CHAPTER 12: CONSERVATION RESOURCES

Contents

List of Figures and Tables

For most of this chapter the Council presents results using the medium range of the forecast. In the section entitled "Total - All Sectors", the Council includes the entire range of uncertainty regarding the drivers. This is done to reinforce the fact that the future is uncertain. The Council's planning process does not use a single deterministic future to drive the analysis. The stochastic variation introduced in the Regional Portfolio Model tests a wide range of future uncertainties in load, fuel prices, etc.

KEY FINDINGS

The Northwest Power Act defines conservation as reduced electric power consumption as a result of improved efficiency in energy use. This means that less electricity is needed to provide the same level of services. Conservation resources are measures that ensure that new and existing residential buildings, household appliances, internal and external lighting systems, new and existing commercial buildings, commercial-sector appliances, commercial infrastructure such as street lighting and sewage treatment, and industrial and irrigation processes are energy efficient. These efficiencies, when cost-effective, reduce operating costs by cutting back on the operation of the least-efficient existing power plants; ultimately reducing the need to build new power plants and expand transmission and distribution systems. Conservation also includes measures to reduce electrical losses in the region's generation, transmission, and distribution systems where the measures result in a reduction in electrical power consumption.

The Council's assessment of conservation resources includes six major updates since the Sixth Power Plan:

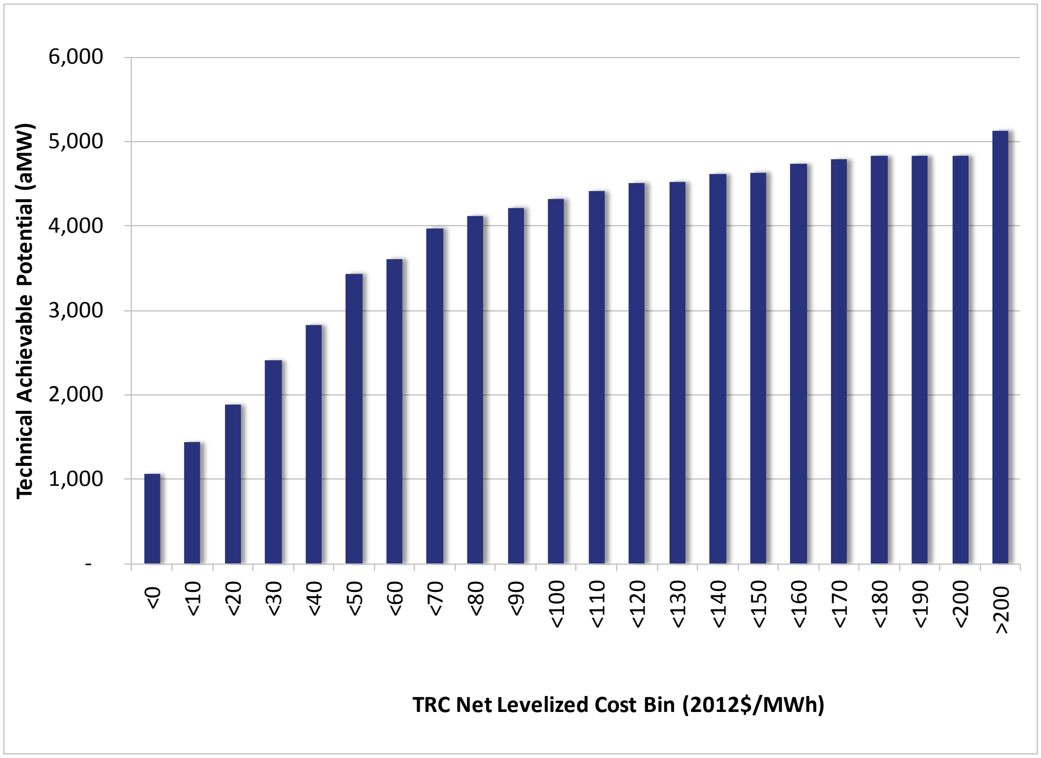
1. Accounting for utility conservation programs and other savings since 2010, including removal of measures that have saturated the market (e.g. LED TVs).
2. Adjusting both the load forecast[1] and the conservation assessment to reflect improvements in federal and state standards for lighting, appliances, and other equipment.
3. Adding potential savings from new technologies and practices that have matured to commercial readiness since the development of the Sixth Power Plan's estimates.
4. Updating estimates of energy equipment saturation, gas and electric fuel shares, and other key building characteristics from the residential, commercial, and industrial stock assessments.
5. Updating forecasts of the number of new homes, businesses, and farms.
6. Updating costs to be in 2012 constant dollars.

The Council identified around 5,100 average megawatts[2] of technically achievable conservation potential in the medium demand forecast by the end of the forecast period. Not all of the conservation potential identified is cost-effective to develop in all future scenarios; nor is all of it immediately available. The Council uses its regional portfolio model (RPM) to identify the amount of conservation that can be economically developed. The results presented in this chapter serve as an input to the RPM, which tested varying amounts and pace of conservation development against other resource options across a wide range of future conditions. The results of the RPM analysis are presented in Chapter 15.

[1] See Chapter 7 for details on the load forecast
[2] All savings values are at busbar.

The total technical achievable potential in 2035 by total resource cost (TRC) net levelized cost[3] bin is shown in Figure 12 - 1. Around 4,300 average megawatts of conservation are available at costs less than $100 per megawatt-hour (2012$). Another 800 average megawatts are available at costs above $100 per megawatt-hour.

Figure 12 - 1: Technical Achievable Conservation Potential in 2035 by Levelized Cost



The achievable savings break down by sector as follows:

- Over 2,300 average megawatts of conservation are technically achievable in the residential sector. Most of the savings come from improvements in water-heating efficiency, lighting efficiency, and heating, ventilating, and air-conditioning (HVAC) efficiency.
- Nearly 1,900 average megawatts of potential savings are available in the commercial sector. Nearly two-thirds of these potential savings are in lighting systems. New technologies like solid-state lighting (LEDs) and improved lighting fixtures and controls offer added potential savings in both outdoor and indoor lighting. Savings in ventilation, server rooms, and other 'plug loads'[4] account for much of the remainder.

[3] TRC net levelized cost includes all quantifiable costs and benefits directly attributable to the conservation measures such as changes in consumption of other-fuels, operations and maintenance expenses, non-electric costs or benefits such as water savings, and environmental costs and benefits. Further discussion is in the Methodology section.

[4] Plug loads are those from equipment that is plugged into a wall outlet; e.g. computers, copiers, monitors and other peripherals.

- Potential savings in the industrial sector are estimated to be around 580 average megawatts by the end of the forecast period. The industrial assessment found that effective business management practices could significantly increase savings from equipment and system optimization measures.

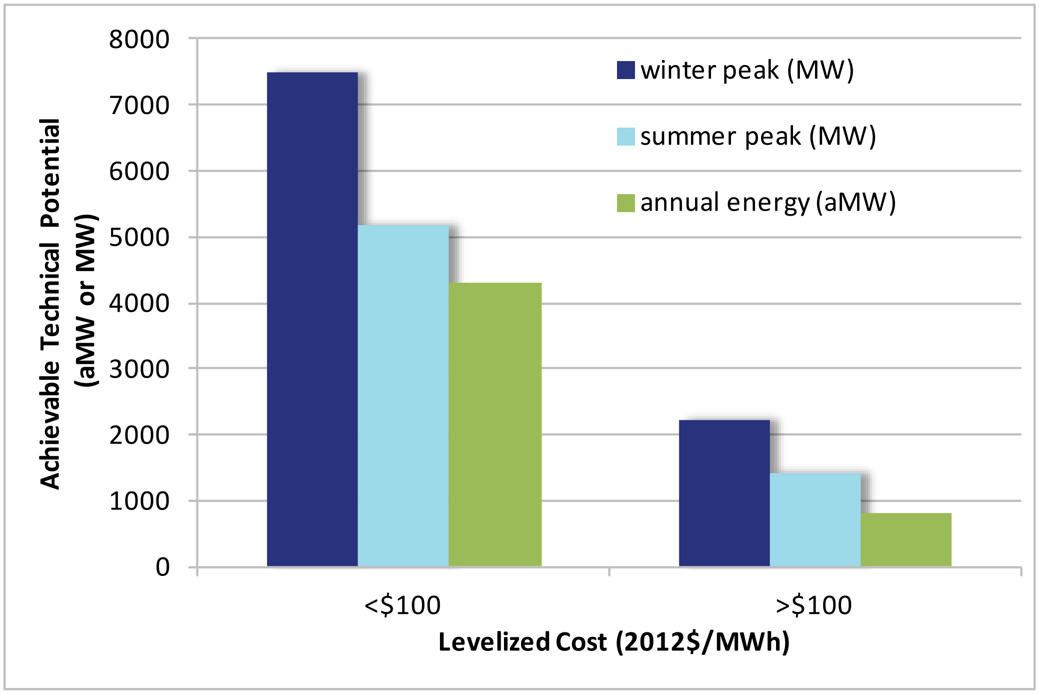
- Approximately 130 average megawatts of conservation are available in the agriculture sector through irrigation system efficiency improvements, improved water management practices, and more efficient dairy milk processing.

- Finally, potential savings from improved efficiency in utility distribution systems are estimated to be over 200 average megawatts by the end of the forecast period.

In addition to providing energy benefits, conservation measures also provide capacity benefits. Using best-available load shapes by measure category, the Council estimates the 5,100 average megawatts of energy translates to 9,700 megawatts of capacity savings during the regional peak winter hour (6pm on a weekday in December, January, and February) and 6,600 megawatts of capacity savings during the regional peak summer hour (6pm on a weekday in July and August).[5] The peak and energy impacts by total resource cost (TRC) net levelized cost bins of below and above $100 per megawatt-hour are provided in Figure 12 - 2. TRC net levelized cost includes all quantifiable costs and benefits directly attributable to conservation measures such as changes in consumption of other-fuels, operations and maintenance expenses, non-electric costs or benefits such as water savings, and environmental costs and benefits and is described further in Appendix G.

[5] The peak impacts presented in this Chapter do not include the Associated System Capacity Contribution (ASCC). For more information on the ASCC, see Chapter 11.

Figure 12 - 2: Peak and Energy Impacts by Levelized Cost Bundle for 2035



The availability of energy efficiency over time is another key aspect of this resource assessment. Many resources (such as new water heaters) only become available at the point of equipment turnover or new construction. Other resources (such as insulation upgrades), while technically available immediately, will only be achieved over time due to infrastructure and resource constraints. To account for this, the Council applied ramping assumptions to estimate the proliferation of each conservation measure over time. The maximum potential by cost bin is provided for each year in Figure 12 - 3 and Figure 12 - 4. Figure 12 - 3 illustrates the availability for the Council's entire 20-year plan horizon and Figure 12 - 4 for the first six-year period only.

Figure 12 - 3: Maximum Cumulative Availability of Conservation Resources Over 20-year Plan Period

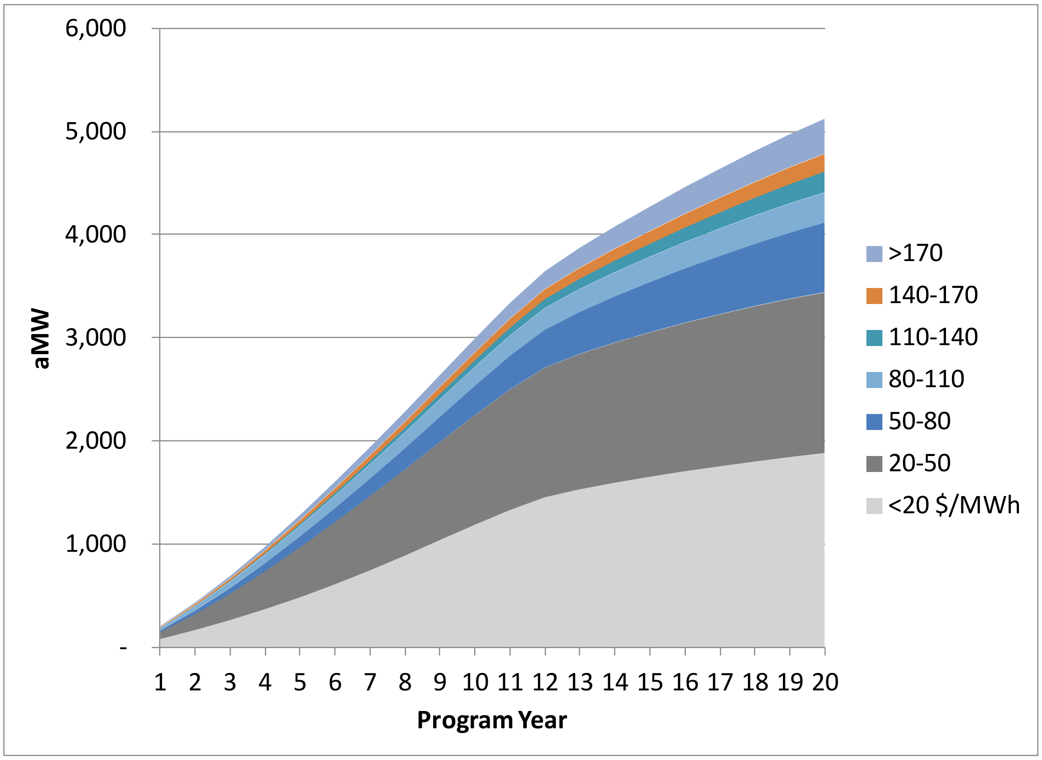
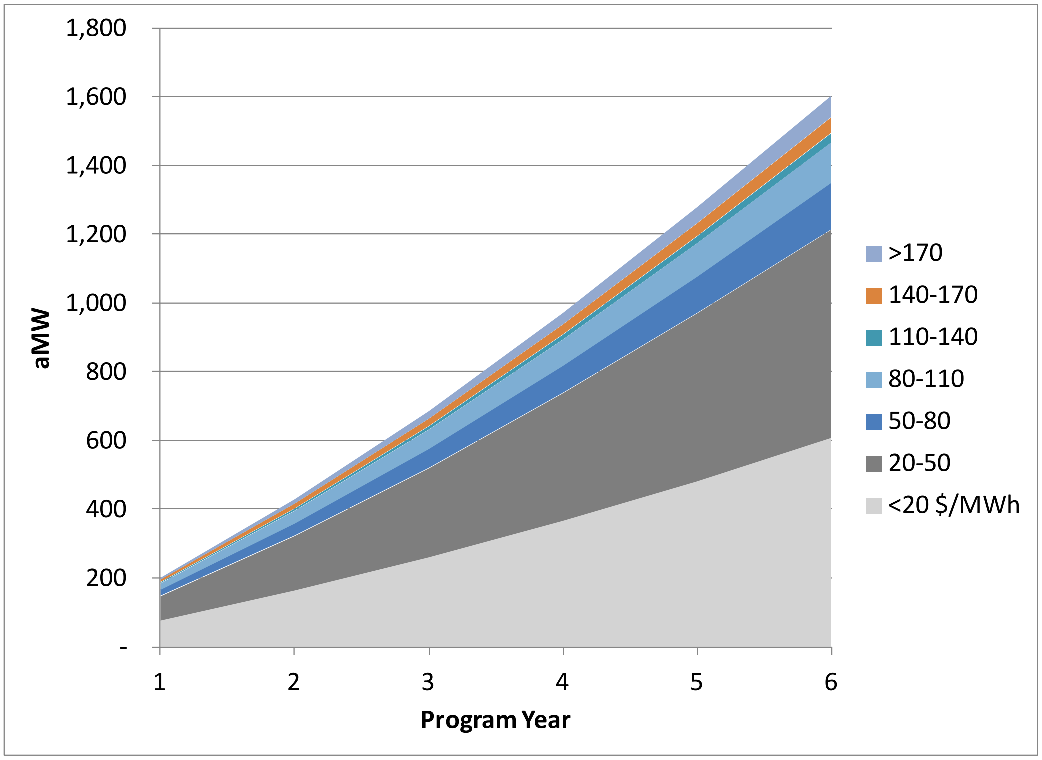


Figure 12 - 4: Maximum Cumulative Availability of Conservation Resources Over First Six Years



OVERVIEW

The conservation supply curves described in this chapter serve as *inputs* to the Regional Portfolio Model (RPM).[6] The RPM provides the Council with least-cost and least-risk portfolios of resources that include a specific amount of conservation for each resource strategy. Based on analysis of the RPM results, input from constituents, review of historical achievements, and other factors, the Council establishes new multi-year conservation targets. These targets are described in the Action Plan and in Chapter 3 on the Resource Strategy.

Power Act Requirements for Conservation

The method to determine conservation potential is outlined in the Northwest Power Act. The Act establishes three criteria for determining which conservation resources are analyzed and included as cost-effective resources. Resources must be 1) reliable, 2) available within the time they are needed, and 3) available at an estimated incremental system cost no greater than that of the least-

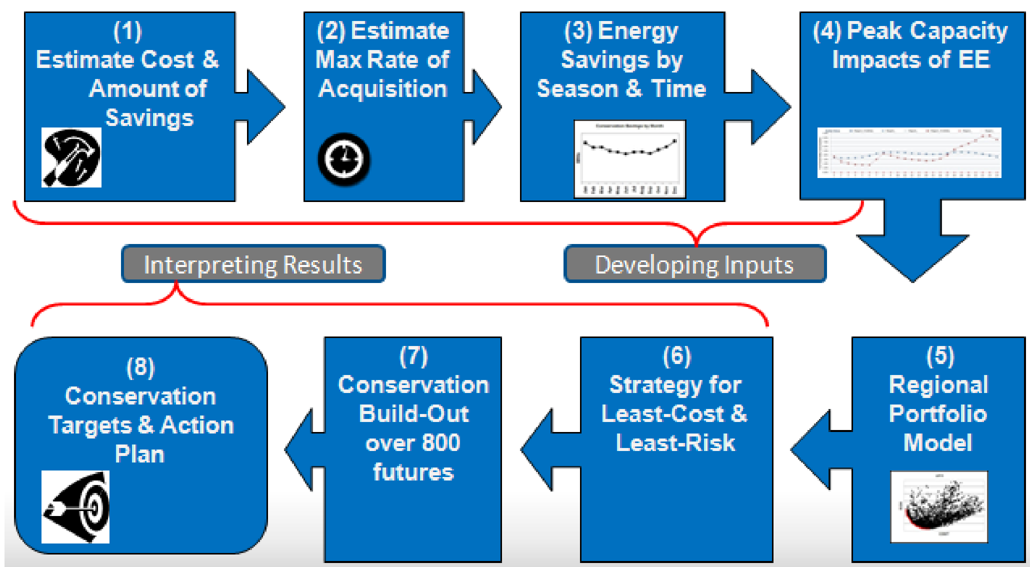
[6] See Chapter 15.

cost similarly reliable and available alternative.[7] Beginning with its first power plan in 1983, the Council interpreted these requirements to mean that conservation resources prioritized in the plans must be:

- Technically feasible (reliable)
- Achievable (available)
- Economically feasible (lower cost)

Each of these characteristics is discussed below. This chapter focuses on the first two elements – determining which conservation resources are reliable and available. Economic feasibility is determined through analysis of all resources within the RPM. The Regional Power Act also specifies that conservation resources get a 10 percent advantage when compared to non-conservation resource.[8] The Council's regional conservation target setting process is illustrated in Figure 12 - 5.

Figure 12 - 5: Approach to Setting Conservation Targets



Details for developing inputs are provided in the Methodology section below and in Appendix G (Conservation Resources and Direct Application Renewables). Chapter 15 (Analysis of Alternate Resource Strategies) provides details on interpreting the results.

---

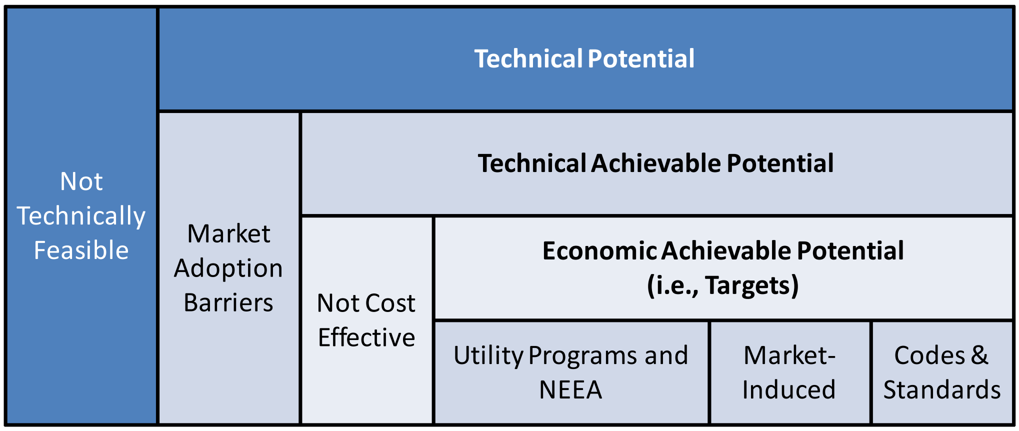
[7] See Section 839a(4)(A)(i) and (ii) of the Northwest Power Planning and Conservation Act. This section defines "cost-effective" as a measure or resource that is forecast to be "reliable and available within the time it is needed… to meet or reduce the electric power demand, as determined by the Council or the Administrator, as appropriate, of the consumers of the customers at an incremental system cost no greater than that of the least-cost similarly reliable and available alternative measure or resource, or any combination thereof."

[8] See Section 839a(4)(B) of the Northwest Power Planning and Conservation Act.

Estimating Conservation Potential

The Council considers three factors in ascertaining the cost-effective conservation potential of particular measures: technical feasibility, technical achievability and economic achievability. When each of these factors is applied, it results in different levels of potential: technical, technical achievable, and economic achievable. The relationship among the three factors and level of potential is illustrated in Figure 12 - 6.

Figure 12 - 6: Levels of Conservation Potential



Adapted from National Action Plan for Energy Efficiency[9]

Technical potential assumes that the most energy-efficient measures considered are installed everywhere they are technically feasible. The measures must be commercially available and reliable. The Council also considers emerging technologies for efficiency, but may not include them in the supply curve, depending on the Council's assessment of their current reliability. Rather, they are treated in a separate emerging technology scenario, described in the Emerging Technology scenario section. After the assessment of technical feasibility, the next step is to apply market barriers. The Council assumes that up to 85 percent of all technical potential can be achieved by the end of the plan period (20 years) to determine the technically achievable potential. Finally, through the RPM, the Council looks at whether potential conservation measures are economically achievable. This potential is then translated into savings targets, to be achieved from utility programs, market transformation activities of the Northwest Energy Efficiency Alliance (NEEA), and activities outside of programs including market-induced savings and savings from codes and standards (also known as momentum savings).

---

[9] National Action Plan for Energy Efficiency (2007). *Guide for Conducting Energy Efficiency Potential Studies*. Prepared by Philip Mosenthal and Jeffrey Loiter, Optimal Energy, Inc. <www.epa.gov/eeactionplan>

Distributed photovoltaics (PV) are not part of the conservation supply curves for the Seventh Power Plan, but are included as a direct application renewable (DAR) and discussed separately, along with solar water heaters.

Conservation Resource Characteristics

The cost, amount, energy and capacity contributions, and availability of conservation measures over time are key characteristics that the Council uses to compare them with generating resources, power purchases, and demand response programs.

Levelized total resource cost (TRC) of conservation is used to compare costs with other resources (more specifically, TRC is the net levelized cost in 2012 dollars per megawatt-hour). The amount of conservation resource is expressed in both energy and capacity savings. The annual, seasonal, and heavy-versus-light load hour energy uses are compared. Energy use is usually denominated in average megawatts. The effect of conservation on capacity is measured in megawatts and is estimated at the time of electric system peak. The availability of conservation over time is another key resource characteristic. Availability over time can include annual total buildable energy and capacity and the maximum rate of increased acquisition from year to year. Finally, each conservation measure is described in terms of the decision event for its adoption. Some measures are retrofit measures that can be adopted any time. For others, referred to as “lost-opportunity” measures, the adoption decision occurs only when an appliance or piece of equipment is purchased for a new installation or to replace burned-out equipment.

These resource characteristics are described for each conservation measure analyzed by the Council. The measures and their key characteristics are then combined into conservation supply curves for resource modeling. To simplify analysis, conservation resources are grouped into bins of similar cost based on levelized cost per megawatt-hour.

Although the Council includes much of the universe of measures into the supply curves, not all measures were included due to lack of data during time of supply curve development. This does not imply that the missing measures are not viable options for conservation. A list of missing measures that may prove to be viable options is provided in Appendix G.

Methodology for Determining Conservation Potential

The first step in the Council’s methodology is to identify all of the technically feasible potential conservation savings in the region. This involves reviewing a wide array of commercially available technologies and practices for which there is documented evidence of electricity savings, accounting for current baseline conditions. For example, measures need to be more efficient than current codes and standards. Around 100 conservation measure bundles were evaluated in developing the conservation potential for the Seventh Power Plan and more than1,600 measure permutations are combined into the conservation supply curves.[10] This first step also involves determining the number of potential applications in the region for each of these technologies or practices. For example, electricity savings from high-efficiency water heaters are only “technically feasible” in homes that have, or are forecast to have, electric water heaters. Similarly, increasing attic insulation in homes can only produce electricity savings in electrically heated homes that do not already have fully insulated attics.

The Council next determines the levelized total resource cost of energy savings from all measures that are technically feasible. TRC net levelized cost includes all quantifiable cost and benefits directly attributable to the conservation measures such as changes in consumption of other-fuels, operations and maintenance expenses, non-electric costs or benefits such as water savings, and environmental costs and benefits.[11] Benefits include deferred transmission and distribution expansion costs on the electric system if measures reduce coincident peak load. Estimating TRC net levelized cost requires comparing all the costs of a measure with all of its benefits, regardless of who pays those costs or who receives the benefits. In the case of efficient clothes washers, the cost includes the difference (if any) in retail price between the more efficient ENERGY STAR model and a standard efficiency model, plus utility program administrative and marketing costs.[12] On the other side of the equation, benefits include the energy and capacity savings, as well as water and wastewater treatment savings.[13] While not all of these costs and benefits are paid by or accrue to the region’s power system, the total resource cost perspective is used because all costs must be included in resource comparisons and because, ultimately, it is the region’s consumers who pay the costs and receive the benefits. For some measures, TRC net levelized cost is less than zero because electric plus non-electric benefits exceed cost.

The Council’s analysis assumes conservation measures comply with environmental regulations and thus incorporate any cost associated with compliance. In developing its methodology for determining quantifiable environmental costs and benefits, the Council also considered assessing benefits of environmental effects after compliance with environmental regulations. Health benefits are one example of environmental benefits that may be directly attributable to some conservation measures. For example, installing energy-efficiency measures that improve the heating efficiency of a home where wood is burned for heat may result in less burning of wood and thus reduced harmful particulate air emissions. For example, installing a ductless heat pump, which is often in the same room as the existing stove, might result in a homeowner relying more on the ductless heat pump to stay warm and, in return, less on the wood stove.

[10] Measure bundle, measure, and measure permutation represent different levels of aggregation, where the permutation is the most disaggregated. For example, a low-flow showerhead represents a measure bundle, 1.5 gallons-per-minute showerhead represents a measure, and a 1.5 GPM showerhead in a single-family home represents a permutation.
[11] See Appendix G for a detailed description of the components and calculation of TRC levelized cost.
[12] For the Seventh Plan, administrative costs are approximated to equal 20 percent of the measure’s incremental cost.
[13] Energy-efficient clothes washers use less water.

The contract analysts of the Council's Regional Technical Forum investigated whether health benefits from reduced wood smoke can be directly attributed to energy-efficiency program activity, and whether these benefits can be quantified and monetized given the current state of science.[14] A significant portion of electric heated homes in the Northwest use supplemental wood heating and careful analysis can show a reduction in wood use due to efficiency programs aimed at reducing space heating. The report concludes that the health effects resulting from changes in wood smoke emissions due to some efficiency programs could be quantified using the methodology that air regulators rely on. But this would require a comprehensive and costly analysis on a measure by measure basis.

For a variety of reasons, the Council decided that it is not possible to develop quantitative cost estimates related to health benefits from reduced wood smoke resulting directly from energy efficiency measures and add them into the new resource cost estimates in any consistent and reasonable way for the Seventh Power Plan.[15] At the same time, the Council recognizes the very real environmental and human health benefits that result from energy-efficiency investments that lead to a reduction in particulate emissions.

The energy savings and costs for each measure are incremental to its baseline energy use. This baseline is determined either by market practice or the pertinent code or standard. For example, the savings from a high-efficiency refrigerator are incremental to an estimate of the average efficiency energy use of refrigerators sold within the region. Where applicable, the assumptions are equivalent to those used by the Regional Technical Forum (RTF) in establishing the unit energy savings for reviewed measures.

The estimates of health impacts from reduced wood smoke have wide error bounds. As an example, a screening analysis on impacts of a region wide ductless heat pump program was conducted by Regional Technical Forum contract analysts. The analysis indicated that the monetary value of health benefits ranged from about 20 percent to 200 percent of the value of the electricity saved.

The total technical potential is determined by the per-unit savings multiplied by the number of units in the region. Using the refrigerator example again, the Council estimates (generally from secondary data such as regional stock assessments) the total number of refrigerators per household. This, multiplied by the number of households in the region, will provide the total number of refrigerators within the region. The total regional potential is then calculated by the total number of units times the savings per refrigerator. In addition, the annual technical potential accounts for the turn-over rate of refrigerators. That is, a refrigerator lasts approximately 15 years; as such, the Council estimates that each year 1/15 of all refrigerators in the region are replaced.

[14] Preliminary Report: Quantifying the Health Benefits of Reduced Wood Smoke from Energy Efficiency Programs in the Pacific Northwest RTF Staff Technical Report November 4, 2014

[15] The Council's methodology for determining quantifiable environmental benefits is described in Chapter 19.

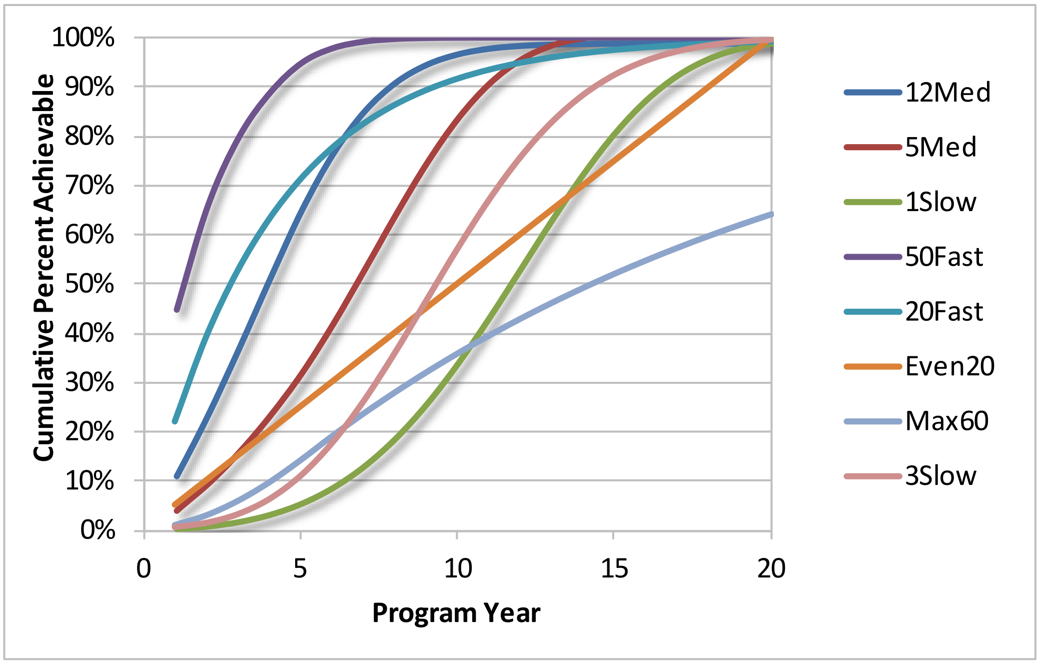
The technical achievable potential is the technical potential multiplied by two factors: the maximum achievable acquisition assumption and the annual acquisition ramp rate (step two in Figure 12 - 5). The first factor assumes that no more than 85 percent of the total potential could be acquired over the 20-year plan period.[16] The second factor is the rate of annual deployment, which represents the upper limit of annual conservation resource development based on implementation capacity. Such constraints include the relative ease or difficulty of market penetration, regional experience with the measures, likely implementation strategies and market delivery channels, availability of qualified installers and equipment, the number of units that must be addressed, the potential for adoption by building code or appliance standards, and other factors.

The upper limit of annual conservation resource development reflects the Council's estimate of the maximum that is realistically achievable. Since there is no perfect way to know this limit, the Council used several approaches to develop estimates of annual achievable conservation limits. First, the Council reviewed historic regional conservation achievements and considered total achievements, as well as year-to-year changes. The Council also considered future annual pace constraints for the mix of conservation measures and practices on a measure-by-measure basis.

The annual acquisition ramp rates used in the Seventh Power Plan are illustrated in Figure 12 - 7. This family of ramp rates is applied to all the measures to reflect the pace of acquisition over the 20-year plan period. Measures for which there is an established infrastructure or for which the market is rapidly changing are given a fast ramp rate, while measures that are new in the region, or that have experienced sluggish adoption rates are assigned a slow ramp rate. The annual acquisition rate multiplied by the total number of units available in a given year provides the maximum annual technical achievable potential. Note that acquisition year one corresponds to the first year in which that measure is selected in the RPM, which may not be the first year of the Seventh Power Plan (2016). More details on this are provided in Appendix G and Appendix L.

[16] In 2007, Council staff compared the region's historical achievements against this 85 percent planning assumption. The results of this review supported continued use of the estimate, or perhaps even the adoption a higher one in the Sixth Power Plan. The paper is on the Council website at http://www.nwcouncil.org/library/2007/2007-13.htm.

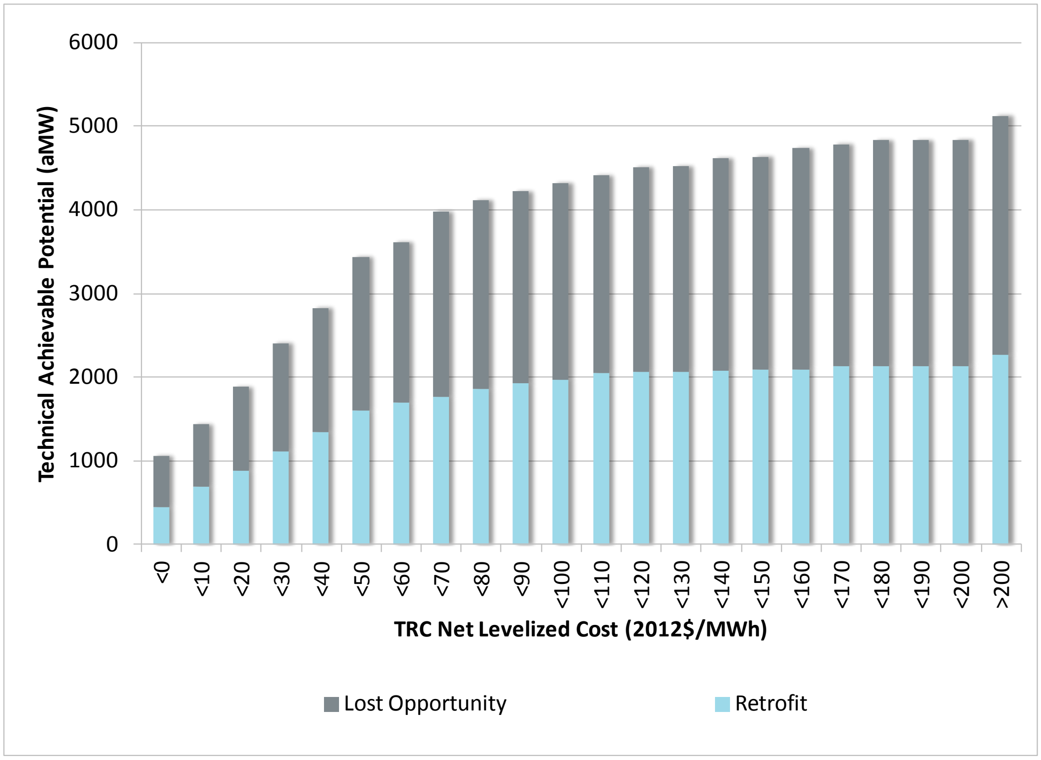
Figure 12 - 7: Conservation Acquisition Ramp Rates



In addition to the amount of conservation potential, the supply curve inputs also include the cost of achieving that potential. The costs are estimated based on a *net levelized cost* (levelized over the life of the conservation resource) of each of the conservation technologies or practices. These technologies are then ranked by net levelized cost using the same approach as for new generating resources.

One supply curve represents all of the retrofit resources. The other represents all the lost-opportunity conservation resources. Both supply curves are shown together in Figure 12 - 8 by cost bin for all conservation available through 2035. The Council divides conservation resources into these two categories because their patterns of deployment are limited by different decision events. Retrofit opportunity conservation resources can be deployed at any time, limited only by resources and infrastructure. Lost-opportunity resources, on the other hand, are only available during specific periods. For example, the option to include more wall insulation in high-rise commercial buildings is only available when new buildings are designed and constructed. In addition, savings from most appliances are available only as appliance stock turns over. If the savings from these lost-opportunity resources are not acquired within this limited window of opportunity, they are treated as lost and not available until the next decision event, for example when the appliance has reached its end of life and needs to be replaced. The figure shows that nearly half the conservation potential is in lost-opportunity resources.

Figure 12 - 8: Conservation Supply Curve by Resource Type



In addition to the energy savings, efficiency measures also provide capacity savings. These savings are estimated based on the savings shape over the year (step three in Figure 12 - 5). The savings shapes provide a relative impact of the energy savings during peak hours compared to the rest of the year. For example, whereas savings from efficient air-source heat pumps would have peak impacts for a winter-peaking system, savings from efficient residential air conditioners do not. The peak and energy savings are both included as data in the RPM.

Key Data Sources

To inform the individual measure costs and savings, several sources are used. Primary among them is the RTF. The Seventh Power Plan incorporates the most recent updates by the RTF until the date when these inputs went into the RPM (through February 2015 for the draft plan inputs). For measures not considered by the RTF, the Council relies on secondary studies, including evaluation results by regional utilities, the Energy Trust of Oregon, and the Bonneville Power Administration (Bonneville), research conducted by the U.S. Department of Energy National Labs (e.g. Pacific Northwest National Lab, Lawrence Berkeley National Lab), and other sources.

The total number of units in the region is largely based on the sector-specific stock assessments conducted by NEEA. These include:

- Residential Building Stock Assessment, completed in 2012
- Commercial Building Stock Assessment, completed in 2014
- Industrial Facilities Site Assessment, completed in 2014

These assessments provide a snapshot of the appliance and equipment saturations of buildings across the region.

In addition, to estimate the seasonal variation of the savings, the Council relies on end-use metering data; loads collected at the final point of consumption of electricity. For many end-uses, these are based on the End-Use Load and Consumer Assessment Program (ELCAP) database. The ELCAP database, it should be noted, is more than 30-years old, and so its accuracy in representing modern load shapes is questionable. The 2012 Residential Building Stock Assessment included a metering component, and so many of the residential non-heating and cooling end-use load shapes were updated based on the newer data. Additional end-use load shapes are estimated from metering work in California,[17] or lacking any metered data, engineering analysis and staff judgment.

Other sources for applicability factors or other inputs include: the Energy Information Agency's Manufactured Energy Consumption Survey and Commercial Building Energy Consumption Survey, Bonneville's energy efficiency implementation manual, other regional conservation potential assessments, EPA's ENERGY STAR program reports, federal standards rulemaking documents of the U.S. Department of Energy, and market and building codes analyses completed by NEEA.

FACTORS IMPACTING CONSERVATION POTENTIAL SINCE THE SIXTH POWER PLAN

The Seventh Power Plan's assessment of conservation potential reflects program accomplishments, changes in codes and standards, technological evolution, and the overall adoption of more energy-efficient equipment and practices since the Sixth Power Plan was adopted in 2010. There are six significant changes:

1. Accounting for utility conservation programs and other savings since 2010, including removal of measures that have saturated the market (e.g. LED TVs).
2. Adjusting both the load forecast and the conservation assessment to reflect improvements in federal and state standards for lighting, appliances, and other equipment.
3. Adding potential savings from new technologies and practices that have matured to commercial readiness since the development of the Sixth Power Plan's estimates.
4. Updating estimates of energy equipment saturation, gas and electric fuel shares, and other key building characteristics from the residential, commercial, and industrial stock assessments.
5. Updating forecasts of the number of new homes, businesses, and farms.
6. Updating costs to be in 2012 constant dollars.

[17] California Commercial End-Use Survey (CEUS), completed in 2006.

Of these, items 1 through 5 account for changes in the magnitude of conservation, while item 6 only influences cost and cost-effectiveness.[18] Details on the drivers of the changes in magnitude of conservation are discussed below.

Significant Conservation Achievements

The Sixth Power Plan recommended that the region develop at least 1,200 average megawatts of cost-effective conservation savings from 2010 through the end of 2014. Based on surveys conducted by the Council's RTF, regional conservation programs (utility and NEEA) the region had achieved more than 1,000 average megawatts of cost-effective energy savings by the end of 2013. Including savings from codes and standards that have taken effect during the Sixth Power Plan period, total regional savings are close to 1,300 average megawatts through 2013. Based on conservative projection data, the region will likely exceed 1,400 average megawatts by the end of 2015. These savings reduce the remaining potential for the Seventh Power Plan.

Federal and State Codes and Standards

Improvements in codes and standards have a significant impact on the remaining conservation potential. Since the Sixth Power Plan was adopted, the U.S. Department of Energy has promulgated new electric efficiency standards for more than 30 products for a suite of residential and commercial appliances.[19] Baseline assumptions for energy use of new appliances and equipment have been updated in the new conservation assessment to reflect these improved standards. Table 12 - 1 shows a summary of all the federal electric standards that have changed since the adoption of the Sixth Power Plan and the effective dates of these new and/or revised standards. Taken together, the Council forecasts that improvements in federal and state appliance standards reduce forecasted power loads by around 1,300 average megawatts by 2035 (see Appendix F for more details), an approximately 5 percent reduction in total regional consumption.

[18] More information on changes in the load forecast, including the impact of codes and standards (items 2 and 5), can be found in Chapter 7 and Appendix F.
[19] U.S. DOE has also promulgated a number of gas efficiency standards in this timeframe, but those are not discussed here.

Table 12 - 1: New or Revised Federal Electric Standards Incorporated in Seventh Power Plan Conservation Assessment Baseline Assumptions

Sector	Product Regulated	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
All	Battery Charger Systems*					✓						
	Candelabra & Intermediate Base Incand Lamps			✓								
	External Power Supplies							✓	✓			
	Fluorescent Lamp Ballasts					✓						
	General Service Fluorescent Lamps			✓		✓				✓		
	General Service Incandescent Lamps			✓	✓	✓						✓
	Incandescent Reflector Lamps								✓			
	Metal Halide Lamp Fixtures								✓			
Residential	Boilers			✓								
	Central Air Conditioners and Heat Pumps						✓					
	Clothes Dryers						✓					
	Clothes Washers						✓			✓		
	Dehumidifiers			✓								
	Dishwashers				✓						✓	
	Furnace Fans										✓	
	Microwave Ovens							✓				
	Pool Heaters				✓							
	Refrigerators/Freezers					✓						
	Room Air Conditioners					✓						
	Water Heaters						✓					
Commercial	Automatic Ice Makers	✓								✓		
	Boilers			✓								
	Clothes Washers				✓							
	Packaged AC and Heat Pumps (65-760 kBtu/hr)	✓									✓	
	Packaged AC and Heat Pumps (<65 kBtu/hr)									✓		
	Packaged Terminal AC and Heat Pumps	✓								✓		
	Refrigerated Beverage Vending Machines			✓								
	Refrigeration Equipment	✓		✓					✓			
	Single Package Vertical AC and Heat Pumps	✓								✓		
	Walk-in Coolers and Freezers					✓			✓			
	Water and Evaporatively Cooled CAC and HP				✓	✓						
	Water Heaters										✓	
	Water Source Heat Pumps		✓							✓		
Commercial/ Industrial	Distribution Transformers							✓				
	Pumps									✓		
	Small Electric Motors						✓					
	Electric Motors	✓						✓				

* Battery chargers are an Oregon state standard, not a federal standard

State building codes have also improved since the adoption of the Sixth Power Plan. Since then, Idaho and Montana have adopted the 2012 International Energy Conservation Code (IECC), which is a significant improvement over the codes in place at the time of the Sixth Power Plan development. In addition, Washington and Oregon both have adopted state-specific codes that are comparable, or better than, the 2012 IECC. State building code improvements also reduce forecasted power loads. For example, commercial sector state building codes adopted since the Sixth Power Plan are expected to reduce regional loads by about 100 average megawatts by 2035.

New Sources of Conservation Potential

Many new measures were added to the Seventh Power Plan that were not included in the Sixth Power Plan. In fact, new measures comprise around 40 percent of the total 20-year potential. Some examples of significant potential sources of savings include: recent advances in solid-state lighting (LEDs), variable refrigerant flow systems for HVAC loads, advanced power strips, advanced rooftop controllers, and low-energy spray application irrigation systems.

Stock Assessments

As discussed above, the Seventh Power Plan relied on saturation and fuel share estimates developed through the regional stock assessments for residential, commercial, and industrial facilities. These stock assessments were all performed since the release of the Sixth Power Plan and thus provide a more updated view of the existing building stock.

ACHIEVABLE POTENTIAL ESTIMATES BY SECTOR

The potential estimates by sector are presented below. The sectors include: residential, commercial, industrial, agriculture, and utility. High-level summaries of the findings on remaining conservation potential are discussed by sector. Appendix G contains links to all measure workbooks with details on savings and costs.

Residential Sector

The residential sector includes single-family detached homes, manufactured homes, low-rise (1-3 stories) multifamily, and medium/high-rise (4 stories and above) multifamily homes. For medium- and high-rise multifamily homes, the residential sector only assesses in-unit conservation potential (i.e., this assessment excludes improvements in building shell, common-area lighting, or building-area HVAC systems). Across the four residential segments, there are more than 700 different identified measure permutations. The Seventh Power Plan estimates over 2,300 average megawatts of potential energy efficiency in the residential sector, over 1,600 of which are less than $100 per megawatt-hour. The total potential (2,300 average megawatts) represents approximately 27 percent of the projected 2035 residential sector load.

Resource Type

Of the 2,300 average megawatts of potential in the residential sector, around two-thirds (1,600 average megawatts) are from lost-opportunity measures, including heat pump water heaters, ductless heat pumps, lighting, and clothes washers. Within the lost-opportunity measures, the annual potential is dictated by the natural turn-over of each measure. Retrofit measures (e.g., weatherization, advanced power strips, showerheads) comprise the remaining third of savings potential.

Comparison to Sixth Power Plan

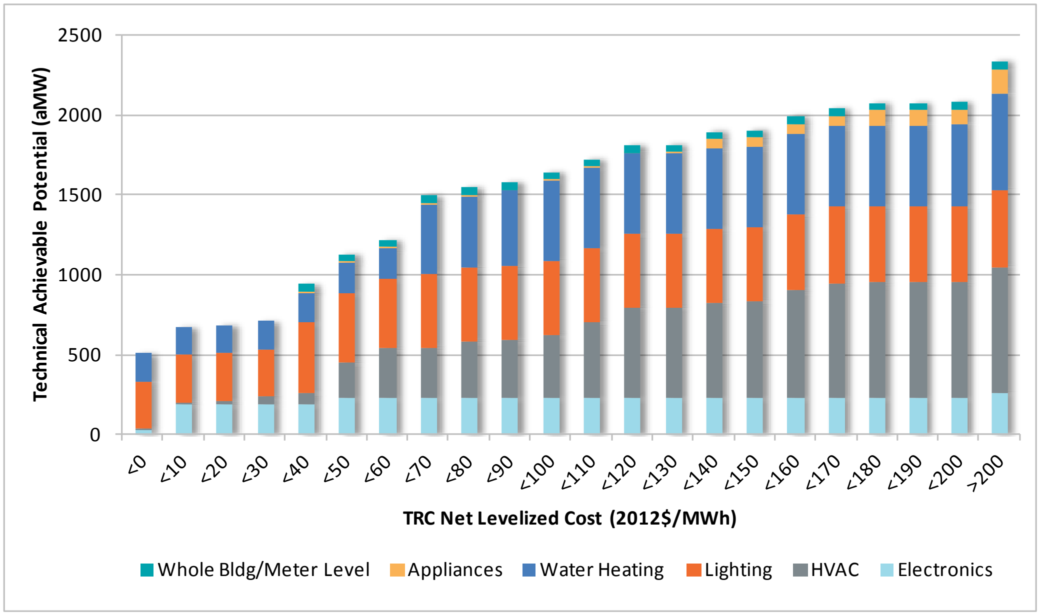
In the Sixth Power Plan, the Council estimated the residential sector to offer nearly 2,700 average megawatts of potential energy efficiency at less than $100 per megawatt-hour. The Seventh Power Plan estimates 1,600 average megawatts of potential but also includes the addition of many new measures. The decrease in potential from the Sixth Power Plan is primarily driven by programmatic accomplishments and improvements in codes and federal standards. For example, in the Sixth Power Plan, there were nearly 400 average megawatts of potential from LED backlit televisions. Television savings identified in the Sixth Plan have been already captured. As older TVs are replaced, the savings from the purchase of new TVs are incorporated as load reductions. The Seventh Power Plan sets at zero the remaining potential for TVs.[20] Another 220 average megawatts were identified in the Sixth Power Plan for residential new construction shell upgrades. With the improvement of energy codes across all states in the region, this potential is now significantly decreased and electric use forecasts for future new homes has similarly been decreased where the savings are now required and thus being realized (no longer potential) as a matter of statute or code.

Savings by End-use

The residential potential is dominated by lighting, HVAC, and water heating, as illustrated in Figure 12 - 9. Other contributing end-uses include appliances (including microwaves, refrigerators, clothes washers, and dryers), electronics (including advanced power strips, efficient computers and monitors), and whole building/meter level (including behavior and electric vehicle supply equipment).

[20] Note that the television market is rapidly changing. With the recent advent of ultra-high definition TVs, it is likely there can be new initiatives to improve the efficiency of those units. None were identified at the time of the Seventh Plan supply curve development.

Figure 12 - 9: Residential Potential by End-use and Levelized Cost by 2035



Major and New Residential Measures

The largest contributor to the potential in the residential sector is water heating. The potential is just over 600 average megawatts, 500 of which is available at less than $100 per megawatt-hour. This measure category includes heat pump water heaters, water-using appliances (dishwashers and clothes washers), as well as low-flow showerheads and bathroom aerators.

The second largest contributor is lighting, with a potential of nearly 500 average megawatts, most of which is available at less than $70 per megawatt-hour. This potential is largely driven by the advent of low-cost solid-state lighting (LEDs) in the marketplace, which allows for highly efficient bulbs that work in a variety of settings and applications. As the technology is rapidly changing, though with uncertainty about how much, the Council decided to include projected improvements in cost and efficacy of LEDs through 2017. The projections are based on work completed by Pacific Northwest National Labs in October 2013.[21] This is an exception to our standard frozen-efficiency baseline that assumes, for purposes of developing the load forecast, that the end-use consumption remains fixed over the 20-year plan period.[22]

In developing the supply curves for residential lighting, the Council needed to consider how to treat the forthcoming lighting standards, known as the Energy Independence and Security Act's backstop provision. This provision stipulates that in 2020, general service incandescent lighting must have a minimum efficacy of 45 lumens per watt. This in turn means that savings from bulbs less efficient than this backstop standard of 45 lumens per watt are only available until 2020. Given the value of continued lighting programs, and uncertainty about whether the 2020 standard will take effect, the

[21] Tuenge, JR, *SSL Pricing and Efficacy Trend Analysis for Utility Program Planning*, October 2013. PNNL-22908.
[22] See Chapter 7 for further description.

Council decided to include a lighting potential that is more efficient than current standards, but less than the 2020 backstop. This, however, creates a challenge when modeling this in the RPM because once conservation is selected as a resource, its savings are expected to persist throughout the 20-year plan period. Therefore, the portion of lighting potential from bulbs used before the 2020 standard takes effect is treated separately from the other lighting resources.

Another significant measure not considered in the Sixth Power Plan is advanced power strips that offer 210 average megawatts of potential savings. This measure represents the growing savings from sophisticated controls. Advanced power strips can be used for home entertainment centers and home offices, shutting off peripheral and potentially primary equipment when the main appliance (TV or computer) is not actively in use.

Two measure categories that were in the Sixth Power Plan and still have significant savings potential going forward are weatherization (250 average megawatts, 100 of which is less than $100 per megawatt-hour) and ductless heat pumps (DHP), in both electric resistance zonal-heated homes and to supplement electric forced air furnaces (290 average megawatts, 165 of which is less than $100 per megawatt hour).

Residential Sector Summary

Table 12 - 2 provides a summary of the residential measure bundles' maximum achievable technical potential energy savings at years 2021, 2026, and 2035 and TRC net levelized costs of each of the bundles. The TRC net levelized costs are the weighted average cost (weighted by maximum achievable technical savings potential). Also included are the minimum and maximum levelized costs for each of the measures within each bundle.

Table 12 - 2: Summary of Potential and Cost for Residential Measure Bundles

Measure Bundle	Maximum Achievable Technical Potential (aMW)			TRC Net Levelized Cost ($/MWh)		
	2021	2026	2035	Weighted Average	Min	Max
HVAC	**248**	**460**	**793**	136		
Weatherization	166	233	248	104	(16)	843
Air Source Heat Pumps	12	45	130	363	22	1,075
Heat Pump Controls Commissioning and Sizing	4	16	46	54	29	285
DHP for zonal heated homes	12	45	132	134	94	153
DHP for forced air furnace homes	28	76	158	45	41	57
Duct Sealing	21	30	32	60	12	133
Ground source heat pumps	0	3	19	169	157	181
WIFI Enabled Thermostats	4	10	12	40	40	43
Heat Recovery Ventilation	0	3	16	124	76	140
Lighting	**177**	**380**	**484**	1		
Lighting	136	334	425	(9)	(120)	353
Lighting (pre-2020 general service lamps)	38	38	38	(59)	(74)	0
Linear fluorescent lighting	3	9	20	301	154	617
Water Heating	**111**	**261**	**603**	104		
Showerheads	67	100	121	(176)	(282)	(110)
Heat Pump Water Heaters	11	75	323	164	62	5,759
Solar Water Heater	17	35	56	656	533	705
Clothes Washer	10	27	61	33	(76)	94
Aerator	5	21	34	(263)	(300)	(171)
Dishwasher	0	0	1	(4)	(11)	2
WasteWater Heat Recovery	0	1	8	190	153	424
Electronics	**69**	**171**	**252**	45		
Advanced Power Strips	33	133	211	28	(2)	225
Computer	29	31	33	151	41	824
Monitor	6	7	8	49	49	49
Refrigeration	**1**	**9**	**56**	235		
Refrigerator	1	9	53	239	175	325

Freezer	0	1	3	154	154	154
Food Preparation	**7**	**17**	**34**	327		
Electric Oven	5	13	28	395	368	436
Microwave	1	4	6	32	32	32
Dryer	**4**	**15**	**53**	135		
Clothes Dryer	4	15	53	135	135	135
Whole Bldg/Meter Level	**17**	**39**	**53**	142		
Behavior	17	38	45	30	30	30
EV Supply Equipment	0	1	7	827	827	827
Grand Total	**634**	**1,352**	**2,328**	**95**		

Commercial Sector

The commercial sector includes 3.4 billion square feet of floor area (as of 2013) and 18 different building type categories.[23] Across the 18 building types are more than 540 measure permutations. The Seventh Power Plan estimates nearly 1,870 average megawatts of energy efficiency potential in the commercial sector, about 1,770 of which costs less than $100 per megawatt-hour. The total potential represents approximately 20 percent of the projected 2035 commercial sector load.

Resource Type

Of the 1,870 average megawatts of potential savings in the commercial sector, around two-thirds (1,200 average megawatts) are from lost-opportunity measures. Approximately 200 average megawatts of this lost-opportunity conservation is in new buildings, primarily from new lighting systems that have fairly high turnover rates for remodel and tenant improvements, as well as variable refrigerant flow (VRF) systems. For the lost-opportunity measures, the annual potential is dictated by the natural turnover of each measure and new additions. Retrofit measures (e.g. advanced rooftop unit controllers, lighting retrofits, energy management, DHP) comprise the remainder.

Comparison to Sixth Power Plan

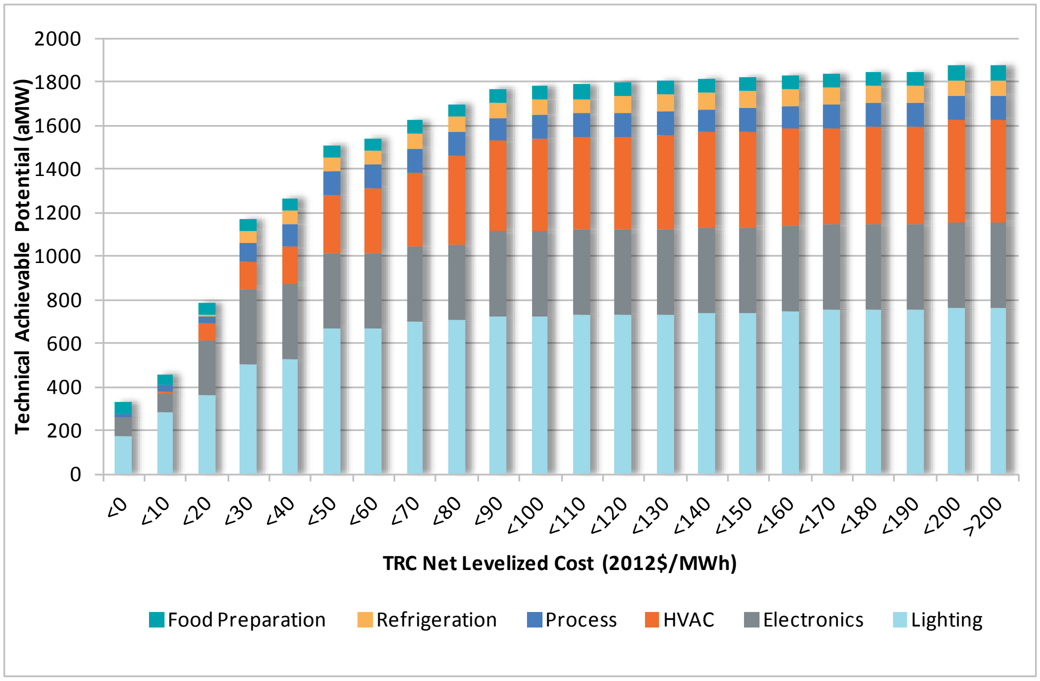
In the Sixth Power Plan, the Council estimated in the commercial sector more than1,300 average megawatts of potential savings, costing less than $100 per megawatt-hour. The Seventh Power Plan finds an increase of around 500 average megawatts in potential, which is primarily due to new or emerging measures. These measures include solid state lighting, embedded data center improvements[24], advanced rooftop unit controllers to optimize rooftop unit HVAC systems, and variable refrigerant flow HVAC systems.

Savings by End-use

The commercial potential is dominated by lighting (LED lighting and controls for interior, exterior, and street lighting, applications), HVAC (rooftop unit controller, energy management, variable refrigerant flow systems, ductless heat pumps), and electronics (embedded data centers, smart plug power strips, computers and monitors) as illustrated in Figure 12 - 10. Other contributing end-uses include refrigeration, food preparation, and process loads (sewage treatment, water supply, motors/drives, water heating, and compressed air).

[23] Building types include: Large, medium and small office, extra large, large, medium and small retail, K-12 schools, university, warehouse, supermarket, minimart, restaurant, lodging, hospital, residential care, assembly, and other.
[24] Embedded data centers are those found in many commercial buildings and does not include the stand-alone data centers.

Figure 12 - 10: Commercial Potential by End-use and Levelized Cost by 2035



Major and New Commercial Measures

The largest contributor to savings potential in the commercial sector is lighting. The potential savings are more than 700 average megawatts, most of which are available at a cost of less than $50 per megawatt-hour. This potential is largely driven by the advent of low-cost LEDs, which allow for highly efficient bulbs and fixture combinations. Since the technology is rapidly changing, the Council decided to include projected improvements in cost and efficacy of LEDs through 2017. The projections are based on work completed by Pacific Northwest National Labs in October 2013.[21] This is an exception to our standard frozen-efficiency baseline.

The lighting end-use category is comprised of measure bundles targeted at common applications in both interior and exterior spaces. In the Sixth Power Plan, only three applications of solid-state lighting were viable – roadway lighting, refrigerator case lighting, and some down lighting. But this has changed. For each of the main lighting application types, the Council identified viable LED fixtures, retrofit kits or lamp replacement technologies. Viable savings measures now exist for all application types.

Savings are higher and costs are lower where LED technology replaces halogen incandescent lamps commonly used in display lighting or metal halide lamps commonly used in outdoor fixtures and high bay lighting. There are more viable LED measures for recessed can down lighting applications, than there are CFL sources. LED high bay fixtures are now competing against high-performance, high-output T5 fluorescent fixtures. New solid state lighting fixtures and fixture retrofit kits are available to replace the most common linear fluorescent fixtures. There are low-cost savings available from solid state lighting that promise improvement beyond today's high-performance linear fluorescent lighting systems, particularly in new, remodel and replace-on-burnout applications.

Significant savings are also available from high performance low-power fluorescent lamps in the lamp replacement markets during the transition to solid state lighting.

Significant numbers of street and roadway lighting has already switched to LED technology. Both Portland and Seattle are scheduled to complete LED streetlight installation by the end of 2015. But potential remains in other jurisdictions and in high-mast applications. Other lighting bundles include lighting control measures for interior spaces where controls are not already required by code, bi-level stairwell lighting, and bi-level parking garage lighting. The assessment also includes savings for light-emitting capacitor exit signs.

The second largest new measure bundle in the commercial sector is embedded (not stand-alone) data centers (260 average megawatts). The embedded data center measure bundle consists of 22 unique measures in three tiers. Individual measures include server virtualization, decommissioning of unused servers, energy-efficient servers, energy-efficient data storage management, efficient power supplies, and cooling-related measures.

Another significant measure is the advanced unit controller for rooftop HVAC systems. Rooftop systems provide heating, cooling, and ventilation to numerous small and mid-sized buildings throughout the region and are notoriously inefficiently maintained and operated. Approximately one third of commercial floor space is conditioned by rooftop air conditioning or heat pump systems. The advanced rooftop unit controller measure provides a relatively simple approach for targeting these systems, especially buildings that are excessively ventilated.

The variable refrigerant flow (VRF) technology represents more than 90 average megawatts of potential by 2035, with most of this potential in the range of $40-$80 per megawatt-hour. VRF is relatively new to the U.S. market and the Northwest, but is a well-developed technology utilized broadly in Japan, Europe, and Australia. One of the significant advantages of the VRF system is its design flexibility resulting in more precise temperature and air control. The Seventh Power Plan assumes VRF systems are primarily applicable to new construction and major retrofits.

The DHP measure is also new to the commercial sector in the Seventh Power Plan. The DHP is especially applicable to small commercial buildings with electric resistance zonal heat and less than five tons of cooling capacity.

As in the Residential sector, advanced power strips are a new measure in the commercial sector (47 average megawatts). This measure represents the growing savings from controls. Advanced power strips apply to the numerous miscellaneous plug loads and ancillary electronic equipment found in commercial office spaces.

A few other commercial sector new measures include secondary glazing systems, water cooler controls, web-enabled programmable thermostats (WEPT), compressed air systems, showerheads, and efficient electric resistance water heater tanks.

Commercial Sector Summary

Table 12 - 3 provides a summary of the commercial measure bundles' maximum achievable technical potential energy savings at years 2021, 2026, and 2035 and TRC net levelized costs. The TRC net levelized costs are the weighted average cost (weighted by maximum achievable technical savings potential). Also included are the minimum and maximum levelized costs for the measures within each bundle.

Table 12 - 3: Summary of Potential and Cost for Commercial Measure Bundles

Measure Bundle	Maximum Achievable Technical Potential (aMW)			TRC Net Levelized Cost ($/MWh)		
	2021	2026	2035	Weighted Average	Min	Max
Lighting	249	502	760	23		
Lighting Power Density Package	126	240	435	21	(76)	657
Low Power Linear Fluorescent Lamps	14	39	39	24	24	24
Lighting Controls Interior	8	19	44	138	40	445
Exterior Building Lighting	59	126	142	12	(128)	28
Street and Roadway Lighting	30	57	61	(34)	(119)	18
Parking Lighting	6	8	8	25	25	25
Bi-Level Stairwell Lighting	2	5	11	79	69	155
LEC Exit Sign	4	9	19	13	10	27
Electronics	104	314	392	19		
Data Centers	55	230	261	16	10	27
Advanced Power Strips	30	42	47	81	81	81
Desktop	13	28	56	(8)	(8)	(8)
Monitor	6	12	24	(8)	(8)	(8)
Laptop	0.3	1.4	4	(8)	(8)	(8)
HVAC	144	322	471	64		
Advanced Rooftop Unit Controller	22	84	119	31	12	88
Commercial Energy Management	46	67	73	44	17	168
Demand Control Ventilation in Parking Garage	8	12	13	40	40	40
Demand Control Ventilation for HVAC	15	21	22	75	0	1,391
DHP	12	43	60	61	46	74
Secondary Glazing Systems	4	18	40	216	10	334
VRF	8	34	96	70	44	140
Premium Fume Hood	0.4	1.2	4	40	40	40
Economizer	19	27	27	43	6	90
Demand Control Ventilation	6	8	8	51	38	74

Restaurant Hood						
Web-Enabled Programmable Thermostats	3	7	7	61	54	79
Refrigeration	43	69	76	34		
Grocery Refrigeration Bundle	41	57	63	35	20	112
Water Cooler Controls	2	11	12	35	18	142
Food Preparation	6	23	64	(26)		
Cooking Equipment	6	23	63	(23)	(44)	80
Pre-Rinse Spray Valve	0.6	0.9	1.0	(224)	(298)	(104)
Process Loads	19	42	47	25		
Municipal Sewage Treatment	14	32	35	26	(10)	40
Municipal Water Supply	5	11	12	24	24	24
Motors/Drives	6	17	35	23		
Electronically Commutated Motor-Variable Air Volume	4	12	30	23	20	33
Motors Rewind	2	4	5	27	5	38
Compressed Air	4.8	9	17	5	3	13
Compressed Air	4.8	9	17	5	3	13
Water Heating	4	6	10	(204)		
Showerheads	3	4	4	(510)	(689)	(217)
Electric Resistance Water Heater Tanks	0.4	1.1	2	30	23	38
Commercial Clothes Washer	0	2	4	(60)	(60)	(60)
Grand Total	581	1,305	1,871	30		

Industrial Sector

The industrial sector conservation potential is a direct function of the individual industrial segment loads. The Council's conservation assessment does not include savings potential for the Direct Service Industrial (DSI) customers of Bonneville. Non-DSI industrial consumption is forecasted to be approximately 30,800 gigawatt-hours (3,520 average megawatts) at the start of the planning period and growing to more than 39,000 gigawatt-hours, or about 4,480 average megawatts by 2035 (medium forecast). The industrial sector includes 19 distinct segments each with a unique composition of end-use loads. The resulting conservation potential is about 580 average megawatts, with most of that potential available at a cost of less than $50 per megawatt-hour. The total savings potential represents approximately 13 percent of the projected 2035 industrial sector load.

Resource Type

The industrial measures were all categorized as retrofit.

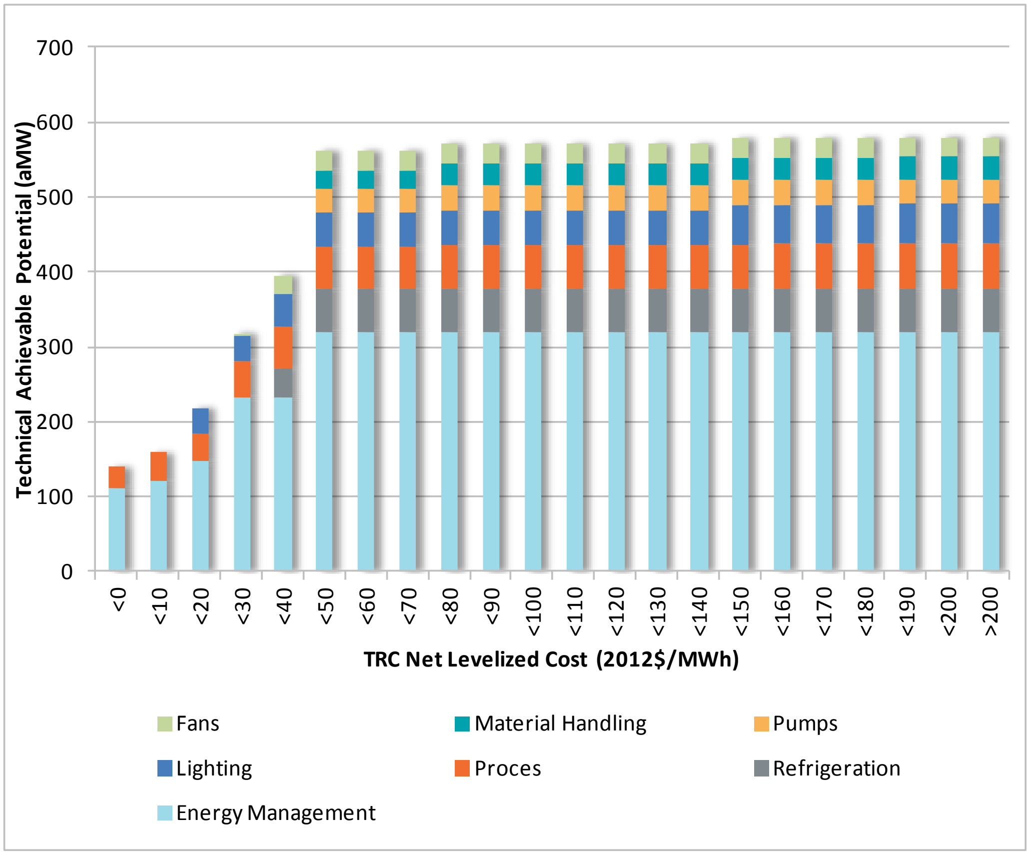
Comparison to Sixth Power Plan

In the Sixth Power Plan, the Council estimated energy efficiency savings in the industrial sector to be nearly 800 average megawatts at a cost of less than $100 per megawatt-hour. The 550 average megawatts identified in the Seventh Power Plan are a reduction in industrial sector conservation potential. This reduction is primarily due to the significant regional accomplishments that have occurred in this sector since the Sixth Power Plan. Some standards improvements also played a role in moving Sixth Power Plan potential into the baseline. In addition, total industrial production is forecast to be lower compared to Sixth Power Plan levels.

Savings by End-use

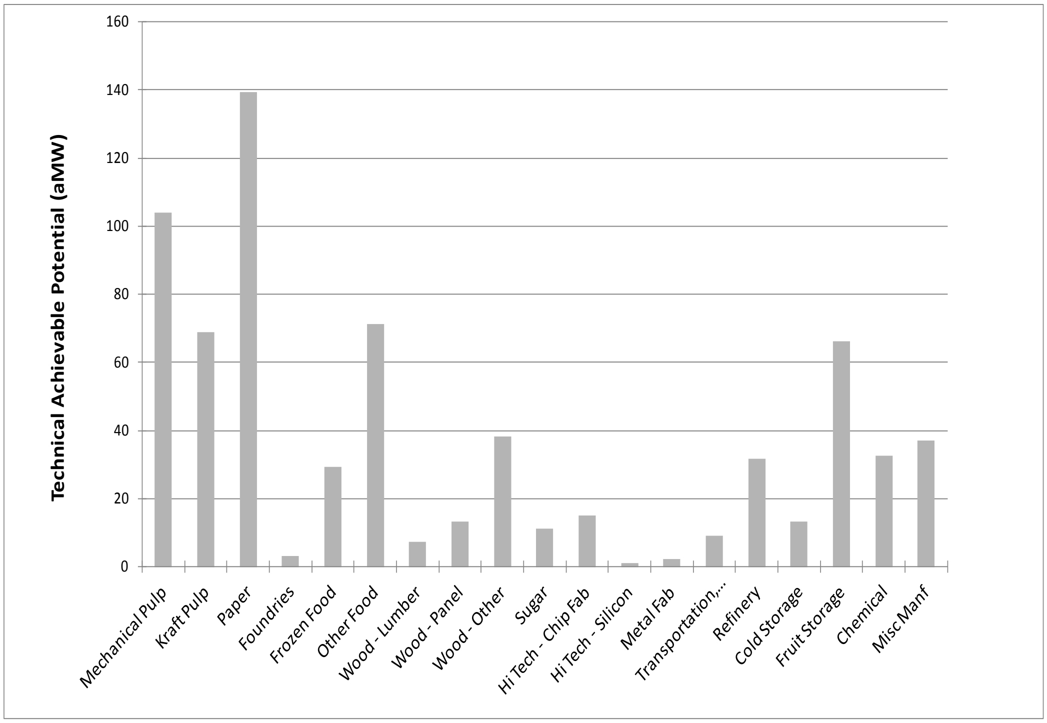
The industrial potential is dominated by the general category of "energy management" as illustrated in Figure 12 - 11. The energy management bundle includes measures and practices to optimize industrial processes. Specific measures are aimed at fan, pump, and compressed air systems, process lines, as well as whole facility energy management. Other contributing end-uses include refrigeration, process loads, lighting, pumps, fans, and material handling. Note also that the majority of the industrial conservation potential costs less than $50 per megawatt-hour.

Figure 12 - 11: Industrial Potential by End-use and Levelized Cost by 2035



Another way to look at the industrial sector conservation potential is by industry segment as shown in Figure 12 - 12. The pulp and paper industries are very strong in the Pacific Northwest, and therefore have strong conservation potential. Segments like frozen food, cold storage, and fruit storage have significant refrigeration loads and associated conservation potential.

Figure 12 - 12: Industrial Sector Savings Potential by Industry Segment by 2035



Most industrial conservation measures are complex and require considerable design and careful implementation. Many measures and practices need continuing management and operational attention to ensure continued savings. Support from the plant's employees, owners and management is also critical. Implementation strategies will need to continue to take these factors into consideration in order to achieve the industrial conservation potential.

Major and New Industrial Measures

The industrial sector measure categories and methodologies in the Seventh Power Plan are the same as those in the Sixth Power Plan. Significant updates were made based on achievements since the Sixth Power Plan, as well as new data and information obtained through the Industrial Facility Site Assessment. These data sources served primarily to adjust the end-use shares and remaining potential of the measures.

The Seventh Power Plan lighting measures are now based on LED technology similar to the residential and commercial sectors. Significant advances in high-bay lighting, for example, are included in the lighting potential.

Industrial Sector Summary

Table 12 - 4 provides a summary of the industrial measure bundles maximum achievable technical potential energy savings at years 2021, 2026, and 2035 and TRC net levelized costs. The TRC net levelized costs are the weighted average cost (weighted by maximum achievable technical savings potential). Also included are the minimum and maximum levelized costs for the measures within each bundle.

Table 12 - 4: Summary of Potential and Cost for Industrial Measure Bundles

Measure Bundle	Maximum Achievable Technical Potential (aMW)			TRC Net Levelized Cost ($/MWh)		
	2021	2026	2035	Weighted Average	Min	Max
Pumps	42	74	81	16	(16)	46
Fans	26	54	60	25	13	38
Energy Project Management	37	79	87	44	44	44
Integrated Plant Energy Management	23	42	77	(1)	(1)	(1)
Lighting	37	48	52	39	16	147
Plant Energy Management	27	38	41	26	26	26
Food Processing	9	12	14	47	47	47
Food Storage	43	61	67	33	27	43
Compressed Air	12	16	18	17	3	32
Material Handling	12	27	30	50	43	76
Hi-Tech	8	13	15	(39)	(76)	44
Pulp	3	5	8	14	5	43
Paper	4	6	12	60	23	184
Wood	8	17	19	(64)	(68)	25
Metals	0.1	0.1	0.2	(2,054)	(2,054)	(2,054)
Grand Total	290	493	580	22		

Agriculture Sector

The potential in the agriculture sector is primarily from improvements in irrigation, but also includes dairy farm measures and LED barn lighting.

Resource Type

All of the potential in the agriculture sector is treated as retrofit, except for scientific irrigation scheduling. Since irrigation scheduling measures require annual re-engagement by the farmer, the potential exists anew every year.

Comparison to Sixth Power Plan

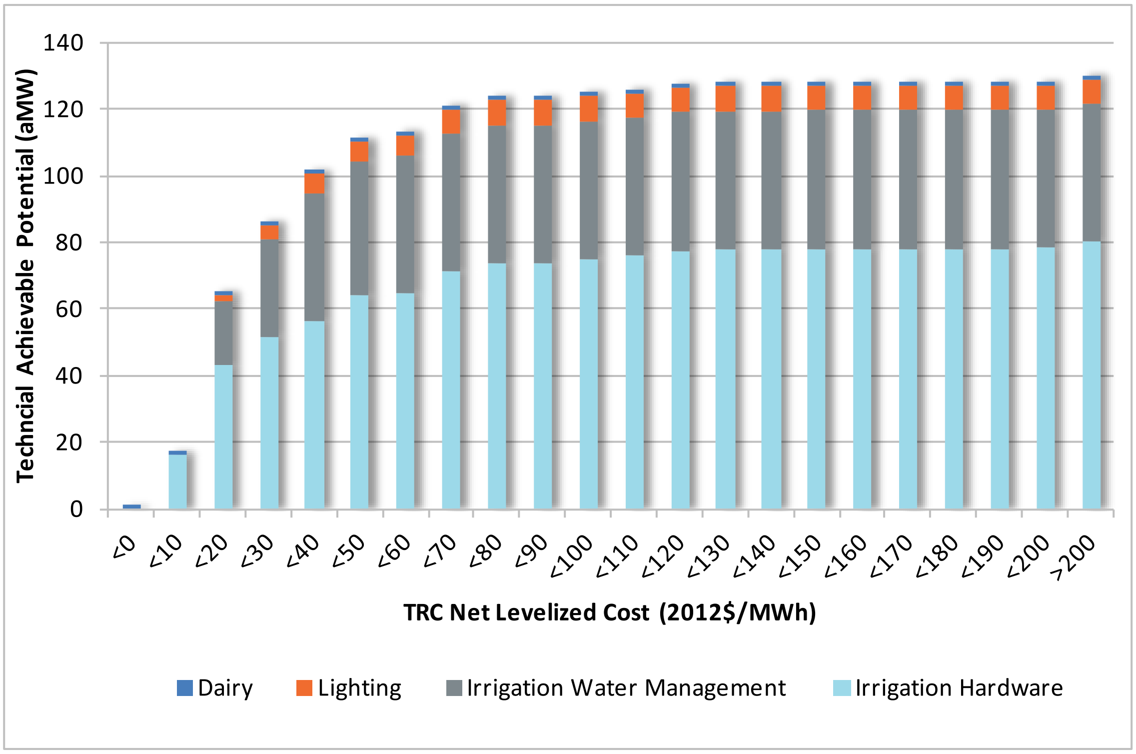
The Sixth Power Plan identified approximately 100 average megawatts of conservation potential in the region. The Seventh Power Plan is slightly higher at 130 average megawatts. The increase in potential is primarily due to an approximately 35 percent increase[25] in the number of acres of land irrigated by pressurized sprinkler systems and the addition of two new measures: barn area lighting and low-elevation spray applications (LESA).

Savings by End-use

The potential across the four major end-uses are provided in Figure 12 - 13, by TRC net levelized cost. Irrigation hardware continues to have the most savings potential (80 average megawatts), followed by irrigation water management (LESA and scientific irrigation systems [SIS]), at 41 average megawatts. The dairy savings potential is decreased from 10 average megawatts in the Sixth Power Plan, to just over 1 average megawatt in the Seventh Power Plan. The decrease in savings potential is caused by the adoption of many of the measures identified in the Sixth Power Plan as common practice. Lighting comprises the remainder at 7 average megawatts.

[25] The Sixth Power Plan relied on 2003 Farm and Ranch Irrigation Survey (FRIS), while the Seventh Power Plan relies on the 2013 FRIS.

Figure 12 - 13: Agriculture Potential by End-use and Levelized Cost by 2035



Major and New Agricultural Measures

Improvements in irrigation hardware are the largest source of agricultural savings potential in the Seventh Power Plan. This category includes: converting high/medium pressure center pivot systems to low pressure systems, converting wheel or hand-line systems to low pressure center systems on alfalfa acreage, and replacing worn or leaking hardware. Nearly half of the irrigation water management savings are anticipated from the new low-energy spray application measure. This measure converts a center pivot system into an ultra-low pressure (<10 pounds per square inch) system where the nozzles are 12 to 18 inches above the ground. Pilot testing indicates significant savings can be achieved.

The dairy measures include: installing variable frequency drives on milking machines, plate milk pre-coolers, heat recovery ventilation, and energy-efficient lighting. As many dairy farms have converted to large-scale farms (particularly in Idaho), most have already adopted many of these measures and thus limited potential savings remain.

Agricultural Sector Summary

Table 12 - 5 provides a summary of the agricultural measure bundles' maximum achievable technical potential energy savings at years 2021, 2026, and 2035 and TRC net levelized costs. The TRC net levelized costs are the weighted average cost (weighted by maximum achievable technical savings potential). Also included are the minimum and maximum levelized costs for the measures within each bundle.

Table 12 - 5: Summary of Potential and Cost for Agriculture Measure Bundles

Measure Bundle	Maximum Achievable Technical Potential (aMW)			TRC Net Levelized Cost ($/MWh)		
	2021	2026	2035	Weighted Average	Min	Max
Irrigation	59	89	118	33		
Irrigation Hardware	34	48	53	36	4	1,271
Irrigation Pressure	2	10	24	36	9	204
Irrigation Water Management	22	22	22	33	24	100
Irrigation Efficiency	2	8	19	19	19	19
Lighting	2	3	3	(25)		
Dairy	0.1	0.3	0.3	5	(8)	5
Lighting	5	7	7	33	14	68
Motors/Drives	2	3	3	27		
Dairy	0.0	0.1	0.1	(6)	(8)	5
Irrigation Motor	2	3	3	28	24	31
Refrigeration	0.3	0.7	0.8	(6)		
Dairy	0.3	0.7	0.8	(6)	(8)	5
Grand Total	**67**	**99**	**130**	**32**		

Utility Distribution Systems

The utility distribution system conservation potential is based on regulating voltage on distribution lines within closer tolerances and thus minimizing system and end-use losses. Both energy and capacity savings are produced by measures typically referred to as conservation voltage regulation (CVR). The measures also include upgrading components of utility systems where losses can be reduced. The distribution system efficiency potential consists of four measures identified by a 2007 study conducted on behalf of NEEA[26] and developed for the Sixth Power Plan. Savings occur on both the utility- and the customer- side of the meter. Customer-side savings are typically greater and are dependent on the mix of inductive and resistive loads of the equipment in homes and businesses. Performing system improvements such as phase load balancing and reactive power management is the largest contributor to energy savings on the utility side of the meter. Four measures are used to estimate the range of costs and savings available from optimizing distribution systems for energy efficiency.

1. Lowering the distribution voltage level only using the line drop compensation voltage control method.
2. System improvements including reactive power management, phase load balancing, and feeder load balancing using either line drop compensation or end-of-line voltage control methods.
3. Voltage regulators on 1 of every 4 substations and select reconductoring on 1 of every 2 substations.
4. Lowering the distribution voltage level using the end-of-line voltage control method.

The measures differ with respect to the techniques used to manage voltage and other system electrical characteristics to maximize efficiency. Line drop compensation uses a controller at the substation to lower and raise the feeder bus voltage based on the real and reactive power flowing into the source of the feeder. Using line drop compensation along with system improvements will capture the majority of the potential energy savings at a fairly low cost. However, because this method uses calculations to determine the end-of-line voltage as compared to actual metered data, additional safety margins are necessary to make sure the voltage levels are above the minimum criteria. Because of this, the voltage level is above the minimum required and not all of the potential energy savings can be achieved.

End-of-line voltage feedback control systems will achieve the maximum energy savings. This type of voltage control measures the end-of-line voltage level of the distribution system and can keep the feeder voltage level at the minimum criteria at all load levels and does not require the same margin of safety as compared to the line drop compensation voltage control method. However, the cost of the implementing, maintaining, and operating an end-of-line system is higher.

---

[26] Leidos (formerly RW Beck). (2007). *Distribution Efficiency Initiative*.

Other measures to improve efficiency of distribution systems exist, but were not analyzed in the Seventh Power Plan. For example, the deployment of automated metering infrastructure systems may provide for accomplishing the above measures less expensively and more efficiently.

The overall distribution system potential in the Seventh Power Plan is 215 average megawatts, all of it available at cost less than $100 per megawatt-hour.

Resource Type

The distribution system efficiency measures are all classified as retrofit.

Comparison to Sixth Power Plan

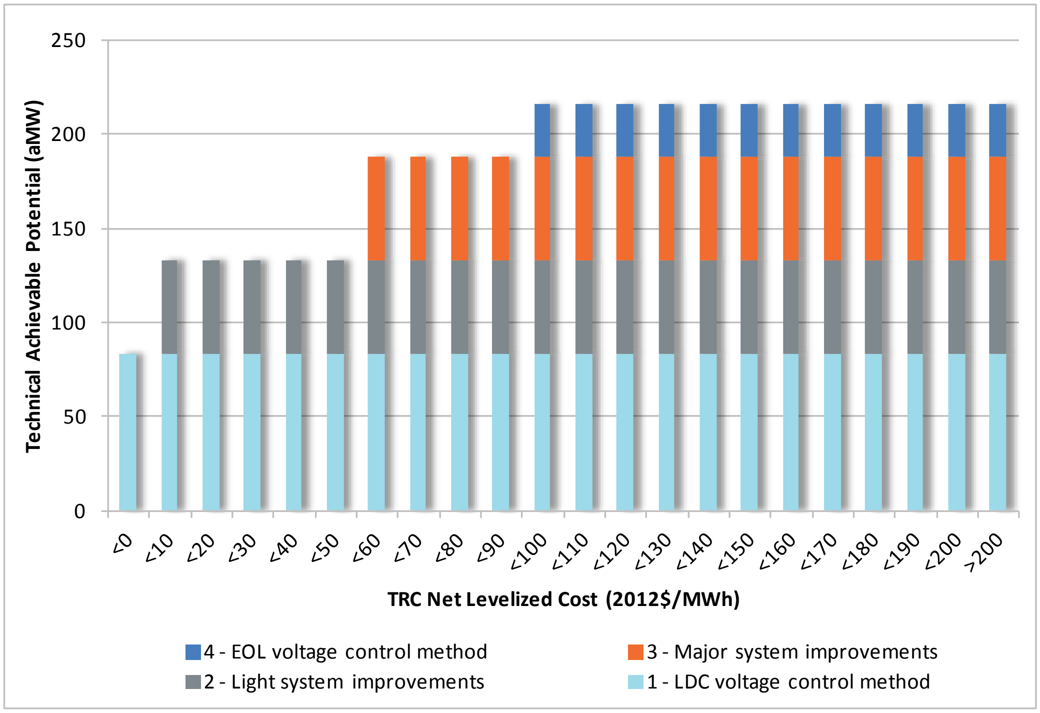
The Sixth Power Plan included 400 average megawatts of distribution system conservation potential, compared to the Seventh Power Plan potential of 215 average megawatts. The reductions in potential compared to the Sixth Power Plan are based on several factors. Some projects identified in the Sixth Power Plan have been completed. Utility experience implementing CVR since 2009 has provided information to adjust the potential, federal standards requiring more efficiency transformers have helped reduce distribution system losses and an overall lower load forecast changes the amount of electricity passing along lines. Nonetheless, significant savings potential remains.

Distribution systems savings measures are complex and require significant system engineering and analysis. The measures are not typically deployed by utility conservation departments that deliver programs to customers. Instead the measures are often part of utility distribution system maintenance and expansion efforts. Finding viable mechanisms within utilities to identify and capture these savings continues to be a challenge.

Savings by Measure

The distribution system efficiency supply curve is shown in Figure 12 - 14.

Figure 12 - 14: Distribution System Potential by Measure and Levelized Cost by 2035



Major and New Distribution System Measures

The measure with the largest distribution system savings potential and lowest cost is the line-drop compensation voltage control measure.

Utility Distribution System Sector Summary

Table 12 - 6 provides a summary of the utility measure bundles' maximum achievable technical potential energy savings at years 2021, 2026, and 2035 and TRC net levelized costs. The TRC net levelized costs are the weighted average cost (weighted by maximum achievable technical savings potential). Also included are the minimum and maximum levelized costs for the measures within each bundle.

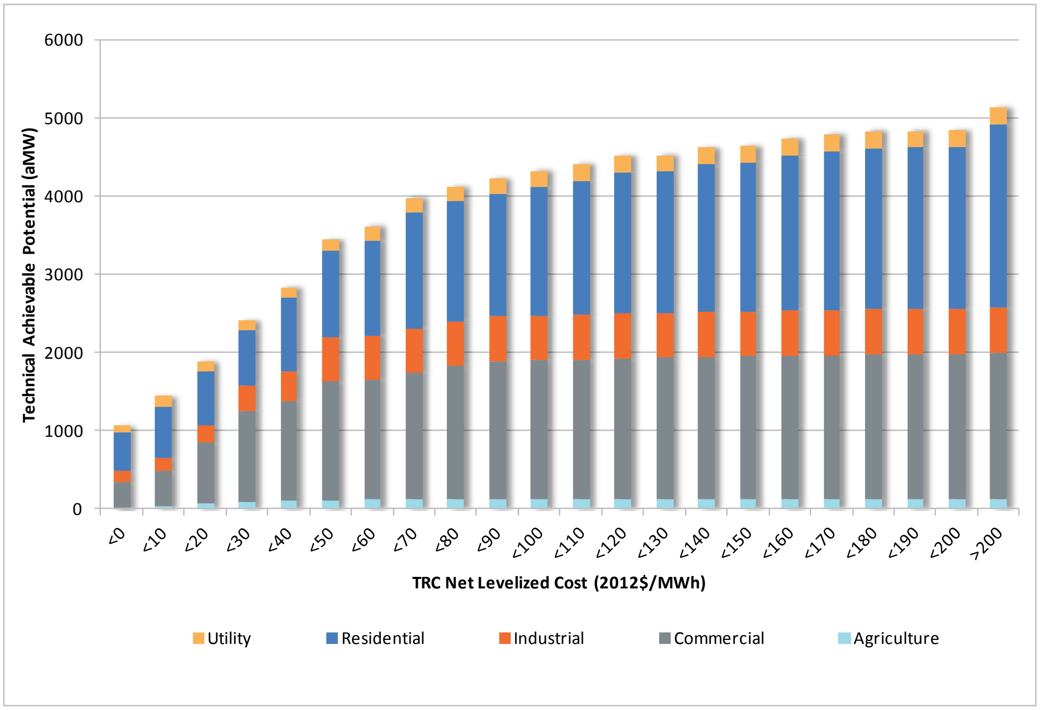
Table 12 - 6: Summary of Potential and Cost for Utility Measure Bundles

Measure Bundle	Maximum Achievable Technical Potential (aMW)			TRC Net Levelized Cost ($/MWh)		
	2021	2026	2035	Weighted Average	Min	Max
1 - LDC voltage control method	12	34	83	(2)	(2)	(2)
2 - Light system improvements	7	20	50	3	3	3
3 - Major system improvements	8	22	55	60	60	60
4 - EOL voltage control method	4	11	28	96	96	96
A - SCL implement EOL w/ major system improvements	0.3	1	2	320	320	320
Grand Total	**33**	**89**	**218**	30	-	-

Total Conservation Potential- All Sectors

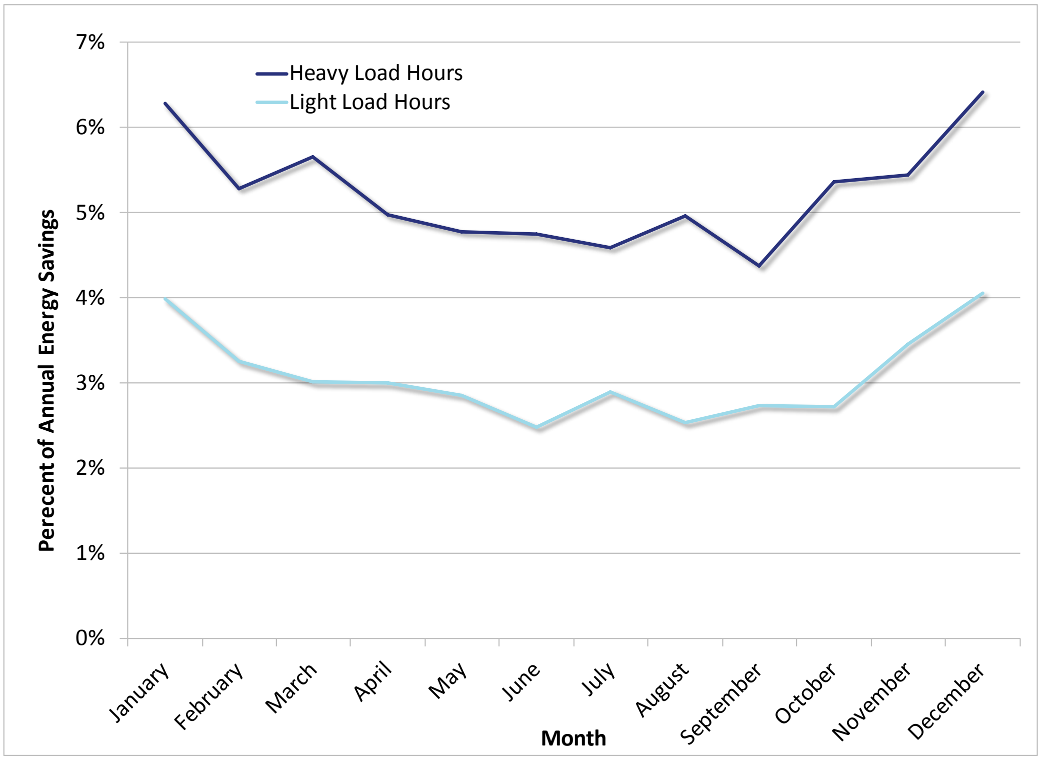
Figure 12 - 15 shows the Seventh Power Plan's estimate of the amount of conservation available by sector and TRC net levelized cost by 2035. The Council identified nearly 4,300 average megawatts of technically achievable conservation potential in the medium demand forecast by the end of the forecast period at a TRC net levelized life-cycle cost of up to $100 per megawatt-hour (2012 dollars). Slightly more than half of the potential is from lost-opportunity measures. Given the uncertainty in the demand forecast, the conservation potential has an associated uncertainty range. The Council determined, based on the range in the load forecast, that if loads were to increase or decrease by 100 percent, the potential would increase or decrease by 62 percent (an elasticity of 0.62).

Figure 12 - 15: Cumulative Potential by Sector and Levelized Cost by 2035



This energy savings potential also has a capacity benefit, the magnitude of which depends on the shape of the savings. The shape of the savings for all measures during heavy and light load hours is provided in Figure 12 - 16. As is shown, the energy savings are greater during the winter season than summer, in large part due to significant savings from conversion of electric resistance heating to more efficient heat pump technologies and increased use of lighting during the winter period.

Figure 12 - 16: Monthly Savings Shape for All Conservation Measures during Heavy and Light Load Hours



The Council estimates the technically achievable potential by 2035 is approximately 9,700 megawatts of capacity savings during the region's peak winter hour (6pm on a weekday in December, January, and February) and over 6,600 megawatts of savings during the peak summer hour (6pm on a weekday in July and August). By 2026, if all available conservation were deployed, there would be 3,300 average megawatts of energy savings; the winter peak capacity savings potential would be nearly 6,200 megawatts and summer is nearly 4,000 megawatts.

CONSERVATION SCENARIOS MODELED

The Council tested two scenarios in which the conservation inputs were modified. These scenarios include:

- Varying the annual pace of conservation by including accelerated and decelerated paces, and,
- Reviewing emerging technologies above and beyond those already considered in the supply curves, including distributed photovoltaics.

The inputs and rational behind these scenarios are discussed below. The results of these sensitivity tests within the RPM are discussed in Chapter 3.

Conservation Scenario 1: Testing Annual Pace Constraints[27]

Because the maximum annual pace of conservation achievement is to a major extent a function of the level of resources dedicated to acquiring conservation, the Council performed sensitivity tests to estimate the impact of achieving conservation faster and slower than assumed in the base case. For this scenario, the Council held total savings nearly constant at 2035 so that only the pace of conservation would impact the present value of system costs.[28] For the high-case sensitivity, the Council assumed individual program ramp rates were accelerated in early years and decelerated in later years. The resulting maximum cumulative achievable potential was about 20 percent more by year five (2020) than the base case. This means a maximum of 1,560 average megawatts of conservation within the first five years, or an average pace of about 310 average megawatts per year across all cost bins. A similar approach was taken for the low-case sensitivity, but in reverse, with program ramp rates slower in early years and higher in later years. The resulting maximum cumulative achievable potential is about 20 percent lower by year five compared to the base case. This results in a maximum of about 1,020 average megawatts that could be developed in the first five years of the plan, or on average about 200 average megawatts per year across all price bins. Figure 12 - 17 shows the total conservation available for the three scenarios over the 20 years of the plan period. Figure 12 - 18 provides the details over the first six years.

[27] These scenarios (**Faster Pace of Conservation** and **Lower Pace of Conservation**) were only analyzed for the draft Seventh Power Plan, so updates to the supply curve inputs between draft and final are not reflected in this section. However, Appendix O describes the draft plan results for these two scenarios.
[28] The 20-year potential is not exactly constant due to rounding assumptions as well as the interplay between ramp rates and turn-over rates for lost-opportunity measures.

Figure 12 - 17: Comparison of Maximum Conservation Available For Pace Scenarios over Plan Period

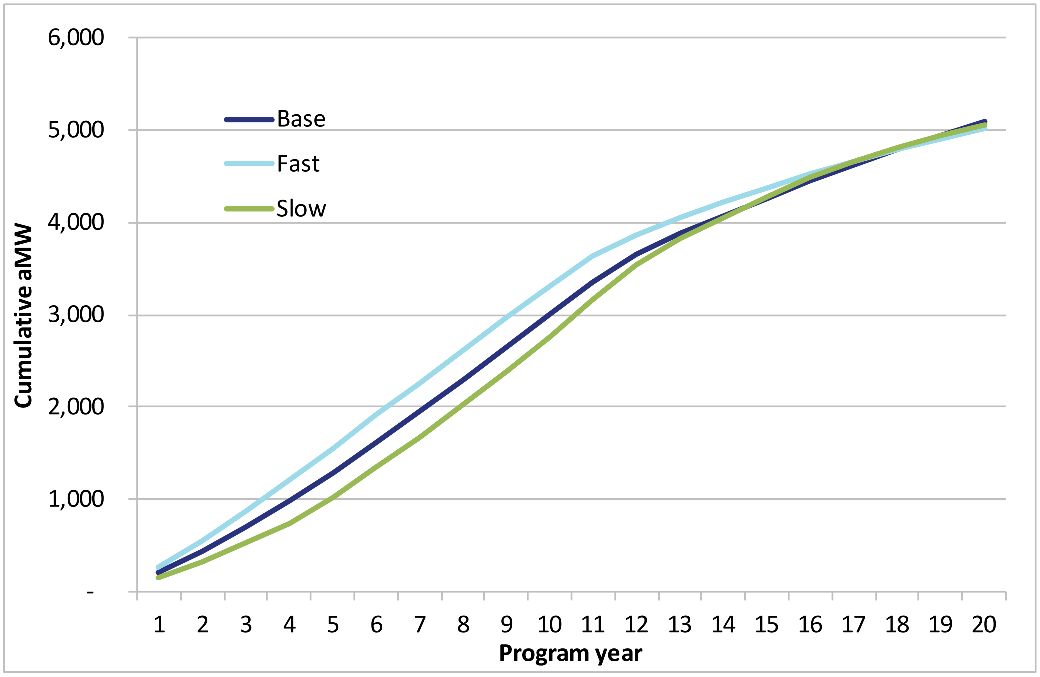
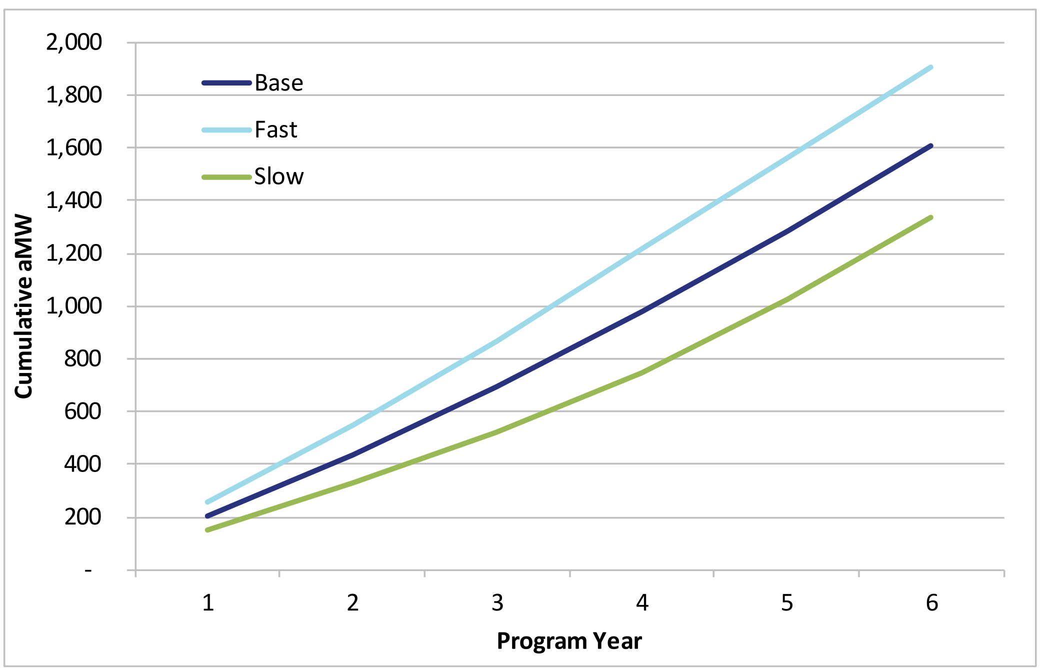


Figure 12 - 18: Comparison of Maximum Conservation Available for Pace Scenarios during First Six years of Plan



Conservation Scenario 2: Testing Emerging Technologies' Deployment Assumptions

Another scenario was tested to estimate the potential impact of emerging technologies on future resource needs. These emerging technologies are beyond what the Council includes in its standard supply curves. Within the standard set of supply curves, all measures and resources, under the Act, need to be "forecast to be reliable and available within the time it is needed".[29] As such, only those technologies that are currently available and accepted in the marketplace are included in the supply curves as resources that can be counted on to provide energy and capacity reductions. The standard supply curves include some measures considered "emerging" that are commercially available, but that have current low market penetration, for example variable refrigerant flow HVAC systems and, heat pump water heaters.

For the Seventh Power Plan, the Council also looked at technologies that are not yet commercially available, or not available at reasonable cost, but which may become available at reasonable cost within 5 to 10 years and thus could influence resource decisions in the near term. For the emerging technologies scenario, the Council estimated the cost and savings potential from these measures in 2025 and 2030. These technologies, and the associated potential energy and capacity savings, are above and beyond the most efficient measures already included within the supply curves. In addition, the Council considered two behind-the-meter generation options: combined heat and power and distributed solar photovoltaics (PV).[30] Combined heat and power is discussed in the Generation Resources Chapter 13, PV is discussed below.

To develop these estimates, the Council considered research and analysis done by others including the national laboratories, Electric Power Research Institute, U.S. Department of Energy, Washington State University Energy Program, Bonneville staff, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, manufacturers, and expert judgment. Estimates from these sources were calibrated and scaled to Pacific Northwest applications and stock estimates. The results are summarized in Table 12 - 7 below. The peak impacts presented are for winter. These measures also provide summer peaking impacts, particularly evaporative coolers and distributed PV.

[29] Northwest Power Act 839a(4)(A)(i)
[30] Distributed PV is also included as a potential resource in other scenarios; see Chapter 15.

Table 12 - 7: Emerging Conservation Technologies

Emerging Technology	2025			2030			Required Conditions
	aMW	MW (winter)	TRC Net Lev Cost ($/MWh)	aMW	MW (winter)	TRC Net Lev Cost ($/MWh)	
Additional Advances in Solid-State Lighting	200	400	$0-$30	400	800	$0-$30	Continued tech improvement, resource availability
CO_2 Heat Pump Water Heater	110	200	$100-150	160	300	$90-140	UL approval; U.S. market development
CO_2 Heat Pump (space heat)	50	160	$130-170	130	350	$110-160	Best suited for hydronic heating, need research and development (R&D) for U.S. applications
Highly Insulated Dynamic Windows - Commercial	20	130	$500+	35	200	$300	Intensive R&D effort needed to bring down cost; slow ramp due to window replacement schedule
Highly Insulated Dynamic Windows - Residential	80	230	$500+	120	350	$400	
HVAC Controls – Optimized Controls	140	230	$90-120	200	350	$80-110	Significant developments expected in next 5 years
Evaporative Cooling	50	0*	$100-130	80	0*	$90-120	Need R&D on configurations & applications in PNW
Distributed Photovoltaics	800-1400	0*	$70-280	2200-4000	0*	$60-250	High penetration may require additional integration costs and distribution system upgrades

* These measures provide non-zero summer peak impacts.

From this table, the measures that are likely to have the most significant impact are solid-state lighting, combined heat and power, and CO_2 heat pump water heaters. Solid-state lighting is currently commercially available and included in the supply curves. The emerging technology scenario assumes significant (20-100 percent, depending on application) increases in efficacy over what is already within the plan at a very low cost. The increase in efficacy assumption and the cost forecasts are based on U.S. Department of Energy work that considered detailed examination of potential technological gains along with industry trends incorporating new developments.[31] Except for a portion of combined heat and power (covered in the generation resources Chapter 13), no other emerging technology measures are expected to be low cost in the timeframe of the next decade when they would have the most impact on resource decisions.

Most other emerging technologies have expected costs of about $100 per megawatt-hour or greater. Although CO_2 heat pump water heaters have been available in other markets (e.g. Japan, Europe), they are only starting to enter the U.S. market. Currently, there are a few pilot projects being performed within the region, with promising results. These units can serve both hot water and space heat needs, if coupled with a hydronic heating system. Depending on the products introduced, the CO_2 heat pump water heaters are likely to be about 50 percent more efficient than current heat pump water heater technologies.

Other technologies considered include dynamic and highly insulated windows for both commercial and residential applications. These windows provide less heat loss due to higher insulating value, and also change the solar heat gain coefficient (SHGC) depending on the amount of sunlight. The SHGC will decrease during sunny, warm days, blocking solar energy from entering the building and thus reducing cooling loads. During cloudy, cool days, more solar energy enters the building, lowering heating loads. Currently, these windows are expensive to produce and will require significant cost declines to be commercially competitive.

Over the next five to 10 years, improved controls are likely to become a major influence in energy use. Better controls will lead to lower energy use. For this scenario, the Council focused on improved HVAC controls. This market is rapidly evolving, and the deployment of these controls and their impact will be better understood after five or so years.

The final emerging conservation measure considered is evaporative coolers, in which air is cooled through the evaporation of water instead of traditional vapor-compression or absorption refrigeration cycles. These units have traditionally been used in hot and dry climates (where water quickly evaporates), and they have not garnered significant market penetration in the Pacific Northwest. As such, research is needed to better understand their applicability and likely savings within this region. Areas east of the Cascade Mountains are prime targets for evaporative cooling systems.

[31] U.S. DOE Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, August 2014.

Direct Application Renewables

In addition to the conservation resources, direct-application renewables (DARs) beyond that already reflected in the frozen efficiency load forecast are also considered as potential resources.[32] DARs are consumer-owned renewable resources used to meet on-site load requirements. The Council included two DAR resources in the Seventh Power Plan: solar water heaters and distributed solar photovoltaics (PV). Solar water heaters are included in the residential conservation supply curves, distributed PV is treated separately. These resources are treated similarly to conservation in the RPM, though DARs do not include the 10 percent Regional Act credit.

Distributed Solar Photovoltaics

In addition, the Council considered the potential from distributed solar PV panels, which can be mounted on the rooftop of a house, or commercial building or other structure to provide on-site electricity and also send power to the grid. While distributed PV technology is technically a generation technology, when deployed as a rooftop application it typically reduces site electricity consumption more than it adds to grid generation, thus making it appear much like a conservation measure. These distributed PV systems are considered in the Council's conservation emerging technology analysis because of uncertainty about the pace and magnitude of the changes in the costs and performance.

Like utility scale solar, residential and commercial distributed PV installations across the U.S. are growing. According to the U.S. Energy Information Administration, rooftop solar electricity production grew an average of 21 percent per year from 2005 through 2012. In the Northwest region, as of 2012, there are over 10,000 utility customers with installations that were selling a small amount of power back to the grid (net metering). Third party leasing became a more popular option than customer-owned systems in 2012 and it now accounts for about two-thirds of annual rooftop installations.

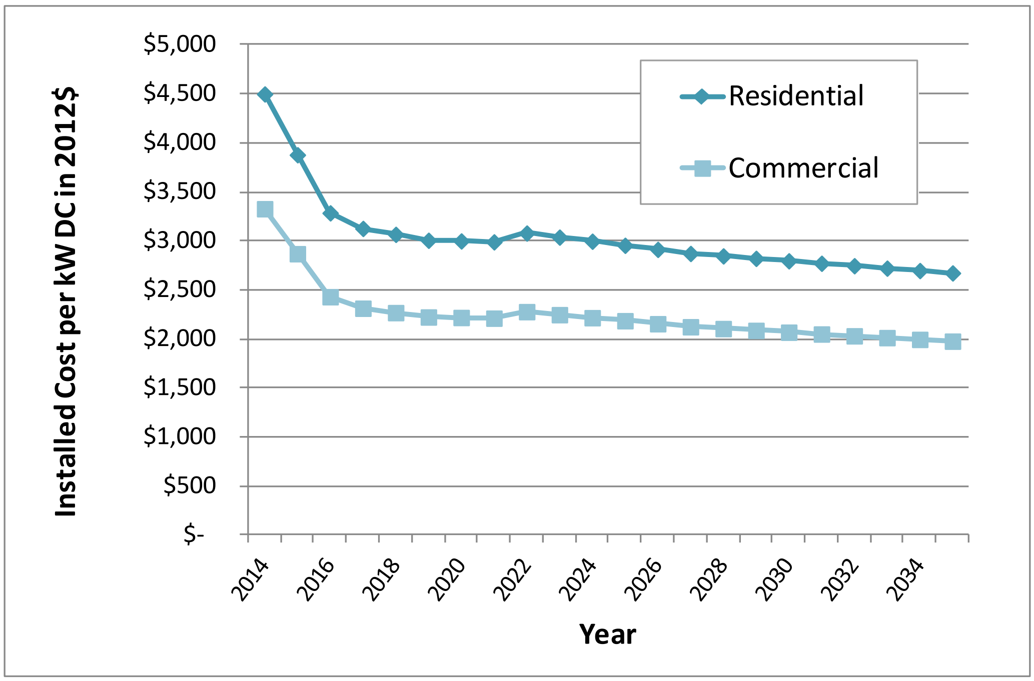
Typical residential and commercial-sized installations are used to estimate costs for distributed PV. Like utility-scale solar, a wide range of values for the TRC net levelized cost of energy can result for distributed PV depending on the location, orientation, sizing, financing model, and availability of tax credits. The Council modeled four configurations. These are divided into residential and commercial-sized applications to reflect economy of scale available in larger commercial applications. Estimates are also produced for east and west of the Cascades Mountains to account for variant insolation levels, which impact cost of energy generated. PV cost and sizing parameters are based on recent

[32] The Council's frozen efficiency (i.e., pre-conservation) load forecast includes consumer adoption of a specific amounts of distributed solar. By 2035, the Council forecast that 500 to 1,400 megawatts of solar PV systems will be installed in the region. On an annual basis, the energy generated from these distributed PV systems is forecast reduce regional loads by 80 to 220 average megawatts. In addition, these distributed solar PV systems also reduce winter and summer peak loads. Summer peak impacts from distributed solar PV are forecast to be lower by as much as 600 megawatts by 2035. See Appendix E for more details.

program data from Energy Trust of Oregon and include total installed cost and program administrative costs, marketing, and overhead.

Based on these data, the Council estimated the residential installed costs averaged $4,500 per kW_{DC} in 2014. Commercial costs are lower, $3,300 per kW_{DC}, due to economy of scale. Recent extension of the federal investment tax credit will reduce both residential and commercial costs through 2021. But underlying costs are expected to continue to drop for this emerging technology because of technology improvements and economy of scale. The Council forecasts distributed PV costs will fall by the same relative factor used for falling costs of utility-scale PV (see Chapter 13). Figure 12 - 19 shows that by 2025, costs are estimated to be about 66 percent of 2014 costs. Other key factors on costs and production are described below. The TRC net levelized cost for distributed solar PV falls in the range of $120 to $200 per megawatt-hour by 2025 depending on application and location. There is a wide band of uncertainty around these forecast cost estimates. More detail of solar PV costs is provided in Chapter 13. The upper and lower bounds of TRC net levelized costs, across all configurations, are provided in Table 12 - 7.

Figure 12 - 19: Cost Trend for Distributed Photovoltaics



Residential installation size for PV has been increasing over the last few years and is now up to 5.3 kilowatts per home.[33] Commercial installations show a wider range of sizes, but have tended to run in the 30 to 35 kilowatt size range on average. Distributed PV installations are assumed to have a 25 year lifetime, with an annual average degradation of 0.4 percent. The solar calculator PVWatts®[34] was used to estimate the expected annual capacity factor of 0.13 for west of the Cascades

[33] Energy Trust of Oregon program data.
[34] http://rredc.nrel.gov/solar/calculators/pvwatts/version1/change.html

(Portland) and 0.17 for east of the Cascades (Boise). Generally, residential PV installations produce enough electricity to supply about half of the annual electricity requirements of a typical residential home. Prime generation months occur from April through September when there may be excess generation available to deliver to the grid. But in winter in the Pacific Northwest, PV contributes a smaller share of site energy requirements because requirements increase and solar production decreases. In the Pacific Northwest, rooftop solar systems typically deliver about three times as much energy in summer months as they do in winter months. Peak capacity contribution of PV is negligible in winter, but increases to 26 to 35 percent of installed PV capacity in summer because there is more sunlight available during the system peak hour (6pm) in the summer.

Expected fixed operations and maintenance (O&M) costs include inverter replacements at 10 years for residential and 15 years for commercial installations, along with periodic cleaning of the modules. Distributed PV costs also include a cost of integrating solar energy into the grid based on Bonneville’s 2014 integration tariff. Converting DC power to AC power incurs losses for conversion, wiring, diodes and other factors. Total losses are estimated at 16 percent including inverter losses based on analysis by National Renewable Energy Lab in PVWatts. Financial parameters for development of distributed PV are based on the same parameters as residential conservation measures.[35]

Table 12 - 8: Distributed Solar PV Estimated Costs and Maximum Achievable Potential

	2025			2035		
Distributed Solar PV	Annual Energy (aMW)	Nameplate Capacity (MW_{DC})	TRC Net Lev Cost ($/MWh)	Annual Energy (aMW)	Nameplate Capacity (MW_{DC})	TRC Net Lev Cost ($/MWh)
East of Cascades Residential	330	2000	$150	1000	6000	$130
East of Cascades Commercial	200	1200	$120	630	3800	$100
West of Cascades Residential	500	3800	$200	1470	11400	$180
West of Cascades Commercial	320	2400	$150	930	7100	$140
Total	1350	9400	$120-200	4000	28100	$100-180

There is a large amount of distributed PV that is available for deployment. Its contribution as an emerging technology is more limited by the pace at which it can be deployed, than by the total megawatts of capacity that could be developed. Distributed PV is typically installed on residential and commercial building rooftops, car ports, and other structures as a matter of convenience. But

[35] See Appendix G

applications are not limited to buildings. For example, a recent trend toward towards community-based solar PV projects has emerged with projects developed on under-used urban land.

The Council estimated the available PV by considering total area of residential and commercial roofs taken from the recent residential and commercial building stock assessments and forecast growth. Only a fraction of this roof area is eligible for solar systems. Limitations include roof orientation, shading, and obstruction factors, which exclude 75 percent of residential and 40 percent of commercial roof area. With these limits, total technical potential is in the range of 40,000 to 50,000 megawatts of capacity by 2035. A small fraction of that technical potential, about 5 percent, is forecast to be developed and is included as load reduction in the Council's demand forecast.[36] Not all remaining technical potential is achievable within the 20-year forecast period. Because of the high number of installations required and other barriers to adoption, this emerging technology resource would take time to build. The Council limited the maximum achievable technical potential based on analysis done by the National Renewable Energy Lab (NREL).[37] The NREL study considers cost, adoption rates, financing alternatives, material availability, manufacturing and installation capability and other factors to estimate ranges for the achievable pace of development. At the highest rate, total achievable potential for rooftop PV capacity reaches about 20 percent of technical potential by 2025 and 50 percent of technical potential by 2035. The Council used the NREL high ranges to estimate the maximum total remaining potential in Table 12 - 8.

STATE OF WASHINGTON'S ENERGY INDEPENDENCE ACT IMPLICATIONS

The Energy Independence Act, or Initiative 937 (I-937) in the state of Washington, approved by the voters in 2006, obligates any Washington utility with more than 25,000 customers to "pursue all available conservation that is cost-effective, reliable, and feasible."[38] The law requires these utilities to develop and implement 10-year conservation plans that identify the "achievable cost-effective [conservation] potential". Every two years, each utility must review and update its assessment of conservation potential for the subsequent 10-year period. At the end of each two-year cycle, the utility's target and achievement are reviewed by a regulator or auditor.

Washington's Energy Independence Act and the Northwest Power Act intersect in that the state's utilities are to engage in conservation planning "using methodologies consistent with those used by the Pacific Northwest Power and Conservation Council in its most recently published regional power plan". The Council's conservation planning methodology is described in this chapter and in Appendix G. The Washington Department of Commerce has adopted a rule summarizing 15 elements of the

[36] See Chapter 7 and Appendix E
[37] Easan Drury, Paul Denholm, and Robert Margolis, *Sensitivity of Rooftop PV Projections in the SunShot Vision Study to Market Assumptions*, Technical Report NREL/TP-6A20-54620, January 2013
[38] Section 19.285.040(1) of Revised Code of Washington

Council methodology used in the Sixth Power Plan.[39] Each utility is required to develop a conservation potential using data specific to its own customers and service area.

The two mandates (Washington's Energy Independence Act and the Northwest Power Act) are legally distinct. The Energy Independence Act is a matter of state law, and does not alter or obligate the Council in its conservation and power planning under the Northwest Power Act. Similarly, the Council has no authority to interpret, apply or implement the Energy Independence Act for the utilities and regulators in the state of Washington.

[39] WAC 194-37-070(5). After I-937 was enacted, Washington initially adopted a rule allowing utilities to set targets based on proportionate share of regional potential, but this rule was amended in 2014 to require utility-specific assessment using Council methodologies.