The Market Effects of SDG&E's and PG&E's Commercial Lighting Efficiency Programs

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ABSTRACT

This paper summarizes the methods and findings of a project to assess the market effects of commercial lighting efficiency programs sponsored by San Diego Gas & Electric and Pacific Gas & Electric. The study focused on effects on the markets for efficient fluorescent lighting components: electronic ballasts, T-8 lamps, and fixtures that integrate those technologies. The research for the project consisted of surveys of representative samples of end-users in the sponsors' service territories and a "non-program" area in which no utility DSM programs had operated, in-depth interviews with manufacturers and other supply side actors in both the sponsor and non-program areas, and review of secondary sources. The study found that the sponsors' programs, as part of a larger national utility effort, had a significant effect on levels of customer demand for efficient ballasts and lamps at the national as well as regional level. The sponsors' programs also had important effects on the local markets, such as increased promotion by designers and contractors and very rapid up swings in demand among certain sectors of end-users. Market share for efficient fluorescent components continues to increase in the face of decreased utility program support. This and other evidence suggests that some of the market effects of the sponsors' programs will be durable.

Introduction

Operational Definitions and Objectives of the Project

During the latter half of 1997, San Diego Gas & Electric and Pacific Gas & Electric undertook a study to assess the effects of their energy efficiency programs on the commercial market for efficient fluorescent lighting equipment. Both utilities had offered large-scale programs of various kinds to encourage the use of efficient fluorescent lighting equipment since the mid-1980s. The study focused on the effects of programs that operated between 1992 and 1996.

This paper summarizes the scope, methods, and findings of the commercial lighting market effects study. We also present observations on "lessons learned" from the study regarding technical aspects of evaluating a program's market effects. Finally, we identify a number of questions raised by our findings concerning the features of the complex commercial market for efficient lighting equipment, which merit further study in support of continued market transformation efforts.

We adopted as the basis for this evaluation the operational definitions of *market transformation* and *market effects* of energy efficiency programs put forth in the *Scoping Study* on market transformation commissioned by the California Demand-Side Management Measurement Advisory

Committee (CADMAC) and completed in 1996. The key definitions from the *Scoping Study* (Schlegel et al. 1996) include the following:

- *Market Transformation* "means a reduction in market barriers due to a market intervention, as evidenced by a set of *market effects*, that lasts after the intervention has been withdrawn, reduced or changed."
- A *Market Effect* is "a change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy efficiency products, services, or practices and is causally related to market interventions."

The primary objectives of the project were to:

- Identify changes in the commercial lighting markets that favor the adoption of efficient fluorescent technologies, both in the sponsors' service territories and in the nation as a whole;
- Assess the extent to which these changes were attributable to the sponsors' programs; and,
- Project the expected durability of any observed effects.

Other project objectives were to develop detailed demand-side and supply-side fluorescent lighting market characterizations, including segmentation and to characterize the nature and extent of interventions in the market by the sponsors, other utilities, and government agencies.

Research and Analysis Activities

The following research activities were undertaken in support of the analytical objectives.

- ***Customer surveys.*** Telephone surveys were conducted with representative random samples of 579 commercial customers in the sponsors' service territories and 287 commercial customers in a 9-state "nonprogram" area in which no utility lighting rebate programs had been offered. These were supplemented by in-depth interviews with 25 facilities managers working for Real Estate Investment Management firms (REIMs) and chain retailers both within and outside the sponsors' territories. These surveys captured information on adoption of efficient technologies and related practices, as well as the experience and effects of efficiency programs among the sponsors' customers.
- ***Interviews with Supply-Side Market Actors.*** In-depth interviews were carried out with 183 individuals working on the supply side of the commercial lighting market. These included distributors, designers, installers, manufacturers, and government officials involved in product standard and code development and enforcement. These interviews captured information on a wide range of issues, including production, stocking, and promotion decisions in regard to efficient lighting equipment and program impacts on those decisions. In addition, 90 closed-ended interviews were conducted with distributors to estimate market penetration of efficient equipment.
- ***Secondary Sources.*** The project used a wide range of secondary sources, including prior utility program evaluation, saturation, and market studies, Census data on equipment sales and construction volumes, and a variety of reports and articles on lighting technologies and markets.

Overview of the Sponsors' Programs

The sponsors' programs to support efficient commercial fluorescent technologies can be summarized as follows.

- ***Scale of activity.*** The volume of the sponsors' program activity was huge in relation to the markets targeted. During the period January 1992 - July 1997, PG&E paid rebates on about 9 million four-foot ballasts and 15.6 million four foot lamps. These subsidized purchases accounted for 40 percent of *all* ballast sales (not just electronic ballasts) in the PG&E service territory during the study period and 80 percent of all electronic ballast sales. SDG&E paid rebates on 2.1 million ballasts and 4.7 million lamps. We estimated that subsidized ballast purchases accounted for 30 to 35 percent of the market for *all* ballasts in the San Diego territory for the study period, or 60 to 70 percent of electronic ballast purchases. Rebate activity for both programs peaked in 1994 and 1995.
- ***Sponsor's programs in the context of national activity.*** During the period 1988 - 1996, utilities nationwide paid out nearly $2 billion in rebates for efficient fluorescent lighting components. These rebates subsidized the purchase of roughly half of all electronic ballasts shipped domestically during this period. This is 16 percent of *all* ballasts shipped during the study period. The sponsors' programs accounted for over 13 percent of these rebates.
- ***Focus on applications in existing buildings.*** About 80 percent of the electronic ballasts on which PG&E paid rebates were installed in projects in existing buildings. The results of customer surveys suggest that that roughly one-half of these ballasts were used in retrofit projects and the remainder in renovation and remodeling projects. Based on analysis of program expenditures, a similar pattern appeared to hold for SDG&E.
- ***PG&E Program Strategies.*** PG&E promoted the use of efficient commercial fluorescent lighting in existing buildings through a variety of mechanisms. The largest of the programs oriented to existing buildings was Retrofit Express, which paid a fixed rebate amount per component. Retrofit Express accounted for 6.5 million of the 9 million ballasts rebated over the study period. The Customized (Retrofit) program accounted for roughly 0.5 million ballasts rebated. This program based rebate payments on estimated KW and kWh savings, using lighting power densities (LPDs) specified in the California Building Code (Title 24) as the benchmark. Incentives for the use of efficient lighting in new construction were always based on Lighting Power Densities. Over time, qualifying design LPDs have been reduced to their current level, which ranges from 10 to 30 percent below Title 24 requirements, depending on building type.

  PG&E has promoted the development of both the supply and demand side of the market for efficient commercial lighting through a number of other strategies, including: designer education through the Pacific Energy Center, provision of tools to support efficient lighting designs, participation in statewide processes to revise Title 24 (with lower LPDs), and energy audit programs. Marketing of the programs focused on the office, retail, and institutional sectors.[1]

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[1] For this study, the institutional sector includes the following kinds of buildings: primary and secondary school, government office buildings, health and hospitals, lodging, colleges and universities. Utility records did not distinguish government from other kinds of office buildings.

- ***SDG&E Program Strategies.*** SDG&E's programs to promote retrofit and replacement with efficient lighting among commercial customers began on a significant scale in 1989. Since that time, the programs have evolved substantially in terms of target markets, measures supported, customer incentive levels and formats, and delivery mechanisms. One constant throughout has been a high level of customer contact and logistical support for retrofit projects, including project planning, prescreening of contractors, and, for some customers, full turnkey project management.

Size and Segmentation of the Sponsor's Commercial Lighting Market

Methodological Challenges

Any analysis of a program's market effects proceeds from a detailed profile of the target market. The key elements of this profile include the total size of the market, its segmentation in terms of adoption of efficient lighting technologies, and the size and description of the segments. Assembling such a profile required the integration of data from a number of sources, each denominated differently, e.g.: number of square feet equipped with certain kinds of lighting; percentage of total wattage installed accounted for by different kinds of equipment; number of efficient units sold, number of units sold through various programs.

The key integration task was to express information from the various sources in terms of numbers of units installed (stock) or purchased in a given year (flow). The fulcrum for integrating these sources is the pair of ratios: square feet/customer and fluorescent ballasts (or fixtures or lamps)/square foot. We used reported number of employees from the customer surveys and employee/square foot factors from CBECS[2] to synthesize square footage for each sample facility. We also obtained the respondents' estimates of the floorspace involved in each project involving the installation of fluorescent lighting equipment. These data allowed us to integrate and compare the results of the customer surveys with the analysis of Census shipment data, distributor surveys on market penetration, the sponsors' equipment saturation surveys, and program records of units rebated. This supported flexible analysis, as well as cross-checking to assess the plausibility of the individual data sources.

Results

The sponsors' commercial lighting markets are, simply put, huge. They constitute 4 percent of the total US market for commercial lighting equipment. The study results indicate that the commercial market is highly segmented in terms of adoption of efficient lighting equipment and related variables. Generally, the segmentation reflects the strength of customers' motivations to invest in energy efficiency and organizational resources available to develop and manage efficiency improvements and equipment purchases. Thus, penetration of efficient equipment is highest in the institutional and owner-occupied office sectors. Customers in these segments stand to benefit more than others from investments in energy efficiency because they are more likely to own their facility and the facility is likely to be larger and thus use more lighting energy. Moreover, these customers are likely to be part of

[2] Energy Information Administration, *Commercial Building Energy Survey: Energy End-Use Intensities in Commercial Buildings, 1995.*

larger organizations which have can assign staff to energy management tasks. The relatively high levels of efficient product market share in the leased office sector reflects the high motivation of Real Estate Investment Management companies (REIMs) to control costs and deliver net operating income to investors. Table 1 summarizes descriptive information on the market segments identified by the study.

Table 1
Summary Information on Market Segments: SDG&E and PG&E Service Territories

Segment	Percent of Estab's.	Percent of Floorspace	Average Facility SF*	Percent of SF Owner-Occupied	Market Share: El. Ballast	Market Share: T-8 Lamps	Percent w/ Energy Mgrs.**
1. Office/Owner	17%	8%	145,544	96.6%	71%	48%	53%
2. Office/Leased	17%	22%	51,432	0.0%	48%	46%	74%
3. Retail/Sole	29%	7%	15,336	28.0%	25%	16%	30%
4. Retail/Multi-site	8%	8%	41,373	23.6%	30%	29%	51%
5. Institutional	14%	43%	509,267	78.0%	53%	41%	77%
6. Other	15%	12%	112,285	42.6%	12%	10%	36%
All Segments	**100%**	**100%**	**198,567**	**50.4%**	**47%**	**41%**	**67%**

* Average size of sample facilities, not weighted to reflect actual representation in the population.
** Expressed as percentage of total square feet in the segment.

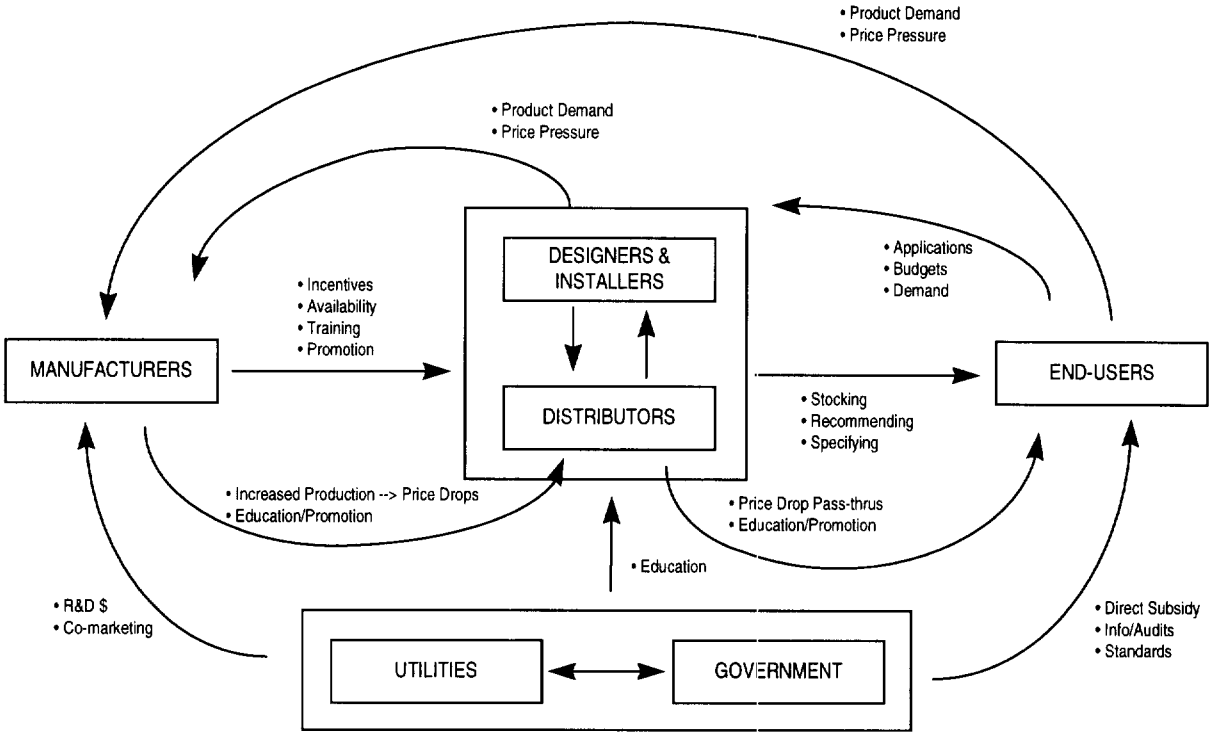
Market Effects of the Sponsors' Commercial Lighting Programs

Figure 1 depicts the market effects of utility programs on the national markets for efficient fluorescent lighting components and, within that framework, the effect of the sponsors' programs on the local markets. The basic story can be summarized by the following propositions.

- Beginning around 1991, intervention by utilities nationwide into the commercial fluorescent lighting markets reached sufficient scale to increase significantly customer demand for electronic ballasts and T-8 lamps. These interventions and customer response are represented by the outside arrows on the left-hand side of Figure 1. This increase in demand led manufacturers to increase production, improve product quality and reduce prices..
- As volumes of electronic ballast and T-8 lamp production rose, competition for the "efficient segment" of the market increased and prices fell. This feedback process continues to the present.
- With the support of this "feedback loop", the sponsors' programs led to the development of the market for efficient lighting equipment further down the supply chain. These effects are represented by the inner arrows of Figure 1, and they are described in more detail below
- A variety of evidence suggests that current levels of market penetration will persist in the sponsor's territories. In addition to the 1998 revision of Title 24, this evidence includes the broad base of

knowledge concerning product benefits and the continued increase in efficient product market share in the face of decreases in utility support.

Figure 1
Basic Mechanisms of Transformation
in the Commercial Lighting Markets



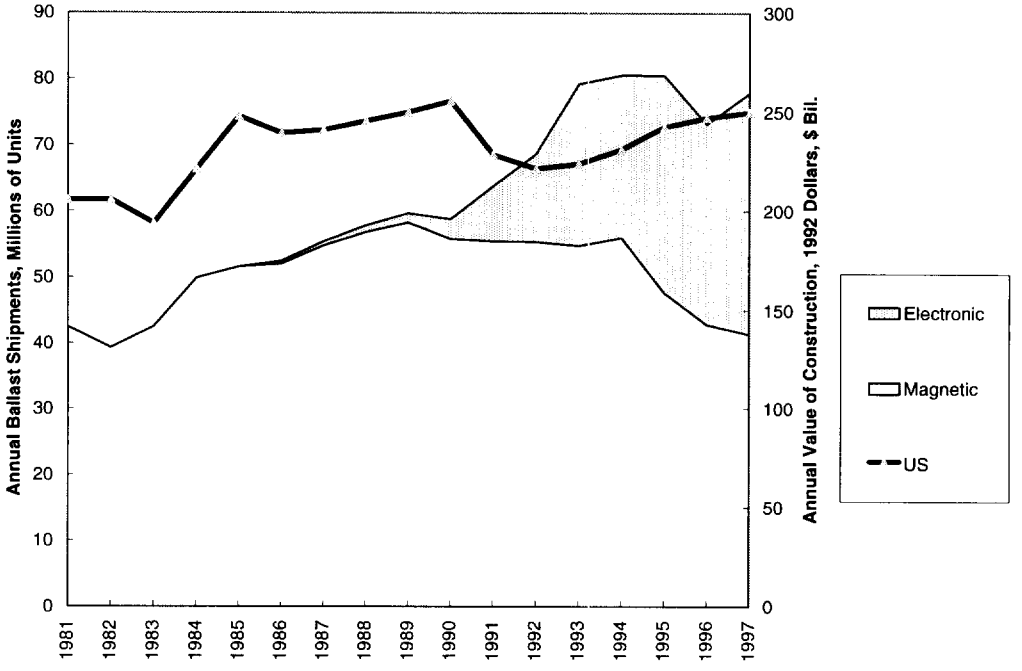
The Impact of Utility Programs on National Equipment Shipments

At the national level, the concerted efforts of utilities and government agencies led to a rapid increase in the demand for electronic ballasts and T-8 lamps. This growth consisted of two trends: (1) an expansion in demand for ballasts and lamps far beyond levels required to keep pace with current levels of commercial construction; and (2) a rapid increase in the market share of efficient equipment. Based on manufacturers' shipment data, the market share of 4-foot electronic ballasts increased from 13 percent in 1991 to 47 percent in 1997.

Figure 2 illustrates the dramatic impact of utility programs on the national markets for efficient fluorescent components. The solid areas show power factor corrected fluorescent ballast shipments from 1981 through 1997; the darker area represents electronic ballast shipments. The black line shows

the value of new construction put in place in constant (1992) dollars.[3] Prior to 1990, changes in ballast sales tended to parallel changes in construction expenditures with a lag of about a year. In 1991 and 1992, levels of construction spending dropped sharply, reflecting national recession conditions, and have not yet returned to pre-recession levels. Ballast shipments, on the other hand, increased over 36 percent between 1990 and 1994, and most of this increase was accounted for by the steep rise in electronic ballast shipments. The rapid increase in the market share of efficient ballasts is also apparent from Figure 2.

Figure 2
Trends in Electronic Ballast Shipments and Non-residential Construction Expenditures: 1981 - 1996



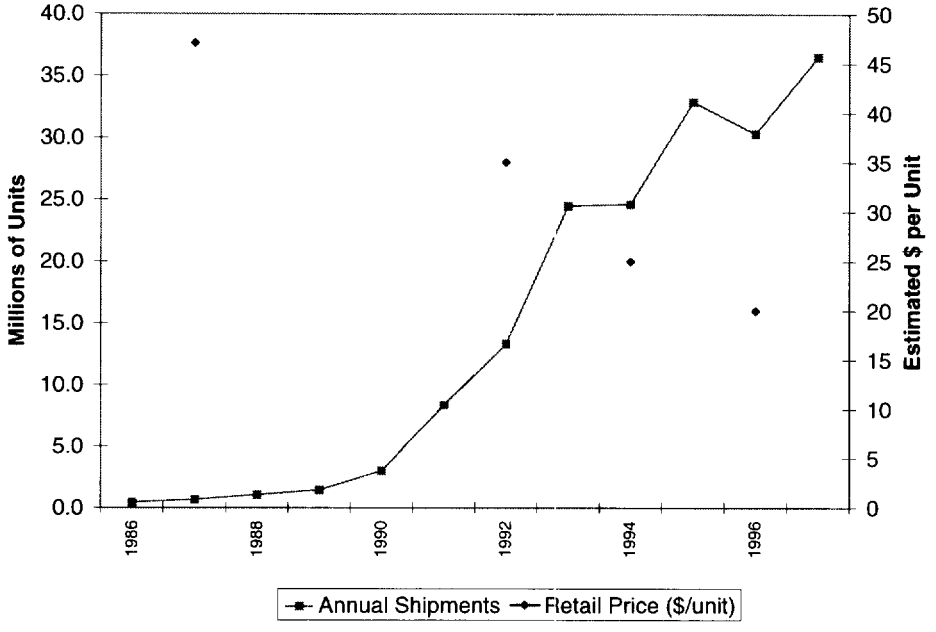
The Impact of Increased Demand on Component Prices and Features

The rapid expansion of demand for electronic ballasts and T-8 lamps contributed to increased competition among manufacturers for market share. This competition led to improvements in product reliability and features, increased levels of promotion and significant decreases in price. For example, the difference in price between a 2-lamp electronic ballast and a magnetic ballast decreased from $10 in 1992 to $5 in 1996. For some fixture configurations, electronic ballasts currently cost less than magnetic ballasts. The difference in price between T-12 and T-8 lamps decreased from $2.25 in 1992 to $1.25 in 1996. Figure 3 illustrates the rapid decrease in electronic ballast prices along with the rapid

[3] Sources: U.S. Bureau of the Census, *Current Construction Reports*, Series C30. Represents value of construction put in place during the year. Includes renovations and additions and installed cost of normal building services. For ballast shipments: U.S. Bureau of the Census, *Current Industrial Reports.*

increase in shipment volumes. Interviews with manufacturers confirmed the link between utility program efforts, increases in shipment volumes, and decreases in unit prices. The combination of increased demand, declining prices, product improvements, and enhanced promotion appears to have created a feedback loop that has supported the "take-off" of efficient fluorescent lighting systems and their components. Penetration of electronic ballasts, the core of efficient fluorescent lighting systems, has reached 47 percent nationwide, with shares as high as 80 and 90 percent in some regions and market segments.

Figure 3
National Electronic Ballast Shipment and Price Levels



Market Effects in the Sponsors' Service Territories: End Users

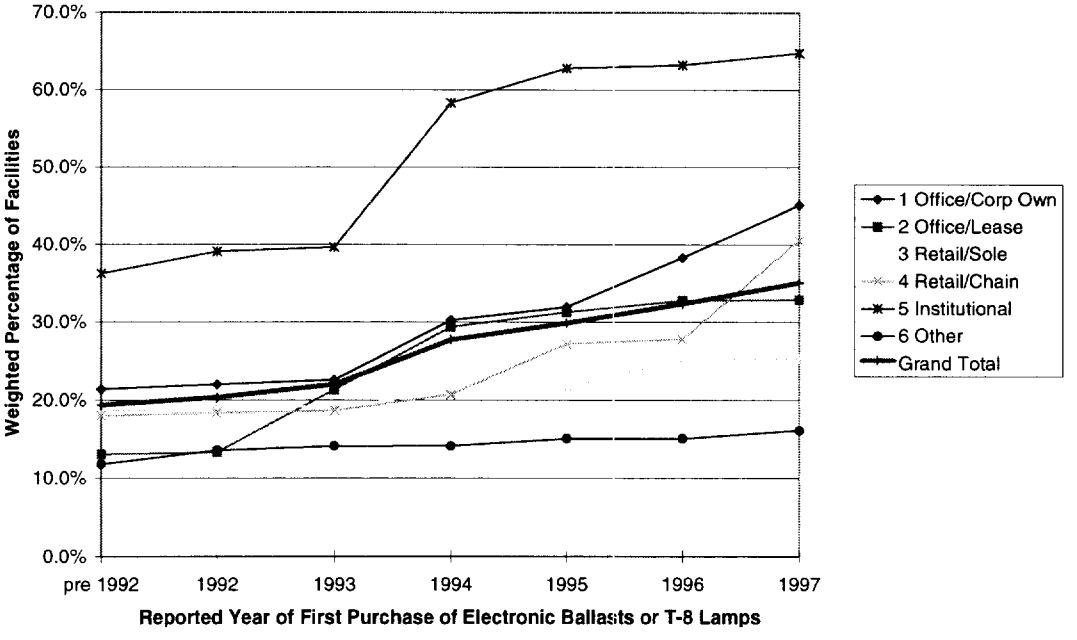
Efficient Product Adoption. The national trends in the ballast and lamp markets were even more pronounced in the sponsors' service territories. The programs had a large net impact on the number of electronic ballasts and T-8 lamps purchased by their commercial customers during the study period. The penetration of electronic ballasts increased from 17 percent in 1991 to 55 percent in 1997; the market share for T-8 lamps in the sponsors' territories grew from 11 percent to 51 percent over the same period. By contrast, as Table 2 shows, electronic ballasts have only achieved 29 percent penetration in programs where no utility programs have been offered. The market share of T-8 lamps is estimated at 27 percent in nonprogram areas.

Table 2
Market Share of Efficient Equipment
Reported by Sample Distributors

Technology	Area	% Annual Market Share by Year		
		1997	1994	1991
T-8 Lamps	Program	51%	27%	11%
	Nonprogram	29%	12%	3%
Electronic Ballasts	Program	55%	29%	17%
	Nonprogram	27%	13%	3%

The impact of the programs in terms of net purchases of efficient fluorescent components appears to be concentrated in the institutional and office sectors – and particularly in owner-occupied office buildings. The program had little effect on the penetration of efficient equipment in the retail sector, wholesale, and miscellaneous other sectors. In these market segments, the penetration of efficient equipment in the program and nonprogram areas was basically the same. As Figure 4 shows, cumulative adoption of efficient equipment changed hardly at all in the retail and "other" sectors during the program period.

Figure 4
Timing of Adoption of Electronic Ballasts and T-8 Lamps by Market Segment
Cumulative Percentage of Facilities by Year of First Adoption



Other Demand-Side Market Effects. The sponsors' programs reduced a number of important barriers to customer adoption of efficient fluorescent technologies. Most importantly, they:

- ***Increased customer awareness of efficient fluorescent technologies***. Seventy-four percent of program participants interviewed for the study reported that the main reason they had not used electronic ballasts or T-8 lamps prior to program participation was that they were not aware of these products. 80 percent of participants in PG&E programs and 87 percent of participants in SDG&E programs reported that their first purchases of electronic ballasts or T-8 lamps were made through the programs.
- ***Increased customer awareness of the full range of benefits associated with efficient fluorescent technologies.*** Forty-one percent of customers in the program area mentioned longer useful life in an unprompted question concerning the benefits of efficient fluorescent components. By contrast, only 1 percent of non-program area customers mentioned this benefit. Virtually all program participants were able to name at least one legitimate benefit of efficient fluorescent components. By contrast, 62 percent of program area nonparticipants and 39 percent of nonprogram area customers were *unable* to name *any* legitimate product benefits. These results may indicate the educational effects of program participation.
- ***Helped customers reduce perceived costs of replacing inventories of standard equipment.*** Distributors and designers identified high first cost as the major barrier to adoption of efficient fluorescent products that the sponsors' programs helped customers overcome. Surprisingly, only 19 percent of program participants mentioned high first cost as a reason for *not* buying efficient fluorescent components prior to program participation. Fifty-one percent did mention, however, that the costs of maintaining inventories of both kinds of equipment did deter them from purchasing efficient equipment.
- ***Effect on organizational infrastructure for efficient equipment selection.*** Results of the customer survey showed that the presence of an energy manager and the application of investment decision rules to lighting equipment selection were very strongly associated with purchase of efficient equipment. We hypothesized that the sponsors' programs may have induced customers to hire energy managers in order to take advantage of the programs and that their experience in the programs may have accustomed them to applying payback analysis to lighting purchases. We found that the difference overall between program area and nonprogram area customers on these two indicators was relatively small and not statistically significant.

Market Effects in the Sponsors' Service Territories: Supply-Side Actors

The sponsors' programs contributed to reducing a number of important barriers to the promotion of efficient fluorescent technologies by supply-side actors in the sponsors' service territories. Most importantly, they:

- ***Encouraged distributors, designers and installers to use the provision of efficient equipment as a strategy to gain and retain market share.*** By far the majority of designers and installers in the sponsors' service territories reported that they increased their promotion and specification of efficient fluorescent components during the study period. About one-half of those reporting such changes reported pro-actively promoting efficient equipment to their customers as a competitive strategy. The rest reported responding to increased customer demand. Most

attributed increased customer demand for efficient components in part to the sponsors' programs.

- ***Set the stage to make revisions in California's Title 24 building code which effectively require the use of efficient components politically acceptable to most supply-side actors.*** The impact of the utility programs in this area was strong. Prior to the rapid increase in efficient product penetration, the California Energy Commission had been hesitant to revise required Lighting Power Densities. PG&E staff were deeply involved in the revision process for Title 24 and forcefully advocated the reduction of Lighting Power Densities.

The Durability of Market Changes

We believe that evidence gathered through this study generally supports the conclusion that current levels of market share for efficient components would persist in the absence of further local utility market interventions. This evidence includes:

- Persistence in the growth of market share both nationally and in the program area in the face of declining utility support and incentive payments.
- Widespread awareness (facilities encompassing 70 percent of total floorspace) among end-users of the benefits of efficient fluorescent lighting equipment.
- Low and declining incremental costs for efficient equipment..
- The promulgation of revisions to Title 24 which will effectively require the use of electronic ballasts and T-8 lamps in most permitted construction.

We also identified evidence which suggests that the recent pace of growth in efficient product market share is unlikely to be sustained. This evidence includes the following.

- Despite a decade of intense promotion and plentiful rebates, the retail and miscellaneous sectors have not adopted efficient fluorescent technology in great numbers. Moreover, adoption of efficient products by smaller customers in virtually all sectors is relatively low.
- Manufacturers continue to resist the phase-out of magnetic ballasts and associated lamp technology. This resistance may be prompted by fear of loss of market share in other countries and loss of margin, which is relatively higher for magnetic than for electronic ballasts.

Lessons Learned

This project yielded a great deal of insight into the practicalities of conducting a large-scale market effects study and identified areas in which additional research would yield significant value. The most important of these for future studies are as follows.

Additional Analysis and Research Infrastructure

- ***Size, segmentation, and current strategies of the Real Estate Management Industry.*** Nearly 50 percent of commercial floorspace is leased in the sponsors' territories. In the leased office sector (22 percent of floorspace), lighting selection is entirely the province of the property manager. In the retail sectors, lessees exercise more choice, but not in all cases. A study of the segments of the real estate management industry and the motives and *modus operandi* of the denizens of those segments would benefit future program design.

- ***Sample frame for market actors.*** At the moment, there are no accurate, comprehensive lists of key types of firms on the supply side: installers, designers, distributors. This situation defeats the implementation of probability-based estimation strategies for indicators such as market share of efficient products based on reports from distributors. Information from these sources is nonetheless valuable. For the time being, the samples for such interviews are necessarily judgmental and the process for selecting them needs to be made explicit in the evaluations. Future research on the commercial market would benefit from work to develop better sample frame information on the companies that provide services to commercial building owners.

Comments on Research Methods

- ***Assess hypotheses using multiple methods.*** Analyzing a hypothesis using two approaches – say cross-sectional and historical – can help clarify the case for or against a hypothesized market effect where the evidence from one approach or the other is indecisive. For example, we found that the percentage of organizations with energy managers was higher in the sponsors' program areas than in the non-program areas, but that the difference was not statistically significant. However, we did not include questions in the survey regarding the extent to which organizations hired energy managers to take advantage of utility programs. Capturing such data would have allowed us to better evaluate the cross-sectional findings in assessing program attribution.
- ***Think through the connection between customer survey results, shipment data, and other market share indicators.*** Appropriate indicators of market share and sources for these data vary by end-use technology. Market effects researchers need to think through the factors required for integrating market share information in a variety of units from multiple sources in designing their projects.

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