An Era of Energy Efficiency in the Commercial Sector: Investigation and Findings

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ABSTRACT

The paper describes the specification and estimation of an energy demand model that focuses on electricity use in the U.S. commercial sector from 1989 to 2000. The panel model is designed to separate state effects and market-driven effects from energy efficiency program effects, thereby obtaining long-run estimates of the impact of commercial sector energy efficiency programs, including DSM and market transformation programs, on national energy use. The preliminary finding of this study is that publicly-funded energy efficiency programs have had a discernable impact on annual electricity demand.

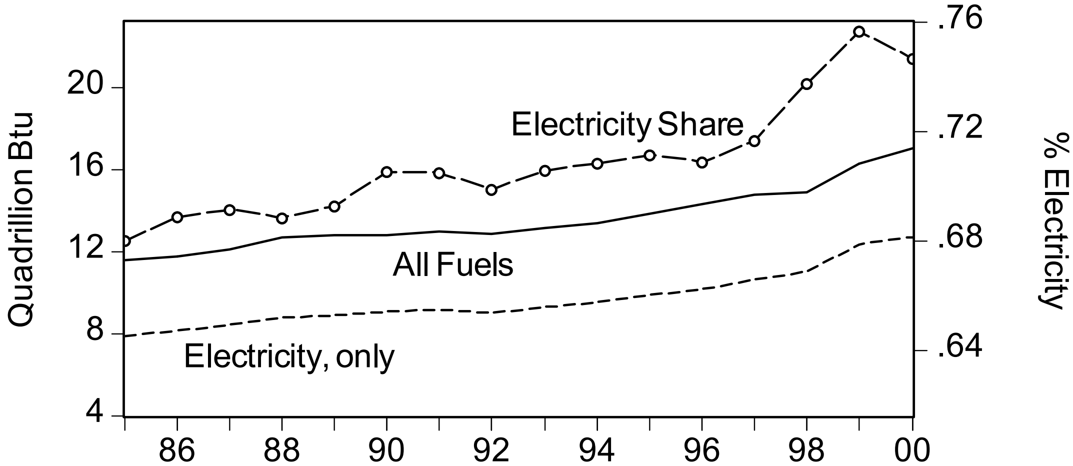
INTRODUCTION

For the past twenty years, energy efficiency program evaluators have been focusing their efforts on assessing the annual operational character and quantitative impacts of specific local and state programs. This scrutinizing approach has been of great practical value as it provided timely and specific monitoring, oversight, and feedback. Yet, in the midst of all this evaluation activity, policymakers and energy professionals have not been able to see the forest for the trees. Energy efficiency program and policy impacts at the aggregate national level have never been rigorously estimated. This has led to misconceptions, indeed pessimism, as to the ability of our country to solve future energy and environmental problems.

The trends exhibited in Table 1 seem to provide evidence, at the national level, that pessimism is warranted. Not only has total commercial sector energy use been increasing since 1985, but electricity use has been increasing at an even more rapid rate than the use of other fuels. This has occurred despite tens of billions of dollars of investment, both public and private, in energy efficiency products and services for commercial buildings. Moreover, it seems to belie the successes documented by hundreds of individual electric utility demand side management program impact evaluations; typical estimates of weather-adjusted realization rates, net of free ridership and self selection, have been in the range of 50 and 100 percent. Inclusion of spillover or market transformation impacts tends to lift program net savings estimates even higher.

How is it possible to explain and reconcile these macro-trends relative to all of the energy efficiency activity that has taken place throughout the U.S. since 1989 at the local level? To address this question it is necessary to investigate the major economic trends that drive electricity use. The answer, in brief, is that it is possible for energy use to be simultaneously growing in absolute magnitude, and becoming more efficient. The remainder of this paper will describe how this conclusion has been reached.

Table 1: Growth in U. S. Commercial Sector Energy Use



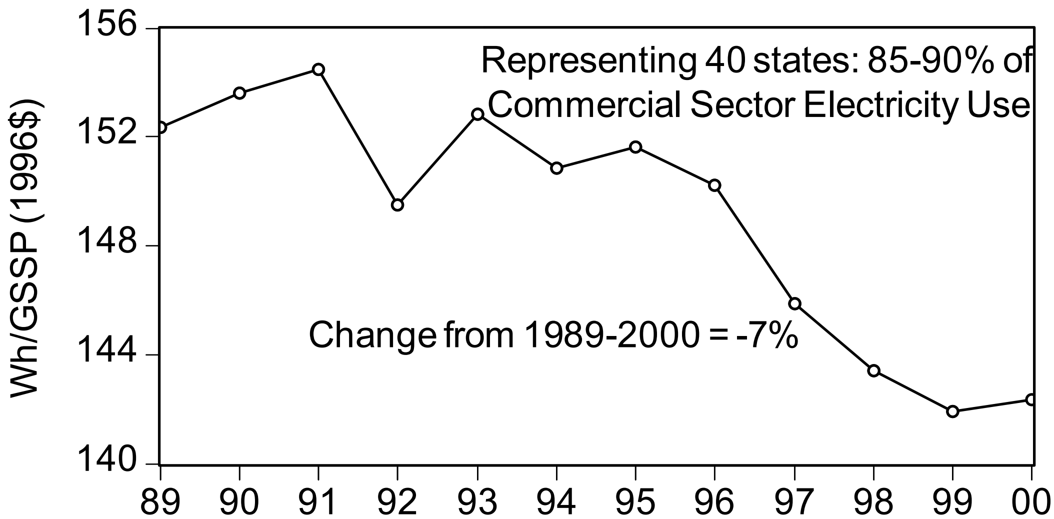
ELECTRICITY USE RELATIVE TO INCOME

There are many trends in the economy and society that can be misinterpreted when viewed in too narrow a context. For example, an increase in the absolute amount of calories consumed by the population in a given year can be interpreted as leading to increased obesity in the population. However, a good portion of the increase in calories could be related to changing demographics or a boom in the number of individuals in the population that are growing from childhood to adulthood. Without correctly normalizing annual calorie consumption to population demographics it would be easy to draw incorrect conclusions. Likewise, an absolute increase in energy use does not necessarily provide reliable evidence that energy efficiency programs have failed to curtail energy use. For the facts to be meaningful, other factors must be taken into consideration.

A more telling trend than the change in the level of demand for understanding energy use is a composite statistic, or index, called *energy intensity*. Table 2 displays the changing relationship between commercial sector electricity use and size of the commercial sector for 40 of the 50 states. Commercial sector size is measured by the income generated by a state's service sector, referred to as gross state service product, or *GSSP*. This index measures service sector energy productivity in its broadest sense, revealing the amount of energy *input* associated with a unit of *output*, i.e., a dollar of income. The trend in this index reveals that the U. S. service sector has become consistently less energy intensive, or more energy productive, over time.

This index begins to provide evidence that energy efficiency programs, while not causing the absolute level of demand to fall, may have at least led to greater energy productivity. Unfortunately, even the energy intensity index provides only a small amount of useful information. Many other variables besides public programs may also cause energy intensity to change. For example, movements in prices or adoption of technologies may cause the index to increase or decrease. In other words, changes in energy intensity are not necessarily due to *energy efficiency* programs. Without controlling for market-based factors, it is not possible to determine how much of the change in energy intensity is due to public programs.

Table 2: U.S. Commercial Sector Electricity Intensity



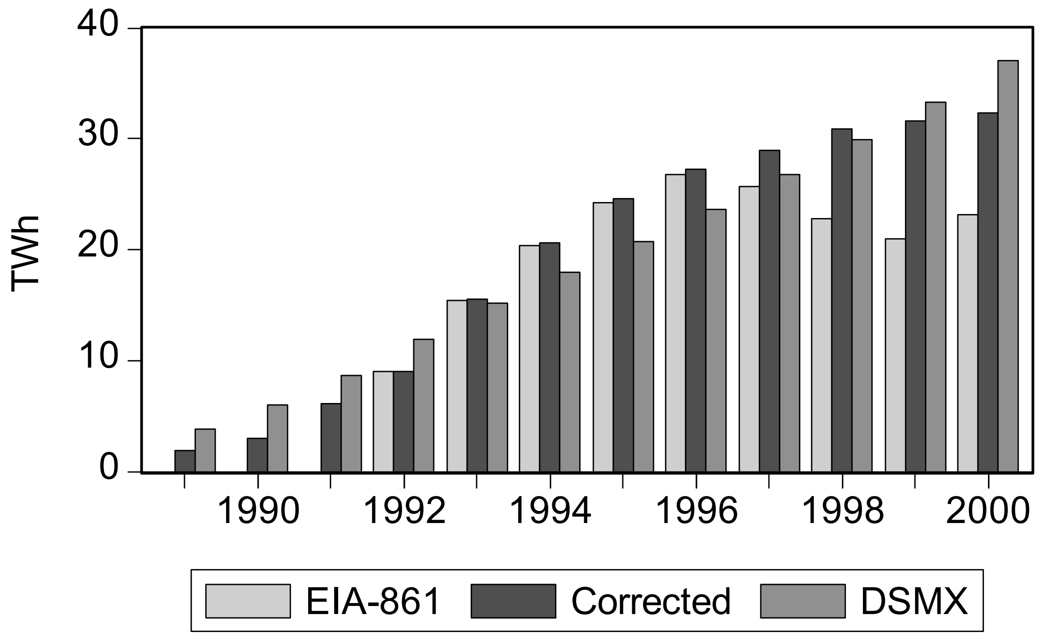
PUBLICLY-FUNDED PROGRESS

Before turning to the statistical analysis of this trend it is necessary to describe the data that document the accomplishments of commercial sector energy efficiency programs. In 1989 EIA began collecting DSM data on Form EIA-861. These data, which all electric utilities above a certain size were required to report, included annual incremental DSM costs, annual incremental DSM savings, and annual *cumulative* DSM savings. Unfortunately, although DSM data continue to be collected to this day on Form EIA-861, the DSM data collected beyond the mid-1990s are of questionable quality. The deterioration in data quality is not glaringly evident for annual incremental costs and incremental savings statistics, but it is detectable, and thus correctable up to a point, for the annual cumulative savings data series.

According to the EIA reporting instructions, each electric utility is to report the cumulative savings resulting from the DSM activities implemented in the present year and all prior years. EIA requests that these values be reported as net savings, that is, savings that they take into account free rider rates, measure retention or degradation rates and other factors that can affect savings. Hence, when cumulative savings declines by a significant amount from one year to the next, it is apparent that underreporting has occurred.

Table 3 presents three versions of annual DSM savings for the commercial sector. The first series represents the raw data from Form EIA-861. As is evident, the series peaks in 1996 and then declines, obviously violating the formal definition of the variable of *cumulative* savings. The second, *corrected* series adjusts the "cumulative" DSM data for consistency. It also proportionally allocates the DSM savings for the commercial sector for the three earliest data collection years in which cumulative DSM savings were reported in aggregate rather than by sector. Finally, the third savings estimates, referred to as *DSMX*, are projections derived from the technique of instrumental variables. These projections control for measurement error and are taken to be the most reliable of the three estimates of DSM program accomplishments.

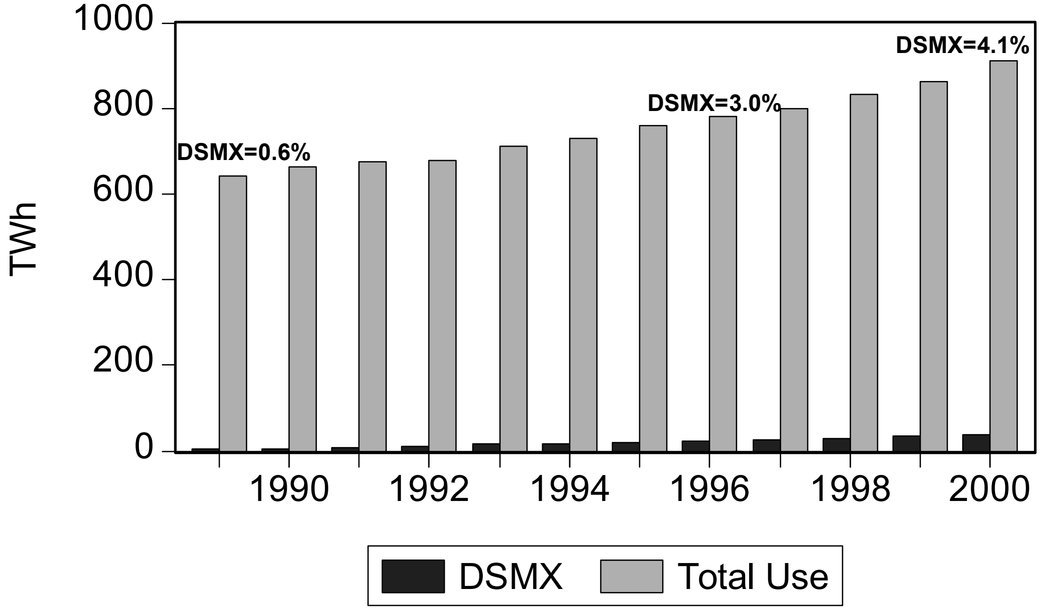
Table 3: DSM Savings Estimates (40 States)



In Table 4, *DSMX* is compared in magnitude to total electricity use in the commercial sector for the 40 states for which DSM savings data are available. As can be seen, taking *DSMX* at face value suggests that electric utility commercial building programs achieved cumulative savings in 2000 that were equivalent to over 4 percent of commercial building consumption.

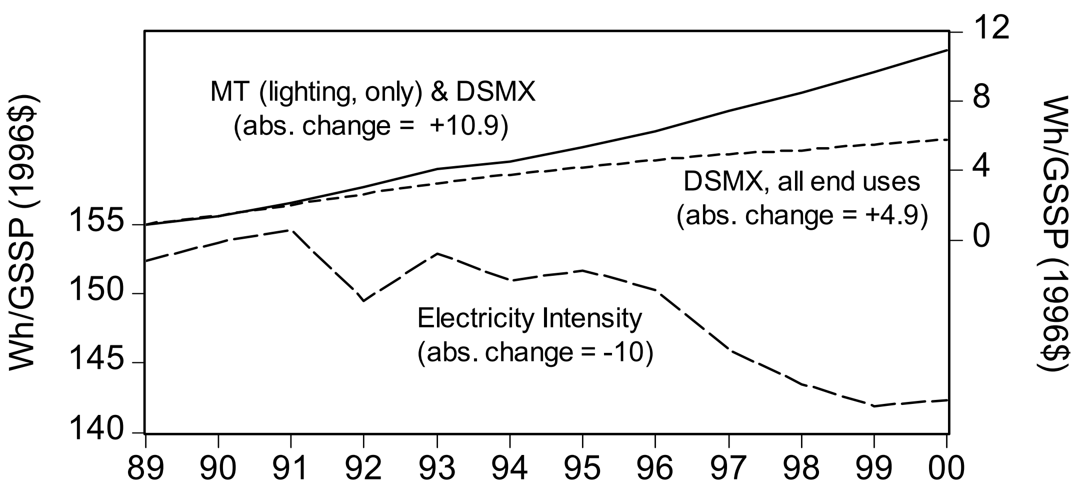
This picture of the impact of energy efficiency programs on commercial sector electricity use is incomplete. Even more telling is the combined effects of DSM and lighting market transformation (MT) derived from national programs that transformed the electronic fluorescent ballasts market. These programs included EPA's Green Lights and ENERGY STAR and DOE's FEMP and Rebuild America. Estimated savings from these programs are based on a recent study I conducted of the lighting industry ("Economic Indicator of Market Transformation; Energy Efficient Lighting and EPA's Green Lights," *The Energy Journal*, Vol. 22, No. 4, 2001).

Table 4: *DSMX* Relative to Total Commercial Sector Electricity Use (40 States)



As can be seen by the upper-most trend in Table 5, the combined impacts of DSM savings and lighting savings from MT programs in 2000 is substantial. Given the magnitude and timing of these combined savings, it appears quite possible that DSM and lighting MT savings may have been entirely responsible for the decline in commercial sector electricity intensity. However, this evidence is merely impressionistic. For the reasons described above, more authoritative attribution of the changes in energy intensity to energy efficiency programs requires a rigorous statistical analysis that controls for many other market-related factors that could also have affected commercial sector energy use.

Table 5: *DSMX* Relative to Total Commercial Sector Electricity Use (40 States)



STATISTICAL MODEL OF COMMERCIAL SECTOR ELECTRICITY INTENSITY

The energy demand model specified for this study is a version of the Houthakker-Taylor flow adjustment model that converts an otherwise static time series cross section model into a dynamic one. It is implemented by adding a lagged endogenous variable to the collection of independent variables, something which, of course, is not possible when working with cross section data only. This specification is desirable because the demand for energy, viewed over time, is determined by two factors. The first is an equipment *utilization rate* that can be varied from instant to instant, and the second is an equipment *stock* that is fixed in the short run but can be varied in the long run. By permitting energy use in every period to be explained by past energy use, the flow adjustment model explicitly describes a process by which an equilibrium in energy consumption -- formed by the combination of optimized utilization rates and equipment stocks -- is achieved.

The sample frame for the model is the 40 states with the full *DSMX* data series and the 12 years from 1989 to 2000. The model is specified as fixed effects so as to control for state-specific factors, such as state energy codes, that may be correlated with the independent variables. In addition, it is estimated using weighted least squares, thereby controlling for statistical inefficiencies caused by wide differences in state-level energy use determinants. In addition to the lagged dependent variable, the full list of independent variables that are both cross sectional and time series include: average commercial sector electricity prices and natural gas prices; annual heating and cooling degree days; and total gross state product. Two additional variables are time series, only. One of these is an index of market transformation activity, *MTX*. The values of this index are the annual volumes of electronic fluorescent ballasts attributable to market transformation programs. The other is an index of installed electronic office equipment, *COMPUX*. The values of this index are the Federal Reserve Board index of industrial production for computers and electronic office equipment (SIC 357). This SIC group includes electronic computers, computer storage devices, computer terminals and peripheral equipment, printers, and many other electronic items, such as fund transfer and point of sale devices.

The preliminary findings indicate that the coefficients of all but the *COMPUX* variable are highly statistically significant; the COMPUX variable is statistically significant at the 90 percent level, only, no doubt due to its colinearity with the *MTX* variable. Quantitatively, a 100 percent change in the index is associated with four-tenths of percent change in electricity intensity.

The coefficient of the DSM variable, which is in semi-log form, indicates that a marginal change in the level of cumulative DSM savings is associated with small, but significant, change in electricity intensity. The coefficient of the second energy efficiency program variable, *MTX*, suggests that a 100 percent increase in market transformation activity is associated with about five-tenths of a percent decrease in electricity intensity. Interpretation of the coefficient of log-transformed independent variables is straightforward since the coefficients represent constant elasticities, meaning that a given percentage change in the independent variable always leads to the same percentage changes in the dependent variable, irrespective of the absolute values of the dependent variable. Thus, the effect of market transformation activity on the change in electricity intensity from any given year to any other can be calculated by multiplying the percentage change in the index over the range of years, by the coefficient. Since demand-oriented market transformation programs directed at commercial sector end users began in 1991, this year is chosen as the base from which to calculate market transformation impacts for 2000.

From 1991 to 1992 the market transformation index changed by 66 percent; by 2000 this index had changed by 1,695 percent. The percentage impact on energy intensity, calculated by multiplying the percentage change in the index by the model coefficient, indicates that from 1991 to 2000 the change in market transformation activities resulted in a decrease in aggregate energy intensity of 7.9 percent. Extrapolating these findings to the 48 contiguous states by taking the 1991 TWh consumption value for the 48 states as the base and holding gross service sector product constant, the model suggests that market transformation activities resulted in national saving of 59.8 TWh by 2000.

Conclusion

This *preliminary study* separates fixed state effects and market-driven effects from energy efficiency program effects, thereby obtaining long-run estimates of the impact of publicly-funded commercial building energy efficiency programs on national electricity use. The preliminary findings of the energy demand model indicate that the decreases in commercial sector electricity intensity observed since 1991 are most likely due to demand side management and market transformation programs. These finding support the impression that energy efficiency programs have been effective in preventing a rise in commercial sector energy use. They suggest that in the absence of these programs, electricity use in the commercial sector would have climbed discernibly higher than its current level.