Integrated Impact and Market Evaluation of Multiple Residential Programs at Florida Power and Light

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Florida Power & Light Co. (FPL) is undertaking large-scale, comprehensive evaluations of its eight major residential DSM programs. Combined participation in these programs is over 200,000 customers, with expected load reduction of over 99 MW and energy savings of greater than 58,000 MWh in 1993. These programs range from an HVAC program to a load management program. This "mega-evaluation" is simultaneously conducting the process, impact, and market evaluations for all programs to ensure a systematic and consistent assessment of DSM activity in the residential sector.

We will present how this *sectorial* evaluation's integrated impact, process, and market evaluation results have been developed to enhance the performance of FPL's individual residential programs. By conducting evaluations of FPL's individual DSM programs in a consistent manner, performance comparisons across programs can be made in a systematic fashion. These comparisons are robust because the evaluation methods produced "oranges and oranges" (it's Florida, after all) for each program, not "apples and oranges" as is usually the case. For example, a sectorial evaluation approach required accounting for multiple program participants consistently. By using these integrated results, individual program managers can modify specific program features that include a target marketing approach, program incentives, and new measures that address the needs of specific customer segments.

Introduction

The integration of impact, market and process evaluation methods and results across programs is the primary focus of this study. The six FPL residential programs that were evaluated included four general types of building Envelope programs, where ceiling insulation, window treatment, water-heating, duct testing/repair and shell measures were provided and analyzed separately [these programs are identified as Building Envelope I through IV], and two types of space conditioning programs, where central air conditioners and heat pump components were analyzed separately. The load management program was also analyzed separately, but is not discussed in this paper.

The paper begins with a discussion of FPL's residential DSM evaluation goals and objectives, presented in the context of FPL's corporate DSM goal. The selection of evaluation methods is then discussed. Next, impact evaluation results are presented so that cross program comparisons can be made. Market evaluation results are combined with impact results to identify key program components expected to deliver significant impacts in the future. The effects of the programs on participants' perceptions of the quality of service offered by FPL, as well as a comparison of the perceived quality of the programs evaluated, are then presented. The remainder of the paper concentrates on one key program, the HVAC I program, determined to be crucial from a resource planning perspective.

Evaluation Goals and Objectives

Evaluation goals and objectives illustrated in Figure 1 follow directly from FPL's overall corporate DSM goal, which is: "To assist in developing DSM as a viable component of FPL's integrated resource portfolio." Meeting this goal supports the objectives of three FPL departments, which can be summarized as follows: (1) Marketing-maximize DSM program efficiency; (2) System Planning-ensure that all DSM programs implemented are cost effective; and (3) Regulatory Affairs—meet the regulatory requirements necessary to ensure allowable DSM program cost recovery and return on investment.

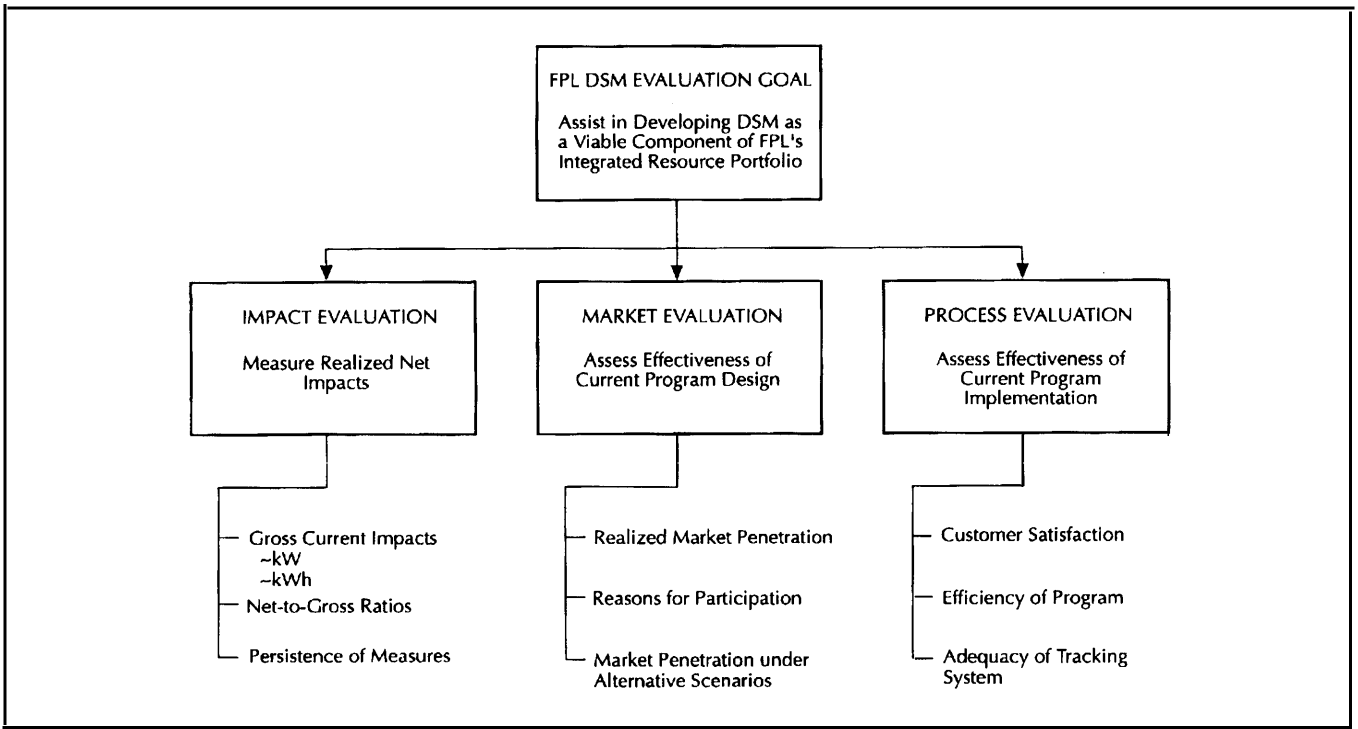

Figure 1. FPL DSM Program Evaluation Goals and Objectives

As shown, the objectives of FPL's impact, market and process evaluation are as follows: (1) impact evaluation—measure realized gross and net program impacts; (2) market evaluation-assess the effectiveness of program design in providing the most cost-effective DSM resources possible; (3) process evaluation—assess the effectiveness of the program delivery mechanism in providing cost-effective DSM resources in a manner that optimizes customer satisfaction. The residential programs' evaluations were undertaken with these objectives in mind.

Evaluation Method Selection

In order to properly compare evaluation results across each of FPL's residential conservation programs, a systematic procedure was used to select the evaluation methods used for each program, to determine what data to collect and to implement analysis activities. This section describes this procedure, with an emphasis on selection of the impact evaluation methods.

For each program, a general nine-step method for implementing impact evaluations was implemented with three analysis approach options. Figure 2 illustrates each of the steps and the options as they apply to FPL's residential programs.

There were three types of generic impact evaluation approaches available. Selection of the approach arose from assessment of the program type, expected program characteristics (e. g., number of participants, relative size of per participant impact, on-peak versus off-peak impact, and impacts attributable to measures with high or low saturation), and required relative accuracy for measuring impacts. In Figure 2, this selection is shown in the first row, labeled "Analysis Approach." The characteristics of the approaches used for FPL are as follows:

Analysis Approach 1 was used for programs that require impacts to be estimated with low relative accuracy. These programs typically have low impacts, measures that are of lower complexity, and measures with constant load. FPL's Building Envelope III program warranted this approach.

Analysis Approach 2 was used for programs, such as the Building Envelope II Program, that require impacts to be estimated with moderate relative accuracy. These programs typically have medium-sized impacts, or measures that are of medium complexity with variable load.

Analysis Approach 3 was applicable to programs that require impacts to be estimated with high relative accuracy. These programs typically have large impacts, or measures that are complex with variable load. An example of a program that used such an approach is FPL's HVAC I Program.

In general, a characteristic that distinguishes these approaches is the type and level of data collection activity undertaken. In Figure 2, it is only Analysis Approach 3, the high-accuracy approach, that requires end-use load data and site survey data. Having selected the analysis

ANALYSIS APPROACH	1	2	3	
End Use or Program	• Bldg. Env. III • Bldg. Env. IVa	• Bldg. Env. II • Bldg. Env. IVb	• Bldg. Env. I • HVAC I	• Bldg. Env. IVc
Expected Relative Accuracy / Options for Completing Analysis Steps	Low	Moderate	High	
STEP 1 - Specify Customer Segment Prototype and Select Analysis Category				
Program Related Reports	◉	◉	◉	●
Analyze Customer Tracking Data & Participant Information	◉	◉	◉	●
Conduct Staff Interviews	◉	◉	◉	●
STEP 2- Conduct Baseline Assessments				
Literature Reviews	●	●	●	●
Trade Ally Survey	○	○	●	●
Target Market Surveys	○	○	●	●
STEP 3 - Specify Engineering Method				
Engineering Algorithm from Participant Tracking System				
Enhanced Engineering Estimates		◉		
Engineering Simulations	◉		◉	●
STEP 4 - Data Collection				
Follow-up Participant Telephone Surveys (CRS)	●	●	●	●
Post-Impact Participant Telephone Surveys	◉	◉	◉	●
Nonparticipant Surveys	◉	◉	◉	●
Existing Site Surveys (HES)	◉	◉	◉	●
Billing Data	◉	◉	◉	●
Whole Premise Load Data: Existing RLR Sites	◉	◉	◉	●
End-Use Load Data: On Call/ Other Program Component	●	●	◉	●
End-Use Load Data/Site Survey	○	○	●	●

KEY	
◉	Activities Conducted in 1993
●	Additional Activities Planned for the Future
○	Not Planned
	Not Applicable

Figure 2. Systematic Procedure for Evaluation Method Selection and Analysis

approach, we followed a nine-step method for ensuring that cross-program comparisons could be made consistently. These steps are described now.

Step 1 - Specify Customer Segment Protoype and Select Analysis Category. This step consists of analyzing program-related reports, analyzing customer tracking data

End Use or Program	• Bldg. Env. III • Bldg. Env. IVa	• Bldg. Env. II • Bldg. Env. IVb	• Bldg. Env. I • HVAC I	• Bldg. Env. IVc
Options for Completing Analysis Steps / Expected Relative Accuracy	Low	Moderate	High	
STEP 4 - Data Collection (cont.)				
Billing Data	▓●	▓●	▓●	●
Whole Premise Load Data: Existing RLR Sites	▓●	▓●	▓●	●
End-Use Load Data: On Call/ Other Program Component	●	●	▓●	●
End-Use Load Data/Site Survey	○	○	●	●
STEP 5 - HELP Disaggregation				
HELP Disaggregation of Whole-Premise Load Data	▓●	●	▓●	●
STEP 6 -Calibrate Engineering Model				
Limited End-Use Data	▓●	●	▓●	●
Disaggregated Load Data	●	●	●	●
End-Use Load Data/Site Survey	○	○	●	●
STEP 7 - Estimate kWh Realization Rates				
Conduct SAE Billing Analysis	▓●	▓●	▓●	●
STEP 8 - Estimate kW Operating Factors and/or Realization Rates				
Estimate Operating Factors	▓●	●	▓●	●
Conduct SAE Load Analysis	○	○	●	●
STEP 9 - Generalize Integrated Results to all Participants				
Conduct Integrated Analysis	▓●	▓●	▓●	●

KEY	
▓●	Activities Conducted in 1993
●	Additional Activities Planned for the Future
○	Not Planned
	Not Applicable

Figure 2. (contd)

and participant information, and conducting staff interviews. These activities are used develop a customer segmentation and identify which impact analysis approach should be implemented for each segment.

Step 2 - Conduct Baseline Assessments. This step consists of performing literature reviews, trade ally survey and target market surveys. These activities are used to develop a baseline for the program measure. For Analysis Approach 1 and 2, no trade ally or target market surveys were conducted.

Step 3 - Specify Engineering Method. Specifying the engineering method begins with analyzing the engineering algorithms currently used. The next step consists of either enhancing the existing algorithm, or performing separate engineering simulations, such as using DOE-2.

Step 4 - Data Collection. There are eight types of data that can be collected as part of this step, ranging from FPL billing data to program-specific end-use load data.

Step 5 - *HELP Disaggregation.* Residential space conditioning and water heating loads can be disaggregated from the premise-level data available using QC's Heuristic End-Use Load Profiler (HELP™). The disaggregation of whole-premise loads into end-use load profiles has been efficiently carried out for FPL with the heuristic disaggregation software for several of FPL's programs. A description of how the algorithm works is found in Powers, et al. 1992.

Step 6 - *Calibrate Engineering Model.* Engineering models, such as DOE-2 models, can be calibrated using an array of data sources. The most accurate data that can be used to calibrate models is the use of application-specific pre- (if available) and post-treatment billing and end-use metered load data. These data were used for the Analysis Approach 3 evaluations such as the HVAC I program. Other accurate data sources include application-specific disaggregated end-use load data and whole-premise load data. Less accurate data sources include available billing and disaggregated load data.

Step 7 - *Estimate kWh Realization Rates.* Estimating energy impacts and engineering realization rates can be obtained through various methods. The least accurate method would consist of using existing engineering algorithms in performing the impact estimates. A more accurate method would include performing engineering analysis based on calibrated engineering models. The most accurate method entails performing SAE analysis.

Step 8 - Estimate kW Operating Factors and/or Realization Rates. Estimating load impacts, engineering realization rates, and appliance operating factors can be obtained through various methods. The least accurate method would be to use existing engineering algorithms in performing the impact estimates. A more accurate method would be to perform engineering analysis based on calibrated engineering models. Engineering estimates of load impacts can be adjusted for diversity and/or snapback with operating factors and "day type" diversities obtained from the analysis of the available load data to increase accuracy. HVAC I program evaluation used the most accurate methods, SAE load analysis.

Step 9 - Generalize Integrated Results to All Participants. The final analysis step consists of aggregating the per-unit impact results obtained in Steps 7 and 8 across all participants to obtain a program- or segment-level impact estimate. In 1993, this was done for each FPL program except the Building Envelope IVc program.

Impact Evaluation Approach and Results

The 1993 energy (kWh) impacts were estimated using actual participant and nonparticipant billing (energy usage) data, and are more accurate than the demand (kW) impacts, which were all based on ex-ante engineering estimates adjusted for the percentage of units likely to be operating during system peak conditions. In 1994, a significant end-use metering sample will contribute data to the evaluation efforts and significantly enhance the accuracy of the demand impact analysis results.

In the impact evaluation, engineering and statistical analyses are integrated to calculate energy and demand impacts. In the absence of participants' behavioral responses to the program measures (such as occupancy patterns, snapback and free ridership effects) demand impacts were calculated through engineering analysis. The engineering models are used to estimate electricity usage for prototypical residences with usage patterns that are subject only to day-to-day variations in weather. The effects of individual household occupancy patterns are not modeled. That is, the engineering analysis accounts only for the physical, and not behavioral, change in energy usage attributable to program measures.

The statistical billing analysis accounts for variations from the engineering assumptions in the sample. These variations may be a result of participants' occupancy patterns and behavioral responses to program measures (snapback, for example), as well as changes in baseline energy usage, which are controlled through the use of a comparison group of nonparticipants. Load data analysis was used to adjust the engineering-based demand impacts to produce initial estimates of diversified coincident peak demand impacts. Only operating factor adjustments are made for the demand estimates; therefore, variances from the engineering assumptions are not accounted for in the demand impact estimates.

The initial per participant energy impact estimates, aggregated to the program component level, are compared to the pre-evaluation estimates in Figure 3. Ninety percent confidence intervals are included in the seasonal energy impacts to allow for a meaningful comparison to the ex-ante pre-evaluation estimates.

An important advantage shown in Figure 3 is the "oranges and oranges" comparisons of key impact and market

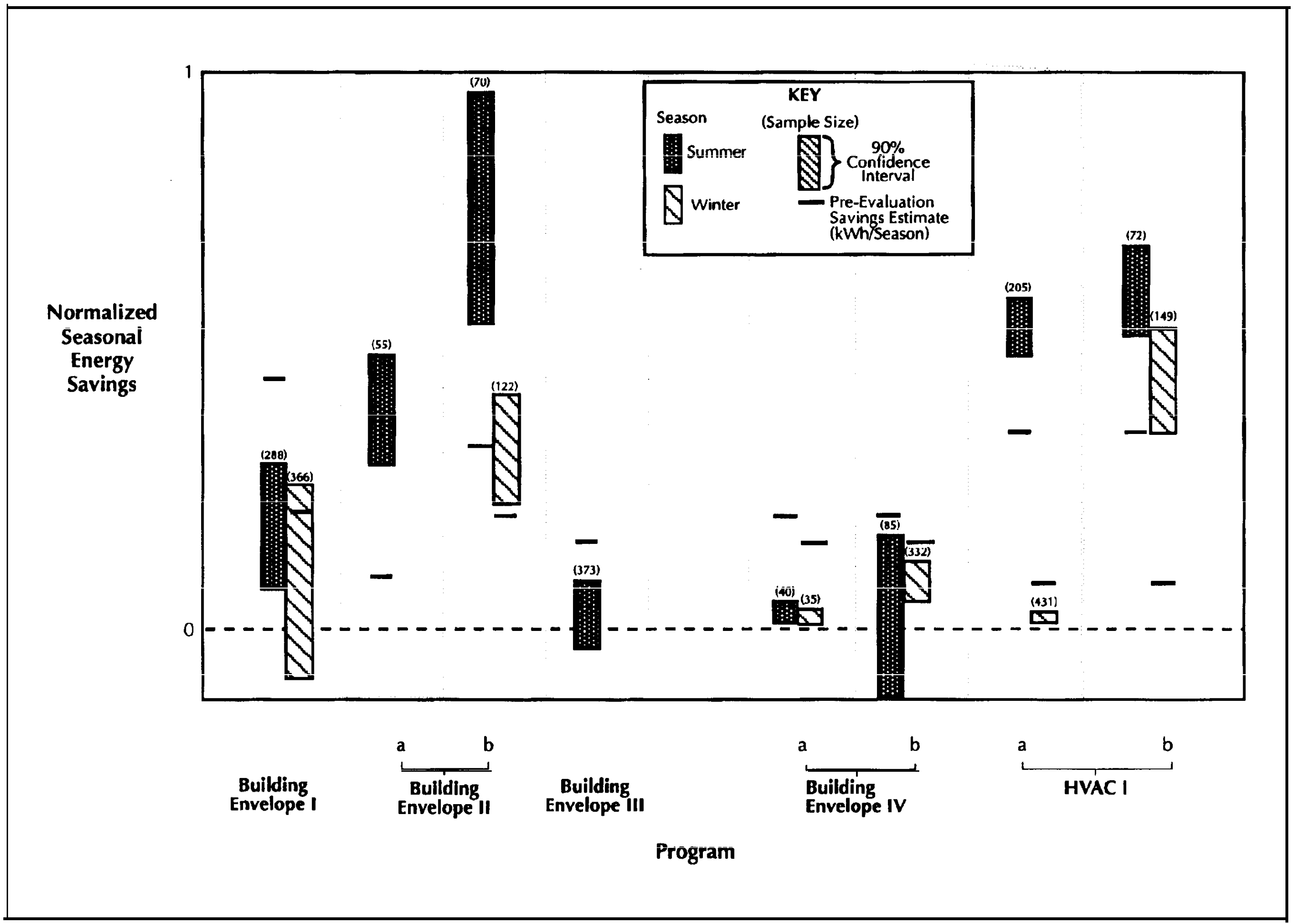

Figure 3. Comparison of Pre-Evaluation Estimates to 1991 Evaluation Results (Per-Participant) Energy Impacts

results for each program. Unlike many other evaluations, the application of a consistent method to each and every program produces evaluation results that are internally consistent and are comparable without requiring adjustments to account for different methods and assumptions. From the figure, the normalized energy impact results of the HVAC I program components statistically exceed the pre-evaluation estimates for the summer season for both program components. Moreover, the energy impacts are estimated with high accuracy.

Integration of Impact and Market Evaluation Results

The major emphasis of the programs' market evaluation was to develop initial estimates of future market penetration at the program, premise type, demographic segment, and area level. Estimates of current program penetration from 1993 through 2002 were generated with the MarketTREK software package for each of the residential conservation programs evaluated. These results are integrated with the impact as described above. Figure 4 combines market penetration results with impact results. Market penetration is shown through the vertical axis, where larger energy impacts indicate higher penetration. Demand impacts are shown on the horizontal axis. The ratio of energy to demand impacts, termed the Load Impact Factor, is shown by the dotted lines.

Figure 4 reveals that three major program components—HVAC Ia, HVAC Ib, and Building Envelope I—have relatively high levels of both summer energy and demand impacts, while the remaining program components have moderate-to-low energy impacts and low demand impacts. In this figure, the "best" summer program components are those with high market potential *and* high demand impacts (those with a low summer load impact factor).

All three of the major program components have mean summer load impact factors of less than 0.50, with HVAC Ia and Building Envelope I having the highest summer load impact factor. Other program components, such as

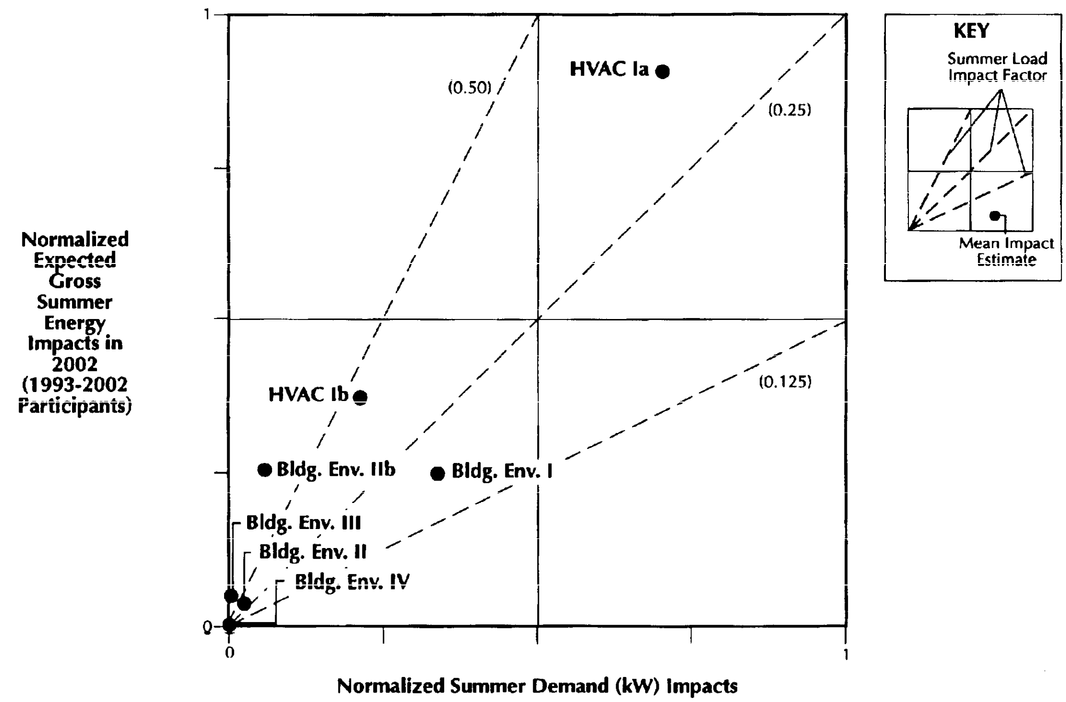

Figure 4. Program Component Summer impact Results

Building Envelope IIb, have mean summer load impact factors of greater than 0.50, indicating that these programs primarily provide energy conservation (as opposed to peak demand reduction) benefits.

Segment-Specific HVAC Program Component Analysis

FPL's existing HVAC program incentive structure is much more cost-effective for the utility at higher cooling capacities and, to a lesser extent, efficiency levels. FPL's current HVAC I program incentive structure offers distinct incentive levels for different cooling capacities and efficiency (SEER) ranges. In Figure 5 the ratios of incentive payment to mean, system-wide 1991 per participant gross energy and demand impacts are plotted against mean cooling capacity. This provides an indication of the cost of the resource FPL purchases this program.

If the incentive structure were developed so that the resource purchased by FPL for each incentive dollar spent was independent of system size or efficiency, the graphs presented in Figure 5 would be horizontal lines, with the solid and dashed lines overlapping.

As illustrated in the figure, there are some variations in the resource FPL receives for its incentive dollar. First, the costs of a unit of both energy and demand impacts decrease with cooling system size. Additionally, impacts per incentive dollar were higher for 1991 participants purchasing units with SEERS greater than 12 than for those purchasing units with SEERS between 11.0 and 11.9. The effects of this variable incentive structure on expected program participation will be examined in 1994.

By combining data on cooling system size, SEER with data on cooling degree-days in different parts of FPL's service territory and analyses of the behavioral characteristics of participants in diverse demographic segments, possible differences in energy and demand impacts across segments can be generated. In Figure 6, Area-specific per-participant central air conditioner gross energy impacts for High and Medium Income demographic segment are compared for participants in single-family detached premises. Note that mean impacts are higher for the High demographic segment than for the Medium demographic segment in all areas, primarily because participants in the High segment tend to purchase larger air conditioners than do participants in the Medium segment.

Across the areas shown in Figure 6, Mean impacts are lower in the cooler Area I especially in the Medium demographic segment than in the other areas. Additionally, the Medium and High Income demographic segment customers in this area realized higher impacts than customers in the remaining three areas. Also note that segment-specific estimates are statistically significantly

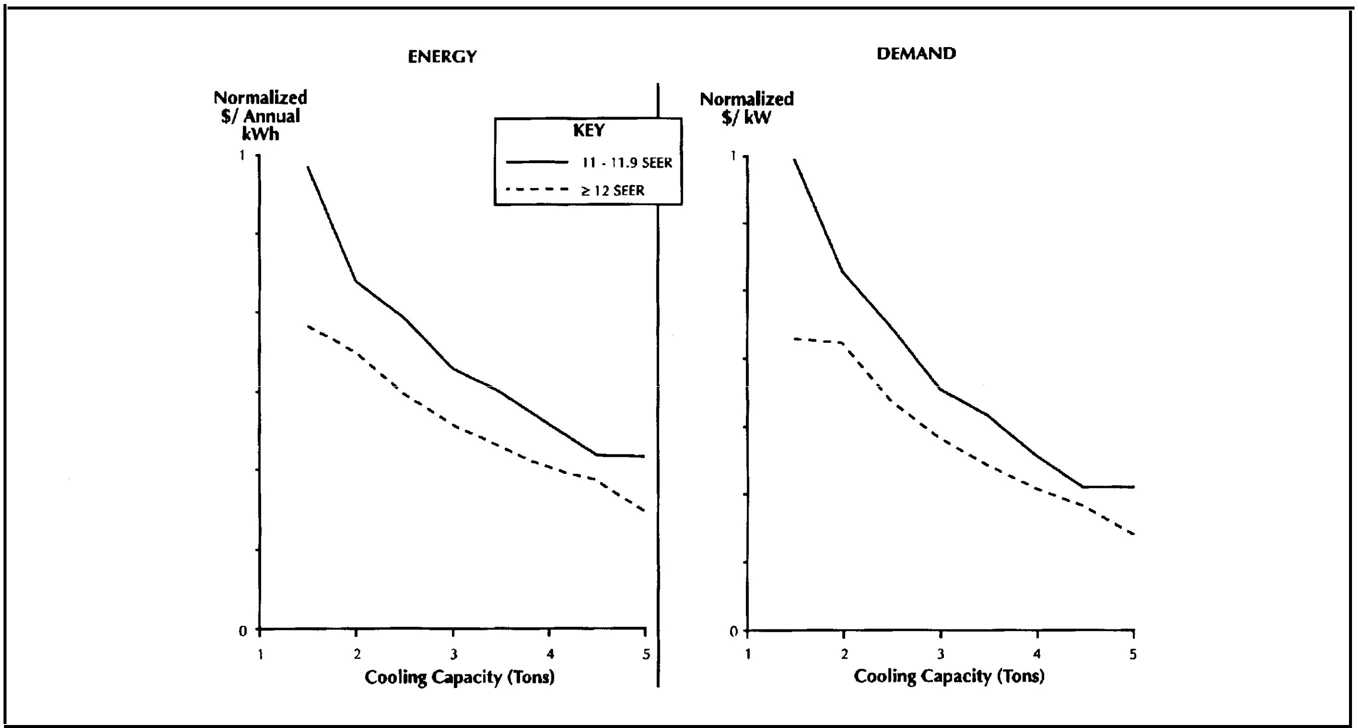

Figure 5. HVAC Ia Program Component Indication of Resource Costs at Different Incentive Levels (System-Wide Average for 1991 Participants)

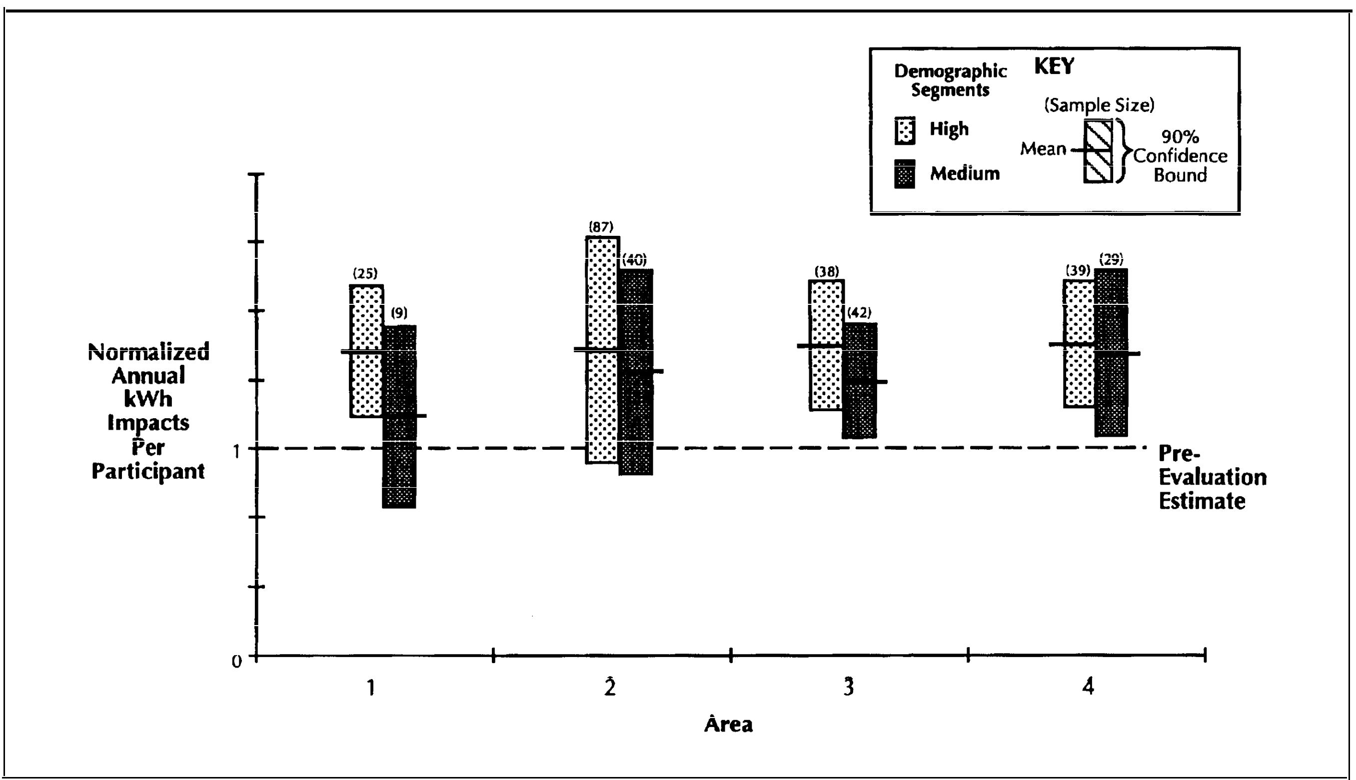

Figure 6. HVAC Ia Program Component Per Participant Gross Energy Impacts by Segment (1991 Participants in Single-Family Detached Premises)

above the pre-evaluation estimate for all segments analyzed except Medium/Area 1, High/Area 2, and Medium/Area 2. Similar segment-specific differences were observed for demand impacts. Analysis of these gross impact estimates and incentive cost data indicates that the central air conditioner program component is most cost-effective among High demographic segment customers in the warmer areas of FPL's service territory. As the incentive cost and summer kW saved are considerably lower for the warmer areas of FPL's service territory than they are for the cooler areas. In fact, the $/kW impact estimates in Area I are significantly higher than those estimated for the other areas.

Both HVAC participation and market penetration to 2002 are expected to be highest in Area 4, while market penetration is expected to be highest among the Medium segment customers in this area. Participation is expected to be the highest in Areas 2 and 4. while participation is expected to be in Areas 1 and 3, the smaller eligible markets in these areas result in higher relative market penetration than is expected in Area 2.

Conclusions

The major impetus for FPL's ongoing residential DSM program evaluation efforts is to provide its residential DSM programs as viable utility resources. The application of internally-consistent program evaluations for each of FPL's residential programs has allowed FPL to compare individual program components' performance. This will allow FPL to enhance its DSM programs' cost-effectiveness and maintain and/or improve customer satisfaction.

This systematic approach to program evaluation is being improved in 1994. Four examples of up-coming improvements are: (1) statistical estimation of demand impacts with program-specific end-use metered data conducted for the major program components; (2) an enhanced market penetration model constructed primarily for the development of reliable estimates of net-to-gross ratios, as well as stated preference analysis to estimate DSM investment decision functions for major program components; (3) the development of a quality-of-service model for the identification and quantification of the key factors affecting customers perceptions of the DSM program-related aspects of the quality of FPL's service; and (4) enhancing segmentation analysis using new Donnelley clusters based on 1990 Census data, and segmenting the statistical impact analyses by climate zones. In addition, the evaluation will continue to address other aspects of Marketing, System Planning, and Regulatory Affairs in its ongoing efforts to make evaluation results as useful as possible.

Reference

Powers, J. T., and Mark Martinez. 1992. "End-Use Load Profiles from Whole House Data: A Rule-Based Approach", 1992 *Summer Study,* 4:193-99. American Council for an Energy-Efficient Economy, Washington, D.C.