Examining the Peak Demand Impacts of Energy Efficiency: A Review of Program Experience and Industry Practices

Dan York, Marty Kushler and Patti Witte

Executive Summary

Over two decades of experience with “demand-side management” (DSM) and related programs addressing customer energy use has demonstrated clearly that customer demand is indeed a variable that can be affected through utility and other types of programs. The two primary types of DSM programs—energy efficiency and load management—have historically had relatively different core objectives. Energy efficiency programs primarily seek to reduce customer energy use (kilowatt-hours or kWh) on a permanent basis through the installation of energy-efficient technologies. Load management, by contrast, generally focuses on either curtailing or shifting demand (kilowatts or kW) away from high cost, peak demand periods. The relative costs and benefits of each main type of program vary from utility to utility.

There are obvious overlaps between energy efficiency and load management. Reducing peak demands may also yield energy (kWh) savings, and most energy-efficient technologies also yield some peak demand savings. While energy efficiency programs can and often do produce reductions in peak demand (measured in kW), such impacts historically have not been an area of priority focus for such programs. The focus on energy savings impacts also has affected evaluation priorities. The primary emphasis has been on estimating the energy (kWh) savings that have resulted from the programs. Quantifying the peak demand impacts generally has not been a high priority for evaluation, and practical limitations, such as the general lack of time-differentiated customer end-use data, also have limited efforts to estimate such impacts.

Over the past decade, however, increased concerns about electric system reliability have combined with concerns about the cost of new generation and transmission and distribution (T&D) investments to create a renewed interest and need for energy efficiency to be able to reduce peak demands as well as reduce overall energy use. Because energy efficiency produces a number of additional benefits that load management alone does not, there is an understandable desire to use energy efficiency as a first priority resource to address both demand and energy resource needs…if energy efficiency can be shown to produce reliable peak demand reductions. This has led to a growing interest in being able to quantify the effects of energy efficiency on system peak demand.

In this study we reviewed experience with peak demand savings from energy efficiency programs. In our review we examined selected program results and experience. We sought to identify examples of energy efficiency programs that have achieved clear, significant peak demand savings. Certain states and regions have achieved significant—even dramatic—peak demand savings from energy efficiency, such as California during its 2000–2001 electricity crisis.

In the process of examining various state and regional examples, we selected thirteen programs as case studies of programs that have achieved significant peak demand savings via energy efficiency. These case studies clearly illustrate that energy efficiency programs can yield measurable, significant peak demand savings. The case studies also demonstrate the evaluation approaches and techniques necessary to measure and quantify peak demand impacts.

Quantification of the energy and demand impacts of energy efficiency and other DSM programs is central to relying on these programs as viable resources within utility resource portfolios and

energy markets. Energy program evaluation employs a variety of tools and approaches to measure and quantify such impacts. The science and practice of energy program evaluation has developed hand-in-hand with the programs themselves. Energy program evaluation professionals and key stakeholders have developed industry protocols for approaches, specific techniques, and standards of professional practice for quantifying energy program impacts. Two leading examples of energy program evaluation protocols are: (1) The International Performance Measurement & Verification Protocol and (2) Evaluators' Protocols, California Public Utilities Commission.

Estimating the demand impacts (kW) from energy efficiency and other programs often builds on the estimates of energy savings impacts. This is true for a number of reasons, many having to do with the availability and costs of data. Energy use data (kWh) are readily available from customer billing data on electricity consumption. In contrast, utility metering of customer power demand or time-of-use is not routine, particularly for residential and small commercial/industrial customers. Consequently, estimating peak demand impacts of energy efficiency often involves application of various load shapes and load factors, which are developed as the result of customer load research used most typically for load forecasting and system operations.

To examine evaluation trends relative to measurement of peak demand impacts of energy efficiency programs, we reviewed two key sources within the energy efficiency program industry: the conference proceedings for the International Energy Program Evaluation Conference (IEPEC) from 1993–2005 and the ACEEE Summer Studies on Energy Efficiency in Buildings from 1994–2006. One of the most important findings in this review was the small number of energy efficiency studies that documented demand impacts in the fourteen years of conference proceedings. Whereas energy savings (kWh) were commonly provided in the energy efficiency evaluations, demand savings were established much less often. Another related key finding is the change in these numbers over time. In the early '90s we found a relatively large number of papers directly on this topic—but as the '90s proceeded, we found fewer and fewer such papers. Published papers in this latter period tended to rely on applying load curves (developed in the '80s and early '90s) to the estimated energy (kWh) impacts, rather than using metered demand data specific to the program being evaluated. These findings reflect evaluation priorities, and technical and cost issues associated with estimating peak demand impacts.

With the renewed interest and use of energy efficiency as a resource, the importance of estimating both energy and demand impacts accurately is increasing. Emerging market structures and transactions that allow demand resources to participate in energy markets similarly will increase the importance of accurate estimation of these resources.

The expanding use of more advanced customer metering technology will facilitate the use of demand data in program evaluations. New and expanded use of advanced metering technologies also may help address cost issues associated with estimation of peak demand impacts. As utilities increase the number of customers with time-of-use meters in place for routine billing purposes, program evaluators will be able to use this time-differentiated usage data without the need to install separate, dedicated metering and logging equipment.

There well may be an advantageous convergence of need, capabilities, and costs emerging for estimating peak demand impacts. As utilities and system operators rely more and more on demand-side options to address peak demand and related reliability concerns, their needs for accurate and timely quantification of demand-side impacts increases commensurately. Parallel with these trends are rapid increases in the capabilities of monitoring and communications technologies that can yield relatively low costs for data gathering and analysis. It will be important for utilities and regulators to work with the program evaluation community to address these issues and weigh the many factors that go into developing evaluation plans, including program objectives, evaluation priorities, budgets, costs, capabilities, and needs.

A final objective of this project was to create a practical comparative database of estimated peak demand impacts for selected energy efficiency measures. The purpose of this component of the project was to create a simple and practical information resource that program planners and evaluators could access to obtain reasonable "representative" estimates of the peak demand impacts of common energy efficiency measures, for use in initial program design and assessment.

We began this aspect of the project with a review of leading technical references used to estimate energy and peak demand impacts of energy efficiency measures, which in several cases take the form of electronic databases. We conducted a search to identify databases and similar technical references that are used by leading utility-sector energy efficiency programs. From this review we selected the following databases and technical references to use in the creation of a comparative database of selected energy efficiency measures:

- Database for Energy Efficiency Resources (DEER). California Energy Commission.
- Deemed Savings Database, Version 9.0. New York State Energy Research and Development Authority.
- Deemed Savings, Installation & Efficiency Standards: Residential and Small Commercial Standard Offer Program, and Hard-to-Reach Standard Offer Program. Public Utility Commission of Texas.
- Conservation Resource Comments Database. Northwest Power and Conservation Council.
- Technical Reference User Manual (TRM). Efficiency Vermont.

To compare data across these references we identified a set of common end-use energy efficiency measures included in programs. We then collected data on these measures from each of the technical references and databases to create a comparative database. The purpose of this review and collection of data is to illustrate the types of measures commonly included in utility sector program databases. In these examples we also sought to show typical values used for peak demand and energy savings associated with specific measures with data drawn from the databases we selected for inclusion in this review. Our comparative database should be viewed as a selected detail from a much larger picture. The data we compiled and report are really starting points for program design, implementation, and evaluation. The data could readily be used at the program scoping and development stage for certain types of programs.

In reviewing these databases we found that the measures for which it is possible to have the most uniform definition (for example, residential 15 watt compact fluorescent light bulb replacing a 60 watt incandescent) show the most uniformity in terms of reported energy and demand savings. Other measures that were not as uniformly defined (for example, variable speed motor drives or packaged rooftop HVAC units) tended to show wider variations. Similarly, measures that are climate sensitive also tend to show wider variations, as would be expected. The databases and technical references are most useful for fairly well-defined, "standard" measures. Energy efficiency measures that involve more complex or customized services generally require a project-specific estimation of energy and demand savings; standardized or deemed savings estimates are not well suited to such applications. We found that generally the databases provide reasonably good documentation of the data references and key assumptions. This is critical to allow ready checking on the source and accuracy of reported data and to understand key assumptions. It also easily allows updating and comparison to other references.

Our major findings in this study are:

- Energy efficiency programs clearly have achieved significant peak demand reductions. We found examples of clear, well-documented estimates of such impacts from individual measures, entire programs, and entire state and regional utility systems.

- While we found well-documented estimates of peak demand impacts of energy efficiency, most program evaluations have not used direct, on-site measurement of the demand impacts. Rather, program evaluations typically have relied on customer billing or other measurements of kilowatt-hour use as primary data. Load shapes or load factors are then applied to these data to estimate the peak demand impacts.
- As utilities and system operators increase their use of energy efficiency programs as energy system resources to deliver both energy (kWh) and peak demand (kW) savings, the need for greater understanding and accurate quantification of the peak demand impacts of energy efficiency will increase.
- There are solid foundations in place for establishing a firmer, broader knowledge base of the peak demand impacts of energy efficiency. There are numerous technical references and databases in use that provide measure-by-measure quantification of these impacts and the professional evaluation community has well-established practices and protocols for addressing this growing need.

There well may be an advantageous convergence of need, capabilities, and costs emerging for estimating peak demand impacts. Rapid increases in the capabilities of metering and communications technologies can yield relatively low costs for data gathering and analysis. Utilities and regulators will need to work with the program evaluation community to address emerging needs for program evaluation—weighing the many factors that go into developing their evaluation plans, including new technological capabilities, program objectives, evaluation priorities, available budgets, and evaluation costs.

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