DSM Technology Forecasting: Market Transformation and the Dynamic Baseline

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DSM programs often have market transformation as a primary or secondary goal. Market transformation is accomplished by altering customer awareness, equipment supplier behavior, production costs, or the rate of technology innovation. Successful transformation implies a change in program cost effectiveness, since the DSM baseline is altered. This paper examines the issue of market transformation and technology modeling for two key DSM technologies: (1) electronic ballasts, and (2) high-efficiency motors. Results are based on published evaluation studies, industry shipments, data and technology forecasting methods.

Introduction

As DSM Programs mature, there is increasing evidence that the broad-based presence of these programs has altered equipment markets. These alterations take three basic forms. The first is a change in customer and vendor awareness of efficient technologies and acceptance of these technologies as valid and economic options. The second is a change in production and marketing costs associated with higher volumes. The third is an increased rate of development of new advanced equipment options.

As these market transformations occur, they alter the calculus of DSM programs. These dynamic “free driver” effects that would live on without the program become future “free rider” effects if programs are continued. In essence, cumulative program effects have moved the baseline, and this has important impacts on the cost effectiveness of continued programs.

This paper looks at the issue of market transformation and technology modeling for two key DSM technologies: electronic ballasts and high-efficiency motors. The results are based on a blend of technology forecasting estimates, industry shipments data, and published DSM evaluation studies.

The Market Transformation Debate

Many DSM programs set out with the explicit goal of transforming equipment markets. The idea is to expose customers and vendors to efficient technologies and to increase market acceptance of these technologies. There is an on-going debate about the need for this type of market intervention. The pro-intervention side argues that there are significant market imperfections and that cost-effective DSM is justified. The anti-intervention side argues that equipment markets work well enough on their own. Although the intervention debate is not the focus of this paper, a few comments are needed to motivate the analysis that follows.

Information Costs. A prerequisite for successful DSM programs is that the technology involved must have clear cut benefits that outweigh any extra costs. Benefits and costs must include equipment performance and aesthetic impacts, as well as equipment cost and operating cost.

The first justification for market intervention revolves around information costs related to energy efficiency. It starts by noting that energy efficiency is an abstract concept to most utility customers. Three points are relevant.

- First, energy costs are small, representing about 1% (U.S. Dept of Commerce, 1992 and EIA, 1992) of operating budgets in the commercial sector and 2% in the industrial sector. As a result, actions that have a fractional impact on a fraction of cost are not strategic. Although energy availability and reliability of service are key business needs, fine-tuning the energy budget is not.

- Second, in most cases, customers do not observe directly the cost of operating specific pieces of equipment. Paying the monthly bill is not like pumping gas into a car. As a result, most customers do not know how much they spend on lighting, cooling, or operating computers.

- Finally, most electric equipment, such as fluorescent lighting, is already relatively efficient. Promotion of new and more efficient options involves computations on the margin, with gains stated from an already small base.

The bottom line is that customers do not watch energy being consumed, nor can they see it being saved. Even when an action is taken, savings are often lost in the dynamics of other operating changes. As a result, we find that interest is high for tangible conservation actions, like recycling paper, but is relatively low for less concrete actions, like energy conservation.

This argument concludes that the arithmetic of energy efficiency is not immediately accessible to most customers. They could learn about equipment options on their own, but the cost of becoming informed would most often outweigh the benefit of saved energy. As a result, most utility customers remain uninformed about options for marginal efficiency improvements, and any underlying demand for energy efficiency does not get registered with equipment providers.

Equipment Cost. The second argument for intervention has to do with equipment costs, economies of scale, and market dynamics. If DSM technologies are cheaper to produce at higher volumes, then efforts to give the market a jump start could push providers "over the hump," resulting in a lasting drop in cost and an increase in market share. Interestingly, this argument is often applied to mature technologies, as well as to relatively new technologies.

This argument is applied to distribution costs as well as to manufacturing costs. For example, distributors will typically stock a subset of existing equipment. In these markets, when a customer is faced with a replacement upon failure, the determining factor is ready availability of a replacement option. Because the cost of stocking both high-efficiency and standard efficiency equipment is high, efficient options are often available only as a special order item.

Principal/Agent Behavior. The third argument for intervention revolves around the fact that equipment decisions are often made by an agent other than the customer who ends up paying the operating bill. Examples are developers versus building owners, landlords versus tenants, and equipment maintainers versus owners and occupants. To support this argument, it must further be argued that energy efficiency is difficult to observe, and is therefore not fully reflected in property values or in rental rates, As a result, the incentive in most equipment purchase decisions is to minimize the first cost, independent of the preferences of the eventual bill payer.

The Other Side of the Coin. The competing argument is that energy equipment markets work well, and intervention is not justified. Because these markets work, manufacturers and distributors sense the underlying demand for efficiency. If they sense that efficiency provides a strategic advantage for their product, they will rush to introduce and market the efficient option, with expectation of increasing their market share. Market pressures will force the competition to follow. This argument continues to suggest that if there is an information problem, this only reflects the real costs of obtaining information about energy efficiency.

We do not take a position in this argument. It is an empirical question whether DSM does or does not move specific technology markets. If it does, then the implied dynamic effects beyond the program life should be considered in the cost/benefit calculations. If it does not, then market shares will return to pre-program trends when programs stop.

Transformation in Mature Technology Markets

The role of utility DSM in mature technology markets is illustrated in Figure 1. This figure shows the fraction of equipment purchases that are high efficiency. In the initial years, before the introduction of utility programs, the market share is stable with a relatively small share for the premium efficiency option. With the introduction of a strong DSM program, this share increases significantly.

Reflecting the stable market before the program, it is reasonable to project a flat profile for the high-efficiency share in absence of the DSM program. This is labeled as the static baseline, and it represents a "No-DSM-Ever" forecast. Given this baseline, market data on equipment sales clearly identify the net program impact. Evaluation studies will go further to decompose this effect into several pieces.

- *Free riders.* These buyers are indicated by the fraction of static baseline buyers who participate in the program.

- *Participants.* This group includes all equipment purchasers who participate in the program and obtain an

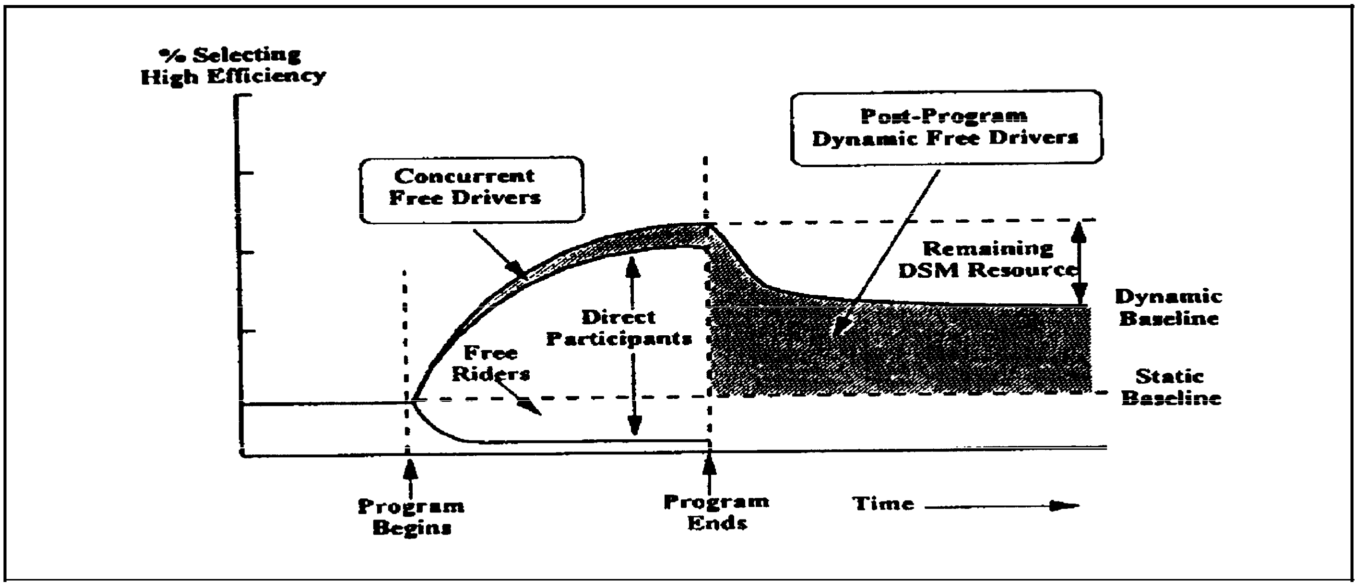

Figure 1. Depiction of Equipment Purchase Shares for a Mature Technology

incentive payment. Some fraction of these participants are free riders.

- *Concurrent Free Drivers.* This group includes additional purchasers who are induced to buy the efficient option, but who do not participate in the program or receive incentive payments.

To provide the "no-further-DSM" baseline, the program is left in place for some period of time, after which incentives are eliminated and the program ends. Beyond the end of the program, the extended market share can follow one of two paths.

- No *Market Transformation,* If it is believed that the market will return quickly to the static baseline, then there are no dynamic spill-over effects. In this case, the program has an immediate effect on equipment purchases within the program domain, but has no lasting impact on customer or supplier behavior thereafter.

- *Market Transformation.* If it is believed that the program has had a lasting impact on technology awareness and acceptance, then DSM has moved the market, and the dynamic baseline is above the static baseline. In this case, there is a spill-over effect beyond the life of the program.

From the perspective of the program, the area between the static and dynamic baselines is a measure of dynamic free drivers. These are high-efficiency purchases that would not have happened without the program, although the program is no longer in place when they occur.

This depiction has important implications for program evaluation, program planning and IRP calculations. For program evaluation, the dynamic free drivers become potential free riders in future programs. From the perspective of program planning, the costs of program continuation are not changed, but the benefits are decreased by the higher baseline. From the perspective of IRP, the DSM resource is both smaller and more costly when measured with respect to the dynamic baseline.

As DSM programs mature, increasing levels of effort are being aimed at identifying the location of the dynamic baseline for mature technologies. For some technologies, continued incentives, although perhaps at a reduced level, may prove to be cost effective, and these will remain viable options in the IRP process. For others, DSM will prove to have moved the market, and further efforts will not be warranted. In either case, it is important that these market conclusions become imbedded in technology forecasts used in the planning process.

Example: The BC Hydro Motor Program. Energy-efficient induction motors are not a new technology. Serious concern for energy efficiency in motor design originated in the mid 1970's, and premium efficiency units were introduced in the late 1970's and early 1980's. Initial efficient designs reduced Watt losses by about 25%, and later improvements increased this reduction to 35% (Andreas, 1992). Although these reductions in losses are significant, the bottom-line energy savings are relatively small, ranging from about 10% of electricity consumption for small motors to as little as 1% for large motors. At the same time, testing methods were improved, and in the late 1980's, NEMA developed a formal definition for premium-efficiency motors in the most frequently used categories.

The best example of a market transformation in the area of industrial motors comes from the evaluation reports of the BC Hydro motor program. Data for this program are depicted in Figure 2. Specifics are as follows:

- The BC Hydro program began in the early 1980's with information and education programs intended to increase customer awareness of high-efficiency motors and to demonstrate the favorable economics of these options.
- Through 1988, these information programs had little noticeable impact on premium-efficiency shares, which remained below 5%. Most vendors still did not stock premium-efficiency motors, implying prohibitive delivery delays.
- In 1989, following a one-year pilot program, the Power Smart Motors program began, with customer incentive of $400 per kW.
- In 1990, a vender incentive was introduced, set at 20% of the participant incentive.

In 1992, the participant incentive was reduced to $350 per kW. In 1993, it was further reduced to $300 per kW. In 1994, the participant incentive was reduced to $200 per kW.

Figure 2 presents market data from the program evaluation. The evaluation was performed in 1992, and included data through 1991. Values for 1992 through 1994 are approximate based on the observation that market shares have remained relatively stable, despite the decreasing incentive level. Whereas most vendors did not stock premium-efficiency units before the incentive program, stocking of these units is now nearly universal. Any delay in filling orders is now likely to apply to customers demanding standard efficiency motors.

Beyond 1994, three paths are shown. In the top path, rebates are continued until standards take over, making premium-efficiency motors mandatory beyond some point. (Under EPACT, premium-efficiency is mandated for the most commonly used motors between 1 and 200 horsepower beginning in late 1997. Comparable laws are under consideration in Canada.)

The middle and bottom paths both assume that incentives are phased out in 1995 and that standards are not imposed. In the middle path, the market has been transformed, and the removal of the incentive results in a market share drop to about 50%. In the bottom path, there is a complete return to the original baseline, implying absence of market transformation.

Because the program is still in place, it remains unclear whether there has been market transformation or not. It is clear that vender stocking practices have changed, and that premium-efficiency motors are now the most commonly available options. It is clear that most manufacturing customers developed a better understanding of the economic benefits of high-efficiency motors through program participation. It is clear that the premium-efficiency share of the market has remained strong, despite reductions in the incentive level. If the incentive is further reduced or eliminated in the near future (before efficiency standards

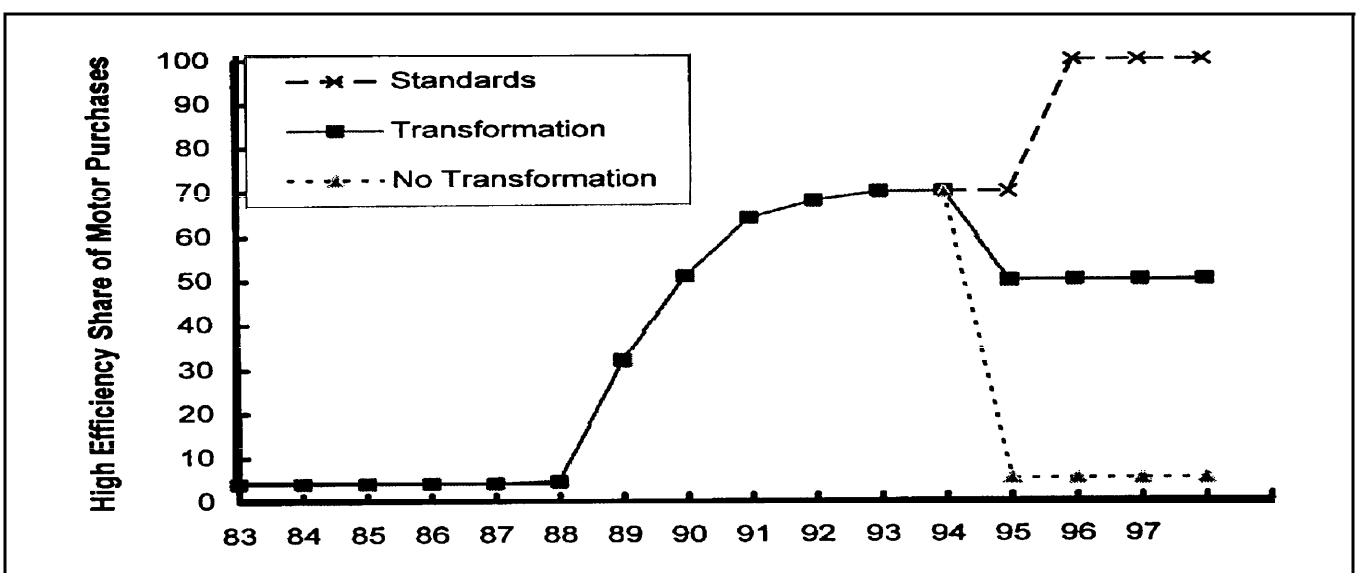

Figure 2. Depiction of BC Hydro Motor Program

become effective), this program will provide an excellent test case in the ability of DSM programs to transform the motor efficiency market.

Transformation for New and Emerging Technologies

For new technologies, the issues are somewhat different, as shown in Figure 3. In this figure, the new technology has a zero or very small initial market share. During this early period, utility testing and demonstration projects are intended to display the product in operation and to determine the scope of any problems with the technology. In part, the goal of this testing is to avoid providing incentives for products that turn out to be faulty or have unexpected side effects. Once this phase has passed, the program begins, and the top line of the chart tracks actual market sales of the DSM technology with the program in place.

As in Figure 1, the bottom line is labeled "No-DSM-Ever," and it gives the market adoption or technology diffusion path that would have occurred without the utility program. During the program period, evaluation efforts identify the degree of participation from program records, and attempt to sort out free riders and concurrent free drivers through a variety of market research techniques. The free-rider estimate is particularly important, because it is, in essence, an estimate of what market adoption would have been without the program.

When the program ends, and incentive payments are phased out, the adoption rate declines to the dynamic baseline.

- If the market has been moved, the dynamic baseline will remain above the No-DSM-Ever diffusion path, In this case, the program spill-over effect is indicated by the shaded area, labeled "Post Program Dynamic Free Drivers."

- If the market has not been transformed, the dynamic baseline will return to the No-DSM-Ever diffusion path.

- In either case, if the program continues, there is a remaining DSM resource. If the market transformation effects are large, then the remaining resource will be small. If the market transformation effects are small, then the remaining resource will be large.

One key difference between a new technology market and a mature market is the degree of difficulty in identifying the appropriate No-DSM-Ever baseline. In the mature case, the pre-program trend is well established, and can be used with confidence as the static baseline. In the new technology case, there is no existing share or established trend. The estimated baseline must be based on market analysis and assumptions about naturally occurring technology diffusion.

According to the logic of most diffusion models, any adoption impact during the program period will have a continuing effect on shipments after the program has ended. This continued market push occurs through the hastened market exposure and customer familiarity. That is, by making the market share larger earlier in the diffusion process, adoption rates will be elevated after the program is removed. In simple modeling frameworks, the long-run market share is not impacted, but the path to this

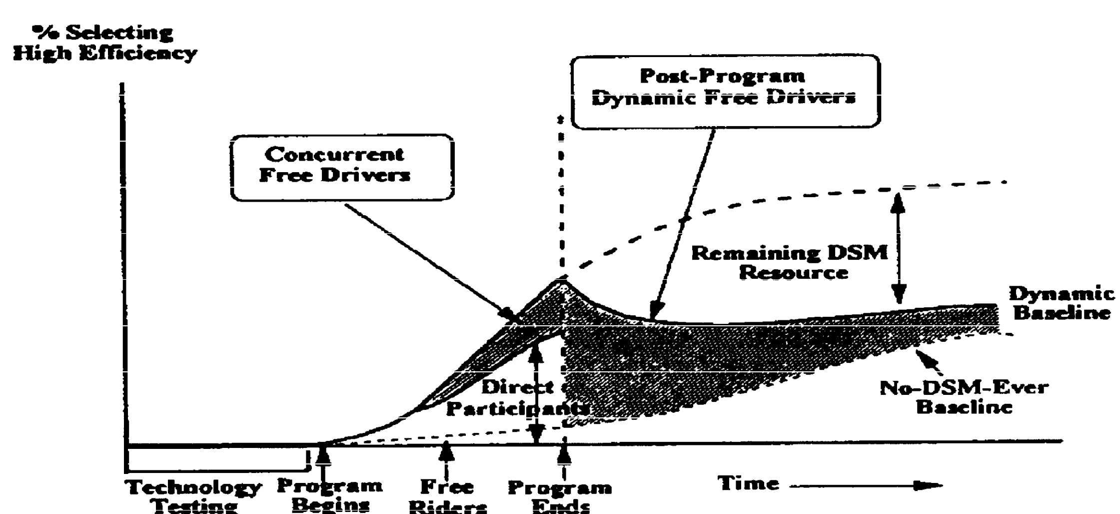

Figure 3. Depiction of Equipment Shipments for a New Technology

share is significantly steeper. In more complex frameworks, the long-run share may be impacted as well.

Through market research and shipments data, we can observe technology success to date. Given these data, evaluation results can be used to estimate free-rider and free-driver effects with respect to initial programs. For DSM planning and technology analysis, however, the interesting questions revolve around the dynamic baseline. As shown in Figure 3, the technology share without further DSM may remain quite high with elimination of DSM programs. Still, continued efforts could be warranted to impart additional momentum to the technology. The important point is that the No-Further-DSM projection should include the same dynamic baseline assumptions that are used to determine the cost effectiveness of further programs.

Example: Electronic Ballasts. The electronic ballast is one of the key DSM technologies. It is a high quality technology with some non-cost advantages, such as lower noise levels and more even light. Although there were some initial reliability and power factor problems with some brands, these problems seem to have been worked out, and most DSM program staff and lighting specialists feel that electronic ballasts can be recommended strongly to customers.

Significant sales of electronic ballasts began in the late 1980's, and sales broke 1/2 million units in 1987. With the support of early DSM programs, sales increased to 13 million by 1992, and are expected to exceed 25 million in 1993. In 1992, shortages were reported by several utilities, which caused minor problems for some programs, but the availability picture appears to have improved. During this same period, sales of competing power-factor-corrected magnetic ballasts have remained stable at about 50 million units per year (U.S. Dept. of Commerce).

There is little doubt that the rapid success of the electronic ballast was hastened by strong utility backing in the form of rebates and incentives in new construction and retrofit activity. Conversion of existing systems to electronic ballasts and T8 lamps has emerged as the centerpiece of most lighting programs in the country. In addition to utility programs, federal policy has played a role by applying an efficiency standard to magnetic ballasts, as well as through conservation campaigns, such as the EPA Green Lights program.

Analysis of the ballast market is presented in Figure 4. The top line shows actual electronic ballast shipments through 1992, an estimate for 1993 and two projections for 1994 and beyond. The projections were developed through estimation of a Bass diffusion model. Steps in the estimation process were as follows:

- First, an estimate was developed for electronic ballast shipments without early DSM programs. Initial shipments were assumed to be primarily the result of innovators trying a new technology. However by 1992, with full scale DSM programs in many major markets, it was assumed that most activity was the result of DSM programs. The typical lighting program evaluation has a free-rider estimate of about 15%, and this fraction is used to estimate the No-DSM shipments level.

- Second, based on the economics of electronic ballasts, market potential was set at about 40% of the ballast stock without utility incentives, and about 80% of the ballast stock with utility incentives that pay half of incremental cost.

- Given these data, a Bass diffusion model was estimated, using the following form:

$$Adopt_t = \left(p + q\ \frac{CumAdopt_{t-1}}{Stock_t}\right) x$$

$$\left(Potential_t - CumAdopt_{t-1}\right)$$

- The coefficient of imitation (p) was about 0.001, and the coefficient of innovation (q) was about 0.8.

Applying this model to estimates of the total ballast market gives the lower line in Figure 4. Following this line, ballast shipments would have reached about 5 million in the mid 1990's and 15 million by 2000. Beginning in the late 1990's, this line also includes ballast purchases for replacement of units purchased earlier in the period.

The middle line tracks actual shipments through 1993 and applies the diffusion model parameters beyond that point. Without further programs, this diffusion path is constructed relative to economic potential without incentive programs. The top line also applies the diffusion model parameters beyond 1993, but the diffusion path is constructed relative to economic potential with continued utility incentives.

These simple diffusion models, by construction, suggest some degree of market transformation. Because the coefficient of innovation is relatively large (.8), and because initial programs appear to have provided a strong jump-start to the technology, the program impacts live beyond the life of the initial programs. This effect is illustrated in Figure 5. By the year 2000, the cumulative market share without further programs is above 20% of the ballast stock, compared to a value below 10% had there been no programs. However, there is still significant room for further program impacts, because utility programs reduce

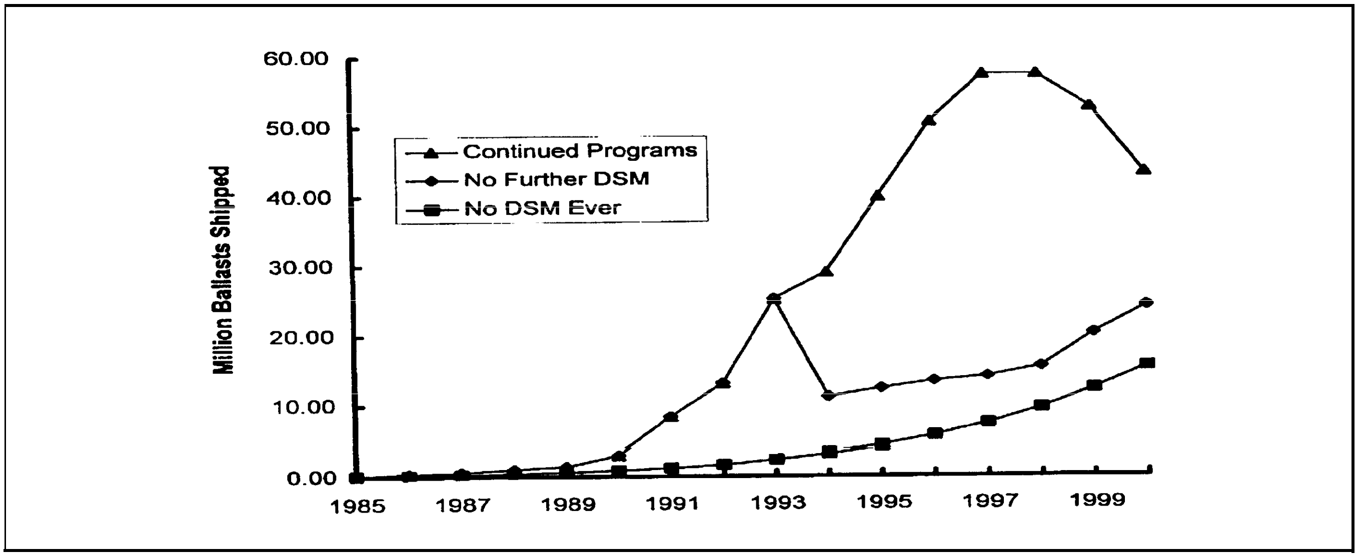

Figure 4. Electronic Ballast Shipments

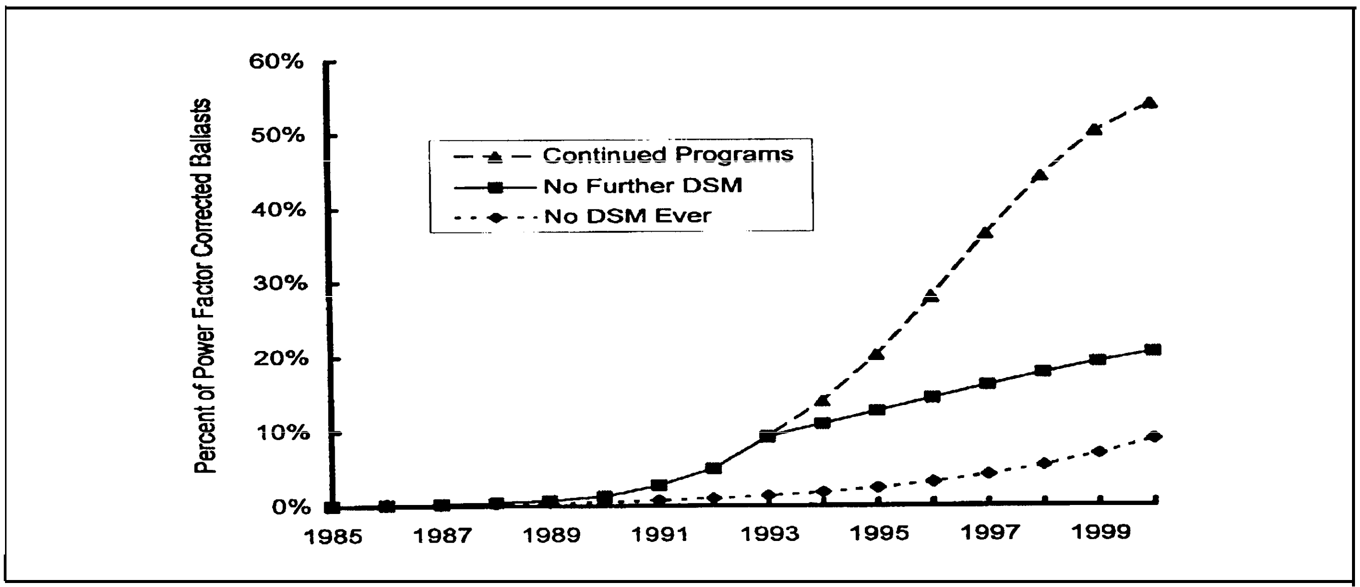

Figure 3. Electronic Ballast Market Share

typical payback rates from 4 years to 2 years, which is a significant change.

Arguably, the electronic ballast would have succeeded on its own. It is a high-quality technology that offers significant operating cost savings as well as a higher quality of light. Because of the strong role of utility programs in the early success of this technology, we will never know with certainty where this baseline diffusion profile would have been in absence of these programs. The important forward-looking issue, however, involves a comparison of the costs and benefits of continued programs relative to the dynamic baseline. Evaluation results over the next few years should provide interesting information about the location of this baseline, as utilities experiment with reductions in incentive levels and other possible exit strategies.

Conclusion

DSM programs appear to have had a significant impact on the market share for some efficient technologies. As these program impacts accumulate, utilities will increasingly face the issue of evaluating the degree of market transformation. As the above discussion suggests, if there is a dynamic spill over, there is a higher baseline for the evaluation of future programs. This higher baseline may be due to (a) improved customer awareness, (b) economics of scale, (c) altered vendor practices, or (d) enhanced technology innovation. In any case, if markets have been transformed, it is time to consider an exit strategy, unless the forward-looking economics suggest that continued incentives remain cost effective.

The two examples provided in this paper differ strongly. In the case of motors, the example program can be evaluated with respect to a well-established static baseline. Strong gains in share are clearly attributable to the program, and the fact that the high-efficiency share has remained strong, despite declining incentives, suggest a successful transformation. In the case of electronic ballasts, the evidence is less conclusive. It is clear that DSM programs have prompted adoption of this technology, but the diffusion path in absence of programs is difficult to establish with certainty.

For both technologies, the forward-looking question is the same. Regardless of the historical reason for success, the cost effectiveness of future programs depends on the new baseline, which includes transformation effects. This suggest that programs should explicitly account for the possibility of a dynamic baseline. And establishing this baseline path should be an important part of on-going evaluation efforts, especially where market transformation is a primary goal of the program.

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