Chapter 2
Technology Assessment: Energy Efficiency Programs in Pacific Northwest

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Abstract This chapter introduces a hierarchical decision modeling framework for energy efficiency program planning in electric utilities. The proposed approach focuses on assessment of emerging energy efficiency technologies and is proposed to bridge the gap between technology screening and cost/benefit evaluation practices. The proposed approach is expected to identify emerging technology alternatives, which have the highest potential to pass cost/benefit ratio testing procedures, and contribute to effectiveness of decision practices in energy efficiency program planning. Proposed framework also incorporates a sensitivity analysis for testing the robustness of decisions under varying scenarios in an attempt to enable more informed decision-making practices. Proposed framework was applied for the case of Northwest USA, and results of the case application and future research initiatives are presented.

2.1 Introduction

Nature of resource planning has changed dramatically since 1970s due to increased diversity in resource options such as renewable alternatives, demand-side management (DSM), cogeneration of heat and power (CHP) in industrial applications, and deregulation of the energy market. New objectives have been added to the utilities' decision-making processes beyond cost minimization, requiring utilities to address environmental and social issues that may emerge as a result of their operations [1]. Moreover, rapidly changing business conditions caused by technological

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development, instability in fuel markets, and government regulations have significantly increased complexity of and uncertainty involved in utility decision-making practices.

Prior to 1970s, utilities' main strategy in meeting increasing demand mostly consisted of capacity extensions; however due to increasing marginal cost of generation this approach was abandoned and replaced with more efficient use of existing resources. As a result, DSM initiatives were considered as a resource and a part of integrated resource plans. DSM programs have been widely utilized to meet increasing demand until the mid-1990s when the oil prices were again at a relatively lower level. Until this point, electric utilities were required to prove cost-effectiveness of DSM programs within certain definitions imposed by the Public Utilities Commission. These definitions were primarily set in order to ensure that proposed programs would recover cost of investments from a number of stakeholder perspectives. After reduction of oil prices and restructuring of electricity markets in 1990s, new approaches for justifying cost-effectiveness of DSM programs emerged. For instance, feasibility of DSM programs was evaluated by accounting for market externalities that had not been taken into consideration by the preceding assessment approaches. Inclusion of social and environmental externalities led recognition of societal and environmental perspectives which eventually enabled a large number of energy efficiency programs, which were previously infeasible, to be feasible [2]. Although DSM programs have often been characterized as being part of integrated resource planning, their value as a resource has not reached to its full potential due to a number of reasons discussed in the barriers literature.

2.2 Background

A review of existing energy efficiency program management practices reveals that there are four major components associated with energy efficiency program evaluation and deployment. These are program screening, evaluation, characterization, and deployment. Aforementioned process starts with screening of energy efficiency technologies, which have savings potential for a given case. Criteria for screening practices are mostly technical considerations. Following the screening phase, candidate technology applications are defined and evaluated based on their potential benefits. Evaluation phase mostly employs multiple perspectives considering technical, economical, and environmental impacts. Those technology applications, which pass evaluation phase, are moved to characterization phase where field tests are conducted for quantification of costs and benefits associated with them. Based on the quantified data cost/benefit ratio tests are conducted, reimbursement levels are determined for specified cases. Lessons learned are documented and used as input for creating measure implementation procedures for ensuring reliable energy savings. Those measures, which pass cost/benefit ratio tests, are moved to deployment phase where energy efficiency measures are officially released and marketed through various channels.

Energy efficiency has been traditionally a significant part of Pacific Northwest's energy portfolio and its increasing contribution is expected to continue in the future. In the last 30 years, energy conservation programs in the Pacific Northwest have achieved 4,000 average megawatts of electricity savings, meeting the half of the region's demand growth between 1980 and 2008. Conserved amount of electricity is expressed as being enough to power the states of Idaho, Western Montana, and city of Eugene for 1 year, avoiding 8–10 new coal- or gas-fired power plants and saving ratepayers $1.8 billion. Energy efficiency savings have been contributing to the region's power system in a number of ways by keeping electricity rates low, avoiding new construction projects, reducing environmental footprint, and contributing to regional economic growth. Recent increases in cost of energy resources, increasing electricity demand and straining the limits of the existing power system, potential carbon policies have increased the importance of energy conservation more than ever before. Accordingly, region's resource plan demands 80 % of the load growth in the next 20 years to be met by energy efficiency efforts.

Management of technology has been critical to Northwest's historical success in utilizing energy efficiency as a resource. It has been asserted that many of today's successfully diffused energy efficiency technologies, compact fluorescent lamps (CFLs), resource-efficient cloth washers, super-efficient windows, and premium efficiency motors, were results of research projects initiated in the 1980s and 1990s. Due to deregulations taken place in mid-1990s, utility-driven technology development efforts have halted significantly and its impacts are felt today in a way that there is no portfolio of technologies that can enable significant savings potential for the future. In order to meet the aggressive energy efficiency goals of Pacific Northwest's public power, investor-owned utilities and other energy efficiency organizations have restarted technology management initiatives in 2008.

Considering its background in energy efficiency investments and future plans, Pacific Northwest USA has been identified as a potential case application for this chapter.

2.3 Research Methodology

Methodology employed in this research is hierarchical decision modeling (HDM), which is one of the widely used multi-variable decision-making methodologies. HDM breaks down complex decision problems into smaller subproblems and provides decision makers a systematic way to evaluate multiple decision alternatives. HDM can be used for decision analysis problems with multiple stakeholders and provides basis for group decision making. Its ability to make use of qualitative and quantitative decision variables makes it very flexible and applicable to a wide range of application areas. For instance, HDM has been applied in a number of energy-related applications such as policy development and analysis [3, 4], electricity generation planning [5, 6], technology evaluation [7–11], R&D portfolio management [12], site selection [13, 14], integrated resource planning [15–18], evaluation of DSM implementation strategies [19, 20], evaluation of lighting efficiency measures [21], and prioritization of energy efficiency barriers in SMEs [22]. Further information about the mechanics of the methodology can be obtained from studies published by Dundar F. Kocaoglu and Thomas L. Saaty, who are the leading contributors to development of this methodology.

Case application of this research consisted of multiple phases, which include model development, model validation, and data collection. In the following sections you will be provided with further detail on aforementioned phases.

Model development process was initiated by constructing a preliminary assessment model based on findings from a comprehensive literature review on energy efficiency program assessment. It was observed that energy efficiency programs are utilized to accomplish a number of power system objectives and goals. Parallel to that a large body of assessment literature was observed to utilize utility objectives and goals as a measure for evaluation purposes. See Table 2.1 below for breakdown of the current literature with respect to assessment perspectives, utility objectives, and goals.

Preliminary assessment model was presented to a group of five experts, whose participants had at least 15+ years of experience in the area of emerging energy efficiency technologies. Based on the focus group feedback it was observed that the preliminary model would be suitable for post-evaluation of energy efficiency programs at government level. However, for the case of emerging energy efficiency programs it was emphasized that it would be difficult for experts to provide judgment for each utility value stream due to lack of data and complexity of the system. It was further noted that value of programs varies depending on different parts of the system; thus it would be difficult for experts to account for all sub-systems and come up with a value for the whole system. Accordingly, use of variables that could combine all value streams was suggested being more practical and accurate. Another important suggestion referred to the notion that program selection should not be limited to value potential only, but also address program development and market diffusion considerations. Within the evaluation of value streams, it was communicated that non-energy savings are important, and however should be separated from energy savings. Based on the focus group feedback preliminary model was revised.

Total of 26 subject matter experts with various backgrounds, 15 utility, 7 nonprofit organization, 2 research lab, 1 university, and 1 consulting, and positions participated in judgment quantification process. Experts had experience in the areas of management, planning, engineering, and economics. A large number of energy efficiency organizations, 5 utilities, 4 nonprofit organizations, 2 research labs, 1 university, and 1 consulting company, from the Pacific Northwest region were represented.

Judgment quantification was conducted through six expert panels, which were focused on quantifying different parts of the assessment model. Each panel required different types of expertise and experts were assigned to panels accordingly. See Table 2.2 below for focus of each expert panel and required expertise.

Judgment quantifications for panels 1 through 5 were performed by using pairwise comparison method. Response with inconsistencies greater than a predetermined threshold value was communicated back to its owner for further

Table 2.1 Taxonomy of energy efficiency program assessment literature

Objectives	Goals	References
Promoting regional development	Creating or retaining job opportunities	[15, 16, 21, 23, 24]
	Keeping local industry competitive	[16, 21, 23, 24]
	Improving life standards (non-energy benefits)	[16, 21, 24–26]
Reducing environmental impacts	Reducing GHG emissions	[15, 16, 21, 24–32]
	Reducing emission of soil, air, and water contaminants	[15, 16, 21, 23–28, 30]
	Avoiding flora and fauna habitat loss	[15, 16, 24, 30]
Increasing operating flexibility and reliability	Reducing need for critical resources	[15, 16, 21, 23, 24, 26–30, 32–39]
	Increasing power system reliability	[15, 16, 21, 24, 28–30, 32, 33, 36, 37, 39, 40]
	Increasing transmission and distribution system reliability	[15, 16, 21, 24, 28–30, 32, 33, 36–42]
Reducing system cost	Reducing/postponing capital investments	[15, 16, 21, 23–31, 34, 35, 37, 38, 42–45]
	Reducing operating costs	[15, 16, 21, 23, 24, 26, 27, 29–32, 34, 35, 37, 42, 45]
Reducing adverse effects on public	Avoiding noise and odor	[16, 24]
	Avoiding visual impacts	[16, 24]
	Avoiding property damage and impact on lifestyles	[16, 21, 24, 25]

Table 2.2 Focus and required expertise per expert panel

Panels	Focus	Required expertise
Panel 1	Energy efficiency program management considerations	Executive management
Panel 2	Variables under energy savings potential	Program planning and evaluation
Panel 3	Variables under ancillary benefits potential	Program planning and evaluation, market transformation
Panel 4	Variables under program development and implementation potential	Project and program management, measurement and verification
Panel 5	Variables under market dissemination potential	Market research and market transformation

treatment. Expert panels with disagreements greater than a predetermined threshold value were further analyzed. Subgroups with similar opinions were identified by using hierarchical clustering method. Rank order analysis was conducted for identified subgroups in order to determine whether differences in opinions would have significant impact on end results. All experts demonstrated acceptable degree of consistency in their judgments; however there were significant group disagreements in panels 2 and 3.

2.4 Results and Data Analysis

Results and data analysis section is divided into three major threads. Synthesis of priorities section provides relative importance of model variables and decision alternatives derived from aggregation of expert judgments. The following section provides results of rank order analysis based on expert disagreements that were identified. Finally, sensitivity analysis section provides allowable perturbations on relative importance of program management considerations before a given incumbent program alternative would lose its current ranking to a given challenger program alternative. Based on panel results, synthesis of priorities is calculated for different levels of the decision hierarchy. For instance, relative importance of sub-factors with respect to mission, relative importance of program alternatives with respect to program management considerations, and overall importance of decision alternatives with respect to mission are presented in this section. See Fig. 2.1 below for overall importance of model variables with respect to mission.

Peak savings potential (0.166), base load (off-peak) savings potential (0.146), and end-use adoption potential (0.115) are the highest; whereas equity considerations (0.021), promotion of regional development (0.026), ease of compliance with codes and standards (0.039), and reduction of environmental footprint (0.039) are the lowest weighted sub-factors. The rest of the sub-factors, direct impact on power system operations (0.075), intensity of market barriers and availability of leverage points (0.074), ease of savings measurement and verification (0.070), supply chain acceptance potential (0.068), ease of measure deployment (0.061), ease of maintaining measure persistence (0.055), and degree of rebound effects (0.044), have relatively closer weights.

2.5 Conclusions

Energy efficiency program planning is performed considering long-term needs, which may be up to 20 years of time horizon. Since planning periods are significantly long, it is very likely that priorities will change in an attempt to adapt to new business environments. This research approach integrated a sensitivity analysis with the assessment model and enabled decision makers to observe how optimum decisions could change in different future scenarios. Integration of sensitivity analysis through the proposed approach was observed to provide decision makers more insight, enabling better decision-making practices.

Overall, proposed improvements contributed to existing level of knowledge by enabling a more accurate energy efficiency program evaluation and planning approach that can provide better understanding of the potential implications of the strategic decisions.

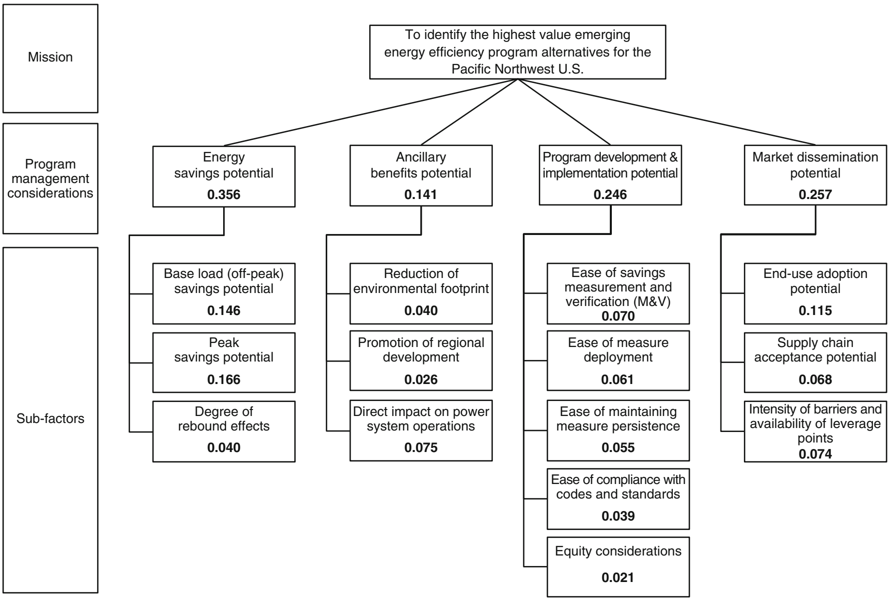

Fig. 2.1 Overall importance of model variables with respect to mission

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