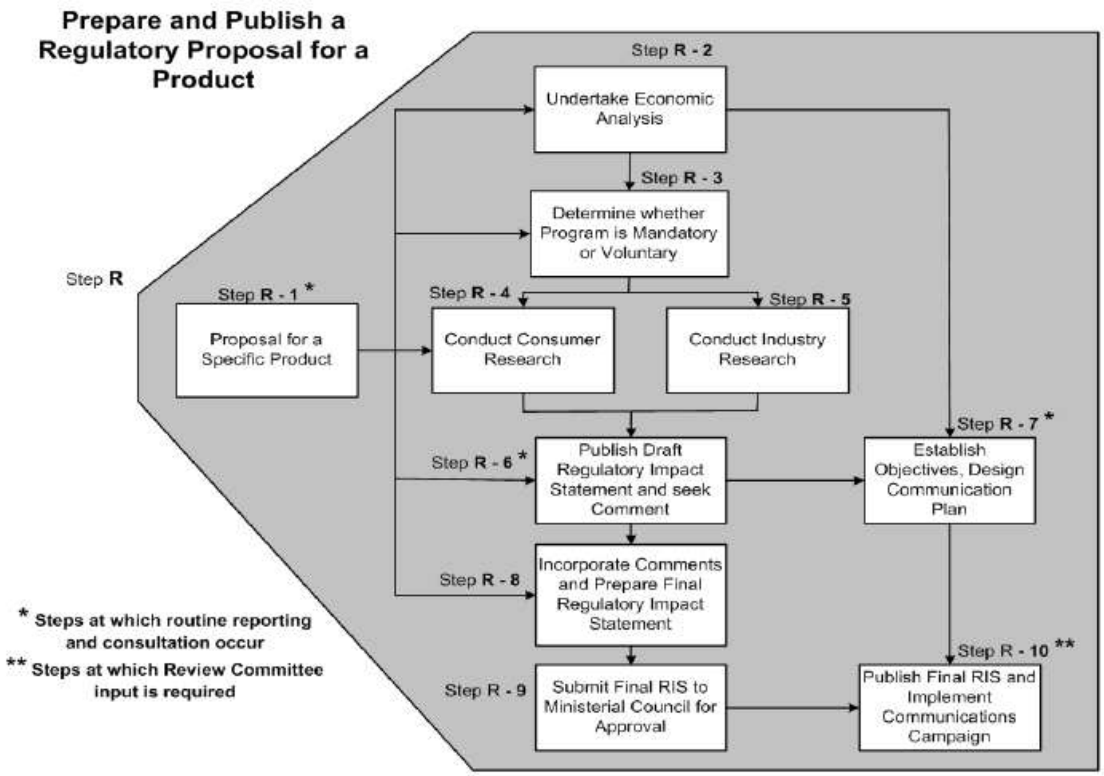
- Addressing market failures to reduce life-cycle cost;
- Minimizing negative impacts on product quality and function;
- Minimizing negative impacts on manufacturers and suppliers; and
- Ensuring consistency with other national policy objectives (e.g., reducing emissions of ozone-depleting substances and matching "world best practice" standards)

In the beginning of the regulatory impact statement (RIS) for proposed MEPS, the problems related to these criteria that the proposed MEPS would help address are identified and described with supporting data. For example, in the 2011 RIS for air conditioner MEPS, the problems identified include increasing energy consumption and greenhouse gas emissions from air conditioners, existing market failures regarding energy efficiency, effectiveness of current regulations for improving efficiency and ongoing problems and limitations of current MEPS levels (E3 2010).

3.1 MEPS Process Overview

The Australian standard setting and revision process begins with product selection in which potentially regulated products are identified by the E3 Committee. The committee is responsible for analyzing and projecting product level energy use in order to determine if identified products have significant current or projected energy use on either a per unit basis or due to high sales volume. To make this determination, the committee commissions product profiles and formulates a regulatory proposal to consider if policy intervention is necessary and if so, which policy option (MEPS, labeling, both MEPS and labeling, or another policy option) is the most appropriate. The regulatory proposal is based on economic analysis, consumer research and industry research and is published in the form of a draft RIS for public comment before the final regulatory impact statement is submitted for approval. The specific process is depicted in Figure 6.

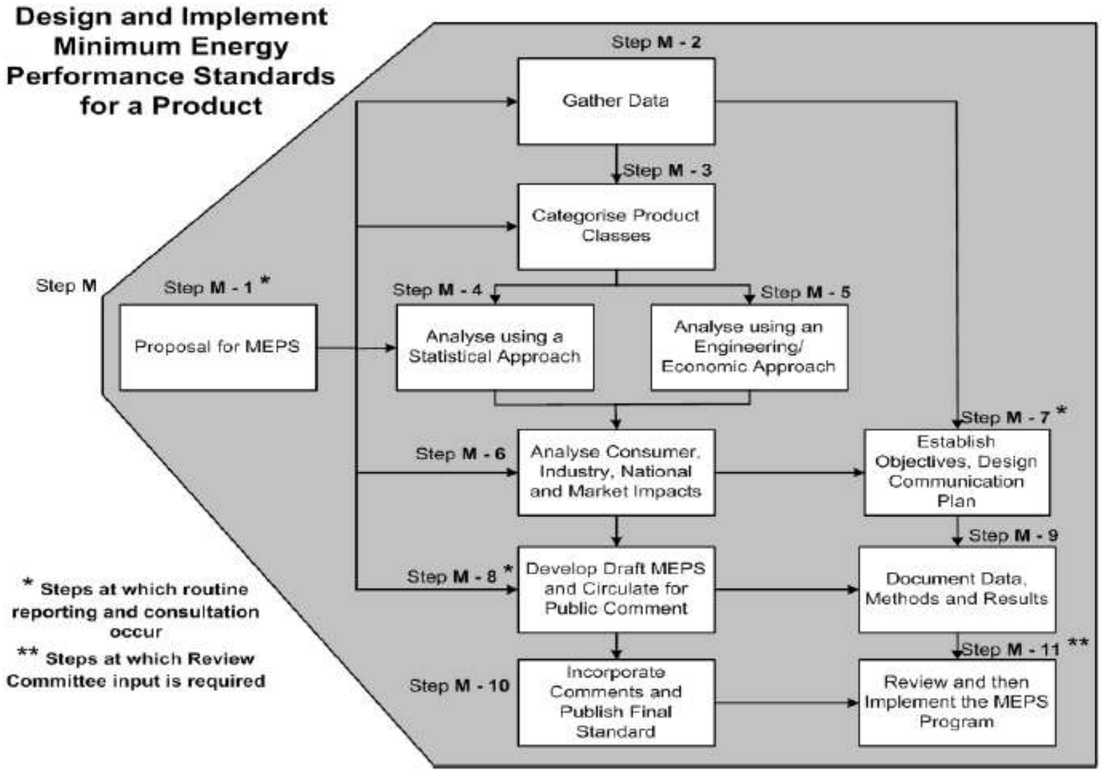
Figure 6. Processes in Preparing Regulatory Impact Statement in Australia



Source: E3, 2006, "The MEPS and Energy Labeling Process in Australia and New Zealand." Available at: www.energyrating.gov.au/pubs/meps-labelling-process-au-nz.pdf

Once the regulatory impact statement has been approved, further steps are taken to design and implement MEPS and/or labeling for a given product. Data collection and categorization of product classes is undertaken, followed by statistical, engineering/economic, consumer, industry, national and market analysis. As with the regulatory impact statement, a draft standard is circulated for public comment before it is finalized and published. The specific steps and processes in the formulation and implementation of an Australian MEPS are shown in Figure 7.

Figure 7. Processes in the Design and Implementation of MEPS in Australia



Source: E3 2006.

3.2 Supporting Analyses and Tools

The main analytical method in support of the MEPS program in Australia is the regulatory impact analysis that must be conducted before a product can be included in standards and labeling programs. The purpose of the regulatory impact analysis is to identify and compare the cost and benefits of each regulatory approach where benefits outweigh the costs across industry, consumers and regulators. The underlying basis for the regulatory impact statement and subsequent regulatory proposal include economic, engineering and statistical approaches of analysis, with consumer and industry research to inform analysis of consumer, industry, national and market impacts. The regulatory impact statement must include analysis of regional impacts and impacts of stakeholders likely to be most adversely effected, as specified by the Office of the Best Practice Regulation. The key analyses undertaken as part of a regulatory impact study are described in more detail below.

Market and Technology Assessment

Since Australia's appliance market is largely dominated by imported products, it tends to rely more on current market data for its market and technology assessments. For the market assessment, Australia uses import and sales data by model to characterize its market shares from different regions of the world. The manufacturers, importers and distribution channels in Australia are also analyzed and interpreted using annual data over a period of several years. In the example of the air conditioner MEPS proposal, the market assessment provided information about the household penetration rate of air conditioners from Australia Bureau of Statistics surveys and market shares and sales of different air conditioner models from industry data, retailers and suppliers.

For the technology assessment, Australia uses different methods to define the current product and identify possible technological changes to improve efficiency and reduce greenhouse gas emissions. For products with detailed market data, Australia rely more on the data in the current market to understand the potential for efficiency improvements and may not perform its own computer simulations and engineering analyses (McMahon 2004). For other products that do not have detailed market data, Australia may either look at engineering simulation studies done elsewhere or conduct limited computer simulations to identify options for improving efficiency.

Selection of Candidate MEPS Levels

In order to determine the price-efficiency relationship for evaluating and selecting candidate MEPS levels, Australia tends to rely more on statistical analysis of the price and efficiency of current products. Because it has limited domestic equipment manufacturing and production, Australia generally will not conduct an extensive engineering analysis of new combinations of technologies as is typically done in the U.S. Instead, Australia uses current market data to derive a statistical relationship between price and product characteristics while also examining the price-efficiency relationships reported in European and US studies (McMahon 2004). A small number of candidate MEPS levels are then selected for in-depth life-cycle cost and impacts analysis.

Life-Cycle Cost Analysis

Australia uses a similar methodology and data inputs for calculating the economic life-cycle costs associated with each candidate MEPS levels as the U.S. The major difference in Australia's life-cycle cost analysis is that it calculates the life-cycle cost as national average estimates which do not distinguish between population subgroups. This means that a single national average is determined for each data input and included in the life-cycle cost calculations (e.g., national average equipment price, energy price, average real discount rate, product lifetime), rather than the more nuanced distribution functions used to represent variability amongst the different data inputs in the U.S. As such, the results of the life-cycle cost analysis in Australia are presented only in the form of national benefits and costs as described in the following section.

National and State Benefits and Costs

Australia's economic analysis of candidate MEPS levels is conducted based on costs and benefits at both the State and national level, including (E3 2010):

Costs:

- to the consumer due to incremental price increases of product due to MEPS;
- to the State and Federal governments for implementing and administering the MEPS program

- to the product supply businesses (e.g., manufacturers, distributors) for complying with the MEPS program requirements;

and,

Benefits due to the avoided consumer electricity purchase costs and possibly peak demand savings[5].

Sensitivity analysis of the cost-benefit analysis is also conducted to test the sensitivity of analysis outputs including factors such as sales growth, usage, and sensitivity to BAU efficiency increase. Sensitivity analyses of the assumed discount rates are also conducted to examine the potential impacts on net benefits and costs. The outputs of the life-cycle cost analysis and national and state benefits and costs include total costs, benefits and net benefits in net present value terms and benefit-cost ratio. Examples of outputs of the life-cycle cost analysis and national and state costs and benefits results are shown in Tables 1 and 2.

[5] For some products such as air conditioners, there may be peak demand savings associated with proposed MEPS levels. In these cases, the impact of reducing energy costs (e.g., generation and network costs) over the peak demand period through more efficient equipment may be included in the analysis.

Table 1. Australia Example of Financial Analysis – National MEPS Scenarios with Various Discount Rates

Scenario	NPV Nil (0%)	NPV Low (3%)	NPV Med (7%)	NPV High (11%)
MEPS2010+10%				
Total Costs	$1,719,691,146	$1,326,349,107	$968,310,516	$729,836,189
Total Benefits	$4,815,396,303	$3,366,649,144	$2,199,845,256	$1,512,336,598
Net Benefits	$3,095,705,156	$2,040,300,037	$1,231,534,740	$782,500,409
Benefit Cost Ratio	2.8	2.5	2.3	2.1
Proposal A				
Total Costs	$2,481,369,898	$1,912,557,498	$1,395,088,417	$1,050,655,858
Total Benefits	$6,511,752,514	$4,586,396,441	$3,021,609,841	$2,091,161,072
Net Benefits	$4,030,382,616	$2,673,838,943	$1,626,521,424	$1,040,505,214
Benefit Cost Ratio	2.6	2.4	2.2	2.0
Proposal A1				
Total Costs	$1,802,408,284	$1,389,959,665	$1,014,565,568	$764,562,224
Total Benefits	$4,902,025,224	$3,433,112,135	$2,247,858,375	$1,548,048,869
Net Benefits	$3,099,616,940	$2,043,152,469	$1,233,292,808	$783,486,644
Benefit Cost Ratio	2.7	2.5	2.2	2.0
Proposal B				
Total Costs	$3,095,082,857	$2,344,288,340	$1,667,426,555	$1,222,405,668
Total Benefits	$7,673,389,697	$5,333,068,778	$3,443,487,158	$2,330,155,757
Net Benefits	$4,578,306,840	$2,988,780,438	$1,776,060,604	$1,107,750,090
Benefit Cost Ratio	2.5	2.3	2.1	1.9
Proposal C				
Total Costs	$8,818,509,095	$6,563,335,013	$4,557,253,308	$3,260,899,039
Total Benefits	$14,686,105,415	$10,032,842,605	$6,349,406,626	$4,224,919,167
Net Benefits	$5,867,596,320	$3,469,507,591	$1,792,153,318	$964,020,128
Benefit Cost Ratio	1.7	1.5	1.4	1.3

Source: EnergyConsult modelling based on stock, sales, hours of use and EER assumptions detailed in Section 5.6 and cost benefits detailed in Section 5.7

Source: E3, 2010, Decision Regulatory Impact Statement: Minimum Energy Performance Standards for Air Conditioners: 2011.

Table 2. Australia Example of Benefit-Cost Ratios for States and Peak Demand Savings for Air Conditioner Proposed MEPS

State	NPV Nil (0%)	NPV Low (3%)	NPV Med (7%)	NPV High (11%)
NSW & ACT	2.5	2.3	2.1	1.9
NT	3.6	3.2	2.8	2.5
QLD	3.0	2.7	2.4	2.2
SA	2.7	2.5	2.2	2.0
TAS	1.7	1.5	1.3	1.2
VIC	2.2	2.0	1.9	1.7
WA	2.8	2.5	2.3	2.1

Source: EnergyConsult modelling based on stock, sales, hours of use and EER assumptions detailed in Section 5.6 and cost benefits detailed in Section 5.7

Source: E3, 2010, Decision Regulatory Impact Statement: Minimum Energy Performance Standards for Air Conditioners: 2011.

Analysis of Costs to the Government

This analysis focuses on quantifying the additional government costs related to the introduction of new MEPS levels, which differs from the administrative costs of managing the MEPS program. Because the administrative or program operating costs already exist under existing MEPS regulation, they are not considered in this analysis as there will be no additional operating costs for revised MEPS. However, the introduction of new or revised MEPS will incur additional costs related to research for MEPS development and increased compliance. For example, in the case of the 2011 revised air conditioner MEPS, the government needs to check and test a greater range of air conditioning units in the first year of the new MEPS in order to ensure compliance with the new MEPS levels (E3 2010). The regulatory impact assessment found that the additional cost of the increased compliance for new MEPS totaled AUD $300,000.

Analysis of Industry Costs

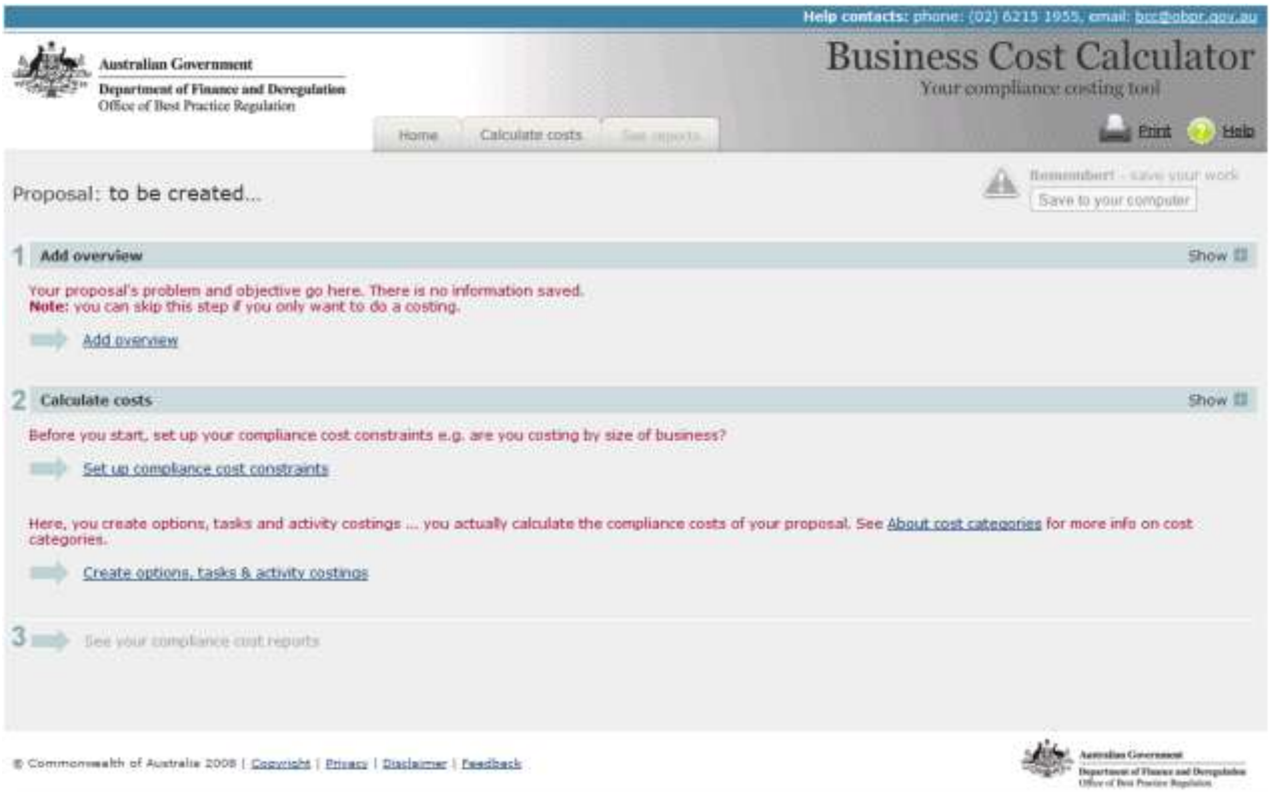
The analysis of industry costs for complying with MEPS is conducted using the national Business Cost Calculator and includes three main categories of compliance costs (E3 2010):

1. Education Costs: the cost of maintaining awareness of legislation and regulations and changes to regulatory details, involving the need to train staff to be up-to-date with regulations
2. Permission: the costs of following the procedures to retain permission to conduct an activity (i.e., sell or import products), such as testing each model and completing the MEPS registration
3. Record Keeping: the costs of keeping mandatory statutory documents up-to-date

It's important to note that the costs of materials and equipment purchased to comply with the regulation, such as more efficient technologies or components, are not included in this analysis because costs of design changes to meet more stringent MEPS have already been captured in the life-cycle cost benefits analysis from the consumer's perspective.

The Business Cost Calculator is a free and publicly available online tool provided by the Australian Department of Finance and Deregulation to help estimate the compliance costs of regulatory proposals. It provides an easy-to-use template for nine existing compliance cost categories, including notification, education, permission, purchasing, record-keeping, enforcement, publication and documentation, procedural and other costs. The tool allows users to set up cost constraints, create a cost option or task within the nine cost categories and generate reports of the results. A screenshot of the Business Cost Calculator tool is shown in Figure 8.

Figure 8: Screenshot Sample of Australia's Business Cost Calculator



Source: Australia Government, 2012. https://bcc.obpr.gov.au/

In the case of the revised air conditioner MEPS, the industry cost calculation inputs needed for the Business Cost Calculator are shown in Table 3.

Table 3. Australian Example of Inputs to Business Cost Calculator for Industry Cost Analysis

Category	Task	Cost Inputs	Source
Education	Train staff, keep up-to-date with regulations	80 hours/year per supplier	Estimated from other MEPS programs
Permission	Testing each model	$4,000 per model supplied	Based on laboratory costs
Permission	Complete MEPS registration	8 hours per model supplied	Estimated from other MEPS programs
Record Keeping	Maintain documents for 5 years	8 hours per 5 years per supplier	Estimated from other MEPS programs
Other inputs:		Staff costs $40/hr	*Australian Jobs 2010* (DEEWR 2010)

Source: E3 2010.

Once the Business Cost Calculator has been used to determine the cost per business, the costs are totaled using the total number of businesses importing and supplying air conditioners and then divided by the total number of models supplied to obtain a "per model" cost for the cost-benefit analysis (E3 2010). The per model costs for the revised air conditioner MEPS are shown in Table 4.

Table 4. Australian Example of Business Compliance Costs for MEPS

Category	Task	Costs / model
Education	Train staff, keep up-to-date with regulations	$152
Permission	Testing of models for energy performance	$4,000
Permission	Complete MEPS registration	$520
Record Keeping	Maintain documents for 5 years	$320
Total/model		$3,492
Total Cost	All businesses (approx 1,000 models will require re-testing)	$4.99M

Source: E3 2010.

Analysis of Supplier Costs

The costs to suppliers for a new or revised MEPS fall into two main categories that have already been discussed in detail in previous sections: compliance costs and increased cost of producing or supplying more efficient equipment. The compliance costs are described in the above section on Analysis of Industry Costs while the increased costs of producing or supplying more efficient equipment were described in the section on the Selection of Candidate Levels.

Analysis of National Energy and Greenhouse Gas Emissions Impacts

Similar to the U.S., Australia also uses a national stock accounting model of installed and operating equipment to calculate the energy consumption under business-as-usual (BAU, i.e., no regulatory change) and MEPS scenarios. The stock turnover model was developed as a function of existing stock, replacements and new sales and inputs into the stock turnover model include projected sales by state and survival functions for each product category for calculating replacements. The stock model is used to develop estimates by state and year with additional details on product category, capacity range, average efficiency and year of purchase or installation. The stock model is then multiplied by the average energy value (e.g., power input) and usage for BAU and MEPS scenarios by state. Greenhouse gas emissions in turn are determined by multiplying energy consumption by State-specific electricity emission factors (E3 2010). For each candidate MEPS scenarios, outputs of the analysis may include annual energy consumption for both BAU and MEPS, potential energy savings from MEPS by product category and projected annual greenhouse gas emissions reductions. Tables 5 and 6 and Figure 9 represent three examples of outputs from Australia's national energy and greenhouse gas emissions impact analysis.

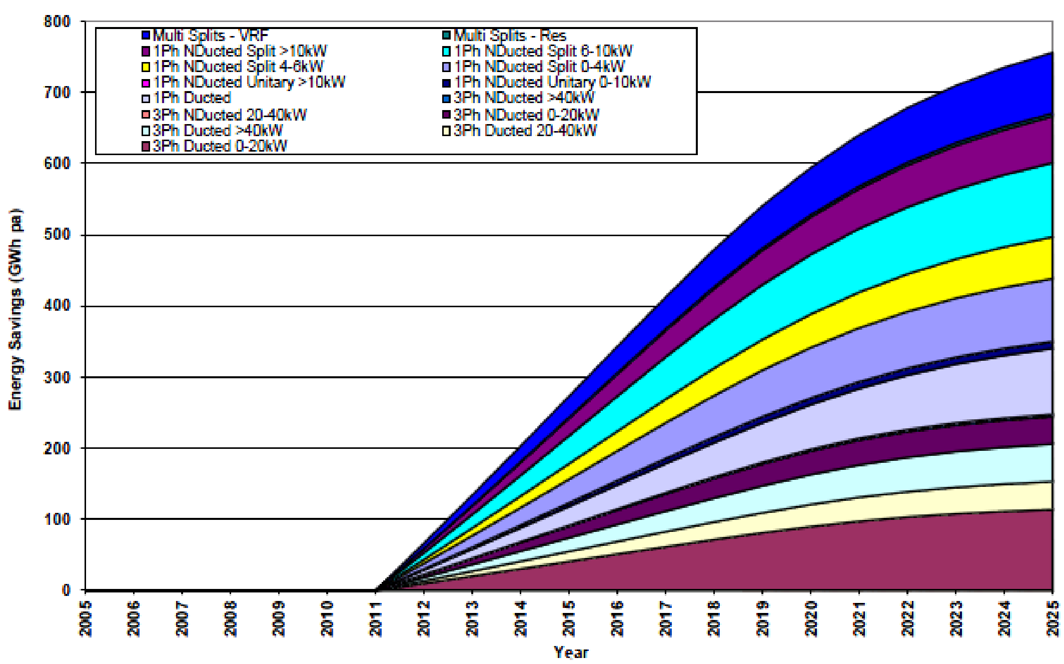
Table 5. Australia Example of Projected Annual Energy Savings (GWh) by Scenario and Year

Scenario / Year	2015	2020	2025
MEPS2010+10%	278	605	769
Proposal A	342	743	942
Proposal A1	273	594	756
Proposal B	324	860	1,158
Proposal C	591	1,839	2,652

Source: EnergyConsult modelling based on stock, sales, hours of use and EER assumptions detailed in Section 5.6

Source: Taken from E3 2010.

Figure 9: Australia Example of Potential Energy Savings from MEPS for Proposed MEPS Scenario



Source: EnergyConsult modelling based on stock, sales, hours of use and EER assumptions detailed in Section 5.6

Source: Taken from E3 2010.

Table 6. Australia Example of Projected Annual Greenhouse Gas Reductions (kt CO_2e) by Scenario and Year

Scenario / Year	2015	2020	2025
MEPS2010+10%	257	517	636
Proposal A	316	634	780
Proposal A1	253	507	626
Proposal B	300	734	958
Proposal C	548	1,571	2,194

Source: EnergyConsult modelling based on stock, sales, hours of use and EER assumptions detailed in Section 5.6

Source: Taken from E3 2010.

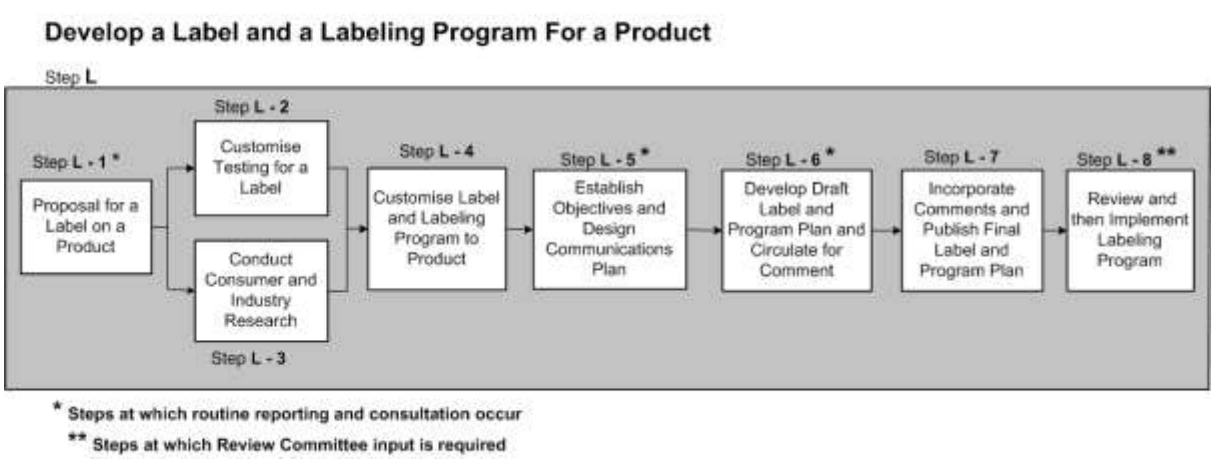
Industry, Competition and Trade Issues

Industry, competition and trade issues are considered in Australia using data on the total number of domestic manufacturers, imported models and existing market share information. For example, one issue considered is how compliance with more stringent proposed MEPS could initially reduce the range of models available in the market and whether this reduction would significantly affect consumer choice. An evaluation of how the implementation of the proposed MEPS could affect the competitiveness of one supplier over another is also undertaken, taking into consideration different manufacturers' resource and technical capacity, availability of technologies and consistency with global trends. The analysis of industry, competition and trade issues are conducted in consultation with manufacturers, importers and consumers through public meetings and consultative bodies (e.g., product-specific working groups) during the development of candidate MEPS levels (McMahon 2004).

3.3 Energy Label Development Overview

In developing energy labels, Australia follows a shorter process with fewer analyses as illustrated by Figure 10 below.

Figure 10. Process for Developing Energy Label in Australia



Source: E3 2006.

Revisions of label thresholds are generally determined in several ways, including in long-term strategies formulated for the next ten years for certain products, the outcome of jurisdictional commitment to a regular review process 3 to 5 years after implementation, or identified by a reach level with or without a stated timeframe. The implementation of a revised label is usually accompanied by three specified dates: the date before which only the original label is permitted, the transition period set by state or territorial legislation in which both the original and revised labels may be used, and a compliance date after which only the revised label may be used. As previously mentioned, in rare cases where a consensus cannot be reached in negotiations between states and territories, MEPS or label revisions may also be undertaken unilaterally by local jurisdictions.

4. Overview of European Union Ecodesign Framework

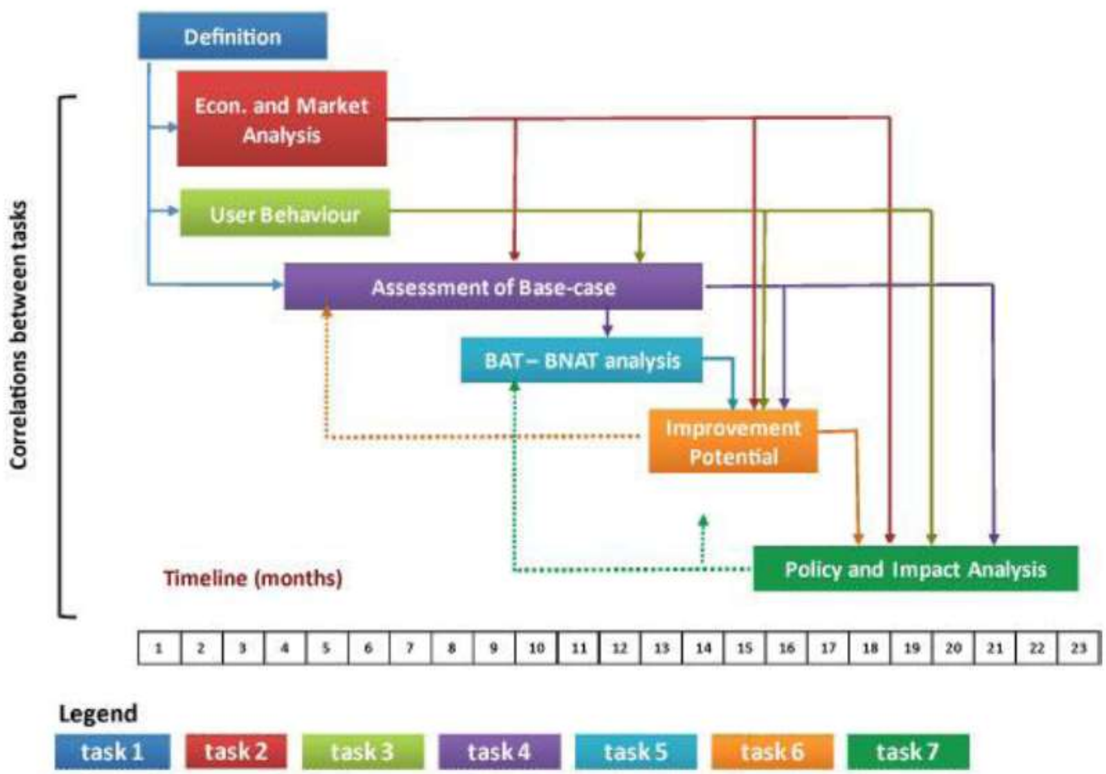
The European Union (EU) first introduced mandatory comparative energy information labeling for household refrigerators, washing machines and dryers, dishwashers, ovens, water heaters and hot water storage, lighting and air conditioners in 1992. This was followed in 1996 by the first MEPS requirements being introduced for household refrigerators, freezers and combinations. In 2005, the MEPS requirements were integrated into a new proposal for Ecodesign requirements, also known as implementing measures, which widened the scope to include lifetime performance criteria with new emphasis on the energy consumption and environmental aspects of the non-use phases of energy-using products. The subsequent 2008 Ecodesign Framework Directive lays out a working plan and includes a list of priority product groups to adopt implementing measures between 2009 and 2011.

4.1 Ecodesign Process Overview

As a new initiative with its implementation plan dictated by the 2008 Ecodesign Framework Directive, a more comprehensive process has been laid out for setting Ecodesign requirements that must also be economically and technically justified. More specifically, a product must first meet three basic criteria to be regulated by the Ecodesign requirements. First, the product must have significant volume and trade, measured by sales greater than 200,000 units per year within the EU Community. Second, the product must have a significant environmental impact within the Community. In the UK, this impact is defined by high primary energy consumption, e.g., exceeding 1000 PJ per year, with other possible indicators of water consumption, long operating time, and parts that contribute to energy consumption or expected increase in the next decade due to high growth market rate. Finally, the product must also have significant potential for improvement in environmental impact without incurring excessive costs, as indicated by market failures, the absence of policy intervention and a wide disparity in environmental performance of products with equal functionality. For the UK, this criterion can be met by energy savings potential of greater than 20% during the use phase and taking into consideration specifications in other countries and the latest information on technology development.

After a product has been determined to meet the qualifying criteria, the Methodology Study of Ecodesign of Energy-using Products known more commonly as preparatory studies are undertaken to evaluate and set the implementing measures. The specific processes and analyses included in each preparatory study are shown in Figure 11 and the specific analyses undertaken are covered in greater detail in the next section. For each product or group of products, the preparatory study begins by defining the product, existing standards and legislation following economic and market analysis. Consumer behavior analysis, local infrastructure analysis and technical analysis of existing products are also used to inform the development of a base case. The base case is then used to reflect the underlying emissions and resources in a product's life-cycle. Next, a technical analysis of best available technology serves as the basis for assessing improvement potential. Lastly, policy, impact and sensitivity analyses are conducted to evaluate the proposed implementing measure. All of the supporting documents and underlying analyses for each preparatory study process are publicly available online and can be accessed at specific websites dedicated to each preparatory study.

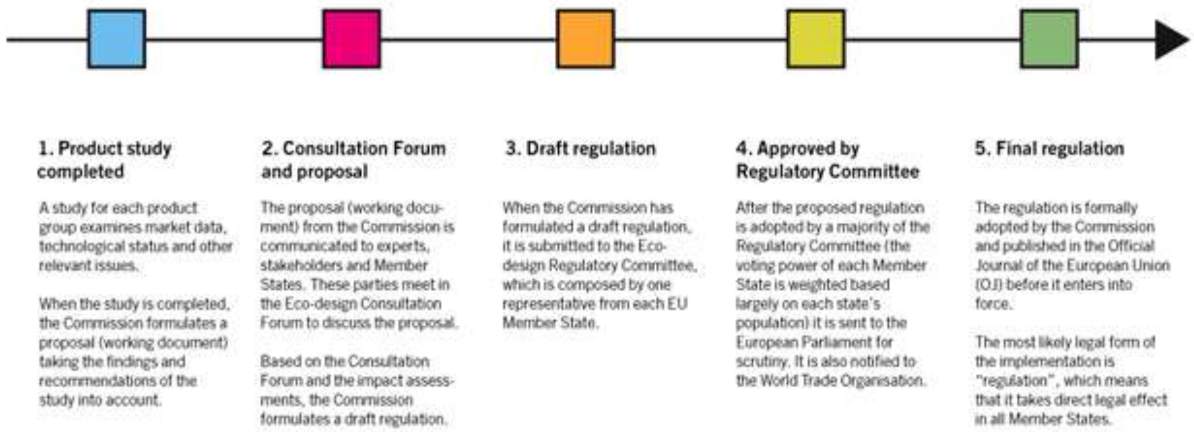
Figure 11. EU Ecodesign Preparatory Study Processes



Source: Waide, P., and L. Harrington, 2010, "Opportunities for Success and CO_2 Savings from Appliance Energy Efficiency Harmonization." London: CLASP Report.

The entire process for the preparatory study involves different research and analytical teams and occurs over a timeframe of approximately two years. Once the preparatory study has been completed, then a Consultation Forum is held for stakeholders and member states to discuss the study findings and formulate a draft regulation. The draft regulation is submitted to the Regulatory Committee for review and upon Committee approval, is forwarded to the European Parliament for further review and the World Trade Organization is notified. Lastly, the regulation is formally adopted by the European Commission and published as a directive before entering into force. This process is illustrated in Figure 12.

Figure 12. Ecodesign Regulatory Process



Source: ECEEE 2011. http://www.eceee.org/Eco_design/products

The final Ecodesign implementing measure must meet the following criteria:

- No significant negative impact on a product's functionality
- Health, safety and the environment must not be adversely affected
- No significant negative impact on consumers
- No significant negative impact on industry's competitiveness
- Does not impose proprietary technology on manufacturers
- No excessive administrative burden on manufacturers

4.2 Supporting Analyses and Tools

The Ecodesign Preparatory Studies are the main analytical tools that serve as the basis for setting Ecodesign Implementing Measures on a country by country basis. These preparatory studies and related assessments are conducted by external experts and the European Commission. The preparatory studies comprise of seven task major tasks, each of which is intended to review and summarize the main supporting analyses conducted to evaluate potential Ecodesign implementing measures.

Task 1: Defining the Scope

The first stage in the Ecodesign Preparatory Study involves defining a product and scope of the implementing measure, based on the listing of priority products for regulation. In this task, a preliminary product scope is identified by examining existing product classification schemes and the functional parameters used to define the product in the EU Eurostat Prodcom, EU or ISO standards and EU labeling categories. Once a product scope has been set, a review of existing test standards at the regional or global level (EN or ISO/IEC standards), at the individual member state level and at the third country level (ASHRAE, Japan, ANSI) regarding product functional performance parameters, resource use, safety, noise and vibrations is undertaken (European Commission 2011). Similarly, a comparative analysis for legislation at the EU, member state and third-country levels is conducted to evaluate their relevance to the product scope.

Task 2: Economics and Market Analysis

Once a product has been defined, the second task of the Ecodesign preparatory studies involve conducting economic and market analysis in order to ensure that the product meets the significant sales and trade volume criteria. For this task, various sources are used to gather trade and production time series data, market and stock data, market trends and consumer expenditure data. For trade and production time series data, the official European Community customs database PRODCOM is used to collect free and publicly available data. Market data is also taken from PRODCOM, in addition to market analyses and data generated by specialty market research firms and sector-specific databases. Historical and forecasted stock data from 1990 through 2050 are also collected or estimated using annual sales and product lifetime data. Market trends on design features and functionality and consumer behavior are also evaluated as part of the market analysis, along with analysis of consumer expenditure data such as purchase prices, installation, repair and maintenance and disposal costs. On the basis of this thorough market analysis, recommendations are made to refine the product scope and to highlight product-specific barriers and opportunities for Ecodesign. Figure 13 shows a detailed list of the data inputs and factors considered in the economic and market analysis.

Figure 13: Detailed Data Requirements and Inputs for EU Ecodesign Preparatory Study Task 2 Market Analysis

2	**MARKETS**	
2.1	**Generic economic data**	
	Identify and report	
	a.	EU Production;
	b.	Extra-EU Trade;
	c.	Intra-EU Trade;
	d.	EU sales and trade= production + import - export.
	Data should relate to the latest full year for which at least half of the Member States have reported to Eurostat. Preferably data should be in physical volume (e.g. units) and in money units and split up per Member State. Information for this subtask should be derived from official EU statistics so as to be coherent with official data used in EU industry and trade policy.	
2.2	**Market and stock data**	
	In physical units, for EU-27, for each of the categories as defined in 1.1 and for reference years	
	a.	1990 (Kyoto and "20-20-20" reference);
	b.	2010 (or most recent real data);
	c.	2013-2016 (forecast, presumable entry into force of measures);
	d.	2020-2030-2050 (forecast, years in which all new ecodesigns of today will be absorbed by the market).
	the following parameters are to be identified:	
	a.	Installed base ("stock") and penetration rate;
	b.	Annual sales growth rate (% or physical units);
	c.	Average Product Life (in years), in service, and a rough indication of the spread (e.g. standard deviation);
	d.	Total sales/ real EU-consumption, (also in €, when available);
	e.	Replacement sales (derived);
	f.	New sales (derived).
2.3	**Market trends**	
2.3.1.	General market trends (growth/ decline, if applicable per segment), trends in product-design and product-features.	
2.3.2	Market channels and production structure; identification of the major players (associations, large companies, share SMEs, employment);	
2.3.3	Trends in product design/ features, illustrated by recent consumer association tests (valuable, but not necessarily fully representative of the diversity of products put on the market);	
2.4	**Consumer expenditure base data**	
	For each of the categories defined in subtask 1.1, determine:	
	a.	Average EU consumer prices, incl. VAT (for consumer prices; streetprice)/ excl. VAT (for B2B products), in Euro.
	b.	Consumer prices of consumables (detergent, toner, paper, etc.) (€/kg or €/piece);
	c.	Repair and Maintenance costs (€/product life);
	d.	Installation costs (for installed appliances only);
	e.	Disposal tariffs/ taxes (€/product);
	For electricity, fossil fuel, water, interest, inflation and discount rates use values for Jan. 2011 in MEErP Chapter 2, including the average annual price increases mentioned there .	
	For regional differentiation of consumer prices (for sensitivity analysis) also see Chapter 2	
2.5	**Recommendations**	
	Make recommendations on	
	2.5.1	refined product scope from the economical/ commercial perspective (e.g. exclude niche markets)
	2.5.2	barriers and opportunities for Ecodesign from the economical/ commercial perspective

Source: European Commission 2011.

Task 3: Consumer Analysis and Local Infrastructure

In Task 3, consumer behavior and local infrastructure are evaluated in order to understand how the product is used and its end-of-life options. Because consumer behavior is an important parameter for energy use phase as well as the product life and end-of-life phases of a product, data collection and analysis are needed to establish user-defined parameters and actual end-of-life behavior for the given product. In addition, analysis of data related to local infrastructure including energy, water, telecommunications, physical distribution and product installation is conducted to understand how infrastructure may pose barriers or opportunities for Ecodesign requirements. The completion of this task will enable further refinement of product scope and identification of additional barriers and opportunities for Ecodesign from the perspective of consumer behavior and infrastructure.

A detailed list of parameters considered for the analysis of consumer behavior and local infrastructure in Task 3 is shown in Figure 14.

Figure 14: Data Inputs and Parameters for EU Ecodesign Preparatory Study Task 3: Consumer Analysis and Local Infrastructure

3 USERS

3.1 System aspects use phase, for ErP with direct energy consumption

Identify, retrieve and analyse data, report on the environmental & resources impacts during the use phase for ErP with a direct energy consumption effect, with impact levels subdivided in

3.1.1 a strict product/ component scope (e.g. steady state efficiency and emissions at nominal load, as in traditional standards)

3.1.2 an extended product approach: considering that the ErP will be subject to various loads/user demands; the product scope could extend to controllability (flexibility and efficiency to react to different load situations, e.g. modulating burner, variable speed drive,'inverter'), the quality of possible controls (sensors, actuators, central processing unit) and/or the quality of auxiliary devices that may or may not be part of the ErP as placed on the market (e.g. separate heat recovery devices such as PFHRD[22],)

Examples of possibly important factors to consider, depending on the nature of the ErP, are:

- Load efficiency (real load vs. nominal capacity);
- Temperature- and/or timer settings;
- Dosage, quality and consumption of auxiliary inputs (detergents, paper- and toner use, etc.);
- Frequency and characteristic of use (e.g. hours in on, standby or off mode);
- Identification of use of second hand auxiliary inputs during product life (e.g. toner, recycled paper);
- Power management enabling-rate and other user settings;
- Best Practice in sustainable product use, amongst others regarding the items above.

3.1.3 a technical systems approach: considering that the ErP is part of a larger product system and –through certain features of the ErP—can influence the functional performance and/or the resources use and emissions of that of that larger product system. E.g. central heating boiler regulation influencing indoor temperature fluctuation (discomfort), thus increasing heat demand. Other example: combination and possible synergy from combining strict ErP with other ErP (consumer electronics TV/ PC/ phone/ camera; combi-boiler with both space and hot water heating; hybrid boiler combining gas boiler with heat pump, etc.). Note that this still considers solutions of which the ErP is a physical part.

3.2 System aspects use phase, for ErP with indirect energy consumption effect

Identify, retrieve and analyse data, report on the indirect environmental & resources impacts during the use phase for ErP with an indirect [23]energy consumption effect (e.g. windows, insultation material, shower head, water taps), specifically

3.2.1 describe the affected energy system(s), i.e. the systems/products whose energy consumption in the use phase of the ErP is influenced by features of the ErP

3.2.2 repeat Tasks 1.2, 1.3 (relevant standards, legislation) and Task 2 (economic and market analysis) for the affected energy system, but only related to technical parameters that relevant for the aforementioned interaction with the ErP and only in as much as they are not already taken into account in Task 1 and 2 for the ErP.

3.2.3 information retrieval and analysis of the use phase energy consumption of the affected energy system (repeat 3.1 but only for the use phase of the affected energy system).

3.2.4 assess the interaction between the ErP and the affected energy system: describe the basic physical/chemcical or other parameters and mechanisms behind the interaction, possible backed-up by statistical data or field trial or laboratory data.

3.2.5 quantify the energy use and the energy-related resources & environmental impacts during the use phase of the affected energy system(s) that is influenced by the ErP, following the outcomes of the relevant parts of Tasks 4 to 7 for the affected energy system.

3.3 **End-of-Life behaviour**

Identify, retrieve and analyse data, report on consumer behaviour (avg. EU) regarding end-of-life aspects. This includes:

3.3.1 Product use & stock life (=time between purchase and disposal);

3.3.2 Repair- and maintenance practice (frequency, spare parts, transportation and other impact parameters);

3.3.3 Collection rates, by fraction (consumer perspective);

3.3.4 Estimated second hand use, fraction of total and estimated second product life (in practice);

3.3.5 Best Practice in sustainable product use, amongst others regarding the items above.

3.4 **Local Infra-structure**

Identify, retrieve and analyse data, report on barriers and opportunities relating to the local infra-structure regarding

3.4.1 Energy: reliability, availability and nature

3.4.2 Water (e.g. use of rain water, possibilities for "hot fill" dishwashers);

3.4.3 Telecom (e.g. hot spots, WLAN, etc.);

3.4.4 Installation, e.g. availability and level of know-how/training of installers;

3.4.5 Physical environment, e.g. fraction of shared products, possibilities for shared laundry rooms, etc.

3.5 **Recommendations**

Make recommendations on

3.5.1 refined product scope from the perspective of consumer behaviour and infrastructure

3.5.2 barriers and opportunities for Ecodesign from the perspective of consumer behaviour and infrastructure

Source: European Commission 2011.

Task 4: Assessment of Base Case

Task 4 is used to develop and assess a base case that can serve as a reference for improvement and to determine if there is significant potential for improvement without entailing excessive costs. As the reference for determining improvements in potential design options, the base case represents the average product or product characteristics on the EU market in terms of resource efficiency, emissions and functional performance. Furthermore, in order to differentiate between standard energy consumption as measured by test standards and actual energy consumption based on real-life usage, two base cases are established. The standard base case considers a base case technology which consumes energy as measured by a harmonized test standard. The real-life base case considers the same technology but with actual energy consumption as reported in the EU to account for variations in consumer behavior and loads. Both base cases are then assessed using two life-cycle analysis methods: environmental impact assessment and financial life-cycle cost assessment.

The environmental impact assessment evaluates four key phases of product life: raw materials use and manufacturing, distribution, use and end-of-life phases. Both the standard and real-life base cases are assessed using three steps: life cycle inventory assessment, life cycle impact analysis and life cycle assessment. In the life cycle inventory assessment, emissions and resources use from all individual processes are assessed at the lowest aggregation level. The life cycle impact analysis then uses the results of the inventory assessment to determine impact unit indicators or multipliers for determining the impacts associated with emissions and resource use. Lastly, the life cycle analysis multiplies the unit indicators from the impact analysis with the total amount of materials used or disposed to calculate the total life-cycle impact of the product.

The main tool used for the environmental impact assessment is the Energy-using Product EcoReport Tool. This Excel-based tool is publicly available online and designed to facilitate the environmental analysis of a selected number of key indicators. For these key indicators, the EcoReport tool provides a set of predefined Unit Indicators, which indicate the environmental impact per unit of product. The tool can then use the Bill-of-Materials, Energy and other resources and key input parameters for manufacturing, distribution and end-of-life along with the Unit Indicators to calculate the total environmental impact of the base case.

Table 7 shows the comprehensive list of environmental impact indicators and the associated necessary data inputs for the environmental impact assessment.

Table 7. EU Ecodesign Preparatory Study List of Environmental Impact Indicators and Inputs

Impact Category	Indicators	Inputs
Material Resources	Bulk plastics	production: bill-of-materials, scrap from metal parts
	Technical plastics	use phase: auxiliary materials produce life, spare parts
	Ferrous metals	end-of-life: material recycling rate, re-use rate, landfill/incineration rates
	Non-ferrous metals	
	Electronics	
	Miscellaneous	
	Refrigerants (if applicable)	
	Mercury (if applicable)	
	Critical raw materials	
Energy Resources	Total primary energy	energy use during use phase and product life
	Electricity	specific electricity consumption and usage
	Heating energy	average/nominal heat power output, usage and heating efficiency
Water Resources	Process water	same inputs as for "Materials"
	Cooling water	water consumption per year
Waste	Hazardous waste	same inputs as for "Materials" and "Energy"
	Non-hazardous waste	
Emissions	Global Warming Potential (GWP-100)	same inputs as for "Materials" and "Energy", especially refrigerants
Acidification Potential	Acidification impact	same inputs as for "Materials" and "Energy"
Non-Methane Volatile Organic Compounds	VOC-content	same inputs as for "Materials" and "Energy"

Persistent Organic Pollutants	Total concentration equivalent of dioxins and furans	same inputs as for "Materials" and "Energy"
Heavy Metal Emissions to Air	Nickel equivalent	same inputs as for "Materials" and "Energy"
Polycyclic Aromatic Hydrocarbon Emissions to Air	Nickel equivalent	same inputs as for "Materials" and "Energy"
Particular Matter	PM10 equivalent	same inputs as for "Materials" and "Energy"
Heavy Metal and PAH emissions to water	Hg/20 equivalent	same inputs as for "Materials" and "Energy"
Eutrophication Potential of emissions to water	PO4 equivalent	same inputs as for "Materials" and "Energy"
Hazardous Substance	Use of Mercury	
	Use of Cadmium	
	Use of Lead	
	Use of hexavalent chromium	
	Polybrominated biphenyls concentration	
	Polybrominated diphenyl ethers concentration	
Physical Impacts	Sound Power level	
	Radiation	
	Vibration	
	Electromagnetic Fields EMF	

Source: European Commission 2011.

The second assessment of the base case is an economic assessment focused on quantifying the financial life-cycle cost of the base case. The life-cycle cost calculation considers the purchase price, operating and maintenance expenses, product lifetime and real discount rates. In order to calculate the financial life-cycle cost, detailed data on components in the product price and costs are needed. The product price needs to be broken down into estimated production cost and margins for distribution, production and taxes. Actual consumer prices including taxes are often obtained from consumer association testing or list prices. Product costs need to be broken down into costs by component and assembly activities. Since detailed product component costs may be difficult to obtain directly from manufacturers, they can often be estimated by an experienced engineer familiar with the specific product type.

Additional data inputs for the financial life-cycle cost analysis include discount rates, energy prices and water prices. For the real discount rate, a rate of 4% is adopted because there is a very small difference between the official inflation rate and the market interest rate for loans. Electricity, gas and oil prices are typically taken from Eurostat and averaged across the EU with an assumed annual growth rate of 4% for future prices. Water prices vary significantly within member states (i.e., across different sectors) and across member states, but an average water price including sewage tax is estimated to be €3.7 per m^3 with an assumed annual nominal growth rate of 2.5% (European Commission 2011).

Using these data inputs, a basic formula is applied in calculating the life-cycle cost of the two base cases:

LCC = PP + PWF * OE + EoL,

where

LCC is Life Cycle Costs to end-users in €,

PP is the purchase price (including installation costs) in €,

OE is the annual operating expense in €

PWF (Present Worth Factor) is

$$\mathrm{PWF} = \frac{1 - \frac{1}{(1+d)^N}}{d} \qquad (d \neq 0)$$

in which

N is the product life in years and

d is the discount rate rate in %

and in case *d=0* the value of *PWF=N*

EoL: End-of-life costs (disposal cost, recycling charge) or benefit (resale).

Source: European Commission 2011.

Task 5: BAT-BNAT Analysis

The Best Available Technology (BAT) and Best Not Yet Available Technology (BNAT) analyses are the core technical analyses of possible design options in the Ecodesign preparatory studies, similar to the technology assessments and engineering analyses conducted in the U.S. and Australia. The BAT analysis evaluates possible design options with a focus on available technology that is expected to be introduced over the next two to three years timeframe. To be considered a BAT, the product should have the lowest environmental impact but be at least equivalent to the Base Case in terms of functional performance, quality and durability. Three main types of technologies are considered in determining the BAT design options (European Commission 2005):

1. State-of-the-art applied research or prototype for product
2. State-of-the-art components, including prototypes and test and field trial samples
3. State-of-the-art best existing product technology outside of the EU

The BAT analysis serves as input to the selection of four to eight design options for further economic lifecycle cost and environmental impact evaluations.

Economic Life-cycle Cost Assessment of BAT Design Options

Three complementary approaches are used in evaluating the lifecycle costs of the selected design options to determine the least life cycle cost, which is the designated target level for Ecodesign measures. The first approach is a product approach, which focuses on collecting real price data for a real product that represents a BAT technology. The use of this approach requires some adjustments of prices obtained from catalogues, including adjusting local or national prices to average-EU level prices, taking into account margins and distribution costs representative of EU averages and separating out the price impact of features unrelated to resource efficiency and emissions (EU Commission 2011).

Because of difficulties with these price adjustments, analysts often prefer to use the design option approach. This second approach looks at prices not from the perspective of a whole product, but rather, attempts to break down the product price by individual design options. In this approach, economic data of new components and materials for a large sample of products from different origins are assessed to determine the relative effect that an extra design option has on the long-term price increase trend of a design option (European Commission 2011).

The last approach is the engineering approach which requires specialized engineers with expertise and familiarity with real component prices, mark-ups and learning curves to estimate the price breakdown for a particular design option. Because a comprehensive engineering approach faces budgetary and technical capacity constraints as well as a large number of variables that could affect cost calculations, a simplified and more realistic engineering approach is often adopted for the BAT analysis. This approach estimates the relative change in production costs for a limited amount of product features or design options in one particular cost model instead of estimating the change in production costs for all design options in different cost models (European Commission 2011). The cost model typically follows the manufacturer cost breakdowns used in in-house cost calculation model for EU-based manufacturers.

Regardless of which approach is followed, consensus amongst stakeholders and engineers will then be used to determine the improvement potential of different design options.

Environmental Assessment of BAT Design Options

In addition to the economic life-cycle cost assessment, environmental assessments of each of the selected design options must be conducted. The environmental improvement for each design option must be assessed quantitatively using the EcoReport tool in processes similar to those for the base case environmental assessment. The results of this environmental assessment are then compared and only the environmental impacts that change significantly with design options are reported (European Commission 2011).

BNAT Analysis

In addition to the economic and environmental assessment of the selected BAT design options, a qualitative assessment of BNAT technologies is also conducted as part of Task 5 in preparatory studies. The BNAT Analysis involves a qualitative analysis and discussion of technologies that are not yet commercially available in order to evaluate the long-term technical potential of the product. Technologies and products identified as BNAT help characterize the space for future innovation and product-differentiation after the introduction of Ecodesign measures. BNAT technologies can also be incorporated into EU incentive programs and serve as an indicator for future new energy classes (e.g., A+, A++, A+++).

In analyzing BNAT technologies, the analysis is often restricted to technologies that are technically proven with at least five to ten years of research and development work completed. It will then typically be at least another three to five years before the technologies enter the market, and may take much longer for some technologies to reach full commercialization (European Commission 2011). Based on these guidelines, the technical potential included in the BNAT analysis is commonly based on (European Commission 2005):

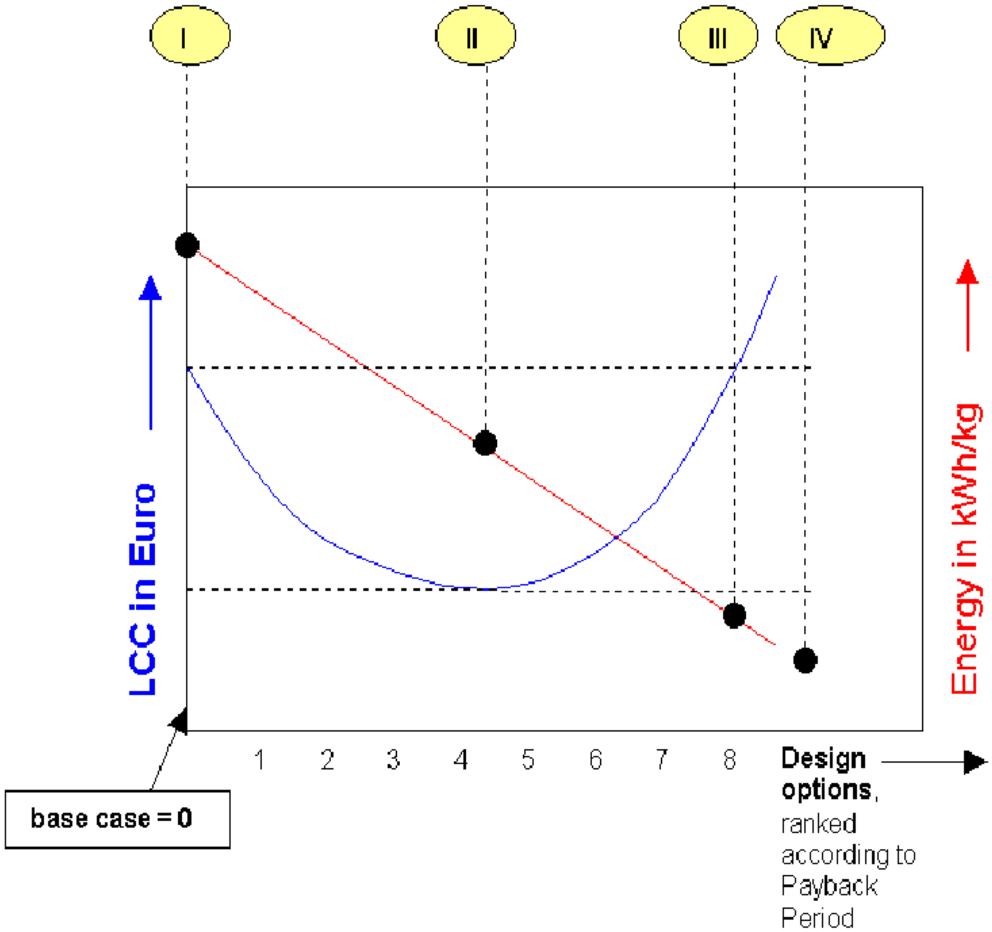
1. Outcomes of applied and fundamental research, but still in the context of the present product archetype
2. Changes of the total system to which the present archetype product belongs: societal transitions, product-services substation, dematerialization, etc.

Task 6: Improvement Potential

Once the life-cycle costs and environmental performance of the selected design options have been reviewed, the improvement potential of each design option relative to the base case is ranked in order to determine the point of Least Life-cycle Cost for target-setting. In ranking the improvement potential, individual design options are first ranked individually by their life-cycle cost and environmental improvement. Next, possible positive or negative side effects (e.g., rebound effect) of individual design options are assessed. The accumulative environmental improvement and cost effect of implementing combinations of ranked options simultaneously are then estimated, taking into consideration both interactions between multiple design options and possible side effects of design options. It is important to consider the accumulative improvement and cost effect because the implementation of multiple design options often results in smaller incremental improvement than the sum of improvements per individual design option. Accumulative design options are then ranked to identify the Least Life-cycle Cost point and the Best Available Technology point.

Figure 15 illustrates how design options are ranked both individually and accumulatively and how the Ecodesign target requirement is set based on the ranking.

Figure 15: Ecodesign Ranking of Design Options



Four key points summarizing the results of the Ecodesign preparatory study assessments are shown in Figure 15. The first point, with the highest energy consumption (in kWh/kg as shown on the right axis) and a high life-cycle cost in Euros (shown on left axis), represents the current baseline. The second point shows an improvement in environmental performance with decreased energy consumption and is also the lowest point of the life-cycle cost curve. This point represents the least life-cycle cost and the socially optimal point for setting the Ecodesign requirement because it embodies an environmentally superior product where the total cost over the product's life-cycle is lowered relative to the baseline. In other words, the environmental parameter at the point of least life-cycle cost will be proposed as the threshold value for minimum Ecodesign requirements. The third point represents the break-even point, where the new technology or design options pose no financial loss with the same life-cycle cost as the current baseline but has improved environmental performance. The last point represents the Best Available Technology, which is only intended to serve as an indicator of what is technically feasible in terms of the best environmental performance because it also has the highest life-cycle costs. The BAT is not intended to be a target for Ecodesign requirements, but does help evaluate the room for product differentiation in the short-term.

Task 7: Policy and Impact Scenario Analysis

In the last task (Task 7) of the preparatory study, scenario, policy, impact and sensitivity analysis are conducted to evaluate the impact of different policy options and uncertainties surrounding the projected impacts. The three types of analyses conducted as part of Task 7 are intended to summarize and total the outcomes of all previous tasks by using scenario analysis from 1990 to 2030 to quantify potential improvements relative to a Business-as-Usual (BAU) scenario. Qualitative discussions of potential improvements from 2030 to 2050 for each design option are also included in Task 7.

Policy and Scenario Analysis

The first part of the policy and scenario analysis seeks to summarize the stakeholder consultation process and findings from Tasks 1 through 4 in terms of barriers and opportunities for improving environmental performance and for Ecodesign measures. The effects of existing EU legislation and voluntary agreements are then evaluated and overlaps between Ecodesign measures and existing policies are identified. The benefits and disadvantages of combining Ecodesign measures with other policy instruments are also reviewed. Further analysis for selected policy measures such as setting the best available technology as a promotional target, the LLCC option as the MEPS level, legislative or voluntary agreements and labeling are also included, with emphasis on timing and target levels (European Commission 2011).

Scenario analysis from 1990 to 2030 is conducted to assess the effects of policy options other than the Ecodesign Directive implementing measures and to assess other factors that influence the environmental impact of policy measures, including the current market distribution of environmental characteristics, replacement rates and growth rates and substitution effects. To do this, a stock model is set up for 1990 to 2030 with baseline data on annual sales, stock, and net performance demand per unit. Additional scenarios are then created using the stock model to estimate the total annual and cumulative impact of different policy mixes for selected policy options based on assumed timing and target levels.

Impact Analysis for Industry and Consumers

Each policy evaluation also includes impact analysis using consumer cost-benefit analysis, manufacturer impact analysis and assessments of impacts on competition, small firms, legal aid, sustainable development, carbon assessment, other environmental factors, health, race equality, gender equality, human rights and rural development (Defra, 2010). This is done by introducing economic parameters such as baseline product price; energy, water, repair and maintenance costs; and cost of margins for manufacturers, wholesalers, retailer and taxes to the stock model and running the previous policy option scenarios. Program results including running costs, consumer expenditure, annual revenue for industry, wholesale, retail, product VAT and other taxes as well as the share of small and medium enterprises are evaluated as indicators for competition and employment effects in evaluating the policy impact on various stakeholders (European Commission 2011).

Sensitivity Analysis

Lastly, sensitivity analysis of all relevant factors including energy and resource prices, raw material and production costs and discount rates are included in the Ecodesign Preparatory Study. Specifically, selected scenarios are recalculated in the stock model to test for 50% higher and lower energy prices, 50% higher and lower elasticity between product price, cost of raw materials or production costs, discount rates, policy target levels and differences in timing. Possible external environmental costs such as cost of carbon are also included in the sensitivity analysis for societal costs. The effect of recycling credits may also be considered in the sensitivity analysis if material substitution of greater than 10% of original product weight is feasible.

The results of the policy and scenario, impact and sensitivity analyses are summarized through main policy recommendations for each product, main outcomes of the scenarios for baseline, 2020 and 2030 and risk of possible negative impacts on health and safety.

5. Key Findings and Conclusions

Several key findings can be drawn from the similarities and differences that emerged in the review of leading international frameworks for standards and labeling setting and development. First, it is apparent from the U.S., Australian and EU experiences that each region's regulatory context for standard-setting has significantly influenced the specific processes and analyses used in setting or revising efficiency standard levels. In the U.S., the standard-setting process is shaped by legislation that requires a designated set of criteria to be evaluated through very specific analyses and examined during mandatory open public comment periods. Australia's framework for standard-setting and label development, including its principle of adopting at least the equivalent of existing world-best regulatory target and heavy reliance on customs and trade data for analyses, are influenced by its import-dominated appliances market. The EU framework and Ecodesign preparatory process and analyses are the result of the directive's holistic approach to evaluating life-cycle, "cradle-to-grave" environmental impacts beyond just energy and life-cycle consumer costs. This finding suggests that there is not necessarily a "one size fits all" framework for standards setting and label development but rather, the framework should be developed based on specific national conditions such as market factors, purpose and goals of standards and labeling programs and data availability.

Another overarching trend illustrated by the three national and regional frameworks examined is that there are considerable variations in the rigor and scope of core techno-economic analyses conducted in standard-setting and label development, despite similarities in a common approach to conducting shipments, national impacts and energy and environmental analyses. For all three regions, national stock accounting models are used to determine future shipments forecasts while the national impacts and energy and environmental analyses are conducted using a business-as-usual or base scenario and a standards scenario. In conducting techno-economic analyses, however, the U.S. uses greater rigor in conducting its engineering analysis by often purchasing actual product samples and utilizing a "tear down" method to determine manufacturing costs for individual components as inputs to its mark-up analysis. Similarly, the U.S. adopts a comprehensive approach to calculating the proposed standards' life-cycle costs to consumers by using statistically representative samples to provide cross-section of impacts, rather than a single national average impact. This approach of conducting life-cycle cost sub-group analysis is feasible in the U.S. largely because of available data from recurring national residential energy consumption surveys. Australia, on the other hand, is limited by data availability to using primarily statistical analysis and engineering simulations for its engineering analysis, but conducts more detailed cost-benefit analysis that distinguishes the costs to consumers, government and industry. The EU Ecodesign process takes a more nuanced approach in defining a base case by conducting environmental and life-cycle costs analyses for both a standard base case and a real-life base case that adjusts for variations in consumer behavior and loads. In addition, the EU approach also explicitly considers Best Not Yet Available Technology in examining possible long-term technological development and in determining potential future target in its analytical framework.

Lastly, although most of the supporting analyses in each region are conducted using Excel-based spreadsheets, each region has also developed specific tools designed to help carry out the most rigorous analyses. For example, the U.S. uses its life-cycle cost model with Crystal Ball to conduct the Monte Carlo simulations for the life-cycle cost subgroup analysis while Australia provides users with a Business Cost Calculator to conduct the regulatory cost-benefit analysis. The EU specifically designed the Energy-using Product EcoReport Tool to provide default environmental impact factors per unit of product in order to expedite and simplify the life-cycle environmental impact analysis. In the case of Australia and the EU, both tools are readily accessible by the public and can be used by stakeholders to confirm analyses in the standard-setting process. In the U.S., the calculations and results of the analyses are provided as part of the technical supporting documents of the rulemaking process.

In sum, while similar types of analyses are embodied in the standard-setting and label development framework of the U.S., Australia, and the EU, there are distinct features in each of the three frameworks that are shaped by the regulatory context and conditions of that region. Each of the frameworks in turn has distinguished itself by incorporating more rigor into specific areas of analysis ranging from engineering and life-cycle subgroup impact analysis to cost-benefit and environmental impact analysis in order to meet specific regulatory goals. At the same time, these regions have also developed the necessary supporting tools and data inputs to conduct the more rigorous analyses, making it possible for the standards setting and label development framework to be fully implemented.

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