

## **R&D Programs in Support of Market Transformation: An Approach to Evaluation**

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### **ABSTRACT**

The **New York Energy Smart<sup>sm</sup>** program, administered by the New York State Energy Research and Development Authority (NYSERDA), and funded through a non-by-passable electric system benefits charge, offers a diverse portfolio of programs. Collectively, the **New York Energy Smart<sup>sm</sup>** program is designed to achieve a number of broad public policy goals including developing self-sustaining markets and demand for energy efficiency products and services. In addition to various energy efficiency programs, the **New York Energy Smart<sup>sm</sup>** program supports activities more traditionally defined as research and development (R&D). Whereas the evaluation of market development programs is centered on market indicators such as increased awareness, market share, and infrastructure development, evaluation of R&D programs, if conducted at all, is usually project specific and seldom linked to market outcomes. This paper suggests a framework for linking R&D to market development, showing how increasing the flow of information between R&D and market deployment activities can accelerate the achievement of market development goals. Examples are provided to illustrate the interactions among the various stages on the path to market transformation, and to present a model for R&D evaluation that stresses its contribution to market development and product deployment.

### **Introduction**

Market transformation is a process whereby energy efficiency innovations are introduced to the marketplace and over time penetrates a large portion of the eligible market (Geller & Nadel, 1994). Like R&D outcomes, a long time is required before outcomes from market transformation programs can be measured. However, whereas market transformation activities emphasize education and development of markets, R&D activities are usually product-focused, emphasizing the creation of new products or improvements to existing products and processes to better serve customers' needs. Consequently, R&D efforts are based on a "market push" strategy for bringing new innovations to markets. The market transformation approach relies on a "pull" strategy by using information and outreach to demonstrate the benefits of greater efficiency, creating consumer demand for high-efficiency products. It also uses a "push" strategy that is directed at mid-stream actors.

Another difference between the market transformation and R&D perspectives is the evaluation approach. Evaluation of market transformation efforts begins with an identified sequence of events called a program logic. Outcomes are evaluated against these logical

events to measure progress. R&D projects are evaluated individually and without regard to its relationship with other projects, other technologies, or markets. These similarities and differences between R&D and market transformation perspectives are shown in Table 1.

**Table 1. Similarities and Differences Between Market Transformation and R&D Programs**

	Market Transformation	R&D
Time-frame	Both have a longer-term perspective compared to more traditional energy efficiency programs.	
Goals	Development of market infrastructures; expanded purchase of targeted product or service.	Product innovations to improve efficiency, reduce costs, expand applications, and create new products and opportunities.
Primary Program Features	Provide information and financial assistance for product purchases.	Provide financial and technical assistance for product development.
Primary Market Strategy	Both push and pull.	Push.
Primary Evaluation Approach	Program logic.	Project specific.

## Stages of Market Transformation

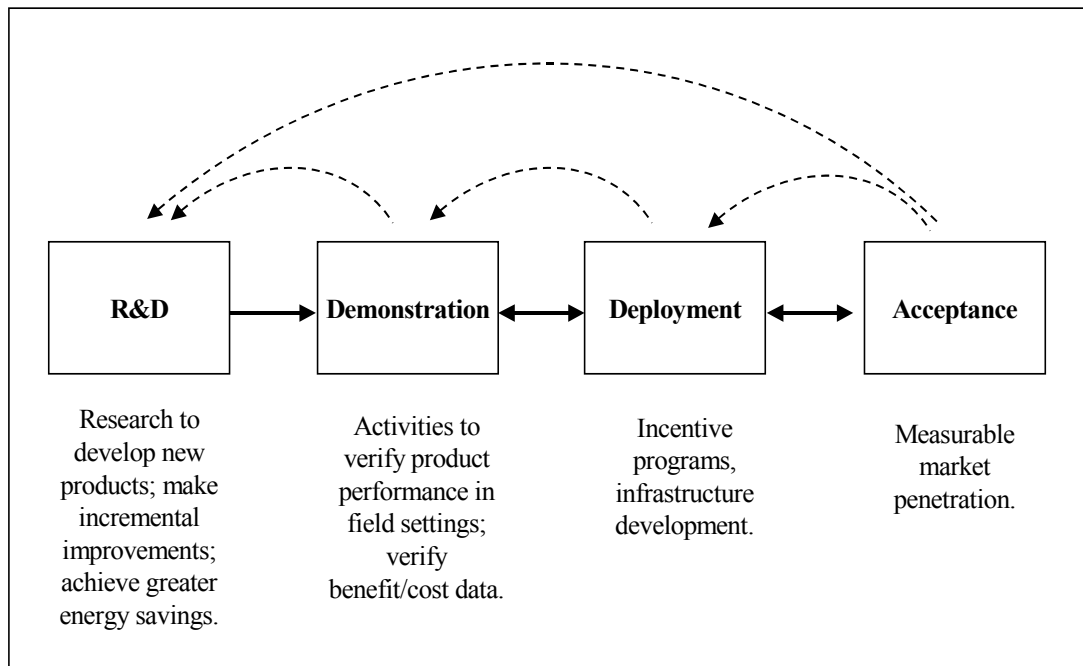
To describe the role of R&D in market transformation, Figure 1 depicts R&D as a very first step on the path toward market transformation. The process itself consists of four stages: (1) R&D, (2) demonstration, 3) deployment, and (4) acceptance. R&D activities include, but are not limited to, incremental improvements made to existing products, enhancements to manufacturing processes to reduce the cost of manufacturing, or development of radical approaches to delivering energy savings. Demonstration activities include field verification of product performance and verification of benefits afforded by the product. The deployment stage is identified by a product’s introduction into a wider market. At this stage, government intervention can be helpful in accelerating adoption of commercially-available but under-used products. The acceptance stage occurs when products become widely used and eventually become standard practice. At this point, markets have been successfully transformed from earlier levels of market activity and behavior.<sup>1</sup>

At each stage, barriers addressed will differ, as will objectives and success indicators. Examples of barriers and success indicators for each stage are shown in Table 2. At the product development stage, the primary barrier is technological. An important evaluation criteria for projects at this stage might be whether a product was improved and the degree of improvement. At the demonstration stage, regulatory barriers may exist, as in the case of interconnection of distributed generation technologies to the electric grid. Interconnection is also an example of a standardization barrier. For example, standardized interconnection

<sup>1</sup> Although several indicators would be used to determine whether markets had been successfully transformed, this example is simplified to use only wide acceptance as a critical indication.

procedures would decrease installation costs as well as risk. Lack of information about product performance and reliability are also barriers at this stage. Evaluation criteria for projects aimed at this stage would include impact on regulatory changes, impact on development of standards, documentation of performance data, and dissemination of information. At the deployment stage, institutional, infrastructure, and awareness barriers are

**Figure 1. Stages on the Path to Market Transformation**



**Table 2. Illustrative Barriers and Success Indicators at Different Product Stages**

Product Stage	Barriers	Success Indicators
Development	Technological	Product or process improvements.
Demonstration	Regulatory, Standardization, Information.	Changes in regulation, development of standards, cost-benefit data, information dissemination.
Deployment	Institutional, Infrastructure, Awareness,	Units deployed, availability of supply.
Acceptance		Market share relative to alternative, associated energy savings.

further targeted. Examples of institutional barriers include resistance to change on the part of energy managers, or risk avoidance behavior. Example of an infrastructure barrier is the lack of energy efficiency or renewable energy service providers. Evaluation indicators for deployment activities would be customers that have participated, energy savings, and availability of supply. At the acceptance stage, evaluation criteria include market share increases and the associated energy savings.

The perspective of including R&D activities as an initial step or stage on the path toward market transformation provides several benefits. Even when markets for certain products are fully developed or transformed, there is still a role for R&D in improving a product to reap additional benefits. Thus, product development, demonstration, and deployment activities could occur simultaneously for a particular technology. For example, NYSERDA provides incentives for T8s and electronic ballasts. Concurrently, NYSERDA also funded a fluorescent lighting demonstration project which examined the validity of manufacturers' claims regarding lamp lives and lumens per watt. The results were made available on the internet. The next step in efficient lighting activities will focus more on design practices to enhance the application of current technologies. To aid in this stage of transformation, NYSERDA asked lighting R&D experts to develop a set of "lighting quality metrics" that would define an effective, energy-efficient lighting system. It was anticipated that once these metrics were established, designers would have objective standards for determining whether their designs were energy-efficient, aesthetically pleasing, and would enhance the visual capability of people using the space. Before these lighting quality factors were finalized, several demonstration projects were undertaken to test and evaluate the feasibility of applying the standards. NYSERDA's Small Commercial Lighting Program then began to deploy the lighting quality standards by offering incentives to electrical contractors and lighting designers who complete projects that meet the standards. The role of R&D in this process was critical because although the technologies were generally accepted and understood by end users, the quality factors were not.

The simultaneous attention to product development, demonstration, and deployment provides synergies that can speed up the market transformation effort (DeCotis, Tonn, Pakenas, & Eisenberg, 2002). For example, early deployment of combined heat and power (CHP) technologies can lead to early identification of technological issues or other barriers and point out the need for additional R&D activities. Examples of technologies for which simultaneous activities are occurring at NYSERDA are shown in Table 3. The checkmarks

**Table 3. Examples of Multiple Activities Within NYSERDA**

Technology	Development Activity	Demonstration Activities	Deployment Activities
CHP	√	√	√
Direct Load Control	√	√	
Price-Responsive Load	√	√	
Bio-fuels	√	√	√ (Panned)
Anaerobic Digesters	√	√	
Fuel Cells	√	√	
Microturbines	√	√	
Superconductivity	√	√ (Planned)	
Energy storage	√	√	
Photovoltaics	√	√	√
Wind		√	√
Alternative Fuel Vehicles	√	√	√
Submetering		√	√
Daylighting		√	√
Lighting Fixtures/controls	√	√	√

indicate areas in which NYSERDA is currently funding projects. Although product development, demonstration, and deployment activities can occur simultaneously, it is expected that there will be an inverse relationship between the level of R&D and deployment activities for a particular technology, because the role of R&D decreases gradually as deployment activities increase. This is the case of submetering and wind technologies which are at the commercialization stage. For technologies that still have extensive barriers that need to be overcome, emphasis is currently on the development end of the continuum with deployment activities planned for the future. This is the case currently for bio-fuels and superconductivity.

## **Examples of Integration Between R&D and Deployment**

This section presents additional examples of integrated R&D, demonstration, and deployment activities. The following technologies are illustrated: combined heat and power (CHP), electricity submetering, and customer-sited wind and photovoltaic systems.

### **Distributed Generation/Combined Heat and Power**

Distributed generation (DG) is any small-scale generation technology that provides electric power at a site closer to customers than central station generation. When heat is recovered as part of the power generation process, *i.e.*, cogeneration or combined heat and power (CHP), DG can provide the consumer with a more energy-efficient and reliable energy supply option at prices competitive with the grid while reducing emissions. The DG/CHP systems can reach 80% fuel-use efficiency and can significantly reduce NO<sub>x</sub> and other air pollutant emissions. DG technologies and CHP applications are in varying stages of development and many uncertainties remain to be addressed before becoming economically and commercially viable. Some barriers and success indicators for DG/CHP are shown in Table 4. These barriers are being addressed by a combination of product development, demonstration, and deployment activities.

An example of a demonstration project supporting DG/CHP is the performance and emissions testing of CHP systems at five project sites. These sites are demonstrating the emissions performance for a wide range of CHP applications including micro-turbines fueled by anaerobic digester gas, residential fuel cells, a new previously untested micro-turbine product in a CHP installation, and an integrated micro-turbine in a power/heat & cooling application. Timely and accurate data will guide NYSERDA's programs and will be a valuable tool in assisting the New York State Department of Environmental Conservation in its development of emissions standards for DG systems. Future demonstrations will need to focus on identification of applications where electricity demand and thermal load matches equipment performance. This matching is likely to be developed sector by sector, *i.e.*, supermarkets, restaurants, etc.

In the past, R&D solicitations for DG/CHP offered funding for product development and demonstrations, as well as feasibility studies for both types of projects. As a result of early successes, funding for DG/CHP feasibility studies will now be offered through one of NYSERDA's deployment programs. This solicitation is likely to result in projects that apply CHP equipment that is readily available and has been demonstrated to be effective for specific applications.

**Table 4. Some Barriers and Success Indicators for DG/CHP**

Barriers	NYSERDA Activities that Address Barrier	Success Indicators
Grid stability, safety, power quality	<p>Demonstration of successful interconnections.</p> <p>Support the Public Service Commission’s efforts to expand Standard Interconnection Requirements (SIR) to include systems larger than 300 kVA.</p>	<p>Number of successfully interconnected systems.</p>
Environmental permitting and local siting issues	<p>Streamlining of permitting process.</p> <p>Emissions verification testing and development of database to document emissions of installed CHP systems.</p>	<p>Successful development and adoption of the permitting process by 2004.</p> <p>Emissions standards that are rational and easy to implement.</p>
Economic risk	<p>Matching of areas with high electricity costs, high electricity demand, and high coincident thermal load, thereby improving the economics of the CHP system.</p> <p>Cost-sharing of CHP demonstration installations.</p> <p>Cost-sharing of CHP feasibility studies for commercially-available CHP technologies.</p> <p>Development of systems with higher efficiency.</p>	<p>Number of sites that provide a good match and have installed CHP.</p> <p>Number of cost-shared systems installed.</p> <p>Number of cost-shared feasibility studies.</p> <p>Number of installations resulting from feasibility studies.</p> <p>Increase in efficiency.</p>
Stand-by charges	<p>Test and document CHP system reliability to assess need for stand-by power.</p>	<p>Lower stand-by charges.</p>
Low Awareness	<p>Cost-sharing of CHP demonstration installations.</p> <p>Cost-sharing of CHP feasibility studies for commercially-available CHP technologies.</p> <p>Open-houses at sites with installed systems; conference presentation by contractors that were awarded funding; web-accessible run-time data of installed systems.</p>	<p>Number of respondents to solicitations.</p> <p>Number of CHP systems installed.</p> <p>Market penetration of CHP systems.</p> <p>Availability of CHP vendors.</p>

## **Electricity Submetering in Multifamily Buildings**

Submetering is the measurement and billing of electricity use in individual apartment units in a master-metered (only one meter for the entire building) multifamily building. The installation of advanced master and submetering technologies provides multifamily building owners with detailed load profile information which can facilitate their participation in demand-responsive pricing programs.

A brief list of barriers to submetering in multifamily buildings is provided in Table 5. NYSERDA's R&D group has been addressing various technological, institutional, and awareness barriers to submetering for 20 years. Under NYSERDA's Demonstration of New Submetering Technology project in the mid 1980s, several buildings were equipped with powerline carrier (PLC) technologies. PLC uses existing building wiring for data communications between apartment submeters and the building's central station microprocessor/computer. PLC eliminated the need for expensive building rewiring and addresses aesthetic concerns as well. These projects successfully demonstrated that the payback period for submetering could be cut roughly in half through the use of PLC.

In 1996, NYSERDA funded the publication of a report entitled "Facilitating Submetering Implementation" (NYSERDA 1996) which addressed many institutional and regulatory barriers to submetering. Among other things, the authors of the report recommended the repeal of the Public Service Commission (PSC) requirement for a vote of a majority of shareholders to adopt submetering (for coops and condos), the adoption of a uniform billing dispute resolution mechanism, and recommended that submetering be treated as a major capital investment, allowing it to be eligible for the energy efficiency investment tax credit.

Between 1987 to 1997, NYSERDA co-funded a project to install approximately 3,000 submeters in apartment units under a project administered through Consolidated Edison Company of New York. As regulatory and technical hurdles became less burdensome, it became time to focus on ways to raise awareness in the multifamily community about the benefits of submetering. One of the ways in which this was done was through a series of workshops for various housing organizations. These workshops focused on the new technologies and procedural changes that had been realized. In addition, a website entitled [submeteronline.com](http://submeteronline.com) was created to share the collective knowledge of procedural, technical, and economic issues related to submetering. The site receives approximately 5,000 "hits" per month.

These awareness-building activities were extremely successful and owners of dozens of buildings expressed an interest in learning more about whether it made sense for their facilities to implement submetering. As a result, the Engineering Services for Submetering in Multifamily Housing Program was started in 1997. Under this program, building owners receive a technical and economic feasibility study. Interested building owners can also obtain consultant support for the regulatory approval process and for soliciting and selecting bids from contractors. Over 600 buildings, representing over 54,000 units, are enlisted in this program.

Although the regulatory and technological accomplishments succeeded in generating significant interest, feedback from various buildings made it clear that additional financial incentives were still needed to make submetering more attractive. Therefore, the Comprehensive Energy Management deployment program was created within NYSERDA's

Residential Energy Affordability Program. This program was created to provide incentives to building owners to install advanced meters (including submeters) in both multifamily and 1-4 family dwellings. The short term goal of the program is to install meters in 3,000 multifamily units and 300 in smaller residences.

In the case of submetering, the relationship between R&D and deployment has been generally sequential. In the 1980's, NYSERDA's R&D group focused on addressing technological and institutional barriers. Once these barriers were largely removed, the submetering focus shifted to deployment. However, as New York's wholesale markets continue to become more competitive, an opportunity now exists for owners of submetered multifamily buildings to benefit from various demand response mechanism such as Real-time Pricing (RTP) and Time-of-Use (TOU) rates. A joint R&D/deployment solicitation, scheduled to be released in 2002, will address these opportunities. The projects from this solicitation will further the goal of enabling building owners to use the data from their meters to attract an energy service company (ESCO) that will provide energy efficiency services, cheaper electricity, and innovative rate plans, including price-responsive load management opportunities that reward facilities for using electricity during off-peak periods.

**Table 5. Some Barriers and Success Indicator for Submetering**

<b>Barriers</b>	<b>NYSERDA Activities that Address Barrier</b>	<b>Success Indicators</b>
Economic and technical hurdles	Developed system to monitor power usage using power line control technology, reducing implementation costs of submetering.  Supported research to extend energy-related investment tax credit to submetering projects.	Reduced implementation cost.  Success in changing tax credit legislation.
Institutional barriers such as billing disputes.	Working with the PSC and communities to develop and institute procedures.  Dissemination of procedural information.	Removal of institutional barriers.
Low awareness	Feasibility studies to assess economics.  Education, workshops, case studies, web site, publications.  Financial incentives to increase implementation	Number of customers signing up for incentives.

### **Customer-Sited Photovoltaics and Wind Electricity Generation**

Some barriers and success indicator for PV and wind are presented in Table 6. As with DG/CHP, interconnection has been and continues to be a major barrier for customer-sited photovoltaics (PV) and wind. NYSERDA worked with the PSC to develop standard interconnection requirements for systems less than 300 kVA connected to a radial distribution line. Another barrier is the limited number of qualified technicians and installers. In 1999, there were less than 10 New York companies capable of marketing and installing PV systems. Low degree of awareness also continues to be a barrier. In 1999, there were less than 15 non-residential PV installations totaling less than 200 kW. NYSERDA's R&D group is co-funding demonstration PV installations on 11 commercial and institutional buildings throughout the State. One criteria in the selection of these

building were high-visibility and potential impact on awareness. The nameplate capacity of the systems range from 40 to 260 kW.

In addition to R&D projects, financial incentives for PV are being provided through NYSERDA's deployment programs. Through the **New York Energy Smart<sup>sm</sup>** New Construction program, commercial/industrial customers are eligible to receive financial incentives to reduce the cost of PV installation. The **New York Energy Smart<sup>sm</sup>** Loan Fund program provides low-cost financing to residential and C/I building owners for PV installations.

An example of research in the PV area is a recent project that demonstrated that PV generation coincides by approximately 95% with summer peak demand in the New York City area. Research activities for customer-sited wind energy include a project to develop a wind map of New York State showing areas with high wind resources.

**Table 6. Barriers to Customer-Sited PV and Wind**

<b>Barriers</b>	<b>NYSERDA Activities that Address Barrier</b>	<b>Success Indicators</b>
Interconnection	NYSERDA worked with the New York State Public Service Commission to develop standard interconnect requirements for distributed generation and type testing protocols were validated.	Completed Standard Interconnection Requirements.
Implementation costs	Creation of a Wind Map showing wind availability, reducing need for customers to conduct site-specific studies.	Completed Wind Map.
Network of Suppliers	Establishing a qualified network of installers and maintenance workers by providing funding to support New York-based small businesses engaged in renewable energy systems.  Funding PV and Wind projects to increase experience base.  Developing a training and certification program for installers.	Number of qualified installers.
Performance risk	Wind map of New York State that verifies resource availability.  Demonstrations of wind and PV installation for various sectors.  Increase consumer confidence in on-site renewable energy technologies by disseminating credible information.	Public acceptance of technology as reliable.
Awareness	Develop marketing program to increase demand for green power and customer-sited generation.  Provide incentives to buy down the cost of on-site renewable energy technologies such as wind and PV, particularly in high-visibility sites.	Increased awareness and favorable perceptions of on-site renewable generation.

## Conclusion

R&D activities can play a critical role in the market transformation of high efficiency products. NYSERDA is attempting to leverage its R&D activities to accelerate the widespread adoption of energy-efficient products. This paper described an iterative process that takes into consideration product innovation and proximity to market transformation. By establishing a process-oriented framework that identifies the logical interaction among activities and the expected sequence of events, progress information may be more readily accessible to both evaluators and project staff.

## References

- DeCotis, P. Tonn, B., Pakenas, L. and Eisenberg, J. 2002. "Systems-Based Portfolio Evaluation: Diagnostic Benefits and Methodological Challenges." In *Proceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, D.C.: American Council for an Energy-Efficient Economy.
- Geller, H. & Nadel, S. 1994. *Market Transformation Strategies to Promote End-Use Efficiency*. American Council for an Energy-Efficient Economy. Washington D.C. Research Report #E941.
- New York State Energy Research & Development Authority (NYSERDA). 1996. *Facilitating Submetering Implementation*. Report 96-7.
- New York State Energy Research & Development Authority (NYSERDA). 1997. *Residential Electrical Submetering Manual*.