# Technical Appendix H:
# Conservation Methodology and Potential

## Contents

# Introduction

The Northwest Power Act requires that conservation (or energy efficiency[1]) be defined as a resource: *"Resource" means –*

1. *electric power, including the actual or planned electric power capability of generating facilities, or*
2. *actual or planned load reduction resulting from direct application of a renewable energy resource by a consumer, or from a conservation measure*[2]

As the Council makes decisions about future resources, it can compare conservation measures and bundles to other available resources, including generating resources, to determine the best resource solutions for the region. Energy conservation reduces demand and can displace the need for new generating resources.

For context, the high-level methodology for estimating the conservation resource is illustrated in Figure H - 1. The first part, "Develop Supply Curves," describes the Council's process for defining the conservation resource so it can be compared with other generating resources and demand-side resources. The development of these supply curves is the subject of the remainder of this appendix. These supply curves are used along with myriads of other parameters, such as generating resource definitions, load forecasts, market conditions, etc. and serve as inputs to the Council's optimization models. The Council considers results from these models and other analysis to develop a resource strategy for the region. A part of this strategy is the cost-effective conservation target. The conservation target, or "economic potential" is described in Technical Appendix O **-** Cost-Effective Conservation Methodology and Results.

[1] The Council uses the terms "conservation" and "energy efficiency" interchangeably; they both refer to conservation as defined by the Northwest Power Act.

Northwest Power Act, Section 3(19)(A) and (B)

**Figure H - 1: Process for Developing the Conservation Resource**


Supply Curve Development methodology covered in the remainder of this Appendix.

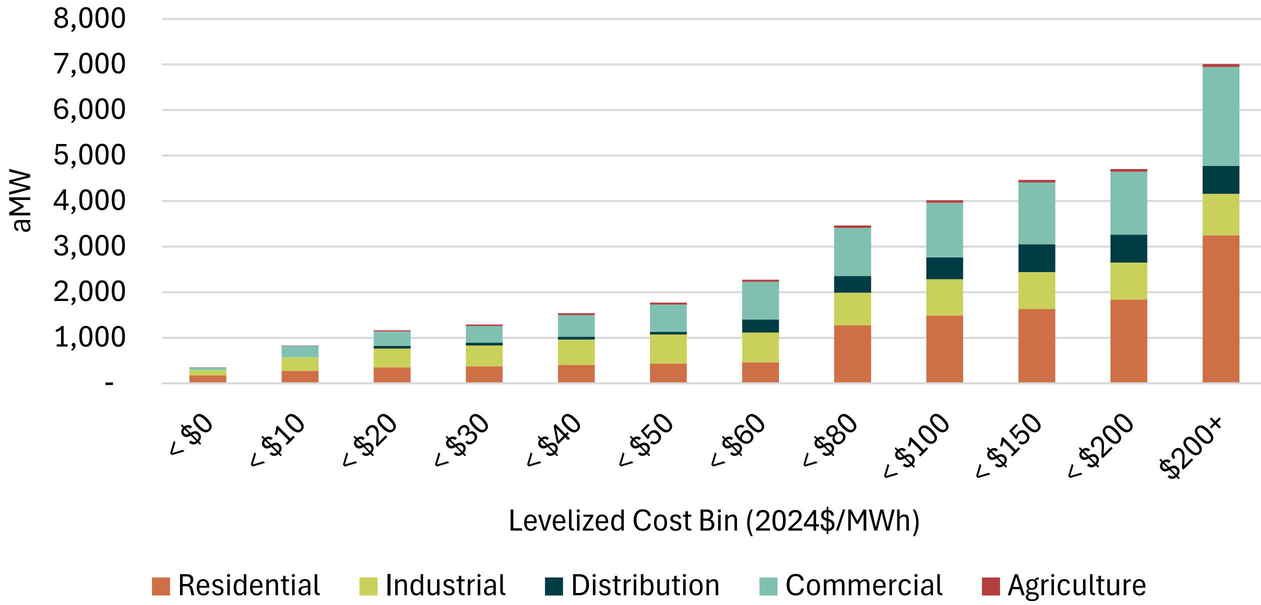
Covered in Appendix O – Cost-Effective Conservation Methodology and Results

# Conservation Supply Curve

Defining the conservation resource requires the compilation of thousands of individual measure applications and bundling them into a format that can be provided to the Council's capital expansion model, OptGen. The measures are compiled into a resource "supply curve." The supply curve groups conservation measures together into levelized cost bins as shown in Figure H - 2. The supply curve in the figure shows all conservation available through 2046, differentiated by sector and by cost bin, for the majority of the Ninth Power Plan analyses. Additional versions of the supply curve used for certain scenarios and load futures are discussed later in the appendix.

Figure H - 2 shows a total of approximately 7,000 average megawatts of achievable conservation potential, as illustrated by the last bar in the far right of the figure. Note that the potential in this chart is cumulative, meaning that each levelized cost bin (e.g., <$40) includes all the potential from the lower cost bins. For example, the chart shows that there is just over 1,000 aMW of conservation potential available for less than $20/MWh. At $80/MWh, the potential jumps to over 3,200 aMW, and the total 7,000 aMW is available with all cost bins included.

**Figure H - 2: Conservation Supply Curve**




The Council uses levelized costs to compare conservation resources to supply-side resources. The Council uses the Northwest total Resource net levelized Cost (NRC) for its analysis of the cost of conservation measures.[3] This includes all the costs and benefits to reflect the full cost of the measure, regardless of who is paying the costs, as consistent with the definition of system cost in the Northwest Power Act (Section 3(4)(B)). ProCost[4] is the tool the Council uses to calculate the NRC for conservation measures. The levelized cost components are described in detail later in this appendix.

The Ninth Plan conservation supply curves include a wide diversity of both existing and emerging technologies. Existing technologies are available immediately in the Council's planning model, while emerging technologies are available later in the planning period.

The remainder of this appendix provides the detailed methodology for developing the conservation supply curves for the Ninth Plan, provided in four primary parts:

- Developing Conservation Measures
- Calculating Technical Achievable Potential

[3] Note: The Council formerly used the term "total resource cost (TRC)" instead of NRC and updated to avoid confusion with other usages of TRC that are not consistent with the Act.
[4] The ProCost tool was developed to characterize the costs and benefits of conservations measures and programs and produce levelized costs and benefit cost ratios. It is used by the Council to develop the conservation supply curves, and by the Regional Technical Forum to evaluate cost-effectiveness relative to the plan findings. https://rtf.nwcouncil.org/work-products/supporting-documents/procost.

- Bundling Conservation for OptGen
- Adjusting for Load Futures and Scenarios

# Developing Conservation Measures

## Measure Definition

A conservation “measure” is any device or method that results in electricity savings compared to its baseline. For example, a heat pump will conserve, or reduce, electricity compared with a baseline electric furnace, or adding insulation to a previously uninsulated attic will reduce heating and cooling energy requirements. The Power Act (the “Act”) defines conservation as “any reduction in electric power consumption as a result of increases in the efficiency of energy use, production, or distribution.”[5] For a measure to constitute conservation under the Act, it must meet both parts of the definition. That is, the measure must reduce electric power consumption, and the reduced consumption must result from an increase in the efficiency of energy use, production, or distribution. A measure that does just one or the other – for example, reduce electricity consumption but not through an efficiency increase – does not qualify as conservation under the Act. For example, turning your thermostat down on cold winter days and wearing more layers of clothing to keep warm is not conservation. It is reducing electricity consumption, but not through a more efficient use of electricity.

The primary component of an efficiency measure is the annual electricity savings (in kilowatt-hours, or kWh) associated with the device or method. Cost and lifetime are two additional key components that define a measure. The measure cost may include a variety of components, including incremental capital costs and operations and maintenance (O&M) costs. All these costs along with some additional benefits are combined to ultimately produce a levelized cost of energy saved (in $/kWh). This section explains all these components.

## Measure Savings Estimates

Estimating or measuring the annual kWh savings is the foundational step in developing the supply curves. The starting point for many savings estimates is the Regional Technical Forum (RTF)[6]. Beyond the RTF, measures are identified from the range of measures currently in utility programs, regional programs (e.g., NEEA, Energy Trust of Oregon), federal government programs and standards (e.g., DOE, EPA), utility potential assessments, technical reference manuals (TRMs), emerging technology research, and input from local, regional, and national experts. Once the measures are identified,

[5] Northwest Power Act, Section 3(3).

[6] The RTF is a technical advisory committee to the Northwest Power and Conservation Council that develops standards to verify and evaluate conservation savings.

Council staff seek to identify reliable savings (and cost) data. Savings values are based on engineering estimates, metered data, survey results, laboratory test data, and evaluations from the operation of existing conservation programs.

Conservation measures are defined from three different baseline types: new construction, natural replacement, and retrofit. In the case of new construction, the stock available for the measure depends on the forecast for new additions (e.g., new homes). Natural replacement (or, “lost opportunity”) measures depend on the life of existing equipment and assumes the measure is applied at the end of its useful life. Retrofit measures can be installed at any time and the baseline is the on-site conditions. These opportunities are tracked separately over the course of the forecast period and limit the annual availability of conservation opportunities.

Savings values are estimated for each of the new construction, natural replacement, and retrofit baseline types. Measure savings are analyzed on an incremental basis relative to the baseline condition. Incremental measure savings can be different depending on the baseline type. For example, incremental savings of high-performance windows in a new construction application only include the additional savings of the windows compared to what would be required by code. In a retrofit application, the savings values are measured based on the incremental difference between the existing equipment and the new equipment.

For new construction and replacement equipment, baseline conditions are the more efficient of either: (1) the minimum applicable code or standard or (2) current practice, which is the average efficiency of all products sold in the market at the time of purchase. State building codes and federal and state standards for equipment are continually being updated. The baseline assumptions for codes and standards used in the Ninth Plan are those that were adopted by the end of 2023, but which may have effective dates that occur in the future. Both savings estimates and the demand forecast reflect the effective dates of adopted standards. If current practice is more efficient than code, then those assumptions are used. The baseline assumptions for each measure in the analysis are described in the measure workbooks.

# Costs of Conservation

## Measure Costs

Typically, the largest cost component of a conservation measure is the incremental capital cost. The incremental capital cost includes all upfront costs for purchasing and installing the measure. These incremental costs will be unique for each measure. For example, the cost of an efficient heat pump upgrade measure is typically the difference between the cost of the efficient heat pump minus the cost of the less efficient, current practice heat pump. Cost estimates are identified separately for each of the new construction, natural replacement, and retrofit baseline types. Incremental measure costs can be different depending on the baseline type. For example, incremental costs of high-performance windows in a new construction application only include the additional cost of the windows compared to what would be required by code (or current practice). In a retrofit application, the labor cost of removing and replacing the existing window is added to the cost, as this is a discretionary decision.

In addition to the incremental costs, the Council includes all other related costs associated with the measure. A measure may have on-going operations and maintenance (O&M) costs (or benefits) compared to the baseline. For example, a heat pump water heater has maintenance costs to clean filters and discharge condensate compared to an electric resistance water heater. The incremental capital and O&M costs are all assumed to be nominally constant throughout the planning horizon. There may also be other fuel costs, such as additional gas heating required when high-efficiency lighting (that produces less waste heat) is installed. Finally, other quantifiable non-energy costs are also included in the cost calculation if they can be sufficiently quantified and are consistent with the environmental methodology for quantifying directly attributable environmental costs and benefits, as defined by the Act. For example, an evaporative cooler might require significant water consumption and these associated water costs compared to a vapor-compression system would be included. Note that many of these other related costs could instead be benefits (negative costs). For more details on these costs (and benefits) see Technical Appendix A – Global Assumptions and Technical Appendix C - Methodology for Quantifiable Environmental Costs and Benefits.

The Council also includes a programmatic administration cost, or "admin cost". The admin cost is the overhead cost (labor) and other related expenses, such as marketing, that are part of executing a utility conservation program. In all prior plans, the admin cost was assumed to be 20 percent of the incremental capital cost. However, for the Ninth Plan, the Council commissioned a study[7] to determine if it could identify enough data to improve on this estimate. This study resulted in the admin costs by sector shown in Table H - 1. The admin costs shown in the table below are multiplied by the first-year annual energy savings of the measure, in kWh, to calculate the final admin cost in dollars.

**Table H - 1: Conservation Program Administration Costs by Sector**

| | |
|---|---|
| Residential | $0.16/kWh |
| Commercial | $0.13/kWh |
| Industrial | $0.06/kWh |
| Agriculture | $0.12/kWh |
| Utility System | $0.12/kWh |

Note that tax credits may also be included in the cost assumptions. In general, they would show up as a reduction to the capital cost.

[7] Presentation of findings to the Council's Conservation Resources Advisory Committee available here: https://nwcouncil.box.com/s/b2h5rmekbiyd0545kchzhjzv002nx528.

### Financial Assumptions

The present value cost of conservation is determined in part by who pays for it and how it is financed. The Council's Conservation Resources Advisory Committee (CRAC) was asked to provide recommendations on the anticipated "cost-sharing" between utilities and consumers. Council staff also developed estimates of the cost of capital and equity used to pay for conservation based on the mix of consumers in each of the major sectors. These cost shares and finance costs are applied to each cost source for each measure at the time they are incurred.

Utilities and other program operators typically offer incentives to customers (end-users) to purchase and install measures. The Ninth Plan assumes the utility pays 100 percent of the cost for conservation measures. This is a new assumption relative to previous power plans. In past plans, it was assumed that the customer always pays a portion of the cost. This assumption better reflects the treatment of conservation as a resource, since it is the utility that needs to purchase that resource.

The cost of capital varies among residential, commercial, and industrial customers. Financial life is the term over which a sponsor's share of capital cost is financed. However, for the Ninth Power Plan, all the costs for conservation are assumed to be paid for up front, so no financing is needed.

### Tax Credits

For some modeling scenarios and sensitivities analyzed in the Ninth Power Plan, federal tax credits are included for measures covered under the 2022 Inflation Reduction Act (IRA). Measures in the Ninth Plan that include these tax credits, for the appropriate sensitivities, include high efficiency heat pumps and weatherization.

As the future availability of tax credits is uncertain, these costs are included for some Ninth Plan scenarios and sensitivities but not all. Table H - 7 in the section Adjusting for Load Futures and Scenarios summarizes which sensitivities include these tax credits and which do not.

## Benefits of Conservation

The primary benefit of conservation is its annual electricity savings (kWh) that can be quantified and valued. However, there are other benefits that can be attributed broadly to all measures or in some cases to individual or groups of measures. This section describes these other benefits that are quantified and applied to conservation measures for the Ninth Plan. All the costs and benefits are ultimately included in the net levelized cost calculation described later in this section.

### Deferred Transmission and Distribution

The deferred transmission and distribution (T&D) capacity is estimated by the contribution of conservation on winter peak loads, defined as the average over the hours ending 8-9 am on a weekday in December, January, or February and, for summer peak loads, as the average over the hours ending

5-8 pm on a weekday in July and August[8]. By reducing the peak load with conservation, ongoing upgrades or expansions to the T&D system and associated costs are deferred, since the new post-conservation loads are lower. The Council used data from utilities in the region to estimate this value: $11.13/kW-yr for deferred transmission and $19.71/kW-year for deferred distribution (both in 2024$).[9] The Council uses these regional average values but also recognizes that transmission and distribution system cost savings are dependent upon local conditions.

**Winter Peak Hours**: Hours ending 8-9 am on weekdays in Dec, Jan, Feb

**Summer Peak Hours**: Hours ending 5-8 pm on weekdays in Jul, Aug

**Deferred T&D Values**: Transmission = $11.13/kW-yr, Distribution = $19.71/kW-yr

## Line Losses

The transmission and distribution power lines incur losses when transmitting electricity from one location to another. These losses need to be accounted for by estimating the difference in savings at the end-use site and the utility busbar.[10] For the Ninth Plan, the Council conducted research[11] and collected data from utilities and the US Energy Information Administration (EIA) to determine the average losses on both the distribution and transmission systems. These values were found to be 2.8 percent for the transmission system and 4.4 percent for the distribution system.

**Average Line Losses**: Transmission = 2.8 percent, Distribution = 4.4 percent

There are two types of losses on the transmission and distribution system. The first are no-load/core losses, or the losses that are incurred just to energize the system – to create a voltage available to serve a load. Nearly all of these occur in step-up and step-down transformers. The second are resistive losses, which are caused by friction released as heat as electrons move on increasingly crowded lines and transformers. Typically, about 30 percent of the average annual losses are no-load or core losses, and about 70 percent are resistive losses for distribution systems.

Losses increase significantly during peak periods. ProCost, the Council's cost-effectiveness tool, uses the formula for the resistive losses, $I^2R$, where "I" is the current on any transformer or distribution line, and "R" is the resistance of the wires through which the current flows. While the "R" is generally constant through the year, since utilities use the same wires and transformers all year

[8] These hours were selected by analyzing hourly forecasted loads for 2031.
[9] Technical Appendix A – Global Assumptions provides more information the assumed T&D deferral values for the Ninth Plan.
[10] The starting point for the utility transmission system. The difference between the site and busbar savings are the transmission and distribution losses.
[11] Research findings presented to the Council's Conservation Resources Advisory Committee available here: https://nwcouncil.box.com/s/opdoxu8ullwi3o0uedeodavgekid2ttt.

long, the "I" is directly a function of the demand that customers place on the utility. Thus, resistive losses increase with the square of the current, meaning losses increase as load increases. Depending on the system load shape, the percentage of generation that is "lost" before it reaches the load is typically at least twice as high as the average annual losses on the system. During the highest critical peak hours (perhaps 5-25 hours per year) when the system is under stress, the losses may be four to six times higher than the average.

ProCost uses the system load shape and the conservation measure load shape to calculate the impact of the measure on system losses, accounting for both the core and resistive losses.

## Deferred Resource

Conservation measures also have a deferred resource value, though the economic value of this is derived from analysis of resource strategies in the OptGen model rather than fixed as an input. As such, the economic value of a deferred resource was set to zero for developing the supply curves. Instead, the derived economic value of a deferred resource (e.g., deferred generation capacity) is captured in the determination of the plan conservation goals and is used for setting cost-effectiveness levels for conservation measures and programs.

## Other Benefits

The other benefits of conservation included in the levelized cost are "other fuel" and quantifiable non-power system benefits. The other fuel benefits are savings in natural gas or heating oil from, for example, increased insulation levels. The homeowner who has air conditioning and a gas furnace will save electricity in reduced cooling usage as well as saving gas from reduced heating usage by adding ceiling insulation. Note that the "other fuel" category can be either a cost or benefit (negative cost).

In addition, the Council includes the value of quantifiable environmental benefits that fit within the Council's environmental methodology. The key one for the Ninth Plan is water savings. For example, by installing an efficient clothes washer, the homeowner will use less water than the baseline equipment. The value of this water reduction is included as a benefit in the net levelized cost calculation.

The Council's 2021 Power Plan called on the RTF to develop a methodology for quantifying the resilience benefit of some conservation measures. Based on this analysis, the Ninth Plan includes a resilience benefit for residential weatherization measures. This benefit, estimated to be approximately $0.002 to $0.008 per annual kWh saved, represents the value that weatherization provides in mitigating and recovering from the negative effects of extreme weather events and/or other electric grid outages.[12]

[12] See methodology and valuation presented to the Council's Conservation Resources Advisory Committee here: https://nwcouncil.box.com/s/pndnd9yyie9j6lbrblq7xgtxxr87166v. Actual resilience value depends on the specific

**Resilience Value**: \$0.002 - \$0.008 per annual kWh saved[13]

## Northwest Power Act Conservation Credit

Finally, the Northwest Power Act directs the Council and Bonneville to give conservation a 10 percent cost advantage over sources of electric generation.[14] The Council does this by calculating the Act credit as 10 percent of the value of energy saved at wholesale market prices, plus 10 percent of the value of savings from deferring electric transmission and distribution system expansion, deferred generation capacity investment, and risk avoidance. This 10 percent value is included in ProCost for developing the levelized costs.

**Regional Power Act Conservation Credit**: 10%

There may be other measure benefits or costs that are not quantified in this analysis. The Council's methodology for determining quantifiable environmental costs and benefits outlines the approach taken to determine if a particular non-energy cost or benefit is included in the analysis. See Technical Appendix C - Methodology for Quantifiable Environmental Costs and Benefits for more information.

## Value of Conservation with Respect to Time

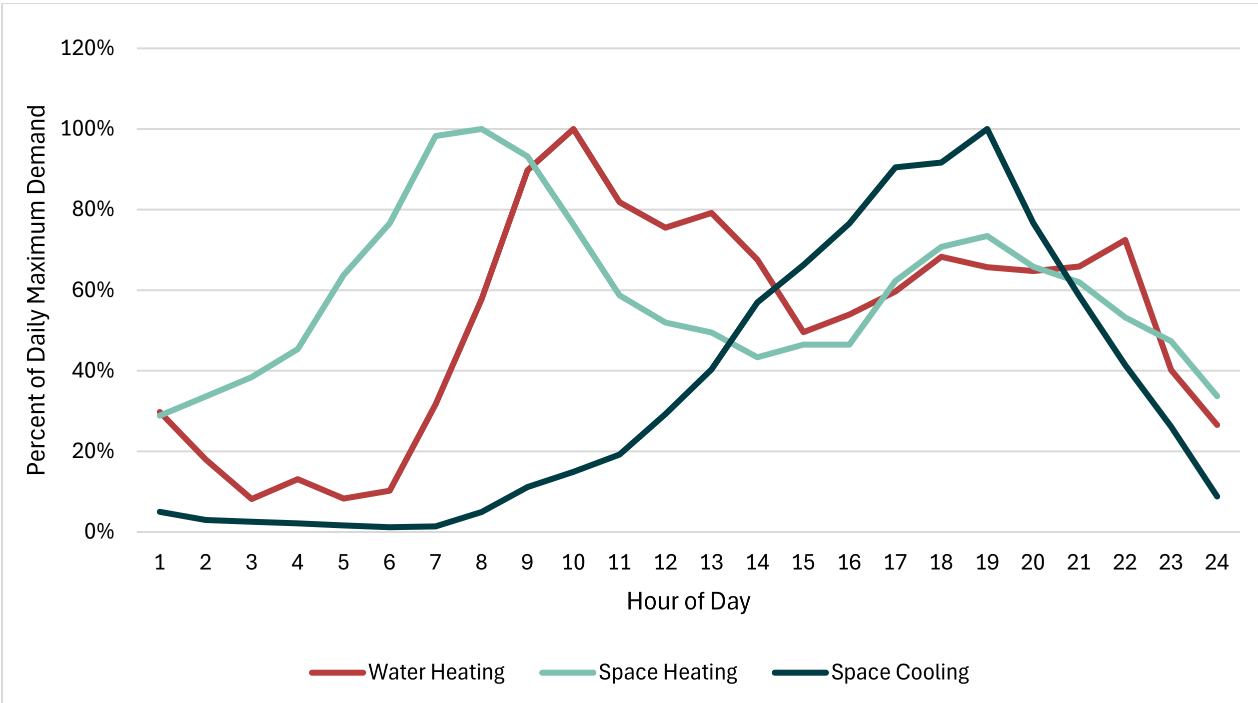
The energy saved from conservation is generally not constant across every hour of the year. For example, efficient street lighting only saves energy from dusk-to-dawn, the hours of which vary over the year. Figure H - 3 shows typical hourly savings profiles for measures that improve the efficiency of space heating, water heating, and central air conditioning in a typical Northwest home. The vertical axis indicates the ratio (expressed as a percentage) of each hour's electric demand to the maximum demand for that end-use over the course of the entire day. The horizontal axis shows the hour of the day, with hour "1" representing midnight to 1 am.

measure and HVAC type but is typically around \$0.002/kWh for homes with gas heating, \$.0.006/kWh for homes with heat pump heating, and \$0.008/kWh for homes with electric resistance heating.

[13] Ibid.

[14] Northwest Power Act, Section 3(4)(D).

**Figure H - 3: Illustrative Hour Load Profile for Three Residential End Uses**




As can be seen from inspecting the figure above, water heating savings increase in the morning when occupants rise to bathe and cook breakfast, then drop while they are away at work and rise again during the evening. Space heating savings also exhibit this "double hump" pattern. In contrast, central air conditioning savings increase quickly beginning in the early afternoon as the outside temperature rises, peaking in late afternoon and declining again as the evening progresses and outside temperatures drop. Measure savings can also vary seasonally and by day of the week. As the price of electricity varies by day and by season, the value of conservation will also vary, depending on its savings shape.

By reducing the peak load with efficiency, ongoing upgrades or expansions to the T&D system and associated costs are deferred. Of course, each individual conservation measure analyzed has a unique shape, which will affect its value as a resource option and its measure cost-effectiveness.

# Calculating Net Levelized Cost

Once all the measures have their costs and benefits identified, the Council uses ProCost to calculate the levelized cost for each. The primary components of the levelized cost are the net present value (NPV) of the measure costs divided by the NPV of the energy savings of the measure. All cost and benefit streams are converted to present-value costs (in 2024$) and benefits based on the financing costs, sponsor[15] cost shares, and discount rates. ProCost uses standard capital recovery factors and present value factors to calculate present value costs and benefits. Finance costs use sponsor-specific interest rates and terms assigned by user input to calculate the present value of capital costs of measures. Annual costs and benefits that are not financed are counted in the years they occur and discounted to present values using standard present value factors and the global discount rate of 3.70 percent used in all analysis for the Ninth Plan.[16]

**Discount Rate**: 3.70 percent

ProCost sums all the present value costs and nets out benefits. This value is then amortized over the life of the Plan (20 years) using standard capital recovery factors and the discount rate. The resulting annual "levelized" cost is divided by the discounted annual energy savings adjusted for transmission and distribution line losses to produce a levelized cost per unit energy saved in dollars per MWh.

The NRC represents all costs minus all benefits regardless of which sponsor incurs the cost or accrues the benefits. In addition to energy system costs and benefits, the NRC includes non-energy, program administration, other-fuel, O&M, Power Act credit, and periodic-replacement benefits and costs. The costs and benefits included in the Ninth Plan are summarized in

Table H - 2.

**Table H - 2: Costs and Benefits of Conservation**

| Costs Included | Benefits Netted Out |
|---|---|
| Capital & Labor | Regional Power Act Credit |
| Annual O&M | Annual O&M |
| Program Administration | Deferred Resource Investment[17] |
| Other Fuel Costs | Other Fuel Benefits |
| Non-Energy Impacts | Non-Energy Impacts |
| | Deferred T&D Expansion |

While not all these costs and benefits are paid by or accrue to the region's power system, the NRC perspective is used because all costs must be included in resource comparisons and because,

[15] "Sponsors" are those paying for the conservation measure. A sponsor can be the end-user, a retail utility, or BPA, and the shares can be split among the sponsors. For the Ninth Plan the sponsor shares are assumed to be 40% for BPA and 60% for the retail utility. No share is assumed for the customer. See Technical Appendix A – Global Assumptions for more information.

[16] More information on the discount rate is available in Technical Appendix A – Global Assumptions.

[17] The value of a deferred resource may be determined as part of the optimization analysis and is not included in the initial levelized costs in the supply curve.

ultimately, it is the region's consumers who pay the costs and receive the benefits. For some measures, the NRC is less than zero because electric plus non-electric benefits exceed the capital cost of the measure. In addition, the Council's analysis assumes conservation measures comply with environmental regulations and thus incorporate any cost associated with compliance. All costs are assumed to be nominally constant – meaning, the levelized cost is assumed to remain the same throughout the plan horizon.

# Existing Technology Measures

The existing conservation technologies considered in the Ninth Plan span across all building sectors and energy end uses. In total, the Ninth Plan looked at over 120 different measures and over thirty thousand individual measure applications. An example conservation measure is residential weatherization. A measure application is a specific and granular implementation of a measure, such as R-49 attic insulation, in a heat pump heated home, in Montana.

Table H - 3 summarizes the existing technology measures analyzed and included in the Ninth Plan.

**Table H - 3: Conservation Measures Included in the Ninth Plan by Sector and End Use**

| Sector | End Use | Measure(s) |
|---|---|---|
| Agriculture | HVAC | Stand-Alone Dehumidification, Efficient High-Speed Fans, Efficient High Volume Low-Speed Fans |
| | Irrigation | Irrigation Hardware, Advanced Irrigation Management, Advanced Irrigation Surveillance, Variable Rate Irrigation, Pump Replacement |
| | Lighting | Efficient Lighting and Controls |
| | Motors/Drives | Dairy Vacuum Pump Variable Speed Drives, Dairy Milk Transfer Pump Variable Speed Drives |
| | Other | Efficient Stock Tanks, Efficient Standby Generator Engine Block Heaters |
| | Refrigeration | Dairy Plate Milk Pre-Coolers, Dairy Heat Recovery Refrigeration, Dairy Compressor Upgrades |
| Commercial | Appliances | Dishwashers, Clothes Washers |
| | Compressed Air | Efficient Compressors |
| | Electronics | Computers, Monitors, TVs, Servers and Power Supplies |
| | Food Preparation | Combination Ovens, Convection Ovens, Rack Ovens, Griddles, Hot Food Holding Cabinets, Overwrappers, Steamers, Fryers, Ice Makers, Vending |
| | HVAC | Efficient Fans, Advanced Rooftop Controls, Packaged Terminal Heat Pumps, Ducted Air Source Heat Pumps, Ductless Air Source Heat Pumps, Chiller Upgrades, Connected Thermostats, Heat Recovery Ventilation, Very High Efficiency Variable Refrigerant Flow with Dedicated Outside Air System (VHE-DOAS), Unitary Air Conditioners, Efficient Windows |

| Sector | End Use | Measure(s) |
|---|---|---|
| | Lighting | LEC Exit Signs, Efficient Lighting and Controls, Street and Roadway Lighting |
| | Motors/Drives | Efficient Clean Water Pumps |
| | Other | Efficient Standby Generator Engine Block Heaters, Water Cooler Controls |
| | Refrigeration | Grocery Refrigeration (Various), Refrigerators, Freezers |
| | Vehicles | Engine Block Heater Controls |
| | Water Heating | Efficient Circulator Pumps, Heat Pump Water Heaters |
| | Whole Building | Energy Management |
| Distribution | Utility Distribution System | Conservation Voltage Regulation |
| Industrial | Compressed Air | New Efficient Compressor, Compressor System Upgrade |
| | Fans and Blowers | New Efficient Fan, Fan System Upgrade |
| | HVAC | Efficient HVAC |
| | Lighting | Efficient Lighting and Controls |
| | Material Handling | Advanced Motors |
| | Material Processing | Advanced Motors, Industrial Heat Pumps, Cement Process Improvements, Chip Fabrication Process Improvements, Kraft and Mechanical Pulp Process Improvements, Wood and Wood Panel Process Improvements, Water and Wastewater Process Improvements |
| | Other | Efficient Forklifts, Efficient Standby Generator Engine Block Heaters |
| | Pumps | Efficient Clean Water Pumps, Pump System Upgrade |
| | Refrigeration | Advanced Motors, Fast Acting Doors, Refrigeration System Retrofit, Thermal Recovery |
| | Whole Building | Energy Management |
| Residential | Appliances | Clothes Washers, Clothes Dryers, Dishwashers, Refrigerators, Freezers, Induction Ovens |
| | Electronics | Desktops, Laptops, Monitors, TVs |
| | HVAC | Ducted Air Source Heat Pump (ASHP) Upgrades, ASHP Conversions, ASHP Retro-Commissioning, Ductless Heat Pumps, Ground Source Heat Pumps, Central Air Conditioner Upgrades, Heat Recovery Ventilation, Weatherization (Windows, Insulation, Air Sealing), Duct Sealing |

| Sector | End Use | Measure(s) |
|---|---|---|
| | Water Heating | Efficient Portable Spas, Efficient Circulator Pumps, Heat Pump Water Heaters, Thermostatic Shower Restriction Valves, Wastewater Heat Recovery |
| | Vehicles | Electric Vehicle Supply Equipment, Engine Block Heater Controls |

A full list of measures can be found on the Council's Ninth Plan webpage.[18]

# Emerging Technology Measures

The Council included conservation emerging technologies in the Ninth Plan. Like the treatment of emerging generating resources, several proxy conservation measures were defined. These measures are emerging in the sense that either more development is needed or more data/definition, but all are expected to be available at some point during the plan period. The emerging conservation technologies analyzed and included in the Ninth Plan include:

- **Commercial Deep Retrofits**: Reductions in commercial whole building energy use intensities (EUI) using a variety of more efficient building equipment and operations.
- **Commercial Heat Pump Dryers**: More efficient commercial tumble dryers utilizing heat pump technology in laundry applications.
- **Residential Passive House Construction**: A voluntary efficiency standard that requires super-insulated, high-performance building envelopes and other efficiency improvements to significantly reduce HVAC and overall building energy use.
- **Industrial Motor Advancements**: Represents a variety of potential efficiency improvements in industrial motors, including superconducting motors, soft magnetic composite motors, magnet-free motors, trapezoidal radial flux motors, and advancements in nanomaterials and thermal management.
- **Distribution System Efficiency Advancements**: Represents a variety of potential improvements to distribution system efficiency, including transformer right-sizing, feeder balancing, phase balancing, and the addition of regulators and capacitors.
- **Electric Vehicle (EV) Efficiency Advancements**: Efficiency improvements such as lighter materials, better vehicle aerodynamics, more efficient motors and drivetrain components, and reduced electrical losses. The RTF conducted a study to characterize the market for EVs in 2023.

Although some of these technologies are available at the time of the Ninth Plan, many are still fairly nascent in programs.

[18] Full measure list workbook available here: https://nwcouncil.box.com/s/v0iys2vw38t1yz08idtd0xvjce032ky4.

# Other Measures Considered but Not Included

There are other conservation measures that the Council considered for the Ninth Plan but ultimately did not include: efficiency measures for large, existing data centers or new data centers; and residential behavior. The following sections provide additional details on why these measures were not included in the Ninth Plan.

## Data Center Measures

While data centers represent a significant fraction of expected future load growth, the Council included only a limited set of measures related to small, “embedded” data centers in commercial buildings (ENERGY STAR Servers) and did not include measures for larger and/or new data centers. The reasons for not including measures for these data centers are:

- **Evidence that newer data centers are built very efficiently, especially the largest hyperscale data centers**. This was reflected in a recent data center market study[19] conducted by the RTF in 2024. As power is generally one of a data center’s highest costs, the study found that the current practice conservation for new, large data centers is very high.
- **Evidence that energy savings realized in data centers is often counteracted by increases in server processing volume**. While such energy savings may still be considered conservation under the Act, there is little value in modeling a conservation resource when the savings will just be consumed by the facility for additional processing.
- **Lack of data.** The Council believes that there is some conservation potential in the mid-sized data centers such as those in older, rented buildings or in shared spaces with mixed uses. However, there is a lack of data, largely due to the confidential nature of data centers, that prevents the ability to make quality estimates of conservation potential. Northwest utilities are and should continue seeking opportunities for custom efficiency projects (especially HVAC related) in these facilities.

## Residential Behavior

The Ninth Plan supply curves do not include a measure for a residential behavior-type efficiency program. Behavior programs are those that send information to utility customers, typically via letter or email, with tips on how to save energy. While some data exists on the energy savings and costs of such programs, there remain challenges and uncertainties that ultimately led the Council staff to not include a behavior measure. These challenges include:

[19] Presentation of data center findings to the RTF in January 2025: https://nwcouncil.box.com/s/5r1ubkq85wees6l5ppr7k53lygulelhz.

- Uncertain underlying drivers of energy savings,
- Unknown overlap between residential behavior savings and savings from other residential efficiency measures,
- Unknown whether behavioral actions meet the Act definition of conservation, and,
- Relatively unknown measure persistence/lifetime.

# Calculating Technical Achievable Potential

Once the conservation measures have been defined, the conservation potential can be determined by multiplying the measure savings by the number of measures. In its simplest form, the Council's method for estimating potential is to multiply the measure or unit savings by the number of measures or units. Achievability factors are then applied to obtain what is called the "Technical Achievable" potential.

Technical potential is the amount of conservation that is technically feasible. It considers conservation measures and the number of these measures that could physically be installed, without regard to cost. For example, electricity savings from adding insulation to an attic does not apply to homes with flat roofs or vaulted ceilings (i.e., no attic). Similarly, increasing attic insulation in homes with attics is only applicable from an electric savings perspective if the home is electrically heated. The technical potential can be viewed as the upper limit of what conservation potential is available.

Total technical potential is determined by the per-unit savings multiplied by the number of units in the region. Using an efficient refrigerator as an example, the Ninth Plan estimates 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. The physical units differ by sector (see Table H - 4). For the residential sector, the primary physical unit is number of homes by house type, for the commercial sector, floor area of commercial buildings by building type, for the industrial sector, total MWh consumption by industry, and for the agricultural sector, total irrigated acres and dairy milk production.

**Table H - 4: Physical Units by Sector**

| Sector | Primary Physical Unit | # in 2027[20] |
|---|---|---|
| Residential | Number of Households (Million) | 6.54 |
| Commercial | Building Floor Area (Billion Square Feet) | 3.48 |
| Industrial | Total Industrial Electric Consumption (GWh) | 33,800 |

[20]Physical unit data are forecasted to the start year of the Plan, or 2027.

| | | |
|---|---|---|
| Agriculture | Irrigated Acres (Million) | 4.86 |
| | 1,000 lbs of Milk | 25.5 million |
| Distribution | Total Regional Electric Consumption (GWh) | 195,000 |

The full set of units can be found in the supporting technical documents on the Council's Ninth Plan web page.[21]

The Council's methodology assumes that once a measure is adopted, it remains in place through the end of the plan (20 years). Each measure has an estimated measure lifetime, and at the end of that lifetime the methodology assumes the measure is re-installed with the same efficiency level. In addition, the annual technical potential accounts for the turnover rate of measures, such as a refrigerator. That is, it is assumed that a refrigerator lasts approximately 15 years, and therefore each year, 1/15 of all refrigerators in the region are replaced.

The number of available units is a function of technical applicability and measure saturation. Technical applicability includes the fraction of stock that the measure applies to and any overlap with mutually exclusive measures. Existing measure saturation reflects the fraction of the applicable stock that has already adopted the measure and for which savings estimates do not apply.

The achievable potential is the technical potential multiplied by two factors: the maximum achievable limit and the ramp rate. The maximum achievable limit assumes a maximum amount of the total potential that could be acquired over the 20-year plan period. This maximum amount assumes that there will be some portion of non-adopters within the plan period, e.g., buildings where the owner has no interest in improving. This maximum achievable fraction was set to 85 percent for all retrofit measures and between 85 and 95 percent for lost opportunity measures. The determination of the upper limit was based on the recent activity around federal appliance standards (more regular updates results in a higher maximum achievability) or the speed of the market change (fast moving markets have higher maximum achievability). For retrofit measures, the 85 percent value has been the traditionally accepted value since the Council's Second Power Plan and was derived from a program called the "Hood River Conservation Project (HRCP)." The HRCP, a $20 million program operated in the early 1980s installed, for free, any weatherization measures that a household energy assessment showed were within a prescribed cost threshold. The program achieved a high response rate for home energy assessments (91% of all eligible participants) and for the subsequent implementation of conservation measures (85% of all eligible participants).[22]

[21] See "9P-Units", available as part of the conservation supply curve supporting documents here: https://nwcouncil.box.com/v/ninthplanEEsupplycurves.
[22] https://eta-publications.lbl.gov/sites/default/files/lbnl-3960e-hrcp.pdf.

**Maximum Achievability Limits**: 85 - 95%

The second achievability factor is the ramp rate, or "annual deployment limit", which represents the upper limit of annual conservation resource acquisition 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 annual ramp rates used in the Ninth Power Plan are illustrated Figure H - 4: Retrofit Ramp RatesFigure H - 4 and Figure H - 5 below. Figure H - 4 illustrates ramp rates used for retrofit measures. These ramp rate values represent the percentage of the stock that can adopt a measure within a given year. The ramp rates represent a wide range of adoption rates from a very slow pace initially (e.g., Retro1Slow) which starts at about one percent of the stock and increases to ten percent midway through the plan. Conversely, Retro50Fast assumes nearly 50% of the stock can be adopted in the first Plan year and approximately 20% of the achievable stock in the second year and then declines rapidly. Figure H - 5 illustrates ramp rates used for lost opportunity measures, which include both new construction and natural replacement measures. Lost opportunity ramp rate values represent the percentage of new or existing construction turnover (for natural replacement measures) that can be achieved within a given year. For example, the fastest lost opportunity ramp rate, "LO80Fast", assumes that nearly 80% of new builds or existing turnover can be achieved in the first year, while some of the slowest lost opportunity ramp rates assume that close to 0% can be achieved in year one.

**Figure H - 4: Retrofit Ramp Rates**

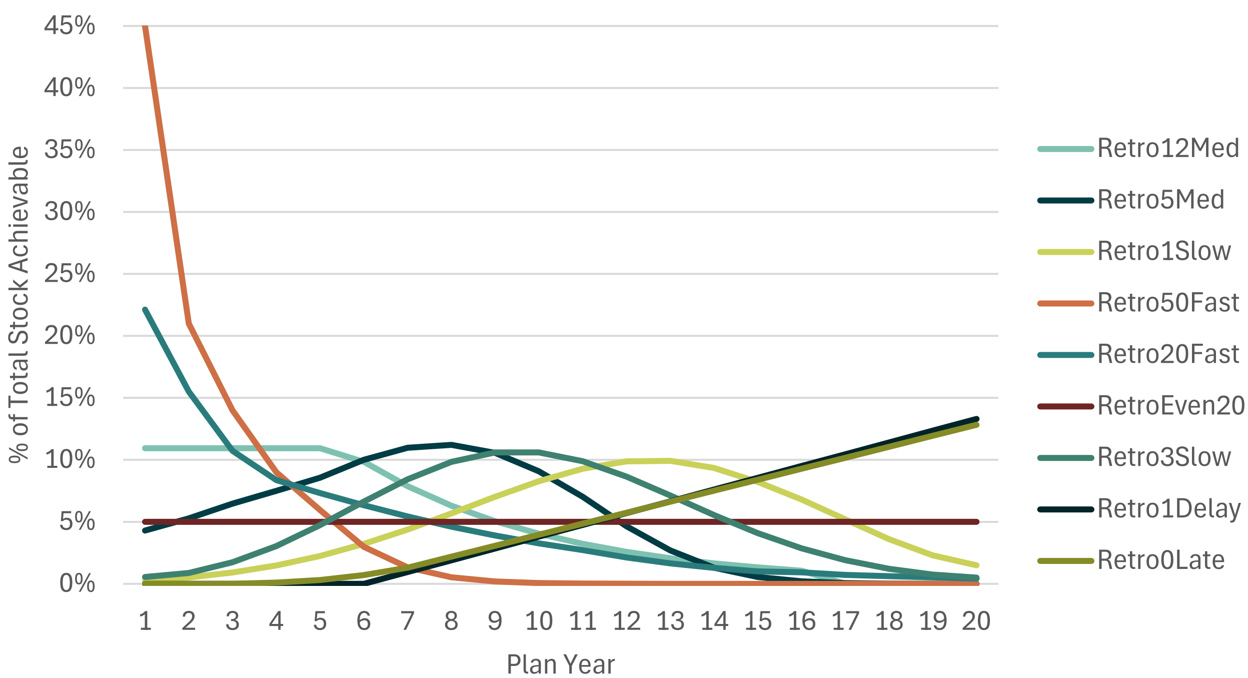
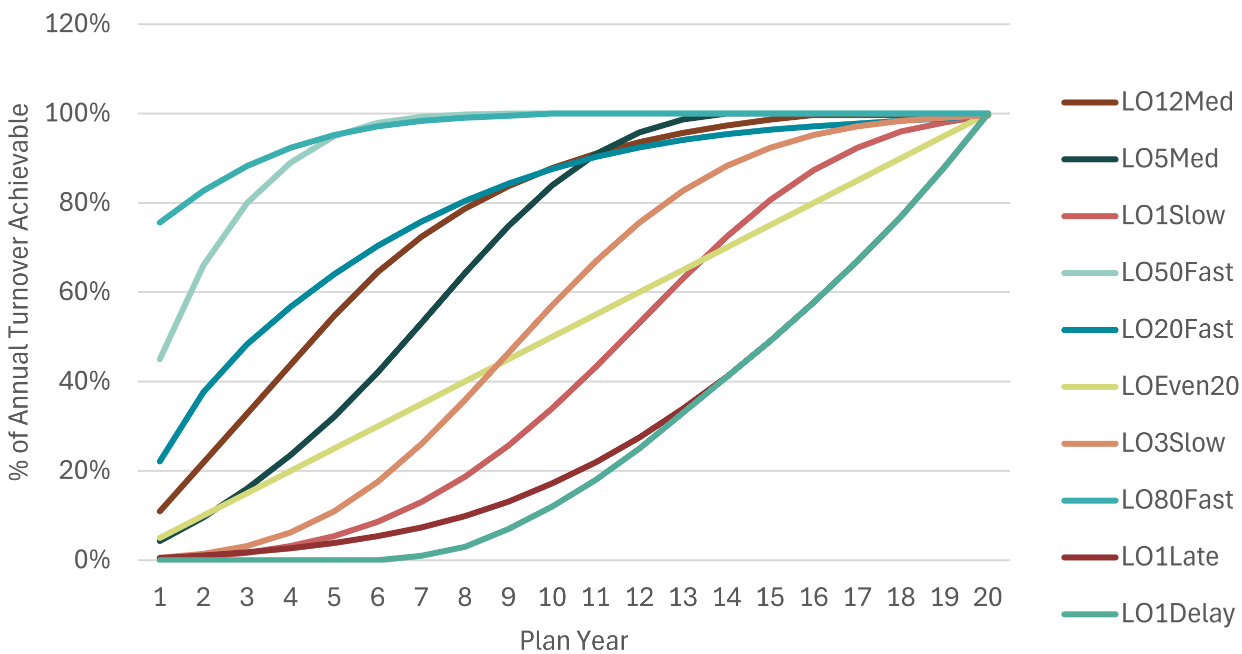


**Figure H - 5: Lost Opportunity Ramp Rates**




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 faster ramp rate, while measures that are newer in the region, or that have experienced sluggish adoption rates, are assigned a slower ramp rate. Specific measures and their associated ramp rates can be found in the Excel workbooks used to develop the supply curves - please see the "Excel Workbooks and Tools" later in this appendix. The annual ramp rate multiplied by the total number of units available each year provides the maximum annual technical achievable potential. The Council also considers region-wide conservation program accomplishments when developing these ramp rates to help align early year potential with recent historic accomplishments.

# Potential by Modeling Zone

In previous power plans, conservation potential was estimated only at the granularity of the entire Council planning region. While this represents an accurate picture of the region's overall conservation availability, it cannot represent potential differences in the types of conservation available on a sub-regional level or in the value of conservation on a sub-regional level. For example, some sub-regions of the Council's overall planning region may be willing to pay higher prices for conservation, given the unique characteristics and constraints of their sub-region.

For the first time, the Ninth Plan estimates conservation potential for a set of seventeen smaller sub-regions or "modeling zones." The modeling zones, summarized in Table H - 5, correspond approximately to the Northwest balancing authorities, or portions of balancing authorities. However, their main purpose is to approximately reflect where different types and magnitudes of conservation are distributed across the region.

**Table H - 5: Modeling Zones**

| Modeling Zone Name | Modeling Zone Abbreviation |
|---|---|
| Avista Utilities | AVA |
| Bonneville Power Administration, Idaho and Montana | BPA_IDMT |
| Bonneville Power Administration, Oregon | BPA_OR |
| Bonneville Power Administration, Washington | BPA_WA |
| Chelan County PUD | CCPUD |
| Douglas County PUD | DCPUD |
| Grant County PUD | GCPUD |
| Idaho Power Company | IPCO |
| NorthWestern Energy | NWMT |
| PacifiCorp, East | PACE |
| PacifiCorp, West | PACW |
| Portland General Electric | PGE |
| Puget Sound Energy, Central | PSE_Central |
| Puget Sound Energy, North | PSE_North |
| Puget Sound Energy, Olympia | PSE_Olympia |
| Seattle City Light | SCL |
| Tacoma Power | TPWER |

The method in which total conservation potential is allocated to the various modeling zones depends on the type of data available and relevant for the conservation sector and measure. For example, for some dairy conservation measures, county-level cattle data is aggregated to the modeling zone level and used as the basis for estimating zone-level conservation. For most residential conservation measures, housing stock data aggregated at the modeling zone level was used. Other data sources used for the purpose of allocating conservation to the modeling zone level include energy sales and customer data, by state and balancing authority, reported by the US Department of Energy's Energy Information Administration (EIA).

## Bundling Conservation for OptGen

For modeling conservation in the Council's capital expansion model (OptGen), it is necessary, as with prior power plans, to aggregate or bundle conservation measures together to represent larger resource options for the model to select. In prior plans, the sole criteria used to bundle conservation was cost – measures within the same levelized cost "bin" were aggregated together.

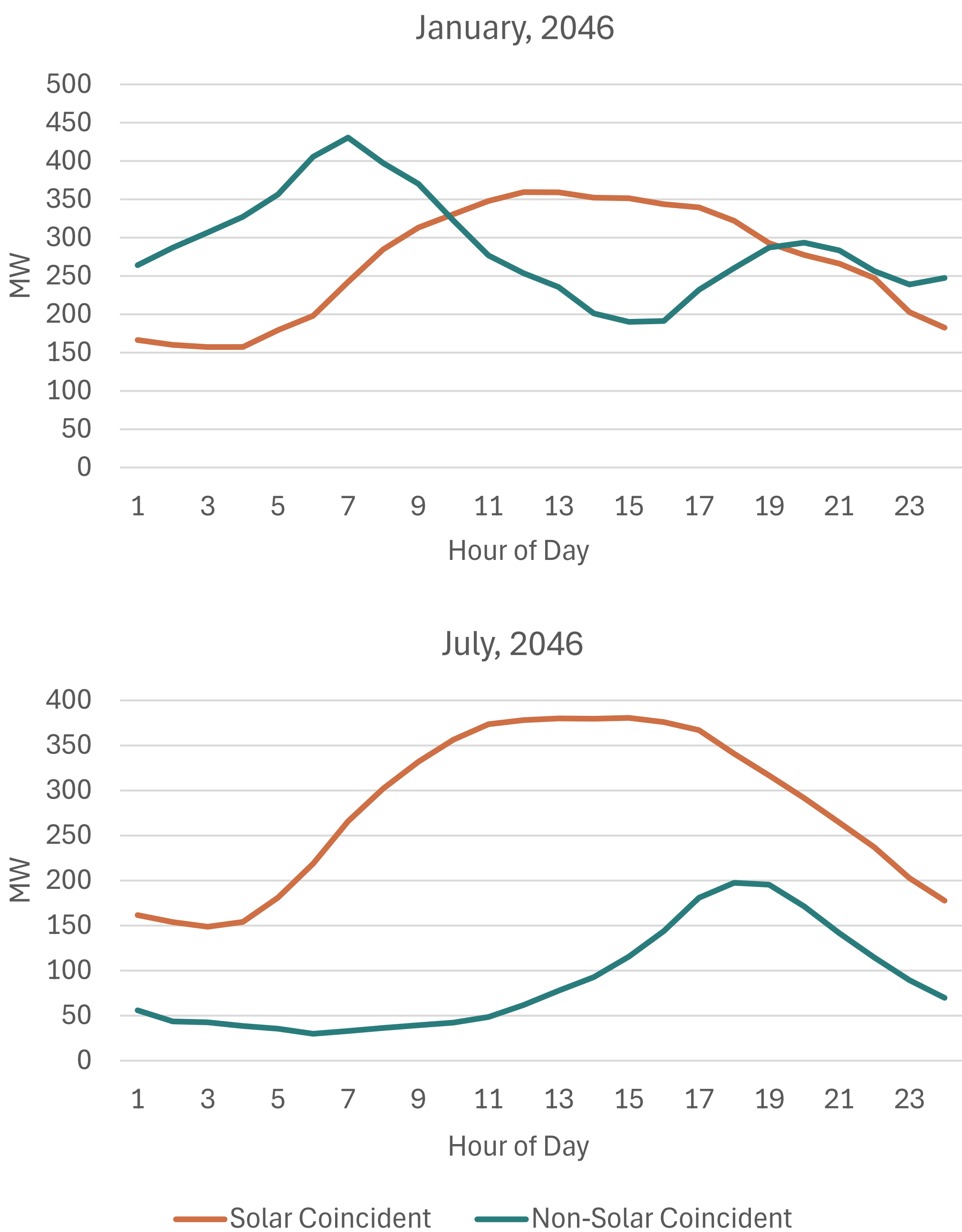
For the Ninth Plan, the additional granularity offered by the OptGen model, both in terms of sub-regional modeling zones and hourly modeling capabilities, allows additional factors to bundle conservation for modeling. The ultimate bundling strategy for the Ninth Plan utilizes three factors to aggregate conservation measures and includes modeling zone, levelized cost, and hourly savings shape type. There are seventeen modeling zones, ten levelized cost bins, and two hourly shape types, resulting in 340 total possible conservation bundles. The bins are summarized in Table H - 6.

**Table H - 6: Conservation Modeling Bins**

| Modeling Zone Bin | Levelized Cost Bin | Hourly Shape Type Bin |
|---|---|---|
| AVA | ≤ $20 | Solar Coincident |
| BPA_IDMT | > $20 - $40 | Non-Solar Coincident |
| BPA_OR | > $40 - $50 | |
| BPA_WA | > $50 - $60 | |
| CCPUD | > $60 - $70 | |
| DCPUD | > $70 - $80 | |
| GCPUD | > $80 - $100 | |
| IPCO | > $100 - $150 | |
| NWMT | > $150 - $250 | |
| PACE | > $250 | |
| PACW | | |
| PGE | | |
| PSE_Central | | |
| PSE_North | | |
| PSE_Olympia | | |
| SCL | | |
| TPWER | | |

The hourly shape type is also a new addition for the Ninth Plan, and it is designed to test whether conservation with a certain hourly shape (i.e., capacity characteristics) is more or less valuable to the system. The shape types used in the Ninth Plan are largely reflective of when forecasted market prices are expected to be higher or lower, which is generally correlated to when solar production is available or not. For example, conservation that is largely coincident with solar production and lower market prices may be less valuable to the system than conservation that is providing capacity and energy savings during the early morning or nighttime. Figure H - 6 shows an example of what the two conservation shape types look like that are used in the Ninth Plan.

**Figure H - 6: Conservation Shape Types Used for Bundling in the Ninth Plan**




# Adjusting for Load Futures and Scenarios

There is ultimately not a single set of conservation supply curves for the Ninth Plan, but rather many variations, depending on the load future and analysis scenario being run in the model. Load futures and scenarios are similar in that they can both have changing assumptions that alter the shape, magnitude, and/or costs of the conservation supply curves; however, they are different in that all load futures are present in every scenario, whereas each scenario is distinct from one another.

Table H - 7 summarizes the adjustments made to the conservation supply curves, depending on the specific load future and scenario. As the table highlights, there are four main drivers of change for the supply curves, depending on the load future and scenario, and they are: the presence of high building electrification, the presence of tax credits, the presence and cost of emerging technologies, and whether there is any assumed delay in conservation availability.

**Table H - 7: Adjustments to Conservation Supply Curves for Ninth Plan Scenario Modeling**

| Analysis Sensitivities | High Electrification | Tax Credits Included | Emerging Tech Included | Availability Delayed |
|---|---|---|---|---|
| Changing Hydro Operations, Evolving Federal Landscape | No | Yes | Yes | No |
| | Yes | Yes | Yes | No |
| Constrained World | No | No | No | No |
| | Yes | No | No | No |
| Emerging Tech Uncertainty | No | No | Yes (50% Higher Cost) | No |
| | Yes | No | Yes (50% Higher Cost) | No |
| | No | No | Yes (25% Lower Cost) | No |
| | Yes | No | Yes (25% Lower Cost) | No |
| Transmission Availability Uncertainty, Short-Duration Storage Limitations | No | No | Yes | No |
| | Yes | No | Yes | No |
| Demand Side Resource Limitations | No | No | Yes | Yes |
| | Yes | No | Yes | Yes |

The first driver, "High Electrification," is a function of the load futures, and therefore, its effect shows up in every scenario. For context, the load futures contain a wide range of potential future load trajectories,[23] and most relevant for conservation, some of these trajectories have lower (status quo) building electrification and some contain significantly higher electrification. As more loads are electrified, there is more conservation potential relative to the current practice baseline; therefore, load futures with higher building electrification will have higher available conservation. Note that

[23] Technical Appendix F – Electricity Demand Forecast provides more information on the approach to the load forecast and its multiple trajectories to capture future load growth uncertainty.

higher electrification loads are only assumed for cooking, water heating, and space heating end uses, in residential and commercial buildings, in Oregon and Washington.[24]

The remaining three drivers shown Table H - 7, relating to tax credits, emerging technologies, and delayed conservation availability, are all a function of the scenario modeling, and therefore their effects are isolated to each individual sensitivity. The sensitivities are designed to examine how conservation, and other demand and supply side resources, may be selected differently depending on several different important factors, such as:

- whether or not federal tax incentives are available for certain conservation measures;
- whether or not certain emerging technology measures become available, or if emerging technology prices are higher or lower than expected; and
- whether conservation measures are available according to the timeline assumed in the starting point.

Technical Appendix N – Scenario Modeling and Results provides more information on the specific assumptions in each scenario.

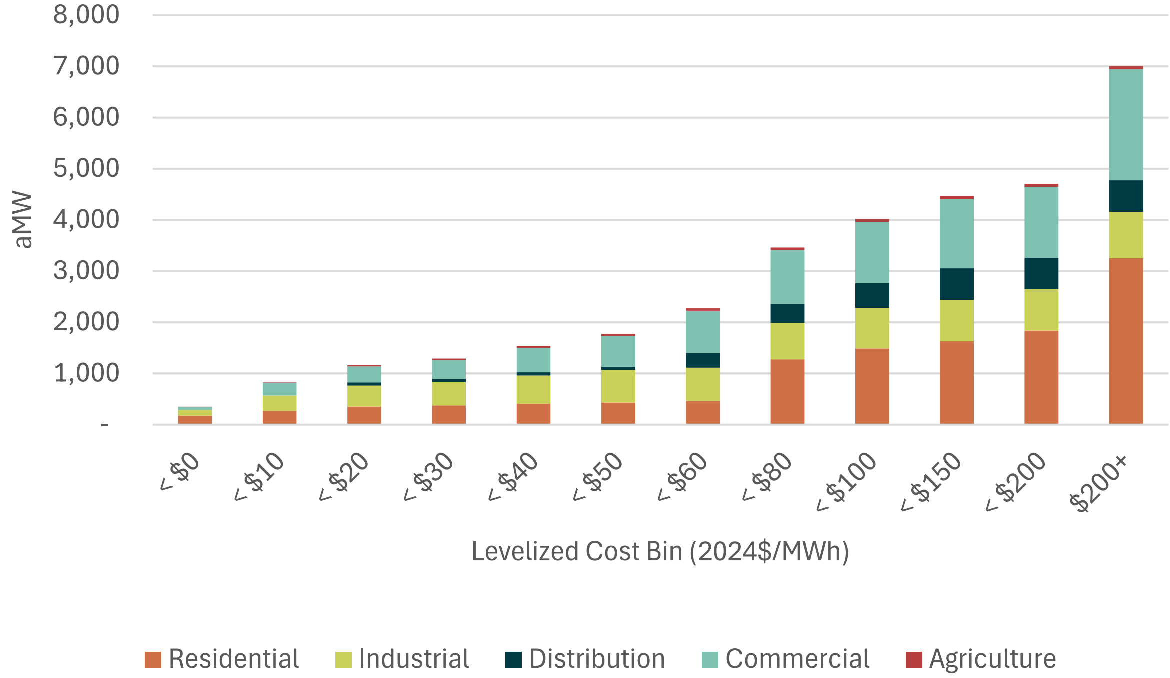
# Final Technical Achievable Potential: Supply Curves and Other Charts

All the work described thus far in this appendix results in a final technical achievable conservation resource that is used to compete against other demand and supply side resources in the Council's capital expansion model. The final conservation resource can be represented by a supply curve, that shows the cumulative conservation potential available up to a given price point, in this case the net levelized cost. Figure H - 7 shows the final Ninth Plan technical achievable conservation supply curve for the majority of sensitivities, by sector, over the 20-yr period from 2027 to 2046. Each levelized cost bin is cumulative and includes all the potential from lower cost bins. The curve indicates, approximately:

- ~ 7,000 aMW of total potential from all cost bins;
- ~ 4,000 aMW of potential up to ~ $100/MWh;
- ~ 2,000 aMW of potential up to ~ $60/MWh; and
- ~ 1,000 aMW of potential up to ~ $20/MWh.

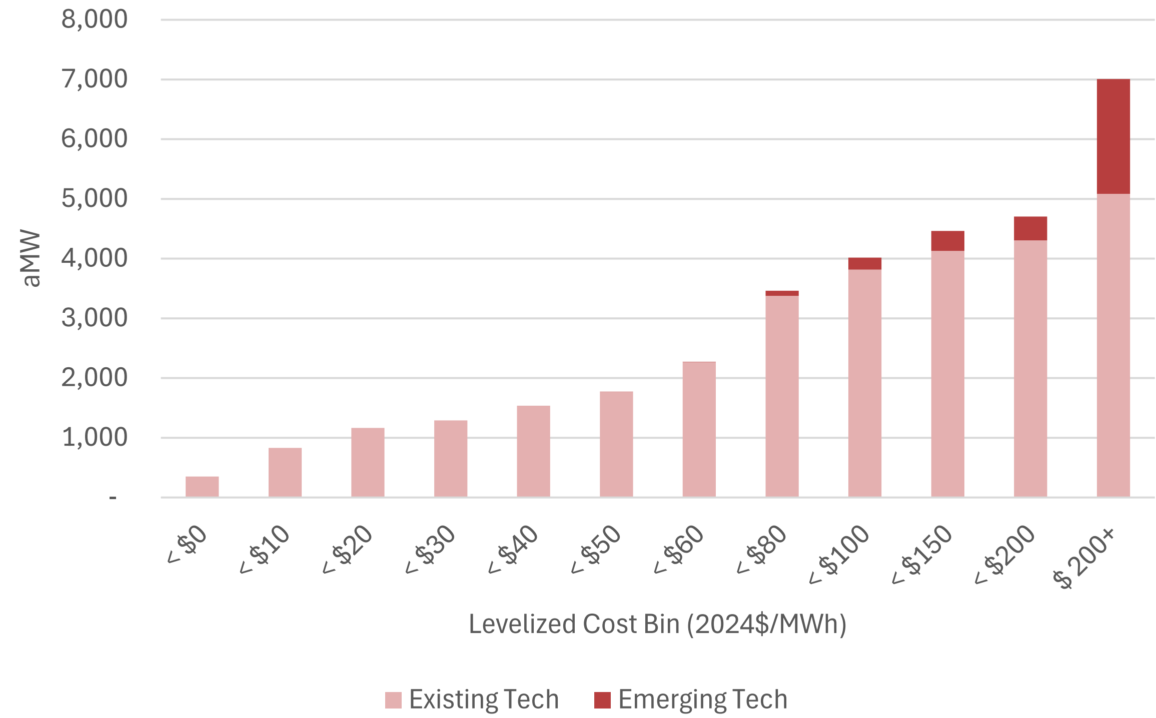
[24] Consistent with the Ninth Plan load forecast.

**Figure H - 7: Final Ninth Plan Conservation Supply Curve**



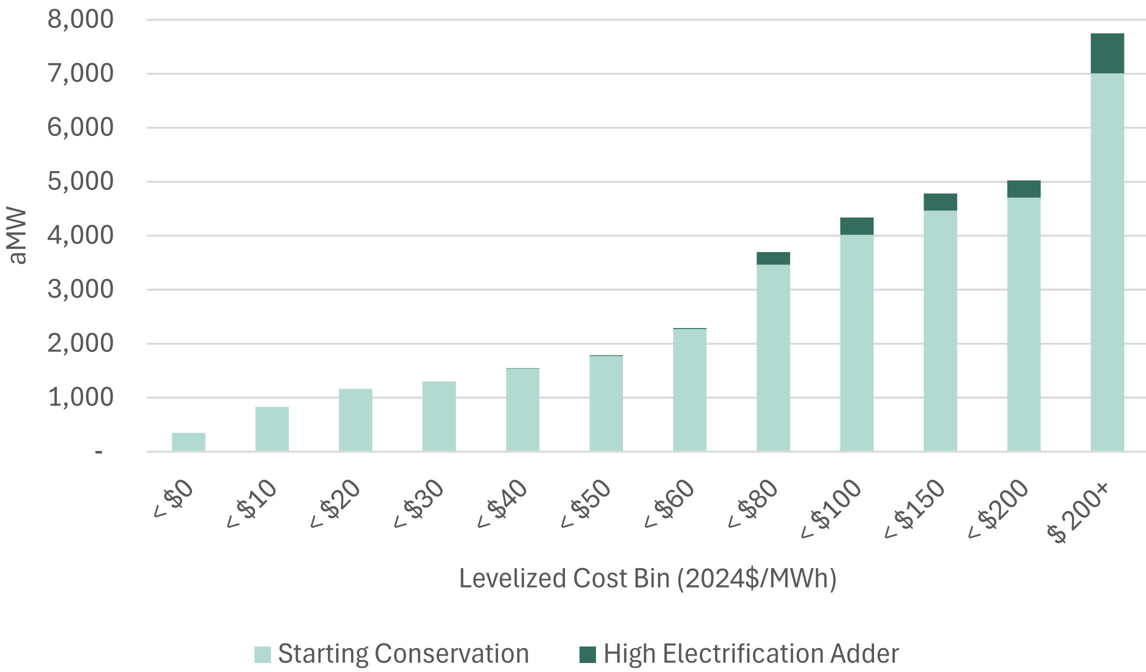

Emerging technologies do make up a significant portion of the conservation supply curve, particularly in higher cost bins and in later Plan years. Figure H - 8 shows that existing technologies make up approximately 5,000 aMW of the total 20-yr conservation potential, while emerging technologies make up the remaining ~2,000 aMW.

**Figure H - 8: Emerging Technology in the Supply Curve**



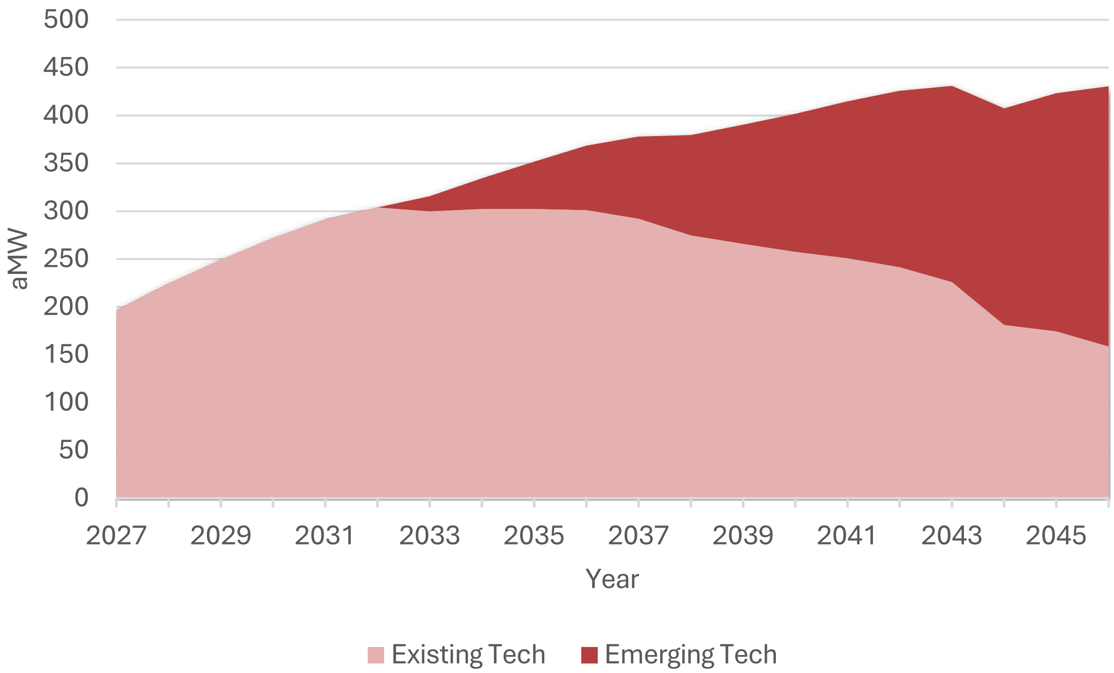

Recall that in load futures with high building electrification, additional conservation resources are available for residential and commercial cooking, water heating, and space heating in Oregon and Washington. In those futures, the Council estimates approximately 740 aMW of additional conservation resource available, as shown in Figure H - 9.

**Figure H - 9: Conservation Supply Curve with Higher Electrification**



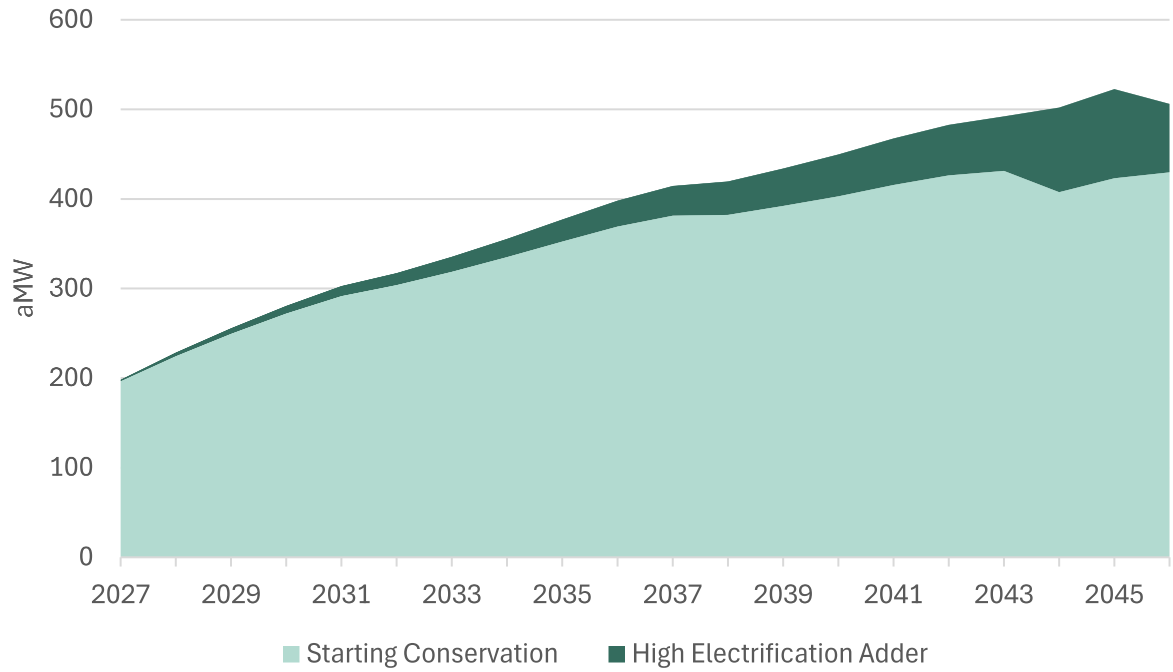

In addition to the cumulative supply curve, it is also informative to represent the conservation resource as incremental conservation available every year over the 20-year period. The incremental conservation available every year depends on a variety of factors, such as the assumed measure ramp rates and stock turnover. Figure H - 10 shows the incremental conservation available every year over the 20-year horizon from 2027 to 2046. Existing and emerging technologies are shaded differently to show that emerging technologies are assumed to appear starting in year seven and make up a significant portion of conservation potential overall, particularly in the "outer years" beyond 2040. Note that the dark shaded portion of this chart representing emerging technologies would not be available in the "Constrained World" sensitivity, where resources are more broadly limited. Also note that this version of the graph does not include additional conservation from high electrification.

**Figure H - 10: Annual Incremental Conservation**




The additional conservation available in high electrification load futures can be layered on top of the yearly incremental potential to show the total incremental potential, by year, available in those high electrification futures. Figure H - 11 shows the "High Electrification Adder," in darker shading, relative to the starting conservation potential. As the figure illustrates, the additional electrification potential is relatively small in early years but becomes a significantly larger portion of overall potential during the later Plan years. This pacing is mostly driven by the relatively slow rate of equipment turning over in the existing building stock.

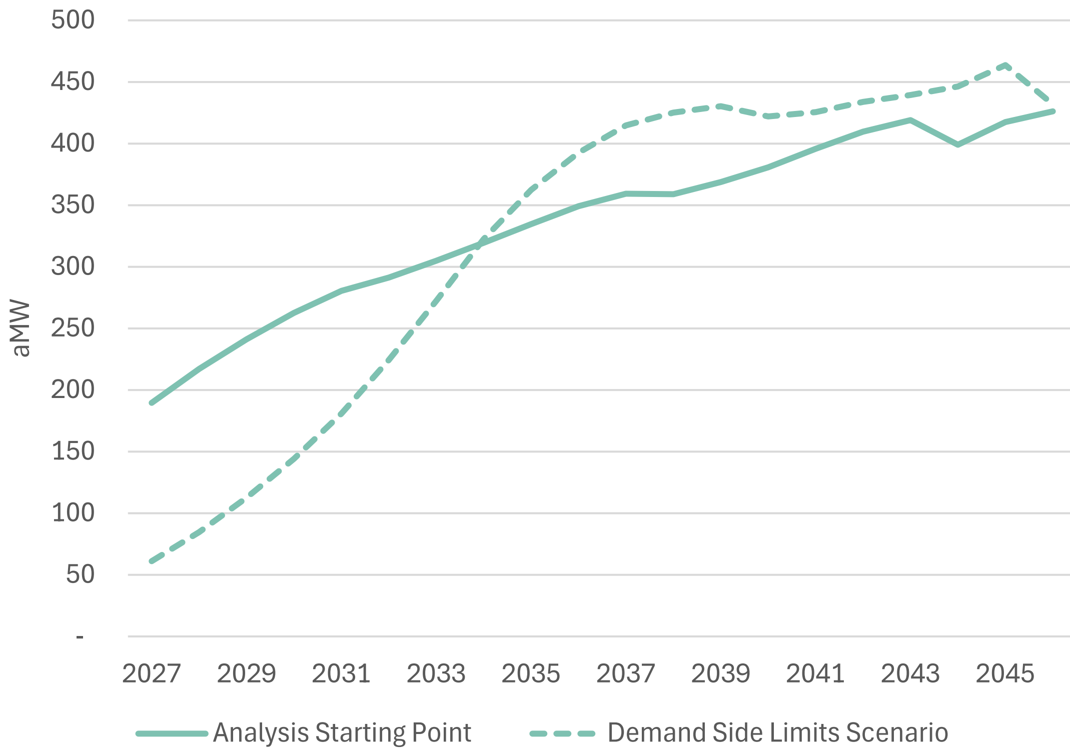
**Figure H - 11: Annual Incremental Conservation Including Electrification**




One additional factor that is used to vary the incremental conservation available each year is the assumed ramp rate for each measure. For all Power Plan sensitivities, except for one, the assumed conservation ramp rates are the same; however, for one sensitivity, “Demand Side Resource Limitations”, ramp rates are assumed to be slower for all conservation measures, to test how resource selections may differ if demand side resources like conservation were not available at the pace assumed in the analysis starting point. Figure H - 12 shows the difference in incremental annual conservation available in the analysis starting point versus the Demand Side Resource Limitations scenario.

Notice that by the end of the 20-Yr Plan period, the two lines in Figure H - 12 reach approximately the same point and have the same approximate areas under their curves. The main difference between them, however, is how quickly they can ramp to reach that potential. In the first six years of the plan period, the Demand Side Limitations sensitivity has only about one third to one half the annual conservation available as compared to the initial supply curve. This is a significant difference, particularly if the region needs resources earlier in the plan period.

**Figure H - 12: Annual Incremental Conservation Compared to Demand Side Resource Limitations ("Demand Side Limits") Sensitivity**




Finally, it is possible to represent the final set of conservation supply curves, and annual incremental conservation curves, used across all Ninth Plan sensitivities. The final supply curves for all sensitivities are shown in Figure H - 13. Note that this figure uses the final levelized cost bin definitions summarized in Table H - 6**.** The final annual incremental conservation curves for all sensitivities are shown in Error! Reference source not found..

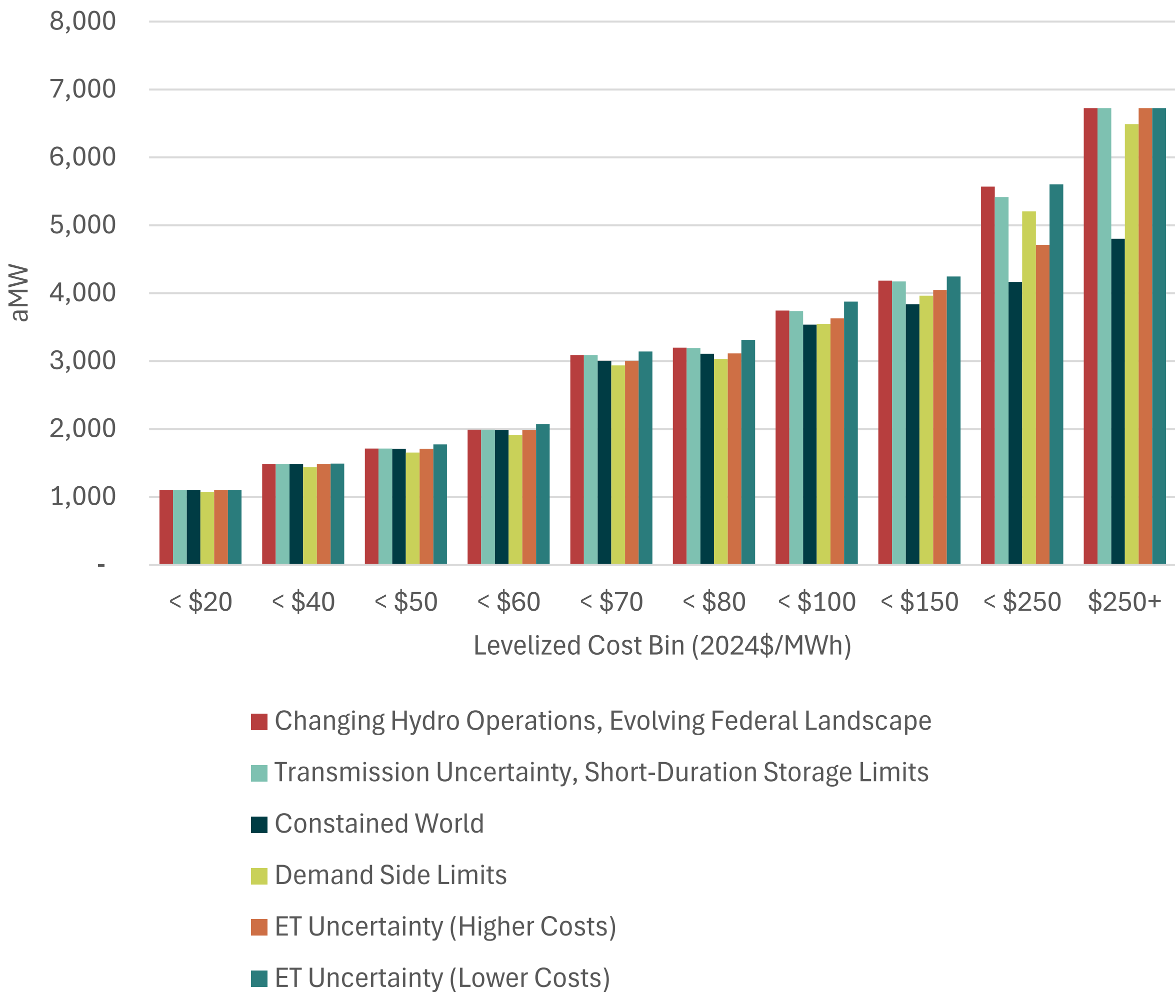
Figure H - 13 illustrates that the conservation supply curves, at least from this 20-yr cumulative view, are relatively stable across Ninth Plan sensitivities, particularly in the lower cost bins. This is largely due to the fact that many of the sensitivities alter assumptions about emerging technologies, which generally reside in the higher cost bins. Sensitivities affecting tax credits also have a relatively limited impact on the supply curves overall, as these credits apply only to a subset of conservation measures in the residential sector[25]. In addition, those measures eligible for tax credits tend to reside in the higher cost bins.

The sensitivity that looks the most different than the others, the "Constrained World", has such a large reduction in potential, because this sensitivity removes all emerging technologies for both demand and supply resources from the analysis – and recall that emerging technologies represent

[25] These measures include high efficiency heat pumps and weatherization.

approximately 2,000 aMW of potential by the year 2046. The are other differences apparent in Figure H - 13, however, all of them are less stark than the Constrained World. For example, in the sensitivity "ET Uncertainty (Higher Costs)" (where ETs cost 50% more than expected), Figure H - 13 shows that there is significantly less potential available at the < $250 bin, and all of that potential has moved to the > $250 bin.

**Figure H - 13: Final Set of Supply Curves Used Across All Ninth Plan Sensitivities**



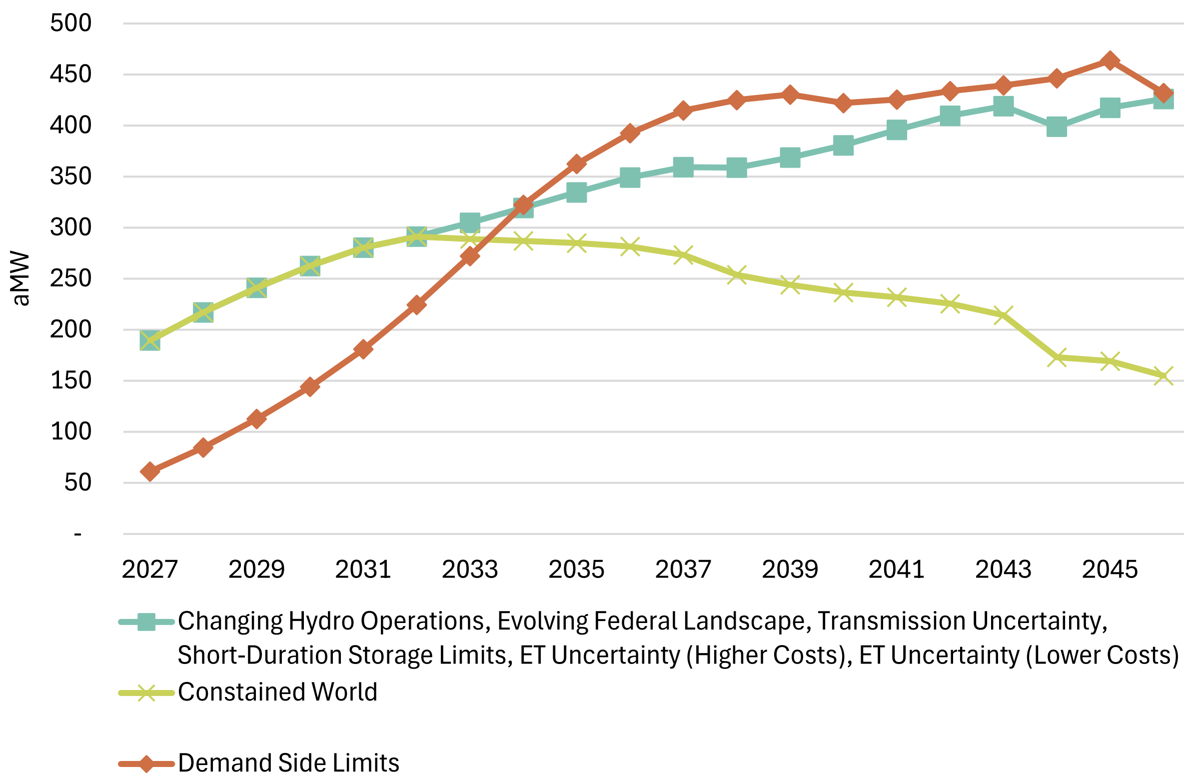

Note that the total potential reached in Figure H - 13 is slightly less than that shown in Figure H - 7, because of the way that Conservation Voltage Reduction (CVR) versus Demand Voltage Reduction (DVR) are modeled in OptGen. Since CVR and DVR are essentially the same technology,[26] the CVR savings are removed from the conservation supply curves in Figure H - 13, so that OptGen can apply

[26] With the main difference being that CVR is DVR that runs all the time.

DVR whenever the model selects it,[27] therefore, ensuring no double-counting of CVR and DVR. Also note that the effect of high electrification is not shown in Figure H - 13.

The annual incremental conservation corresponding to all Ninth Plan scenarios is shown in Figure H - 14. First note that the annual incremental conservation does not differ for all sensitivities. This is because some sensitivities affect costs alone, and do not affect either total or annual conservation acquisition. Therefore, the annual incremental conservation curves for many of the Ninth Plan sensitivities are the same.[28] The major differences in annual incremental conservation potential arise from two specific sensitivities: the Constrained World and the Demand Side Limits. For the Constrained World, the absence of ETs does not affect conservation potential in the first six years, but significantly limits it in years seven through twenty, when ETs are available. Conversely, for the Demand Side Limits sensitivity, conservation potential is significantly reduced in the first six years (by approximately 50 to 66%), but significantly increases in pace after year six.

**Figure H - 14: Annual Incremental Conservation Across All Ninth Plan Sensitivities**




[27] Including running DVR all the time, which would be interpreted as a model preference for CVR.
[28] Namely, the scenarios: Changing Hydro Operations, Evolving Federal Landscape, Transmission Uncertainty, Short-Duration Storage Limits, ET Uncertainty (Higher Costs), and ET Uncertainty (Lower Costs).

# Economic Potential

The Economic Potential is the result of the optimization modeling and final decision making by the Council and is covered in Technical Appendix O – Cost Cost-Effective Conservation Methodology and Results. Once the target has been set, the final cost-effectiveness methodology for the plan is defined. The cost-effectiveness methodology utilizes results from the modeling process to define various avoided cost components so that each current and future conservation measure can be evaluated relative to the next available resources identified in the Plan's resource strategy.

# Excel Workbooks and Tools

## Supply Curve Materials

The general structure of the Ninth Plan conservation materials consists of three different types of files:

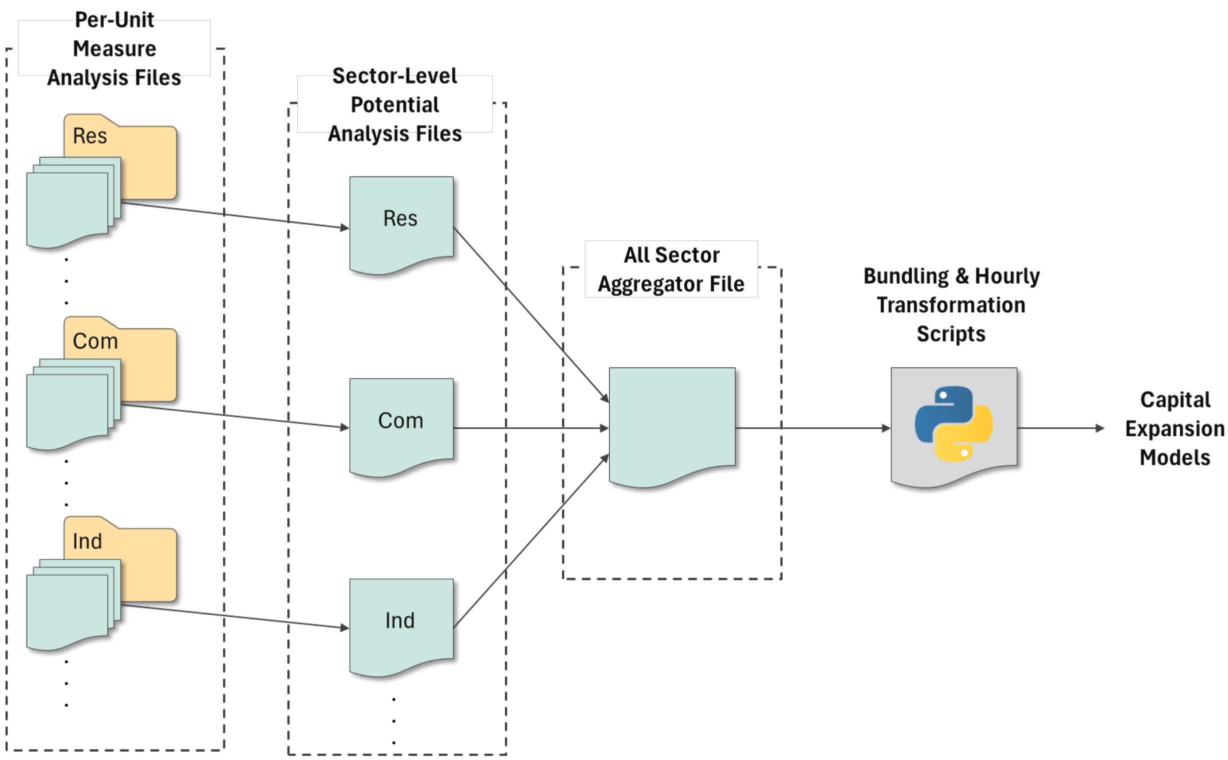
- **Per-Unit Measure Analysis Files**: These files contain the energy savings and cost analysis for one unit of a given conservation measure. For example, if a user were interested in how much energy a single residential ductless heat pump saves, or the methodology used to estimate those energy savings, they would want to look for the per-unit measure analysis for residential ductless heat pumps.
- **Sector Level Potential Analysis Files**: The sector level potential analysis files are where regional conservation potential is ultimately estimated. They accomplish this by:
    - extracting all the relevant data from the per-unit measure analysis files;
    - multiplying the per unit estimates by the number of estimated units in the region; and,
    - applying additional factors for annual achievability (ramp rates) and total overall achievability.

  The result of these calculations is a final estimate of total achievable conservation potential.
- **All-Sector Aggregator File**: This file extracts all the relevant data from the sector potential files, creating a single, annualized table of conservation potential. It also maps all conservation measures to various levelized cost and shape bins, as these are used downstream of this process, where measures are bundled by cost, shape, and modeling zone.

# Supply Curve Analysis Flow

Figure H - 15 illustrates how the supply curve data and analysis flow from one file type to another, with the per-unit measure analyses flowing into the sector potential files, the sector files flowing into the aggregator file, and the aggregator file flowing into a set of Python scripts, which are used to bundle and transform the aggerated data into a final, hourly dataset for capital expansion modeling.

**Figure H - 15: Supply Curve Analysis Flow**

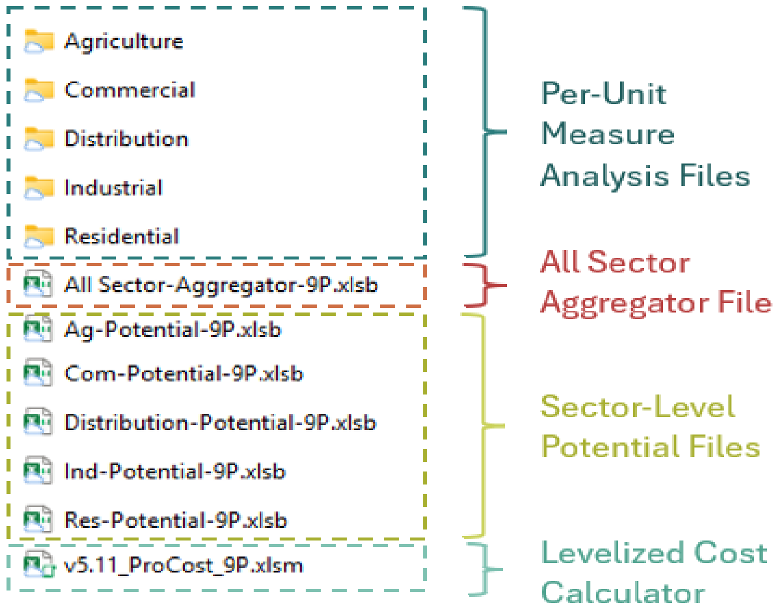



# File and Folder Structure

The files and folders that make up the Ninth Plan supply curve materials are organized according to Figure H - 16. As there are many measure analysis files, they are organized within a folder named for each sector. The measure analysis files themselves are named according to the convention "[Sector]-[Measure Name]-9P". For example, the measure analysis file for residential clothes washers is named "Res-ClothesWashers-9P.xlsm".

At the same level as the measure analysis file folders are the sector-level potential files, which are named according to the convention "[Sector]-Potential-9P", and the all-sector aggregator file ("All Sector-Aggregator-9P"). Lastly, there is a file called "v5.11_ProCost_9P". This is the Council's conservation levelized cost calculator, ProCost, that uses inputs from the measure analysis files (for energy savings, costs, and lifetime) to calculate levelized costs for each measure.

**Figure H - 16: Supply Curve File and Folder Structure**




# Where to Find More Information

For more information on these supply curve materials, please visit the Council's Ninth Plan website,[29] which contains a number of presentations, videos, and supporting materials for this work. You can also visit the Council's Conservation Resources Advisory Committee website,[30] which also contains presentations and discussions that helped guide and shape this work.

[29] https://www.nwcouncil.org/energy/ninthpowerplan.
[30] https://www.nwcouncil.org/energy/energy-advisory-committees/conservation-resources-advisory-committee.