PACIFICORP CONSERVATION POTENTIAL ASSESSMENT FOR 2021-2040, VOLUME 2

Volume 2: Supporting Material

February 26, 2021

Report prepared for:
PACIFICORP

Energy Solutions. Delivered.

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ENERGY MARKET PROFILES AND BASELINE PROJECTIONS

This appendix presents information used to characterize base-year energy consumption within PacifiCorp's service territory and to project consumption over the study period in the absence of future demand-side intervention.

Energy Market Profiles

As described in the Analysis Approach in Volume 1, Chapter 2, the market for each state, sector, and market segment is characterized by a market profile that allocates energy consumption to the available end-use and technology categories. These market profiles are calibrated to PacifiCorp equipment saturation surveys, technology and measure databases, and finally to the energy control totals listed above. Market profiles for each state and market segment in the residential, commercial, and industrial sectors are provided in the accompanying spreadsheets.

Baseline Projection

The baseline projection forms the starting point from which to assess energy efficiency opportunities over the study period. To enable a robust assessment of available potential, AEG projects baseline consumption by state, sector, market segment, end use, technology, and construction vintage, incorporating PacifiCorp's customer growth projections and known changes in equipment standards and building codes, as presented in Volume 1, Chapter 3. Detailed projections of baseline consumption are provided in the accompanying spreadsheet.

APPENDIX B

ENERGY EFFICIENCY EMERGING TECHNOLOGY MEASURES

As described in Chapter 3 of Volume 1 of this report, AEG developed the energy efficiency measure list based on a comprehensive review of measures implemented in current industry best practice programs and exhaustive research into the pipeline of technologies that may become viable over the study time horizon. The emerging technologies selected for inclusion in the study (shown in Table B-1) are measures that have not yet gained mainstream adoption but can reasonably be expected to reach commercial availability within the study time horizon.

Table B-1 Emerging Technology Measures Included in Energy Efficiency Analysis

Sector	Measure Name
Residential	Central AC: SEER 24.0 VRF
Residential	Room AC: Dual Invertor CEER 14.7
Residential	ASHP: SEER 24.0 / HSPF 10.9 EIA 2030 Projection
Residential	GSHP: EER 42 / COP 5.2
Residential	HPWH: NEEA Tier 4 Heat Pump (UEF 3.0)
Residential	LED 2025 LED 2030
Residential	Clothes Dryer: UCEF 6.65 - Heat Pump Clothes Dryer: UCEF 8.0 - Heat Pump
Residential	Stove/Oven: Induction
Residential	Home Energy Management System (HEMS)
Residential	Interior Lighting - Networked Fixture Controls
Residential	Exterior Lighting - Networked Fixture Controls
Residential	Ductless Mini Split Heat Pump with Optimized Controls (Ducted Forced Air)
Residential	Space Heating - Heat Recovery Ventilator
Residential	CO2 Heat Pump Water Heater/Space Heating
Residential	Pool Cleaner - Robotic
Residential	Building Shell - Liquid-Applied Weather-Resistive Barrier
Residential	Insulation - Wall Sheathing - External - Insulated Vinyl Siding
Residential	Stove - Smart Burners
Residential	Insulation - Wall Cavity - Thermal Break Shear
Residential	Ozone Laundry
C&I	RTU: IEER 18 - Advanced Tier VRF RTU: IEER 21.5 - EIA High Efficiency VRF
C&I	ASHP: IEER 20.3 / COP 3.7 - EIA High Efficiency
C&I	GSHP: EER 25 / COP 4.5 EIA High Efficiency
C&I	Water Heater: EF 3.90 - Heat Pump
C&I	LED 2025 LED 2030
C&I	Commercial Laundry - Ozone Treatment
C&I	Dairy - Heat Recovery from Refrigeration
C&I	Data Center - Cutting Edge Measures
C&I	Interior Lighting - Embedded Fixture Controls
C&I	Interior Lighting - Networked Fixture Controls
C&I	Interior Lighting - LEC Exit Lighting
C&I	Miscellaneous - Improved Vertical Lift Technology
C&I	Refrigeration - Permanent Magnet Synchronous Fan Motor

Sector	Measure Name
C&I	Streetlighting - Dimming and Tuning Controls
C&I	Ultra-Low Temperature Freezer - ENERGY STAR
C&I	Ventilation - Permanent Magnet Synchronous Fan Motor
C&I	Interior Lighting - Photoluminescent Exit Lighting
C&I	Center Pivot - Low Energy Spray Application
C&I	Circulating Engine Block Heater
C&I	Municipal Water Treatment - UV-C LED Disinfection
C&I	Commercial Laundry - CO2 Cleaning
C&I	Municipal Water Treatment - Pulsed Air Mixing

Certain technologies reviewed were still in the laboratory stage without reliable estimates of cost or operating characteristics at the time of the analysis and were thus excluded from the estimation of energy efficiency potential in this assessment. In addition, the savings that would be attributed to some of these measures, specifically efficient lighting, are already captured through other technologies included in the assessment, and therefore, including these emerging technologies would not have had a material, net impact on the identified potential. Table B-2 provides a list of measures falling into this category, along with a brief explanation on why each was excluded from the analysis.

Table B-2 Emerging Technology Measures Excluded from Energy Efficiency Analysis

Sector	Measure Name	Rationale for Exclusion
Residential	Ceiling Fan - Occupancy Sensor	AEG does not expect this measure to gain much traction or provide significant savings compared to residential lighting controls due to the fan's low energy use. Fan shutoff could also result in a cooling penalty if the central system must turn on mid-day because the fan stops.
Residential	Central AC - Non-Vapor Compression - Magnetocaloric	Screened out - will be reflected in high efficiency AC if they come on market, but technology is only at prototypical level.
Residential	Central AC - Waste Heat Recovery	Screened out - this measure is not being used in residential applications and would require custom knowledge of specific building loads both for the heat source (compressor superheat) and heat sink (not space heating). We do, however, model heat recovery during the winter when the heat source and sink are one in the same.
Residential	Central AC - Water-Cooled Condenser	Screened out - concept has been validated for hot/dry climates, but likely not effective strategy in PNW. Technology more applicable to larger system size (i.e. C&I chillers); smaller systems waste a lot of water and are not maintained properly. Evaporative AC and hybrid systems with evaporative pre-cooling more prevalent. This measure is not recommended for residential applications, however water-cooled chillers are common in C&I settings and are captured within our standard measure list. There are also significant health risks associated with this application in a residential setting.
Residential	Central Heat Pump - Advanced Defrost Method	Screened out - this feature is assumed to be included in advanced (highly efficient) air-source heat pumps as part of the equipment measures and should not be added as a separate measure.
Residential	Clothes Dryer - Heat Recovery	Screened out - this measure is not currently available residentially and would require custom knowledge of specific building loads to characterize the heat sink.

Sector	Measure Name	Rationale for Exclusion
Residential	Clothes Washer - Polymer Bead Washer	Screened out - Available from a few vendors but have not gained market traction . Major impact = water savings. Revisit in a couple years.
Residential	Ductless Mini Split AC	Screened out: this measure is more appropriate in southern California, where heating loads are minimal. In climates with nontrivial heating loads, this measure would neglect heating benefits realized through installation of a ductless minisplit heat pump. Additionally, central cooling is much more prevalent than zonal cooling across all segments in Utah, which reduces applicability.
Residential	Electronics - Advanced Outlets	Screened out - possible to include, but too much overlap with advanced power strips. E3T even references these as having an advanced power strip incentive from BPA.
Residential	HVAC - District Heating and Cooling	Promising; has mostly been applied to commercial campuses to date. Could be applicable for smaller residential communities (gated community, low-rise multifamily complex, cul-de-sac). Interesting application for an "Eco-Block", community, or rural microgrid; other flavors include residential geothermal loop leasing, etc. Screened out due to characterization difficulty and likelihood of custom project, but pilots should be encouraged. Technology should be explored for commercial and industrial applications.
Residential	HVAC - Electronically Commutated Motors	Screened out - effectively required by residential furnace fans starting 2019. Could be offered as drop-in replacement for existing split capacitor motors, but low operating hours/high programming costs/multi-speed baseline in residential applications would lead to low cost-effectiveness. Could add in COM sector.
Residential	HVAC - Natural Ventilation / Mixed-Mode Conditioning	Screened out - this is a commercial measure. Natural ventilation in residential sector is highly behavioral and already prevalent.
Residential	Insulation - Phase Change Building Materials	Screened out as low emerging technology with low likelihood of gaining market traction. Not commercially available at the moment. Not likely to be implemented in a residential setting.
Residential	Insulation - Aerogel	Screened out - Costs are far too high and not reliable. Recommend revisiting this high efficiency insulation level later. Some target costs are available, but this advanced insulation material is not prevalent at this time.
Residential	Insulation - Wall Cavity - Thermal Break Shear	Possible to add based on rough estimates from 2017 NEEA case study, though separating the wall insulation impacts from total home impacts (that include efficient windows) could prove challenging. This type of measure is likely to be included when designing a Zero Net Energy (ZNE) home. That measure also includes windows and other efficient shell measures.
Residential	Interior Lighting - Heliostat Daylighting	Screened out as low emerging technology with low likelihood of gaining market traction. More applicable to commercial sector, and only cost is available.
Residential	Non-Intrusive Load Monitoring	Screened out - this technology provides load disaggregation based on a single metering point as opposed to submetering each individual end use. This is considered an enabling technology and does not actually

Sector	Measure Name	Rationale for Exclusion
		save energy unless coupled with other measures and programs.
Residential	Photovoltaics - Direct DC Distribution	Screened out - not mature enough but promising. Best applied to zero net energy new construction.
Residential	Radiant Cooling - Chilled Beam/Ceiling Panels	Promising technology to investigate further; unlikely to get robust prescriptive measure characterization.
Residential	Refrigeration - Non-Vapor Compression - Magnetocaloric	Screened out - will be reflected in high efficiency refrigerators if they come on market, but technology is only at prototypical level.
Residential	Solar Pre-heater for Ventilation Air	Screened out as low emerging technology with low likelihood of gaining market traction, especially in residential sector. Consider technology in commercial application.
Residential	Ventilation - Permanent Magnet Synchronous Fan Motor	Should be added to commercial; not applicable to residential
Residential	Water Heater - Advanced Storage Tanks	Screened out - still in R&D, only target cost and savings levels available.
Residential	Windows - Aerogel Insulation	Screened out. This measure for super high-performance windows is possible, but the high cost (estimated by E3TNW to be 6x the cost of a conventional double-pane window) makes the technology unlikely to be cost effective.
Residential	Windows - Automated Shading	Screened out - No cost data available; has to be paired with dimming lighting controls and is an enabling technology for automated dynamic daylighting systems.
C&I	HVAC - Advanced Non-Vapor Compression Systems	While this a large set of important emerging technologies, it is unclear which one will win out; so far only evaporative AC (already a separate measure) and absorption/adsorption heat pumps are commercially available. Other technologies like magnetocaloric, ejector heat pump, and vuilleumier heat pump are in more advanced emerging stage. Most promising with greatest potential (yet still in R&D) is thermoelastic. These technologies are still unproven, with limited to no savings or cost data available. As these technologies come into the market and if they become competitive, the efficiencies will be reflected in HVAC efficiency levels. However, AEG encourages PacifiCorp to fund pilot projects and get better data on these systems.
C&I	Chiller - Evaporative - Sub-Wet Bulb	Given recent demonstrations by PG&E (2017) and SCE (2015), various entities see this as a promising technology. However, it will be difficult to characterize and get reliable data for savings in various locations as well as cost. Could be applicable to UT.
C&I	Commercial Laundry - Clothes Dryer - Heat Recovery	Limited development for laundromat/larger commercial applications, but nevertheless promising application. Likely more applicable to gas dryers, and not enough data to include at the moment.
C&I	Commercial Laundry - CO2 Cleaning	Promising technology that has been implemented, but is an expensive alternative to traditional PCE process. Could include as measure with rough costs and savings estimates.

Sector	Measure Name	Rationale for Exclusion
C&I	Commercial Laundry - Wastewater Recycling	Difficult to characterize and get reliable data for custom process like this, but this measure provides significant energy savings as well was water and wastewater non-energy benefits. Similar to dryer heat recovery, this is likely to be more applicable to gas water heating.
C&I	Electric Arc Furnace - Waste Heat Recovery	New Arc Furnaces are a measure from 7th Plan and in the measure list, so their saturation will have to be quantified and waste heat recovery for these units could be included as an emerging industrial measure. No cost data available; will likely have to use DEER air-to-air heat exchanger cost. However, the waste heat from these systems can be high quality and could be used to generate electricity in a Waste Heat to Power application that will be looked at during AEG's WTP&RT analysis. Therefore, the waste heat recovery measure (often used for low-grade heat) may be supplanted.
C&I	Electronics - Advanced Outlets	Screened out - possible to include, but too much overlap with advanced power strips. E3T even references these as having an advanced power strip incentive from BPA.
C&I	Food Processing - Radio Frequency Defrosting	Promising technology, although costs are not freely available. Have to exclude since this is an electrification technology that mostly replaces gas process heating of air and water for frozen food defrosting.
C&I	HVAC - Natural Ventilation / Mixed-Mode Conditioning	Screened out - difficult to define savings and costs due to the custom nature of natural ventilation flows based on building architecture, and included in Advanced New Construction Designs measure.
C&I	Insulation - Phase Change Building Materials	Screened out as low emerging technology with low likelihood of gaining market traction. Not commercially available at the moment.
C&I	Insulation - Wall Cavity - Aerogel	Screened out - no savings data available, and difficult to get trustworthy costs; recommend revisiting this high efficiency insulation level later. While some target costs may be available, this advanced insulation material is not prevalent at this time and it is especially difficult to justify the cost for the large surface area of a commercial building envelope.
C&I	Insulation - Wall Cavity - Vacuum Insulated Panels	Screened out - no savings data available, and difficult to get trustworthy costs; recommend revisiting this high efficiency insulation level later. While some target costs may be available, this advanced insulation material is not prevalent at this time and it is especially difficult to justify the cost for the large surface area of a commercial building envelope.
C&I	Non-Intrusive Load Monitoring	Screened out - this is an enabling technology that allows for more accurate disaggregation and enables more effective behavioral programs for customer feedback, in-home displays and reports, and further EE measure assessment/recommendation. Could be included as part of behavioral program suite.
C&I	Paper and Pulp - Low Shear Repulping Unit for Coated Paper Recovery	Significant amount of energy and (unquantified) non-energy benefits compared to a thermo-mechanical pulp mill processing virgin material. Can include if more data is found, but not enough to include at the moment.

Sector	Measure Name	Rationale for Exclusion
C&I	Petroleum Pump - Energy Management	This is a measure mix for the petroleum extraction segment, with energy savings of 17-52% of baseline when tested by PG&E at three (3) host sites. Data is limited. Two of the three measures are not included in the scope of the CPA
C&I	Process - Additive Manufacturing - Aerospace - Titanium Brackets	The Pacific Northwest (specifically Washington) has a large aerospace industry. AEG has found significant potential for additive manufacturing in this field. While process measures are always custom and difficult to quantify, AEG can leverage our prior case study and lifecycle analysis for this application to characterize this measure. Note: While AM does provide significant energy savings on a Btu basis, these are typically not electricity savings. Electrification/fuel switching occurs by supplanting large gas heating process with electrified AM/industrial 3D printing methods.
C&I	Process - Additive Manufacturing - Automotive - Aluminum Pump Housing	AEG has found significant potential for additive manufacturing in the automotive field. While process measures are always custom and difficult to quantify, AEG can leverage our prior case study and lifecycle analysis for this application to characterize this measure. Note: While AM does provide energy savings on a Btu basis, these are typically not electricity savings. Electrification/fuel switching occurs by supplanting large gas heating process with electrified AM/industrial 3D printing methods.
C&I	Process - Heat Treatment - Electron Beam Curing	This measure can apply across many manufacturing segments, but no costs are currently available. Possibility of fuel switching when autoclaves are direct fuel-fired, but the autoclaves discussed by E3TNW are electric. Very limited applicability.
C&I	Process - Heat Treatment - Microwave Curing/Sintering/Heat Treatment	This measure can apply across many manufacturing segments, but no costs are currently available. Possibility of fuel switching when ceramic sintering units are direct fuel-fired, but the baseline units discussed by E3TNW are electric.
C&I	Process Heating - Exhaust Energy Recovery	Screened out - custom applications that are often retrofitted on a natural gas system. No costs available.
C&I	Process Optimization - Near-Net-Shape Casting	Screened out - Promising measure, but applicable to direct fuel-fired process and unlikely to save electricity on site.
C&I	Radiant HVAC - Chilled Beam/Ceiling Panels	Promising technology to investigate further; unlikely to get robust prescriptive measure characterization.
C&I	Refrigeration - Heat Recovery	Screened out - no savings data readily available, and difficult to get trustworthy costs for a custom measure such as this. The heat recovery system must be engineered for each industrial application due to the varying parameters of the refrigeration system and heat sinks available at a particular facility.
C&I	Refrigeration - Non-Vapor Compression - Magnetocaloric	Screened out - will be reflected in high efficiency refrigeration if it comes on market, but technology is only at prototypical level.

Sector	Measure Name	Rationale for Exclusion
C&I	Refrigeration - Thermal Storage - Phase Change Materials	While this is primarily a load shifting technology, letting the refrigeration system coast over the peak period also saves energy by operating during off-peak, colder periods. Most demonstration projects have been done in Southern California with one in the Bay Area. AEG recommends further Pacific Northwest pilots and revisiting this measure once it is more prevalent. Energy savings can be included as part of Class 1&3 measure.
C&I	Windows - High Efficiency Glazing - Dynamic	Thermochromic technology not as versatile as electrochromic but potentially cheaper. Unlikely to be cost effective without non-energy benefits from comfort/productivity.
C&I	Commercial Laundry - Clothes Dryer - Automatic Cycle Termination	This feature is assumed to be included in high efficiency options and is unlikely to be implemented as a stand-alone retrofit option on packaged clothes drying systems. Clothes dryers meeting ENERGY STAR specification (20% below standard) typically employ improved automatic termination sensors to avoid wasted energy from over-drying clothes.
C&I	Scientific Irrigation Practices	Standard practice.
C&I	Motors - Two-Stage Gearboxes	Lack of reliable measure data resulted in this measures exclusion.

APPENDIX C

ENERGY EFFICIENCY RESOURCE RAMPING

This appendix presents the methods used by Applied Energy Group (AEG) to develop reasonable estimates of annual energy efficiency potential available for acquisition in PacifiCorp's California, Idaho, Utah, Washington, and Wyoming service territories for consideration in PacifiCorp's 2021 Integrated Resource Plan (IRP).

General Methodology

AEG began by estimating the technical potential for energy efficiency resources in the given territory. That is, the amount of energy that could be saved in the absence of market barriers and cost-effectiveness considerations. This technical potential is then translated to annual technical achievable potential by applying achievability factors and "ramp rates," representing the rate at which these resources could be achieved in each market. The application of achievability factors and ramp rates is consistent with the method used by the Northwest Power and Conservation Council (Council) in its 2021 Power Plan. The resulting quantities are then presented as "annual achievable technical" potential, allowing PacifiCorp's IRP model to determine the amount of technical achievable potential that is cost-effective in a given year, which informs PacifiCorp's acquisition targets in each state.

AEG assumes that energy efficiency measure acquisition is ramped (i.e., acquired) over the planning horizon depending on market availability. In general, market availability is dictated by the existence of programs, customer awareness, technology availability, and other considerations. The intent of this ramp rate is to establish a path to full market maturity for each measure or technology group and ensure that resource planning selections don't overstep acquisition capabilities. Energy efficiency resources are divided into two categories, each of which has its own timing and achievability considerations:

- *Lost Opportunity Resources* are opportunities at the time of equipment burnout or new construction. When equipment is replaced, a unique opportunity exists to upgrade efficiency at incremental (above standard equipment), rather than full cost. If standard equipment is installed, the high-efficiency equipment would not be installed until the new equipment reaches the end of its normal life cycle, without early replacement (usually requiring a significantly higher incremental cost). The same applies for opportunities at the time of new construction.
- *Discretionary Resources* are retrofit opportunities in existing building stock that are not subject to such stringent timing constraints and can, theoretically, be acquired at any point in the planning period assuming customer willingness and necessary delivery infrastructure.

The timing challenges created by lost opportunities make these resources more difficult to acquire than discretionary opportunities. As detailed in the methodology section below, the general assumption is that 85% of discretionary potential can be acquired over the planning period but that a lower share of lost opportunity resources can be acquired depending on the measure life, equipment stock turnover, and other factors. These assumptions are consistent with those used in the Council's 2021 Power Plan.

In addition to the timing considerations for each measure, it is important to recognize the interaction between the two measure types. For example, if a functioning, but inefficient, refrigerator is replaced before the end of its useful life (a discretionary opportunity), then those savings should not also be counted as an equipment replacement opportunity when the original unit would have needed to be replaced (lost opportunity). Similarly, if a home is weatherized (discretionary), upgrading the heating or cooling equipment will save less than it would have in absence of weatherization.

Both methods use recent state-specific program history to inform short-term achievable potential to account for the level of program infrastructure and awareness currently in place in each jurisdiction. This process is designed to avoid large increases or decreases in short-term acquisition, which are unlikely to occur in practice.

Specific Ramp Rate Methodology

This subsection describes AEG's process for applying ramp rates, which are presented in Table E-1 at the end of this section. Annual values for lost opportunity measure ramp rates indicate the share of the annual opportunity deemed achievable, whereas discretionary values indicate the cumulative share of the 20-year opportunity assumed to be achievable by a given year.

Measure Ramp Rates

The study applied measure ramp rates to determine the annual availability of the identified potential lost opportunity and discretionary resources, interpreting and applying these rates differently for each class (as described below). Measure ramp rates generally matched those used in the Council's 2021 Power Plan. For measures not included in the 2021 Power Plan, the study assigned a ramp rate considered appropriate for that technology (i.e., the same ramp rate as a similar measure in 2021 Power Plan).

Lost Opportunity Resources

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

In addition to natural timing constraints imposed by equipment turnover and new construction rates, the AEG team applied measure ramp rates to reflect other resource acquisition limitations over the study horizon, such as market availability. To calculate annual technical achievable potential for each lost opportunity measure, the study multiplied the number of units turning over or available in any given year by the adoption factor provided by the ramp rate times the achievability assumption, consistent with the Council's methodology. Because of the interactions between the equipment turnover and new construction, the lost opportunities of measure availability until the next life cycle, and the timeframe limit at 20 years, the Council methodology for these measures produces potential less than 85% of technical potential.

Discretionary Resources

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

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

Table C-1 Energy Efficiency Measure Ramp Rates

Ramp Rate Name	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Retro12Med	11%	11%	11%	11%	11%	10%	8%	6%	5%	4%	3%	3%	2%	2%	1%	1%	0%	0%	0%	0%
Retro5Med	4%	5%	6%	8%	9%	10%	11%	11%	11%	9%	7%	5%	3%	1%	1%	0%	0%	0%	0%	0%
Retro1Slow	0%	1%	1%	1%	2%	3%	4%	6%	7%	8%	9%	10%	10%	9%	8%	7%	5%	4%	2%	2%
Retro50Fast	45%	21%	14%	9%	6%	3%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Retro20Fast	22%	16%	11%	8%	7%	6%	5%	5%	4%	3%	3%	2%	2%	1%	1%	1%	1%	1%	1%	0%
RetroEven20	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Retro3Slow	1%	1%	2%	3%	5%	7%	8%	10%	11%	11%	10%	9%	7%	6%	4%	3%	2%	1%	1%	1%
LO12Med	11%	22%	33%	44%	55%	65%	72%	79%	84%	88%	91%	94%	96%	97%	99%	100%	100%	100%	100%	100%
LO5Med	4%	10%	16%	24%	32%	42%	53%	64%	75%	84%	91%	96%	99%	100%	100%	100%	100%	100%	100%	100%
LO1Slow	1%	1%	2%	3%	5%	9%	13%	19%	26%	34%	43%	53%	63%	72%	81%	87%	92%	96%	98%	100%
LO50Fast	45%	66%	80%	89%	95%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
LO20Fast	22%	38%	48%	57%	64%	70%	76%	80%	84%	88%	90%	92%	94%	95%	96%	97%	98%	98%	99%	100%
LOEven20	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
LO3Slow	1%	1%	3%	6%	11%	18%	26%	36%	46%	57%	67%	76%	83%	88%	92%	95%	97%	98%	99%	100%
LO80Fast	76%	83%	88%	92%	95%	97%	98%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

APPENDIX D

COMPARISON OF WASHINGTON MEASURES TO THE AND THE RTF AND 2021 POWER PLAN

In compliance with Chapter 19.285 of the Revised Code of Washington (RCW), Chapter 480-109 of the Washington Administrative Code (WAC), and as described in Volume 1 of this report, this study employs methodologies consistent with the Northwest Power and Conservation Council's (Council's) Power Plan to estimate available energy efficiency potential in PacifiCorp's Washington territory. Additionally, AEG conducted a thorough review of baseline and measure assumptions used by the Council or by the Regional Technical Forum (RTF); these included costs, savings, applicability, and base year saturation. Although this study relies on data specific to PacifiCorp's service territory wherever possible, Council/RTF assumptions were incorporated where appropriate.

Previous CPAs have relied heavily on measure assumptions from the most recent Council Power Plan in addition to the latest RTF workbooks in place at the time of the analysis. However, because measure assumptions in the 2021 Power Plan include assumed impacts of future climate change, the current CPA tended to focus on RTF workbooks and only incorporated 2021 Power Plan information for certain non-weather sensitive measures.

As part of this multi-state study, measures were mapped, where possible, to RTF workbooks. However, not all measure names, measure-efficiency tiers, measure iterations, and measure savings will directly mirror the RTF. These differences account for changes in federal equipment efficiency standards, the latest version of Washington energy code(s), and characteristics specific to PacifiCorp's territory, where appropriate. For certain measures, due to the overall complexity of updating the RTF measure savings to current code and standards directly, the measure savings were calculated as a percent of end-use consumption and assumed to apply as such throughout the analysis time horizon.

Comparisons of CPA and RTF/2021 Power Plan measure savings assumptions for the residential, commercial, industrial, and irrigation sectors are provided in the accompanying spreadsheet.

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APPENDIX | E

WASHINGTON LOW-INCOME POTENTIAL ANALYSIS

In previous CPAs performed for PacifiCorp, AEG estimated energy efficiency potential based on average customer profiles without differentiation by household income. However, to address recent developments in Washington State, AEG worked with PacifiCorp to segment Washington customers by income to provide separate estimates of energy efficiency potential in low- and standard-income homes. Most notably:

- Senate Bill 5116 (also known as the Clean Energy Transformation Act or CETA), signed into law by Governor Inslee on May 7, 2019, imposes new requirements on electric utilities regarding energy assistance[1] program development, funding, and reporting.[2]
- In accepting PacifiCorp's 2020-2021 Biennial Conservation Plan, the Washington Utilities and Transportation Commission directed that "[t]he low-income savings potential must be included in the 2022-2023 Biennial Conservation Plan along with a description of how the plan prioritizes energy assistance to low-income households with the highest energy burden and future actions under consideration to improve this prioritization.."[3]

By estimating energy efficiency potential based on PacifiCorp's average customer, previous CPAs have inherently captured energy efficiency in low-income homes, however, given these recent developments, PacifiCorp deemed it necessary to make the assessment of low-income energy efficiency potential more explicit in the current CPA (which will inform PacifiCorp's 2022-2023 Biennial Conservation Plan). This appendix describes AEG's general methodology for segmentation customers and assessing available potential by income level.

Customer Segmentation

Because PacifiCorp proactively identified the need for this analysis prior to the CPA materially beginning, AEG was able to build a distinction by income directly into the residential customer segmentation used for the overall CPA, rather than performing a separate, out-of-model analysis. The typical CPA modeling segments residential customers into three home types: single family, multifamily, and mobile homes. AEG used the following data sources to create new low income[4] segments within each of these building types:

- PacifiCorp's customer database, was used to develop customer counts of energy sales totals by home type. Note, PacifiCorp's customer database does not include information on income.
- PacifiCorp residential survey results were used to estimate the percentage of low income customers in each home type and to develop differing saturations of end use equipment (e.g., electric space heating) by building type and income level.

Using the data above, AEG estimated the number of customers and the associated load in the study base year (2018) for Washington residential customers by home type and income level. As shown in Table E-1, roughly 20% of PacifiCorp's Washington residential customers were classified as low-income. Within the

[1] "Energy assistance" is defined as a program undertaken by a utility to reduce the household energy burden of its customers. This includes weatherization, conservation services and monetary assistance. RCW 19.405.020 (15)

[2] RCW 19.405.120 (2) and RCW 19.405.120 (4)

[3] Order 01 in Docket UE-190908, Attachment A, condition 9(a)

[4] For the purpose of this analysis, "low income" was defined as below 200% of the federal poverty level

group of low income customers, only about half live in single family homes, as compared to 80% of standard income customers.

Table E-1 Base-Year Customers and Load by Segment and Income Level

Home Type	Income Level	2018 Customers	2018 Load (MWh at Gen)	% of Total Customers	% of Total Load
Single Family	Standard	57,460	974,106	53%	56%
Mobile Home	Standard	7,233	138,375	7%	8%
Multi-Family	Standard	8,184	85,534	8%	5%
Standard Income Subtotal			**72,877**	**1,198,016**	**68%**
Single Family	Low	17,455	301,475	16%	17%
Mobile Home	Low	5,497	105,757	5%	6%
Multi-Family	Low	11,988	125,931	11%	7%
Low Income Subtotal			**34,940**	**533,164**	**32%**
Residential Total			**107,817**	**1,731,180**	**100%**

Additional detail on base-year consumption by end use and technology is provided in Appendix A.

Energy Efficiency Potential

Table E-2 presents Washington residential baseline loads and cumulative potential in 2040 by home type and income level. As shown, the analysis identified potential in low-income homes as slightly higher than standard-income homes as a percent of baseline sales. This increase reflects differences in end use and technology saturations identified through PacifiCorp's customer survey. Detailed measure-level results are provided along with all other states and sectors in Appendix G.

Table E-2 Cumulative Energy Efficiency Potential by Home Type and Income Level in 2040

Home Type	Income Level	Baseline Loads (MWh)	Technical Potential (MWh)	Achievable Technical Potential (MWh)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
Single Family	Standard	1,198,866	364,943	242,465	56%	20%
Mobile Home	Standard	152,471	59,715	42,135	10%	28%
Multi-Family	Standard	107,179	26,432	17,035	4%	16%
Standard Income Subtotal		**1,458,516**	**451,090**	**301,634**	**69%**	**21%**
Single Family	Low	330,784	112,411	76,162	17%	23%
Mobile Home	Low	113,551	45,989	32,572	7%	29%
Multi-Family	Low	155,406	39,827	26,065	6%	17%
Low Income Subtotal		**599,740**	**198,227**	**134,799**	**31%**	**22%**
Residential Total		**2,058,256**	**649,317**	**436,433**	**100%**	**21%**

APPENDIX | F

STATE-LEVEL ADMINISTRATIVE COST ANALYSIS AND FINDINGS

Program administration costs are a key consideration in assessing the cost-effectiveness of energy efficiency resources from both the Total Resource Cost and Utility Cost Test perspectives. Because these costs can vary significantly based on specific characteristics of a utility's service territory, it is important for assessments of conservation potential to incorporate reasonable estimates of likely program administrative costs to align resource planning with program delivery. To inform the current CPA, AEG reviewed recent PacifiCorp program experience to update state-specific administrative cost assumptions. The results of this analysis and the administrative cost percentages ultimately used in the CPA are provided below. The results of this analysis were presented to PacifiCorp IRP stakeholders at an August 2020 CPA workshop.[5]

Summary Conclusions

AEG had three key takeaways from this analysis:

- The analysis of PacifiCorp program costs reveals that administrative costs are substantially lower in Utah compared with the other states.
- Administrative costs as a percentage of measure costs have been generally increasing over the past five years, likely as a result of low-cost lighting opportunities moving out of programs. Using five-year average administrative costs to inform future projections likely presents a conservative estimate of actual administration costs.
- AEG recommends varying administrative cost values as a percent of incremental customer costs by state. AEG recommends using a value of 20% of Utah, 38% of Washington, 54% for California, 46% for Idaho, and 37% for Wyoming.

The analysis approach and results are presented in more detail below.

[5] See slide 17 from the presentation available at the following link: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/08-28-2020_PacifiCorp_2021_IRP_PIM.pdf

Approach

AEG focused on administrative costs as a percent of incremental customer, representing utility costs required to administer energy efficiency programs divided by total incremental customer costs (before netting out any energy efficiency incentives provided by the utility). The standard planning assumption used by the Northwest Power and Conservation Council in developing its Power Plans is 20%, meaning that for every $100 a customer spends; the utility must pay an additional $20, not including customer incentives.

AEG utilized data from PacifiCorp's Annual Reports[6] for the five states of interest to quantify utility spending on energy efficiency programs for the years of 2014 through 2018, the most recent years with fully reconciled data available at the time of the analysis. Among other things, the annual reports include data on utility administrative spending, incentives, and gross customer costs at the state, program, and even measure category level. AEG constructed a database containing this data from all reports and then we rolled the data up at the state-level to quantify the impacts. We began by identifying the non-incentive administrative costs to include in the analysis. Within the non-incentive administrative costs, AEG included:

- Portfolio Costs
- Engineering Costs
- Utility Admin Costs
- Program Development Costs
- Program Delivery Costs

The analysis excluded costs for NEEA payments as well as costs for low-income programs and school education. We removed NEEA costs because they have been considered separately of other DSM programs in the past. Low-income program costs were excluded since those programs are administered for reasons that go beyond achieving energy savings, which makes them costlier to run. Finally, energy educational programs were excluded because these programs are not always implemented as a means of acquiring cost-effective energy savings.

The second step was to exclude specific programs from the analysis.

- Home Energy Reports (HER) were excluded because the program is administered separately from other programs and customers do not incur a cost to participate, which is not representative of non-behavioral programs. Additionally, a large majority of HER potential is captured within the potential study baseline since these programs have already matured and expanded within the territory.
- "See Ya Later Refrigerator", PacifiCorp's appliance recycling program, was cancelled in 2016 due to high measure costs and is no longer offered to customers. Since potential from recycling measures will not be captured within the potential study, we excluded these programs as well.

All other PacifiCorp programs namely Home Energy Savings (HES) and Wattsmart Business, were included in the analysis.

Analysis of PacifiCorp Data

Results of this analysis for each state and year are presented below.

[6] Please see "Reports and Program Evaluations by Jurisdiction" for the publicly available data used to conduct this analysis at: http://www.pacificorp.com/es/dsm.html.
California reports have not been published but were provided to AEG for this analysis.

Table F-1 Utility Administrative Costs as Percent of Incremental Measure Cost for PacifiCorp's Service Territory, 2014-2016

Admin % Customer	Utah	Washington	California	Idaho	Wyoming
2014	17%	34%	46%	*60%*	49%
2015	19%	34%	30%	36%	41%
2016	19%	37%	42%	36%	27%
2017	22%	45%	83%	44%	37%
2018	24%	43%	67%	64%	43%
All Years	**20%**	**38%**	**54%**	**46%**	**37%**

AEG noted two key trends from this analysis:

- It is less expensive for PacifiCorp to administer energy efficiency programs in Utah. PacifiCorp's Utah market is substantially larger than PacifiCorp's markets in the other states. In addition, the Utah market has more high-use customers, which are less expensive to serve because relatively few transactions yields substantial savings. In addition, the service territory is more urban, and the higher density makes it easier for PacifiCorp and its trade allies to serve. The fact that Utah is more urban, while the other service territories are more rural, leads us to a recommendation to quantify administrative costs for Utah separately from PacifiCorp's four more rural territories.
- There can be significant variation in year-on-year administrative costs, particularly in smaller states. California and Idaho show large swings in administrative costs over the five-year period. Rather than attempting to determine whether these values were true outliers, AEG averaged costs over the five-year period to reflect that high or low single-year values may occur in the future.

APPENDIX G

ENERGY EFFICIENCY DETAILED RESULTS

The accompanying spreadsheet provides detailed inputs and outputs from the assessment of energy efficiency resources.

APPENDIX | H

DEMAND RESPONSE DETAILED ASSUMPTIONS

The accompanying spreadsheet provides the following information used to perform the demand response analysis:

- Grid services eligibility matrix
- Technology-level assumptions (shed fractions, per-unit impacts, and participation rates)
- Program assumptions (event duration and costs)

APPENDIX

DEMAND RESPONSE DETAILED RESULTS

The accompanying spreadsheet provides the following detailed results from the assessment of demand response resources:

- Levelized costs and annual program potential by event duration
- Annual program potential by grid service

APPENDIX | J

NON-ENERGY IMPACTS OF DEMAND RESPONSE

Overview

Through PacifiCorp's 2021 IRP public input process, stakeholders expressed interest in understanding potential non-energy impacts (NEIs) of demand response programs. While AEG includes NEIs for Washington energy efficiency resources within the Conservation Potential Assessment (CPA), NEIs are historically not considered in assessing demand response potential. To answer stakeholders' questions regarding the applicability of NEIs to demand response resources, PacifiCorp engaged AEG to conduct a limited literature review of industry-standard practices and the extent to which other utilities and planning organizations are considering NEIs in demand response. Specifically, the goal was to determine to what extent utilities in other jurisdictions quantify, monetize, and attribute NEIs to demand response programs.

We summarize the literature sources reviewed, key findings, and recommendations for how PacifiCorp may consider incorporating NEIs into future demand response analysis below.

Summary of Literature Review

To investigate the application of NEIs to demand response resources, AEG reviewed several documents. While AEG did not find any monetized NEIs, some sources did describe potential non-energy benefits or costs, which we assigned to three categories: Societal, Utility, and Participant NEIs. First, we summarize the documents AEG reviewed in the bulleted list below. Subsequently, in Table 1, we map the NEIs into the three categories (e.g., Societal, Utility, Participant), indicate the source document with a footnote, and identify each NEI as either a cost, benefit, or both using a color-coding.

- California Public Utilities Commission. 2016 Demand Response Cost Effectiveness Protocols. July 2016 (CPUC Protocols).[7] The CPUC Protocols provide a method for measuring the cost-effectiveness of demand response programs. The protocols have a section that discusses the non-energy and non-monetary benefits (Section 3.J.) that may benefit utilities, demand response participants, and the society at large from participation in demand response programs. The CPUC Protocols classify non-energy benefits and costs into three categories (e.g., Societal, Utility, Participant) and provide examples of non-energy benefits and costs. While the CPUC Protocols do not provide any monetary values for NEIs, they highlight a document on how to quantify them for low-income energy efficiency programs.8 This document may be beneficial to demand response programs. The CPUC invites load-serving entities or third-party operators to submit evidence (supported by data) of NEIs associated with demand response programs. Because customer costs to participant in demand response programs are hard to quantify but can be significant, the CPUC Protocols recommend using a percentage of the incentive as a proxy for participant costs. Note, AEG included this adjustment factor in the Levelized cost calculations for demand response resources in the Pacific Power states in the current CPA.

[7] The California 2016 Protocols are available at the following URL: https://www.cpuc.ca.gov/General.aspx?id=7023

[8] Skumatz et al. Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California" issued May 11, 2010. URL: https://assets.ctfassets.net/ntcn17ss1ow9/1LNLp3UBSjYLSaWv5BGyss/13518eaf1453294dd8e40cc8ca3d5871/LIEE_Non-Energy_Benefits_Revised_report.pdf

- **EPRI. The Total Value Test: A Framework for Evaluating the Cost-Effectiveness of Efficient Electrification. August 2019**.[9] The Brattle Group prepared this report for EPRI. The report discusses a new metric to determine the cost-effectiveness of electrification programs. The new metric—the Total Value Test (TVT)—uses quantifiable costs and benefits associated with efficient electrification. Although the report focuses on electrification, given the Brattle Group's extensive work assessing demand response resources, including a 2020 presentation as part of a Washington Utilities and Transportation Commission proceeding, AEG contacted The Battle Group for their perspective on the application of NEIs to demand response. Ryan Hledik, a Principal at The Battle Group provided the following:

  "Reports such as the California Standard Practice Manual, the National Standard Practice Manual, and Brattle's "Total Resource Value Test" acknowledge the potential for incorporating non-energy benefits into DR cost-effectiveness evaluations. However, I'm not aware of instances where these methodologies have been fully implemented in practice."

- **National Energy Screening Project, National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources. August 2020**.[10] The National Standard Practice Manual (NPSM) guides developing jurisdiction-specific approaches to cost-benefit analyses of distributed energy resources, including demand response. Chapter 7 of the NPSM discusses the benefits and costs most relevant to demand response resources. Because the NSPM does not provide any monetary values for NEIs, AEG reached out to one of the NPSM co-authors to ask about monetary NEIs applicable to demand response programs. This co-author was unaware of any monetary NEIs currently used to determine the cost-effectiveness of demand response programs.

- **Northwest Power and Conservation Council. Draft 2021 Power Plan Demand Response Supply Curves**. Per email correspondence with Northwest Power and Conservation Council staff, the 2021 Power Plan does not apply NEIs to demand response resources.

[9] The EPRI report is available at the following URL: https://www.epri.com/research/products/000000003002017017

[10] The NSPM is available at the following URL: https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/)

Table 1 Example Non-Energy Benefits and Costs of Demand Response Programs

Societal Non-Energy Impacts	*Utility Non-Energy Impacts*	*Participant Non-Energy Impacts*
Employment above the job creation benefits of manufacturing a combustion turbine or constructing T&D upgrades[1] [2] [3]	Changes in billing costs of utility (e.g., customers unable or unwilling to participate may see bill increases, customers responding to demand response signals may see bill decreases)[1]	Satisfaction/pride from preventing outages and being "green"[1] [3]
Economic development (e.g., changes in gross domestic product)[2] [3]	Changes in the number of customer complaint calls or service requests[1]	Improved ability of integrated load management solutions to manage energy use (e.g., demand response -enabled thermostat)[1]
Improved air quality (avoiding criteria pollutants above and beyond the level of existing environmental regulations)[1] [2] [3]	Changes in the number of delinquent bills or disconnections[1]	Economic well-being (e.g., fewer bill-related calls, fewer power shut-offs/reconnects, reduced foreclosures)[3]
Additional greenhouse gas (GHG) mitigation benefits (beyond avoided GHG cost embedded in the energy price and criteria pollutants included in the generation cost)[1] [3]	Improved customer relations[1]	Better public image for commercial enterprises[1]
Changes in public health including healthcare and healthcare insurance costs associated with lower emission levels, especially decreased air pollution (gains with less pollution, loss with back-up generators, potentially more medical emergencies with malfunctioning medical equipment)[1] [2] [3]	Reduced marketing and administrative costs due to demand response customer participation in multiple distributed energy resource programs[1]	Transaction costs beyond the demand response technology/service itself (e.g., application fees, paperwork, time spent researching processes, developing load shedding plans)[3] [5]
Environmental justice improvements[1] [3]		Productivity losses (e.g., lower productivity levels, more spoilage/defects, lower sales during DR events)[3] [5]
Impacts on cultural resources[1]		Convenience/comfort losses (e.g., thermal, lighting levels/aesthetics)[3]
Changes in noise pollution (e.g., benefit when equipment is shut off, but cost when back-up equipment is turned on)[1] [2]		Safety and health losses (e.g., less lighting may lead to increased crime, non-operational medical equipment)[4]
Biological impacts[1]		Improved asset value (e.g., improved property value, equipment functionality/performance improvement)[3]

Societal Non-Energy Impacts	*Utility Non-Energy Impacts*	*Participant Non-Energy Impacts*
Land use, including impacts of energy infrastructure on local ecosystems (fewer power plants)[1]		
Changes in water use, wastewater treatment, and water quality[1]		
Changes in visual resources (e.g., due to removal of power plant stacks or transmission towers, or adding back-up equipment)[1]		
Increases/decreases in criteria pollutants and GHG emissions (e.g., participants use back-up diesel generators during DR events or increases when loads shift from hours with low- to high-emission resources)[2]		
Improved energy security/resilience (e.g., reduced dependence on imported fossil fuels)[2] [3]		

LEGEND:

Green color = typically a benefit	*Yellow color = either a benefit or a cost*	*Red color = typically a cost*

Data sources and notes:

1. California Public Utilities Commission. 2016 Demand Response Cost Effectiveness Protocol, July 2016.
2. EPRI. *The Total Value Test: A Framework for Evaluating the Cost-Effectiveness of Efficient Electrification.* August 2019.
3. National Energy Screening Project, *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources.* August 2020.
4. AEG added this, as it was missing from the three sources.
5. AEG is already capturing the transaction costs beyond the demand response technology/service itself in the cost-effectiveness analysis.
6. AEG is already capturing the productivity losses in the cost-effectiveness analysis.

Key Findings and Recommendations

AEG's research indicates that many non-energy benefits and costs apply to demand response resources, but we could not find any evidence of these values used in practice. The Brattle Group confirmed our finding. While the industry has conducted significant work to attribute, quantify, and monetize non-energy impacts of energy efficiency, demand response resources have not benefited from this rigor. The estimation of participant costs in the CPUC Demand Response Protocols is a notable exception, which PacifiCorp has already incorporated into its analysis. AEG recommends PacifiCorp continue to monitor developments in this area to determine whether a more rigorous analysis of non-energy impacts of demand response can inform future resource planning efforts.

APPENDIX | K

DEMAND-SIDE RATES SUPPORTING MATERIAL

The accompanying spreadsheet provides the following information used to perform the demand-side rates analysis:

- Participation assumptions
- Impact assumptions during summer and winter peak periods

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