Lighting Policy Modeling in the Commercial Sector

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Introduction

Lighting consumes more electricity than any other end use in the U.S. commercial sector, accounting for approximately 3.8 quadrillion Btu of primary energy in 1990. There is an untapped potential for improving the efficiency of lighting equipment in commercial buildings, using currently available and emerging technologies. In order to assess this potential, and to weight the relative merits of federal policy options, we employed an end-use forecasting model· to predict future energy consumption patterns in the commercial sector. The model simulates the market for end-use technologies and predicts purchases of new and replacement equipment in each year, determining consumption levels of three different fuels (electricity, oil and natural gas) in eleven building types.

The forecasting program models technology options for the lighting end use as functional forms called technology trade-off curves (see Figure 1). A technology is characterized by its Energy Utilization Index (kWh/sq ft.) and its cost. Parameters of the technology trade-off curves are developed by fitting the functional forms to actual technology options. Decision-makers choose points on the curve based on their life-cycle-cost criteria. The major drawback of this type of representation is that the marginal EUIs forecasted cannot be disaggregated into individual technologies. In other words, although the average efficiency of the lighting equipment sales is known, there is no way of quantifying the sales of individual technology options. This also complicates the estimation of national policy costs for the economic analysis.

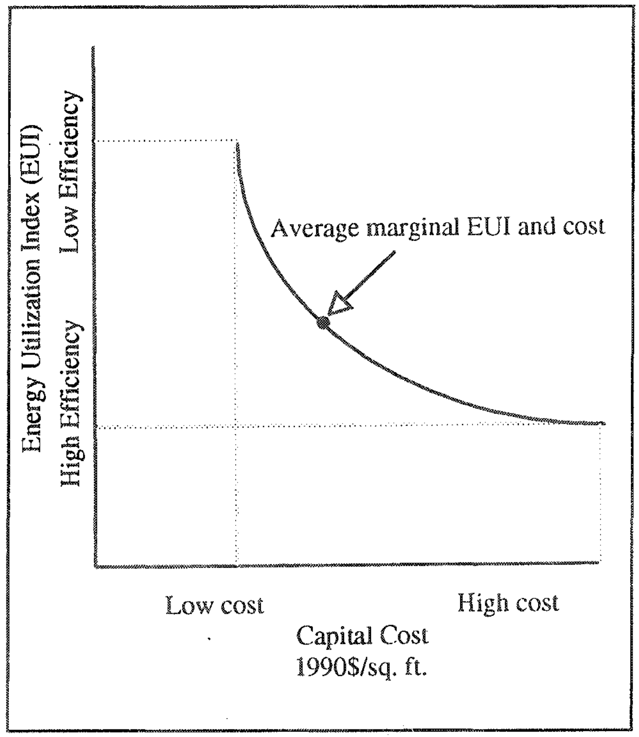

Figure 1. Technology Tradeoff Curve

Model Calibration

Fuel prices and commercial sector floorspace by building type were the primary exogenous inputs to the model. Additionally, several model parameters were modified from the default settings to more accurately represent the current lighting market. Information from a survey of lighting equipment manufacturers and utilities provided the basis for a baseline scenario with two fixed EUI data points in 1986 and 1995. The 1986 data represent the existing state of the market for lighting component technologies in that year, while the 1995 data represent the predicted sales of equipment, as affected by all expected market forces, regulations and utility demand side management (DSM) programs.

Using the 1986 and 1995 data, we established a calibration trend for the model, implemented by assuming a negative capital cost trend for the efficient end of the trade-off curve (as shown in Figure 2). This cost trend was used because DSM programs reduce the cost associated with efficient technologies. In addition to the overall cost trend, choice elasticity and retrofit inertia parameters were used to fine tune EUI trends for individual building types.

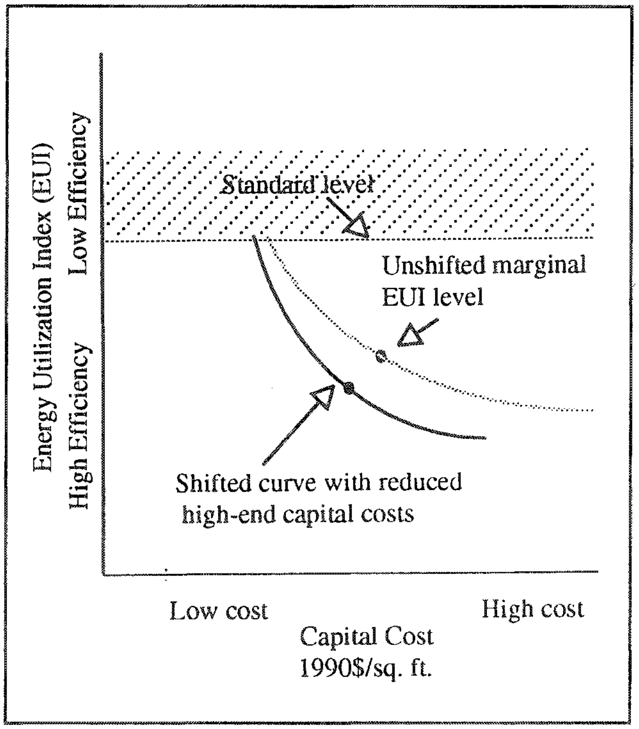

Figure 2. Calibration and Policy Implementation

Engineering Analysis

The object of the engineering analysis was to develop costs and efficiencies for specific technology options. In a set of engineering spreadsheets, the equipment and installation costs, efficiency and lifetime of each option were used together with hours of operation, electricity price and discount rate to calculate the consumer life cycle cost of each option. The table of options began with a "base case" technology (the standard equipment that generally has least first cost but lowest efficiency) followed by more efficient technologies commercially available or in the research stage. Based on these spreadsheet calculations, several technologies were chosen to analyze with the forecasting model. These were usually the base case, the next-highest-wattage design, the minimum life cycle cost design, the best available ("maximum") technology, and a research and development technology.

Policy Implementation

It was fairly straightforward to implement *system performance standards* (e.g., Watts/sq ft. limits by building type) since this policy addresses the overall installed capacity of the lighting system. System performance standards were implemented by limiting the technology trade-off curve at the inefficient end as shown in Figure 2.

Component standards were harder to model. First, the initial-year (1995) market shares for lighting equipment sales were selected. A component standard (or a combination of component standards) prohibits the use of some of the less-efficient options. As market shares of these prohibited options were shifted to other more efficient options, a new market distribution for the lighting equipment sales was obtained. The average Watts/sq ft. for this new distribution were calculated and EUIs for each building type were determined using operating hours. These EUIs were then used to limit the tradeoff curve as seen in Figure 2.

Figure 3 illustrates four projections of lighting energy consumption. The top line represents consumption for a "no-incentives" baseline where choice of lighting equipment is driven by energy prices alone. The next line represents the lower consumption under an "existing-incentives" baseline, in which equipment purchases are influenced by existing utility DSM, EPA Green Lights, and FEMP Federal Relighting programs, assumed to continue at present levels. The two bottom lines show even lower consumption from the use of combinations of higher-efficiency lamps, ballasts, fixtures and controls (including their interactive effects). These combinations are modeled as component standards requiring choice of minimum life-cycle cost technologies and research and development technologies respectively.

Economic Analysis

The economic analysis involved the comparison of the policy forecast to the baseline forecast. From the lighting savings in kWh forecast by the model, the decrease in installed wattage was determined using operating hours. A cost figure was then assigned to this decrease in installed wattage in $/Watt. For the initial year sales, average Watts/sq ft. and $/sq ft. were calculated for the two cases with and without the policy. From these figures, the change in cost/change in wattage for the particular policy was determined. This cost of improved wattage was multiplied by the improved wattage to obtain the cost of the policy.

Conclusions

The next version of the end-use forecasting program will include more explicit technology representation. Thus, the methodology presented in this poster is an interim

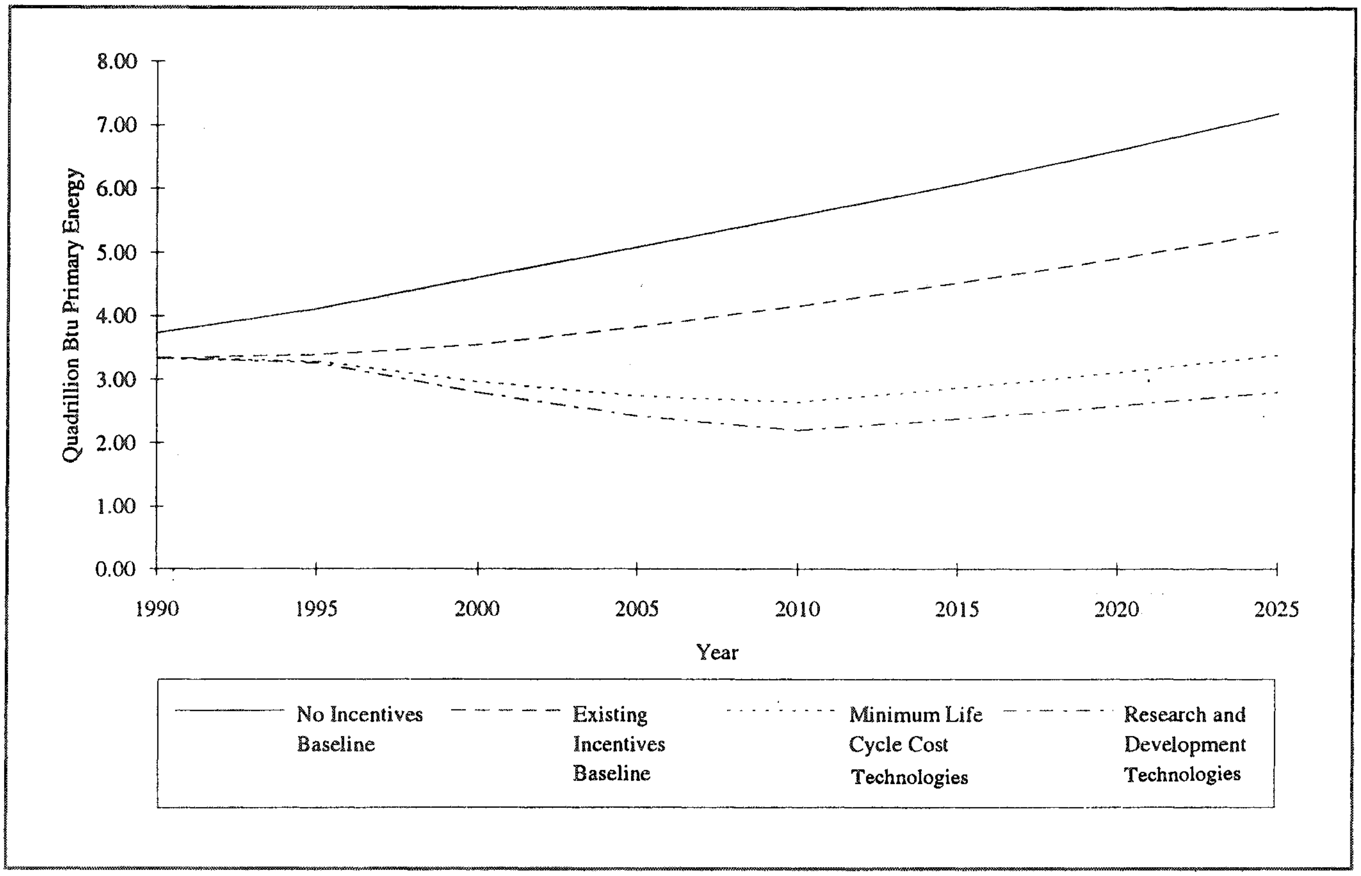

Figure 3. Commercial Lighting Energy Consumption

approach. The inclusion of discrete technology options in the forecasting program will make the above procedures transparent and make it possible to directly estimate technical and economic potential for lighting energy conservation.

Reference

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