Non-Wires Solutions to Defer T&D Upgrades: A Comparison of Two Case Studies in the Pacific Northwest

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ABSTRACT

This paper provides a review of key results and lessons learned from two comprehensive studies undertaken to assess the technical potential for energy efficiency, distributed generation, and demand response initiatives to defer Transmission and Distribution (T&D) System upgrades in the Pacific Northwest.

Two separate studies were completed by the authors, each using the same methodology, but with very different results. Each of the two distribution systems in question is a coastal, rural area and both face up-coming capacity constraints. The customer base in each case is fairly similar, consisting of a few large industrial customers and relatively dispersed commercial and residential loads. Yet the local economic conditions and demographics are very different and, as a result, the outcome of each study was very different.

This paper reviews the technical approach utilized in the studies, as well as the key outcomes. Similarities and differences are compared, as well as the rationale for these results. The authors also discuss key data and analytical constraints encountered in working at a very local level, as well as important implications for program design. In the conference presentation, we will also provide an update on the status of these projects, including how the results have been used in making investment decisions related to T&D upgrades.

Introduction

This paper provides a review of key results and lessons learned from two comprehensive studies undertaken for the Bonneville Power Administration (BPA) to assess the technical potential for energy efficiency, distributed generation, and demand response initiatives to defer Transmission and Distribution (T&D) System upgrades in the Pacific Northwest.

We provide below a summary of the situations posed in each study, followed by an overview of the common methodology used in each study. We then present the results of each study, followed by a comparative discussion of programmatic implications and study challenges.

Situation Overview

The service areas addressed in these studies involve (1) a transmission line extending up the eastern side of the Olympic Peninsula in Washington state, extending north from the city of Bremerton toward the city of Port Angeles, and (2) and a transmission system in the coastal area of southern Oregon near the city of Bandon, Oregon. In each case, the objective of the study was to quantify the potential load reduction resource available to address anticipated T&D system constraints. The specific problem statements for the studies were as follows:

- Olympic Peninsula -- On the Olympic Peninsula in Washington State, the transmission system was forecast to be at risk of potential voltage collapse under extreme winter weather conditions, or in other multiple contingency situations. Further, under Base Case load growth projections (estimated to be approximately 22 MW per year), the maximum capability of the system (1,435 MW) was forecast to be exceeded in 2008. The goal of this study was to examine whether a major refurbishment of this line could be deferred and, if so, for how long.
- Southern Oregon Coast -- The peak winter demand in the Southern Oregon Coast area is currently 100 MW, and is expected to grow by approximately 2 MW per year. At this rate of growth, the load was forecast to reach the voltage stability constraint system limit of 110 MW in approximately five years. Therefore, the main goal of this study was to identify measures that could (1) prevent the load from reaching 110 MW by the year 2010, and (2) prevent further growth of the load beyond 110 MW.

The two service areas are similar in that they encompass largely rural areas and are served predominantly by public utilities with loads served by the BPA. Figure 1 provides a comparative overview of the two study areas. Note that, while both sets of loads have similar makeup, the Southern Oregon Coast load is a fraction (<10%) of the Olympic Peninsula's.

Figure 1. Comparison of System Areas

	Olympic Peninsula	**Southern Oregon Coast**
System Overview		
System Capacity Constraint (MW)	1435 MW	110 MW
Load growth (per annum)	22 MW	2 MW
Number of Utilities	4	2
% Sales Forecast at Target Year		
Residential	62 %	67 %
Commercial	20 %	18 %
Industrial	18 %	13 %
Other	0 %	2 %
Major Industrial End Uses	Wood products, Paper Manufacturing, Pumping.	Wood products, Pumping.

Approach and Methodology

The assessment of energy and capacity savings potential in each area was undertaken using a common methodology, consisting of the following three steps:

- **Development of Base Case Scenario** – Development of base case energy consumption and demand for a variety of market segments drawing upon a combination of data provided by BPA and the utilities. This established a baseline against which the impacts of potential energy efficiency, demand response, and distributed generation measures could be measured.

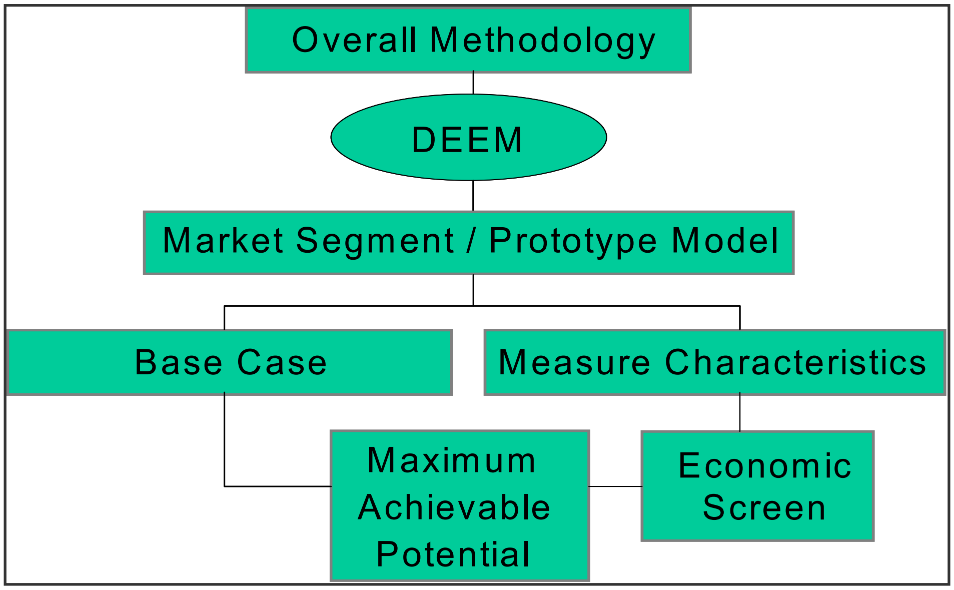
- **Identification and Screening of Options** – Identification of viable energy efficiency, demand response, and distributed generation technologies through a process of qualitative screening, development of measure impacts, costs and lifetimes, and economic screening of the measures that pass the qualitative screen.
- **Assessment of Maximum Achievable Potential** – Estimates of maximum achievable load reduction at times of extreme peak from measures applied to the market segments in the study area. Maximum achievable potential separately identified energy-efficiency impacts (resulting from energy-efficiency measures that yield a permanent savings in energy and peak demand), demand response impacts (resulting from demand response measures and programs that yield demand savings during critical periods of demand shortfalls), and distributed generation impacts.

The overall approach to the energy efficiency and demand response potential portion of this study is illustrated in Figure 2, below. The first activity in each study was to define the relevant set of building types in the utilities' service territories. About one-half dozen key residential and commercial building types were selected for the potentials analysis in each area, based on their historical load importance and discussion with local utility staff about anticipated growth patterns. For each residential and commercial building type selected, a prototype model was developed in order to characterize the energy usage and peak demand by end use for each building type. (Prototype models were not developed for the industrial sector due to the diversity and uniqueness of this sector). The unit load and energy effects of the applicable non-wires measures in these buildings was estimated by applying Global Energy Partner's Database of Energy Efficiency Measures (DEEM) tool[1] to the building prototypes. The results from the prototype modeling fed into the other activities in the study: the base case assessment, the measure characterization, and the maximum achievable potential assessment as discussed below.

The second activity was to develop a base case assessment by segment and end use for each sector. This assessment established a "baseline" against which the impacts of potential energy efficiency and demand response measures and programs could be compared and served as a reference to the maximum achievable potential estimates. A base case represents the current and future building stock characteristics and load forecast, absent a customer's participation in any energy-efficiency programs, going forward. This assessment was conducted in a way that utilizes the available data and industry standards for conducting such analyses. To address the uniqueness of the industrial facilities, it was necessary to utilize an approach that split aggregate information about specific industries down to their specific sector and end-use components.

[1] DEEM was funded by utilities that participated in the 2002 and 2004 EPRI Commercial and Residential Markets (Program 17) managed by Global Energy Partners. DEEM contains comprehensive information on an extensive number of energy-efficiency measures and state-of-the-art technologies for a variety of building types within the residential and commercial sectors. DEEM contains data that represent fifteen geographical regions throughout the United States.

Figure 2: Overall Approach



The measure characteristics portion of this study is where a universe of energy efficiency and demand response measures was identified as possible candidates for eventual implementation in the study area. After a series of screens to narrow the list down to those measures that were most applicable and suitable given conditions in the study area and objectives of the study, each measure was characterized for typical savings, incremental cost, and lifetime. Following the measure characterization, an economic screening of the candidate measures was conducted to screen those energy efficiency and demand response measures that were uneconomical, using total resource cost metrics with local rate, measure cost, and T & D construction cost data.

The Maximum Achievable Potential assessment represents the *maximum* target for energy efficiency and demand response savings that a utility can expect to achieve. Maximum achievable potential is a subset of economic potential. Economic potential represents the maximum savings of the measures that pass the economic screen and ignores program administration costs and customer preferences.

Analysis Results

A summary of results for each of the study analyses is provided below.

Olympic Peninsula Results

Three scenarios were considered within this study served to distinguish between various levels of implementation effort and resulting market penetration: (1) a "current plan" scenario, (2) an "aggressive" scenario, and (3) an "extreme" scenario. Each of these scenarios is defined below.

- **Current Plan Scenario.** Under this scenario, the market acceptance ratios (MARs) for energy efficiency measures reflect a level of market penetration of the measures that is similar to that captured in the past program implementation in the Olympic Peninsula and other regions of the country. Within this scenario, demand response includes the potential attributable to the large customers that were identified as BPA's Demand Exchange Response Pilot project participants, as well as 200 residential customers in Clallam County PUD service territory that have been identified as potential participants in the water heater load control pilot project (using fiber optic technology in Sequim, Washington);
- **Aggressive Scenario**. Under this scenario, the MARs for energy efficiency measures reflect a high level of market penetration by the fifth year of program implementation due to more aggressive program promotion. This scenario also includes the potential attributable to the large customers that were identified as the Demand Exchange Response Pilot project participants and non-participants (with a potential total of approximately 39.5 MW), plus electric water heater load control in single-family homes in Clallam County PUD and Port Angeles City Light service territories;
- **Extreme Scenario**. Under this scenario, the MARs for energy efficiency measures reflect a very high level of market penetration of the measures by the fifth year of program implementation such that the maximum achievable potential is nearly equal to the economic potential. For demand response, this scenario builds upon the aggressive scenario, adding electric water heater load control in single-family homes in all four Olympic Peninsula utilities. In addition to the large customers that were identified as the Demand Exchange Response Pilot project participants and non-participants, this scenario also includes possible expansion of the Demand Exchange Response Pilot project to include10 small industrial customers that can each provide 0.25 MW of demand response in 2005 (escalating to 20 small industrial customers in 2009).

Figure 3 shows the MAP results for all four Olympic Peninsula utilities in aggregate under three different scenarios. In aggregate, the total MAP for energy efficiency, demand response, and distributed generation under the "current plan" scenario is 54.3 GWh and 46.2 MW by the year 2009. These figures increase to 69.2 GWh and 60.8 MW under the "aggressive" scenario, and 110.7 GWh and 79.0 MW under the "extreme" scenario.

Figure 3: Total Maximum Achievable Potential – Olympic Peninsula Utilities

	Current Plan Scenario				Aggressive Scenario				Extreme Scenario			
	Energy (GWh)		Demand (MW)		Energy (GWh)		Demand (MW)		Energy (GWh)		Demand (MW)	
	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009
All Four Utilities												
Energy Efficiency MAP	6.4	54.3	0.9	7.8	6.4	69.2	0.9	9.6	6.4	110.7	0.9	15.3
Demand Response MAP	0.0	0.0	36.2	36.2	0.0	0.0	41.3	49.0	0.0	0.0	45.2	61.5
Distributed Generation MAP	0.0	0.0	2.2	2.2	0.0	0.0	2.2	2.2	0.0	0.0	2.2	2.2
Grand Total MAP	**6.4**	**54.3**	**39.3**	**46.2**	**6.4**	**69.2**	**44.4**	**60.8**	**6.4**	**110.7**	**48.4**	**79.0**

Demand response measures contribute the most to peak load reduction, though the contribution by energy efficiency measures in this study area will ensure that the load reduction potential is enough to keep load below capacity under extreme weather conditions, thus meeting BPA's goal. In the Olympic Peninsula study area, most of the load reduction potential resides in the commercial/industrial facilities with customer participation in load curtailment initiatives. Experience with the Demand Response Pilot in this area provides additional support for pursuing this measure for full-scale operation.

Southern Oregon Coast Results

Figure 4 summarizes the total maximum achievable potential (MAP), for the Southern Oregon Coast region. Since we cannot predict within the scope of this study how many customers will participate in both energy efficiency and demand response activities, we take a conservative approach by assuming that the same set of customers who implement energy efficiency measures also participate in demand response activities. Mathematically, this translates into calculating the demand reduction component of the Grand Total MAP by *summing* the demand reduction MAP due to energy efficiency, demand response, and distributed generation, and then *subtracting* out from this sum half of the demand MAP due to energy efficiency to adjust for the double counting that would occur from customers with energy-efficient equipment that is also subject to load control. This method of calculation is represented by the "Grand Total MAP – No Double Counting" figures.

Figure 4. Total Maximum Achievable Potential – Southern Oregon Coast

	Energy (GWh)			Demand (MW)		
	2007	2010	2015	2007	2010	2015
Entire Southern Oregon Coast Area						
Base Case	*413.4*	*431.4*	*478.5*	*110.9*	*118.7*	*132.8*
Energy Efficiency MAP	0.9	5.9	19.8	0.2	1.2	3.7
Demand Response MAP	N/A	N/A	N/A	3.4	11.6	15.8
Distributed Generation MAP	N/A	N/A	N/A	1.1	1.1	1.1
Grand Total MAP	0.9	5.9	19.8	4.7	13.8	20.6
Grand Total MAP - No Double Counting	**0.9**	**5.9**	**19.8**	**4.6**	**13.3**	**18.7**
% of Base Case	**0.2%**	**1.4%**	**4.1%**	**4.2%**	**11.2%**	**14.1%**

This study identified cost-effective measures that, if deployed, will result in significant peak load reduction, ranging from 4.6 MW in 2007 to an 18.7 MW reduction in 2015. This would keep the load below the system limit for an additional seven years. Even with these reductions, however, peak demand is estimated to exceed the system capacity of 110 MW in 2013. Figure 5 summarizes the effect of the demand reduction potential (MAP) by year.

Figure 5. Demand Forecast Incorporating MAP – Southern Oregon Coast

	Demand (MW)								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
System Limit	**110.0**	**110.0**	**110.0**	**110.0**	**110.0**	**110.0**	**110.0**	**110.0**	**110.0**
Base Case System Demand Forecast	**110.9**	**113.4**	**116.0**	**118.7**	**121.4**	**124.2**	**127.0**	**129.9**	**132.8**
System Demand After MAP - No Double Counting	**106.2**	**106.0**	**105.7**	**105.4**	**107.1**	**108.8**	**110.6**	**112.3**	**114.1**

Figure 6 presents the maximum achievable potential by sector and measure type for the Southern Oregon Coast.

Most of this load reduction potential is from demand response measures. And most of that is from residential water heating and space heating load control. While energy efficiency measures can produce significant energy (kWh) savings, they have far less impact on peak demand. With or without the energy efficiency, the impacts on load can be kept below the system limit for seven years beyond the current forecast.

Figure 6. Total Maximum Achievable Potential in 2015 by Sector and Approach

Sector and Approach	Contribution – MW *	Contribution - %
Residential Demand Response	12.8	62.3%
Residential Energy Efficiency	2.9	14.2%
Commercial/Industrial Demand Response	2.9	14.3%
Commercial/Industrial Energy Efficiency	0.8	3.9%
Commercial/Industrial Distributed Generation	1.1	5.3%
Total	20.6	100.0%

* Note: Possible double-counting effects have not been taken into account in the MW values.

The two main factors contributing to the value of residential peak demand reduction are (1) the contribution of residential energy use during the winter morning peak, which this approach is designed to mitigate, and (2) the market availability of residential load control technologies to control residential space heat and water heat loads, along with readiness of the local utilities to implement load control in this sector.

Comparison of Programmatic Implications

The MAP analysis results indicate that the majority of load reduction potential would come from demand response options in both study areas. However, the potential in the Olympic Peninsula area is greatest in the commercial/industrial sector, while in the Southern Oregon Coast areas the greatest potential lies in the residential sector. Figure 7 below provides a summary of these comparative results. The results have definitive programmatic implications.

Figure 7. Comparison of Study Results

	Olympic Peninsula	Southern Oregon Coast
Source of Load Reductions		
Energy Efficiency	19 %	18 %
Demand Response	78 %	77 %
Distributed Generation	3 %	5 %
Source of Demand Response Resource (expressed as % of total DR resource)		
Residential Sector	0-27 % [2]	82 %
Commercial / Industrial Sector	99-72 %	18 %

On the Olympic Peninsula, the load reduction is anchored in full-scale operation of the commercial/industrial curtailable load program, along with some additional commercial reduction from water heating load control.

[2] Note that this range is the result of the three scenarios developed for the Olympic Peninsula study. A key variation in each scenario was the level of investment made in residential DR measures.

On the Southern Oregon Coast, the results rely in large part upon the attainment of aggressive direct load control in residential space and water heating end uses. The major local utility is currently undertaking a pilot project to assess the viability of substation-to-meter communication using a power line carrier for use in automated meter reading, and potentially for demand response.

Study Challenges

A comparison of these project experiences highlights three significant areas of challenge that may be expected by any analyst undertaking a similar study. These include (1) data availability, market adoption rates assumptions, and data "resolution" required for the analysis.

Data Availability

Perhaps the most significant challenge encountered with these studies involved data development. Utility sales data served as the cornerstone for developing the market segment profiles. For residential accounts, and for the limited number of industrial accounts, this was relatively straight-forward. However, in the case of developing a profile of the broader commercial sector, this proved to be more problematic. Typically, NAICS codes are used to "map" customers into a standard set of building types. Then, by applying EUI assumptions to these aggregated numbers, floorstock estimates may be derived for each building type to facilitate the analysis of technical potential. Working with the data provided by utilities on the Olympic Peninsula was these quite time consuming because the data needed extensive cleaning and augmentation. In addition to NAICS assignments being missing in some cases, we also identified numerous accounts that were mis-coded or mis-assigned in the first place (i.e., residential accounts coded as commercial). In working with the data, it was not possible to review and re-code each and every account. As such, we applied an 80/20 approach and reviewed in detail the classifications for those accounts that comprised 80% of the system energy use.

Market Adoption Rates (MARs) Assumptions

Another key challenge involved the estimation of MARs for the Southern Oregon Coast study. We did not anticipate going into this study that the final results would be heavily dependent upon a single technology: residential direct load control. The attainment of sufficient load reduction on the Southern Oregon Coast will rely heavily upon the aggressive deployment of direct load control for space and water heating in a large number of homes. While the technical impacts of these measures are reliable, there is considerable uncertainty surrounding the market adoption rates for these measures since these technologies are relatively untested in a programmatic sense. Hence, a conservative adoption rate was used in the analysis, and any implementation effort will need to pay particularly close attention to the success being achieved in this area.

Data "Resolution"

For lack of a better term, we use resolution to refer to the level of precision desired and/or anticipated from such a study. Planning exercises such as this necessarily rely upon myriad assumptions that are layered upon one another to create the overall analysis. The results are indicative of the analyst's best effort to model the situation and the expected impacts. However, as with any analytical study, the results are only as good as the data upon which the analyses are founded. When modeling at a smaller scale, the precision of the data becomes much more important and any variance that might, in other studies be "lost in the noise," becomes much more important. In the case of the Southern Oregon Coast, since the service area was very small, it became especially important to ensure that some of the key data were as accurate as possible. Ironically, studies that might be viewed as "smaller" in scope (due to the size of the service area or magnitude of the problem at hand), may require a higher level of investment in data development in order to develop reliable results that satisfy all stakeholders.

Summary

This paper has documented the successful application of established demand planning techniques to address localized transmission and distribution constraints. Several key findings emerged from these studies:

- Non-wires options are viable for the deferral of T & D capacity expansion.
- As effective as energy efficiency measures are in containing energy consumption, significant peak load reduction in these study areas will require aggressive pursuit of demand response measures.
- The specific demand response measures that can generate the load reduction are highly dependent on the makeup of the customer base and local economic and demographic conditions.
- The availability of specific local data that affect the assessment of load reduction potential, such as the energy efficiency of the current equipment stock and customer attitudes/awareness about load reduction measures, is both highly influential on the results and difficult to come by in areas with relatively low population.

References

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