

# Addressing Uncertainty and the Value of Flexibility in the Second Generation of IRP

*Daniel M. Violette and Linda K. Olsson, XENERGY Inc.*

A second generation of IRP efforts will increasingly focus on uncertainty and risk, and the need for flexibility in both short and long-term utility resource plans. Diverse futures and complex options challenge both planners and the limitations of current utility planning models in the attempt to assess alternatives. Practical methods are needed that enable planners to address a broader scope of possibilities, and are understandable by both utility management and regulators. While the problem becomes computationally complex and intractable for most existing models, several techniques can be applied in tandem with these models to address these challenges. Applications of two such analytic tools—reduced form models and innovative Monte Carlo methods—allow utility planners to more fully address uncertainty, risk, and the benefits of flexible resources in an IRP.

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## Introduction

Many utilities have been through one or more formal integrated resource planning efforts. It is time to reflect back on these initial efforts and consider how the second generation of IRP planning efforts might differ from this first. This paper addresses several issues that might influence this second generation of IRP efforts. Specifically, this paper addresses:

- Whether we are losing sight of the basic objective of the IRP, i.e., to make good resource planning decisions;
- Whether factors that are important, if not critical, to making good resource planning decisions are being addressed by IRP efforts;
- Whether a growing reliance on increasingly complex IRP models helps facilitate making good resource planning decisions;
- Finally, this paper discusses some practical actions that can be taken by resource planners to provide insights into important issues and result in improved resource planning decisions.

## Maximizing the Benefits of an IRP Process

Approaches used for IRP must evolve to provide information of value for resource decisions faced by utility

planners in a rapidly changing environment. Increasingly, utilities must anticipate the consequences of diverse futures and evaluate more complex options to determine how best they can maintain flexibility and financial stability. The value of a complex IRP effort resulting in a specific load and resource plan accompanied by voluminous documentation may be questionable for utility decision-making. In some cases, it is our observation that the objective of IRP efforts appears to focus more on compliance with regulatory reporting requirements than on the value of information obtained in the process.

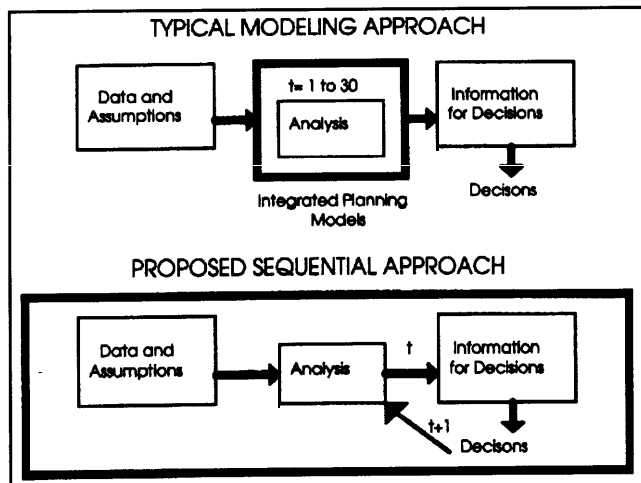
## Critical Factors for Good Resource Planning Decisions

In early IRP efforts, much of the attention was focused on basic organizational issues, selection and application of appropriate evaluation tests, and comparisons of DSM and traditional supply-side options. Good resource planning decisions today require the integration of new market options and strategic issues. Additional options are likely to be considered which may have greater perceived risks due to the lack of experience or historical performance data. These options may include resource bidding, brokered transactions, distributed small power sources (renewable or customer generation), and non-utility generators (NUGS). The role of DSM may be changing as utilities focus increasing attention on rate minimization in a competitive environment. The structure of the utility may be substantially changed from the vertically

integrated organizations of the past. Effectively representing the future in utility planning models is challenged by the need to represent these increasingly diverse resource options with multi-dimensional uncertainties. The decisions to be made in utility resource planning are more complex and comprehensive than the economic assessment of build vs. buy options.

As a result, the second generation of IRP efforts will increasingly focus on selected issues that are likely to include:

- Better representations of *uncertainty and risk* in the resource plan, and resource plans that hedge against specific technical and economic risks;
- Planning procedures that consider *sequential decision making*, incorporating information as it is revealed over time rather than assumptions bound by a fixed horizon (i.e., addressing how decisions may differ in three years depending upon how growth actually occurs during that time). Figure 1 illustrates a fixed horizon modeling approach versus a sequential decision making approach.



Comparison of the relationship among data, assumptions, models, and decisions in typical planning approaches (top) and the sequential approach (bottom); t refers to a year within the analysis.

Adapted from Gettings, Michael, Eric Hirst and Eveline Yourstone, *Diamond: A Model of Incremental Decision Making for Resource Acquisition by Electric Utilities*, ORNL/CON-315, February, 1992

Figure 1. Typical Modeling Approach

Both of these issues suggest a need to understand and address the value of flexibility in the assessment of resource plans. A factor critical for the industry will be

the ability to develop *practical methods* that can address these issues and are understandable by both utility management and regulators. Much of our work has focused on how to better use existing models rather than replacing them with increasingly sophisticated models to address these issues.

### What Have We Learned About Assessing Flexibility?

The potential benefits of supply-side resources with smaller unit sizes and shorter lead times relative to large units with long lead times are well-documented in the literature on utility planning. Similarly, it has been argued that DSM programs may offer planning benefits related to their small unit sizes, short lead times, and the flexibility utilities may have to *scale-up* or *scale-down* DSM impacts by adjusting program incentives or marketing efforts. A few studies have attempted to quantify the potential economic benefits which can result due to the small unit size, short lead times and flexibility of DSM resources. Hirst (1989) has used a simple decision tree approach to show that the indirect benefits of flexible DSM programs with short lead times could equal as much as 5 to 10 percent of avoided costs of typical supply-side alternatives. In a more recent and detailed study, Hirst (1992) has shown that the flexibility and load-tracking characteristics of a DSM portfolio can significantly reduce the financial risk associated with utility planning. Based on data from utilities in the Pacific Northwest, Ford and Geinzer (1990) estimate that the indirect benefits of mandatory performance standards for new construction stemming from reduced demand uncertainty would result in indirect benefits equal to an additional 14% over standard social cost-benefits tests.

While utilities have gained experience with DSM in recent years, projections of future DSM impacts remain subject to uncertainty. Consequently, many utilities remain cautious about relying on DSM programs as a means of deferring or displacing investment in new supply capacity. If DSM savings fail to materialize, electric service may become less reliable or additional-more costly—sources of power may need to be acquired on short notice. At the same time, underestimation of DSM impacts may result in construction of generation capacity which could have been deferred, raising rates for customers and creating increased financial risks for utilities.

In fact, the value of both existing and new resource options is subject to greater uncertainty as a result of increased environmental regulation and potential competition in wholesale and retail markets. The investment concerns described above relative to DSM are equally applicable to resource bidding programs, performance

contracting, or renewable and distributed generation technologies. Examination of efforts made to assess the benefits of uncertainty that might result from DSM provide insights for approaches needed to effectively address the new challenges facing utility planners.

In practice, few studies have been performed to quantify the uncertainty associated with DSM portfolios. For the last few years, the New England Electric System (NEES) has formulated simple judgmental estimates regarding the probability of achieving overall DSM goals incorporated in the utility's long-term resource plan. In the Pacific Northwest, estimates of the supply of DSM resources developed by different utilities and planning agencies range from 60 to 85% of the technical DSM potential. More detailed end-use approaches for developing probabilistic estimates of the long-term technical potential for DSM have been employed in a recent study of nationwide DSM potential sponsored by the Electric Power Research Institute, and in a recent study for Southern California - Edison (XENERGY, 1990). Each of these assessments show a large range of uncertainty concerning DSM impacts over the next two decades. Significantly, however, none of the studies addressed the issue of how DSM may affect underlying planning and demand uncertainties, and how in practice a utility could adjust its DSM portfolio over time to reduce overall demand uncertainty.

### **Complex Planning Models vs. Good Planning Decisions**

In attempting to respond to utility needs to incorporate increasingly diverse options, many of today's utility planning "mega" models require skilled and experienced staffing with a significant investment in time needed to develop and manage data. Mega-models continue to have a role in utility planning to develop shorter-term tactical plans, and for developing a framework for longer-term strategic planning. These models typically have substantial credibility, databases, and support for use in the analytical process. Modelers and decision-makers must simplify the process by reducing the problem dimensions considered or by incorporating methodologies which enable them to address a broader range of interacting uncertainties and complex options at a reasonable cost within the existing utility modeling framework.

This paper discusses two analytic tools—reduced form models and innovative Monte Carlo methods—that we believe will become more prevalent in the future IRP applications. Each can use existing IRP models and can be applied with a minimum of additional analysis. The joint application of these two tools will allow utility planners to more fully address uncertainty, risk and assess the benefits of flexible resources in an IRP.

### **Analytic Tools to Increase Value of Current IRP Modeling Efforts**

The need to understand potential consequences of uncertain futures has been recognized by utility planners for years. Common approaches used to address this concern include sensitivity analyses, scenario planning, and decision analysis. While substantial changes have been made in planning models to incorporate these methods, effectively addressing the number of variables that are uncertain and the range of potential consequences remains a daunting problem. The number of model runs that may need to be made to assess each, along with different interactions of variables, creates a substantial problem for time requirements as well as data management and analyses of results. For example, a recent study undertaken by Hildebrandt (1994) indicated that the runtimes associated with most existing IRP models is approximately 5 minutes. A relatively simple decision tree used to dimension uncertainty in his analysis produced a decision tree with 3,856 end nodes. Each node requires a model run to establish the optimal resource plan associated with that set of variable outcomes. Thus, filling out that decision tree would require 13 days of computation time, without accounting for any set up time between model runs.

Attempting to focus on limited aspects of the problem may result in the inability to fully understand the value of some resource options. The analytical objective must be to address a larger number of interactions and outcomes, but in a way which is more easily manageable and understood. The two approaches discussed below offer solutions to these challenges.

### **Reduced Form Models—Simple Representations of Complex Models**

A useful tool which can be applied to outcomes of existing IRP tools is the use of "reduced form" models, sometimes referred to as response surface analyses. Hildebrandt used this approach to address the problem described above, reducing the computation time from 13 days down to a matter of hours.

What is a reduced form model? Reduced form models use existing IRP model runs in a systematic fashion to create a simpler version of the model that will mimic the results of the full model with acceptable precision. The key issue is whether a limited number of *carefully specified* model runs can provide the information from which a larger number of "approximate solutions" can be inferred using a systematic estimation procedure.

A 1988 study by Mukerjii provides insight into the effectiveness of the reduced form model. Bonneville

Power Administration's production cost model was run 540 times. Then, a set of 60 model runs were selected to develop a reduced form model. The outputs of these 60 model runs were used in a statistical model to estimate how the model responded to changes in inputs. The reduced form model was then used to predict the output of the full model for the other 480 actual runs. In this case, the results of the reduced form model were within  $\pm 6\%$  of the full model result for all of the runs, and over 90% of the reduced form model results were within  $\pm 5\%$  of the full model. Several other applications of these methods can be found in the literature (Hildebrandt, 1994; and Logan, 1992). These applications show that reduced form models may have the necessary levels of precision for addressing risks and uncertainties. These simpler models are then amenable to the application of Monte Carlo methods requiring many model runs since the computation times are so greatly reduced.

### **Monte Carlo Methods—Incorporating Probabilistic Assessments**

The use of Monte Carlo techniques to assign values to uncertain model inputs offers an improved assessment of the net uncertainty affecting outcomes. In sensitivity analysis, the effects of varying a single variable, i.e. projected prices of natural gas, on the outcome can be examined. This approach does not address the interactions of multiple uncertainties or correlations between uncertainty in different variables. In a Monte Carlo simulation, inputs are entered as ranges which follow a particular distribution pattern. Many of today's planning models include this approach for a limited number of problems, particularly to address the uncertainty in generating unit availability. Improved computer-based tools now facilitate the use of this technique for other aspects of IRP.

Monte Carlo simulation methods can be used to develop net estimates of uncertainty surrounding key inputs providing an improved range of values and associated probabilities to represent a resource option in the IRP process. A recent application of this approach to generate expected values and probabilities to represent DSM resources in the framework of an IRP decision tree analysis suggested that the range of uncertainty surrounding DSM impacts may be lower than previous estimates used by the utility planners (Hildebrandt, 1994). In this study, judgmental estimates of the lowest, highest, and most likely values for DSM program inputs were used to create ranges of values with probability distributions for each DSM program. Probability distributions were assigned to annual energy savings, summer and winter demand ratios, measure life, maximum annual participation, years until maximum participation, first year participation, free ridership, variable and fixed program

costs, and participant measure costs. Although the range of uncertainty assigned to most of the program inputs approached or exceeded  $\pm 50\%$  of the most likely value, overall DSM uncertainty was considerably lower. These findings were consistent even under the assumption that some inputs are highly correlated across programs.

### **Flexibility and Reduced Demand Uncertainty—The Options Approach**

The impact of resource flexibility and uncertainty on actual utility planning decisions and total system costs will vary from utility to utility, depending on factors such as the utility's current load resource balance, the underlying level of demand uncertainty, and the cost, size, flexibility and lead-time of alternative supply-side options. Detailed analysis of these impacts requires the development of new techniques for applying the principles of decision analysis within the dynamic context of utility planning under uncertainty. However, one simple method that can be used to estimate the value of reduced demand uncertainty is the "options approach," that has been used in several studies in the Pacific Northwest (Ford 1990; Ford and Geinzer 1990).

The options approach assumes that the utility follows a strategy of "implement for the medium, option the high." Under this strategy, a utility might commit itself to acquiring enough firm supply resources to meet its median load forecast over its planning horizon. In addition, the utility begins to develop flexible supply options for enough additional capacity to meet high demand growth scenarios, such as the level of demand that would not be exceeded with an 80% confidence, based on a probabilistic demand forecast.

In practice, the options developed to ensure against high growth scenarios may take several forms. One approach already being employed by several utilities in the Pacific Northwest involves "site-banking" of pre-approved projects, which can be rapidly brought on-line, or maintained in a "ready" state for a number of years until they are needed. Another approach being developed in New England is to include buy-out provisions in contracts with non-utility power producers, that would allow utilities to cancel or defer non-utility supply projects.

Since the options approach represents one of the simplest approaches for assessing the potential value of changes in net demand uncertainty, results of this study are presented below in terms of a utility that defends against demand uncertainty by following a strategy of "building for the median and optioning for the high." Although no specific economic value is placed on changes in the high/low forecast, sample model results are presented in terms of

the impact of different DSM portfolios and planning strategies on the median and high net load forecast over an seven year planning horizon.

### An IRP Application—Assessing the Value of Planning Flexibility and Reduced Demand Uncertainties

This section of the paper reviews the application of a Monte Carlo method to assess how uncertainty in DSM program performance and the potential for a resource to increase the flexibility of the resource plan can be analyzed. The example given is specific to the assessment of benefits resulting from flexibility due to combinations of representative DSM programs in a resource portfolio. This approach could easily be applied to assess alternative portfolios including other resource options.

**Modeling Approach.** The simplified modeling approach presented in this paper is designed to illustrate the use of the options approach for valuing different types of resource uncertainty and flexibility. The work conducted specifically addressed the value of four different DSM options. The DSM options included represent: (1) load tracking resources, where size and magnitude are a function of demand growth, (2) limited availability programs, or lost opportunity programs for resources typically available as a function of equipment life cycles and building renovation rates, and two discretionary programs which can be modulated over time—a rebate program for retrofit measures, and (3) a higher cost direct install program as a backup for rapid growth. A summary of the four program types and specific model inputs used in this analysis are shown in Tables 1 and 2.

Key characteristics of the model used in this analysis are described below:

- DSM programs are modeled individually, using the same model inputs used by most DSM planning models: Potential market, market penetration, impacts per participant, free ridership and measure lifetime. However, each of these model inputs is represented in terms of a range of values and a probability distribution, rather than a single number representing the utility's best guess for each parameter.
- Selected DSM program options are identified which can be ramped up (or down) in response to changes in projected demand over time. Flexibility is introduced into the model through the incorporation of sequential decision-making in the simulation process. In this study, DSM participation can be ramped up at two year intervals by a specified, limited amount if actual demand exceeds the target level of demand for the year by a given margin. There is a one year lag between observing actual demand and the decision to ramp up DSM efforts.
- Market penetration rates are modeled as function of two uncertain parameters: the maximum long-term level of market penetration, and the number of years it will take to reach this level. This method was used in order to represent the variety of different participation rates that could occur over time.
- Based on the expected value of each model input, a target level of net demand growth is determined for a ten year planning horizon. In effect, this represents the utility's best estimate of net demand, given its median demand forecast and expected impacts of its base case DSM portfolio.
- Monte Carlo simulation is used to assess the impact of the utility's DSM portfolio on overall demand uncertainty.

As shown in Table 2, model inputs were selected to represent a relatively wide range of uncertainty around DSM impacts. In order to emphasize the results of DSM in terms of overall demand, the hypothetical DSM portfolio used in this analysis was designed to offset most of the new demand growth projected for the utility over the next ten years.

**Sample Model Results.** Key results from this analysis are shown graphically in Figure 2 through 4, and are summarized in Table 3. Figure 2 depicts the probability distribution of the utility's baseline demand forecast for the year 2000, corresponding to the eight year planning horizon needed to bring major new supply options on-line. Figures 3 illustrates the impact of the representative rebate programs described above on the underlying demand uncertainty. Figure 4 depicts the impact of the utility's entire DSM portfolio on demand uncertainty.

**Rebate Programs.** As shown in Figure 3 and also in Table 3, the rebate programs decrease the mean demand forecast by 320 MW by the year 2000, but overall demand uncertainty is increased by a relatively small amount. These results may appear somewhat counterintuitive, given the relatively wide range of uncertainty assigned to the market penetration of rebate programs. In this analysis, these results can be attributed to the fact that the uncertainty surrounding DSM impacts assumed to be uncorrelated with baseline demand uncertainty. If actual DSM impacts are correlated with increases in overall demand, i.e., if high demand growth implies that *high* DSM impacts are more likely to occur, then there would have been a decrease in overall net demand uncertainty. Some analysts have argued that DSM impacts reflect current economic trends and therefore are positively

**Table 1. Representative DSM Program Types**

<b>Program Type</b>	<b>Representative Technologies Used to Develop Model Inputs</b>	<b>Key Program Characteristics</b>	<b>Expected Value of Program Impacts (1993-1999) MW (% of DSM Portfolio)</b>
New Construction	Building shell, HVAC, lighting and design measures	<ul style="list-style-type: none"> <li>• Lost opportunities</li> <li>• Potential market tracks load growth</li> </ul>	59 MW (14%)
Rebates for Naturally Occurring Equipment Replacement and Building Renovation	Electronic ballasts, HVAC equipment and motors	<ul style="list-style-type: none"> <li>• Lost opportunities</li> <li>• Potential market is limited in any one year, but new opportunities are created annually</li> </ul>	167 MW (39%)
Rebates for Unplanned Retrofits of Existing Equipment and Buildings	Compact fluorescent, reflective fixtures, occupancy sensors, and shell measures in existing buildings	<ul style="list-style-type: none"> <li>• Potential market in existing buildings decreases as retrofits occur</li> <li>• Could be modeled as discretionary or backup resources to hedge against planning uncertainties</li> </ul>	159 MW (37%)
Direct Installation of Comprehensive Measures	Highly cost-effective lighting, HVAC and shell measures in existing building stock.	<ul style="list-style-type: none"> <li>• Higher cost DSM resource, but can be used to reach difficult customers segments</li> <li>• Modeled as a discretionary or backup resource to defend against high demand growth.</li> </ul>	39 - 64 MW (9 - 14%)

correlated with net demand growth. Then, DSM impacts may, in fact, tend to track demand growth, i.e., high demand growth leads to higher DSM impacts. In this case, the uncertainty in DSM impacts would translate into lower net demand uncertainty, relative to the uncorrelated case used in this analysis.

*New Construction Programs.* Although the new construction program in this analysis represents a relatively small portion of the utility's overall DSM portfolio, this program was found to reduce the high load forecast 20% more than the reduction in the mean load

forecast from this program (see Table 3). These results support other studies by showing that programs for new construction have significant indirect planning benefits in terms of reducing demand uncertainty, even if participation and unit impacts of these program are surrounded by substantial uncertainty.

*Flexible DSM Portfolio.* As shown in Table 3, modeling the flexibility associated with some DSM programs

Table 2. Uncertain Model Inputs

Model Parameter	Expected Value	Range of Uncertainty	Probability Distribution
Baseline Demand Growth	1.5%	1 to 2.5%	Triangular
Maximum Market Penetration	50%	30 to 70%	Uniform
Yrs to Max Mkt Penetration	10 years	8 to 12 years	Uniform
Net Unit Impacts	Program dependent	±20% of EV	Uniform

NOTE: Market penetration rates were assumed to be equal for all program types. Unit impacts are program dependent, but were assumed to be perfectly correlated. No other correlation in model inputs was assumed to exist, except for the direct correlation between baseline growth and the potential market for the new construction program.

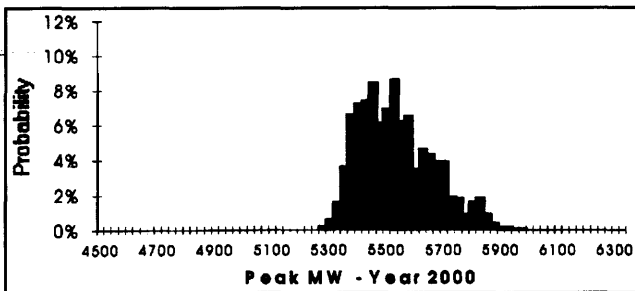


Figure 2. Baseline Demand Forecast 7-Year Planning Horizon

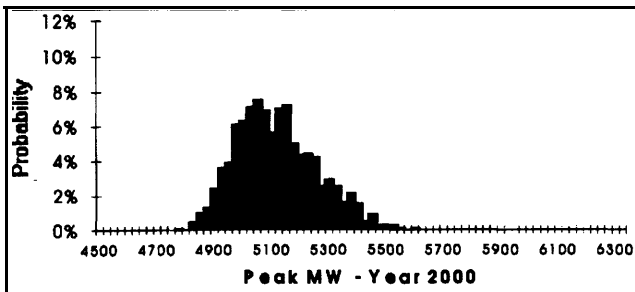


Figure 3. Net Demand Forecast - Rebate Programs Only 7-Year Planning Horizon

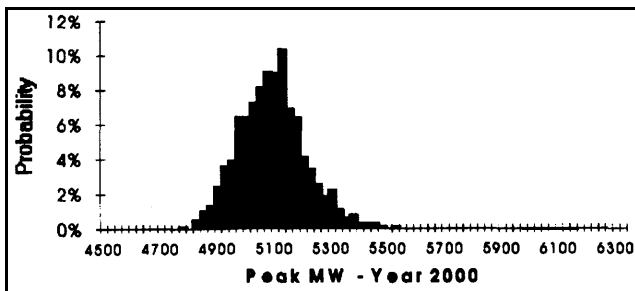


Figure 4. Net Demand Forecast - Flexible DSM Portfolio 7-Year Planning Horizon

significantly changed model results in terms of the overall effect of the utility’s portfolio on demand uncertainty. Without incorporating flexibility in the model, the DSM portfolio resulted in a very slight increase in demand uncertainty. This increase in uncertainty is shown by the negative benefits shown for DSM Case 4 in Table 3. After incorporating a relatively small level of DSM flexibility associated with the direct installation program into the model, Case 5 shows that DSM substantially reduced overall demand uncertainty resulting in net benefits. This is illustrated by the increase in benefits shown between DSM Cases 4 and 5 in Table 3.

**Indirect Benefits of DSM Flexibility that Are Not Accounted for in Traditional IRP Analyses.** The impact of the DSM programs on overall planning uncertainties and the benefits/costs of these uncertainties are shown in Table 3. The standard benefits of each DSM portfolio are reflected in the Column 1. DSM does reduce the mean demand forecast (Column 1), and the DSM programs receive the benefits of this reduction in demand through the avoided cost estimates used in traditional cost-effectiveness tests in an IRP framework.

There is a benefit to DSM that is not accounted for in this IRP framework. This benefit is shown in Column 3 labeled supply options. This is where the uncertainty associated with DSM is expressed. This column shows the amount of capacity that must be “optioned” by the utility to ensure that the high demand forecast can be met.

Case 5 shows the results for the “Flexible DSM Portfolio.” This case shows that, relative to the Base Case, there is a reduction in the mean demand that must be met by building new facilities of 5,546 MW minus 5,103 MW or a capacity reduction of 443 MW. These benefits are accounted for through the avoided cost estimates used in traditional IRP analyses. However, there is another benefit

**Table 3. DSM Portfolio Simulation Results**

DSM Case	Results Used for Supply Planning (Peak MW - Year 1999)			Net DSM Impacts (MW)		
	Mean (Col. 1)	Maximum <sup>a</sup> (Col. 2)	Supply Options <sup>b</sup> (Col. 3)	Firm Capacity <sup>c</sup> (Col. 4)	Supply Options <sup>d</sup> (Col. 5)	Maximum Indirect Benefits (Costs) <sup>e</sup> (Col. 6)
1. Base Demand Forecast	5,546	5,663	117			
2. New Constr. Prog Only	5,487	5,593	105	59	12	20%
3. Rebate Programs Only	5,226	5,355	129	320	(12)	(4%)
4. Inflexible DSM Portfolio <sup>f</sup>	5,128	5,247	119	418	(2)	(0.5%)
5. Flexible DSM Portfolio <sup>g</sup>	5,103	5,189	86	443	31	7%

<sup>a</sup> Maximum level of demand that is expected to occur with 80% confidence.

<sup>b</sup> Assumes the utility develops firm supply options to meet the median demand forecast, and acquires flexible supply options to meet the high load growth scenario (based on 80% confidence level).

<sup>c</sup> Reduction in median net demand forecast with DSM.

<sup>d</sup> Reduction (or increase) in flexible supply options need with DSM. Based on difference in mean net demand forecast and high demand forecast (with 80% confidence) with and without DSM.

<sup>e</sup> Change in flexible supply options as a percentage of the reduction in the mean demand forecast. Indicates the maximum level of indirect benefits that could result from DSM if utility acquired enough firm capacity to meet the high net demand forecast. Actual savings under a strategy of "build for the medium, option the high" would be lower as a percentage of total costs.

<sup>f</sup> Includes net impacts of all DSM programs, *prior* to adjustment of direct installation program based on target load forecast.

<sup>g</sup> Includes net impacts of all DSM programs, *after* adjustment of direct installation program based on target load forecast.

associated with flexible portfolio. Now instead of having to option 117 MW in the Base Case, the utility now only needs to option 86 MW of capacity to ensure against the high demand scenario. This benefit is not captured in the cost-effectiveness tests now used by IRPs. In this case, the benefits of DSM would be under-estimated.

### Implications for DSM Planners and Evaluators

The approach described in this paper could be incorporated into the process of DSM planning and evaluation in several ways:

- The Monte Carlo simulation techniques used in this analysis could be used to identify the most important sources of potential DSM uncertainty and flexibility associated with a utility's DSM portfolio. Based on this type of analysis, DSM portfolios could be modified to limit the probability that net demand forecasts could exceed critical levels with a desired level of

confidence. Results of this analysis could also be used to develop different net load forecasts and corresponding probabilities, for use with other planning models, possibly in conjunction with techniques of decision tree analysis.

- Results of the type of analysis describe above could be used to set evaluation budget priorities by identifying the relative importance or value of reducing the uncertainty assigned to different model parameters. For many utilities, such analysis is likely to indicate that in terms of actual utility planning decisions (other than cost recovery), it may be appropriate to emphasize increased market research to better understand and define the values of these parameters.
- The general modeling approach illustrated in this analysis can also be used to approximate the indirect strategic planning benefits of different types of DSM programs. Such estimates could allow planners and regulatory officials to develop different "flexibility and risk" adjustments (such as that established in

Vermont) or similar mechanisms for differentiating between key categories of DSM programs. For instance, as shown in this analysis, it may be appropriate to apply different criteria in assessing the cost-effectiveness of programs aimed at new construction or other forms of load growth (including periodic renovations), and for programs (such as direct installation programs) that provide the utility with a means of responding to planning uncertainties with relatively short lead times.

- Ultimately, dimensioning DSM uncertainty requires a substantial degree of judgment. Probabilistic assessments may be developed by aggregating estimates of different individuals, especially in the context of a collaborative IRP planning process involving utility staff, regulators and other stockholders with expertise.
- To date, little or no research has actually been done to quantify typical lead times for new DSM programs, or the actual rate at which specific programs could be scaled up or down. A challenge facing DSM planners is the need to dimension the actual flexibility associated with DSM programs.

## Conclusion

The indirect planning benefits of DSM flexibility-and potential risks associated with DSM uncertainty-are not typically captured in methods currently used to compare the relative benefits of different resource portfolios. Failure to incorporate these impacts into the planning process may lead utilities to adopt resource plans which are not optimal in terms of total system costs and risk. To date, however, little analysis exists which directly addresses whether the potential benefits associated with the flexibility of DSM resources significantly outweigh the potential risks associated with DSM uncertainty. If an average percent adjustment factor were to be used as a planning proxy, it is currently unclear whether the indirect impacts of increased reliance on DSM resources should be incorporated into the process of Integrated Resource Planning as a net *benefit* or *cost*. Although the results of this study do tend to support the conventional wisdom that DSM reduces demand uncertainty, actual impacts of DSM on demand uncertainty have yet to be assessed. In any event, increased use of even the simplest approaches for incorporating DSM flexibility and uncertainty into Integrated Resource Planning are apt to improve the assessment of utility costs and risks when DSM is one component of an IRP.

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