Green Lights and Blue Sky: Market Transformation Revealed

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ABSTRACT

This paper describes the research design and findings of the market transformation evaluation of EPA's Green Lights® Partnership. The primary issue addressed in this paper is the change in the fluorescent ballasts market over the past forty-one years, and the degree to which market change was caused by market forces, DSM programs and Green Lights. To understand this change, time series data from the Census Bureau's survey of manufacturers were analyzed and used to model the ballasts market. A time series model, referred to as the *share capture* model, is used to examine the role that relative product prices and electricity prices play in the market for energy efficient ballasts. After controlling for these factors, the model findings are used to quantify the effects that DSM programs and Green Lights have had on high-power factor magnetic and electronic ballasts shipments.

Introduction

With the Green Lights Partnership, the United States Environmental Protection Agency (EPA) carried out its climate protection mission by promoting lighting energy efficiency in commercial buildings. This voluntary public/private partnership aimed at transforming the markets for energy-efficiency products and services. It encouraged building owners and operators to install high-efficiency lighting products when they might otherwise have installed less costly, conventional lighting products. The equipment suggested by EPA included high-efficiency electronic ballasts, high-efficiency fluorescent lamps, compact fluorescent lamps, non-incandescent exit signs, and automatic lighting controls. In addition, EPA encouraged energy efficiency practices, such as delamping in building areas that were overlit.

The concept that is central to this study of market transformation is *market share*. Market share for an energy-efficient product is defined, for any specific time period and product, as the fraction of the total number of units sold of a given type of product that are designated as energy efficient, and thus approved of, by the market transformation program. Focusing on how market sales have changed, and moreover, on understanding the factors causing an energy-efficient product's market share to change, has immediate implications for the research design of this evaluation. In an economically efficient product market, one of the main factors affecting the product's market share is the relative price of substitutable products. Other factors, such as the lending rates, general economic growth and social programs or public policy, are also likely to have major influences on changes product prices and product market share. Hence, to study market transformation it is necessary to investigate the pace of market movement and the extent to which movement occurred due to various market forces and publically-beneficial social programs.

Several advantages are obtained by narrowing the subject of this evaluation of the Green Lights Partnership to the market for fluorescent lighting ballasts, only. First, fluorescent lighting ballasts are the one product for which there are 41 years of continuous, publicly-available national manufacturer shipment data that are differentiated by categories of energy efficiency. Second, fluorescent lamps, which are driven by lighting ballasts, are ubiquitous in commercial and institutional buildings in the United States. Third, installation of electronic ballasts is a precondition for the use of T-8 fluorescent lamps, another major energy-efficient lighting product promoted by EPA's Green Lights Partnership. Fourth and lastly, electronic ballasts and T-8 lamps together account for the overwhelming majority of the pollution prevention that can be attributed to the Green Lights Partnership.

Overview of Related Research

Market transformation programs are intended to quicken the overall pace of market movement. For some programs of this kind, a case in point being EPA's Green Lights Partnership, participants are not just energy consumers, but trade allies, manufacturers and other upstream parties. As a result, for many market transformation programs, accounting for the behavior of a small number of program participants who are energy consumers may have little or no bearing on the ultimate effect of the program on the public at large. Microdata of the kind used in DSM evaluation studies will thus be of little use in trying to estimate the net impact of the program.

Recent market transformation studies include those sponsored by the Pacific Northwest Energy Efficiency Alliance. The subjects of these studies are changes in the markets for various residential and commercial energy-efficient products and services. By and large, these studies shift the energy efficiency program evaluation paradigm away from the analysis of energy savings to the analysis of market baselines, market movements and their determinants. Like numerous market transformation studies undertaken through the California Demand-Side Management Measurement Advisory Committee and other regional organizations, they concentrate on market processes studied through surveys and interviews with upstream, midstream and downstream market actors.

In addition to the present evaluation of the Green Lights Partnership, three published studies have used national fluorescent ballasts market data from the Bureau of the Census to investigate the transformations taking place in the fluorescent lighting ballasts market. First, Koomey et al. (1995) investigated the impact of regulation on changes in the adoption of energy efficient magnetic ballasts during the decade of the 1980's and the early 1990's. Largely through anecdotal data, this study shows how state-enacted standards may have influenced the national market share of energy efficient magnetic ballasts vis-a-vis less efficient magnetic ballasts. Perhaps because electronic ballasts exceed the energy efficiency standards set for high power factor magnetic ballasts, the study does not touch on the subject of how the energy efficiency standards affected the electronic ballasts product market. In a related handbook by Vorsatz et al. (1997) national ballasts shipment data for magnetic and electronic ballasts through 1996 are presented.

A second study to have used national lighting ballasts market data, this time for an investigation into the effects of the Green Lights Partnership on the electronic ballasts market, is by Duke and Kammen (1999). This study analyzes electronic ballasts national shipment data from 1986 to 1997, using a construct referred to as *experience curves* to estimate unit cost reductions as a function of cumulative production. While not explicitly taking into account the role that relative prices for substitute products play in the diffusion of technological innovation, this study finds the Green Lights Partnership to have had a moderate effect on transforming the electronic fluorescent ballasts market.

A third analysis of the national fluorescent ballasts shipment data is contained in a study by Xenergy Inc. and Easton Consultants (1998). This assessment of the commercial lighting market in California presents the national shipments data for high-power factor magnetic ballasts from 1981 to 1997, and of electronic ballasts total shipments data from 1986 to 1997. Based on the changes in the market share of electronic ballasts and other qualitative and survey evidence from supply-side market actors, e.g., ballast manufacturers and distributors, this study concludes that at the national level, the utility programs and government agency efforts led to a rapid increase in the demand for electronic ballasts and T-8 lamps. In addition, the study asserted that there is strong evidence linking utility programs to decreases in the incremental costs of electronic ballasts and T-8 lamps. These assertions are supported by the econometric analysis conducted for the present study.

Market Transformation Evaluation Research Design

For the Green Lights Partnership evaluation, lighting ballasts data extending from 1959 through 1999 have been collected from Current Industrial Reports (CIR), a publication of the United States Bureau of the Census. Based on national surveys of manufacturers, this publication provides quarterly data for thousands of products sold in the United States. These data include, at the manufacturer level, the total number of units shipped and the total value of the shipments. Among the products tracked separately are low- and high-power factor magnetic fluorescent lighting ballasts, for which national data are available from 1959 to the present.

Fluorescent lighting was first introduced into the U. S. market around 1940. Although nowadays low-power factor magnetic ballasts are primarily known to be used in residential applications, there are no features of the equipment that preclude using high power factor ballasts instead of low-power factor ballasts in most commercial and residential applications. Statistical evidence that these two products are substitutes is contained in their historical market shares. According to the earliest recorded CIR data, shipments of low-power factor magnetic fluorescent ballasts in 1959 made up 42 percent of the national market. Over the next fifteen years, the market share of low-power factor magnetic fluorescent ballasts fell by almost a half.

Although close substitutes, high and low-power factor magnetic fluorescent ballasts have different qualities. High-power factor fluorescent ballasts produce less lighting flicker, are quieter, and last longer than low-power factor ballasts. They are therefore considered superior, or of higher quality, than their low-power factor counterpart. Regarding energy efficiency it should be noted that while high-power factor ballasts require less energy to be generated for their operation than low-power factor ballasts, the energy savings experienced by the customer is likely to negligible. Nevertheless, while in 1974 the high-power factor ballasts were on average three-and-a-half times more expensive per unit than low-power factor ballasts, their market share swelled to 77 percent and the market share of the low-power factor ballasts fell to 23 percent.

Since 1986, CIR has published total manufaturer shipments and total value of shipments data for electronic fluorescent lighting ballasts, too. These new, improved products are substitutes for magnetic fluorescent ballasts in most lighting applications, specifically, substitutes for the high-power factor magnetic fluorescent ballasts rather then the low-power factor ballasts. As with the former pair of substitutes, the electronic fluorescent ballasts produce less lighting flicker and are quieter than their counterparts. They are also thought to last longer; however, they have not been in the market long enough for conclusive evidence of this benefit to be collected. For these reasons, as well as for the fact that they require less energy to operate and yield appreciable energy savings to customers, electronic fluorescent ballasts are superior, or of higher quality, than high-power factor magnetic fluorescent ballasts.

Given the two analagous pairs of products -- from 1959 through 1985, high quality high-power factor magentic flourescent ballasts versus lower quality low-power factor ballasts; from 1986 through 1999, high quality electronic fluorescent ballasts versus lower quality high-power factor magnetic ballasts -- the research design for this study rests on the premise that price response behavior related to one pair of products will, in the absence of public policy interventions or social programs, be similar if not identical to the price response behavior for the other pair of products. If so, then to the extent that differences in price responsiveness appear, these differences can be attributed to the impacts of social programs.

Based on the years over which the data for the three types of flourescent ballasts are available, the research design for this study is divided into two periods. The earlier period spans 1959 through 1985 and is referred to as the *comparison* period. The later period spans 1986 through 1999 and is referred to as the *treatment* period. These period divisions track the evolution of market transformation and DSM programs. In the late 1980’s and the 1990’s the overwhelming emphasis of commercial sector DSM programs and later the Green Lights Partnership was on promoting electronic fluorescent ballasts and the companion use of T-8 lamps.

To complete the research design several issues related to the comparison and treatment periods should be noted. With respect to the last 5 years of the comparison period, there are three major factors that may have affected the relative prices and quantities demanded of the different magnetic ballasts that cannot be controlled for in the scope of this study:

- by the early 1980’s many utilities and government agencies began promoting energy efficient magnetic flourescent ballasts through energy audits, rebates and other program promotions; however, there are no readily available data on aggregate national expenditures or levels of program efforts in this period
- in 1982 the state of California adopted an energy efficiency standard for fluorescent ballasts; the standard became effective in 1983 and over the next five years four more states followed California’s lead
- energy efficient magnetic fluorescent ballasts, which were introduced in 1976, are not differentiated from other high-power factor ballasts in the CIR data; according to the congressional testimony of a lighting company executive, referred to in LBNL (1995), these products were slow to be adopted, but, by 1980 had a 10 and 15 percent market share that grew by 1986 to about a 30 percent market share

On the basis of these events, the five years from 1981 through 1985 are omitted from the comparison period for this study. The 32 continuous years from 1959 through 1980 thereby comprise the estimation years for the comparison period. With respect to the treatment period, although the continuous years spanning 1986 through 1999 are included in this study, it must must be noted that ;

- this study does not attempt to ascertain how the 1990 national energy efficiency standard for high power factor magnetic fluorescent ballasts affected the market share of electronic ballasts particularly since, according to LBNL (1995), it is difficult to argue that the energy efficiency standards permanently affected magnetic fluorescent ballasts prices
- since the Green Lights Partnership did not begin until 1991, no attempt is made in this study to disaggregate the changes in electronic ballasts market share between 1986 and 1990 that were due to price effects versus programmatic effects
- national data on utility DSM program expenditures, collected from 1990 through 1998 by the US Energy Information Administration in their U. S. Electric Utility Demand Side Management Report, are used in this study to control for the effects of social policy on relative product prices; for the 5 previous years, DSM expenditures are extrapolated based on the average annual growth rate of 18.2 percent for total DSM program expenditures from 1990 through 1994.

Share Capture Model

The general function for a market analysis of the demand for the higher quality product can be expressed as:

$$Q_x = f(E, R, M).$$

where Q_x is the demand for the higher quality product x and,

E = a vector of product-related economic variables, e.g. price of x, energy prices
R = a vector of regulatory or policy variables, e.g. DSM program funding
M = a vector of business conditions, e.g. economic growth, interest rates, inflation

This framework provides a consistent conceptual basis for econometric analyses of the national fluorescent lighting ballasts market, including the direct estimation of the effects of relative prices on the market shares of different types of fluorescent lighting ballasts. One model form, a *share capture model*, yields coefficients that allow for empirical estimation of the number of electronic fluorescent lighting ballasts units that are attributable to the price effect versus the programmatic efforts. This opens the way for evaluating the resource acquisition aspect of market transformation programs, and consequently, for calculating their social cost-effectiveness.

The share capture model takes as the dependent variable S_x, the market share of the superior product x. The relative price of x, P_x, is assumed to be endogenous, leading to the two-stage least squares model:

$$S_{x,t} = b_{01} + b_{11}(P_{x,t}) + b_{21}(\ln KWHP_t) + b_{31}(\ln PRIME_t) + b_{41}(DCPI_t) + u_t$$
$$P_{x,t} = b_{02} + b_{12}(S_{x,t}) + b_{22}(\ln KWHP_t) + b_{32}(\ln PRIME_t) + b_{42}(DCPI_t)$$
$$+ b_{52}(\ln FRBIP_t) + b_{62}(\ln DSM_{t-1}) + v_t$$
$$u_t = \rho u_{t-1} + e_t$$

where

$KWHP_t$	=	annual cents per kWh, commercial sector, for year *t*
$PRIME_t$	=	national average prime lending rate for year *t*
$DCPI_t$	=	percentage change in national consumer price index for year *t*
$FRBIP_t$	=	Federal Reserve Board index of industrial production, January of year *t*
DSM_{t-1}	=	total annual electric utility demand side management expenditures, lagged on year; these values are zero in the comparison period years
b_{01-41}	=	regression intercept of the second-stage model
b_{02-62}	=	coefficients of the first-stage model
ρ	=	serial correlation coefficient

The model error term u_t is assumed to be first-order autoregressive and the errror terms v_t and e_t are not autocorrelated. Like autocorrelation, the presence of heteroscedasticity in this two-stage least squares model could bias the standard errors of a model and invalidate hypothesis tests. Therefore, the model is corrected for potential heteroscedasticity through estimation of the White heteroscedasticity-consistent covariance matrix. The two-stage least squares autoregressive model is solved using a simultaneous equation estimator.

The highlights of the findings of the share capture model is that in the comparison period a marginal relative price drop for the high quality ballasts -- for example, from being three times more expensive than the inefficient ballasts to two times more expensive -- led to an approximately 3.6 percent increase in its market share. However, the model indicates that in the treatment period, a comparable drop in the relative price of the superior ballasts led to a 15.9 percent increase in market share. Both these estimates are statistically significant in their respective models; in addition, they are statistically significantly different from each other.

With respect to the exogenous variables, the model indicates that in the comparison period marginal increases in energy prices and the prime lending rate are associated with decreased superior product market share; however, increasing price inflation is associated with increased market share. In the treatment period, the model suggests that increases in energy prices and in the prime lending rate are associated with increased market share for the superior product whereas increases in the inflation rate are associated with decreased market share for the superior product.

Green Lights Partnership Accomplishments

The final element in the evaluation of the climate protection impacts of EPA's Green Lights® Partnership involves estimating the units shipped of electronic ballasts, and consequently the national energy savings and mitigated greenhouse gases, that can be attributed to the Green Lights Partnership from 1991 through 1999. To do so it is necessary to remove from the total national shipments of electronic ballasts the effects, in succession, of the following three factors:

1. the market share of electronic ballasts that was attained prior to 1991; since the share capture model is estimated for the full treatment period from 1986 through 1999, the market share of electronic fluorescent ballasts as of the end of 1990 is taken to be the market share *platform* created by other programmatic efforts and price effects prior to the Green Lights Partnership -- it is then assumed that this pre-Green Light Partnership level of market share persists throughout the remaining treatment period years.
2. from 1991 forward, the market share of electronic ballasts attributable to the price effect, that is, the level of market share that was achieved due to changes in the relative prices of high power factor magnetic ballasts and electronic fluorescent ballasts
3. from 1991 forward, the effect on market share of financial promotions and rebates issued by electric utility DSM programs for purchasing and installing electronic fluorescent ballasts

The 1990 market share platform is constructed by taking the market share of electronic ballasts as of 1990, which was 5.1 percent, and applying this estimate to the total number of electronic and high power factor magnetic ballasts shipments in every year from 1991 forward. This removes from the annual electronic ballast shipments those units that would have been shipped due to price effects and program effects occuring in the 1986 to 1990 time span. From the share capture model findings in the comparison and treatment periods, the ratio of the coefficients of the relative price variable for each period is used to calculate the number of electronic ballasts shipped that were the result of changes in relative prices. The equation for the calculation of the total price effect over the 1991 through 1999 period is:

$$\text{Total Price Effect} = \sum_{i=1}^{9} \left(b_{11,Comparison} \big/ b_{11,Treatment} \right) * \left[Units_{x,i} - \left(\left(Units_{x,i} + Units_{y,i} \right) * S_{x,1990} \right) \right]$$

where the *i's* are the 9 years from 1991 through 1999; the first term represents the ratio of the comparison period share capture model price coefficient to the treatment period price coefficient; *Units* represents the total annual unit shipments of product *x* or product *y*; and, S_x is as defined earlier in this report. Once the electronic fluorescent ballasts units resulting from the 1990 market share platform are removed, and the units attributable to the price effect are removed, the remaining units of shipped electronic ballasts can be attributed to programmatic efforts as:

$$\begin{aligned}\text{Total Programmatic Effect} = {} & \text{Total Electronic Ballasts Shipments -} \\ & \text{Total 1990 Platform - Total Price Effect}\end{aligned}$$

Exhibit 1 contains the total shipments of high power factor magnetic and electronic fluorescent ballasts from 1991 through 1999 and the electronic ballasts fraction of the total shipments that are attributable to the 1990 market share platform. The nine years of shipments data indicate that manufacturers shipped a total of over 252 million units of electronic ballasts from 1991 through 1999. Of this amount, the analysis indicates that approximately 14 percent of the electronic ballasts -- 5.1 percent of all shipped units -- would have been shipped due combined market and programmatic factors affecting the electronic ballasts market prior to 1991.

Exhibit 1. Manufacturer Shipments - High-Power Factor Magnetic and Electronic Ballasts

Year	All Ballasts Units	Electronic Units, Only	1990 Platform
1991	63,810,000	8,343,000	3,256,000
1992	68,671,000	13,292,000	3,504,000
1993	79,278,000	24,488,000	4,046,000
1994	80,597,000	24,606,000	4,113,000
1995	80,542,000	32,894,000	4,110,000
1996	73,183,000	30,342,000	3,735,000
1997	79,430,000	36,543,000	4,053,000
1998	82,426,000	39,842,000	4,206,000
1999	83,121,000	41,723,000	4,242,000
Total	627,248,000	252,073,000	35,265,000
% of Total Units	(100.00)	(36.48)	(5.10)
% Electronic Units		(100.00)	(13.99)

Exhibit 2 contains the estimated attribution of electronic fluorescent ballasts shipments to the price effect versus the programmatic effect for 1991 through 1999, calculated by the method described above. This analysis indicates that approximately 19.6 percent of the electronic ballasts would have been shipped due to the effects of decreasing relative prices over this time period. Approximately 66.4 percent of the remaining total shipments, or 167.4 million electronic ballasts, are attributable to the influences of all social programs from 1991 through 1999.

Exhibit 2. Attribution of Electronic Ballasts to Price and Program Effects

Year	Electronic Units, Only	Price Effect	Program Effect
1991	8,343,000	1,159,994	3,926,752
1992	13,292,000	2,232,007	7,555,679
1993	24,488,000	4,661,735	15,780,671
1994	24,606,000	4,673,295	15,819,803
1995	32,894,000	6,563,950	22,219,954
1996	30,342,000	6,067,623	20,539,814
1997	36,543,000	7,409,017	25,080,633
1998	39,842,000	8,126,464	27,509,298
1999	41,723,000	8,547,324	28,933,972
Electronic Units	252,073,000	49,441,408	167,366,576
% Electronic Units	(100.00)	(19.61)	(66.40)

The number of units of electronic ballasts that are attributable to the Green Lights Partnership is derived from the 167.4 million electronic ballast shipments that the share capture model attributes to all programmatic efforts. The Green Lights Partnership share of this amount is acquired by subtracting from the total programmatic effect the number of electronic ballast units that are attributable to utility demand side management programs. These estimates are derived from the C. B. Busch, et al., (2000, hereafter referred to as LBNL, 2000).

In the LBNL (2000) study, the total number of electronic ballasts that were given rebates by electric utility DSM programs was estimated based on two different samples of utilities. The first is referred to as the *core* sample and consists of six electric utilities that together accounted for about 17 percent of national utility spending on energy efficiency from 1992 through 1997. The second sample is referred to as the *expanded* sample and consists of three additional utilities that had gaps in their data. For this sample, rebate estimates are provided for 1992 through 1996, only.

For the present study, cores sample estimates of rebated electronic ballasts units for 1991, 1998 and 1999 are constructed by applying the percentage change in national DSM program expenditures for these years to the LBNL (2000) rebated units estimates. The same rule is applied to the expanded sample estimates for these years, plus the missing year of 1997. Exhibit 3 contains the two full sets of rebated unit estimates.

Exhibit 3. Estimated Number of Rebated Electronic Ballasts Units[1]

Year	Core Sample	Expanded Sample
1991	*2,937,485*	*4,112,479*
1992	4,500,000	6,300,000
1993	9,600,000	8,100,000
1994	18,300,000	11,800,000
1995	15,400,000	13,900,000
1996	10,200,000	7,000,000
1997	6,400,000	*5,499,357*
1998	*5,504,439*	*4,729,825*
1999	*4,780,729*	*4,107,959*
Total	77,622,653	65,549,620

[1] Projections in italics

As revealed in Exhibit 3, the toal core sample estimate of rebated units is about 12 million units, 18.4 percent, higher than the expanded sample estimates of rebated units. Also, based on the trend in rebated units after 1995, it appears that the projections based on the trend in national DSM program expenditures may overstate the actual number of rebates issued in the latter two years. As such, these latter-year projections might be interpreted as including other electronic ballasts promotions from DSM and market transformation programs that have been in effect over these years, such as energy efficiency performance contracting programs

Exhibit 4 contains estimates of shipped units of electronic fluorescent ballasts that are attributable to the various factors associated with the ballasts market. As the data indicate, based on the core sample estimates of rebated units, roughly 31 percent of all electronic ballasts shipped over the 9 year period were purchased with rebates provided through utility DSM programs. The expanded sample estimates indicate that 26 percent of all shipped units in the 1991 to 1999 period were purchased with rebates. On the other hand, based on the core sample estimates there remain 35.6 percent of all shipped units for which rebates were not issued and that are not accounted for by pre-1991 factors or by the price effect. Using the expanded sample estimates, there remain over 40 percent of all shipped units in this category. By the process of elimination, these remaining shipped electronic ballasts are attributable to the effects of *market transformation* on the electronic fluorescent ballasts market. As the primary national market transformation program over this period was the Green Lights Partnership, it may be surmized that the majority of this market transformation effect is due to the Green Lights Partnership.

Exhibit 4. Electronic Ballasts Market Transformation, 1991 through 1999

Attributions	Units	% of Total Units
Total Units Shipped	252,073,000	(100.00)
1990 Market Share Platform	35,265,000	(13.99)
Price Effect	49,441,408	(19.61)
Programmatic Effect	167,366,576	(66.40)
Utility DSM Program Rebates: Core Sample	77,622,653	(30.79)
Utility DSM Program Rebates: Expanded Sample	65,549,620	(26.00)
Green Lights Partnership and other MT Programs		
-- Based on Core Sample	89,743,923	(35.60)
-- Based on Expanded Sample	101,816,957	(40.39)

A speculative issue that is unlikely to be resolved is the degree to which utility DSM programs may have fostered market transformation through a *spillover* effect. Spillover is defined as the purchases of electronic ballasts, without rebates, by DSM program participants and nonparticipants, that are attributable to DSM programs having a positive influence on the market. According to LBNL (2000), unaccounted for spillover could cause the net benefits of the DSM programs to be underestimated. These issue are discussed in the context of estimate uncertainty but remain unanalyzed by the LBNL study. For the present study it is assumed that DSM program ballast rebates can be given 100 percent credit for the units purchased due to the rebates. The remaining units are attributed to the Green Lights Partnership, with the important caveat that DSM and additional market transformation programs also share this credit to an unknown degree. These other programs include smaller local, state and regional DSM and market transformation programs as well as national lighting-related programs such as the Federal Relighting Initiative that targets federal buildings across the nation and the National Equipment Manufacturers Association's Energy Cost Savings Council/Re-Electrify America program.

Recommendations for Future Research

This study calls attention to the central problem in estimating market transformation program accomplishments—quantifying the change in the number of units, or the change in market share, of energy efficiency goods and services sold that can be attributable to the market transformation program. Unlike demand side management programs that were, through rebate documentation, able to track every unit of energy efficiency goods or services that were acquired by consumers, market transformation programs have no such means of directly recording this kind of program accomplishment.

Price theory, mathematical modeling, and innovative data collection thus become more critical for evaluating market transformation program impacts. Engineering and billing analyses that have had decades of application, become less critical. The primary uncertainty regarding market transformation programs is not how much energy savings was saved, but rather whether programmatic efforts were able to quicken the pace of market movement. In this context, attaining ever more precise estimates of energy savings is irrelevant; it puts "the cart before the horse."

This study provides a framework for estimating market transformation accomplishments, showing how economic theory can be employed to understand the demand structure of a given product and how this demand structure changes due to social interventions. It then extends the methodology to directly estimate the marginal changes in product market share due to marginal changes in relative prices. This allows for product attribution and calculation of energy and greenhouse gas savings. Broadly speaking, most market transformation programs can be evaluated based on this approach by using geographic variations in market shares and relative prices, rather than time-related variation, to understand consumer behavior.

References

Busch, C. B., Turiel, I., Atkinson, B. A., McMahon, J. E., and Eto, J. H., "DSM Rebates for Electronic Ballasts: National Estimates (1992–1997) and Assessment of Market Impacts," Energy Analysis Department, Lawrence Berkeley National Laboratory, Final Report, March 2000.

Duke, R. and Kammen, M. " The Economics of Market Transformation Programs," *The Energy Journal*, Vol. 20, No. 4, Fall 1999.

Energy Information Agency. *Lighting in Commercial Buildings*, US Department of Energy, Office of Energy Markets and End Use, March 1992.

Energy Information Administration. *Annual Energy Review*, US Department of Energy, 1960 through 1999.

Energy Information Agency. *Commercial Building Energy Consumption Survey - 1995*," US Department of Energy, 1998.

Energy Information Agency. *US Electric Utility Demand-Side Management*," US Department of Energy, 1990 through 1999.

Eto, J., Kito, S., Shown, L., and Sonnenblick, R., "Where Did the Money Go? The Cost and Performance of the Largest Commercial Sector DSM Programs," Energy Analysis Department, Lawrence Berkeley National Laboratory, Final Report 1995, and The Energy Journal, Vol. 21, No. 2, Spring 2000.

Horowitz, M. J., Parece, A., and Zebedee, A. "Impact Evaluation of Northeast Utilities' 1992 and 1993 Energy Saver Lighting Rebate Program. Final Report and Appendices." Xenergy, Inc., 1995.

Horowitz, M. J. "Equivalence of Energy Impact Model and Net-to-Gross Methods," *Proceedings of the 7th International Energy Program Evaluation Conference*, Chicago, Illinois, July 1995.

Koomey, J. G., Sanstad, A. H., and Shown, L. J. "Magnetic Fluorescent Ballasts: Market Data, Market Imperfections and Policy Success," Energy and Environment Division, Lawrence Berkeley National Laboratory, December 1995.

United States Bureau of the Census. *Current Industrial Reports*, U. S. Department of Commerce, 1959 through 1999.

United States Department of Energy. *Technical Support Document: Energy Efficiency Standards for Consumer Products: Fluorescent Lamp Ballast Proposed Rule*, January 2000.

Vorsatz, D., Shown, L., Koomey J., Moezzi, M., Denver, A., and Atkinson, B., *Lighting Market Sourcebook for the US*, Energy and Environment Division, Lawrence Berkeley National Laboratory, December 1997.

Xenergy Inc. and Easton Consultants. "PG&E and SDG&E Commercial Lighting Market Effects Study," July 1998.