CHAPTER 2. ANALYTIC APPROACH

2.1 INTRODUCTION

The economic effects of trial standard levels depend largely on the relationship between the cost of a consumer product and its energy efficiency. Cost-efficiency relationships are determined for each product class based on engineering analyses. The cost and efficiency of energy-saving technology options are used as inputs to the analysis of the effects at various levels.

This document analyzes the effects of standards for fluorescent lamp ballasts. Each product class is a lamp/ballast combination consisting of ballasts used with a specific lamp type and number of lamps. The analysis covers commercial and industrial interior lighting. Exterior and residential lighting are not covered.

Identification of product classes, baseline units, and technology options is based on information gathered from trade associations, discussions with researchers, a literature survey, comments from public workshops, and comments on the earlier Notice of Proposed Rulemaking (NOPR)[1]. Energy use data have been obtained from NEMA (National Electrical Manufacturers Association), published literature, and manufacturers. Ballast price data were obtained from distributors for ballasts sold in fixtures and ballasts not in fixtures. Other data sources were comments from several public workshops, manufacturer workshops, DOE interim materials, national lighting databases, trade associations, product literature, professional society reference materials, and manufacturer interviews and plant visits.

End-user prices, installation costs, and maintenance costs in conjunction with corresponding efficiencies are used in the national energy savings model (NES) to forecast national energy savings and net present value and in the life-cycle cost (LCC) model to calculate life-cycle costs and payback periods. Retail prices were obtained from data from discussions between electrical distributors and Lawrence Berkeley National Laboratory (LBNL) staff.

This chapter briefly describes how the analysis was performed. Section 2.2 presents an overview of the analytic methodology and discusses the major components of the analysis: the Engineering Analysis, the LCC analysis, the National Energy Analysis, the National Employment Analysis, the Manufacturer Analysis, the Utility Analysis, the Environmental Analysis, and the Regulatory Impact Analysis. This section discusses the ways in which the components are interrelated to ensure consistency throughout the analysis.

Section 2.3 describes the computerized models used in the analysis. The models predict commercial and industrial sector, manufacturer, utility and environmental responses to future changes in the economy. Quantitative estimates of economic effects are calculated from the outputs of the models. The models utilized in the analysis are:

- Life-Cycle Cost Model Including Probability-Based Sensitivity Model
- National Energy Savings Model
- Government Regulatory Impact Model (Manufacturer Impact Model)
- National Energy Modeling System (Environmental and Utility Model)
- ImBuild Model (National Employment Model)

2.2 OVERVIEW OF ANALYTIC FRAMEWORK

The effect of alternative fluorescent ballast trial standards levels is determined by comparing projections of a wide range of variables under existing legislation to projections based on the trial standards scenarios. These projections are first made for a baseline option or base case scenario (which represents the situation under existing legislation) using the analytic models described below. Chapters 3 and 6 describe the data and assumptions used to calculate the baseline options and the base case forecasts, respectively. The calculations are then repeated for the trial standards scenarios as discussed in Chapter 6. The differences between the projections of energy consumption, economic variables, and other variables in the base and trial standards scenarios provide quantitative estimates of the impacts of the trial standards. To evaluate the significance of the differences in LCC, probability-based sensitivity analyses are performed on the key parameters and assumptions.

The analysis of the effect of standards has eight major components:

C *Engineering Analysis*, which establishes technical feasibility and product attributes including efficiency, energy use, and price;

C *Life-Cycle Cost Analysis,* which calculates economic impact effects, including payback period on individual end user . This analysis includes a probability-based sensitivity analysis of the impacts of the variability of four key parameters on life-cycle costs and payback periods;

C *National Energy Analysis*, which characterizes energy end use in the commercial and industrial sectors;

C *National Employment Analysis*, which estimates the net national employment effects of changes in energy use, increased cost of more efficient ballasts, and energy cost savings;

C *Manufacturer Impact Analysis*, which estimates the financial effect of standards on manufacturers and calculates the effect on competition, employment, and manufacturing capacity;

C *Utility Analysis,* which measures the effect of altered energy consumption patterns on electric utilities;

- *Environmental Analysis*, which estimates changes in emissions of carbon and nitrogen oxides because of reduced energy consumption at the power plant; and

- *Regulatory Impact Analysis,* which presents major alternatives to proposed standards that could achieve substantially the same regulatory goal at a lower cost.

A simplified diagram of the analysis is shown in Figure 2.1. Figure 2.1 illustrates the interactions among the Engineering, Life-Cycle Cost, National Energy, Manufacturer, Utility, and Environmental Analyses. The analysis is performed for a base case plus several trial standards scenarios.

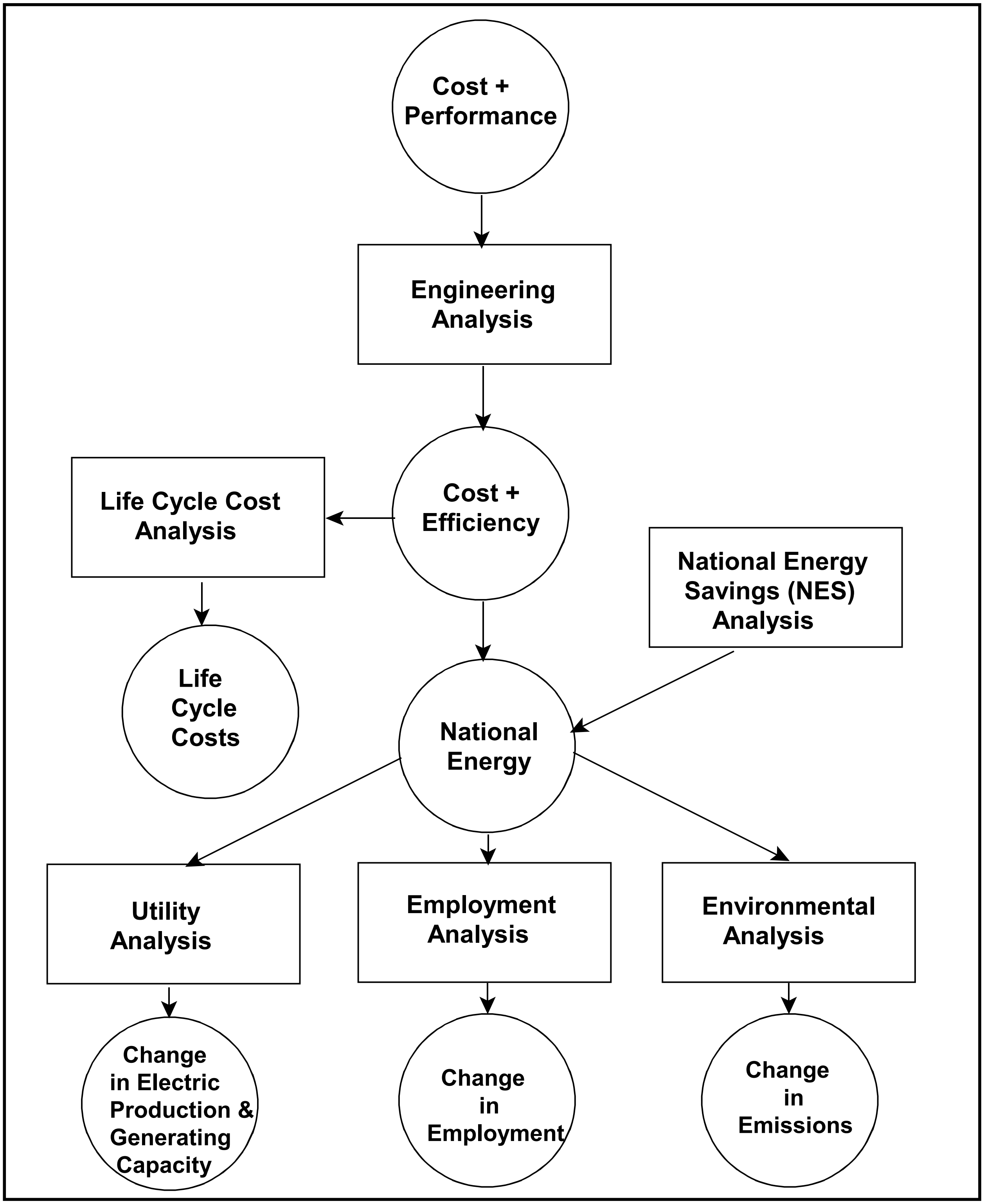

Figure 2.1 Analytic Framework for the Ballast Energy Efficiency Analysis

2.3 MODELS, DATA, AND ASSUMPTIONS

2.3.1 Engineering Analysis

The Engineering Analysis provides information on efficiencies, prices, and other ballast characteristics for use in other components of the analysis. Ballast features that are useful to consumers are accounted for in the analysis by separating ballasts into different lamp/ballast combinations. The Engineering Analysis develops price and efficiency data for a set of technology options within each lamp/ballast combination. The Engineering Analysis is performed in seven steps: (1) select lamp/ballast combinations; (2) select baseline units; (3) select technology options within each lamp/ballast combination; (4) determine maximum technically feasible option; (5) calculate the efficiency improvement provided by each technology option; (6) develop price estimates; and (7) generate price-efficiency relationships.

Lamp/Ballast Combinations. The first step in the Engineering Analysis is the segregation of ballasts into separate lamp/ballast combinations that are found in commercial and industrial buildings. For specific ballasts, lamp/ballast combinations are defined using data collected in discussions with ballast manufacturers, trade associations, researchers, and other interested parties; literature review; and from comments received on the NOPR or at public workshops. The lamp/ballasts covered by the analysis are listed in Chapter 3.

Baseline Units. A baseline unit is the starting point for analyzing technology options for improving energy efficiency. To select a baseline unit, the Engineering Analysis uses information gathered from trade organizations, manufacturers, consultants with expertise in specific product types, and from public comments on the NOPR or at public workshops.

Technology Options. The Engineering Analysis identifies technology options that could improve energy efficiency. Technology options that are commercially available at present are considered. They were selected after discussions with experts and an extensive literature review. The efficiency improvement and end-user price difference resulting from technology options are compared to the baseline unit.

Maximum Technologically Feasible Technology Option. For each lamp/ballast combination, a maximum technologically feasible technology option is identified. This option results in the highest energy efficiency for each lamp/ballast combination. For this analysis, all technologies considered are available in the marketplace.

Efficiency Calculation. For each of the lamp/ballast combinations, the efficiency levels corresponding to various technology options are determined from data supplied by manufacturers.

Price Estimates. Data from discussions with lighting distributors were used to derive end-user prices. A more detailed discussion of how these data were used to derive price estimates is found in Chapter 3.

Price-Efficiency Relationships. The results of the Engineering Analysis are summarized in the price-efficiency relationships, which show the efficiency and price of the technology options for each lamp/ballast combination. The price-efficiency relationships shown in Chapter 3 are a fundamental input to the life-cycle cost and national energy analyses.

Results from the Engineering Analysis. For each technology option considered in the analysis, the models and data provide:

- energy efficiency (expressed as Ballast Efficacy Factor, as defined in Chapter 3),
- annual energy consumption per unit,
- ballast prices, and
- other information on product characteristics such as ballast lifetimes, installation costs, and lamp equipment and replacement costs.

2.3.2 LBNL Life-Cycle Cost Model (LCC)

The LCC analysis is conducted using a spreadsheet model developed in Microsoft Excel for Windows 95, combined with Crystal Ball™ (a commercially available software program). The LCC model is designed to allow user input in studying the effect of changing key parameters. The model results are the life-cycle cost differences between the baseline and technology options, and the payback period for the option. Payback is calculated based on the same inputs as used for the LCC analysis (except that input values are based only on the first year the standard is proposed to take effect).

The Crystal Ball model uses a Monte Carlo simulation to perform the probability analysis, which accounts for variability in input values. The spreadsheet is organized so that ranges (distributions) can be entered for each input variable needed to perform the variability calculations. The outputs are a distribution of LCC differences and a distribution of payback periods. The mean LCC difference and median payback period are also reported.

Refer to Chapter 4 for a detailed description of the LCC model and of the analysis results.

2.3.3. LBNL National Energy Savings Model (NES)

Measures of the effect of ballast efficiency include national energy savings and the net present value (NPV) of total national energy cost savings less incremental equipment costs. Each of the above is determined for selected trial standard scenarios. In order to make our analysis accessible and transparent, we developed a spreadsheet model using Microsoft Excel in Windows 95 to calculate the national energy savings and the national economic costs and savings from new standards. Input quantities can be changed within the spreadsheet. In the NES Spreadsheet, distributions are not used for inputs or outputs. Sensitivities can be demonstrated by running different scenarios using alternate inputs for ballast shipments, electricity prices, and ballast technical, and operating characteristics.

One important component of any estimate of future effects from standards is ballast shipments. Several shipment forecasts for the base case and the trial standards were created as an input to the NES. These are described in detail in Chapter 5 . In addition, users of the NES spreadsheet may adjust the shipments forecast to test the effect of other assumptions.

2.3.4 Net National Employment Analysis Model

Net national employment effects from ballast standards are defined as net jobs created or eliminated in the general economy as a consequence of reduced spending by commercial and industrial sector businesses on electricity, increased spending on the purchase price of ballasts, and reduced spending on new power plants by the utility industry (as well as the associated indirect effects of those three factors). These impacts are reported in Chapter 5.

We used an input/output model of the U.S. economy to estimate the effects on different major sectors of the U.S. economy most relevant to buildings and their net impact on jobs. The model, ImBuild[2, 3] is a Microsoft Excel model developed by the Office of Building Technologies and State Programs. It is a PC-based economic analysis system that consists of national input-output structural matrices that characterize the national economy as a series of interrelationships among 35 sectors. The model can be applied to future time periods. The ImBuild output includes relative changes in employment and wage income. The impacts of new ballast standards are estimated in the NES spreadsheet as energy savings (reduced electricity use), energy cost savings, and increased ballast purchase price. These three impacts are output from NES and input to ImBuild. Direct employment impacts, those that would occur at ballast manufacturing plants, are discussed in the Manufacturer Impact Analysis chapter.

2.3.5 Manufacturer Analysis Model (Government Regulatory Impact Model)

The manufacturer analysis estimates the financial impact of standards on manufacturers and calculates impacts on employment and manufacturing capacity. The manufacturer impact analyses (MIA) was conducted in four phases. Phase 1, Industry Profile and Issue Definition, consisted of two activities: preparation of an industry characterization and the conduct of an issue identification workshop. The second phase, "Strawman" Industry Cash Flow, had as its focus the larger industry. In this phase, the Government Regulatory Impact Model (GRIM) was used to prepare a "strawman" industry cash flow analysis. Here the Department used publically available information developed in Phase 1 to adapt the GRIM model structure to facilitate the analysis of new ballast standards. In Phase 3, Sub-Group Impact Analysis, the strawman cash flow was used by individual manufacturers as a template from which individual company level cashflows were developed using GRIM in cooperation with Arthur D. Little (ADL). Phase 3 also entailed documenting additional impacts on employment and manufacturing capacity through an interview process. Finally in Phase 4, Industry

Cash Flow, ADL aggregated the individual cash flows into three groups: group 1 included all manufacturers, group 2 included full line manufacturers of magnetic and electronic ballasts, and group 3 included manufacturers producing only electronic ballasts.

2.3.6 National Energy Modeling System (NEMS-BRS)

Utility Analysis. A new approach has been used to estimate effects of ballast energy-efficiency standards on electric utilities. The Department of Energy (DOE) used a version of Energy Information Administration (EIA) National Energy Modeling System (NEMS), together with some exogenous calculations, for the utility and environmental analyses. NEMS simulates the energy economy of the U.S. and was developed over several years by the EIA, primarily for the purpose of preparing the Annual Energy Outlook (AEO). NEMS produces a baseline forecast for the U.S. through 2020 that is available in the public domain. The version of NEMS used for appliance standards analysis is called NEMS-BRS and is based on the AEO99 version of NEMS with minor modifications.[1]

NEMS-BRS offers a sophisticated picture of the effects of standards because its scope allows it to measure interactions among the various energy supply and demand sectors and the economy as a whole. The policy scenarios of NEMS-BRS are similar to the AE099 version of NEMS except that energy consumption in the Commercial Demand Module lighting enduse is reduced by the amount of electricity saved due to the ballast standards. The input of energy savings are obtained from the NES spreadsheet. We assess the impact of standards on utilities by reporting several key industry parameters, notably electricity sales, generation and capacity.

Other assumptions in NEMS-BRSwill be the same as those used to produce AEO99. The time horizon of NEMS-BRS is 2020. Alternative price forecasts corresponding to the high and low economic growth cases found in AEO99 will also be generated for use by NES and will be explored in a similar fashion with NEMS-BRS runs.

Environmental Analysis. The environmental analysis provides estimates of changes in emissions of nitrogen oxides (NO_x) and carbon. For each of the standards, total emissions are calculated using NEMS-BRS together with some minor exogenous calculations (as in the utility analysis). The net benefits of the standards are reported as the differences in emissions forecast by the AEO99 version of NEMS-BRS and the scenarios with the standards in place.

The environmental analysis using NEMS-BRS is relatively straightforward. Carbon emissions are tracked by using a detailed carbon module that covers all sectors of the economy and their interactions. The only form of carbon tracked by NEMS-BRS is CO_2, so the carbon discussed in this

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[1] EIA approves use of the name NEMS only to describe an AEO version of the model without any modification to code or data. Because our analysis entails some minor code modifications, and the model is run under various policy scenarios that deviate from AEO assumptions, the name NEMS-BRS refers to the model as used here.

report is only in the form of CO_2 though it is reported as elemental carbon.

The two airborne pollutant emissions that have been reported in past analyses, SO_2 and NO_x, are reported by NEMS-BRS. The Clean Air Act Amendments of 1990 set an SO_2 emissions cap on all power generation. The attainment of this target, however, is flexible among generators and is enforced by applying market forces through the use of emissions allowances and tradable permits. SO_2 trading makes it likely that physical emissions effects will be virtually zero because emissions will always be at their ceiling. This fact has caused considerable confusion in the past. There is virtually no real SO_2 environmental benefit from conservation as long as there is enforcement through emissions ceilings. A small economic benefit can be inferred only if coal generation falls and the reduced demand for SO_2 emissions allowances lowers the allowance price. Because the effects considered here are too small to deliver reasonable estimates, we do not consider this possibility.

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