PacifiCorp Demand-Side Resource Potential Assessment for 2015-2034

Volume 2: Class 2 DSM Analysis

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INTRODUCTION

In 2013, PacifiCorp commissioned Applied Energy Group, with subcontractor The Brattle Group, to conduct this Demand-Side Resource Potential Assessment. This study provides estimates of the potential for electric demand-side management (DSM) resources in PacifiCorp's six-state service territory,[1] including supply curves, for the 20-year planning horizon of 2015–2034 to inform the development of PacifiCorp's 2015 Integrated Resource Plan (IRP) and satisfy state-specific requirements associated with forecasting and DSM resource acquisition.

Since 1989, PacifiCorp has developed biennial Integrated Resource Plans (IRPs) to identify an optimal mix of resources that balance considerations of cost, risk, uncertainty, supply reliability/deliverability, and long-run public policy goals. The optimization process accounts for capital, energy, and ongoing operation costs as well as the risk profiles of various resource alternatives, including: traditional generation and market purchases, renewable generation, and DSM resources such as energy efficiency, and capacity-focused resources i.e. demand response and direct load control. Since the 2008 IRP, DSM resources have competed directly against supply-side options, allowing the IRP model to selectively choose the right mix of resources to meet the needs of PacifiCorp's customers while minimizing cost and risk. Thus, this study does not assess cost-effectiveness.

This study primarily seeks to develop reliable estimates of the magnitude, timing, and costs of DSM resources likely available to PacifiCorp over the 20-year planning horizon mentioned above. The study focuses on resources assumed achievable during the planning horizon, recognizing known market dynamics that may hinder resource acquisition. Study results will be incorporated into PacifiCorp's 2015 IRP and subsequent DSM planning and program development efforts. This study serves as an update of similar studies completed in 2007, 2011, and 2013.[2]

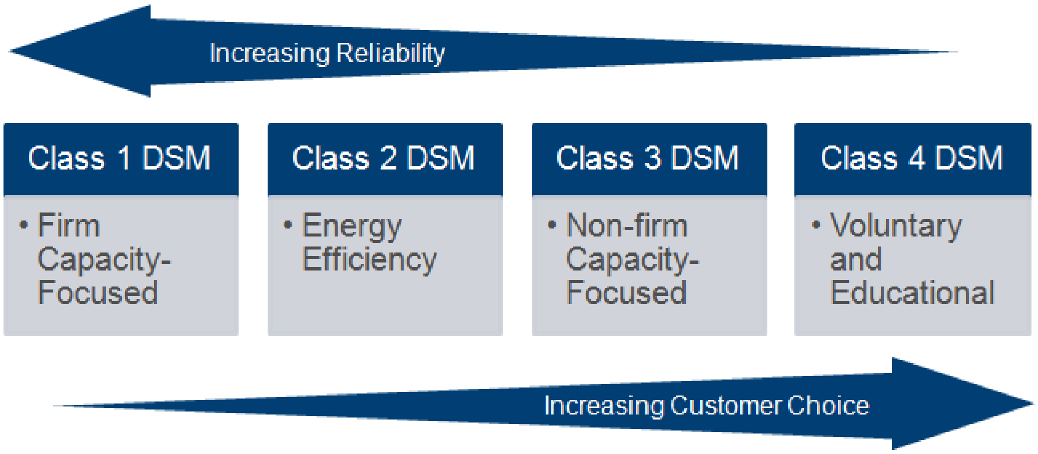
DSM Resource Classes

For resource planning purposes, PacifiCorp classifies DSM resources into four categories, differentiated by two primary characteristics: reliability and customer choice (see Figure 1-1). These resources are captured through programmatic efforts promoting efficient electricity use through various intervention strategies, aimed at changing: energy use peak levels (load curtailment), timing (price response and load shifting), intensity (energy efficiency), or behaviors (education and information).

From a system-planning perspective, Class 1 and Class 2 DSM resources (particularly Class 1 direct load control programs) are considered the most reliable, as once a customer elects to participate in a Class 1 DSM program, the resource is under the utility's control and can be dispatched as needed. Similarly, when a customer invests in a home or business efficiency improvement, the savings are locked in as a result of the installation and will occur during normal operation of the end use. In contrast, behavioral savings, resulting from energy education and awareness actions included in Class 4 DSM, tend to be the least reliable, as savings will vary due to greater customer control and the need for customers to take specific and consistent actions to lower their usage during peak periods.

[1] Class 2 analysis for Oregon is excluded from this report because it is assessed statewide by the Energy Trust of Oregon.
[2] The previous potential studies can be found at: http://www.pacificorp.com/es/dsm.html

Figure 1-1 Characteristics of DSM Resource Classes



PacifiCorp commissioned this DSM resource potential assessment to inform the Company's biennial IRP planning process, to satisfy other state-specific DSM planning requirements, and to assist PacifiCorp in revising designs of existing DSM programs and in developing new programs. The study's scope encompasses multi-sector assessments of long-term potential for DSM resources in PacifiCorp's Pacific Power (California, Oregon, and Washington) and Rocky Mountain Power (Idaho, Utah, and Wyoming) service territories. This study excludes an assessment of Oregon's Class 2 DSM potential, as this potential has been captured in assessment work conducted by the Energy Trust of Oregon[3], which provides energy-efficiency potential in Oregon to PacifiCorp for resource planning purposes. This study does not include assessments of Class 4 DSM resources. Unless otherwise noted, all results presented in this report represent savings at generation; that is, savings at the customer meter have been grossed up to account for line losses.

Interactions Between Resources

This assessment includes multiple resources, actions, and interventions that would interact with each other if implemented in parallel. As explained in more detail later in this report, we take specific actions to account for these interactions to avoid double-counting the available potential. The interactive effects that we have analyzed occur within the major analysis sections; meaning that the interactions of energy efficiency resources are considered across all Class 2 DSM resources. Likewise, the analysis of capacity-focused Class 1 and 3 DSM resources explicitly considers interactions. It should be noted, however, that this study does not attempt to quantify potential interactions between energy-focused and capacity-focused resources. Though an important factor to recognize, this study did not attempt to quantify such interactions due to uncertainties regarding resources likely to be found economic and pursued.

[3] The Energy Trust of Oregon's 2014 Energy Efficiency Resource Assessment Report can be found here: http://energytrust.org/library/reports/Energy_Efficiency__Resource_Assessment_Report.pdf

Report Organization

This report is presented in five volumes as outlined below. This document is **Volume 2, Class 2 DSM Analysis**.

- Volume 1, Executive Summary
- Volume 2, Class 2 DSM Analysis
- Volume 3, Class 1 and 3 DSM Analysis
- Volume 4, Class 2 DSM Analysis APPENDIX
- Volume 5, Class 1 and 3 DSM Analysis APPENDIX

Abbreviations and Acronyms

Throughout the report we use several abbreviations and acronyms. Table 1-1 provides a list of them, along with an explanation.

Table 1-1 Explanation of Abbreviations and Acronyms

Acronym	Explanation
aMW	Average Megawatt, obtained by dividing Megawatt-hours by 8760
C&I	Commercial and Industrial
CAC	Central Air Conditioning
Council	Northwest Power and Conservation Council
DHW	Domestic Hot Water
DEER	California's Database for Energy Efficient Resources
DSM	Demand-Side Management
DLC	Direct Load Control
EE	Energy Efficiency
EIA	Energy Information Administration
EUL	Effective Useful Life
EUI	Energy Usage Intensity
FERC	Federal Energy Regulatory Commission
HVAC	Heating Ventilation and Air Conditioning
IECC	International Energy Conservation Code
IOU	Investor Owned Utility
NEEA	Northwest Energy Efficiency Alliance
NPV	Net Present Value
O&M	Operations and Maintenance
PCT	Programmable Communicating Thermostat
PCT	Participant Cost Test
RTF	Regional Technical Forum
TRC	Total Resource Cost
UCT	Utility Cost Test
UEC	Unit Energy Consumption
UES	Unit Energy Savings
WH	Water Heater

ANALYSIS APPROACH

Energy-focused DSM resources, or energy efficiency resources, are measures that reduce customers' energy consumption relative to what it would have been without installing or enacting the measure. This is what PacifiCorp categorizes as Class 2 DSM resources. In this chapter we will discuss the approach we used to estimate the Class 2 DSM resource potential.

Overview of Analysis Steps

To perform the energy efficiency analysis, AEG used a bottom-up analysis approach following the major steps listed below. We describe these analysis steps in more detail throughout the remainder of this chapter.

1. Perform a market characterization to describe sector-level electricity use for the residential, commercial, industrial, irrigation, and street lighting sectors for the base year, 2012 in five states within PacifiCorp's service territory: California, Washington, Idaho, Utah, and Wyoming. Oregon is not covered in this analysis because the Energy Trust of Oregon handles the planning and implementation of all energy efficiency within PacifiCorp's Oregon service territory.[4] To perform the market characterization, we used results from primary market research conducted by PacifiCorp wherever possible, supplemented by other secondary data sources available from regional and national organizations such as the Northwest Energy Efficiency Alliance (NEEA) and the Energy Information Administration (EIA).
2. Develop a baseline projection of energy consumption by state, sector, segment, and end use for 2015 through 2034.
3. Define and characterize energy efficiency measures to be applied to all sectors, segments, and end uses.
4. Estimate the potential from the efficiency measures. While the analysis ultimately develops estimates of annual potential for each year in the 20-year planning horizon for use in PacifiCorp's IRP, results presented in this volume focus on cumulative impacts at the end of the planning horizon (2034).
5. Compare the results of the present study with those from PacifiCorp's previous (2013) DSM potential assessment[5] to identify important trends and changes.

Definition of Potential

To assess the various levels of resource potential available in the PacifiCorp service territory, we investigated the following cases:

- **Class 2 DSM Technical Potential** – This case is defined as the theoretical upper limit of energy efficiency potential. It assumes that customers adopt all feasible measures regardless of their cost or customer preferences. At the time of existing equipment failure, customers replace their equipment with the most efficient option available relative to applicable standards. In new construction, customers and developers also choose the most efficient

[4] The Energy Trust of Oregon's 2014 Energy Efficiency Resource Assessment can be found here: http://energytrust.org/library/reports/Energy_Efficiency__Resource_Assessment_Report.pdf

[5] http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Demand_Side_Management/DSM_Potential_Study/PacifiCorp_DSMPotential_FINAL_Vol%20I.pdf

equipment option relative to applicable codes and standards. This case is a theoretical construct, and is provided primarily for planning and informational purposes.

- **Class 2 DSM Achievable Technical Potential** - This case refines Technical Potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and other factors that may affect market penetration of DSM measures. We used achievability assumptions and ramp rates developed by the Northwest Power and Conservation Council ("The Council") for their Sixth Power Plan as the customer adoption rates for this study.

LoadMAP Model

For the energy efficiency potential analysis, we used AEG's Load Management Analysis and Planning tool (LoadMAP^{TM}) version 4.0 to develop both the baseline projection and the estimates of potential. AEG developed LoadMAP in 2007 and has enhanced it over time, using it for the EPRI National Potential Study and numerous utility-specific forecasting and potential studies since. Built in Excel, the LoadMAP framework has the following key features.

- Embodies the basic principles of rigorous end-use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life and appliance vintage distributions.
- Balances the competing needs of simplicity and robustness by incorporating important modeling details related to equipment saturations, efficiencies, vintage, and the like, where market data are available, and treats end uses separately to account for varying importance and availability of data resources.
- Isolates new construction from existing equipment and buildings and treats purchase decisions for new construction and existing buildings separately.
- Uses a simple logic for appliance and equipment decisions, rather than complex decision choice algorithms or diffusion assumptions which tend to be difficult to estimate or observe and sometimes produce anomalous results that require calibration or even overriding.
- Includes appliance and equipment models customized by end use. For example, the logic for lighting is distinct from refrigerators and freezers.
- Can accommodate various levels of segmentation. Analysis can be performed at the sector level (e.g., total residential) or for customized segments within sectors (e.g., housing type or income level).

Consistent with the segmentation scheme and the market profiles we describe below, the LoadMAP model provides forecasts of baseline energy use by sector, segment, end use, and technology for existing and new buildings. It also provides forecasts of total energy use and energy-efficiency savings associated with the various types of potential.

Market Characterization

The first step in the analysis approach is market characterization. In order to estimate the savings potential from energy-efficient measures, it is necessary to understand the equipment that is currently being used and its associated energy consumption. This characterization begins with a segmentation of PacifiCorp's electricity footprint to quantify energy use by state, sector, segment, end-use application, and the current set of technologies used.

Segmentation for Modeling Purposes

The market assessment first defined the market segments (building types, end uses, and other dimensions) that are relevant in the PacifiCorp service territory. The segmentation scheme for this project is presented in Table 2-1.

Table 2-1 Overview of Segmentation Scheme for Class 2 Potentials Modeling[6]

Dimension	Segmentation Variable	Description
1	State	California, Washington, Idaho, Utah, Wyoming
2	Sector	Residential, commercial, industrial, irrigation, street lighting
3	Customer Category	Residential: single family, multi family, manufactured home Commercial: by building type Industrial: by industry type Irrigation: by pump horsepower size Street lighting: Customer-owned vs Company-owned
4	Vintage	Existing and new construction
5	End uses	Cooling, lighting, water heat, motors, etc. (as appropriate by sector)
6	Appliances/end uses and technologies	Technologies such as lamp type, air conditioning equipment, motors by application, etc.
7	Equipment efficiency levels for new purchases	Baseline and higher-efficiency options as appropriate for each technology

With the segmentation scheme defined, we then performed a market characterization of electricity sales in the base year to allocate sales to each customer segment. We used PacifiCorp billing data and customer saturation surveys to inform the bottom-up assembly of energy consumption among the various sectors and segments such that the total customer count and total energy consumption matched the PacifiCorp system totals for 2012. This information provided control totals at a sector level for calibrating the LoadMAP model to known data for the base year.

Market Profiles

The next step was to develop base-year market profiles for each sector, customer segment, end use, and technology. A market profile includes the following elements:

- **Market size** is a representation of the number of customers in the segment. For the residential sector, it is number of households. In the commercial sector, it is floor space measured in square feet. For the industrial sector, it is number of employees. For irrigation, it is number of service points. For street lighting, it is number of fixtures.
- **Saturations** define the fraction of the market with the various technologies. (e.g., percent of homes with electric space heating).
- **UEC (unit energy consumption) or EUI (energy-use intensity)** describes the average energy consumed in 2012 by a specific technology in buildings that have the technology. UECs are expressed in kWh/household for the residential sector, and EUIs are expressed in kWh/square foot or kWh/employee for the commercial and industrial sectors, respectively.
- **Intensity** for the residential sector represents the average energy use for the technology across all homes in 2012 and is computed as the product of the saturation and the UEC. For the commercial and industrial sectors, intensity, computed as the product of the saturation

[6] For complete listings of the segmentation categories, please see Market Characterization and Energy Market Profiles in appendix A in Volume 4 of this report.

and the EUI, represents the average use for the technology per square foot or per employees in 2012.

- **Usage** is the total annual energy use by an end use technology in the segment. It is the product of the market size and intensity and is quantified in gigawatt-hours (GWh). As mentioned above, this usage is calibrated to actual sales in the base year.

The market characterization results and the market profiles are presented in appendix A in Volume 4 to this report.

Baseline Projection

The next step was to develop the baseline projection of annual electricity use for 2015 through 2034 by state, sector, customer segment, end use and technology without new utility DSM programs to avoid double counting of the available potential. The end-use projection includes the impacts of building codes and equipment efficiency standards that were enacted as of December 2013, even if they would not become effective until a future date. The study does not, however, attempt to project future changes to codes and standards beyond those that already have a known effective date. For a list of equipment efficiency standards included in residential and commercial baseline projections, see Table 3-3 and Table 3-4. The baseline projection is the foundation for the analysis of savings from future EE efforts as well as the metric against which potential savings are measured.

Inputs to the baseline projection include:

- Current PacifiCorp customer growth forecasts
- Trends in equipment saturations
- Existing and approved changes to building codes and equipment standards

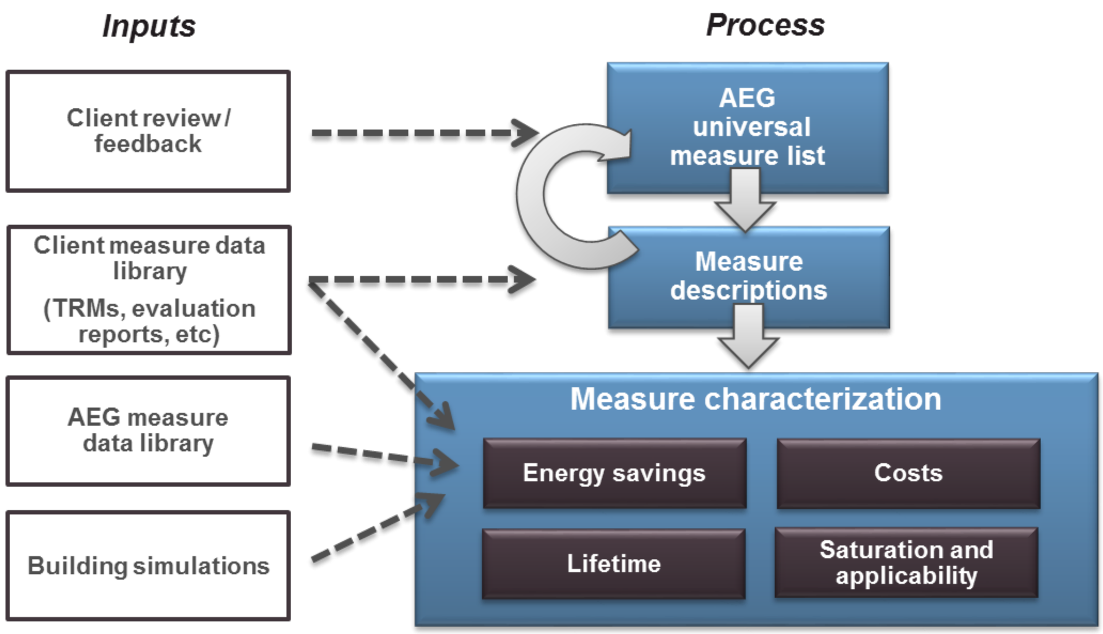
Regarding customer purchase behaviors, the study held purchase trends constant at current levels, except where overridden by a forthcoming code or standard.

Although it uses many of the same input assumptions and aligns very closely with PacifiCorp's official load forecast, the baseline projection for the potential model was developed as an independent projection to ensure that baseline assumptions were consistent with those used to assess energy efficiency measure savings and applicability. We present the baseline-projection results for the system as a whole and for each sector in appendix B in Volume 4 to this report.

Energy Efficiency Measure Analysis

This section describes the framework used to assess the savings, costs, and other attributes of energy efficiency measures. These characteristics form the basis for determining measure-level savings and levelized costs as well as the subsequent build up to sector- and state-level savings and levelized costs. For all measures, AEG assembled information to reflect equipment performance, incremental costs, and equipment lifetimes. Figure 2-1 outlines the framework for measure analysis.

Figure 2-1 Approach for EE Measure Assessment



The framework for assessing savings, costs, and other attributes of energy efficiency measures involves identifying the list of energy efficiency measures to include in the analysis, determining their applicability to each market sector and segment, fully characterizing each measure, and preparing for integration with the greater potential modeling process.

We compiled a robust list of energy efficiency measures for each customer sector, drawing upon PacifiCorp's program experience, the Council's Sixth Power Plan, the Regional Technical Forum (RTF), the Energy Trust of Oregon, AEG's own measure databases and building simulation models, and other secondary sources. This universal list of EE measures covers all major types of end-use equipment, as well as devices and actions to reduce energy consumption.

The selected measures are categorized into two types according to the LoadMAP taxonomy: equipment measures and non-equipment measures.

- **Equipment measures** are efficient energy-consuming pieces of equipment that save energy by providing the same service with a lower energy requirement than a standard unit. An example is an ENERGY STAR refrigerator that replaces a standard efficiency refrigerator. For equipment measures, many efficiency levels may be available for a given technology, ranging from the baseline unit (often determined by code or standard) up to the most efficient product commercially available. For instance, in the case of central air conditioners, this list begins with the current federal standard SEER 13 unit and spans a broad spectrum up to a maximum efficiency of a SEER 24 unit. These measures are applied on a stock-turnover basis, and in general, are referred to as lost opportunity (LO) measures due to the fact that once a purchase decision is made, there will not be another opportunity to improve the efficiency of that equipment item until the lifetime expires again.
- **Non-equipment measures** save energy by reducing the need for delivered energy, but do not involve replacement or purchase of major end-use equipment on a stock-turnover schedule (such as a refrigerator or air conditioner). For this reason, these measures are generally termed discretionary or non-lost opportunity measures.[7] An example is a

[7] An exception to this general definition is in the case of New Construction, where all measures, both equipment and non-equipment, are considered lost opportunity since there is a unique, one-time opportunity to install DSM measures at this time.

programmable thermostat which can be pre-set to run heating and cooling systems only when people are home and which can be installed at any time. Non-equipment measures can apply to more than one end use. For instance, adding wall insulation will reduce the energy use of both space heating and cooling systems. Non-equipment measures typically fall into one of the following categories:

- Building shell (windows, insulation, roofing material)
- Equipment controls (thermostat, energy management system)
- Equipment maintenance (cleaning filters, changing setpoints)
- Whole-building design (building orientation, passive solar lighting)
- Lighting retrofits (included as a non-equipment measure because retrofits are performed prior to the equipment's normal end of life)
- Displacement measures (ceiling fan to reduce use of central air conditioners)
- Commissioning and retrocommissioning
- Residential behavioral programs
- Energy Management programs

We developed a preliminary list of EE measures, which was distributed to the PacifiCorp project team for review. The list was finalized after incorporating comments and is presented in appendix H of Volume 4 to this report.

Once we assembled the list of EE measures, the project team assessed their energy-saving characteristics. For each measure we also characterized incremental cost, effective useful life, and other performance factors.

Table 2-2 summarizes the number of measures evaluated for each segment within each sector. The study considered 465 unique measures across sectors, which expand to over 50,000 permutations when assessed separately by state, vintage, and market segment.

Table 2-2 Number of Class 2 Measures Evaluated

Sector	Measure Count	Measure Count w/ Permutations (States, Vintages, & Segments)
Residential	109	3,270 = count * 5 * 2 * 3
Commercial	171	23,940 = count * 5 * 2 * 14
Industrial	150	22,500 = count * 5 * 2 * 15
Irrigation	19	190 = count * 5 * 2 * 1
Street Lighting	9	188 = count * 5 * 2 * 2
Total Measures Evaluated	**465**	**50,088 =sum**

Calculating Class 2 Energy-Efficiency Potential

The approach we used for this study to calculate the energy efficiency potential adheres to the approaches and conventions outlined in the National Action Plan for Energy-Efficiency (NAPEE) Guide for Conducting Potential Studies (2007)[8] and the Northwest Power and Conservation

[8] National Action Plan for Energy Efficiency (2007). *National Action Plan for Energy Efficiency Vision for 2025: Developing a Framework for Change*. www.epa.gov/eeactionplan.

Council's Sixth Power Plan (2010).[9] These sources represent authoritative and comprehensive industry practices for specifying energy-efficiency potential.

Measure Interactive Effects

When calculating potential, one cannot merely sum up savings from individual measure installations, as significant interactive effects can occur among measures. This analysis accounts for those interactions in the following ways:

Interactions between equipment and non-equipment measures – As equipment burns out, the potential analysis assumes it will be replaced with higher-efficiency equipment available in the marketplace, which reduces average consumption across all customers. The lower average consumption causes non-equipment measures to save less than they would have, had the average efficiency of equipment remained constant over time. The stock-turnover accounting applied in the model manifests this effect as annual trends in equipment energy consumption. For example, installing insulation in a home where the central heating system has been upgraded produces fewer savings than installing insulation in a home with an older heating system.

Interactions among non-equipment measures – There are often multiple non-equipment measures that affect the same technology or end use. In this case, the savings (as a percentage of the relevant end use consumption) are stacked upon one another such that those with lower levelized cost are applied first.[10]

Technical Potential

As described in Chapter 1, two types of potentials were developed as part of this effort: Technical potential and Achievable Technical potential. The calculation of Technical potential is a straightforward algorithm, aggregating the full, energy-saving effects of all the individual Class 2 measures included in the study at their maximum theoretical deployment levels, adjusting only for applicability.

While theoretically, all retrofit opportunities in existing construction (often called "discretionary" resources) could be acquired in the study's first year, this would skew the potential for equipment measures and provide an inaccurate picture of measure-level potential. Therefore, the study assumed the realization of these opportunities in equal, annual amounts, over the 20-year planning horizon. By applying this assumption, natural equipment turnover rates, and other adjustments described above, the annual incremental and cumulative potential was estimated by state, sector, segment, construction vintage, end use, and measure.

Achievable Technical Potential

To develop estimates for Achievable Technical potential, we constrain the Technical potential by applying market adoption rates for each measure that estimate the percentage of customers that would be likely to select each measure, given consumer preferences (partially a function of incentive levels), retail energy rates, imperfect information, and real market barriers and conditions. These barriers tend to vary, depending on the customer sector, local energy market conditions, and other, hard-to-quantify factors.

These market adoption rates are based onramp rates from the Council's Sixth Power Plan. As discussed below, two types of ramp rates have been incorporated for all measures and market regions.

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[9] Sixth Northwest Conservation and Electric Power Plan (2010). http://www.nwcouncil.org/energy/powerplan/6/plan/

[10] This is in contrast to equipment measures, which may require a mutually exclusive decision among multiple efficient options with energy savings relative to the baseline unit. In these cases the algorithm selects the option that is most energy efficient for the Technical Potential Case and the unit that is most efficient for less than $250/MWh levelized for the Achievable Technical Potential Case. For example, a SEER 13 central air conditioning baseline unit might be replaced with a SEER 24 variable refrigerant flow unit for Technical Potential and a SEER 16 unit for Achievable Technical Potential.

Estimated achievable technical potential principally serves as a planning guideline. Acquiring such DSM resource levels depends on actual market acceptance of various technologies and measures, which partly depend on removing barriers (not all of which a utility can control).

In addition to utility-sponsored programs, alternative delivery methods, such as existing market transformation efforts and codes and standards promotion, can be used to capture portions of these resources, depending on actual experiences with various programs. This proves particularly relevant in the context of long-term Class 2 DSM resource acquisition plans, where incentives might be necessary in earlier years to motivate acceptance and installations. As acceptance increases, so would demand for energy-efficient products and services, likely leading to lower costs, and thereby obviating the need for incentives and (ultimately) preparing for transitions to codes and standards.

Measure Ramp Rates

The study applied measure ramp rates to determine the annual availability of the identified potential lost opportunity and discretionary resources, interpreting and applying these rates differently for each class (as described below). Measure ramp rates generally matched those used in the Council's 6th Power Plan, although the study incorporated additional considerations for Class 2 DSM measure acquisition:

- The first year of the 6th Power Plan ramp rates (2010) was aligned with the study's first year (2015).
- For measures not included in the 6th Power Plan, the study assigned a ramp rate considered appropriate for that technology (i.e., the same ramp rate as a similar measure in 6th Power Plan).

Lost Opportunity Resources

Lost-opportunity energy efficiency measures correspond to equipment measures, which follow a natural equipment turnover cycle, as well as non-equipment measures in new construction instances that are fundamentally different and typically easier to implement during the construction process as opposed to after construction has been completed.

In addition to natural timing constraints imposed by equipment turnover and new construction rates, the AEG team applied measure ramp rates to reflect other resource acquisition limitations over the study horizon, such as market availability. These measure ramp rates had a maximum value of 85%, reflecting the Council's assumption that, on average, up to 85% of technical potential could be achieved in a given year by the end of a 20-year planning horizon. When combined with the effects of stock turnover for lost opportunity measures, this equates to potential savings that are lower than 85% of the technical opportunity. This is implicitly accounted for in equipment measures, but for non-equipment measures in new construction applications, a maximum value of 65% is applied to the measure ramp rates. This approximates the effect of the stock accounting model and produces an equivalent end point for the potential modeling as the equipment model. Overall, this results in achievability of 77% of the lost opportunity technical potential over the 20-year study period.

To calculate annual achievable technical potential for each lost opportunity measure, the study multiplied the number of units turning over or available in any given year by the adoption factor provided by the ramp rate, consistent with the Council's methodology. Because of the interactions between the equipment turnover and new construction, the lost opportunities of measure availability until the next life cycle, and the time frame limits at 20 years, the Council methodology for these measures produces potential less than 85% of technical potential.

Discretionary Resources

Discretionary resources differ from lost opportunity resources due to their acquisition availability at any point within the study horizon. From a theoretical perspective, all achievable technical potential for discretionary resources could be acquired in the study's first year, but from a practical perspective, this outcome is realistically impossible to achieve due to infrastructure and budgetary constraints as well as customer preferences and considerations.

As a result, the study addresses technical potential for discretionary resources by spacing the acquisition according to the ramp rates specified for a given measure, thus creating annual, incremental values. To assess achievable technical potential, we then apply the 85% market achievability limit defined by the Council.

Tables of all measure ramp rates are available in appendix E in Volume 4 to this report, both with and without the market achievability limits applied.

Market Ramp Rates

The 2013 assessment applied market ramp rates on top of measure ramp rates to reflect state-specific considerations affecting acquisition rates, such as age of programs, small and rural markets, and current delivery infrastructure. The market ramp rates were applied in California, Idaho and Wyoming. Since that time, PacifiCorp's programs have continued to gain traction, and therefore, the California and Idaho market ramp rates were not applied in this study. However, as momentum in Wyoming's industrial sector is still building, the current assessment applies the "Emerging" market ramp rate from the 2013 assessment, presented in Table E-1 in Volume 4 of this report, to industrial measures in Wyoming.

Accelerated Class 2 Case

In addition to the primary analysis described by Chapters 1 through 5 of this report, this study includes an alternative scenario to assess the feasibility and cost of accelerating Class 2 DSM acquisition relative to the reference case. This is pursuant to Action Item 7a in PacifiCorp's 2013 IRP to "Include in the 2014 conservation potential study an analysis testing assumptions in support of accelerating acquisition of cost-effective Class 2 DSM resources, and apply findings from this analysis into the development of candidate portfolios in the 2015 IRP." Chapter 6 describes the approach, data sources, and results of this analysis.

Levelized Cost of Measures

Using the cost data for measures developed in the characterization step above, we calculate the levelized cost of conserved energy (levelized cost) in order to create Class 2 DSM supply curves. Where possible, the study aligned its approach for calculating levelized costs for each measure to the Council's levelized-cost methodology, while recognizing differences in cost-effectiveness screening in each state within PacifiCorp's service territory.[11] Table 2-3 summarizes components of levelized cost in each PacifiCorp state assessed in this study.

Table 2-3 Economic Components of Levelized Cost by State

State	WA	ID	CA	WY	UT
Initial capital cost	Included				Utility incentive
Reinstallation cost	Included				Not included*
Annual Incremental O&M	Included		Not included		
Secondary Fuel Impacts	Included		Not included		
Non-Energy Impacts	Included		Not included		
Administrative costs	20% of incremental cost				

** Assumes the customer will reinstall the measure upon burnout without utility intervention.*

[11] Failure to align costs used for IRP optimization with methods used to assess program cost-effectiveness could lead to an inability to deliver selected quantities in a cost-effective manner in a given jurisdiction.

Utah's levelized cost is assessed on a Utility Cost Test (UCT) basis, while the other states are evaluated on a Total Resource Cost (TRC) basis. To maintain consistency with the Council, RTF and accepted regulatory practices, secondary benefits, non-energy impacts, and incremental O&M have been included for Washington and Idaho. In California and Wyoming, only capital costs (initial and reinstallation) and administrative costs have been included. For Washington resources, the Council's 10% conservation credit will be applied during the IRP modeling process, and this credit has not been included in the levelized costs presented in this report.

The approach to calculating a measure's levelized cost of conserved energy aligns with that of the Council's, considering the costs required to sustain savings over a 20-year study horizon, including reinstallation costs (except in Utah) for measures with useful lives less than 20 years. If a measure's useful life extends beyond the end of the 20-year study, the analysis incorporates an end effect, treating the measure's levelized cost over its useful life as an annual reinstallation cost for the remaining portion of the 20-year period.[12] For example, if a particular measure life is 15 years, a reinstallation of the measure will occur after year 15, and years 16 through 20 will reflect an annual levelized cost of installing that measure, prorated for the 5 of its 15 years. In this way, all measures are considered on an equivalent, 20-year basis.

For PacifiCorp's Utah service territory, the study adopted the utility's share of initial capital costs (i.e., an incentive amount) in the levelized cost calculation. The following assumptions regarding incentive amounts applied for Utah:

- Specific program measure (e.g., evaporative coolers and appliance recycling) incentives aligned with the current program design.
- Behavioral initiatives for residential customers included an incentive of 100%; indicating that the entire measure delivery is subsidized by the program. Behavioral initiatives for business customers, that is, energy management, included an incentive of 90% of the measure cost; indicating that most of the costs are subsidized by the program.
- Zero and negative incremental cost measures used incentives based on existing PacifiCorp program offerings and typical industry levels.
- Company-owned street lighting incentives were set to 100% of incremental measure costs.
- Incentives for all other measures represented 70% of the incremental measure cost[13], based on a robust incentive level aimed at achieving 85% of the technical potential.

For Utah, the study did not include reinstallation costs, given the assumption that the utility only provided incentives for first measure installations. That is, customers are assumed to reinstall the measure without utility intervention, and savings persist throughout the planning period, though the utility cost is incurred only during the first installation.

An assumption of 20% of incremental costs was used to align with program history, previous potential assessments, and industry benchmarks. This also aligns with the Council's assumed 20% administrative adder in the 6th Power Plan.

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[12] This method applied both to measures with a useful life greater than 20 years and those with useful lives extending beyond the 20th year at the time of reinstallation.

[13] Incremental measure costs vary by resource type (i.e., discretionary or retrofit), with incremental costs equaling full costs for discretionary resources, and for lost opportunities, the incremental cost is the difference between the standard-efficiency and higher-efficiency alternatives.

DATA DEVELOPMENT

This section details the data sources used for the Class 2 DSM analysis, followed by a discussion of how these sources were applied. In general, data were adapted to local conditions. For example, local data sources were used for measure data and local weather was used for building simulations.

Data Sources

The data sources are organized into the following categories:

- PacifiCorp data
- AEG's databases and analysis tools
- Other secondary data and reports

PacifiCorp Data

Our highest priority data sources for this study were those specific to PacifiCorp's system and customers.

- **PacifiCorp customer data:** PacifiCorp provided customer-level billing data for all states and sectors including segment identifiers to parse out the various housing types and business types.
- **Market research data:** Data collected by PacifiCorp customers through recent saturation survey efforts.
- **Load forecasts:** PacifiCorp provided state- and sector-level forecasts of energy consumption and customer counts.
- **Economic information:** PacifiCorp provided a systemwide discount rate and line loss factors by state and sector to calculate levelized costs and energy efficiency potential at the generator.
- **PacifiCorp program data**: PacifiCorp provided information about past and current energy efficiency programs, including program descriptions, achievements to date, and evaluation reports.

Applied Energy Group Data

AEG maintains several databases and modeling tools that we use for forecasting and potential studies.

- **AEG Energy Market Profiles**: For more than 10 years, AEG staff have maintained profiles of end-use consumption for the residential, commercial, and industrial sectors. These profiles include market size, fuel shares, unit consumption estimates, and annual energy use by fuel (electricity and natural gas), customer segment and end use for 10 regions in the U.S. The Energy Information Administration surveys (RECS, CBECS and MECS) as well as state-level statistics and local customer research provide the foundation for these regional profiles.
- **Building Energy Simulation Tool (BEST)**. AEG's BEST is a derivative of the DOE 2.2 building simulation model, used to estimate base-year UECs and EUIs, as well as measure savings for the HVAC-related measures.
- **AEG's Database of Energy Efficiency Measures (DEEM):** AEG maintains an extensive database of measure data for our studies. Our database draws upon reliable sources

including the California Database for Energy Efficient Resources (DEER), the EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, RS Means cost data, and Grainger Catalog Cost data.

- **Recent studies**. AEG has conducted numerous studies of EE potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies, which include studies in the Northwest for Avista Energy, Seattle City Light and Cowlitz PUD. In addition, we used the information about impacts of building codes and appliance standards from our recent reports for the Edison Electric Institute[14].

Other Secondary Data and Reports

Finally, a variety of secondary data sources and reports were used for this study. The main sources are identified below.

- **Council Sixth Plan Conservation Supply Curve Workbooks, 2010.** To develop its Power Plan, the Council created workbooks with detailed information about measures, available at http://www.nwcouncil.org/energy/powerplan/6/supplycurves/default.htm.
- **RTF Unit Energy Savings Measure Workbooks:** The RTF maintains workbooks that characterize selected measures and provide data on unit energy savings (UES), measure cost, measure life, and non-energy benefits, available at http://www.nwcouncil.org/energy/rtf/measures/Default.asp.
- **RTF Standard Protocols:** The RTF also maintains standard workbooks containing useful information for characterizing more complex measures for which UES values have not been developed, such as commercial sector lighting.
- **RTF Residential Simple Energy Enthalpy Model (SEEM) modeling results:** http://rtf.nwcouncil.org/measures/support/Default.asp
- **Residential Building Stock Assessment:** NEEA's 2011 Residential Building Stock Assessment (RBSA) provides results of a survey of thousands of homes in the Pacific Northwest: http://neea.org/resource-center/regional-data-resources/residential-building-stock-assessment
- **Commercial Building Stock Assessment:** NEEA's Commercial Building Stock Assessment (CBSA) provides data on regional commercial buildings. As of the most recent update in 2009, the database contains site-specific information for 2,061 buildings. http://neea.org/resource-center/regional-data-resources/commercial-building-stock-assessment
- **Bonneville Power Administration (BPA) Reference Deemed Measure List**, version 2.5, which was the most recent available when the study was performed.
- **Other relevant regional sources:** These include reports from the Consortium for Energy Efficiency (CEE), the Environmental Protection Agency (EPA), and the American Council for an Energy-Efficient Economy (ACEEE).
- **Annual Energy Outlook**. The Annual Energy Outlook (AEO), conducted each year by the U.S. Energy Information Administration (EIA), presents yearly projections and analysis of energy topics. For this study, we used data from the 2013 AEO.

[14] AEG staff who performed the PacifiCorp study have prepared three white papers on the topic of factors that affect U.S. electricity consumption, including appliance standards and building codes. Links to all three white papers are:
http://www.edisonfoundation.net/IEE/Documents/IEE_RohmundApplianceStandardsEfficiencyCodes1209.pdf
http://www.edisonfoundation.net/iee/Documents/IEE_CodesandStandardsAssessment_2010-2025_UPDATE.pdf.
http://www.edisonfoundation.net/iee/Documents/IEE_FactorsAffectingUSElecConsumption_Final.pdf

- **American Community Survey:** The US Census American Community Survey is an ongoing survey that provides data every year on household characteristics. Data for PacifiCorp were available for this study. http://www.census.gov/acs/www/
- **Weather Data:** Weather from NOAA's National Climatic Data Center for representative cities in each PacifiCorp state service territory was used as the basis for building simulations. These cities were: Yakima, WA; Salt Lake City, UT; Medford, OR (most representative weather station for California service territory); Pocatello, ID; and Casper, WY. Data used is in the Typical Meteorological Year 3 (TMY3) format, which utilizes thirty years of meteorological data to create hourly weather conditions for a standard year.
- **EPRI End-Use Models (REEPS and COMMEND)**. These models provide the econometric variables for elasticities we apply to electricity prices, household income, home size and heating and cooling.
- **Database for Energy Efficient Resources (DEER).** The California Energy Commission and California Public Utilities Commission (CPUC) sponsor this database, which is designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) for the state of California. We used the DEER database to cross check the measure savings we developed using BEST and DEEM.

Data Sources Related to the Accelerated Case

There were several reports that we specifically referred to in order to inform the Accelerated Class 2 DSM Case. These are listed below.

- California Investor Owned Utility DSM plans for 2012
- Efficiency Vermont Annual Report 2012, http://www.efficiencyvermont.com/docs/about_efficiency_vermont/annual_reports/Efficiency-Vermont-Annual-Report-2012.pdf
- Frontiers of Energy Efficiency: Next Generation Programs Reach for High Energy Savings, ACEEE report, 2013
- The Future of Utility Customer-Funded Energy Efficiency Programs in the United States: Projected Spending and Savings to 2025" LBNL Report, http://emp.lbl.gov/sites/all/files/lbnl-5803e.pdf, January 2013
- Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan, 2012
- Residential Deep Energy Retrofits, ACEEE report, 2014

Application of Data to the Analysis

We now discuss how the data sources described above were used for each step of the study.

Data Application for Market Characterization

To construct the high-level market characterization of electricity use by households/floor space/employee for the residential, commercial, and industrial sectors, we applied several data sources. PacifiCorp customer data were used first and foremost to allocate residential customers by housing type. This was compared to NEEA's RBSA and the American Community Survey (ACS) for verification. For the commercial sector, we used PacifiCorp billing data to estimate sales by building type. The estimates were also compared with NEEA's CBSA study, estimates used by PacifiCorp Load Forecasting, and AEG's Energy Market Profiles Database. For the industrial sector, we used PacifiCorp billing data to estimate energy use and employment for the industrial sector, comparing it to employment allocations from the U.S. Bureau of Labor Statistics and AEG's Energy Market Profiles. For the irrigation sector, we used PacifiCorp sales data and customer counts to define the number of service points. Finally, for street lighting, we used PacifiCorp data for number of fixtures.

Data Application for Market Profiles

The specific data elements for the market profiles, together with the key data sources, are shown in Table 3-1. To develop the market profiles for each segment, we used the following approach:

1. Developed control totals for each segment. These include market size, estimated segment-level annual electricity use, and annual intensity defined as the kWh divided by the relevant unit of market size, be it households, square feet, employees, service points, or fixtures for the respective sectors.
2. Used recent PacifiCorp saturation surveys and secondary data sources to incorporate information on existing equipment saturations, appliance and equipment characteristics, and building characteristics.
3. Incorporated secondary data sources to supplement and corroborate the data from items 1 and 2 above.
4. Compared and cross-checked with regional data in the Energy Market Profiles Database and other recent AEG studies.
5. Ensured calibration to control totals for annual electricity sales in each sector and segment.
6. Worked with PacifiCorp staff to vet the data against their knowledge and experience.

Data Application for Baseline projection

Table 3-2 summarizes the LoadMAP model inputs required for the baseline projection. These inputs are required for each segment within each sector, as well as for new construction and existing dwellings/buildings.

Table 3-1 Data Applied for the Market Profiles

Model Inputs	Description	Key Sources
Market size	Base-year residential dwellings, commercial floor space, industrial employment, irrigation service points, and street lighting fixtures	PacifiCorp billing data PacifiCorp saturation surveys
Annual intensity	Residential: Annual energy use (kWh/household) Commercial: Annual energy use (kWh/sq ft) Industrial: Annual energy use (kWh/employee)	PacifiCorp saturation surveys NEEA RBSA and CBSA AEG Energy Market Profiles AEO 2013 Other recent AEG studies
Appliance/equipment saturations	Fraction of dwellings with an appliance/technology Percentage of C&I floor space/employment with equipment/technology	PacifiCorp current saturation surveys NEEA RBSA and CBSA AEG Energy Market Profiles PacifiCorp Load Forecasting
UEC/EUI for each end-use technology	UEC: Annual electricity use for a technology in dwellings that have the technology EUI: Annual electricity use per square foot/employee for a technology in floor space that has the technology	HVAC uses: BEST simulations using prototypes developed for PacifiCorp Council workbooks, RTF Engineering analysis MECS data AEG DEEM Recent AEG studies
Appliance/equipment vintage distribution	Age distribution for each technology	PacifiCorp saturation survey Recent AEG studies
Efficiency options for each technology	List of available efficiency options and annual energy use for each technology	Council workbooks, RTF AEG DEEM AEO 2013 DEER Other recent AEG studies

Table 3-2 Data Needs for the Baseline projection and Potentials Estimation in LoadMAP

Model Inputs	Description	Key Sources
Customer growth forecasts	Forecasts of new construction in residential and C&I sectors	PacifiCorp load forecast AEO 2013 economic growth forecast
Equipment purchase shares for baseline projection	For each equipment/technology, purchase shares for each efficiency level; specified separately for existing equipment replacement and new construction	Shipments data from AEO AEO 2013 regional forecast assumptions[15] Appliance/efficiency standards analysis PacifiCorp program results and evaluation reports
Utilization model parameters	Price elasticities, elasticities for other variables (income, weather)	EPRI's REEPS and COMMEND models AEO 2013

[15] We developed baseline purchase decisions using the Energy Information Agency's *Annual Energy Outlook* report (2013), which utilizes the National Energy Modeling System (NEMS) to produce a self-consistent supply and demand economic model. We calibrated equipment purchase options to match manufacturer shipment data for recent years and then held values constant for the study period. This removes any effects of naturally occurring conservation or effects of future DSM programs that may be embedded in the AEO forecasts.

In addition, the baseline projection captures impacts of known future equipment standards enacted as of December 2013, as shown in Table 3-3 and Table 3-4.

Table 3-3 Residential Electric Equipment Standards[16]

Today's Efficiency or Standard Assumption
1st Standard (relative to today's standard)
2nd Standard (relative to today's standard)

<table>
<tr><th>End Use</th><th>Technology</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="4">Cooling</td><td>Central AC</td><td colspan="14">SEER 13</td></tr>
<tr><td>Room AC</td><td colspan="2">EER 9.8</td><td colspan="12">EER 11.0</td></tr>
<tr><td>Evaporative Central AC</td><td colspan="14">Conventional</td></tr>
<tr><td>Evaporative Room AC</td><td colspan="14">Conventional</td></tr>
<tr><td>Cooling/Heating</td><td>Heat Pump</td><td colspan="3">SEER 13.0/HSPF 7.7</td><td colspan="11">SEER 14.0/HSPF 8.0</td></tr>
<tr><td>Space Heating</td><td>Electric Resistance</td><td colspan="14">Electric Resistance</td></tr>
<tr><td rowspan="2">Water Heating</td><td>Water Heater (<=55 gallons)</td><td colspan="3">EF 0.90</td><td colspan="11">EF 0.95</td></tr>
<tr><td>Water Heater (>55 gallons)</td><td colspan="3">EF 0.90</td><td colspan="11">Heat Pump Water Heater</td></tr>
<tr><td rowspan="2">Lighting</td><td>Screw-in/Pin Lamps</td><td colspan="2">Incandescent</td><td colspan="6">Advanced Incandescent - tier 1 (20 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Linear Fluorescent</td><td>T12</td><td colspan="13">T8</td></tr>
<tr><td rowspan="5">Appliances</td><td>Refrigerator/2nd Refrigerator</td><td colspan="2">NAECA Standard</td><td colspan="12">25% more efficient</td></tr>
<tr><td>Freezer</td><td colspan="2">NAECA Standard</td><td colspan="12">25% more efficient</td></tr>
<tr><td>Dishwasher</td><td>Conventional (355kWh/yr)</td><td colspan="13">14% more efficient (307 kWh/yr)</td></tr>
<tr><td>Clothes Washer</td><td colspan="3">Conventional (MEF 1.26 for top loader)</td><td colspan="3">MEF 1.72 for top loader</td><td colspan="8">MEF 2.0 for top loader</td></tr>
<tr><td>Clothes Dryer</td><td colspan="3">Conventional (EF 3.01)</td><td colspan="11">5% more efficient (EF 3.17)</td></tr>
</table>

[16] Federal standards in this table were overridden in a small number of instances to capture state-specific standards. For example, the 2015 SEER 14 central air conditioner requirement in California.

Table 3-4 Commercial Electric Equipment Standards

Legend: Today's Efficiency or Standard Assumption | 1st Standard (relative to today's standard) | 2nd Standard (relative to today's standard)

<table>
<tr><th>End Use</th><th>Technology</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="3">Cooling</td><td>Chillers</td><td colspan="14">2007 ASHRAE 90.1</td></tr>
<tr><td>Roof Top Units</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Packaged Terminal AC/HP</td><td colspan="14">EER 11.0/11.2</td></tr>
<tr><td>Cooling/Heating</td><td>Heat Pump</td><td colspan="14">EER 11.0/COP 3.3</td></tr>
<tr><td>Ventilation</td><td>Ventilation</td><td colspan="14">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td rowspan="3">Lighting</td><td>Screw-in/Pin Lamps</td><td colspan="2">Incandescent</td><td colspan="6">Advanced Incandescent - tier 1 (20 lumens/watt)</td><td colspan="6">Advanced Incandescent - tier 2 (45 lumens/watt)</td></tr>
<tr><td>Linear Fluorescent</td><td>T12</td><td colspan="13">T8</td></tr>
<tr><td>High Intensity Discharge</td><td colspan="14">88 lumens/watt</td></tr>
<tr><td>Water Heating</td><td>Water Heater</td><td colspan="14">EF 0.97</td></tr>
<tr><td rowspan="6">Refrigeration</td><td>Walk-in Refrigerator/Freezer</td><td colspan="14">EISA 2007 Standard</td></tr>
<tr><td>Reach-in Refrigerator</td><td colspan="14">EPACT 2005 Standard</td></tr>
<tr><td>Glass Door Display</td><td colspan="14">42% more efficient</td></tr>
<tr><td>Open Display Case</td><td colspan="14">18% more efficient</td></tr>
<tr><td>Vending Machines</td><td colspan="14">33% more efficient</td></tr>
<tr><td>Icemaker</td><td colspan="14">2010 Standard</td></tr>
<tr><td rowspan="2">Miscellaneous</td><td>Non-HVAC Motors</td><td colspan="3">62.3% Efficiency</td><td colspan="11">70% Efficiency</td></tr>
<tr><td>Commercial Laundry</td><td>MEF 1.26</td><td colspan="13">MEF 1.6</td></tr>
</table>

Table 3-5 summarizes the building energy codes that are accounted for in the new vintages of LoadMAP customers, buildings, and facilities that come online during the study time horizon. End-use consumption for these new construction buildings therefore accounts for current state-specific energy codes, but it does not attempt to project future changes to codes over the planning horizon.

Table 3-5 Data Applied for the Market Profiles

State	Energy Code Used	
	Residential	Non-Residential
California	2013 Building Energy Efficiency Standards, Title 24	2013 Building Energy Efficiency Standards, Title 24
Washington	Washington State Energy Code 2012 (WSEC 2012)	Washington State Energy Code 2012 (WSEC 2012)
Idaho	2009 IECC	2009 IECC
Utah	2009 IECC	2009 IECC
Wyoming	2009 IECC with adjustments based on survey data for new buildings	2009 IECC with adjustments based on survey data for new buildings

Energy Efficiency Measure Data Application

Table 3-6 details the energy-efficiency data inputs to the LoadMAP model and identifies the key sources used in this study's analysis.

Table 3-6 Data Needs for the Measure Characteristics in LoadMAP

Model Inputs	Description	Key Sources
Energy Impacts	The annual reduction in consumption attributable to each specific measure. Savings were developed as a percentage of the energy end use that the measure affects.	PacifiCorp program evaluations Council workbooks, RTF BEST AEG DEEM AEO 2013 DEER Other secondary sources
Costs	Equipment Measures: Includes the incremental measure cost of purchasing and installing the equipment on a per-household, per-square-foot, or per employee basis for the residential, commercial, and industrial sectors, respectively. Non-equipment measures: Existing buildings – full installed cost. New Construction - the costs may be either the full cost of the measure, or as appropriate, it may be the incremental cost of upgrading from a standard level to a higher efficiency level.	Council workbooks, RTF AEG DEEM AEO 2013 RS Means DEER Other secondary sources
Measure Lifetimes	Estimates derived from the technical data and secondary data sources that support the measure demand and energy savings analysis.	Council workbooks, RTF DEER AEG DEEM AEO 2013 Other secondary sources
Applicability	Estimate of the percentage of either dwellings in the residential sector or square feet/employment in the C&I sectors where the measure is applicable and where it is technically feasible to implement.	PacifiCorp customer surveys Council workbooks, RTF RBSA/CBSA DEER AEG DEEM Other secondary sources
On Market and Off Market Availability	Expressed as years for equipment measures to reflect when the equipment technology is available or no longer available in the market.	AEG appliance standards and building codes analysis Emerging technology data sources

Emerging Technologies

The Class 2 DSM measures considered in this analysis come from a comprehensive review of measures implemented in current industry best practice programs and exhaustive research into the pipeline of technologies that may become viable over the study time horizon. This research leveraged resources such as the Council's Regional Technical Forum, the US Department of Energy's Annual Energy Outlook, and Washington State University's *Energy Efficiency Emerging Technologies* (E3T) databases.

The emerging technologies selected for inclusion in the study represent quantifiable projections of measures that have not yet gained mainstream adoption, but can reasonably be expected to reach commercial availability within the study time horizon. The protracted development cycle for newer, emerging technologies is reflected where appropriate in the potential modeling through assignment of an emerging technology measure ramp rate, which will introduce the resource over a more representative time period. Technologies that are still in the laboratory stage without quantifiable cost and/or operating characteristics cannot have been excluded from the analysis. A list of all included emerging technologies, as well as those excluded and a rationale for the exclusion, can be found in appendix D in Volume 4 of this report.

Data Application for Levelized Cost Calculations

To perform the levelized cost calculations, a number of economic assumptions were needed. All cost and benefit values were assumed to be represented in real 2012 dollars. PacifiCorp provided a discount rate of 6.61% to use in present-value calculations. In general, inflationary effects are assumed to be offset by decreases in technology costs, arising from efficiencies and economies of scale in manufacturing, distribution, and marketing channels. In certain rapidly-changing markets (e.g., LED lighting) where industry-accepted cost projections were available, decreases in costs were assumed to outpace inflation.[17]

Unless otherwise specified, all energy impacts in this report are presented at the generator or system level, rather than at the customer meter. Therefore, electric delivery losses, as provided by PacifiCorp and presented in Table 3-7, have been included in all levelized cost and potential figures.

Table 3-7 Line Loss Factors[18]

Sector	CA	ID	UT	WA	WY
Residential	11.43%	11.47%	9.32%	9.67%	9.51%
Commercial	11.14%	10.75%	8.71%	9.53%	8.90%
Industrial	9.92%	7.52%	5.85%	8.16%	5.61%
Irrigation	11.43%	11.45%	9.24%	9.67%	9.28%
Street Lighting	11.43%	11.47%	9.32%	9.67%	9.51%

[17] For LED lighting, the study relied on cost projections from Appendix C to the 2013 Annual Energy Outlook.
[18] Line loss factors were based on PacifiCorp's 2009 Analysis of System Losses study, conducted by Management Applications Consulting, Inc. dated November, 2011.

CLASS 2 DSM POTENTIAL RESULTS

This chapter presents the identified cumulative potential in 2034 from Class 2 DSM, or energy efficiency, resources in absolute terms and relative to AEG's baseline projection. These savings draw upon forecasts of future consumption, absent PacifiCorp Class 2 DSM program activities. While the baseline projection accounted for past PacifiCorp Class 2 DSM resource acquisition, the identified estimated potential is inclusive of (not in addition to) future planned program savings. As discussed previously, the 2034 forecasted baseline sales presented in this report may differ from PacifiCorp's official sales forecast.

Summary of Overall Energy Savings

Table 4-1 summarizes the 2034 cumulative technical and achievable technical energy-efficiency potential by sector, both in MWh and as a percentage of the 2034 baseline projection. Figure 4-1 shows the cumulative achievable technical potential by sector throughout the time horizon.

- **Technical potential**, which reflects the adoption of all energy efficiency measures regardless of cost or customer preferences, is a theoretical upper bound on savings. Systemwide cumulative savings in 2034 are 13.4 million MWh, or 24.5% of the baseline projection.
- **Achievable Technical Potential**, which adjusts the technical potential by reflecting customer adoption constraints, shows cumulative savings of 10.8 million MWh, or 19.9% of baseline load in 2034.

The commercial sector accounts for the largest portion of the energy savings, followed by residential then industrial. Irrigation and street lighting, with much smaller baseline loads, contribute a smaller amount of potential relative to commercial, residential and industrial. Detailed results by sector are presented later in this section.

Table 4-1 Cumulative Class 2 DSM Potential by Sector in 2034

Sector	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Technical Potential (% of Baseline)	Achievable Technical Potential (% of Baseline)
Residential	14,019,227	3,792,262	2,940,288	27.1%	21.0%
Commercial	16,999,802	6,365,570	5,310,374	37.4%	31.2%
Industrial	22,352,263	3,039,006	2,480,169	13.6%	11.1%
Irrigation	1,021,186	114,326	97,546	11.2%	9.6%
Street Lighting	105,912	45,930	32,893	43.4%	31.1%
Total	**54,498,390**	**13,357,094**	**10,861,270**	**24.5%**	**19.9%**

Figure 4-1 Cumulative Class 2 Achievable Technical Potential by Sector

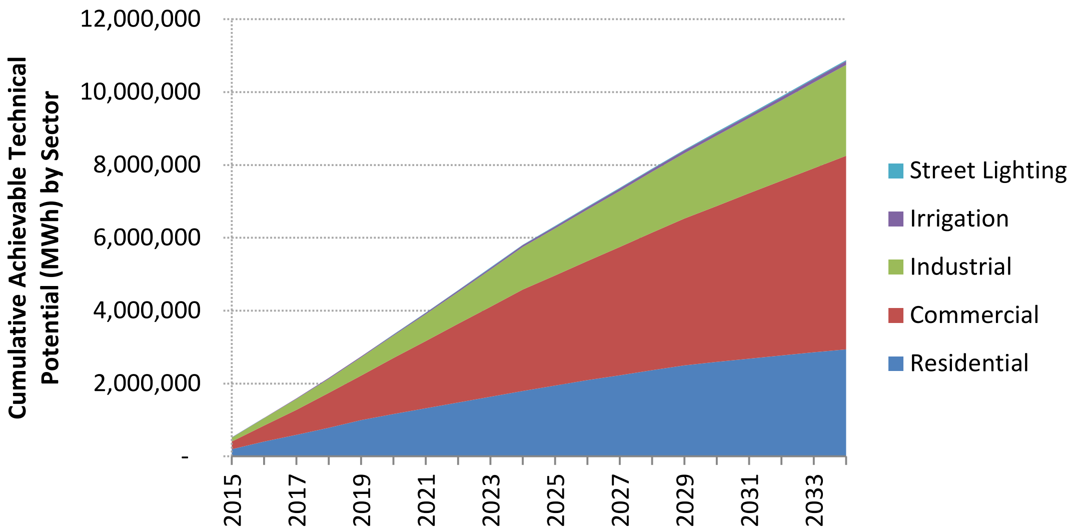


Table 4-2 summarizes the Class 2 DSM potential by state and by PacifiCorp operating company.[19] With the exception of Wyoming, potential as a percent of baseline loads is relatively constant across states; Wyoming results are heavily influenced by the large share of load in the industrial sector, which, as shown in Table 4-1, has lower identified potential as a percent of load than the residential and commercial sectors. Additional variations across states are a function of customer mix, climate, equipment saturations, current saturation or efficient equipment, and other related factors.

Table 4-2 Cumulative Class 2 DSM Potential by State in 2034

Territory	State	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Technical Potential (% of Baseline)	Achievable Technical Potential (% of Baseline)
Pacific Power	California	861,371	265,079	201,602	30.8%	23.4%
	Washington	4,624,342	1,167,533	947,909	25.2%	20.5%
	Subtotal	**5,485,713**	**1,432,612**	**1,149,512**	**26.1%**	**21.0%**
Rocky Mountain Power	Idaho	2,385,115	585,079	467,587	24.5%	19.6%
	Utah	33,614,848	9,150,148	7,453,752	27.2%	22.2%
	Wyoming	13,012,714	2,189,255	1,790,419	16.8%	13.8%
	Subtotal	**49,012,677**	**11,924,481**	**9,711,759**	**24.3%**	**19.8%**
Total		**54,498,390**	**13,357,094**	**10,861,270**	**24.5%**	**19.9%**

Table 4-3 summarizes the Class 2 DSM potential by resource type, differentiating between discretionary measures and lost opportunity measures. Across all sectors, 57% of the cumulative achievable technical potential in 2034 is attributable to lost opportunity resources.

[19] Pacific Power also serves customers in Oregon, however, as discussed previously in this report, the Energy Trust of Oregon assesses energy efficiency in Oregon in a separate study.

Table 4-3 Cumulative Class 2 DSM Achievable Technical Potential by Resource Type in 2034

Sector	Achievable Technical Potential (MWh)	
	Discretionary	Lost Opportunity
Residential	1,562,265	1,378,023
Commercial	1,790,505	3,519,869
Industrial	1,197,779	1,282,390
Irrigation	88,082	9,463
Street Lighting	6,011	26,882
Total	**4,644,642**	**6,216,628**

Residential Sector

Table 4-4 presents estimates for cumulative technical and achievable technical potential for the residential sector by the end of the study period in 2034. The technical potential in 2034 from Class 2 DSM resources assessed in this study is 3.8 million MWh or 27.1% of the baseline projection. The corresponding achievable technical potential is 2.9 million MWh or 21% of the 2034 baseline. Savings as a percent of baseline are very consistent across states. California is slightly higher due to a relatively higher share of electric space heating and water heating.

Table 4-4 Residential Cumulative Class 2 DSM Potential by State in 2034

Territory	State	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Technical Potential (% of Baseline)	Achievable Technical Potential (% of Baseline)
Pacific Power	California	397,921	132,757	92,703	33.4%	23.3%
	Washington	1,838,823	502,360	391,590	27.3%	21.3%
	Subtotal	**2,236,744**	**635,117**	**484,293**	**28.4%**	**21.7%**
Rocky Mountain Power	Idaho	871,193	239,679	183,908	27.5%	21.1%
	Utah	9,746,549	2,608,469	2,024,856	26.8%	20.8%
	Wyoming	1,164,742	308,997	247,232	26.5%	21.2%
	Subtotal	**11,782,483**	**3,157,145**	**2,455,996**	**26.8%**	**20.8%**
Total		**14,019,227**	**3,792,262**	**2,940,288**	**27.1%**	**21.0%**

The residential sector is composed of three segments in this analysis: single family, multi family, and manufactured homes. Figure 4-2 below shows the share of 2034 achievable technical potential that is attributable to each segment, largely driven by the share of sales in the baseline projection. Single family homes represent the largest share, with 83% of total achievable technical potential.

Figure 4-2 Residential Cumulative Achievable Technical Potential by Segment in 2034

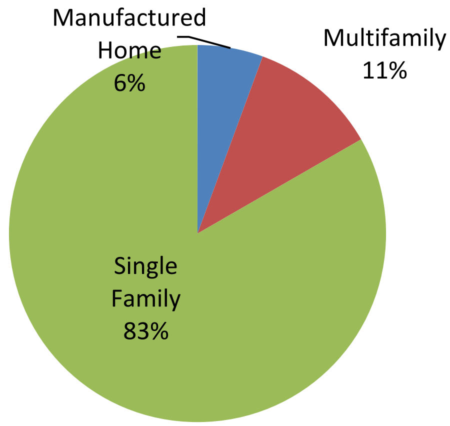


Figure 4-3 and Table 4-5 present the estimates of Class 2 DSM potential for the residential sector from an end-use perspective. Key findings and observations are outlined below:

- Nearly half of the potential (41%) comes from HVAC systems through the application of equipment upgrades and building shell measures.
- The single largest end use within the potential savings is cooling, at 25% of total residential potential, driven by large air conditioning loads in Utah.
- Lighting accounts for 23% of the residential achievable technical potential, primarily due to LED lamps, which are modeled with lumen-per-watt performance doubling over the lifetime of the study.
- Appliances are also a large source of potential, led by refrigerator and freezer recycling opportunities.
- Water heating savings comprise 11% of the total achievable technical through the installation of efficient systems (heat pump water heaters and solar water heating) and upgrades to water-consuming equipment (low flow showerheads, clothes washers, etc.)

Figure 4-3 Residential Cumulative Achievable Technical Potential by End Use in 2034

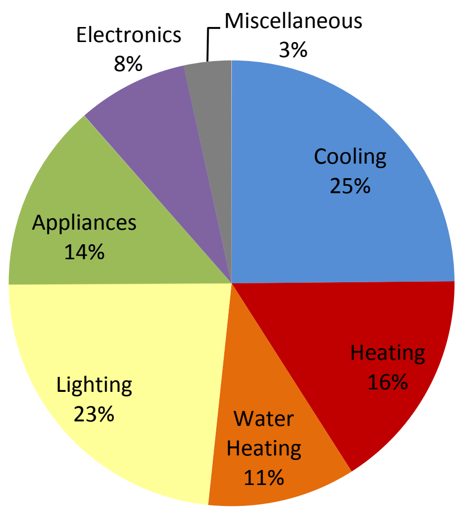


Table 4-5 Residential Cumulative Class 2 DSM Potential by End Use in 2034

End Use	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
Space Cooling	2,023,313	1,004,569	730,964	24.9%	36.1%
Space Heating	2,254,120	578,084	473,752	16.1%	21.0%
Water Heating	883,338	515,780	315,005	10.7%	35.7%
Lighting	1,101,887	696,024	683,073	23.2%	62.0%
Appliances	3,359,461	580,859	399,960	13.6%	11.9%
Electronics	2,077,659	284,862	235,678	8.0%	11.3%
Miscellaneous	2,319,448	132,083	101,857	3.5%	4.4%
Total	**14,019,227**	**3,792,262**	**2,940,288**	**100.0%**	**21.0%**

Commercial Sector

Table 4-6 presents estimates for cumulative technical and achievable technical potential for the commercial sector by the end of the study period in 2034. From the Class 2 resources assessed in this study, the technical potential savings are 6.4 million MWh or 37.4% of the baseline forecast in 2034. The corresponding achievable technical potential is 5.3 million MWh or 31.2% of the 2034 baseline. Savings as a percent of baseline are very consistent across states. Washington potential is slightly lower due to more stringent building codes and greater reach of past energy efficiency efforts. Utah is slightly higher, largely due to a greater presence of cooling loads and their associated potential.

Table 4-6 Commercial Cumulative Class 2 DSM Potential by State in 2034

Territory	State	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Technical Potential (% of Baseline)	Achievable Technical Potential (% of Baseline)
Pacific Power	California	310,741	111,331	91,175	35.8%	29.3%
	Washington	1,505,506	476,212	394,703	31.6%	26.2%
	Subtotal	**1,816,246**	**587,542**	**485,878**	**32.3%**	**26.8%**
Rocky Mountain Power	Idaho	684,262	240,411	195,043	35.1%	28.5%
	Utah	12,449,590	4,789,592	4,016,783	38.5%	32.3%
	Wyoming	2,049,704	748,025	612,671	36.5%	29.9%
	Subtotal	**15,183,556**	**5,778,028**	**4,824,496**	**38.1%**	**31.8%**
Total		**16,999,802**	**6,365,570**	**5,310,374**	**37.4%**	**31.2%**

The commercial sector analysis considers fourteen segments: College, Data Center, Grocery, Health, Large Office, Large Retail, Lodging, Miscellaneous (or unclassified), Restaurant, School, Small Office, Small Retail, Warehouse, and Controlled Atmosphere or Refrigerated Warehouse.[20]

[20] Controlled Atmosphere warehouses are only modeled for Washington, where they are more prominent.

Figure 4-4 below shows the share of 2034 technical potential that is attributable to each segment. Small and large offices represent the largest share, with a combined 29% of total savings potential.

Figure 4-4 Commercial Cumulative Achievable Technical Potential by Segment in 2034

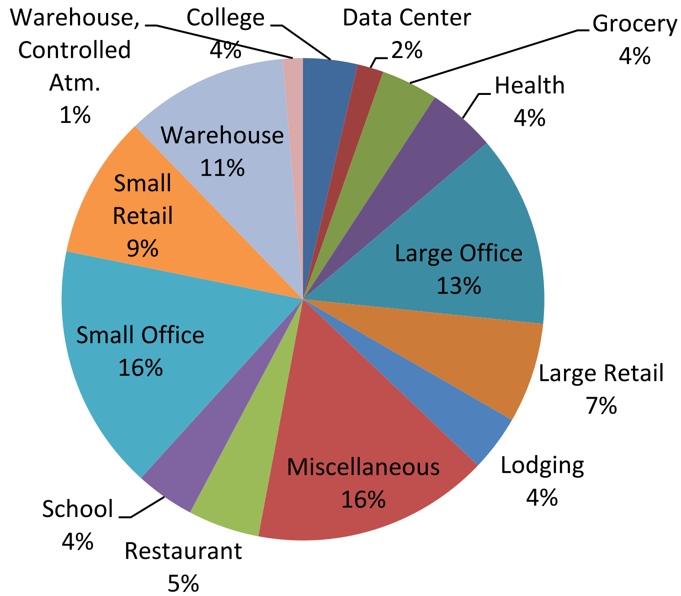


Figure 4-5 and Table 4-7 present the estimates of Class 2 DSM potential for the commercial sector from an end-use perspective. Key findings and observations are outlined below:

- Lighting opportunities represent over half of the identified commercial achievable technical potential, largely attributable to LED lighting. Based on the best projections available at the time of the analysis, these lamps are expected to become significantly more available and efficient over the study time period and be widely applicable for linear fluorescent, high bay, and screw-in applications.
- There is significant achievable technical potential from HVAC systems through the application of equipment upgrades and building shell measures within the cooling, heating, and ventilation end uses. The largest of these three is cooling, at 20% of total commercial potential, driven by large air conditioning loads in Utah.

Figure 4-5 Commercial Cumulative Achievable Technical Potential by End Use in 2034

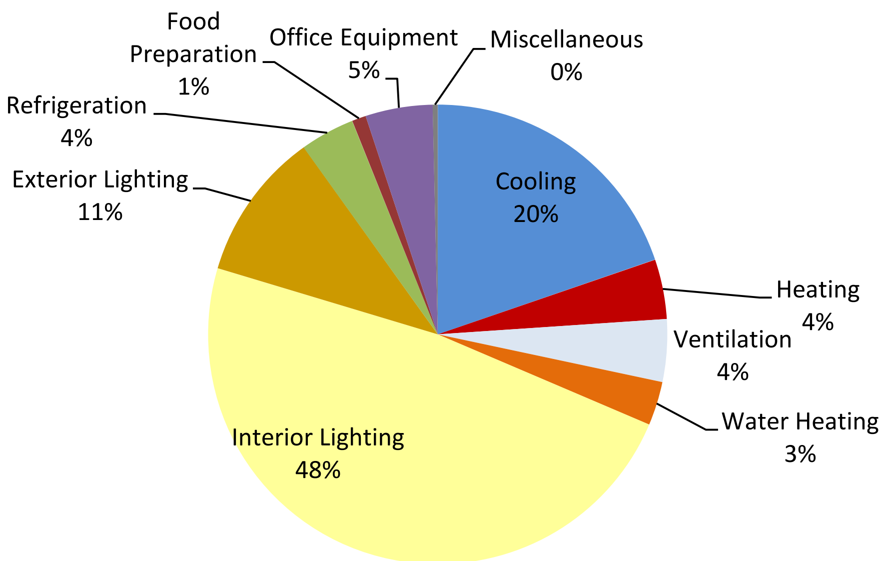


Table 4-7 Commercial Cumulative Class 2 DSM Potential by End Use in 2034

End Use	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
Cooling	3,884,700	1,400,355	1,047,866	19.7%	27.0%
Heating	1,617,424	225,817	223,620	4.2%	13.8%
Ventilation	1,106,217	288,321	233,125	4.4%	21.1%
Water Heating	502,699	215,397	163,795	3.1%	32.6%
Interior Lighting	4,240,956	2,939,039	2,561,109	48.2%	60.4%
Exterior Lighting	905,849	638,482	554,855	10.4%	61.3%
Refrigeration	1,237,403	253,502	203,868	3.8%	16.5%
Food Preparation	317,193	65,662	52,966	1.0%	16.7%
Office Equipment	1,549,358	315,092	250,256	4.7%	16.2%
Miscellaneous	1,638,004	23,901	18,914	0.4%	1.2%
Total	**16,999,802**	**6,365,570**	**5,310,374**	**100.0%**	**31.2%**

Industrial Sector

Table 4-8 presents estimates for cumulative technical and achievable technical potential for the industrial sector by the end of the study period in 2034. From the Class 2 resources assessed in this study, the technical potential savings are 3.04 million MWh or 13.6% of the baseline forecast in 2034 in the absence of DSM programs. The corresponding achievable technical potential is 2.48 million MWh or 11.1% of the 2034 baseline. Savings as a percent of baseline are relatively consistent across states with the exception of Wyoming, which has a much larger industrial sector with loads predominantly in the mining and extraction industry. These industries have more rugged and demanding operating conditions that reduces the applicability of many relevant energy efficiency measures.

Table 4-8 Industrial Cumulative Class 2 DSM Potential by State in 2034

Territory	State	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Technical Potential (% of Baseline)	Achievable Technical Potential (% of Baseline)
Pacific Power	California	53,925	8,942	7,547	16.6%	14.0%
	Washington	1,114,661	168,635	145,363	15.1%	13.0%
	Subtotal	**1,168,586**	**177,577**	**152,911**	**15.2%**	**13.1%**
Rocky Mountain Power	Idaho	267,505	39,879	33,015	14.9%	12.3%
	Utah	11,152,219	1,697,149	1,369,130	15.2%	12.3%
	Wyoming	9,763,952	1,124,400	925,113	11.5%	9.5%
	Subtotal	**21,183,677**	**2,861,429**	**2,327,258**	**13.5%**	**11.0%**
Total		**22,352,263**	**3,039,006**	**2,480,169**	**13.6%**	**11.1%**

The Industrial sector is composed of fifteen segments in this analysis: Agriculture, Chemical Manufacturing, Electronic Equipment Manufacturing, Food Manufacturing, Industrial Machinery Manufacturing, Lumber and Wood Products, Metal Manufacturing, Mining and Extraction, Miscellaneous Manufacturing, Paper Manufacturing, Petroleum Refining, Stone/Clay/Glass Products, Transportation Equipment Manufacturing, Wastewater, and Water. Figure 4-6 below shows the allocation of 2034 achievable technical potential that is attributable to each segment. The mining and extraction segment, with large operations predominantly in Wyoming and Utah, represent the largest share of achievable potential at 48%.

Figure 4-6 Industrial Cumulative Achievable Technical Potential by Segment in 2034

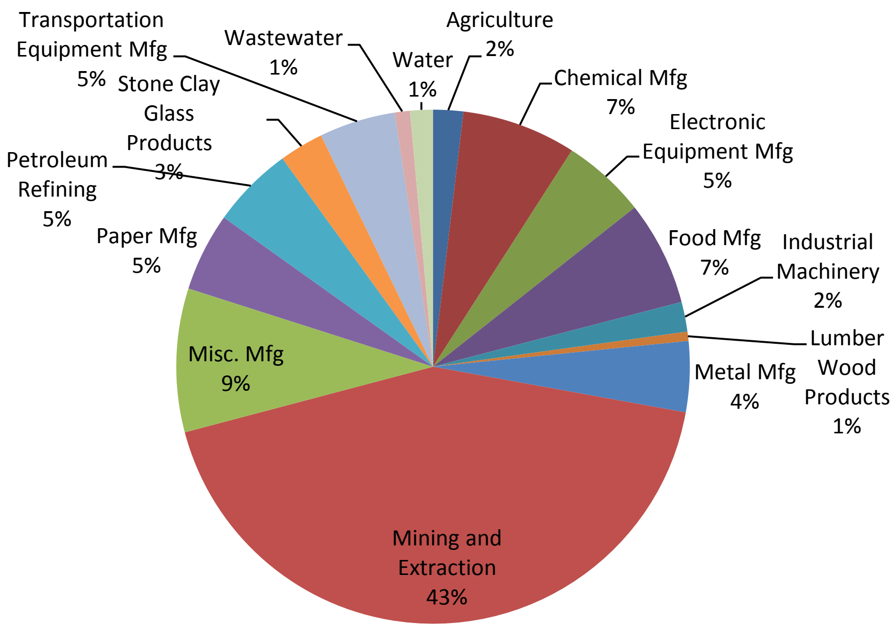


Figure 4-7 and Table 4-9 present the estimates of Class 2 DSM potential for the industrial sector from an end-use perspective. Key findings and observations are outlined below:

- Motor and process loads represent the largest share of end use consumption in the industrial sector and, correspondingly, have the largest identified achievable technical potential. Motor savings comprise 52% of the total sector potential, while process savings account for an additional 9%.[21] Potential savings for motor equipment change-outs have been essentially eliminated by the National Electrical Manufacturer's Association (NEMA) standards, which now make premium efficiency motors the baseline efficiency level for many motors. As a result, the savings opportunities in this end use come from controls, timers, and variable speed drives, which improve system efficiencies where motors are utilized.
- This study identified significant potential in the mining and extraction industry group[22] from variable speed drives and control systems on pumps, drills, crushers, and conveyors.
- Similar to the residential and commercial sectors, the projected improvements in performance and applicability of LED lighting technologies provides a large potential opportunity in the industrial sector, leading to lighting representing one-third of the identified achievable technical potential.

[21] It is often difficult to distinguish between motors used for industrial process and non-process purposes, so in many ways, these two end-use categories can be viewed as a group.

[22] For the purposes of this study, a mining and extraction group was compiled from SIC codes 10XX through 14XX with the addition of several extraction and pipeline-related customers in SIC codes 46XX through 49XX, since many of the end uses are tied to moving fluids or materials as part of the extraction process.

Figure 4-7 Industrial Cumulative Achievable Technical Potential by End Use in 2034

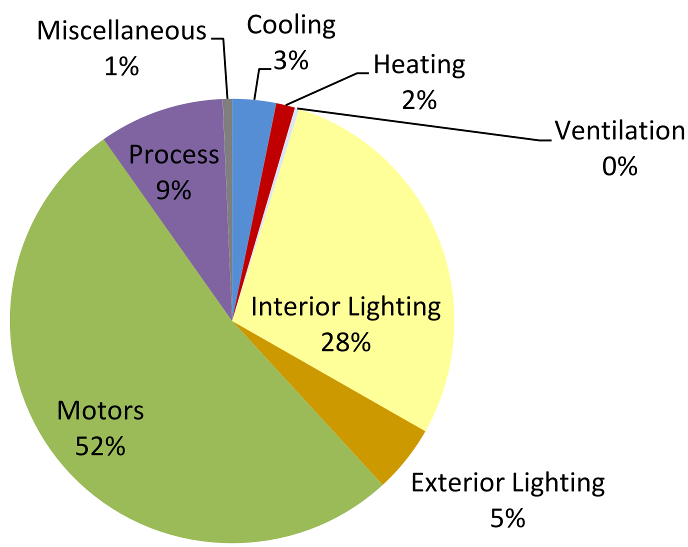


Table 4-9 Industrial Cumulative Class 2 DSM Potential by End Use in 2034

End Use	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
Cooling	297,622	102,075	79,565	3.2%	26.7%
Heating	1,010,558	44,174	34,530	1.4%	3.4%
Ventilation	133,262	12,619	7,810	0.3%	5.9%
Interior Lighting	1,134,142	802,945	696,069	28.1%	61.4%
Exterior Lighting	190,736	133,333	117,920	4.8%	61.8%
Motors	14,993,678	1,630,806	1,299,839	52.4%	8.7%
Process	3,506,837	291,272	227,615	9.2%	6.5%
Miscellaneous	1,085,428	21,780	16,821	0.7%	1.5%
Total	**22,352,263**	**3,039,006**	**2,480,169**	**100.0%**	**11.1%**

Irrigation Sector

Table 4-10 presents estimates for cumulative technical and achievable technical potential for the Irrigation sector by the end of the study period in 2034. From the Class 2 resources assessed in this study, the technical potential savings are 114,326 MWh or 11.2% of the baseline forecast in 2034. The corresponding achievable technical potential is 97,546 MWh or 9.6% of the 2034 baseline.

Table 4-10 Irrigation Cumulative Class 2 DSM Potential by State in 2034

Territory	State	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Technical Potential (% of Baseline)	Achievable Technical Potential (% of Baseline)
Pacific Power	California	96,313	10,959	9,386	11.4%	9.7%
	Washington	155,442	15,882	13,282	10.2%	8.5%
	Subtotal	**251,756**	**26,841**	**22,668**	**10.7%**	**9.0%**
Rocky Mountain Power	Idaho	558,445	63,490	54,377	11.4%	9.7%
	Utah	188,540	21,441	18,364	11.4%	9.7%
	Wyoming	22,445	2,554	2,137	11.4%	9.5%
	Subtotal	**769,430**	**87,485**	**74,877**	**11.4%**	**9.7%**
Total		**1,021,186**	**114,326**	**97,546**	**11.2%**	**9.6%**

For all practical purposes, the irrigation sector is comprised entirely of motor loads that are driving water pumps of various sizes. Key findings and observations are outlined below:

- Similar to the industrial sector, potential savings for motor equipment change-outs have been essentially eliminated by the National Electrical Manufacturer's Association (NEMA) standards, which now make premium efficiency motors the baseline efficiency level. As a result, the savings opportunities for irrigation pumps come from discretionary or non-equipment measures such as controls, timers, and variable speed drives, which improve system efficiencies where motors are utilized.
- Energy consumption varies by state based on presence of surface water, type of crop, and size of the irrigation market sector. In Pacific Power service territories, surface water and specialty crops are more prevalent, leading to smaller pump sizes. In Rocky Mountain Power territories, larger row crop fields and deeper water reservoirs require larger pumps.
- Since the 2013 assessment, the RTF has considered updates to the existing Scientific Irrigation Scheduling protocol to make it compliant with the latest version of the RTF *Guidelines for Estimation of Energy Savings.* While BPA is currently leading development of a research plan to revise the protocol, initial review by the RTF staff indicates a fraction of fields are suitable for SIS implementation, which reduces the energy savings from 10% to 5.7%. The reduced savings percentage was utilized as a planning estimate in the current study since more extensive regional research was not yet available.
- The service territory in Washington has a slightly lower potential than territories in the other states due to the prevalence of more specialty crops and higher value crops such as apples and other fruits. These are not the typical row crops that are mass produced in other states and many of the measures are not suited to these operations. To account for this, the applicability assumptions in the potential models are lower for these measures in Washington.

Street Lighting Sector

Table 4-11 presents estimates for cumulative technical and achievable technical potential for the Street Lighting sector by the end of the study period in 2034. From the Class 2 resources assessed in this study, the technical potential savings are 45,930 MWh or 43.4% of the baseline forecast in 2034. The corresponding achievable technical potential is 32,893 MWh or 31.1% of the 2034 baseline.

Table 4-11 Street Lighting Cumulative Class 2 DSM Potential by State in 2034

Territory	State	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Technical Potential (% of Baseline)	Achievable Technical Potential (% of Baseline)
Pacific Power	California	2,470	1,091	792	44.2%	32.0%
	Washington	9,910	4,445	2,971	44.9%	30.0%
	Subtotal	**12,380**	**5,535**	**3,762**	**44.7%**	**30.4%**
Rocky Mountain Power	Idaho	3,710	1,621	1,245	43.7%	33.6%
	Utah	77,950	33,496	24,620	43.0%	31.6%
	Wyoming	11,872	5,278	3,266	44.5%	27.5%
	Subtotal	**93,532**	**40,395**	**29,131**	**43.2%**	**31.1%**
Total		**105,912**	**45,930**	**32,893**	**43.4%**	**31.1%**

The Street Lighting sector in this analysis is divided into company-owned and customer-owned assets. Figure 4-8 below shows the allocation of 2034 achievable technical potential that is attributable to each of these segments. The large majority of street lighting fixtures in PacifiCorp's service territory are customer owned, leading to this segment representing 73% of the identified achievable technical potential. Company-owned fixtures account for the remaining 27% of potential.

Figure 4-8 Street Lighting Cumulative Achievable Technical Potential by Segment in 2034

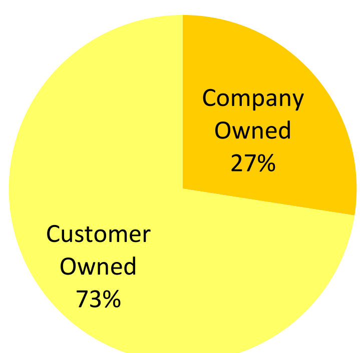


Table 4-12 presents the estimates of Class 2 DSM potential for the Street Lighting sector by segment and wattage range. Key findings and observations are outlined below:

- The primary mode of achieving savings in the street lighting sector is through LED equipment replacements and retrofits. As mentioned for other sectors, the improving performance and cost trends of LED lighting technologies provides a large potential opportunity in street lighting applications.

- The study also considers smart dimming controller as a non-equipment or discretionary measure that is applicable to the street lighting sector. This measure, which can selectively dim or shut down individual bulbs on a multi-head fixture in response to a motion sensor or timer, was considered applicable in areas such as parking lots and low-traffic roadways. This measure represents 18% of the identified achievable technical potential.
- The Other category is applied to a subset of fixtures with more specific functionality such as security lighting or metered outdoor lighting. These fixtures have reduced energy savings potential.

Table 4-12 Street Lighting Cumulative Class 2 DSM Potential by End Use in 2034

End Use	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
Company - 100W	14,592	6,702	3,991	12.1%	27.4%
Company - 150W	11,224	4,878	2,923	8.9%	26.0%
Company - 250W	3,588	1,546	928	2.8%	25.9%
Company - 400W	4,145	2,015	1,191	3.6%	28.7%
Company - 1000W	5	2	1	0.0%	27.3%
Customer - 100W	16,001	7,238	5,600	17.0%	35.0%
Customer - 150W	16,273	6,962	5,394	16.4%	33.1%
Customer - 250W	12,158	5,147	3,989	12.1%	32.8%
Customer - 400W	19,348	9,255	7,150	21.7%	37.0%
Customer - 1000W	3,506	1,676	1,295	3.9%	36.9%
Other	5,073	507	431	1.3%	8.5%
Total	**105,912**	**45,930**	**32,893**	**100.0%**	**31.1%**

COMPARISON WITH PREVIOUS DSM POTENTIAL ASSESSMENT

This assessment uses the same general industry-standard methods for assessing long-term energy efficiency potential as employed in PacifiCorp's previous assessments, published in 2007, 2011, and 2013. Conservation potentials assessments, by nature, provide a best estimate of the available opportunity based on the best data available and accepted assumptions at the time of the analysis. As such, results between assessments will vary based on updated primary and secondary data sources, new building codes and equipment efficiency standards, increased availability and adoption of emerging technologies, and other factors. This chapter compares this assessment's results to those from the 2013 assessment and explains the drivers of key differences.

Key Differences

This assessment of Class 2 DSM reflects the following changes compared to the previous study conducted in 2013:

- Accounts for state energy codes and equipment efficiency standards enacted as of January 31, 2014, even if they have not yet taken effect
- Takes into account PacifiCorp's actual and projected DSM program accomplishments through 2014
- Incorporates adjustments to measure savings, based on recent evaluation results, data available from the Regional Technical Forum (RTF), and other updated secondary sources available before January 31, 2014
- Applies 2012 customer and sales information to determine segmentation; and utilizes updated sales and customer forecasts
- Includes new emerging technologies and updates assumptions around applicability, cost, and efficacy of LED lighting

Potential Results by Sector

Table 5-1 compares cumulative 20-year potential between the current and 2013 assessments, in absolute terms and as a percentage of projected loads, by sector. As shown, the current assessment estimated significantly higher achievable technical potential than the 2013 study: an increase from 648 aMW to 1,240 aMW.[23] Potential in the irrigation and street lighting sectors did not change materially between the two assessments. Industrial potential is also higher than the previous two studies but not substantially. This is primarily driven by changes in the baseline forecast. Factors leading to significant increases in residential and commercial potential are described in additional detail below.

[23] Megawatt-hour (MWh) values from Table 4 1 have been converted to average megawatts (aMW) for direct comparison to Table ES-4 in the 2013 assessment report. 1 aMW = 8,760 MWh.

Table 5-1 Comparison of Class 2 DSM Potential with Previous Assessments

Sector	Achievable Technical Potential (Year-20 Cumulative aMW)		Achievable Technical Potential (Year-20 Cumulative as % of Baseline Loads)	
	2013 Assessment	CURRENT Assessment	2013 Assessment	CURRENT Assessment
Residential	190	336	15%	21%
Commercial	234	606	15%	31%
Industrial	207	283	9%	11%
Irrigation	13	11	10%	10%
Street Lighting	4	4	30%	31%
Total	**648**	**1,240**	**12%**	**20%**

Residential Sector

As shown in Table 5-2, the residential achievable technical potential identified in this assessment is higher than the previous study, primarily driven by the emergence of LED lighting technology as a viable, cost-effective, and rapidly-improving technology option.

Table 5-2 Residential Comparison of Class 2 DSM Potential with Previous Assessment

End Use Grouping	Achievable Technical Potential (Year-20 Cumulative aMW)		Key Drivers of Differences
	2013 Assessment	Current Assessment	
HVAC	111	138	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Lighting (Int & Ext)	16	78	Current CPA reflects improved performance of LEDs, which leads to increased potential.
Water Heating	31	36	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Appliances	20	46	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Miscellaneous / Plug Load / Electronics	15	39	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Total	**193**	**336**	

Commercial Sector

The commercial potential in the current study is substantially higher than in the previous assessment, also primarily driven by the emergence of LED lighting technology as a viable and rapidly-improving technology option. An increase in assumed cooling equipment energy use intensities (EUIs) also drove a large increase in Heating & Cooling potential, as potential is a function of baseline consumption. This is the result of updated data sources utilized in the current study, as shown in Table 3-1. A comparison of potential by end use can be seen in Table 5-3.

Table 5-3 Commercial Comparison of Class 2 DSM Potential with Previous Assessment

End Use Grouping	Achievable Technical Potential (Year-20 Cumulative aMW)		Key Drivers of Differences
	2013 Assessment	Current Assessment	
Heating & Cooling	65	145	Updated data sources used in calculating energy use intensities (EUIs) resulted in an increase in estimated baseline cooling energy consumption, leading to an increase in potential.
Ventilation	31	27	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Water Heating	7	19	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Lighting (Int & Ext)	86	356	Current CPA reflects improved performance of LEDs, which leads to increased potential.
Refrigeration	18	23	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Food Preparation	3	6	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Office Equipment / Servers / Data Centers	24	29	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Miscellaneous	1	2	Updated information on end use and equipment saturations, applicable measures, and measure parameters.
Total	**235**	**606**	

ACCELERATED CLASS 2 DSM SCENARIO

As described in Chapter 2 of this volume, the potential presented in this report, referred to in this chapter as the “reference case,” was developed using assumptions around measure-level acquisition rates (measure ramp rates), long-term achievability, and associated acquisition costs (incentives and program administration). Pursuant to Action Item 7a in PacifiCorp’s 2013 IRP to “Include in the 2014 conservation potential study an analysis testing assumptions in support of accelerating acquisition of cost-effective Class 2 DSM resources, and apply findings from this analysis into the development of candidate portfolios in the 2015 IRP”, this study includes an alternative scenario to assess the feasibility and cost of accelerating Class 2 DSM acquisition relative to the reference case. This chapter describes the approach, data sources, and results of this analysis.

Acceleration Approach

The accelerated case was developed through a four step process, each of which is described in more detail below:

1. Identify measures that would be candidates for acceleration (“acceleratable measures”)
2. Determine appropriate rate of acceleration for identified measures
3. Estimate the additional incentive and administrative cost required to accelerate acquisition of identified measures
4. Based on steps 1-3, recalculate annual achievable technical potential and leveled costs for use in IRP modeling

This scenario does not attempt to assess whether additional opportunities would become available in later years if measures are accelerated. Rather, it relies on the 20-year achievable technical potential identified in the reference case and investigates whether it could theoretically be acquired earlier in the study timeframe and what the cost implications of this accelerated acquisition might be.

Identifying Acceleratable Measures

The analysis sought to assess a realistic level of acceleration, recognizing that there may be barriers to accelerating certain measures, including timing of new construction and equipment replacement, product availability, delivery infrastructure, and other factors. To identify measures that would be candidates for accelerated acquisition, AEG reviewed aggressive program structures that have proven successful in real markets, such as direct installations, early replacements, or neighborhood blitzes. While this accelerated case is speculative and hypothetical in nature, this research allowed the analysis to be grounded in real-world delivery examples with evidence of evaluated program traction and market success.[24,25,26]

Through the review described above, AEG determined it was appropriate to accelerate all discretionary measures, but only certain lost opportunity measures; lost opportunity measures applicable to deep retrofits of existing buildings were considered for acceleration, but opportunities in new construction were not.

[24] Residential Deep Energy Retrofits, ACEEE report, 2014
[25] Massachusetts Joint Statewide Three-Year Electric and Gas Energy Efficiency Plan, 2012
[26] Frontiers of Energy Efficiency: Next Generation Programs Reach for High Energy Savings, ACEEE report, 2013

Accelerating Identified Measures

The next step was to accelerate assumed customer adoption of measures identified through the literature review. As mentioned previously, the reference case uses measure ramp rates from the Council's Sixth Power Plan to specify annual acquisition rates. For the accelerated case, AEG assumed an incremental evolution in this dimension, moving each identified measure's ramp rate to the next most aggressive measure ramp rate option. That is, the accelerated case uses the same underlying set of measure ramp rates as the reference case, but applies them more aggressively to acceleratable measures. If a measure was already on the most aggressive Council ramp rate (typically reaching full penetration within five years), it is assumed that additional acceleration is not possible. The mapping of measure categories and ramp rates in the reference case and accelerated case is shown in Table 6-1 below.

Table 6-1 Mapping Reference Case Ramp Rates to Accelerated Case Ramp Rates

	Reference Case Ramp Rate	Maps to…	Corresponding Accelerated Ramp Rate
Residential Lost Opportunity	Res_LostOp_5yr	----->	*N/A --- No faster option*
	Res_LostOp_10yr	----->	Res_LostOp_5yr
	Res_LostOp_12yr	----->	Res_LostOp_10yr
	Res_LostOp_15yr	----->	Res_LostOp_12yr
	Res_LostOp_ResSTB	----->	Res_LostOp_15yr
	Res_LostOp_20yr	----->	Res_LostOp_ResSTB
	Res_LostOp_ResTV	----->	Res_LostOp_20yr
	Res_LostOp_ResComputer	----->	Res_LostOp_20yr
	Res_LostOp_ResMonitor	----->	Res_LostOp_20yr
	Res_LostOp_ComComputer	----->	Res_LostOp_20yr
	Res_LostOp_ComMonitor	----->	Res_LostOp_20yr
	Res_LostOp_EmergTech	----->	Res_LostOp_ResTV
Residential Non-Lost Opportunity	Res_NonLostOp_5yr	----->	*N/A --- No faster option*
	Res_NonLostOp_10yr	----->	Res_NonLostOp_5yr
	Res_NonLostOp_15yr	----->	Res_NonLostOp_10yr
	Res_NonLostOp_20yr	----->	Res_NonLostOp_15yr
	Res_NonLostOp_Emerging	----->	Res_NonLostOp_15yr
Business Lost Opportunity	Bus_LO Mature	----->	*N/A --- No faster option*
	Bus_LO Fast	----->	Bus_LO Mature
	Bus_LO 10Fast	----->	Bus_LO Fast
	Bus_LO Medium	----->	Bus_LO Fast
	Bus_LO 20Fast	----->	Bus_LO Medium
	Bus_LO 12Fast	----->	Bus_LO 20Fast
	Bus_LO 6Slow	----->	Bus_LO 12Fast
	Bus_LO Slow	----->	Bus_LO 6Slow
	Bus_LO Slow Water heating	----->	Bus_LO Slow
Business Non-Lost Opportunity	Bus_Retro in 5	----->	*N/A --- No faster option*
	Bus_Retro in 10	----->	Bus_Retro in 5
	Bus_New Measure Fast	----->	Bus_Retro in 10
	Bus_Retro in 15	----->	Bus_New Measure Fast
	Bus_Retro in 20	----->	Bus_Retro in 15
	Bus_NonLostOp_Emerging	----->	Bus_Retro in 15
	Bus_New Measure Medium	----->	Bus_Retro in 20
	Bus_New Measure Slow	----->	Bus_New Measure Medium

Quantifying Increased Costs for Measure Acceleration

To determine whether, and by how much, costs might change under an accelerated Class 2 DSM acquisition scenario, AEG began by reviewing spending from states outside PacifiCorp's service territory[27] generally considered to have aggressive energy efficiency portfolios. AEG proposed that these states exemplify an environment of "accelerated" DSM programs; perennially in the top 10 of the ACEEE State Energy Efficiency Scorecard rankings, with motivated regulatory and political environments, long histories of customer engagement and education, comprehensive and far-reaching portfolio designs, and high levels of program spending. Table 6-2 show the results of this research based on dollars spent per first-year kWh saved in 2012, comparing the identified states to the United States as a whole.

Table 6-2 2012 Energy Efficiency Program Spending per First-Year kWh Saved

Region	Program Spending	Net Annual Savings (MWh)	Total$/kWh first year
Massachusetts[28]	$224,352,000	520,319	$0.43
Connecticut[29]	$95,764,663	295,280	$0.32
California[30]	$806,836,000	2,667,319	$0.30
Vermont[31]	$31,999,636	110,179	$0.29
USA[32]	$3,793,887,000	18,569,631	$0.20

It is difficult to compare energy efficiency savings and/or spending across jurisdictions due to differences in climate, retail rates, stringency of building codes, electric equipment saturations, methods used to develop unit energy savings, etc., and thus, the results shown should not be used to assess the relative effectiveness of jurisdictions' acquisition. However, the analysis does suggest that more aggressive Class 2 DSM acquisition does require additional cost on a per-kWh basis.

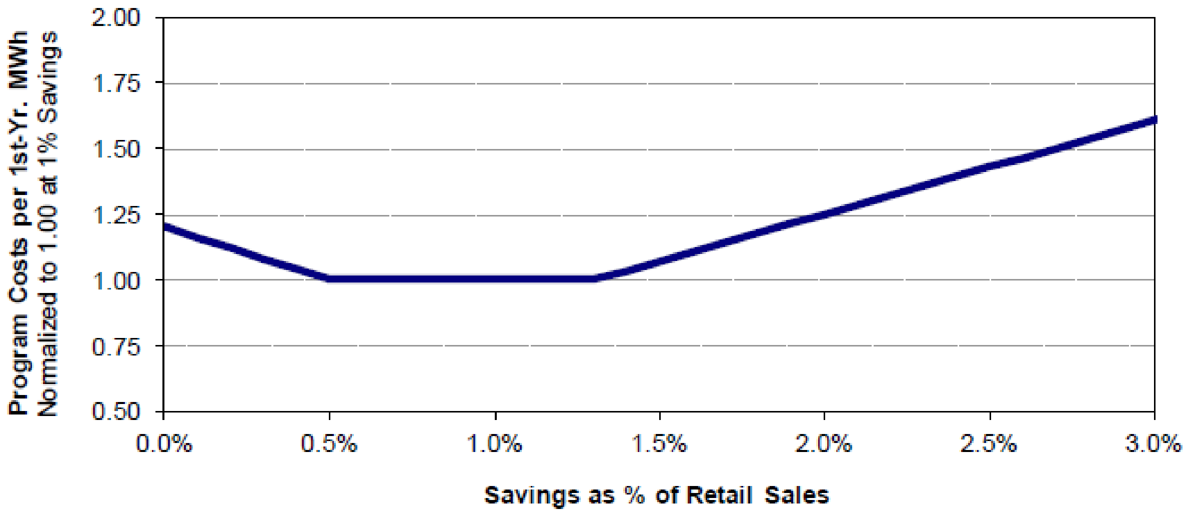
Because of the inherent difficulties associated with comparing DSM program delivery costs across jurisdictions with differing program mixes in varying economic climates, AEG next looked for an analysis of costs that could be applied more broadly. From the literature search, the most comprehensive and defensible data source found to define the cost of accelerating Class 2 DSM measures was a report published by the Lawrence Berkeley National Laboratory (LBNL). [33] LBNL's analysis of recent conservation programs produced the curve shown in Figure 6-1 below, which provides guidance on the incremental spending required to gain marginal savings for a conservation portfolio. There are three regimes identified by the LBNL study, portrayed by the curve on the graph.

- On the flat, middle section of the curve are programs that achieve typical levels of savings (approximately between 0.5% and 1.3% of annual sales) at typical market costs.

[27] California was included in the research, as PacifiCorp's service territory spans only a small portion of the state.
[28] Data source: EIA form 861 responses, 2012, http://www.eia.gov/electricity/data/eia861/
[29] Data source: CT Energy Dashboard, http://energizect.com/about/statewide-dashboard
[30] Data source: EIA form 861 responses, 2012, http://www.eia.gov/electricity/data/eia861/
[31] Data source: Efficiency Vermont Annual Report 2012, http://www.efficiencyvermont.com/docs/about_efficiency_vermont/annual_reports/Efficiency-Vermont-Annual-Report-2012.pdf
[32] Data source: EIA form 861 responses, 2012, http://www.eia.gov/electricity/data/eia861/
[33] "The Future of Utility Customer-Funded Energy Efficiency Programs in the United States: Projected Spending and Savings to 2025" LBNL Report, http://emp.lbl.gov/sites/all/files/lbnl-5803e.pdf, January 2013

- Moving left on the curve toward a smaller portfolio with lower energy savings will increase the per-unit cost slightly, reflecting fixed program delivery costs and typically a portfolio with pilot programs or a ramp-up of administrative and delivery infrastructure.
- Moving right on the curve and accelerating the portfolio savings will also increase per-unit costs, but for different reasons: higher incentive levels coupled with enhanced marketing and program delivery infrastructure required to achieve higher market penetration for hard-to-reach markets and measures.

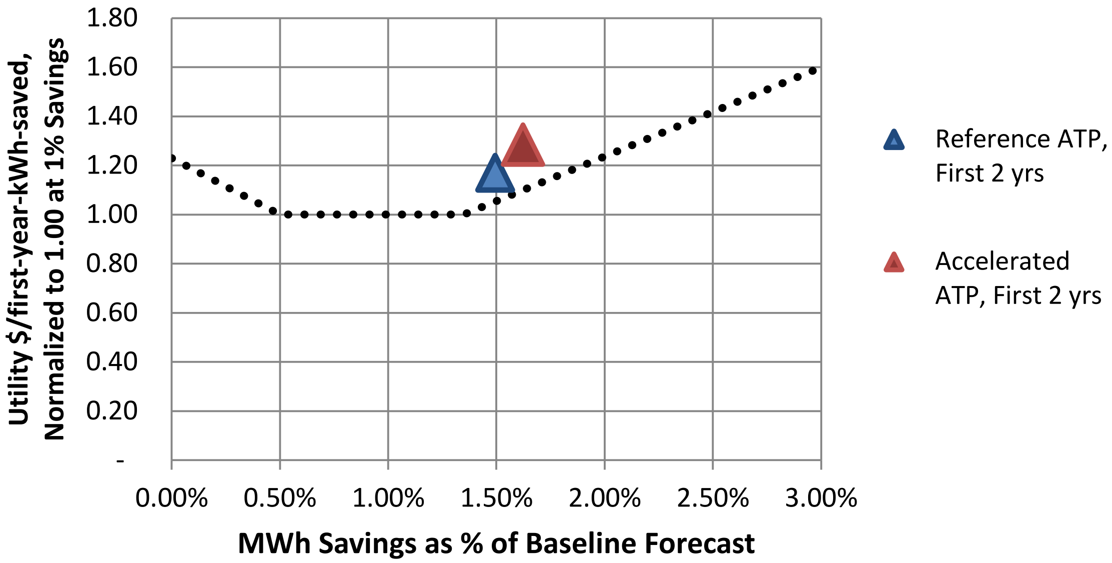
Figure 6-1 LBNL Marginal Cost Curve for Scaling the Size of Energy Efficiency Programs



The next step was to determine where the achievable technical potential identified in the reference case fell on the LBNL curve. As the accelerated analysis seeks to pull resources forward into the earlier years of the study, AEG focused on the reference case cost and savings in the first two years of the study horizon. Note, the LBNL curve was developed from historic data from programs that had actually been delivered in the field, presumably satisfying jurisdiction-specific cost-effectiveness criteria. By contrast, the reference case achievable technical potential has not yet been screened for cost-effectiveness and inclusion of non-economic, high-cost measures causes the achievable technical to lie slightly above the LBNL curve.

Once the reference case achievable technical potential was placed on the curve, (see the blue triangle in Figure 6-2) AEG then increased the assumed delivery cost of migrating all acceleratable measures to the next most aggressive ramp rate. AEG performed this exercise iteratively until the slope of the line running through the reference and accelerated case achievable technical potentials roughly aligned with that of the LBNL curve. The resulting delivery cost and savings of the accelerated scenario are depicted in the red triangle in Figure 6-2.

Figure 6-2 Accelerated Case and Reference Case in relation to LBNL Marginal DSM Cost Curve

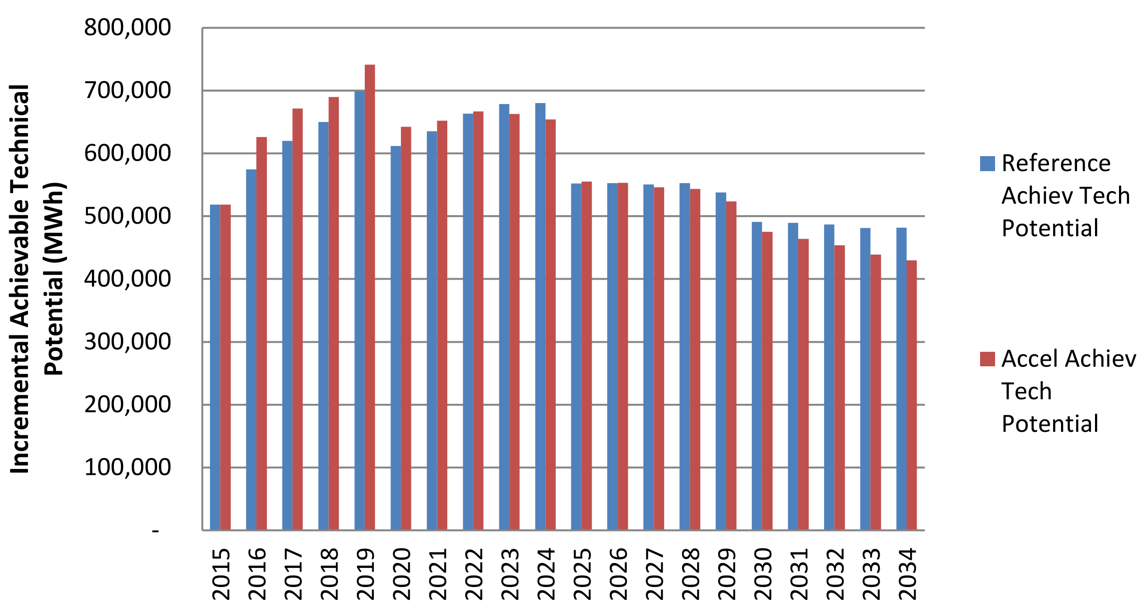


As described in Chapter 2, the reference case generally assumed that incentives would cover 70% of a measure's incremental cost and that program administrative costs would amount to an additional 20% of incremental cost. To achieve the relationship shown in Figure 6-2, the accelerated case assumes that delivery (both incentives and administration) costs would need to increase by 20%.

Accelerated Case Potential Results

Figure 6-3 shows the annual incremental achievable technical potential under the reference and accelerated scenarios. As shown, the accelerated incremental achievable technical potential is higher in the early years relative to the reference case, but falls off in the later years as the potential is exhausted.

Figure 6-3 Incremental Achievable Technical Potential in Reference and Accelerated Cases



This methodology represents AEG's best attempt to derive a quantitative projection using the best available published data. The literature review availed no comprehensive source that provides a clear and accurate process for predicting the amount of acceleration possible and its associated cost. This is a planning exercise meant to provide insight and guidance, and does not prove definitively whether this amount of acceleration is possible or whether the additional assumed costs would be sufficient to achieve it.

About Applied Energy Group (AEG)

Founded in 1982, AEG is a multi-disciplinary technical, economic and management consulting firm that offers a comprehensive suite of demand-side management (DSM) services designed to address the evolving needs of utilities, government bodies, and grid operators worldwide. Hundreds of such clients have leveraged our people, our technology, and our proven processes to make their energy efficiency (EE), demand response (DR), and distributed generation (DG) initiatives a success. Clients trust AEG to work with them at every stage of the DSM program lifecycle – assessing market potential, designing effective programs, supporting the implementation of the programs, and evaluating program results.

The AEG team has decades of combined experience in the utility DSM industry. We provide expertise, insight and analysis to support a broad range of utility DSM activities, including: potential assessments; end-use forecasts; integrated resource planning; EE, DR, DG, and smart grid pilot and program design and administration; load research; technology assessments and demonstrations; project reviews; program evaluations; and regulatory support.

Our consulting engagements are managed and delivered by a seasoned, interdisciplinary team comprised of analysts, engineers, economists, business planners, project managers, market researchers, load research professionals, and statisticians. Clients view AEG's experts as trusted advisors, and we work together collaboratively to make any DSM initiative a success.

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