Advanced Buildings Technology Development: Program Theory Logic Model

Final Report

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Introduction

The System Benefits Charge (SBC) Plan funds public policy initiatives not expected to be adequately addressed by New York's competitive electricity markets, including energy programs targeting efficiency measures, research and development, and the low-income sector. The New York Public Service Commission (PSC) issued the Order Continuing System Benefits Charge and Approving the Operating Plan for a Technology and Market Development (T&MD) Portfolio of System Benefits Charge Funded Programs (The Order) on October 24, 2011. The Order approved the T&MD portfolio proposed by the New York State Energy Research and Development Authority (NYSERDA) for the five-year period of January 1, 2012 through December 31, 2016, and allocated a total budget in excess of $33 million for the Advanced Buildings Technology Development program. The purpose of this document is to present the overarching logic model for the Advanced Buildings Technology Development program. This document's organization is as follows:

1. **Problems/Issues and Stakeholders (Context):** Describes the problem(s) the program is attempting to solve, or issues it will address, and the regulatory and stakeholder environments (context) within which the program is working.

2. **Program Objectives:** Describes, at a high level, the program's ultimate purpose, and targets.

3. **Program Resources:** Identifies the funding, workforce, partnership, and other resources the program is providing.

4. **Program Activities:** Describes the program's various research, product development, demonstration and commercialization progress, support activities.

5. **Program Outputs:** Describes the anticipated immediate results associated with program activities.

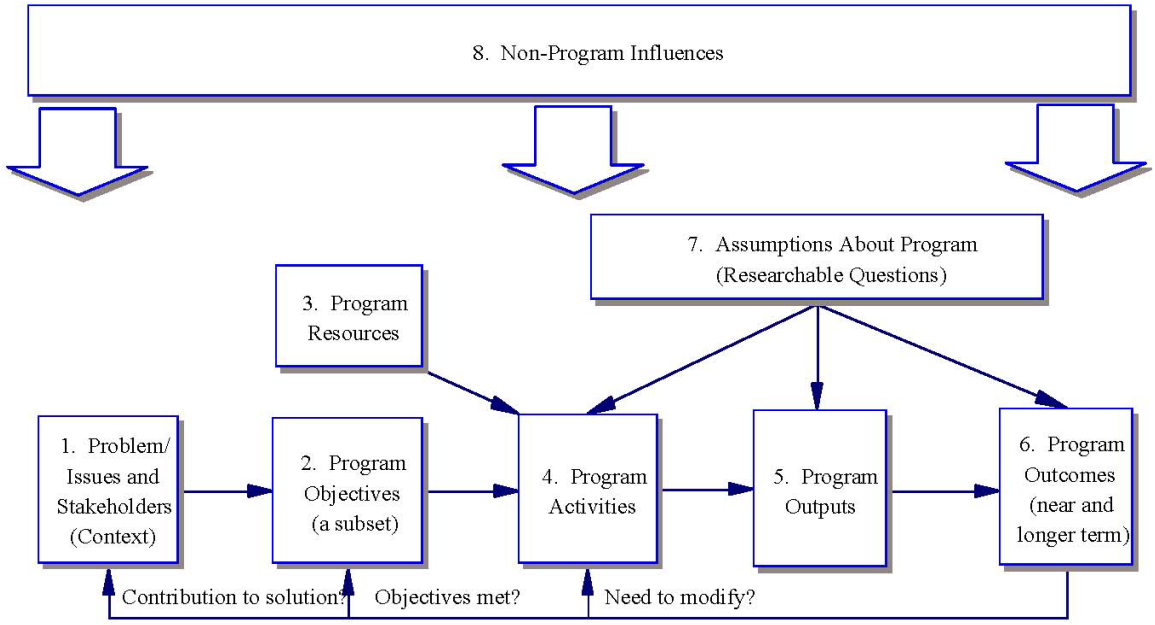
6. **Program Outcomes and Logic Diagram:** Describes expected achievements in the near, intermediate and longer-term.

7. **Assumptions about Strategies:** Describes assumptions about how program activities and outputs will lead to the desired near, intermediate, and longer-term outcomes.

8. **Non-Program Influence on Outcomes:** Describes factors outside the program that may drive or constrain the achievement of outcomes.

Figure I-1 details the relationship between these eight items. The number indicates the section in which each item appears in this report.

Figure I-1: Program Design Template



1 Problems/Issues and Stakeholders (Context)

The Technology Development Program is a component of the Advanced Buildings Initiative under the Technology and Market Development Program (T&MD). The goals of the Advanced Buildings Initiative are to promote the adoption of underutilized technologies and assist in the development of new and emerging technologies. The Advanced Buildings Initiative is part of NYSERDA's strategy to reduce the challenges that affect the development and increased market acceptance of high-performance, high-efficiency building technologies, and practices in New York State. This Initiative seeks to improve building performance, by reducing the energy use of buildings, reducing environmental impacts from buildings, improving buildings' resilience to adverse conditions, and increasing grid reliability. It also seeks to strengthen relationships among stakeholders to build a stronger energy efficiency market in New York State.

There are three subinitiatives of the Advanced Buildings Initiative: 1) Emerging Technologies/Accelerated Commercialization (ETAC), 2) Technology Development, and 3) Enabling Demand Response and Load Management. The major difference between the Technology Development program and ETAC is that Technology Development focuses on the technology/supply, and ETAC focuses on the market/demand. The ETAC program focuses on accelerating adoption of technologies that already are commercialized; they are in production and have distribution channels, but are not yet in widespread use. The Technology Development program focuses on accelerating the development of new and improved pre-commercial technologies. These technologies (or products, processes, services, or measures) may be in the initial prototype stage or nearer to commercialization with remaining needs before launch such as redesign or integration with complementary systems or protocols. Such integration is the focus of one element of the Technology Development program—an Advanced Buildings Consortium (ABC)—that will further research and technology development (R&D) in thematic technology areas. The consortium approach will help accelerate the introduction and adoption of integrated new technologies by involving stakeholders with multiple perspectives and roles starting with the design of a technology. The objective of the Enabling Demand Response and Load Management effort is to develop a large capacity of smart-grid-ready, demand-side resources at various end-use customer sites throughout the State.

Program staff understands the needs and resources of the other programs during the planning stage; program staff understands that NYSERDA programs can be resources for each other given their common goal of moving new technologies toward utilization and realizing the benefits from that utilization. Some technologies supported by the Advanced Buildings Technology Development program will enter the market without further incentive programs. Other supported technologies will enter a deployment program, such as the Energy Efficiency Portfolio Standard (EEPS) Program to support further adoption. In both cases, the new technologies offer continued opportunities for cost-effective energy savings.

The Technology Development program is the "front end" of innovation. Thus, coordination with other Advanced Buildings initiatives and other NYSERDA existing resources that support technology development and adoption by the market are essential. Coordination with other programs can shorten timelines, for example by exploring specific technologies requested by other NYSERDA initiatives. Instead of relying on the market to produce the desired options, the Technology Development program can solicit and support technology projects that fulfill that need. By supporting technologies before they enter the commercialization pipeline, NYSERDA can further benefit not only through the existence and knowledge of upcoming technologies, but through leveraging familiarity with the technologies in the pipeline in order to most effectively market and use them.

Within the context in which the Technology Development program operates, there are numerous obstacles for the program achieving success, some of which the program attempts to address directly. Thus, progress toward solving these challenges provides markers along the road to meeting program objectives. Other obstacles are more general and beyond program control or influence, such as general economic conditions that influence investment in research and building construction. These are discussed in Section 8. The challenges the program is addressing are in three general areas: technical, economic, and informational challenges and are discussed below.

1.1 Technical Challenges

The technological challenges this program will address are those faced by all research and technology development efforts. There are technical problems in proving a concept, designing and building a lab prototype, and improving its functionality at larger scales until there is a full-scale commercial prototype that has been tested and improved—in iterative steps—until the technology works as required in the actual operating environment.

One of these problems involves technical challenges related to the standardization that is necessary to integrate and synchronize components within the larger system. Technical challenges in that operating environment, such as operations and maintenance and safe disposal can require technical modifications to the technology or separate technical solutions. These challenges can be addressed earlier in the design process with a diverse technical team and stakeholder input. Further, there can be technical challenges and solutions anywhere in the supply chain for a technology, from raw materials, to components, products, systems, application standards, or operation and maintenance. Thus, the technical hurdle might be the need for a new or cheaper raw material, or a new modular design that avoids the problem of a technology too complex to install easily.

The program intends to address specific technical challenges in advanced buildings. One of these is the need for better ways to integrate renewable energy into buildings. Another is optimization and compatibility in buildings systems. Since buildings are complex, system optimization is both difficult and promising; it provides an important opportunity to achieve

efficiency benefits. In addition, there is the potential to use technical solutions to circumvent problems that are behavioral or historical. These solutions include innovative building controls and analysis that can address challenges to energy efficiency in multifamily buildings, and research to support the design of educational materials for the installers or users of a new technology.

1.2 Economic Challenges

As is true for most emerging technologies, R&D for energy-efficient technologies is inherently risky, and market actors hesitate to invest in them because many efforts fail to become commercially viable. As a result, inventors and early-stage companies often are unable to attract the capital necessary to advance their technologies or products. This challenge has been commonly referred to as the two "valleys of death," or the stages of greatest risk to the success of emerging clean-energy technologies (Jackson 2012):

- The initial stage of risk is when the potential commercial applicability of a promising new technology has not yet been made clear to investors. At this stage, companies - particularly small companies and young companies - risk failing to attract the interest of funders. Even larger companies may lack the funding that will allow them to demonstrate the potential of their idea, or they may not be willing to allocate existing funding to the project.

- The second phase of greatest risk to emerging technologies occurs when the commercial viability of a new technology has been proven, but the technology requires considerable capital investment in order to reach commercial scale. Without investors to carry companies beyond this stage, new and innovative clean-energy technologies stall.

Further, promising technologies that have been commercialized and produced only in small quantities may appear too risky for the producers, distributors, and other market actors to invest in. They may need more independent data about the product/technology and its performance, and perhaps hands-on experience with the product/technology, to be convinced of its benefits and marketability.

1.3 Informational Challenges

Several informational challenges exist for the market adoption of energy-efficient technologies. The systems within buildings are complex, resulting in potentially complicated installations, interactions between systems, and interactions between different equipment and other design choices. In addition, there are different challenges within the single-family residential, multifamily residential and commercial/industrial sectors. Thus many technical and market barriers that could be a priority to address might not yet have been identified. There is also a general lack of knowledge about a new or improved technology when it is first introduced. This

lack of awareness can be overcome by demonstrating the technology to potential users and providing information about the overall performance, energy savings, reliability, and support for these technologies. New/improved technologies usually require new knowledge in order to use them, and depending on complexity, may require educational materials and other support.

A part of the need for clear information is due to the experienced variability among and within building technologies. These data are collected during the testing phase and after commercialization. It is helpful if data on performance and cost is collected or verified by a party independent to the technology developers and sellers.

Table 1-1 outlines the challenges to development of new energy technologies and practices in buildings and describes the stakeholders affected by these challenges.

Table 1-1: Challenges to be addressed by NYSERDA's Advanced Buildings Technology Development Program

Challenge Area and Details	Stakeholders Affected and/or Involved
1. Technical Challenges	
a. Technical challenges include proving concepts and their application, and developing and testing prototypes at increasing scale with functionality and cost that meet requirements. b. Technology-specific roadblocks require further research and examination to continue development. Diverse expertise and perspectives are required to begin to investigate solutions. c. Technical problems and problems of strategy, methods, and practice arise in building optimization and compatibility of systems. Complicated interactions between equipment result in uncertainty, incompatibility, and negative impacts on business practices. Standardization is necessary to integrate and synchronize components within the system and to meet requirements in the operating environment. d. Technical challenges can limit integration of renewable energy into building systems. There are challenges involved in finding technology/technical solutions to behavioral and institutional problems, such as smart meters and HVAC retrofits compatible with old buildings.	Inventors, scientists, engineers, product manufacturers, independent testing facilities, building designers, vendors, entrepreneurs. Technical consortia, building owners, contractors, building tradespeople; deployment programs.

continued

Challenge Area and Details	Stakeholders Affected and/or Involved
2. Economic Challenges	
a. Early stage research and technology development is risky, leading to "valleys of death" where investment capital is not available to take R&D to next stage. b. Promising technologies ready for commercialization may appear too risky for the market (entrepreneurs, building owners, etc.) to invest in. Firms need the capital to allow them to initially offer the technology for a price less than the price that would allow them to recover the costs of the R&D. c. Building owners, contractors, and vendors are risk-averse, need evidence of technology value, know-how to apply the technology, and capital to manufacture/sell/purchase the technology.	Inventors, scientists, engineers, manufacturers, building designers; venture capital and other investors; builders/contractors/building tradespersons; entrepreneurs.
3. Informational Challenges	
a. Because the building market is complex, technical and market challenges may not yet be identified. b. Uncertainty exists throughout the delivery chain regarding emerging technologies. c. Verifying energy savings and other benefits is a complex process. d. New/improved technologies can require new know-how to use, and depending on complexity, require educational materials and other support.	Researchers, engineers, building designers; builders/contractors/ building tradespersons, building owners/operators, end-users.

2 Program Objectives (High Level)

The ultimate objective of the Technology Development program is to accelerate the development of new and improved energy technologies and systems for buildings so a wider range of proven energy efficiency equipment and energy-efficient strategies is available to the market. A secondary objective is that some of these technologies will increase the integration of renewable energy into buildings and increase the resiliency of buildings to energy disruptions. In the longer-term, this will lead to improvements in the performance of the building stock in New York State, and to economic benefits, including those resulting from the introduction of new technologies manufactured in the State.

New and improved existing technologies will be pursued to meet a range of needs for single-family residential, multifamily residential and commercial sectors. The Technology Development program is interested in supporting all promising clean-energy technologies in these categories of technologies:

- Construction materials, strategies and methods;
- Heating and cooling;
- Lighting;
- Demand response smart buildings and demand-side resources, particularly to allow customers to participate in demand response programs; and
- Other building-related technologies and regulatory measures.

Program objectives to be met at the conclusion of five years include:[1]

- Funded projects assist technologies through one or more stages of development (discovery [scoping/analysis], business case, development, testing, and launch).
- Stakeholders necessary to deliver integrated technical solutions are engaged, including through consortia like the ABC.
- Companies producing clean-energy technical solutions receive financial support.
- Funds for technology development of advanced building technologies are leveraged through co-funding of projects and follow on outside investment.

[1] From the T&MD Operating Plan, 2013, Tables 7.3 and 9.8.

- Promising technologies needing further support for adoption by the market are picked up by deployment programs in NYSERDA and elsewhere.
- Supported technologies reach commercial availability, and some attain substantial commercial sales.

3 Program Resources

Table 3-1 identifies the dollar, workforce, and partnership resources the program provides under the Initiative. NYSERDA has a wide range of stakeholders to leverage for additional support, as well as the benefit of leveraged, intangible resources.

Table 3-1: Program Resources

T&MD Funding

• Average annual budget of $6.72 million
• Total budget of $33.61 million of which:
  o $25 million available through PON 2606, of which $22 million is T&MD Program funds, and $3 million is statutory funds
  - Construction materials, strategies and methods, $5 million
  - Heating and cooling, $5 million
  - Lighting, $5 million
  - Demand response smart buildings and demand-side resources, $5 million
  - Other technologies or opportunities, $5 million
• $7.5 million available for ABC projects (includes $3 million reallocated from SBC III)

NYSERDA Staff Resources
• 5.6 employees (full-time equivalents [FTE])
External Resources

• Leverage (including co-funding in some cases) these existing resources:
  o National labs
  o National Home Performance Council
  o New York trade associations, consortia, and councils
  o New York universities and other academic resources
• Public and private companies

Intangible Resources
• Past technology development and demonstration program experience • Existing relationships with technology and business professionals engaged in energy efficiency technology market

4 Program Activities

Program activities center on the identification of research and technology development and demonstration projects and on assisting development through the NYSERDA-defined stages of the product development process.[2]

> "To stimulate the development of new and improved technology and reduce the cost of clean-energy technologies, NYSERDA can employ a rigorous stage gate process [discovery (scoping/analysis), business case, development, testing, and launch] for granting support for new product development from idea to commercialization. At each gateway between stages of the product development process, progress will be evaluated to determine if the effort should advance to the next stage. Use of the stage gate process can help direct NYSERDA support to projects with the highest technical and business case potential, accelerate speed-to-market, increase the likelihood of product success, and introduce portfolio management and discipline."[3]

For this program theory logic model, the program activities are defined in five groups, of which three are stages in the product development process: applied research, development and testing, and demonstration of new technologies. The program addresses movement of a new or improved existing technology through the following activities:

1. Select and Support Projects with Stakeholder Input
2. Fund Applied Research
3. Fund Consortium for Thematic R&D
4. Fund Technology Development
5. Fund Demonstrations of New Technologies

The following is a description of each of these major activities of the Technology Development program within the Advanced Buildings Initiative.

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[2] NYSERDA has built upon the Stage Gate model, which is credited and trademarked to R.G. Cooper. See http://www.prod-dev.com/stage-gate.php and Cooper 2006.

[3] Technology and Market Development Portfolio System Benefits Charge Briefing Paper March 18, 2011, page 20.

4.1 Select and Support Projects

NYSERDA uses a deliberate process that engages stakeholders to identify technology gaps and priorities. This process provides extensive input into the development of Program Opportunity Notices (PONs). The selection of proposals for awards is done competitively. While the PONs target five technology areas (construction materials, strategies and methods, heating and cooling, lighting, demand response smart buildings and demand-side resources, and other related technologies and strategies), the solicitation is flexible. Solicitations will adjust to NYSERDA's needs and stakeholder input, exploring a broad definition of technology that includes strategies, processes, and policy research. Since the PONs are open to technologies in all stages of market-readiness, this strategy also leaves a wide range of opportunities to assist development where assistance is needed. The PON solicitation is open every six months. The amount of funds available to a project increases from research stage, to development stage, to demonstration stage.

Once selected, each project is assigned a NYSERDA staff member as project manager. The project manager is a subject matter expert in that project's field. The project manager and recipient develop a contract with a statement of work. Experienced NYSERDA staff and the ABC will provide support for projects throughout the development cycle. NYSERDA may help projects through multiple stages of technology development. Companies that need assistance to move through subsequent stages may reapply for funds for that stage through a PON. For identified technology projects, NYSERDA provides, in addition to funding, other services as needed, such as technology development guidance and R&D networking with outside experts. Feedback from participants in previous NYSERDA projects shows that this comprehensive technical and business advice and market insight are valued as much as the NYSERDA funds.

4.2 NYSERDA held meetings with stakeholders to design the ABC. At these meetings, NYSERDA purposefully asked proposers to bring together and organize stakeholders to conduct research and demonstrations that focus on new technologies that have real benefits that all key stakeholders (tradespeople, owners, and occupants) perceive as valuable. A version of PON 2630 was released in January 2014, however no awards were made based on the submitted proposals. A modified version of this PON is may be issued later this year. Fund Applied Research

During the initial discovery phase of NYSERDA's product development stages, there may be promising ideas that have not had the support needed to develop into a more concrete concept. NYSERDA assists these research efforts through funded projects to support applied research to prove a concept, and develop and test an initial laboratory or bench scale prototype. Concepts that prove technically promising undergo a business analysis to describe how that concept might solve a problem and use that to build a business case. Ideally, the business analysis would address the potential market for the product, market size, and target cost. Subject matter

experts review the results of this business case analysis. When both the technical and business cases are positive, the effort may request follow-on funding from NYSERDA under the development category.

The "other opportunities" category in the PON covers opportunities to promote the development and introduction of new energy-saving technologies that do not fit into the four specific technological categories in the initial Technology Development PON. In particular, energy improvements in buildings can also result from activities that do not involve the development of products, services, or methods. The program funds policy research, regulatory research, and statewide technology assessments that have potential for use in regulatory policy development, as well as the development of codes and standards or educational materials. Examples of outcomes of this activity are helping set guidelines for the size of fasteners for installing insulation and providing advice to the Governor of New York on performance and efficiency thresholds. Such activities must be assessed differently from technology development efforts.

4.3 Fund Consortium for Thematic R&D

NYSERDA may fund one Advanced Buildings Consortium (ABC), which will introduce new and integrated building products and services that will be adopted more rapidly into the market than would be the case with individual efforts that are not integrated. By putting together a diverse group of participants from research, development, production (building design, construction and operation) and utilization (trades, owners and occupants) of a technology in the design stage, the new technology will have multi-faceted value propositions that all the key stakeholders will value. The ABC is responsible for identifying either a broad technology area (such as building automation) or an overarching technology theme (such as innovative retrofit technologies). Proposers must develop and provide a multi-year research plan or roadmap for the funding in their proposal including identified subcontractors. Subsequent additions to the research agenda will be subject to NYSERDA's standard subcontracting and cost-modification processes. Working in an integrated way facilitates the transfer of knowledge and reduces the amount of redesign and rework. It also can allow for a group to address challenges with a broader scope or greater degree of difference from existing practices. The ABC will be a technical resource to its members by providing them technical assistance subject to qualifying criteria and cost share. The ABC is expected to transfer the knowledge gained from supported activities (funded research and services provided) through publications, workshops, networking, and new or improved product introductions.

4.4 Fund Technology Development

For projects that have moved from the proof-of-concept and initial laboratory-scale prototype into development, NYSERDA supports further development and testing of select concepts and technologies to move them closer to product launch. For a number of technologies, commercial

launch can occur in one to two years (a fast track) with just a small amount of funding from NYSERDA. Technology development involves success at increasing scale of a product or process until the technology is working as needed at commercial scale in the target operating environment. This includes efforts to design and build into the technology the performance and cost features that will make the technology an attractive alternative for the proposed market. There are many steps that a technology must go through to progress from a compelling technical and business case to market-ready technology, and different technologies will be at different points along this process when they first receive NYSERDA funding and development will progress at different speeds. Statements of work may include - depending on the technology--developing custom or unique parts, testing the prototypes, developing a full case business plan that leads to defining the product requirements, submitting products for testing for regulatory approval, and designing for manufacturing.

NYSERDA project managers will pilot for this program the assessment of the "readiness level" of the technologies supported at points in time to track progress. First developed by the National Aeronautics and Space Administration as a tool for communicating to stakeholders the status of development of a technology for a particular application,[4] Technology Readiness Levels (TRLs) are now used by the U.S. Departments of Defense and Energy, among others. There are nine levels in the system, from basic R&D concepts, to validating the technology system in its operating environment. Knowing progression along the TRLs is important because progress in technology development is iterative and often slow and at best, only one in seven technologies supported will ever be commercialized[5].

4.5 Fund Demonstration of New Technologies

Once products have been fully developed, tested, validated, and have become commercially available, there are still opportunities to provide demonstrations of the technology to debut the new technology and provide data on performance, cost, compatibility, and benefits of use in a particular context. This validation is more complete than savings estimates, including aspects such as acceptability and ease of maintenance. Statements of work for demonstration projects include the tasks of developing a case study report and completing measurement and verification. If a technology successfully demonstrates potential at the demonstration stage, the ETAC team and other interested stakeholders are informed about its status.

[4] For definitions of the TRLs, see http://esto.nasa.gov/files/trl_definitions.pdf.

[5] From discussions with program staff.

5 Program Outputs

Table 5-1 presents the anticipated immediate results associated with program activities (outputs), and indicators and potential data sources for the indicators.

Table 5-1: Outputs, Indicators, and Potential Data Sources.

Outputs	Indicators	Data Sources and Potential Collection Approaches
1. Outputs from Selecting and Supporting Technology Projects		
Stakeholders engaged	Number of meetings, attendance Audience for events by event type (website, conference, workshop, training, media event)	Staff reports, files Project metrics reports (annual)
Consortium contract signed	Date signed	Staff files
Projects selected (not consortium)	Number funded, by type	Staff files
Project support provided (not consortium)	Clients given technical advice, business advice, or both	Staff project files
2. Outputs from Funding Applied Research		
Applied research and analysis projects funded	Number of projects by type Number, name of companies supported	Staff reports, files
Research results published, disseminated	Number and type of publication (final/technical report, newsletter, newspaper article, primer, peer-reviewed publication, abstract)	Project Metrics reports (annual)
Policy and methods briefings, market intelligence and educational materials produced	Number by type Audience name	Project Metrics reports (annual)
Concepts proven	Number Brief description	Technical reports, publications, if not Project Metrics reports (annual)
Product/process prototypes tested at lab level (TRL 2-3)	Development stage (initial prototype)	Project Metrics reports (annual)
3. Outputs from Funding Consortium for Thematic R&D		
Stakeholders engaged	Number of meetings, attendance Audience for events by event type	Consortium annual report
Applied research, technology development and pilot demonstration projects underway	Number, characteristics Number of companies receiving funds/technical support	Consortium annual report
Technical support provided to members	Instances and type	Consortium annual report
Research and technical reports	Publications by type	Consortium annual report
		continued

Outputs	Indicators	Data Sources and Potential Collection Approaches
4. Outputs from Funding Technology Development		
Development projects funded	Number of projects Number of companies supported Product name Characteristics of participants Number that "graduated" from NYSERDA applied research projects	Staff records Project Metrics reports (annual)
Dissemination of R&D results	Event name, host, number attending (or engaged) Presentations given, event name Publications: number, journal name, type	Project Metrics reports (annual)
Known technical challenges solved (such as components standardized)	Progress against project's stated technical objectives	Interviews if not in Project Metrics reports (annual)
Intellectual property generated	Number of patents applied for, granted Number of licenses	Project Metrics reports (annual) Patent databases (purchased)
Products/processes tested at intermediate scale (TRL 4-6)	Number in each development stage (refined prototype, etc.) Current performance and/or cost for each technology	Project Metrics reports (annual) or technical reports
Products/processes tested at commercial scale (TRL 7-9)[6]	Number in each development stage Current performance (efficiency, etc.) and/or cost for each technology	Project Metrics reports (annual) or technical reports
Commercial launch (fast track technologies)	Number of commercial launches Production volume, sales; refinements made to existing products Current performance (efficiency etc.) and/or cost for a technology	Project Metrics reports (annual) or technical reports Project Closeout reports
Energy and other resources saved by use of the technology	General and specific resource type saved, unit of measurement, units saved	Project Metrics reports (annual) Project Closeout reports Third-party verification
		continued

[6] TRL 7-9 are at full-scale. In TRL 7, it is similar system configuration and a relevant operating environment; in TRL8 it is identical configuration, limited range of operating environment.

5. Outputs from Funding Demonstration of New Technologies		
Demonstrations funded	Number of projects Number of demonstrations Product/technology name Expected duration (years) Listing of aspects included in addition to energy	Project Metrics reports (annual) Demonstration design description
Installation status	Current status (design, commissioning, etc.)	Project Metrics reports (annual)
Cost share	Amount of non-NYSERDA funds invested in the demonstration In-kind contributions	Project Metrics reports (annual)
Demonstration progress and progress reporting	Number of demonstrations in progress Number of progress reports Nearness to completion of each demonstration	Staff records Project Metrics reports (annual)
Information disseminated	Event name, host, number attending (or engaged) Presentations given, event name Publications: number, audience Number of web postings, downloads	Project Metrics reports (annual)
Energy and other resources saved by use of the technology	General and specific resource type saved, unit of measurement, units saved	Project Metrics reports (annual) Project Closeout reports Third-party verification

6 Outcomes and Logic Diagram

This section presents NYSERDA's Advanced Buildings Technology Development Program logic model diagram (Figure 6-1) showing activities, outputs, a series of outcomes, and the relationships among them. The diagram presents information provided in other Sections but at a higher level of abstraction, aggregating in order to tell the program's "performance story" in just one page.

The logic model suggests project outcomes that are expected achievements of the program over different time periods. Table 6-1, Table 6-2, and Table 6-3 provide short-term, intermediate-term, and longer-term details on the Technology Development program's expected achievements (outcomes), as well as observable indicators that would signify the presence of these achievements. In addition, the tables show the data sources and potential data collection approaches that an evaluation effort might undertake to determine the achievement of the expected outcomes.

Figure 6-1: Advanced Buildings Technology Development Program Logic Model

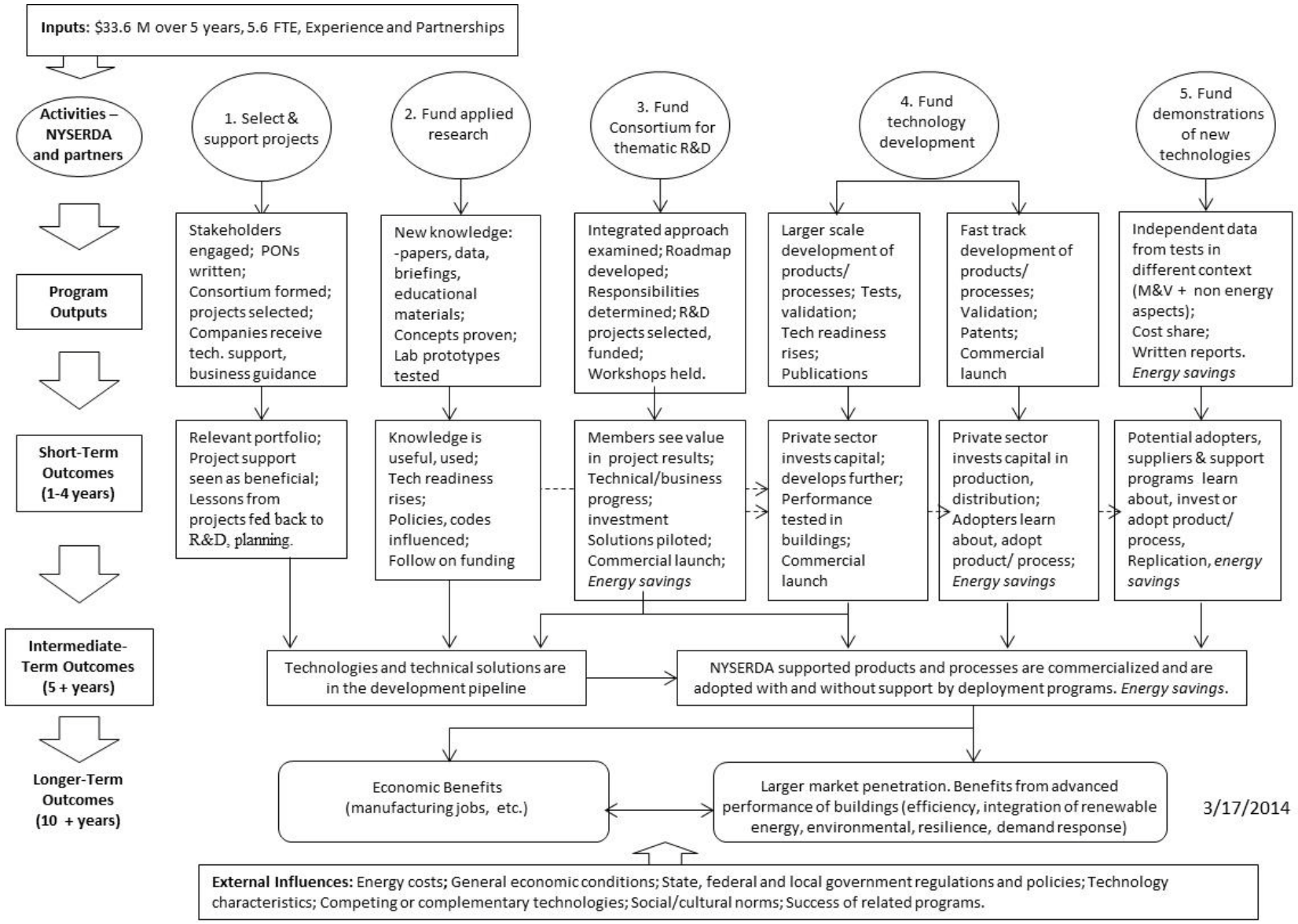

Table 6-1: Short-term Outcomes (1-4 years), Indicators, and Potential Data Sources

Short-term Outcomes	Indicators	Data Sources and Potential Collection Approaches
1. Short-term Outcomes from Selecting and Supporting Projects		
Portfolio of projects relevant to program goals	Description of portfolio and its relevance (rationale for project choices)	Staff opinion Stakeholder meetings
Support provided to projects is viewed as useful by recipients	Percent of project principals with favorable opinion of support received	Interviews
NYSERDA staff feeds lessons learned back to other R&D staff and uses in planning	List of examples of feedback and use in planning	Staff records
2. Short-term Outcomes from Funding Applied Research		
Supported technologies continue to move through stages (pipeline) toward commercialization	Product name Current development stage Commercial launch (for some)	Project Metrics reports (annual)
Research is useful to other researchers, developers	Citation of publications Patents applied for, received Licenses, copyrights New companies established	Project Metrics reports (annual) Web of Science or Scopus databases (purchased) Patent database (purchased data)
Policymakers, code developers, regulators are influenced by research programs	Reference to supported research/analysis appearing in policy, code, regulation documents, new standards, legislation or proceedings	Project Metrics reports (annual)
Investment: Supported research/technologies receive complementary and/or follow-on funding	Total investment dollars Source(s) (including (NYSERDA development funds)	Project Metrics reports (annual)
3. Short-term Outcomes from Funding Consortium for Thematic R&D		
Consortium members maintain memberships and attract new members	Membership levels Amount of Consortium funds from members Percent reporting benefits received from membership	Consortium annual report (includes Metrics) Survey or Interviews with members
Progress is made along roadmap	Progress achieved toward technical goals Progress achieved toward business goals	Consortium annual report Staff observation
Research disseminated	Publications: Number and type	Consortium annual report
Follow-on funding received by member companies	Product, company names Amount, type, source	Consortium annual report

continued

Short-term Outcomes	Indicators	Data Sources and Potential Collection Approaches
Supported technologies move through stages toward commercialization	Product names Current development status Commercial launch (for some)	Consortium annual report
Integrated solutions are tested in pilot demonstrations	Number of pilot demonstrations Success of demonstration Level of integration	Staff observation, records Interviews
Integrated solutions are tested in full-scale demonstration(s) in buildings	Number of full-scale demonstrations Success of demonstration Level of integration	Staff observation, records Interviews
Installation of supported technologies in buildings in New York State	Name of product Number launched Units sold	Consortium annual report Interviews
Energy and other resources saved by use of the technology	General and specific resource type saved, unit of measurement, units saved	Project Metrics reports (annual) Project Closeout reports Third-party verification
4. Short-term Outcomes from Funding Technology Development		
Intellectual property produced	Patents applied for, patents received Copyrights received	Project Metrics reports (annual) Patent databases (purchased)
Funds leveraged (co-funding, outside investment)	Total investment dollars	Project Metrics reports (annual)
Use of R&D results	Citations in other journal papers Citations in government policy documents Products improved/developed with R&D results	Project Metrics reports (annual) Web of Science or Scopus databases (purchased)
Supported technologies/ products/processes continue to move through stages toward commercialization	Product name Current development stage	Project Metrics reports (annual)
Functionality and cost improvement meet or exceed minimum performance requirements or standards	Status of key product functions, such as durability, efficiency Current product cost	Interviews or technical or sales reports, if not in project reports or publications
Supported technologies reach commercial scale (TRL 7)	Product name Current development stage	Project Metrics reports (annual)

continued

Short-term Outcomes	Indicators	Data Sources and Potential Collection Approaches
Technology tested in operating environment (buildings), modified as needed (TRL 8-9)	Product name Description of modification tested Data on performance and cost	Project Metrics reports (annual)
Commercial launch	Number of commercial launches Production volume, sales Current performance (efficiency etc.) and/or cost for a technology	Project Metrics reporting form (annual) or technical reports Project Closeout reports
Market awareness and penetration (number of users) increases	Percent of target population aware of the product Percent of target population adopting product/process Sales (number sold)	Survey Sales data
Energy and other resources saved by use of the technology	General and specific resource type saved, unit of measurement, units saved	Project Metrics reports (annual) Project Closeout reports Third-party verification
5. Short-term Outcomes from Funding Demonstration of New Technologies		
Funds leveraged (co-funding, outside investment)	Total investment dollars Source	Project Metrics reports (annual)
Results disseminated	Publication number and type	Project Metrics reports (annual)
Energy and other resources saved by use of the technology in the demonstration	General and specific resource type saved, unit of measurement, units saved Dollars saved	Project Metrics reports (annual) Third-party verification
Companies invest in the technologies or licenses	Amount of cost share ($ and in-kind) Number, dollar value of license agreements Number of startups Number, size of manufacturers, distributors, retailers, O&M firms	Project Metrics reports (annual) Interviews Industry statistics
Degree to which current functionality and cost meet requirements	Status of key product functions, such as durability, efficiency Current product cost Compliance achieved	Technical reports, publications Interviews
Researchers and manufacturers raise capital	Venture/other capital raised	Interviews if not in Project Metrics reports
Unsuccessful products/processes are identified; development discontinued or redesign is done	Number of such identified Current status of NYSERDA, other support for each	Staff observation, records Market research reports

continued

Short-term Outcomes	Indicators	Data Sources and Potential Collection Approaches
Codes, policies, regulations are influenced	List and description of these that have been formalized Potential number of consumers reached	Interviews if not in Project Metrics reports
Deployment programs provide support for adoption/purchase	Name of program(s) Amount of support	Program staff records, requests for information
Market awareness and penetration in New York State of supported products/processes with and without incentives	Percent of target population aware of the product Percent seeking more information Separating those with incentives from others Number sold or adopted Number repeating, expanding purchase/adoption	Survey Sales data
Energy and other resources saved by use of the technology, in addition to the demonstration	General and specific resource type saved, unit of measurement, units saved	Project Metrics reports (annual) Project Closeout reports Third-party verification

Table 6-2: Intermediate-term Outcomes (5+ years), Indicators, and Potential Data Sources

Intermediate-term Outcomes	Indicators	Data Sources and Potential Collection Approaches
Technologies and technical solutions (products/processes) in the development pipeline	Movement of supported technologies in each stage of development Number commercialized	Analysis of Project Metrics reports Interviews with project participants Expert panels
Replication of product/system installation that has been demonstrated	Product name Number of replications, size, companies involved	Interviews, if not in Project Metrics reports
Supported technologies are commercialized	Number offered commercially Sales of each	Project Metrics reports Sales data Interviews
Supported products/processes further supported (incentivized) by deployment programs	Product name and supporting program Amount of the incentive	Interviews, if not in Project Metrics reports
Increased market penetration of new or improved supported products/processes, with and without support from deployment programs	Separating those with/without deployment support Number of units sold total, number sold in New York Product sales ($) Recoupment to NYSERDA	Project Metrics reports (annual) Reports from deployment programs Survey
Resources saved by use of the technology	General and specific resource type saved, unit of measurement,	Project Metrics reports (annual)

	units saved	

Table 6-3: Longer-term Outcomes (10+years), Indicators, and Potential Data Sources

Longer-term Outcomes	Indicators	Data Sources and Potential Collection Approaches
Market penetration of new or improved supported products/processes	Number of units sold total, number sold in New York Percent market share Product sales ($) Amount owed NYSERDA	Project Metrics reports (annual) Impact assessment study
Jobs created as result of product/process commercialization	Jobs created (net of jobs displaced) by sector Number of jobs created in New York State	Project Metrics reports (annual) Impact assessment study
Integration of renewable energy	List instances of integration, describe	Interviews if not in Project Metrics reports
Increased building resilience	Building/product performance under extreme events compared to baseline building performance	Interviews if not in Project Metrics reports
Electric energy savings achieved from improved building stock performance	MWh saved and quantified load reduction	Project Metrics reports (annual) Impact assessment study
Electric demand savings achieved from improved building stock performance	kW peak saved and quantified load reduction	Project Metrics reports (annual) Impact assessment study
Gas energy savings achieved from improved building stock performance	MMBTU saved and quantified load reduction	Project Metrics reports (annual) Impact assessment study
Resources saved: non-energy	Avoided monetary savings (such as plant expansion) Avoided cost of chemicals, raw materials, water not used, or waste not generated Increased labor productivity or added value to product	Project Metrics reports (annual) Impact assessment study
Resources saved: air emissions	Reductions in NOX, SOCs, VOCs	Project Metrics reports (annual) Impact assessment study
Market penetration of new or improved supported products/processes	Number of units sold total, number sold in New York Percent market share Product sales ($) Amount owed NYSERDA	Project Metrics reports (annual) Impact assessment study

7 Assumptions About Strategies

This section describes the testable hypotheses or testable assumptions about the program to be explored in the evaluations. These are key evaluation questions about how activities and outputs under this program will lead to desired near-term, intermediate-term, and longer-term outcomes.

1. Did the activities and outputs of such activities occur as planned and reach the target audiences?

2. Did target audiences react to the outputs as anticipated so the following short-term outcomes occurred?

    a. Have key research community and industry stakeholders been involved in and supportive of project implementation? Have they added their own resources to the effort?

    b. Have companies involved in projects received technical and business support?

    c. Have researchers published their findings?

    d. Have research applications been proven in concept? Have the projects developed or tested prototypes at a small/laboratory scale?

    e. Have technologies been tested at larger scale, as components and as part of a larger system? Have these been demonstrated in relevant and actual operating/working environments?

    f. Have research projects and development projects achieved performance targets and other targets, such as cost targets? Have some faster track products/processes been commercialized?

    g. Are the recommended Consortium projects, which are part of an integrated solution to known challenges, underway and making technical and business progress?

    h. Have demonstrations of new technologies resulted in energy or other resource savings, and have demonstrated products/processes achieved larger market penetration?

3. Have the changes above led in the intermediate-term and longer-term to further development and commercialization and to reduced challenges to adoption of supported products and processes?

    a. Has the increased knowledge base about supported technologies and system challenges been used by the relevant constituents?

b. How have the recipients of technical and business support benefited from that help?

c. Has the Technology Development program used lessons learned in projects in its planning and provided lessons learned and project outcomes to relevant R&D and deployment programs?

d. Have findings of applied research been recognized as useful? Have they been utilized in research or policy, code, or regulation considerations?

e. Have technologies, products, and measures supported received follow-on funding?

f. Have technologies in development projects met performance targets and moved closer to commercialization?

g. Have technologies in research or development or Consortium projects reached commercial scale? Have they been tested in buildings? Have they been commercialized?

h. Have companies invested in and been able to raise capital for supported technologies?

i. Have Consortium companies and government deployment programs decided to support adoption of supported technologies?

j. Have there been increased sales of supported technologies, with and without incentives?

k. Have supported research results, technologies, and demonstrations of new technologies resulted in energy or other resource savings?

4. What important spillover mechanisms should be investigated during research to quantify participant spillover and nonparticipant impacts?

a. Have participants repeated an action without further NYSERDA funds/assistance (e.g., continued research and development with other sources of funding, or replicated a demonstration)? Or have participants pursued other consortia or building technologies without NYSERDA funds/assistance due to program influence?

Causal Mechanisms: Gained skills, resources, connections, and determination that the action was worthwhile based on the experience funded by NYSERDA; continue to see opportunities.

b. Have nonparticipants become aware of and utilized research results in related or unrelated research and development or supported technologies in markets other than energy efficiency?

Causal Mechanisms: Learned personally about "it" and its benefits from interaction with a participant (researcher or market actor), or from NYSERDA staff, publications, or other source, and were persuaded to take the necessary steps and actions; took action, and continue to see opportunities.

c. Has the program directly changed behavioral norms which then cause changes/have an impact on former/current participants and nonparticipants? These would happen when end-users who participate in a demonstration or the Consortium try the technology or integrated approach, confirm that there are enough benefits, and achieve consensus to make it a standard operating procedure for other applications or situations.

Causal Mechanisms: The benefits are noticed and incentives strong enough to incentivize changes in the way business is done, and these incentives are self-sustaining.

d. Has the program directly changed general economic equilibrium, which then causes changes/has an impact on former/current participants and nonparticipants?

Causal Mechanisms: This would happen only in the unlikely scenario that one or more of supported technologies had large benefits in terms of cost savings, business profits, or jobs.

8 Non-Program Influences on Outcomes

This section describes the influences that are external to the program that may affect the outcomes. These external influences include the economy and other influences over which NYSERDA programs have no direct influence.

8.1 General Economic Conditions, Including Cost of Energy

The cost of energy varies depending in large part on supply and demand. When the cost of energy is low, incentives to be more efficient in energy use are low. More generally, the health of the economy influences income levels for all sectors of the economy. During times of recession when income falls, industry investment and consumer spending also fall. This is particularly true for high-risk investment and purchases with higher up-front costs. Historically, research and energy efficiency investments have suffered in economic downturns.

8.2 State, Federal, and Local Government Regulations and Policies

State, federal and local government regulations can shape the market's focus on different energy-related issues, technologies, and strategies through taxation, subsidies, regulations, codes and standards, local citing requirements and code inspection, government procurement, and government demand side programs. The incentives these put in the system may stimulate or hinder investment and progress in research, development, and deployment of new technologies.

8.3 Technology Characteristics and Competing Technologies

The nature of technologies and their markets differ. In some cases, development or deployment may be slow, for example if there is technical complexity and a lack of delivery infrastructure. Even if the nature of the technology means a reasonably quick development-to-adoption cycle, market penetration may not occur. Sometimes, despite the program's best efforts to select projects to develop and demonstrate technologies with promise, and work with consortia designed to overcome system-level challenges, other development efforts may encounter fewer technical hurdles and competitive market forces may bring to market a new technology that better suits customer needs. It also is possible that supporting technologies may become available and market conditions change to enhance the likelihood of success of some funded technologies.

8.4 Social and Cultural Norms

Individuals and groups have beliefs, attitudes, and ways of doing and behaving based on social and cultural norms they have learned. These change slowly unless an event compels change.

8.5 Success of Deployment and Other Related Programs

The success of the Technology Development program depends, in part, on the design, funding, and success of related programs administered by NYSERDA and others. If budget cuts or changing priorities at the federal or state levels reduce spending on programs (e.g., for NYSERDA Deployment programs or the energy technology research, development, and deployment programs of the U.S. Department of Energy), or implementation is not successful, it would make it more difficult for the program being evaluated to be successful. Collaboration with related programs, such as NYSERDA's ETAC program, makes longer-term success more likely.

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