Using Logic Models to Describe Complex Programs in Multi-program Agencies

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ABSTRACT

The term "logic model" has now entered the lexicon of energy program implementers, evaluators, and regulators in some jurisdictions require a logic model as part of submission for approval of energy efficiency program filings. While logic models are becoming more common, they are often done to fulfill a requirement and their practical usefulness and contribution to manager decision-making, program implementation, and evaluation is limited.

This paper describes three complex large-scale logic models that have been developed for three complex Federal energy efficiency programs, EERE's Industrial Deployment Program, DOE's Regional Combined Heat and Power Application Centers, and the Federal Energy Management Program. The usual intent of logic modeling is to provide a systematic and simple view of a program. When programs are highly focused with a few key activities and well-defined goals, relatively simple models can be developed. When dealing with large-scale multi-program agencies, it is useful to construct more complex logic models that show the activities and the relations or lack thereof between programs and then simplify the models.

There are two important aspects to the way these models were constructed. First, the evaluator collected information from the program staff and constructed a preliminary model. Program staffs were then involved in reviewing the models. The models were revised until there was consensus about the validity and descriptiveness of the models.

The second aspect is that the approach used Rogers' theory of *Diffusion of Innovations* (2003) as described in the book, *Impact Evaluation Framework for Technology Deployment Programs* (Reed, Jordan, Vine, 2007) to layout each of these models.

What is unique about these models is that the outcome space is much more highly articulated than is generally the case for logic models. As a result, the commonalities and differences in the outcomes associated with specific activities are quite clear. Instead of pursuing an evaluation of each activity, it is easier to see how a much more limited set of common evaluation tasks can be constructed that will provide an opportunity for a much more coherent overall evaluation, that will more effectively describe the performance of the various program elements, and increase the ability to identify changes to the programs that could make them more effective.

The response to the logic models has been quite dramatic. After studying one of the logic models for some time, the head of a program pointed out that the logic model helped to move understanding of the program from an assemblage of program parts to that of a designed program. The implementers reviewing another of the logic models began to get excited when they realized that they could measure and possibly demonstrate the causal connections between the program activities, the responses of the target audiences, and the long-term energy savings. They also realized that they did not necessarily have to show savings in year one but that they could justify the program by showing a progression of outcomes that would lead to

[1] This work would not have been completed without the efforts and support of many colleagues. The work of Gretchen Jordan and Ed Vine on the framework document needs especially to be acknowledged. Jeff Dowd funded much of the work that is reported in this document. We also want to recognize Peter Salmon-Cox, Robert Gemmer, and Joseph Konrade who oversaw the development of the three models. Finally, we need to recognize the contributions of 30-40 individuals within the ITDP program who contributed to the development of the ITDP model, the committee of seven individuals who participated in the development of the Regional Combined Heat and Power Application Center Model, and the 25 or so staff of the FEMP program.

savings in the longer term.

Introduction

In the last few years, there has been an increasing focus on accountability and measurement of the performance of government programs and the need to develop a finite set of performance measures that capture the essence of what a program is doing. Developing and managing performance measures for large, complex, multi-program agencies is challenging. Agencies are often unable to roll-up the performance claims of their constituent programs, even if they are within the same area or 'portfolio', because the logic and measures for program components tend to be developed separately by different individuals and subunits. The result is numerous performance measurement systems collecting very different performance measures that are difficult if not impossible to combine.

Further, the performance measures may not connect well to the overall goals of the agency or contribute to the attribution of outcomes. Agencies sometimes address this by creating a set of agency-level performance measures and then reach back into the organization to obtain data to support these performance measures. The agency-level performance measures may represent the agency-level goals but are infrequently calibrated with the goals of constituent programs, resulting in overlapping and burdensome data-collection efforts that do not serve either the agency or the constituent programs well.

At present, programs are typically left to develop a theory or theories of how program outputs induce desired changes. Because the programs in many agencies are assembled, that is, cobbled together from earlier programs rather than intentionally designed, program theory may be absent or quite minimal. Even in the best of programs, there is sometimes a lack of clarity about who the target audiences and partners are. Also it is often unclear how program implementers expect target audiences to respond to program outputs, thereby producing the to produce the short-term outcomes or market effects that lead to the desired long-term outcomes (impacts).

This paper describes how three complex large-scale logic models have been developed for Federal energy efficiency programs: EERE's Industrial Deployment Program, DOE's Combined Heat and Power Program, and the Federal Energy Management Program. These models provide a much clearer view of how each of these program operates.

Logic modeling and logic models

Logic modeling is a process that connects the elements of projects, programs, and organization in causal sequences that result in a logic model. The actual logic model is an artifact of the process that can be used for communication, analysis, and other purposes. For implementers and evaluators, a substantial part of the value of logic modeling arises from the process of developing, refining, updating, and using logic models and less from the production of the graphic.

Logic models can take a number of forms (Knowlton and Phillips, 2008). For the purposes of this paper, a logic model is defined as a simple or complex graphic with a double logic that is usually accompanied with a small amount of explanatory text.

The two dimensions of the logic model are the performance path and the performance spectrum. The performance path is a logical sequence of program activities (e.g. outreach, financial incentives, etc) that lead to the desired outcomes. The performance spectrum is a logic for the successful performance of an activity including inputs, outputs, outcomes, intermediate outcomes, and long-term impacts associated with each of the activities in the performance path. In addition, a logic model includes the identification of partners, allies and the target audience, as well as external factors that may influence the program. Figure 1 is a template for the layout of a logic model. The reader may view Figure 2 to see a practical example of this schema for EERE's Industrial Technology Deployment Program.

One frequent piece of advice about logic models is that they should fit on one page. At least initially and based on our experience, this advice should probably be ignored when modeling complex multi-program environments. Logic models should not be artificially constrained because it is important to see program detail. In addition, participants in the process may dismiss a simplified model and opt out of the process if they cannot locate themselves in the model. Later, the complexity can be reduced. In one of our endeavors, senior management took the logic model and reduced it to a seven-box model. However, they understood and appreciated what was beneath the boxes. As an example of the level of detail, the initial FEMP model that is described later was only readable when placed on a six-foot by four-foot sheet of paper. The best strategy may be to develop a detailed model, a model with intermediate detail, and a simple model.

Inputs or Resources	Inputs to the project such as budget, time, knowledge, and skills are identified here	**External Factors** List things over which the program has no control but which may influence the outcomes. Examples are policy changes, the economy, regulatory changes, other efficiency activities, etc.
Activities	Seven to ten high level activities are arranged horizontally and in sequence. Examples are infrastructure development, outreach, audits, appliance pick-up etc.	
Outcomes	This space usually contains a list of outputs for each activity such as brochures mailed, appointments scheduled, audits completed, etc.	
With whom	Partners and allies are usefully identified here	
For whom	The targets of the activities are identified here. Examples, are engineering firms, trade allies, households, large retail chains, etc.	
Short-term and intermediate outcomes	The immediate and near term attitudinal and behavioral responses of partners, allies, and target audiences to the program activities are identified here. Examples are becoming aware, finding more information, discussing with friends and colleagues, deciding to act, signing up for the program, signing a contract with a contractor, etc. These results provide the logical link between activities and long-term results.	
Long-term outcomes / impacts	The long term results (impacts) of the activities are identified here. For energy and climate change programs these are typically kW and kWh saved, and emissions reduced, but they could also be long-term behavioral changes, cultural change and other results.	

Figure 1 A Template for Logic Model Development

The Fundamental Problem — Connecting Outputs to Outcomes and Impacts

Typically federal programs are very good at accounting for their activities and the outputs of their activities. A quick perusal of agency and program annual reports will usually reveal a myriad of statistics about publications produced, publications distributed, software developed, software distributed, training developed, numbers of government workers trained, etc. The more difficult problem is connecting these activities to short and intermediate outcomes and demonstrating that they produce the long-term outcomes or impacts.

There are two key issues. For an agency such as EERE whose mission is to help reduce energy use and increase the availability of renewable energy, there is constant pressure to translate activities into estimates of energy saved or renewable resources acquired. But in many instances, the savings and the acquisition of renewable resources may not occur for some years. It is difficult to link activities and impacts through the mists of time.

The second problem is that EERE programs operate in an environment where there are many other forces at work that influence the demand for energy efficiency and renewable energy. There are utility efficiency programs, public goods charge programs, state organizations, various public interest groups, as well as voluntary organizations promoting efficiency and renewable goals. Certain business groups, for example, the World Business Council for Sustainable Development, that see their interests aligned with energy efficiency and renewable energy are influencing the rate of adoption of energy efficiency and renewable energy as well. From a performance perspective, there must be demonstrable savings that are separable from other public and private efforts and that are attributable to the program. Otherwise, it is difficult justify a program's activities.

The Role of Logic Modeling

An important problem is articulating the short and intermediate term outcomes so that the linkages between activities and long-term outcomes or impacts are clear. It is possible to trace the influence of program activities and outcomes to partner and stakeholders outcomes, and then to demonstrate that target audience behaviors lead to savings that are linked to the program.

Logic modeling can be used to identify the short-term and intermediate outcomes but it requires that the modeler figure out what those outcomes may be. Often this is not easy. In effect, the modeler is required to develop a hypothesis describing how the target recipient(s) will respond. This takes some knowledge of the target audience and some understanding of social theory. Program implementers and evaluators are not always well equipped to handle this task.

Reed, Jordan, and Vine (2007) attempted to address this problem by introducing two innovations to the modeling process. The first was to point out that energy efficiency and renewable energy programs typically address four domains:

- Knowledge (laboratories, universities, consultants, media specialists, web developers, ect.)
- Policy Makers and public entities (regulatory commissions, legislatures, state energy officials, public goods charge officials, community organizations, agricultural extension service, etc.)
- Manufacturers and businesses (materials suppliers, product manufacturers, distributors/wholesalers, retailers, builders, architects, engineering consultants, etc.)
- Energy end-users (householders, commercial building owners, tenants, industrial facilities,

When developing a model of program influence it is useful to explore each of these domains to understand whom the partners, allies, and target audiences may be. Some or all may play a role and those roles need to be understood. When introduced to the idea of domains, implementers have frequently identified additional players that they had failed to consider.

The second innovation was to employ a theory of change, diffusion of innovations (Rogers 2003), to assist in understanding how each of the players might respond to a program. Roger's theory has five major elements. There is the ***diffusion process*** composed of five stages, awareness, information gathering and analysis, decision-making, implementation and confirmation that people/organizations follow when adopting something new. Diffusion occurs within a ***socio-cultural environment and in particular the market*** environment that may support or impede diffusion. It is therefore important to understand the environment. ***Communication*** occurs through broadcast or contagion processes and the process may be quicker or slower depending on which communication processes are invoked. There are ***adopter and other personality characteristics***, innovators, early adopters, early majority, late majority, and laggards, which may encourage or impede diffusion. And finally, the ***product characteristics***: relative advantage, complexity, compatibility, trialability, and observability, which help to define level of acceptance of a technology or concept.

Employing the domain concept and diffusion of innovations theory increases the likelihood that a more adequate logic model for a program will be developed.

The Methods Employed to Develop the Logic Models

A brief word about the methods for the developing the logic models is in order. The development of logic models requires the engagement of program personnel. In the case the Industrial Technology Deployment Logic Model, model development was initiated with a discussion/interview with the program managers followed by a review of program materials and multiple brainstorming sessions with program personnel. The outline of a model was constructed during one of the brainstorming sessions. Development of the draft model was then completed off-line. The model was reviewed by the program managers who suggested a number of changes. This was followed by a presentation to program staff who suggested additional changes.

The Regional Combined Heat and Power Application Center model followed a somewhat different development trajectory. The participants in the CHP modeling exercise had previously attempted to develop a set of performance measurements. After encountering some difficulties, they sought assistance to develop a logic model. The model was developed during three half-day sessions. In the initial session, logic modeling concepts, the concept of domains, and the theory of diffusion of innovation were introduced. The participants were able to immediately begin parsing their earlier work using these concepts. The model was fleshed out off-line and the participants met a second time to critique the revised model that then underwent further revisions. At a third session, the participants were able to refine the details especially with respect to the outcome space.

The FEMP model had a completely different development cycle. After a review of existing documents, the model development team conducted one-hour interviews with approximately 20 people. A preliminary model was developed on the basis of that input. The model was then presented to selected personnel who provided additional guidance especially with respect to language. The model was then presented to the staff in a public meeting. Subsequent to the meeting the model was posted in a hall way and staff were invited to use sticky notes to post comments on the model. Revisions were made to the model and a final round of input was sought from program managers.

There are two important points with respect to methods used. First, the development of the models was contingent on easy accessibility to program staff. Second, staff participation was key to both the development and acceptance of the model. The model development was well received in all three cases.

An Industrial Technology Deployment Logic Model

EERE's Industrial Program is multifaceted. One part of the Industrial Program, the Industrial Technology Deployment Program (ITDP), is responsible for deployment of efficient industrial technologies and practices to industry. The activities of ITDP have changed since this model was first developed but it is still instructive to consider the model.

The Industrial Technology Deployment Program:

- ***Analyzes*** the market and its own activities and plans content and tactics
- ***Creates knowledge resources*** such as publications, software, a call center, websites, protocols, trained specialists and other information and information delivery channels for experts and end-users and to support training and delivery
- ***Creates partnerships*** to extend its resources
- ***Conducts outreach*** through ESA teams, Industrial Assessment Centers, Manufacturing Extension Partnerships, utilities, websites and other
- ***Conducts training*** for ESA specialists, plant personnel, students at Industrial Assessment Centers, consultants, plant personnel and others
- ***Delivers practices and technology*** through Energy Saving Assessments, the EERE Information Center, IAC assessments, Manufacturing Extension Partnerships and EPACT agreements and financing
- ***Tracks, evaluates and reports***

ITDP activities produce a large number of outputs such as software downloads, publications, trained personnel, and industrial plant assessments. ITDP's activities are especially designed to motivate industrial firms to take specific steps to increase energy efficiency, reduce energy intensity, and repeat those steps. Additionally, the activities are intended to train, inform, and provide hands on experience to inculcate efficiency knowledge, an efficiency ethic, and motivate plant personnel, consultants, student engineers, qualified specialists, utility personnel and others to use efficient technology and practices.

ITDP outputs generate direct and indirect outcomes. Examples of direct outcomes are recommendations from savings assessments or IAC assessments that are implemented; decisions to act and measures implemented in response to the use of the call center, software, publications, or the website; changes in consultant behaviors in response to training they receive; changes to technology or practices in response to training; decisions to invest in equipment or process changes resulting directly from the program; and energy savings resulting from any of the preceding activities.

With more than 200,000 manufacturing plants in the industrial sector, the ITDP program will never have sufficient resources to directly touch every plant or every firm. Indirect outcomes arise from replication, spillover, emulation, and sustained behaviors. The largest portion of the savings produced by the program are likely to come from direct participants who replicate what they learn in their own plants and other facilities that they own. Substantial savings will also come from spillover, using other services, or undertaking other efficiency related activities as a result of the initial activities. Substantial savings will result from non-participants observing and emulating the actions of participants. And finally, savings will accrue from participants who sustain their behaviors by embedding the efficient behaviors and the concepts underlying the behaviors into their corporate culture.

The savings stream from installing an efficient technology may continue over a 5, 10, or even 15 or more year technology lifetime. The lifetime is bounded either by the physical lifetime of the technology, the introduction of a replacement technology, or the closure of the system. Future savings need to be adjusted for technological persistence factor, that is, by the amount of degradation in the efficiency of the components that are installed or for reversion to less efficient components.

The current and future savings are also influenced by behavior. Behavior may have a much greater impact on changes in savings than mechanical degradation. Improper commissioning, failure to re-commission, improper maintenance, failure to train employees either initially or when new employees are introduced to the system, can all contribute to reduced savings, no savings and even increased consumption. These factors need to be considered in estimating the cumulative savings from industrial efficiency projects. In a recent evaluation of an highly regarded industrial program, equipment for 20 percent of the projects was

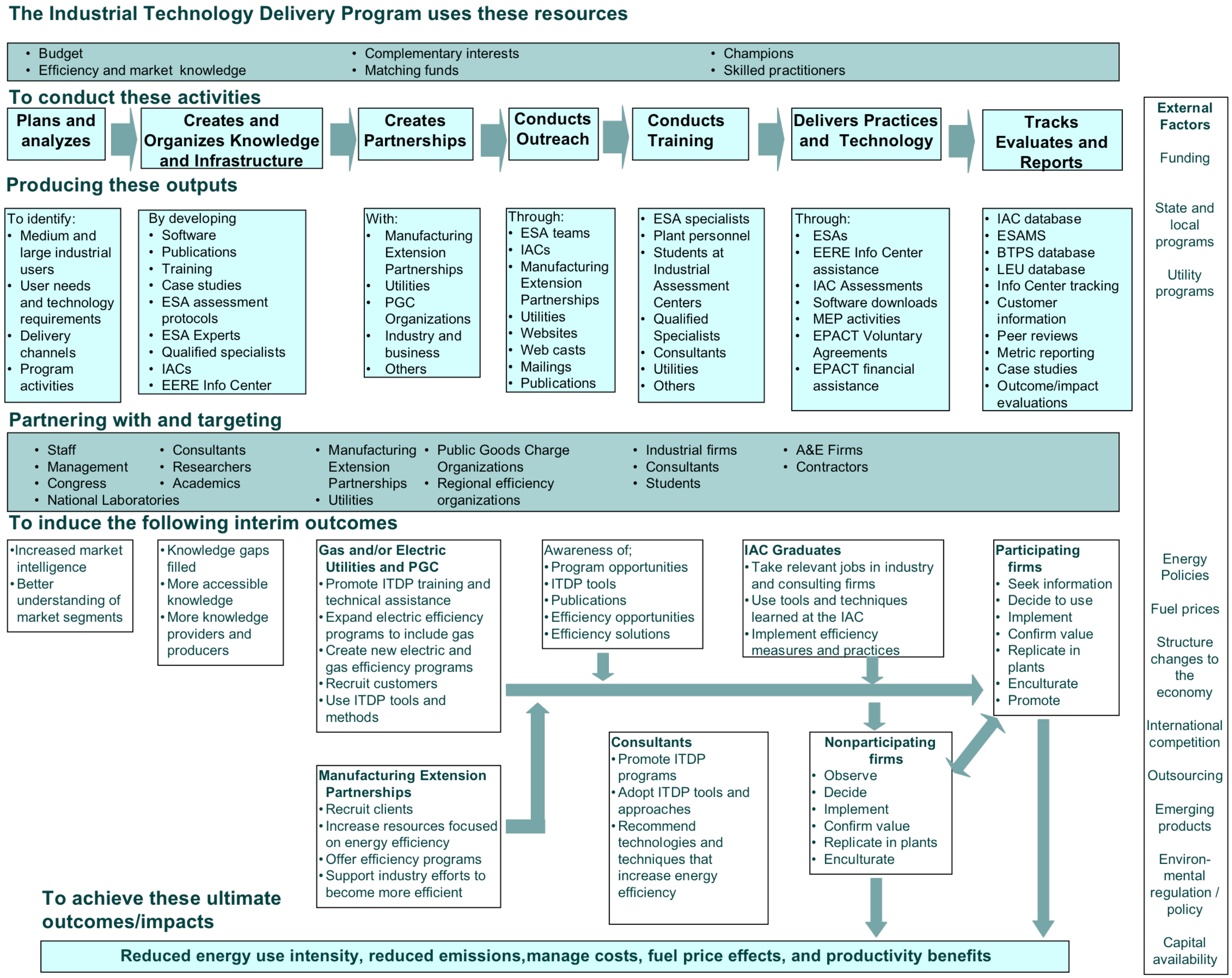

Figure 2. Industrial Technologies Delivery Program Logic Model

not initially commissioned properly. This program requires commissioning and final inspection so these units were commissioned properly before being placed into service. In less well-run programs, the initial rates might be substantially higher and equipment not commissioned.

Finally, savings have to be adjusted to account for whether or not measures were implemented in the absence of the program. In a recent evaluation of an industrial program (not the EERE industrial program) about 67 percent of the respondents said that they would have definitely (11 percent) or probably have (56 percent) done the upgrade without the program. If the measures were implemented without the program, no savings can be claimed. If the measures would have been implemented but the implementation accelerated the schedule then the savings can be counted for the amount of time by which the measures were accelerated. In the above referenced program, nearly half of the respondents said that the program accelerated the upgrade by a median of 10 months. The outcome space in this model makes use of the diffusion of innovations theory. For example, the stages of diffusion — awareness, persuasion, decision, implementation and confirmation — are clearly visible in the boxes representing participating and nonparticipating firms. These stages are less apparent for some of the other players such as IAC graduates, consultants, MES partnerships and others but could be easily elaborated for them. This was not done because this model was created before the evaluation framework, discussed in the earlier section, was fully developed. The arrows also represent some of the social network influences that one might expect. For example, nonparticipants, especially among the early and late majority might emulate the participants.

Combined Heat & Power Application Center Logic Model

EERE supports a number of Regional Combined Heat and Power Application Centers. The purpose of these centers is to assist organizations to locate, design, and implement economically viable distributed energy projects that make appropriate use of recoverable waste heat. Like many other EERE related organizations, the regional centers are faced with the problem of demonstrating that they are performing satisfactorily in the absence of energy savings that only occur when steel is in the ground three to five years out. The centers were attempting to develop a set of performance indicators that could be used to demonstrate progress. After an initial attempt to brainstorm a set of indicators, the group responsible for developing the performance indicators decided that a more systematic approach was needed and decided to develop a logic model that could then be used to identify performance measures.

The logic model that was developed is too detailed to display in this paper. Those interested in the model can view the model on-line.[2]

The model identifies seven key activities: planning and analysis, collaboration development, information development, outreach and awareness building, education, technical assistance and project support, and tracking and evaluation. This provided a framework into which many of the outputs identified during the brainstorming could be placed. For each of these activities the group identified seven to ten outputs. They also developed lists of partners, allies, and target audiences representing the four domains described earlier.

Initially, there was some struggle with the concepts of output and outcomes but it wasn't long before the group was able to place the outputs and outcomes from the brainstorming in the right categories.

When the group got to the outcomes section, they developed outcomes for three of the four domains. For the public entities domain, they developed outcomes for policy makers and regulatory agencies. For the business community, they developed outcomes for investor owned utilities, municipal and co-operative utilities, financiers, and developers. The group did not differentiate among end-users choosing instead to developing just one set of outcomes.

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[2] www.evalframework.org/logicmodels

A notable part of the model development activity was the use of the diffusion process model. The group quickly grasped the concepts of awareness, persuasion/information, decision, implementation, and confirmation. They used these concepts to identify outcomes for each set of actors within each of the three domains.

Figure 3 shows the set of outcomes that were generated for financiers. Note the feedback arrows within the process. The group also included a feedback loop among the actors in the three domains representing the interactions among the actors in the different domains.

The outcomes for the financiers can quickly be translated to usable performance measures.

- The number of financial firms aware of CHP
- The number of financial firms exploring CHP
- The amount of capital that is available for CHP
- The amount of capital committed to CHP projects
- The number of firms continuing to invest
- The number of firms undertaking additional projects

A key point is that if the measures are tracked through time and if the actions of the financial firms can be tracked to the activities of the application centers, the application centers can demonstrate that they are having an effect. Further, by looking across the sets of actors in the different domains, they can assess where they are having an effect and where their efforts may need to be reinforced or dropped.

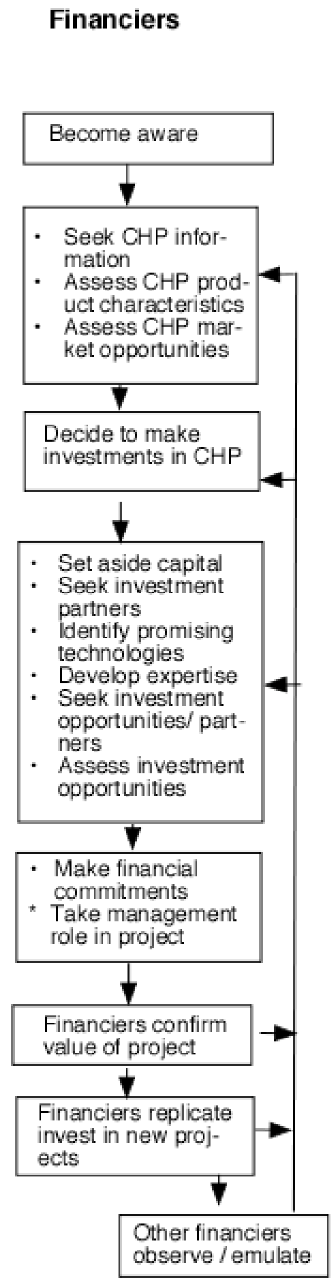

Figure 3 Outcomes for Financiers in CHP Logic Model

Federal Energy Management Program Logic Model

The Federal Energy Management Program (FEMP) provides assistance through project transactions, applied technology, and decision support services for the facilitation and implementation of cost effective energy management and investment practices to enhance the nation's energy security and environmental stewardship.

FEMP is a complex program that:

- Provides assistance to Federal facility managers purchasing and implementing renewable energy technologies including the design, operation, and maintenance of the technologies in Federal buildings.
- Develops and provides guidance to help Federal agencies to meet reporting requirements including those for facilities and fleets
- Develops and provides resources including publications, analytical reference tools for calculating water and energy consumption, hosting conferences and meetings to help managers learn more about energy efficiency and renewable energy, and providing a glossary of terminologies associated with energy management. It also provides information about energy efficient products, renewable energy, distributed generation, and combined heat and power technologies, and gives recommendations for energy smart technologies.
- Helps Federal facility managers decide how to fund energy improvements through energy savings performance contracts, utility energy service contracts, incentive programs, or a combination.

FEMP assists Federal agencies but the agencies determine what they are going to do about energy efficiency and how they will meet Federal requirements.

Like the regional CHP Application center model, the FEMP model is too detailed to include in this paper. However, it can be viewed at www.evalframework.org/logicmodels.

One of the challenges with the FEMP logic models was and continues to be the very large number of activities. At least for the initial model, it was not possible to reduce that number of activities to less than ten. Thus, the technical assistance and implementation activities, of which there are many, were grouped under the headings of TEAM, financing programs, and technology services.

The FEMP logic model proved to be important because it is one of the few attempts to systematically describe the historic, current and future scope of the program. It demonstrates how extensive the FEMP portfolio is. Because of this, no further attempt will be made to describe the model in this paper.

The development of this model reinforces the utility of using the diffusion of innovations theory in model development. The diffusion process model provided a systematic way to identify outcomes for each of the numerous activities. Without the process model, it would have been very difficult to develop a systematic set of outcomes.

Figure 4 shows the outcomes for two FEMP Technology Service activities: operations and maintenance best practices and metering. Historically FEMP has attempted to encourage operations and maintenance best practices by developing guidance, conducting pilots, providing case studies and other activities. Federal Agencies are now mandated to install metering at the building rather than the site level. To this end, FEMP has developed guidance, provided seminars and workshops, conducted pilots and case studies, and generally promoted metering best practices. The issues are ongoing and it essential to understand the progress and the effects of FEMP's efforts within agencies.

Figure 4 also displays the difference between short-term and intermediate outcomes. The boxes near the top present the traditional diffusion process stages of awareness, knowledge and persuasion, decision, etc as applied to operations and maintenance and metering. The boxes at the bottom represent intermediate outcomes or the potential results of the short-term outcomes. For example, as a result of installing the metering it is possible to know the energy consumption of buildings and to benchmark them. In turn, this can lead to a prioritization of buildings needing attention and the effective use of conservation dollars. In turn, this can lead to sustained efficient operation of buildings

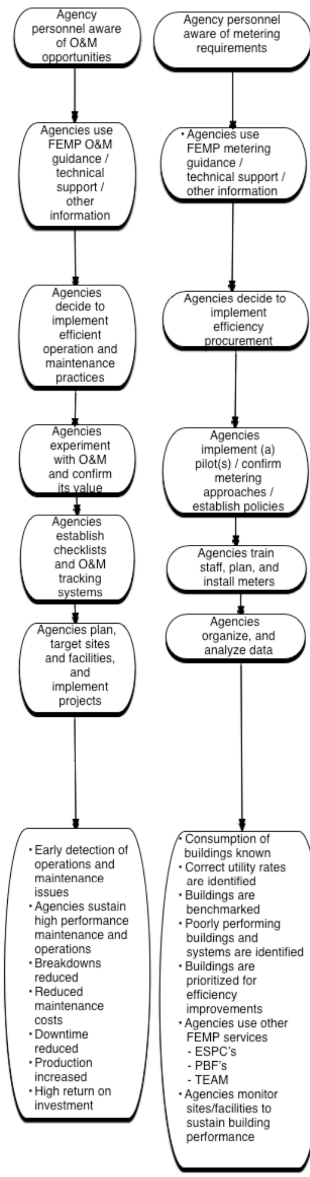

Figure 4, Outcomes for Operations and Maintenance and Metering from FEMP Logic Model

Summary and Conclusions

Generally, we think of logic models in terms of their use with single purpose programs such as a refrigerator recycling program. This paper illustrates the development of detailed logic models for complex multi-faceted programs. The paper also illustrates the importance of focusing on outcomes, especially short-term and intermediate outcomes. As well, the paper demonstrates the use of the concept of domains and the theory of diffusion of innovation to aid in the systematic development of the logic models.

This approach has been used to develop a strategic evaluation plan for the Industrial Technologies Delivery Program, performance measures for the Regional Combined Heat and Power Applications Centers, and a strategic evaluation plan for FEMP. In each case, the approach enabled the implementers to create models of the effects of their activities that were more detailed and systematic than would have been the case without the models. The models also helped some personnel to better understand the scope of their activity and led to discussions about changes in the program structure. Ultimately, the goal of such models is to develop a more systematic understanding of programs and to facilitate the development of a smaller more focused set of performance measures that more broadly capture program outcomes.

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