

Systems-Based Portfolio Evaluation: Diagnostic Benefits and Methodological Challenges

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ABSTRACT

This paper reports on initial research conducted by the New York State Energy Research and Development Authority (NYSERDA) to understand and measure synergies among its portfolio of **New York Energy SmartSM** energy efficiency programs. Synergy can be said to exist if the total contributions of all the energy efficiency programs designed to achieve public policy goals is more than the sum of the contributions of the individual programs. Two research approaches are described. One approach focuses on managing program portfolios to yield synergies. It is argued that NYSERDA program managers need to apply a set of ten systems principles to create necessary conditions for synergy to take place within the program portfolio. A preliminary program portfolio and organization assessment suggests that these principles are being met. The second research approach focuses on measuring synergy quantitatively. Several concepts to achieve this challenging task are presented. Because the majority of the programs under study have only recently been implemented, data were not available to rigorously test for synergy. Nonetheless, in this paper, the authors identify a wide range of program activities and market transformation data in the residential energy-efficient lighting market that suggests that synergies are taking place among programs in this market sector. This paper concludes with an identification of some next steps to assessing synergy.

Introduction

Synergy is an important research topic for NYSERDA given the scope and scale of its energy efficiency program activities. It is also an important topic for the energy efficiency research community, in general, as many states, utilities and the federal government are striving to develop coordinated programs under the expectation that synergistic benefits will arise.

NYSERDA manages a portfolio of nearly 40 programs that: (1) support research and development of new energy-efficient technologies; (2) offer financial incentives, including loans and grants, to help overcome economic barriers to adoption of energy-efficient technologies; and (3) provide information to manufacturers, retailers, contractors, energy service companies (ESCOs), and energy customers about energy-efficient products and where they can be bought. These programs fall under the **New York Energy SmartSM** public benefits program, which is supported by a Statewide system benefits charge program. In the first three years of this program, the New York State Public Service Commission (PSC) identified two broad public policy goals: (1) to promote competitive markets for energy efficiency services; and (2) to provide direct benefits to electricity ratepayers, or be of clear economic or environmental benefit to the people of New York. Recently, the PSC extended

the program for another five years, doubled funding, and expanded the program's goals to include: (1) improving system-wide reliability through end-user efficiency actions; (2) reducing environmental impacts of energy production and end-use; (3) facilitating competition to benefit customers; and (4) improving energy efficiency and access to energy options for under-served customers.

The potential for synergies within the portfolio of programs appears tremendous. The challenge is to develop a framework and methodology to evaluate the existence and magnitude of these synergies. Two approaches to meeting this challenge are described in this paper. The first approach, which is discussed in the next section, focuses on the manner in which programs are managed for synergy. In other words, determining how NYSERDA manages its portfolio to maximize the likelihood that synergies among programs will arise. Ten systems conditions related to managing for synergy are presented. A preliminary program portfolio and organization assessment suggests that these conditions are appreciably being met.

The second research approach, presented in the third section, focuses on measuring synergy quantitatively. Several concepts to achieve this challenging task drawn from the technology innovation and diffusion literature are presented. Because the majority of the programs under study have only recently been implemented, data were not available to rigorously test for synergy. This measurement of synergy is illustrated through a wide range of program activities and market transformation data that suggests that synergies are taking place among programs.

Achieving Synergies Through Systems Thinking

Ten Conditions for Creating Synergies in a Portfolio of Programs

The ten conditions listed in the following text were developed under the primary assumptions that: program synergy is an organization-wide goal of NYSERDA; systems thinking is an important component in program design; and continuous learning and improvement are highly valued. The order in which the conditions are presented is important, in that meeting prior conditions is generally necessary for meeting conditions that follow with the exception that the ninth and tenth conditions are not dependent on the preceding conditions. A further assumption is that if these kinds of necessary conditions are not met, then it will only be by chance that any synergistic benefits will accrue from the program portfolio. The development of the ten conditions benefited from previous NYSERDA work on synergistic effects (DeCotis et al. 2001; Ellefsen et al. 2001) and from important concepts about organizational learning and systems thinking (Senge 1990). The conditions are as follows:

1. **Shared Vision.** Program managers must work toward a common set of clearly articulated goals, and programs are designed to help achieve the same goal(s) instead of working toward different and perhaps conflicting goals.
2. **Systems Thinking.** Program managers need to understand the fundamentals of system thinking, including positive and negative feedback loops, limiting conditions, inherent delays in some cause and effect connections, and system leverage points.

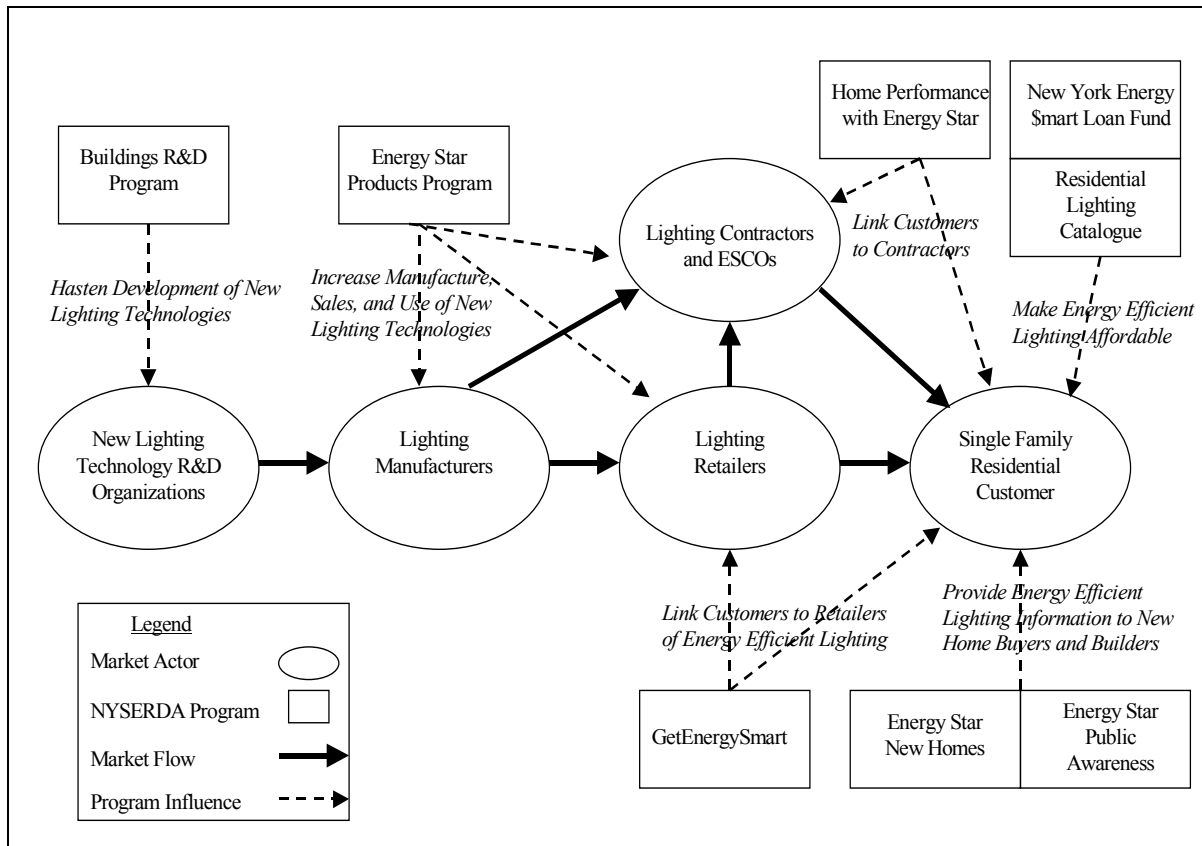
3. **Shared Understanding of Organizational Systems.** Program managers need to understand that they work within an organizational system and need to have a shared understanding about how that system works, both formally and informally.
4. **Shared Understanding of Current Market System.** Program managers need to understand the market for various energy-efficient technologies and how their programs could influence those markets.
5. **Shared Understanding of Future Market System.** Program managers must have some conceptions or beliefs about the future market system so that today's programs have more strategic synergistic potential (Schwartz 1991). Particular attention should be paid to future R&D activities and technology deployment programs, as suggested in Kim et al. (2002).
6. **Synergistic Market Transformation.** Through systems thinking and shared understandings about the current and future marketplaces and how NYSERDA operates, the portfolio of programs should target key leverage points in the market systems, including market channels and actors from researchers to wholesalers to retailers to customers in different sectors.
7. **Portfolio Diversity.** There could be uncertainties concerning understandings of existing and future market systems and about how influential and timely programs could be in transforming markets for energy-efficient technologies. This implies that the portfolio of programs must minimize the risk that a subset of programs could prove ineffectual.
8. **Synergies Recognized by Market Actors.** Market actors should benefit from having a comprehensive knowledge of all available programs. For example, it could be beneficial for contractors selling energy-efficient lighting to know and so inform their prospective clients about loans and technical assistance available to overcome barriers to the design and purchase of energy efficient lighting products.
9. **External Feedback Effectively Communicated.** NYSERDA collects information about market changes and influences of its programs (*e.g.*, through surveys). External feedback coming to any program manager needs to be seamlessly, accurately, and regularly communicated to other program managers in NYSERDA.
10. **Systems Understanding of Responses to External Feedback.** NYSERDA program managers need to react appropriately to external feedback. It is tempting to respond as quickly as possible to information coming into NYSERDA from the marketplace. In some cases, quick response could be justified. In other cases, patience could be rewarded because influences of programs already in place might not have had time to work their way through the system. Only by understanding the marketplace and how the programs relate to the system can NYSERDA program managers decide which course of action is most beneficial.

Evidence of Systems Thinking at NYSERDA

It is readily apparent that NYSERDA meets several of these necessary conditions. To begin, NYSERDA has implemented a diverse portfolio of programs that appear to map well to the current market system. Figure 1 illustrates how the portfolio of programs promotes the adoption of energy-efficient lighting technologies by single-family residential customers. The figure shows market actors (denoted by circles), programs and initiatives (denoted by rectangles) and indications (arrows) about how each influences the others. With respect to the

residential customer focus illustrated in Figure 1, there are five market actors: (1) developers of new lighting technologies, (2) manufacturers of energy-efficient lighting technologies, (3) retailers, (4) contractors, including ESCOs, and lastly, (5) single-family residential customers. Similar diagrams have also been constructed for the large commercial and industrial, small commercial, and municipal lighting markets (See Tonn 2002).

Figure 1. NYSERDA Lighting Programs Single Family Residential Focus



At least eight different **New York Energy SmartSM** programs influence the single-family residential market for energy-efficient lighting. Two programs, the **New York Energy SmartSM** Loan Fund and the Residential Lighting Catalogue, which is a component of the Residential Appliances and Lighting Program, help to make the new technologies more affordable to the customers. The Home Performance with ENERGY STAR[®] Program links customers with contractors, whereas the GetEnergySmart website links customers with retailers of energy-efficient lighting products. The ENERGY STAR[®] Products Program provides information about energy-efficient lighting products to manufacturers, retailers, contractors, and ESCOs. The ENERGY STAR[®] New Homes Program provides information to prospective home-builders about energy-efficient lighting systems and other measures. The ENERGY STAR[®] Public Awareness Program provides information to a broader range of residential customers. The Buildings R&D Program funds research that, in part, focuses on developing and demonstrating new energy-efficient lighting technologies. Thus, it can be strongly argued that the market system for residential lighting products is well understood and that through systems thinking, the portfolio of programs maps well to the market system.

It is also likely that NYSERDA program managers have a shared vision of NYSERDA's widely publicized public policy goals set out by the PSC and stated in the introduction of this paper. Additionally, it is likely that NYSERDA program managers share a common understanding of NYSERDA's internal system. This is because NYSERDA has a well-known and understood internal system for developing programs through a multi-stage planning process overseen by NYSERDA's Board of Directors, President and Project Development Management Committee (PDMC). This process has eight steps, which range from developing objectives to technical review of the proposed new project to establishing project management.

However, it is not entirely clear that program managers share an understanding of more informal processes, such as the system of informal communication about programs' performances and revisions. It is also not entirely clear that the depth of understanding of systems principles and the market system is the same for all program managers. It is also unlikely that NYSERDA has developed scenarios and other descriptions of potential future market systems related to energy-efficient technologies.

Quantitatively Assessing Synergy

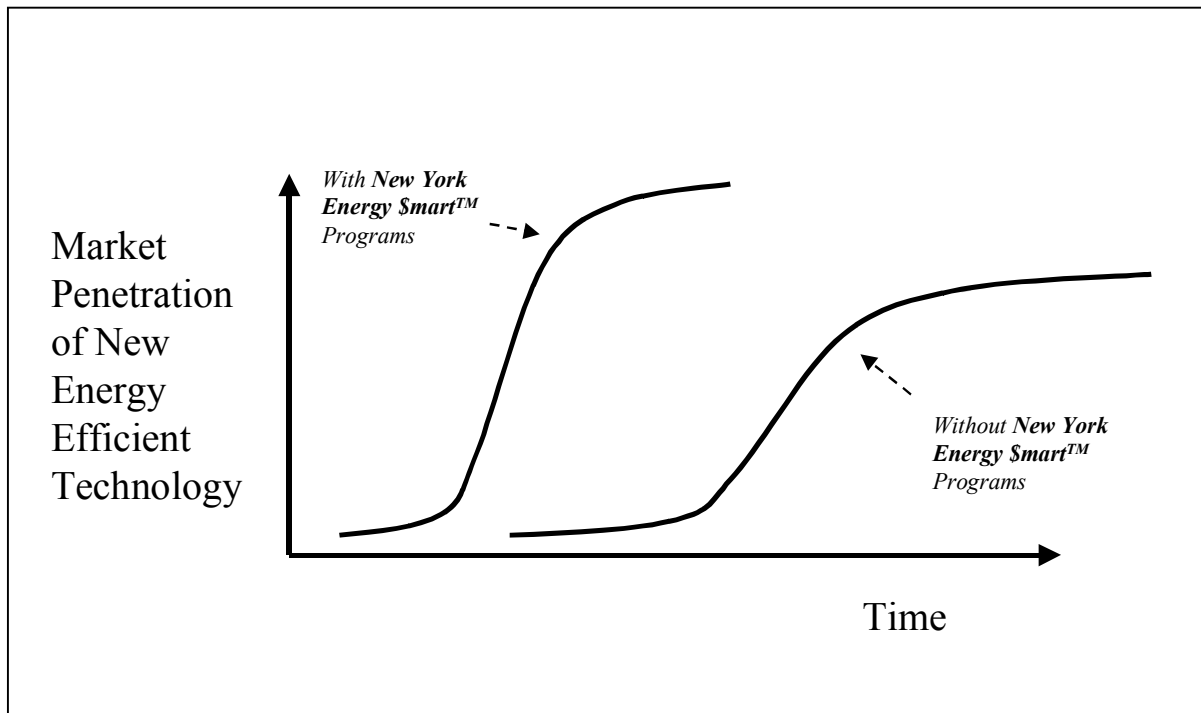
Satisfying the ten conditions presented above is expected to greatly increase the probability that synergistic benefits will accrue from the portfolio of programs. The challenge addressed in this section is how to measure synergistic effects. The initial part of this section presents three conceptual approaches to measuring synergy. The first approach compares changes in market penetration rates of NYSERDA-supported energy-efficient technologies to historical data on the market penetration rates of new technologies. The second focuses on identifying relationships amongst program outcomes that could indicate substantial levels of program synergy. The third is a statistical modeling approach for measuring synergy. This section concludes with a presentation of some preliminary data and analysis.

Measuring Synergy: Concepts

Comparison of Market Penetration Rates.

Viewed most broadly, the totality of **New York Energy SmartSM** programs should act to hasten the market penetration of energy-efficient technologies. Figure 2 presents two S-curves that depict the market diffusion process for new technologies. Market penetration is small in the early stages of a product's lifecycle, when only a few early adopters are willing to risk investing in the new, perhaps still unproven technology. Further along the continuum of time, the larger pool of potential customers recognizes the positive experiences of early adopters and market penetration rates increase more quickly. After some time, the market penetration rate then slows, as the penetration approaches a theoretical maximum, or a point of near-market saturation. A synergistic portfolio of programs is expected to move the S-curve to the left and increase its slope, or rate of adoption. The programs should collectively hasten the date when new products enter the market place, reduce the time needed until the market ramps up, and increase the maximum market penetration of energy-efficient products and services above what might otherwise be expected. These effects are shown in the hypothesized differences in the S-curves with and without **New York Energy SmartSM** programs.

Figure 2. New York Energy Smart™ Programs' Impact on Market Penetration of New Energy Efficiency Lighting Technologies



Both objective and subjective means can be used to estimate S-curves for energy-efficient technologies. Objectively, customers can be regularly surveyed about their purchases, as is already being done in the residential lighting products area. Additionally, visits can be made to retailers to inspect retail space devoted to energy-efficient products. Vendors and manufacturers can also be surveyed. If, for whatever reason, these data do not exist or are incomplete for any target technologies, then NYSERDA program managers and other knowledgeable people could be asked for their subjective estimates of the market penetration of new energy-efficient technologies, past and present (and the future, too). The quality of the subjective estimates should be fairly high since program managers have demonstrated substantial knowledge of the markets they are working to transform and would be relatively cost-efficient to collect.

A limitation of this approach is that such analysis can only suggest what the total impacts of **New York Energy SmartSM** programs on markets could be. This methodology cannot help determine the magnitude of incremental synergistic benefits. Another limitation is that this approach does not control for exogenous factors that may be impacting technology adoption rates (such as nationwide attitude changes about energy efficiency). To help control for these influences, S-curves can be developed for technologies supported by the programs and compared to historical data on these technologies and to like technologies either supported by organizations other than NYSERDA or similar technologies not being highlighted by **New York Energy SmartSM** programs. The literature contains market penetration rates for many analogous technologies (*e.g.*, see Mansfield 1995, Ausubel and Langford 1997, Chapman 1999).

NYSERDA Synergistic Program Relationships.

A second approach to assessing synergies is to focus on relationships between programs. At least four relationships can be hypothesized. One hypothesis is that changes in informational programs should result in changes in demand for NYSERDA's incentive programs. Thus, the more customers know about the benefits of energy-efficient lighting systems, the more they will demand such systems and the more likely they might be to participate in programs offering financial assistance to purchase energy those products.

A second hypothesis related to the first one is that changes in direct technical assistance to potential purchasers of energy-efficient technologies will result in increased demand for financial incentives. For example, the introduction of the ENERGY STAR® New Homes program can be hypothesized to lead to increased applications to the **New York Energy SmartSM** Loan Fund (see Figure 1).

A third hypothesis is that the more messages that customers receive about a particular energy-efficient product, the higher will be the demand for that product (DeCotis et al. 2001).

A fourth hypothesis is that the more messages customers receive about the benefits of energy efficiency in general (*e.g.*, from all NYSERDA program advertisements, brochures, and websites and indirectly through retailers, contractors, ESCOs, and word of mouth), the higher will be the likelihood that customers will adopt energy efficiency attitudes. It could even be that the impact of more messages upon an end-use customer could have non-linear impacts upon attitudinal change (*i.e.*, that the messages have a compounding impact upon the customers).

Data on program participation, exposures of customers to program information, and technical assistance provided are required to test the first two hypotheses. Additional data on market penetration rates, as discussed in the preceding sub-section, are needed to test the last two hypotheses. NYSERDA is already collecting most of the needed program data.

Statistical Modeling Approach to Measuring Synergy.

Lastly, it is possible to statistically test for synergy. The basis for this approach is simple in that the market penetration rate for energy-efficient products is related to (*i.e.*, a function of) some combination of types and activity levels of programs promoting those products. Formally, this relationship can be written as follows:

$$(1) \quad \text{MPR}_{ij} = f(X_1, X_2, X_3, \dots, X_n),$$

where MPR_{ij} stands for the market penetration rate for product or set of products i in a geographic area j (such as an area served by a particular utility), and X_i stands for the market transformation activity of a particular type of program, where there are n types of programs. The set of programs could contain the following: R&D, information to mid-stream actors, information to end-users, financial incentives to mid-stream actors, and financial incentives to end-users.

The extent of synergy among the programs can be measured by the form of the function relating these independent variables to the market penetration rate dependent variable. Generally, the function can take on these two kinds of forms:

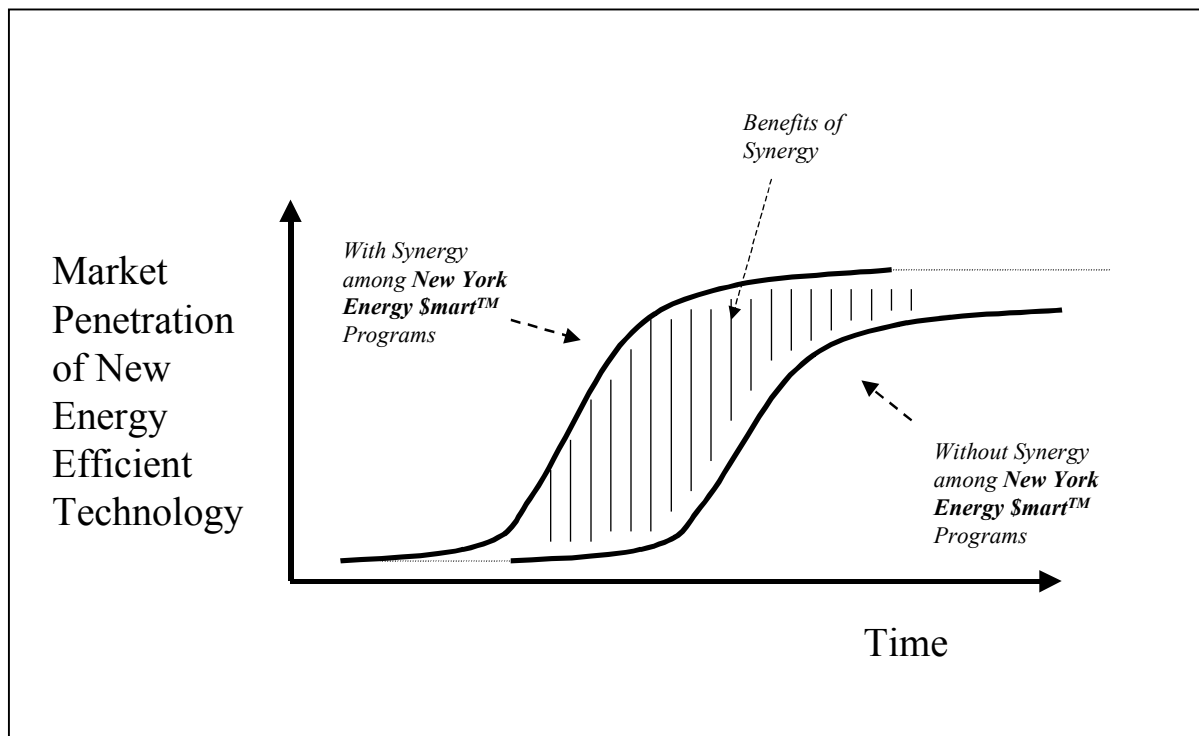
$$(2) \quad \text{MPR}_{ij} = a + b_1X_1 + b_2X_2 + b_3X_3, \dots + b_nX_n$$

$$(3) \quad \text{MPR}_{ij} = a * X_1^{b_1} * X_2^{b_2} * X_3^{b_3} , \dots * X_n^{b_n}$$

Equation (2) represents a linear model and Equation (3) represents a non-linear or multiplicative model. The first model assumes there is no synergy among the programs; each program's impact upon the market penetration rate dependent variable is independent of the other. The second model assumes there is synergy among the programs; the overall impact of the programs is greater than the sum of their parts.

Statistical techniques, such as multiple regression, could be used to estimate the coefficients of the two types of equations. Synergy could be identified in any one of three ways. First, one could assume positive synergies if the "with synergy" equations fit the data better than the "without synergy" equations. Second, if the magnitude and direction of the coefficients in the "with synergy" equations met certain pre-conceived specifications (e.g., all b_i 's ≥ 0), then synergy could be assumed. Lastly, the two types of equations could both be used to estimate market penetration rate curves, with and without synergy. As shown in Figure 3, synergy could possibly be measured by the area between the two market penetration curves.

Figure 3. Measuring Synergy among New York Energy Smart™ Programs



Implementing this approach to measure synergy is much more complicated than this brief explanation indicates. There are several challenging methodological issues that must be dealt with, which include: specifying the functional forms of the equations; developing program 'activity' measures; choosing appropriate statistical techniques; and dealing with the influences of varying levels of program activities over time.

Graphically Illustrating Synergy

Rigorous statistical analyses of data to identify potential synergies, as described above, were not possible simply because enough data were not available. Many of the most important **New York Energy SmartSM** programs are, at most, only a few years old. This is not enough time to assess with confidence impact of programs on market penetration rates (*i.e.*, S-curves) for specific energy efficient technologies. It is expected that rigorous statistical analysis will be possible a few years hence.

Instead, graphical methods were employed to explore the potential existence of synergies among programs. The basic idea is to plot data and describe activities of programs that could be influencing each other in synergistic manners on the same sheet of paper. This is necessary because synergies among programs can only be visually detected if all the pertinent data appear together in some way. Synergies could be visually detected when programmatic activity levels appear to trend together in a mutually reinforcing and logical fashion.

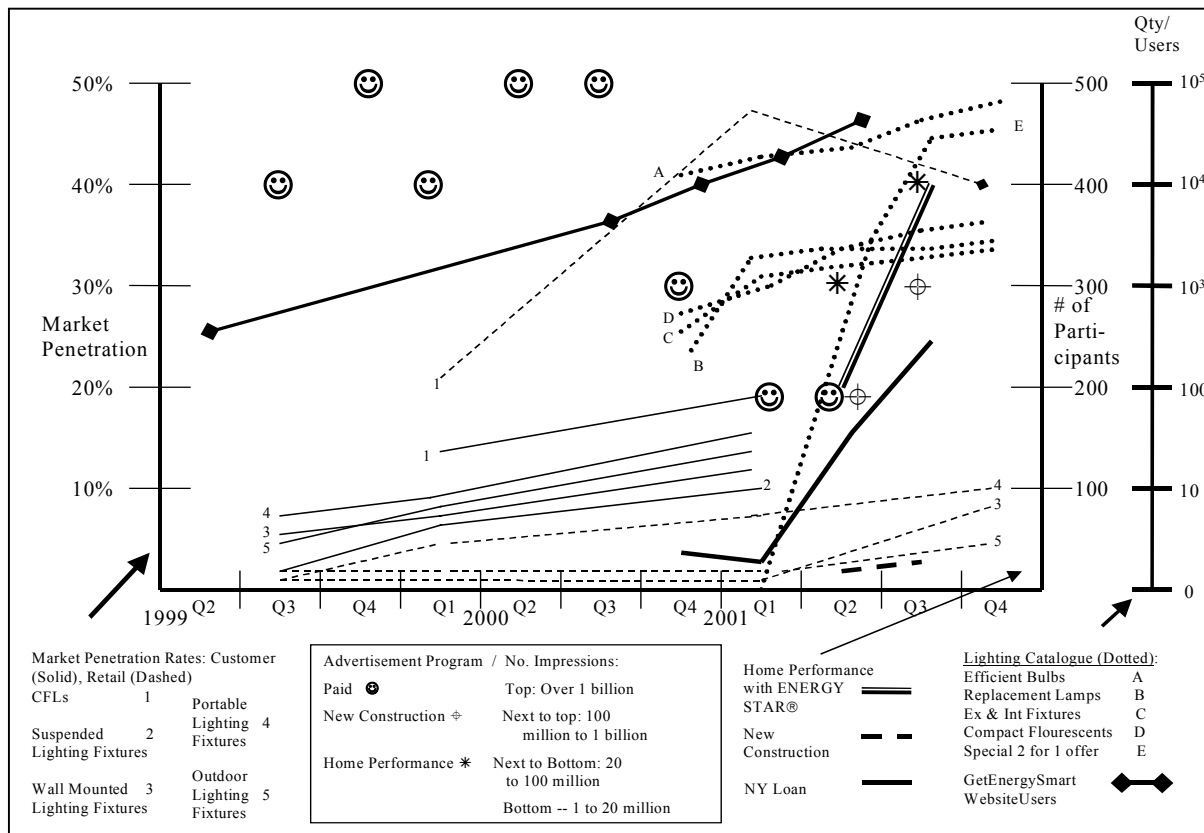
The inspiration for the graphic depicted in Figure 4 is an award winning, three book series on data and information illustration by Edward Tufte (1983, 1990, 1997). In these books, Tufte demonstrates how to use color, shapes, icons, and spatial relationships among images to represent multi-dimensional data and information within the two-dimensional limitations of the printed page. Figure 4 was originally developed in color and has been adapted to the black and white requirements of this publication.

Figure 4 illustrates Statewide **New York Energy SmartSM** programs that have residential components and residential customer purchases of energy-efficient lighting products. Ten data items, described in the left-hand side of the legend, pertain to market penetration rates of five representative energy efficient lighting technologies. Five data items relate to customer purchases as determined from household surveys (thin solid lines). The other five data items relate to percentage of retail shelf space for each technology, as determined from retail outlet surveys (thin dashed lines). Three data items describe the number of impressions in the residential sector generated by paid advertising and more specific advertising related to two programs, New Construction and Home Performance with Energy Star[®]. Data that describe activities in these two programs, along with a third program, the **New York Energy SmartSM** Loan Program, are graphed using an assortment of thicker black lines. Five types of purchases of lighting products from the Residential Lighting Catalogue, see right-hand side of the legend, are graphed (dotted lines). Lastly, the number of users of the GetEnergySmart.org website are depicted by the line with diamonds. The graph runs from the 1st quarter of 1999 to the 4th quarter of 2001.

This graph suggests the existence of synergies among programs. Almost all of the data items are trending upward together. Most notable are the increases in the number of participants in the Home Performance with Energy Star[®] and **New York Energy SmartSM** Loan Programs, users of the GetEnergySmart.org website and purchases from the Residential Lighting Catalogue. Market penetration rates, as measured by residential customer purchases, are also trending up, although the fact that these data do not yet extend past the first quarter of 2001 constrains our ability to fully assess potential synergies. Retail shelf space market penetration rates also appear to be trending up, although the magnitude of the rates is still relatively low. The relationship of these trends in purchases and program activity also appear to be somewhat correlated with impressions, which is to be expected.

The synergy story that Figure 4 suggests is one where residential customers are exposed to multiple messages about energy efficiency, are increasingly seeking out information about energy efficiency purchases, are participating in financial incentive programs as necessary, and are increasingly purchasing energy-efficient lighting products. Following the traditional theory of market transformation, it can be expected that at some point in time the low levels of market penetration rates for energy-efficient lighting products will increase rather rapidly over a short period of time and then even out thereafter (*i.e.*, producing an S-curve). It is unclear from Figure 4 exactly when the rapid increase will take place, although the rapid rise in the number of purchases of some residential lighting products suggests that the rise may come sooner than later. Program participation, while increasing, is still relatively low in numbers Statewide, in part due to the newness of the programs. It is also unclear if and when participation levels will rise.

Figure 4. Residential Program Activities: Entire State



Next Steps

Synergy is a quixotic concept. It is easy to conceptualize but difficult to measure. The evidence is strong that the NYSERDA program managers have implemented a portfolio of programs that can potentially benefit from synergy. While it is too early to measure synergy quantitatively, an illustration suggests that synergies may be taking place in the residential market for energy efficiency lighting products. It is assumed that after the passage of time, more data will be available to measure synergy.

Additionally, there are several other steps for NYSERDA to consider in assessing synergy created by the **New York Energy SmartSM** program portfolio. More and better market penetration data are needed in every sector for the most important energy-efficient technologies. Currently, the only available market penetration data are in the residential sector. Existing databases can be mined and new surveys could be conducted to reveal whether program participants are participating in multiple programs.

It is recommended that a more in-depth assessment be conducted with NYSERDA program managers to ascertain their understanding of systems principles, their own organization, and the market system. They could also be asked how external feedback is communicated throughout the organization and how they decide between quick response versus a more patient response to various types and levels of external feedback. It is also recommended that they be engaged in a scenario-building exercise to develop a shared understanding of future market systems. Continuous monitoring of how understandable NYSERDA's programs are to market actors is also recommended and has been taking place to some extent.

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