AEG

PACIFICORP CONSERVATION POTENTIAL ASSESSMENT FOR 2023-2042

Volume 2: Supporting Materials

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A | 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.

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: CEER 15.0
Residential	Air-Source Heat Pump: SEER 24 / HSPF 13
Residential	Ductless MSHP: SEER 30 / HSPF 14.0
Residential	HPWH: NEEA Tier 4 Heat Pump (UEF 3.0) HPWH: NEEA Tier 5 Heat Pump (UEF 3.5)
Residential	Int. and Ext. Lighting: LED 2030 Int. and Ext. Lighting: LED 2035
Residential	Clothes Dryer: UCEF 6.1 - Heat Pump Clothes Dryer: UCEF 8.0 - Heat Pump
Residential	Building Shell - Liquid-Applied Weather-Resistive Barrier
Residential	Building Shell - Whole-Home Aerosol Sealing
Residential	CO2 Heat Pump Water Heater/Space Heating
Residential	Exterior Lighting - Networked Fixture Controls
Residential	Home Energy Management System (HEMS)
Residential	HVAC - Energy Recovery Ventilator
Residential	Insulation - Wall Cavity - Thermal Break Shear
Residential	Insulation - Wall Sheathing - Pre-Insulated Vinyl Siding
Residential	Interior Lighting - Networked Fixture Controls
Residential	Stove - Smart Heating Elements
Residential	Building Shell - High Reflectivity Shingles
Residential	Water Heating - Connected Hot Water Controller
Residential	Windows - Dynamic Glazing
Residential	Windows - High Efficiency (U-0.17)
C&I	Air-Source HP: IEER 20.3 / COP 3.7 - EIA High Efficiency
C&I	Geothermal HP: EER 25 / COP 4.5 EIA High Efficiency
C&I	Int. and Ext. Lighting: LED 2030 (with and without Controls) Int. and Ext. Lighting: LED 2035 (with and without Controls)
C&I	Interior Lighting - Photoluminescent Exit Lighting
C&I	Interior Lighting - Retrofit - Networked Lighting Controls
C&I	RTU: IEER 21.5 - EIA High Efficiency VRF
C&I	WC Chiller: COP 13.03 (0.27 kW/ton) WC Chiller: COP 14.07 (0.25 kW/ton)

Sector	Measure Name
Commercial	Clothes Dryer: UCEF 6.1 - Heat Pump Clothes Dryer: UCEF 8.0 - Heat Pump
Commercial	Commercial Laundry - Ozone Treatment
Commercial	Commercial Laundry - CO2 Cleaning
Commercial	Data Center - Cutting Edge Measures
Commercial	Kitchen Ventilation - Heat Recovery
Commercial	Ventilation - Adsorbent Air Cleaning
Commercial	Ventilation - High Efficiency Motors
Commercial	Water Heater: EF 3.90 - Heat Pump
Commercial	Windows - Dynamic Glazing
Commercial	Windows - High Efficiency Glazing - Thin Triple-Pane
Industrial	Municipal Water Treatment - UV-C LED Disinfection
Industrial	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 in 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.

Sector	Measure Name	Rationale for Exclusion
Residential	Clothes Dryer - Heat Recovery	Screened out - this measure is not currently available residentially and would require much larger heat sources to realize significant savings for recovering heat through domestic hot water or space heating end uses. Heat pump clothes dryers (already included in measure list) recover internal waste heat.
Residential	Clothes Washer - Polymer Bead Washer	Screened out - Available from a few vendors but have not gained market traction. Major impact = water savings. Same situation in 2022 as in original screen; main model is offered by Xeros and is more applicable to commercial segment due to higher volumes and higher uniformity of laundry material.
Residential	Ductless Mini Split AC	Screened out: this measure is more appropriate in southern areas 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. If advanced power strips were deactivated for RTF purposes, there is limited appetite for outlets. California only deems power strips.
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, but is too complex for Class 2 inclusion for the time being.
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 - this advanced insulation material is not commercially available for building envelope applications at this time. While some target costs are available, these are still too high for cost-effective implementation. A project for lower-cost aerogel insulation production is currently in Phase 1 of federal funding (as of 2022).
Residential	Interior Lighting - Heliostat Daylighting	Screened out as low emerging technology with low likelihood of gaining market traction. More applicable to commercial sector, and high costs are still an issue.
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 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. While this measure could save a significant amount of energy, the niche end uses and technologies it requires(e.g., direct-wired DC lighting, HVAC with DC motors, EV charging station without inverter) make it too immature to include for now.

Sector	Measure Name	Rationale for Exclusion
Residential	Radiant Cooling - Chilled Beam/Ceiling Panels	Promising technology to investigate further; unlikely to get robust prescriptive measure characterization. Best in hot, dry climates and is more applicable to commercial, but has had limited market penetration to date. Incorporated as part of commercial Advanced New Construction Designs measure.
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	Windows - Automated Shading	Screened out - No cost data available; for lighting savings this measure has to be paired with dimming lighting controls and is an enabling technology for automated dynamic daylighting systems. Significant overlap with other measures, such as cellular shades and external shading already in manual shading measure.
Residential	Ductless Mini Split Heat Pump with Optimized Controls (Ducted Forced Air)	Was in the prior measure list based on a proposed RTF measure, but the measure data is not available yet. RTF is still waiting on research.
Residential	Advanced New Construction Design - Connected Communities	Screened out - Connected Communities (CCs) are collections of buildings (e.g., homes, schools, campuses, mixed use etc.) that incorporate central controls (or intelligence) to manage multiple DERs at the multi-building scale, enabling communication to and from the grid for optimized and coordinated operations and dispatch. This set of holistic measures includes smart electric panels, district HVAC, and intelligent controls for proper balancing of DERs and home systems. Too early to quantify energy savings, and significant overlap with private generation considerations.
Residential	Clothes Washer - Ozone Laundry	Counted as commercial multifamily for common area. A new ozone laundry system is added-on to new or existing residential clothes washing machine(s) or washing machines located in multifamily building common areas.
C&I	Electronics - Advanced Outlets	Screened out - possible to include, but too much overlap with advanced power strips. If advanced power strips were deactivated for RTF purposes, there is limited appetite for outlets. California only deems power strips.
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	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.

Sector	Measure Name	Rationale for Exclusion
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	Motors - Two-Stage Gearboxes	Lack of reliable measure data resulted in this measures exclusion.
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	Radiative Sky Cooling System	Screened out: demonstration results limited to California, only applicable to hotter climates. These roof-mounted radiative sky cooling panels have a specialized film that cools when outside. Case study results from Sacramento (SMUD) show that savings from this measure yield less energy savings than photovoltaic panels covering a similar roof footprint.
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. Furthermore, impacts are almost always on gas systems rather than electric ones. 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.
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, and there is very limited information focusing on energy savings instead of peak shifting. AEG recommends further Pacific Northwest pilots and revisiting this measure once it is more prevalent.
C&I	Ventilation - Hybrid Exhaust Fan	Screened out: technology still in testing mode. The hybrid turbine-style exhaust fan combines high-efficiency, variable-speed, Electrically-Commutated (EC) motors with a turbine-style fan, to harness wind and reduce power usage. This combination of technologies is more generally known as a "hybrid" exhaust system.
Commercial	Advanced New Construction Design - Connected Communities	Screened out - Connected Communities (CCs) are collections of buildings (e.g., homes, schools, campuses, mixed use etc.) that incorporate central controls (or intelligence) to manage multiple DERs at the multi-building scale, enabling communication to and from the grid for optimized and coordinated operations and dispatch. This set of holistic measures includes smart electric panels, district HVAC, and intelligent controls for proper balancing of DERs and building systems. Too early to quantify energy savings, and significant overlap with private generation considerations.
Commercial	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 is still difficult to characterize and get reliable data for savings in various locations as well as cost. Most applicable to UT, but no reliable meta-analysis available for the characterization of this custom measure.

Sector	Measure Name	Rationale for Exclusion
Commercial	Commercial Laundry - Clothes Dryer - Heat Recovery	Limited development for recovering heat to water or space heating, but nevertheless promising application. Likely more applicable to gas dryers. Heat pump clothes dryers are already recovering heat internally, which reduces drying energy use by up to 60% and is already covered by the more advanced heat pump dryer levels.
Commercial	Commercial Laundry - Tunnel Washers	Screened out: already have advanced laundromat measures. Limited energy savings, significant water savings. A tunnel washing machine utilizes a porous Archimedes screw to move laundry and wash water in opposite (or counterflow) directions. The laundry travels in the upslope direction, while the wash water travels downslope through the holes in the Archimedes screw. The limited costs that are quantified are very large.
Commercial	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.
Commercial	Induction Cooktops	While this is a promising technology that saves significant energy as compared to electric coils, this is primarily an electrification measure as most current stovetops in commercial food preparation are gas-fired.
Commercial	Insulation - Phase-Change Building Materials	Screened out as an emerging technology with limited market traction so far; more academic research has become available but reliable savings and costs are difficult to quantify. Phase-change materials that can both store thermal energy and solar electricity are especially interesting.
Commercial	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. Screened out - this advanced insulation material is not commercially available for building envelope applications at this time. While some target costs are available, these are still too high for cost-effective implementation. A project for lower-cost aerogel insulation production is currently in Phase 1 of federal funding (as of 2022). Major current applications are much more targeted and include insulation for oil and gas, aerospace, refrigeration, automotive, and performance coatings; refrigeration insulation would be reflected in efficient (and very expensive) options).
Commercial	HVAC - Predictive Energy Optimization	This measure acts as an automated supervisory control system for HVAC systems in commercial buildings, using artificial intelligence and sensors to reduce energy consumption, operating costs, and emissions. It connects to most existing building energy management systems (BEMS). While some pilot field validation data is available for one particular vendor, it is limited in scope and costs are not available. Recommend revisiting.
Industrial	Electric Arc Furnace - Waste Heat Recovery	New Arc Furnaces are a measure from 2021 Power 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.

Sector	Measure Name	Rationale for Exclusion
Industrial	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.
Industrial	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.
Industrial	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
Industrial	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.
Industrial	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.
Industrial	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 (no longer an actively updated database) are electric. Very limited applicability.
Industrial	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 (no longer an actively updated database) are electric.
Industrial	Process Heating - Exhaust Energy Recovery	Screened out - custom applications that are often retrofitted on a natural gas system. No costs available.
Industrial	Process Optimization - Near-Net-Shape Casting	Screened out - Promising measure, but applicable to direct fuel-fired process and unlikely to save electricity on site.
Irrigation	Scientific Irrigation Practices	This is no longer included in the Power Plan and has been identified as standard practice by the Council.

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 2023 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 C-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.

Inflation Reduction Act Methodology

The Inflation Reduction Act (IRA) and Infrastructure Investment and Jobs Act (IIJA) provide more than 25 billion dollars for programs and tax incentives to help with energy efficiency, electrification, and greenhouse gas reduction. These tax incentives became available starting on January 1st, 2023, the first year of this study's forecasting horizon. Most of the programs target low- and moderate-income households or disadvantaged communities. Funds are provided for but are not limited to, heating and cooling equipment upgrades, weatherization, and whole home upgrades.

AEG worked with PacifiCorp to develop an approach on how to incorporate IRA and IIJA in the study. Ultimately, the IRA and IIJA were accounted for by assuming the accelerated adoption of measures within specific customer types that were targeted by these two laws. While the Council ramp rates from the 2021 Power Plan were still leveraged, AEG chose ramp rates that represented quicker adoption than those used in the 2021 Power Plan for affected measures; the adjustments are presented in Table C-2 Table C-3.

Table C-1 Energy Efficiency Measure Ramp Rates

Ramp Rate Name	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
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%

Table C-2 Ramp Rates Adjustments for Select Residential Measures to Reflect Recent Federal Legislation

Measure Name	Existing Construction		New Construction	
	Default Ramp Rate Assignment	Adjusted Ramp Rate Assignment	Default Ramp Rate Assignment	Adjusted Ramp Rate Assignment
Air-Source Heat Pump	LO3Slow	LO5Med	LO3Slow	LO5Med
Ductless Mini Split Heat Pump	LO3Slow	LO5Med	LO3Slow	LO5Med
Windows - High Efficiency (U-0.22)	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow
Windows - High Efficiency (U-0.17)	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow
Windows - Low-e Storm Addition	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow
Windows - Install Reflective Film	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow
Doors - Storm and Thermal - ENERGY STAR (6.0)	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow
Ductless Mini Split Heat Pump (Zonal)	Retro5Med	Retro12Med	Retro5Med	Retro12Med
Supplement Central System with Ductless Mini Split Heat Pump	Retro5Med	Retro12Med	Retro5Med	Retro12Med
Conversion to Ductless Mini Split Heat Pump	LO3Slow	LO5Med	LO3Slow	LO5Med
Central Heat Pump - Cold Climate Adder	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow
ENERGY STAR Home Design	LOEven20	LO5Med	LOEven20	LO5Med
Advanced New Construction Design - Zero Net Energy	LO3Slow	LO5Med	LO3Slow	LO5Med
Manufactured Home Replacement	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow

Table C-3 Ramp Rates Adjustments for Select Commercial Measures to Reflect Recent Federal Legislation

Measure Name	Existing Construction		New Construction	
	Default Ramp Rate Assignment	Adjusted Ramp Rate Assignment	Default Ramp Rate Assignment	Adjusted Ramp Rate Assignment
Water Heater (UT Only)	LO1Slow	LO3Slow	LO1Slow	LO3Slow
Water Heater (All Other States)	No Change		No Change	
Insulation - Ceiling	No Change		Retro1Slow	Retro3Slow
Insulation - Ducting	No Change		Retro1Slow	Retro3Slow
Insulation - Wall Cavity	No Change		Retro1Slow	Retro3Slow

Measure Name	Existing Construction		New Construction	
	Default Ramp Rate Assignment	Adjusted Ramp Rate Assignment	Default Ramp Rate Assignment	Adjusted Ramp Rate Assignment
Windows - High Efficiency Glazing	Retro1Slow	Retro3Slow	Retro1Slow	Retro3Slow
Windows - Dynamic Glazing	No Change		Retro1Slow	Retro3Slow
Advanced New Construction Designs	LO1Slow	LO3Slow	LO1Slow	LO3Slow

D | Comparison of Washington Measures to 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.

As part of this multi-state study, measures were mapped, where possible, to RTF and 2021 Power Plan 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.

E | Washington Non-Energy Impact Mapping

The accompanying spreadsheet documents the non-energy impacts (NEIs) as they were mapped to measures analyzed in the Washington territory within the current Conservation Potential Assessment. These are in addition to any impacts specified by the Regional Technical Forum. Apart from one measure (Plant Shade Trees),[1] all non-energy impacts were sourced from DNV GL's study for PacifiCorp's Washington territory.[2] The DNV GL study included a mapping of non-energy impacts to the following affected parties, which are noted for each measure in the spreadsheet:

- Utility
- Customers
- Participant
- Vulnerable Population
- Highly Impacted Communities
- General Public

[1] Sourced from the U.S. Forestry Service iTree Calculator and work conducted for Idaho Power.

[2] DNV GL . (2021). (rep.). PacifiCorp Non-Energy Impacts Final Report.

F | Low-Income Potential Analysis

In the previous CPA performed for PacifiCorp, AEG estimated energy efficiency potential based on average customer profiles without differentiation by household income except for in Washington, where residential customers were segmented by two levels of income. For the current CPA, the income-based segmentation was expanded to apply to all states. This appendix describes AEG's general methodology for the segmentation of residential customers and assessment of available potential by income level.

Customer Segmentation

AEG used the following data sources to create low-income, moderate-income, and regular-income segments[3] 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 develop differing saturations of end use equipment (e.g., electric space heating) by building type and income level.
- US Census American Community Survey (ACS) was used to determine household characteristics in geographic blocks.

Using the data above, AEG estimated the number of customers and the associated load in the study base year (2021) for residential customers by home type and income level. To estimate the number of households in each income level, AEG mapped address data for PacifiCorp residential accounts back to corresponding geographic blocks in the ACS. Each customer account was assigned to the nearest matching US Census geographic block at the most granular level available based on service address. These geographic subtotals were then assigned proportional demographics such as housing types or average income per household and summed to produce the final estimates for modeling segment allocation. Final totals for each state and segment were developed using the percentage allocations by segment from the US Census analysis and the official sector-level totals for customers and energy provided by PacifiCorp. AEG then leveraged PacifiCorp's most recent residential customer survey to inform the energy use characteristics across income levels and building types. Table F-1 shows the customer energy consumption by home type and income level in the base year, 2021.

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

State	Home Type	Income Level	2021 Customers	2021 Loads (MWh at Gen)	% of Total Customers	% of Total Load
CA	Single Family	Moderate	11,795	143,551	34%	37%
	Multi-Family	Moderate	1,464	10,912	4%	3%
	Manuf. Home	Moderate	2,387	30,299	7%	8%
	Moderate Income Subtotal			**184,762**	**15,646**	**47%**
	Single Family	Low	10,206	113,418	29%	29%
	Multi-Family	Low	2,598	21,072	7%	5%
	Manuf. Home	Low	2,398	26,974	7%	7%
	Low Income Subtotal			**161,464**	**15,202**	**41%**
	Single Family	Regular	2,892	35,142	8%	9%
	Multi-Family	Regular	334	3,438	1%	1%

[3] For Idaho and Utah, "low income" was defined as below 200% of the federal poverty level. For California and Wyoming, "low income" was defined as below 60% of the state median income. For Washington, "low income" was defined as below 60% of the state median income for households less than 7 people and below 200% of the federal poverty level for households greater than 7 people. For all states, "moderate income" was defined as below 100% of the state median income and "regular income" was defined as above 100% of the state median income.

State	Home Type	Income Level	2021 Customers	2021 Loads (MWh at Gen)	% of Total Customers	% of Total Load
	Manuf. Home	Regular	726	8,198	2%	2%
		Regular Income Subtotal		**46,779**	**3,952**	**12%**
		CA Residential Total		**393,005**	**34,800**	**100%**
ID	Single Family	Moderate	24,293	310,603	37%	40%
	Multi-Family	Moderate	2,234	14,350	3%	2%
	Manuf. Home	Moderate	3,253	42,442	5%	6%
		Moderate Income Subtotal		**367,395**	**29,780**	**48%**
	Single Family	Low	6,390	81,755	10%	11%
	Multi-Family	Low	4,798	31,185	7%	4%
	Manuf. Home	Low	990	10,964	2%	1%
		Low Income Subtotal		**123,904**	**12,178**	**16%**
	Single Family	Regular	19,767	243,346	30%	32%
	Multi-Family	Regular	1,393	9,739	2%	1%
	Manuf. Home	Regular	1,707	23,893	3%	3%
		Regular Income Subtotal		**276,977**	**22,867**	**36%**
		ID Residential Total		**768,276**	**64,825**	**100%**
UT	Single Family	Moderate	265,472	2,603,337	32%	34%
	Multi-Family	Moderate	93,303	524,897	11%	7%
	Manuf. Home	Moderate	12,173	93,489	1%	1%
		Moderate Income Subtotal		**3,221,723**	**370,948**	**42%**
	Single Family	Low	43,702	428,275	5%	6%
	Multi-Family	Low	32,044	190,997	4%	2%
	Manuf. Home	Low	3,277	25,121	0%	0%
		Low Income Subtotal		**644,392**	**79,023**	**8%**
	Single Family	Regular	323,246	3,504,812	38%	45%
	Multi-Family	Regular	63,510	361,844	8%	5%
	Manuf. Home	Regular	3,212	23,886	0%	0%
		Regular Income Subtotal		**3,890,542**	**389,968**	**50%**
		UT Residential Total		**7,756,657**	**839,939**	**100%**
WA	Single Family	Moderate	34,482	543,443	31%	33%
	Multi-Family	Moderate	6,639	58,524	6%	4%
	Manuf. Home	Moderate	5,846	105,097	5%	6%
		Moderate Income Subtotal		**707,064**	**46,967**	**43%**
	Single Family	Low	32,152	497,394	29%	30%
	Multi-Family	Low	13,095	135,999	12%	8%
	Manuf. Home	Low	5,890	99,987	5%	6%
		Low Income Subtotal		**733,380**	**51,137**	**45%**
	Single Family	Regular	9,812	165,480	9%	10%

State	Home Type	Income Level	2021 Customers	2021 Loads (MWh at Gen)	% of Total Customers	% of Total Load
	Multi-Family	Regular	1,196	9,272	1%	1%
	Manuf. Home	Regular	896	17,603	1%	1%
		Regular Income Subtotal		**192,355**	**11,904**	**12%**
		WA Residential Total		**1,632,800**	**110,008**	**100%**
WY	Single Family	Moderate	42,003	411,746	38%	40%
	Multi-Family	Moderate	8,602	51,326	8%	5%
	Manuf. Home	Moderate	7,937	68,450	7%	7%
		Moderate Income Subtotal		**531,522**	**58,542**	**52%**
	Single Family	Low	9,675	86,583	9%	8%
	Multi-Family	Low	3,957	23,942	4%	2%
	Manuf. Home	Low	2,231	16,946	2%	2%
		Low Income Subtotal		**127,471**	**15,863**	**12%**
	Single Family	Regular	28,609	303,172	26%	30%
	Multi-Family	Regular	4,224	30,657	4%	3%
	Manuf. Home	Regular	3,250	29,984	3%	3%
		Regular Income Subtotal		**363,813**	**36,083**	**36%**
		WY Residential Total		**1,022,806**	**110,488**	**100%**

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

Energy Efficiency Potential

Table F-2 presents residential baseline loads and cumulative potential in 2042 by home type and income level. As shown, the analysis identified potential in low-income and moderate-income homes as slightly higher than regular-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 in Appendix H.

Table F-2 Cumulative Energy Efficiency Potential by Home Type and Income Level in 2042

State	Home Type	Income Level	Baseline Load (MWh at Gen)	Technical Potential (MWh at Gen)	Achievable Technical Potential (MWh at Gen)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
CA	Single Family	Moderate	140,232	41,302	31,593	33%	23%
	Multi-Family	Moderate	13,158	3,799	3,008	3%	23%
	Manuf. Home	Moderate	33,108	9,901	8,047	8%	24%
		Moderate Income Subtotal	**186,498**	**55,002**	**42,647**	**45%**	**23%**
	Single Family	Low	119,334	34,496	27,153	29%	23%
	Multi-Family	Low	26,383	6,762	5,428	6%	21%
	Manuf. Home	Low	32,115	10,550	8,598	9%	27%
		Low Income Subtotal	**177,832**	**51,808**	**41,179**	**43%**	**23%**

State	Home Type	Income Level	Baseline Load (MWh at Gen)	Technical Potential (MWh at Gen)	Achievable Technical Potential (MWh at Gen)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
	Single Family	Regular	41,561	10,790	7,953	8%	19%
	Multi-Family	Regular	3,711	916	715	1%	19%
	Manuf. Home	Regular	13,367	3,249	2,620	3%	20%
		Regular Income Subtotal	**58,639**	**14,955**	**11,289**	**12%**	**19%**
		CA Residential Total	**422,970**	**121,765**	**95,115**	**100%**	**22%**
ID	Single Family	Moderate	483,067	158,438	126,589	41%	26%
	Multi-Family	Moderate	22,876	7,313	5,410	2%	24%
	Manuf. Home	Moderate	74,870	27,181	22,192	7%	30%
		Moderate Income Subtotal	**580,813**	**192,932**	**154,191**	**50%**	**27%**
	Single Family	Low	132,745	44,103	35,303	11%	27%
	Multi-Family	Low	53,034	18,380	14,042	5%	26%
	Manuf. Home	Low	19,844	7,991	6,531	2%	33%
		Low Income Subtotal	**205,624**	**70,473**	**55,875**	**18%**	**27%**
	Single Family	Regular	337,289	111,398	87,174	28%	26%
	Multi-Family	Regular	15,028	4,185	2,995	1%	20%
	Manuf. Home	Regular	41,803	13,685	11,157	4%	27%
		Regular Income Subtotal	**394,120**	**129,268**	**101,325**	**33%**	**26%**
		ID Residential Total	**1,180,556**	**392,673**	**311,392**	**100%**	**26%**
UT	Single Family	Moderate	4,529,280	1,970,984	1,658,106	35%	37%
	Multi-Family	Moderate	1,060,167	364,530	260,229	6%	25%
	Manuf. Home	Moderate	198,773	84,104	69,762	1%	35%
		Moderate Income Subtotal	**5,788,219**	**2,419,619**	**1,988,097**	**42%**	**34%**
	Single Family	Low	825,446	335,984	282,145	6%	34%
	Multi-Family	Low	415,807	147,286	109,837	2%	26%
	Manuf. Home	Low	55,617	22,773	18,877	0%	34%
		Low Income Subtotal	**1,296,870**	**506,043**	**410,860**	**9%**	**32%**
	Single Family	Regular	10,088,793	2,504,632	2,097,449	45%	21%
	Multi-Family	Regular	1,267,763	232,332	172,673	4%	14%
	Manuf. Home	Regular	50,782	19,774	16,308	0%	32%
		Regular Income Subtotal	**11,407,338**	**2,756,738**	**2,286,430**	**49%**	**20%**
		UT Residential Total	**18,492,427**	**5,682,400**	**4,685,387**	**100%**	**25%**
WA	Single Family	Moderate	653,049	200,569	154,258	32%	24%
	Multi-Family	Moderate	80,920	20,388	16,126	3%	20%
	Manuf. Home	Moderate	123,839	43,867	34,468	7%	28%
		Moderate Income Subtotal	**857,808**	**264,824**	**204,852**	**43%**	**24%**

State	Home Type	Income Level	Baseline Load (MWh at Gen)	Technical Potential (MWh at Gen)	Achievable Technical Potential (MWh at Gen)	Achievable Technical Potential (% of Total)	Achievable Technical Potential (% of Baseline)
	Single Family	Low	649,835	184,689	147,219	31%	23%
	Multi-Family	Low	191,753	46,308	36,504	8%	19%
	Manuf. Home	Low	124,941	44,883	34,816	7%	28%
		Low Income Subtotal	**966,529**	**275,879**	**218,539**	**46%**	**23%**
	Single Family	Regular	284,314	62,950	47,488	10%	17%
	Multi-Family	Regular	23,934	3,719	2,835	1%	12%
	Manuf. Home	Regular	21,351	6,972	5,372	1%	25%
		Regular Income Subtotal	**329,599**	**73,641**	**55,695**	**12%**	**17%**
		WA Residential Total	**2,153,936**	**614,345**	**479,086**	**100%**	**22%**
WY	Single Family	Moderate	444,024	124,800	88,909	39%	20%
	Multi-Family	Moderate	55,222	19,752	14,760	6%	27%
	Manuf. Home	Moderate	76,380	21,636	16,166	7%	21%
		Moderate Income Subtotal	**575,625**	**166,188**	**119,835**	**52%**	**21%**
	Single Family	Low	94,386	27,692	20,112	9%	21%
	Multi-Family	Low	27,046	8,754	6,632	3%	25%
	Manuf. Home	Low	19,108	7,064	5,467	2%	29%
		Low Income Subtotal	**140,541**	**43,510**	**32,210**	**14%**	**23%**
	Single Family	Regular	330,053	88,437	63,152	27%	19%
	Multi-Family	Regular	37,464	9,546	6,931	3%	18%
	Manuf. Home	Regular	32,695	10,811	8,135	4%	25%
		Regular Income Subtotal	**400,211**	**108,794**	**78,218**	**34%**	**20%**
		WY Residential Total	**1,116,377**	**318,492**	**230,263**	**100%**	**21%**

G | 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 a September 2022 public input meeting.[4]

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 due to 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 recommended varying administrative cost values as a percent of incremental customer costs by state. AEG recommended using a value of 22% of Utah, 48% of Washington, 45% for California, 40% for Idaho, and 48% for Wyoming.

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

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[5] for the five states of interest to quantify utility spending on energy efficiency programs for the years of 2014 through 2021, 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

[4] See slide 66 from the presentation available at: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2023-irp/IRP_PIM_Sept%201-2_2022.pdf

[5] Please see "Reports and Program Evaluations by Jurisdiction" for the publicly available data used to conduct this analysis at: https://www.pacificorp.com/environment/demand-side-management.html.

California reports have not been published but were provided to AEG for this analysis.

- 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 (i.e., Home Energy Savings and Wattsmart Business) were included in the analysis.

Analysis of PacifiCorp Data

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

Table G-1 Utility Administrative Costs (as Percent of Incremental Customer Cost) for PacifiCorp's Service Territory, 2014-2021

Admin % Customer	Utah	Washington	California	Idaho	Wyoming
2014	18%	30%	46%	54%	44%
2015	21%	35%	29%	32%	38%
2016	24%	35%	41%	30%	29%
2017	23%	44%	73%	36%	34%
2018	23%	41%	55%	59%	40%
2019	22%	46%	36%	39%	59%
2020	22%	68%	44%	34%	75%
2021	21%	83%	37%	39%	62%
Average	**22%**	**48%**	**45%**	**40%**	**48%**

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.

H | Energy Efficiency Detailed Results

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

I | 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)

J | 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

K | Non-Energy Impacts of Demand Response

Overview

Through PacifiCorp's 2023 IRP public input process, stakeholders expressed continued 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 refresh the limited literature review it conducted for 2021 CPA, which covered industry-standard practices and the extent to which other utilities and planning organizations have considered NEIs in demand response. Specifically, the goal of this review 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 note 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, Table K-1, Table K-2, Table K-3 map the NEIs into the three categories (Societal, Utility, and Participant) and identify each NEI as either a cost, benefit, or both.

- **California Public Utilities Commission. 2016 Demand Response Cost Effectiveness Protocols. July 2016 (CPUC Protocols).**[6] 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.[7] 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. Some research on NEIs has provided estimates of their impacts, but extrapolating NEIs across regions for benefit-cost testing is still inappropriate given the limited scope of research, variation in program and state estimations and quality of the values.[8] 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.
- **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

[6] The California 2016 Protocols are available at the following URL: [Demand Response Cost-Effectiveness (ca.gov)]

[7] Skumatz et al. "Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California" Issued May 11, 2010. [Findings and Next Steps in Energy Efficiency Measurement and Attribution: (ctfassets.net)]

[8] Skumats et Al. "Non-Energy Benefits/Non-Energy Impacts (NEBs/NEIs) and Their Role & Values In Cost-Effectiveness Tests: State Of Maryland" Issued March 31,2014. [2014 _NEBs_report_for_Maryland.pdf (ctfassets.net)]

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

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. The Power Plan Demand Response Supply Curves.**[11] Per email correspondence with Northwest Power and Conservation Council staff, the 2021 Power Plan does not apply NEIs to demand response resources.

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

Cost or Benefit	Societal Non-Energy Impacts
Benefit	Employment above the job creation benefits of manufacturing a combustion turbine or constructing T&D upgrades.[1,2,3]
	Economic development (e.g., changes in gross domestic product)[2, 3]
	Improved air quality (avoiding criteria pollutants above and beyond the level of existing environmental regulations).[1,2,3]
	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
	Environmental justice improvements[1, 3]
	Biological impacts[1]
	Land use, including impacts of energy infrastructure on local ecosystems (fewer power plants)[1]
	Improved energy security/resilience (e.g., reduced dependence on imported fossil fuels)[2, 3]
Benefit and Cost	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]
	Impacts on cultural resources[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]

[10] The NSPM is available at the following URL: NSPM-DERs_08-24-2020.pdf (nationalenergyscreeningproject.org)

[11] The Northwest Power Plan: 2021powerplan_2022-3.pdf (nwcouncil.org)

Cost or Benefit	Societal Non-Energy Impacts
	Changes in noise pollution (e.g., benefit when equipment is shut off, but cost when back-up equipment is turned on)[1, 2]

Table K-2 Utility Non-Energy Benefits and Costs of Demand Response Programs

Cost or Benefit	Societal Non-Energy Impacts
Benefit	Improved customer relations[1]
	Reduced marketing and administrative costs due to demand response customer participation in multiple distributed energy resource programs[1]
Benefit and Cost	Changes in the number of delinquent bills or disconnections[1]
	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]
	Changes in the number of customer complaint calls or service requests[1]

Table K-3 Participant Non-Energy Benefits and Costs of Demand Response Programs

Cost or Benefit	Societal Non-Energy Impacts
Benefit	Satisfaction/pride from preventing outages and being "green"[1, 3]
	Improved ability of integrated load management solutions to manage energy use (e.g., demand response -enabled thermostat)[1]
	Economic well-being (e.g., fewer bill-related calls, fewer power shut-offs/reconnects, reduced foreclosures)[3]
	Better public image for commercial enterprises[1]
Benefit and Cost	Improved asset value (e.g., improved property value, equipment functionality/performance improvement)[3]
Cost	Productivity losses (e.g., lower productivity levels, more spoilage/defects, lower sales during DR events)[3, 5]
	Convenience/comfort losses (e.g., thermal, lighting levels/aesthetics)[3]
	Safety and health losses (e.g., less lighting may lead to increased crime, non-operational medical equipment)[4]
	Transaction costs beyond the demand response technology/service itself (e.g., application fees, paperwork, time spent researching processes, developing load shedding plans)[3, 5]

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 accurately 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. Additionally, at PacifiCorp's request, AEG de-rated costs by 10% in Washington to reflect potential non-quantifiable NEIs in the current study. 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.

L | 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

M | Existing Demand-Side Rates Analysis

Introduction

As part of the 2023 Conservation Potential Assessment (CPA), AEG updated the impacts of existing time-varying rates across PacifiCorp's territory. The analysis leveraged analysis completed by the Brattle Group in 2015 but incorporated updates to reflect PacifiCorp's current rate structures and participants. Table M-1 presents the list of rate schedules we included in the analysis.

Table M-1 Rate Schedules Included

Class	State	Schedule	Voluntary?	Participation (12/2021)	Average kW (July 2021)
Residential	Utah	Sch.2	Yes	456	2.8
Residential	Oregon	Sch.4,5,210	Yes	1,009	2.1
Residential	Oregon	Sch.6	Yes	91	2.1
Residential	Idaho	Sch.36	Yes	10,250	1.9
Small/Medium C&I	Utah	Sch.6A	Yes	2,712	3.5
Large /Extra Large C&I	Utah	Sch.8	Mandatory	220	1,658.9
Large /Extra Large C&I	Utah	Sch.9,9A	Mandatory	166	4,281.9
Small/Medium C&I	Oregon	Sch.23,210	Yes	209	20.2
Large /Extra Large C&I	Oregon	Sch.47	Mandatory	6	3,841.6
Large /Extra Large C&I	Oregon	Sch.48	Mandatory	178	3,091.2
Large /Extra Large C&I	Wyoming	Sch.46	Mandatory	78	3,239.0
Large /Extra Large C&I	Wyoming	Sch.48T	Mandatory	29	3,210.3
Large /Extra Large C&I	Washington	Sch.48T	Mandatory	67	2,023.0
Large /Extra Large C&I	California	Sch.AT-48	Mandatory	19	1,084.6
Irrigation	Utah	Sch.10	Yes	258	54.2
Irrigation	Oregon	Sch.48	Yes	2	4,248.5

Methodology

The analysis used the following five-step approach:

- Determine the rates to include. During this step, we reviewed all rate schedules with time-varying elements across the six states. We excluded rates with extremely low participation or lack of billing data.[12] We also excluded rates that were only for supplemental power and backup charges.
- Characterize enrollment in each rate. For each included rate, we used participation from December 2021 (provided by PacifiCorp). Based on the billing data, we also calculated the per-customer peak demand for July and the total average per-customer energy consumption for July.

[12] A list of excluded rates and exclusion criteria are included in Supplemental Details.

- Establish all-in estimates of existing rates. Assessments of customer price response are established using an all-in rate. All-in rates are computed by converting each non-volumetric charge to a volumetric charge (cents/kWh) using the per customer average energy and demand, and then layering this converted charge on top of the existing volumetric charge. The underlying assumption is generally that customers do not respond to individual charges on their bill but rather to the entire bill itself, with some general awareness of how it varies by time of day or with monthly consumption.
- Simulate the impacts of existing rates. Participant peak demand reductions are a function of the peak-to-off-peak price ratio in the TOU rate, with a higher price ratio leading to larger peak reductions. The impact estimates were developed by the Brattle Group using their "Arc of Price Responsiveness" as follows.[13] The residential Arc incorporates estimates of customer price responsiveness from over 160 different pricing tests conducted in North America and internationally over the past decade. The C&I Arcs, also developed by Brattle, vary by customer class and are based on pilots and full-scale deployments in California and the Northeastern US. The appendix to this memo includes screen shots of the residential and C&I Arcs developed by Brattle for the 2015 analysis.
- Aggregate impacts to the system level. Impacts were aggregated to the system level by multiplying the per-customer impact by the number of participants.

Results

Table M-2 below presents the price ratio, percent impact, average peak demand, and per-customer impact for each rate.

Table M-2 Per Customer Impacts by Rate Schedule

Class	State	Schedule	Demand[14] (kW/Cust.)	Ratio	Impact[15]	kW Impact (kW/Cust.)
Residential	Utah	Sch.2	2.8	1.8	6.2%	0.17
Residential	Oregon	Sch.4,5,210	2.1	1.9	6.2%	0.13
Residential	Oregon	Sch.6	2.1	4.1	9.7%	0.20
Residential	Idaho	Sch.36	1.9	2.7	6.2%	0.12
Small/Medium C&I	Utah	Sch.6A	3.5	5.0	5.0%	0.17
Large /Extra Large C&I	Utah	Sch.8	1,658.9	4.3	5.8%	95.39
Large /Extra Large C&I	Utah	Sch.9,9A	4,281.9	4.9	5.8%	246.21
Small/Medium C&I	Oregon	Sch.23,210	20.2	2.4	2.6%	0.53
Large /Extra Large C&I	Oregon	Sch.47	3,841.6	1.7	3.1%	119.09
Large /Extra Large C&I	Oregon	Sch.48	3,091.2	2.0	3.1%	95.83
Large /Extra Large C&I l	Wyoming	Sch.46	3,239.0	4.2	5.8%	186.25

[13] AEG used the Arcs that were developed for this analysis. We did not update the residential Arc given that impacts from residential pricing programs are very stable. Brattle developed estimates using different arcs for C&I. The small and Medium C&I impacts were developed based on the results of the California Statewide Dynamic Pricing Pilot. The C&I impacts for large customers were based on experience with full-scale programs in the Northeastern US. AEG did not update the C&I Arcs or impact assumptions, our review of the impacts showed that they are consistent with impacts we currently use for PacifiCorp and other clients.

[14] For Residential and Oregon Irrigation customers AEG leveraged the average residential peak from the load forecast provided by PacifiCorp. For all other rate schedules, AEG calculated the demand from the billing data provided.

[15] For price ratios between 1-3, we used Brattle's TOU impact estimates reflecting an average 2:1 on to off peak ratio. For price ratios between 3-5, we used a 50/50 split between TOU and CPP impacts where the CPP impacts reflect a 6:1 on to off peak ratio.

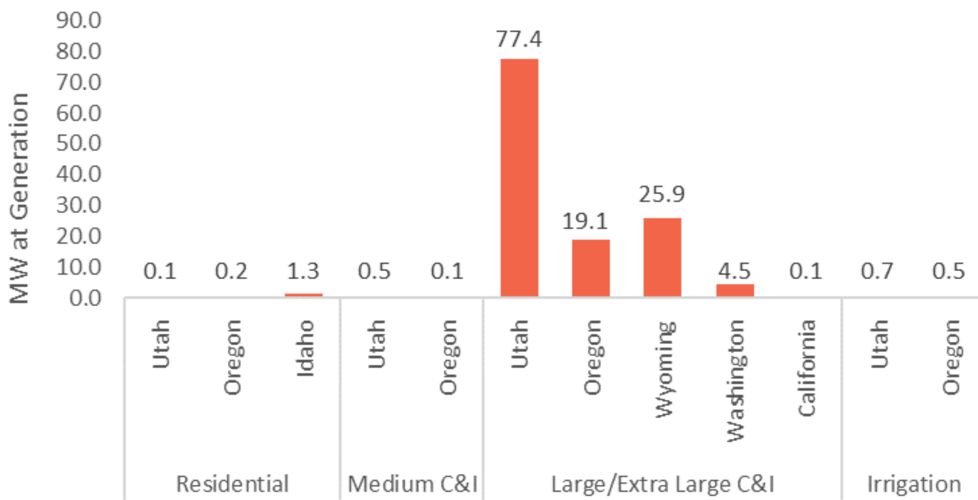
Class	State	Schedule	Demand[14] (kW/Cust.)	Ratio	Impact[15]	kW Impact (kW/Cust.)
Large /Extra Large C&I	Wyoming	Sch.48T	3,210.3	4.4	5.8%	184.59
Large /Extra Large C&I	Washington	Sch.48T	2,023.0	2.0	3.1%	62.71
Large /Extra Large C&I	California	Sch.AT-48	1,084.6	1.1	3.1%	33.62
Irrigation	Utah	Sch.10	54.2	2.6	4.7%	2.55
Irrigation	Oregon	Sch.48	4,248.5	2.0	4.7%	199.68

In Table M-3 and accompanying Figure M-1, we present the total MW impact across all of PacifiCorp. The total MW contribution of all existing rates is 122 MW at the meter and 130 MW at generation. Note that the vast majority of the impacts (97%) come from large and extra-large C&I customers on mandatory rates.

Table M-3 System Level Impacts from Existing Time Varying Rates

Class	State	Schedule	MW (@ Meter)	MW (@ Generation)
Residential	Utah	Sch.2	0.08	0.08
Residential	Oregon	Sch.4,5,210	0.13	0.14
Residential	Oregon	Sch.6	0.02	0.02
Residential	Idaho	Sch.36	1.19	1.30
Small/Medium C&I	Utah	Sch.6A	0.47	0.50
Large/Extra Large C&I	Utah	Sch.8	24.82	26.27
Large/Extra Large C&I	Utah	Sch.9,9A	48.33	51.17
Small/Medium C&I	Oregon	Sch.23,210	0.11	0.12
Large/Extra Large C&I	Oregon	Sch.47	0.71	0.77
Large/Extra Large C&I	Oregon	Sch.48	17.06	18.29
Large/Extra Large C&I l	Wyoming	Sch.46	17.18	18.90
Large/Extra Large C&I	Wyoming	Sch.48T	6.33	6.96
Large/Extra Large C&I	Washington	Sch.48T	4.20	4.52
Large/Extra Large C&I	California	Sch.AT-48	0.10	0.11
Irrigation	Utah	Sch.10	0.66	0.70
Irrigation	Oregon	Sch.48	0.40	0.43
Irrigation	Oregon	Sch.41,201	0.02	0.03
Irrigation	Oregon	Sch.41,210	0.01	0.01
Total			**121.8**	**130.3**

Figure M-1 System Level Impacts from Existing Time Varying Rates by State and Class



Comparison to Previous Study

Table M-4 and Figure M-2 show a comparison of the current study (AEG 2022) to the Brattle study (Brattle 2015). At a high level, the AEG study estimates a total of 130 MW vs. Brattle's old estimate of 97 MW, an increase of approximately 30%. The key drivers of the difference are as follows:

Substantial increase in the impacts in Utah (35.6MW) among Large/Extra Large C&I customers primarily resulting from:

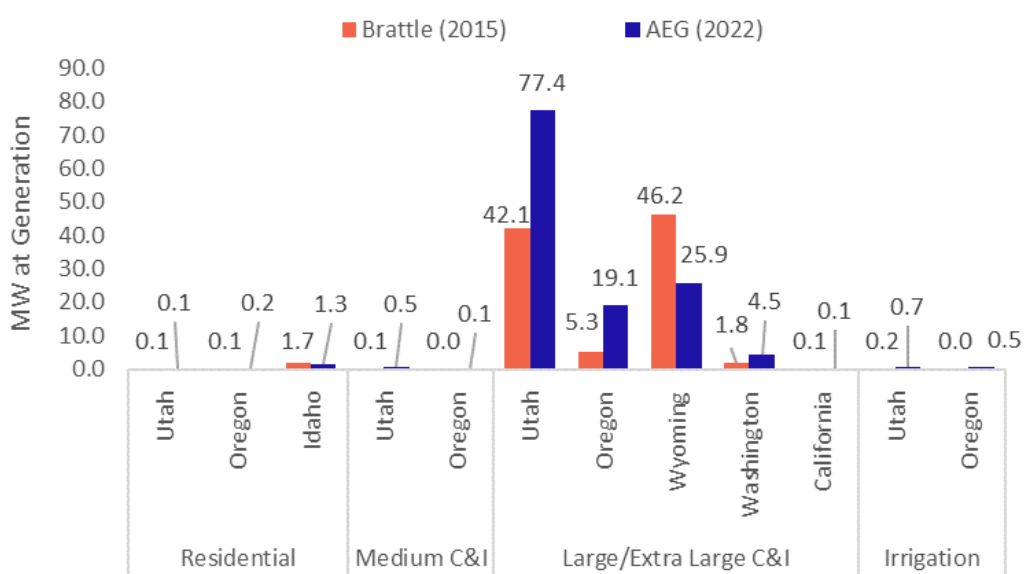
- An increase in the on-to-off-peak price ratio from 2.5 to 1 to 4.5 to 1 with an associated increase in impacts from 4.1% to 6.8%
    - A moderate increase in the number of participants from 343 to 386
    - A Moderate increase in the average on-peak demand from approximately 2.4 MW to 2.9 MW per customer.
- Increase in the impacts in Oregon among Large/Extra Large C&I customers primarily resulting from:
    - An increase in the on-to-off-peak price ratio from 1.4 to 1 to 2.0 to 1
    - Increase in average on-peak demand from approximately 1.5 MW to 3.2 MW
- Decrease in the impacts in Wyoming Large/Extra Large C&I customers primarily resulting from:
    - A reduction in average on-peak demand from approximately 5.5 MW to 3.2 MW

Note that changes in on-peak demand are likely due to differences in analysis approaches between the two studies. AEG used the billing data for participants on each rate to estimate the peak demand, while Brattle used the segment-level coincident demand.

Table M-4 Comparison to Previous Study

Class	State	Brattle Group (2015) MW @Generation	AEG (2022) MW @ Generation
Residential	Utah	0.1	0.1
	Oregon	0.1	0.2
	Idaho	1.7	1.3
Medium C&I	Utah	0.1	0.5
	Oregon	0.0	0.1
Large and Extra-Large C&I	Utah	42.1	77.4
	Oregon	5.3	19.1
	Wyoming	46.2	25.9
	Washington	1.8	4.5
	California	0.1	0.1
Irrigation	Utah	0.2	0.7
	Oregon	0.0	0.5
Total		**97.6**	**130.3**

Figure M-2 System Level Impacts from Existing Time Varying Rates by State and Class



Supplemental Details

In Table M-5 we present the rates that were excluded from the analysis and the exclusion criteria.

Table M-5 Excluded Rates and Criteria

Class	State	Schedule	Participation (12/2021)	Exclusion Criteria
Residential	Utah	Sch.2E	453	Low participation, closed rate
Residential	Wyoming	Sch.19	4	Low participation
Residential	Washington	Sch.19	6	Low participation
General	Utah	Sch.31	7	Low participation
General	Oregon	Sch.29	-	No participation
General	Oregon	Sch.45	29	No rate information
General	Wyoming	Sch.29	-	No participation
General	Wyoming	Sch.33	11	Supplemental and backup charges
General	Idaho	Sch.35,35A	2	Low participation
General	Washington	Sch.29	-	No participation
General	Washington	Sch.45	3	Low participation
General	Washington	Sch.47T	1	Supplemental and backup charges
Irrigation	Wyoming	Sch.40	4	Low participation
Irrigation	Washington	Sch.40	-	No participation
Irrigation	California	Sch.PA-115	19	Low participation

Figure M-3, Figure M-4, and Figure M-5 show the three Arcs that were used to develop impact assumptions from the 2015 Analysis.

Figure M-3 Residential TOU Results

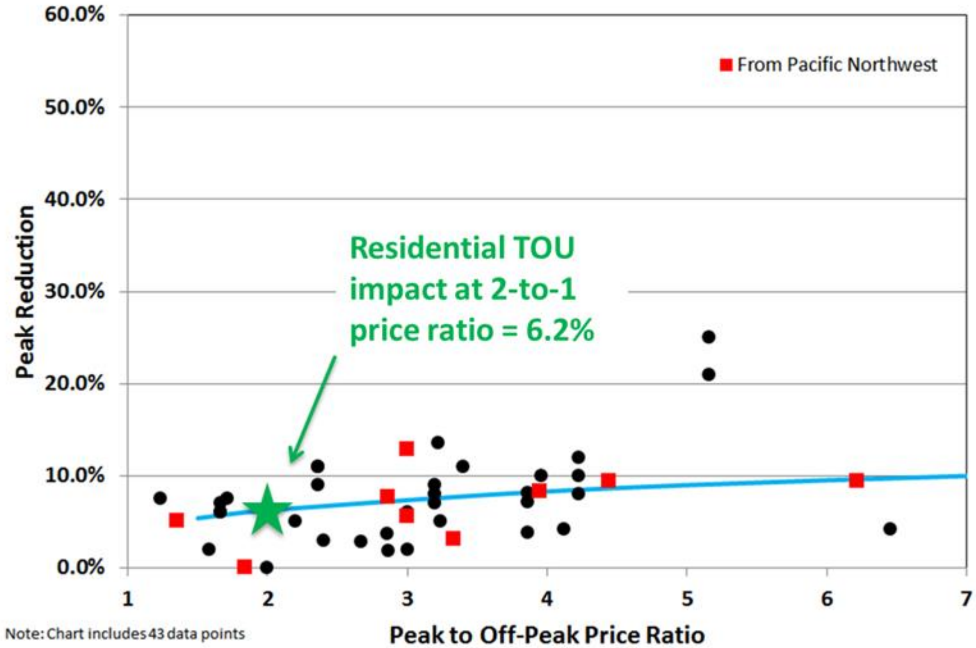


Figure M-4 Residential Non-TOU Results

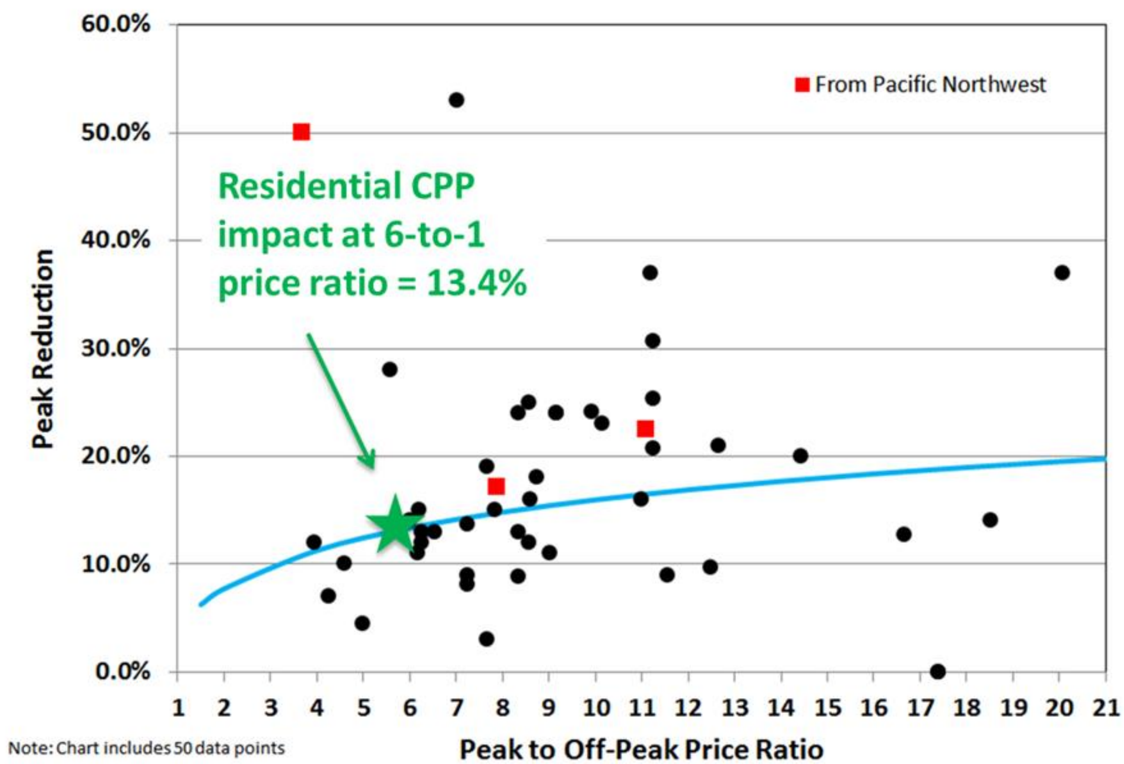
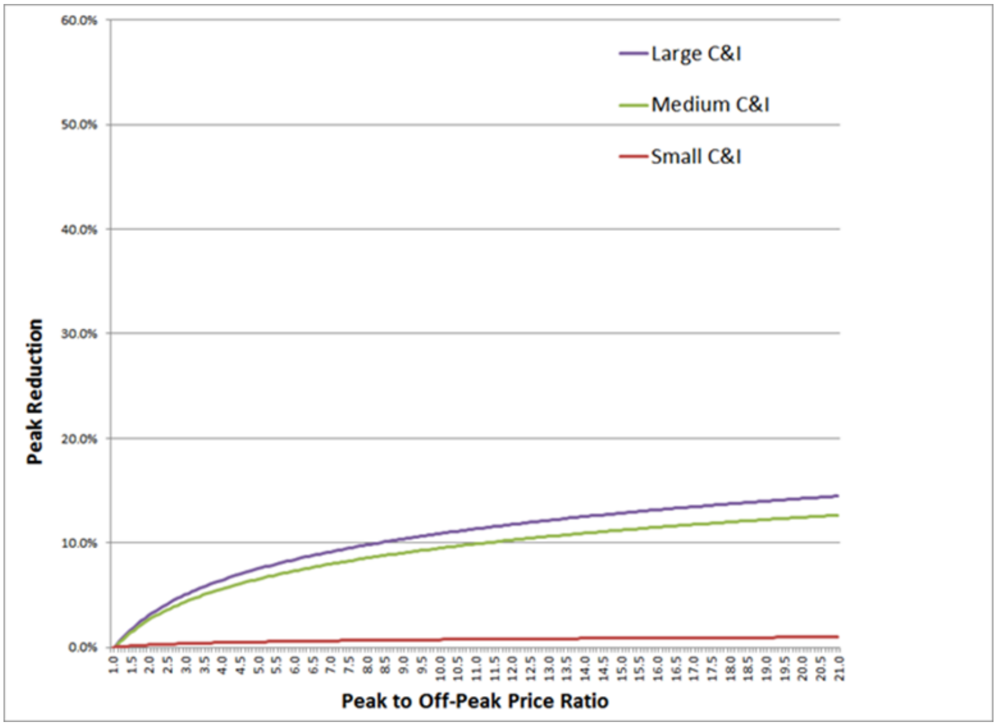


Figure M-5 Commercial and Industrial Results



N | Education and Information Measures

Background and Objective

PacifiCorp separates demand-side management (DSM) resources into four classes, depending on the firmness of impact: Demand Response (Class 1), Energy Efficiency (Class 2), Demand-Side Rates (Class 3), and Education and Information (Class 4). This appendix focuses on the Education and Information (E&I) Class 4 DSM resources, which PacifiCorp defines as "non-incented, behavioral-based impacts achieved through broad energy education and communication efforts."[16] PacifiCorp last assessed E&I measures in its first conservation potential assessment in 2007.[17] Since the 2007 assessment, Home Energy Reports (HERs) and Strategic Energy Management (SEM) have become included in the Conservation Potential Assessment model as Class 2 DSM measures due to the firmness of their impact. PacifiCorp engaged AEG to review more recent information on the ability of E&I DSM resources to provide energy savings and capacity reductions. The remainder of this document presents AEG's research methodology, findings, and recommendations for the next steps PacifiCorp can take to validate the energy savings and capacity reductions of several additional E&I measures for inclusion in future conservation programs.

Methodology

In the first research phase, AEG developed an initial list of residential and non-residential E&I DSM resources and worked with PacifiCorp to identify broad categories for further assessment and characterization. We developed the initial list by reviewing behavioral measure-related material published by federal and state government entities, national energy efficiency organizations, and electric utilities. Three publications were especially helpful in identifying utility behavioral programs and impact evaluation reports:

- Consortium for Energy Efficiency (CEE). 2020 Behavior Program Summary Overview.[18] CEE is a consortium of North American energy efficiency program administrators. As part of its work, CEE has conducted annual online surveys of its members' behavioral approaches and programs since 2010 to develop a yearly Behavior Program Summary.[19] This annual Excel spreadsheet summarizes the CEE member utilities' behavior programs and related evaluations. The most recent publicly available version contains information on approximately 20 utility behavioral programs active in 2020; CEE plans to update their database in 2023. but will not do so in 2022.[20]
- California Public Utilities Commission (CPUC). 2021 Energy Efficiency Potential and Goals Study.[21] The California 2021 Energy Efficiency and Potential and Goals Study, performed by Guidehouse, include estimates of energy and peak demand savings potential in the service territories of the California investor-owned utilities. The report presents results by program type, including the Behavior, Retrocommissioning, and Operational Efficiency (BROs) program. The BROs program measures involve customer behavioral changes that may not rely on new equipment installations. Appendix C of the CPUC report discusses the data sources, assumptions, and methodologies employed for the residential and commercial BROs measures.

[16] Quantec. Assessment of Long-Term, System Wide Potential for Demand-Side and Other Supplemental Resources. Final Report. Prepared for PacifiCorp. July 11, 2007.

[17] Ibid.

[18] The Consortium for Energy Efficiency 2020 Behavior Program Summary spreadsheet is available at the following URL: https://library.cee1.org/content/2020-behavior-program-summary-public-version

[19] Consortium for Energy Efficiency, Now and Then: A Decade of Behavioral Approaches in Efficiency Programs. Jennifer Smith. Presented at the Behavior, Energy, & Climate Change Conference. November 19, 2019.

[20] Email correspondence with Kira Ashby, Principal Program Manager, Consortium for Energy Efficiency (CEE), March 15 and August 29, 2022.

[21] The 2021 Energy Efficiency Potential and Goals Study is available at the following URL: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M411/K195/411195774.pdf

- California Public Utilities Commission (CPUC). 2021 PG BROs Input Database.[22] The 2021 PG BROs Input Database spreadsheet summarizes the detailed input values for the behavioral measures for each California IOU. The 2021 PG BROs Input Database spreadsheet accompanies the CPUC report discussed above. In addition to providing energy savings and peak demand reduction values, the database presents costs and lifetimes for the measures and identifies appropriate building types for each BROs measure.

AEG presented PacifiCorp with an initial list of approximately 30 E&I DSM measures or programs, which were then categorized into 11 more generic program types across residential and non-residential sectors for further assessment (see table below). While most selected resources target annual energy savings, a few E&I resources target capacity reductions. For example, Non-Targeted Conservation Messaging During Critical Events targets capacity reductions and applies to residential and non-residential customers.

In the second research phase, AEG focused on leveraging third-party impact evaluations to estimate the potential for energy and capacity reductions in PacifiCorp's service territory for each selected resource. AEG reviewed and summarized more than 10 0 resources, including 20 evaluations of utility behavioral programs, and compiled the impact estimates across the various data sources to determine appropriate ranges for each resource's energy savings and capacity reduction. The following table summarizes the E&I resources chosen for investigation.

Table N-1 Residential and Non-Residential Education and Information Resources Selected for 2023 CPA Review

Resource	Sector[23]	Energy-Focused	Capacity-Focused
Targeted Behavioral Demand Response Messaging: encourages electricity customers to reduce consumption at peak times and relies on AMI data and Randomized Control Trials (RCT). Importantly, this messaging does not offer any financial incentives for customers to reduce their energy use.	Res		√
Non-Targeted Conservation Messaging During Critical Events: public appeals via radio, TV, text message, or social media asking end-users to voluntarily conserve electricity at peak times.	Res, Non-Res		√
Direct Community Energy Engagement: typically target neighborhood or municipality residents with energy education to help elicit specific energy conservation behaviors.	Res	√	
Virtual Home Energy Assessment: includes a questionnaire to collect information on the home as well as an agent-led video walkthrough with the customer. The resulting assessment typically provides energy conservation measure recommendations and identification of available incentives.	Res	√	
Residential Energy Challenges and Competitions: a behavioral intervention approach in which participants compete in challenges to reduce energy consumption, either directly raising awareness, increasing knowledge, or encouraging one or more types of behavioral changes.	Res	√	
Real-Time Home Energy Use Feedback: relies on an online tool and AMI data to generate real-time home energy use information, which is then presented to the customer via a Web interface or a smartphone.	Res	√	
School Youth Energy Education: involves educating students and their families about energy efficiency to achieve home energy savings, primarily via behavioral changes.	Res	√	
Building Energy Benchmarking: involves comparing a building's energy use to similar structures, past energy use, or a reference performance level. It often includes goal setting and reward recognition.	Non-Res	√	

[22] California Public Utilities Commission, 2021 PG BROs Input Database 4-16-21. Prepared by Guidehouse. URL: https://www.cpuc.ca.gov/General.aspx?id=7023

[23] Residential (R), Non-Residential (NR)

Resource	Sector[23]	Energy-Focused	Capacity-Focused
Building Operator Certification: a competency-based training and certification for commercial building operators focusing on building system optimization.	Non-Res	√	
Business Energy Reports: track energy use and translate the AMI data into low- and no-cost money-saving tips and easy-to-understand charts and graphs.	Non-Res	√	
Virtual Business Energy Assessment: involve a dedicated energy advisor remotely analyzing AMI energy usage data to identify energy savings opportunities.	Non-Res	√	√

Results and Recommendations

AEG's high-level results are presented in the following tables, with Table N-2 and Table N-3 summarizing the characterization results for the residential and non-residential E&I resources, respectively. Because behavioral measure savings are difficult to quantify, AEG could not find sufficient evidence of firm savings for most E&I resources. Therefore, most resources are listed with "unconfirmed" energy savings or capacity reductions. AEG's research indicates that while U.S. electric utilities offer various education and information measures to residential and non-residential customers, most do not currently claim energy or capacity reductions. We found sufficient evidence of savings for only a few E&I resources, with energy or demand savings documented by third-party impact evaluators for Targeted Behavioral Demand Response Messaging and Real-Time Home Energy Use Feedback (see Table N-2). AEG also identified savings associated with Building Operator Certification (see Table N-3). We discuss the three resources with confirmed savings in greater detail following the two tables.

Table N-2 Characterization of Residential Education and Information Measures

Residential Measure	Description	Typical Annual Electric Energy Savings Range	Typical Capacity Range	Estimated Useful Life	Example Utilities with Programs	Do Utilities Typically Claim Savings?
Targeted Behavioral Demand Response (DR) Messaging	Targeted Behavioral DR Messaging encourages electricity customers to reduce consumption at peak times. While traditional DR programs typically involve automated technologies and price signals, this program relies on AMI data and Randomized Control Trials (RCT) and is typically more cost-effective since it does not require additional automated control technologies to be installed. Importantly, this messaging does not offer any financial incentives for customers to reduce their energy use. Behavioral DR programs are similar to Home Energy Reports but target capacity reductions rather than energy use.	Unconfirmed	2-5% or 0.02-0.08 kW per event	1 year	CPS Energy | National Grid | Consumers Energy | DTE | Hydro Ottawa | PG&E | Glendale Water & Power | Efficiency Vermont | BGE | First Energy	Some
Non-Targeted Conservation Messaging During Critical Events	Conservation messaging alerts are public appeals via radio, TV, text message, or social media asking end-users to conserve electricity at peak times voluntarily. Example requests can include turning off unnecessary lights, setting thermostats to 78°F or higher, and shifting appliance use after the critical event. Ideally, non-targeted conservation messaging is most effective when issued a day in advance. Hence, consumers have time to adjust their electricity use by pre-cooling the house and turning thermostats up or off before leaving for work.	Unconfirmed	Unconfirmed	n/a	SCE | PG&E | SDG&E	No
Direct Community Energy Engagement	Direct community energy engagements typically target neighborhood or municipality residents with energy education. They can also target members of community organizations or residents in homeless shelters and transitional housing properties where families may be required to participate in life skills classes. The training helps elicit specific energy conservation behaviors.	Unconfirmed	Unconfirmed	n/a	Fortis BC | SMUD | TVA | Hawaii Energy	No

Residential Measure	Description	Typical Annual Electric Energy Savings Range	Typical Capacity Range	Estimated Useful Life	Example Utilities with Programs	Do Utilities Typically Claim Savings?
Virtual Home Energy Assessment	A virtual home energy assessment usually begins with a questionnaire to collect information on the home (such as age and home type), customer demographics, HVAC system details, home appliance condition, service type (e.g., electric, gas), and primary energy use. The assessment typically includes a trained agent conducting a video walkthrough of the home with the customer. A walkthrough often lasts 30-60 minutes; the resulting assessment typically provides energy conservation measure recommendations and identification of available incentives.	Unconfirmed	Unconfirmed	1 year	PSE	PG&E	SCE	SDG&E	ComEd	DTE	UI	Focus on Energy	TVA	NIPSCO	Efficiency Vermont	National Grid	NEEP	Some
Residential Energy Challenges and Competitions	Residential energy challenges and competitions are a behavioral intervention approach in which participants compete in challenges to reduce energy consumption, either directly raising awareness, increasing knowledge, or encouraging one or more types of actions. The challenges focus on behavioral changes rather than equipment upgrades to generate energy savings. Competitions can run from a single month to multiple years.	Unconfirmed	Unconfirmed	1 year	PG&E	SCE	SDG&E	SCG	Hawaii Energy	Yes
Real-Time Home Energy Use Feedback	Real-Time Home Energy Use Feedback relies on an online tool and AMI data to generate real-time home energy use information, which is then presented to the customer via a Web interface or a smartphone.	1.6-2.6%	3% or 0.08-0.1 kW per event	1 year	PG&E	SCE	SDG&E	SMUD	DTE	CPS Energy	BC Hydro	Hawaiian Electric	Some
School Energy Education	School Energy Education involves educating students and their families about energy efficiency to achieve home energy savings. Utilities typically use presentations conducted by professional educators from the National Energy Foundation (NEF) to teach students and teachers about the importance of energy efficiency and how their choices impact energy savings.	Unconfirmed	Unconfirmed	n/a	PacifiCorp	Hawaiian Electric	DTE	PG&E	OG&E	No

Table N-3 Characterization of Non-Residential Education and Information Measures

Non-Residential Measure	Description	Typical Annual Electric Energy Savings Range	Typical Capacity Reduction Range	Estimated Useful Life	Example Utilities with Programs	Do Utilities Typically Claim Savings?
Building Energy Benchmarking	Building energy benchmarking involves comparing a building's energy use to similar structures, past energy use, or a reference performance level. It often includes goal setting and reward recognition. Energy benchmarking typically requires compliance using the ENERGY STAR Portfolio Manager online tool. Most programs target buildings greater than 50,000 sq. ft.	Unconfirmed	Unconfirmed	2 years	PacifiCorp | SCE | PG&E | SDGE | ComEd | CenterPoint Energy | Xcel | ConEd | DCSEU	No
Building Operator Certification	Building Operator Certification (BOC) is a competency-based training and certification for commercial building operators. The curriculum teaches participants how to improve building comfort and efficiency by optimizing their building systems. There are two levels of certification. BOC Level 1 ("Building Systems Maintenance") emphasizes energy-efficient building operation and maintenance practices, while BOC Level 2 ("Equipment Troubleshooting & Maintenance") emphasizes equipment preventive maintenance and troubleshooting.	14-300 kWh /1,000 sq. ft./ participant	Unconfirmed	3-5 years	PacifiCorp | SCE | PG&E | SDGE | Cape Light Compact | Eversource MA | National Grid | Energize CT | Focus on Energy | Ameren Illinois | Minnesota Power | MER | CenterPoint | Xcel Energy | ComEd | KCP&L	Some
Business Energy Report	Business Energy Reports track energy use and translate the AMI data into low- and no-cost money-saving tips and easy-to-understand charts and graphs. The educational information typically targets small- and medium-sized businesses and encourages them to engage in their energy use, including making behavioral changes that can result in energy savings.	Unconfirmed	Unconfirmed	1-2 years	PacifiCorp | ComEd | FirstEnergy | Evergy | BG&E | SMUD | PG&E | KCP&L	Some

Non-Residential Measure	Description	Typical Annual Electric Energy Savings Range	Typical Capacity Reduction Range	Estimated Useful Life	Example Utilities with Programs	Do Utilities Typically Claim Savings?
Non-Targeted Conservation Messaging During Critical Events	Conservation messaging alerts are public appeals via radio, TV, text message, or social media asking end-users to reduce energy use at peak times voluntarily. Example requests include turning off unneeded lights and setting thermostats to 78°F or higher. During these DR events, the utilities measure customer energy uses relative to their counterfactual baseline energy use estimate.	Unconfirmed	Unconfirmed	n/a	CAISO	No
Virtual Business Energy Assessment	Virtual business energy assessments involve a dedicated energy advisor remotely analyzing energy usage data from the smart meter to pinpoint custom-tailored solutions for the facility. Participants receive energy management and information system services to manage their energy use better, identify energy savings opportunities, and achieve energy savings through low- or no-cost energy-saving operational changes or adjustments. The virtual assessments typically target small and medium-sized businesses, including franchisees of national chains, which the utilities deem to have significant potential for achieving energy savings through low- or no-cost operational changes or adjustments.	Unconfirmed	Unconfirmed	n/a	ComEd | Tampa Electric | DTE | Avangrid | PG&E | Efficiency Vermont	No

We discuss the three E&I DSM resources with confirmed energy savings and capacity reductions in greater detail below.

Targeted Behavioral Demand Response Messaging

Targeted Behavioral Demand Response (DR) Messaging encourages customers to reduce their energy consumption at peak times. Customers receive emails or phone calls before the critical peak periods, called DR events, asking them to lower their energy consumption. Their consumption is then measured relative to their estimated counterfactual consumption baseline to estimate the impacts of the messaging. Behavioral DR programs are very similar to those in the well-established Home Energy Report (HER) programs. The critical difference is that behavioral DR messaging targets only a few hours on days when electric demand is high rather than energy use. Behavioral DR programs can complement existing HER, Direct Load Curtailment, and other DR programs. Example utilities operating or piloting behavioral DR programs include CPS Energy, National Grid, Consumers Energy, DTE, Hydro Ottawa, PG&E, Glendale Water & Power, Efficiency Vermont, BGE, and First Energy.

AEG identified capacity reductions of 2-5% or 0.02-0.08 kW per customer during targeted behavioral demand response messaging events in a dozen third-party impact evaluations (see Table N-2). While traditional DR programs typically require automated technologies and price signals, behavioral DR programs rely on AMI data and Random Control Trials (RCT) and therefore are more cost-effective. Importantly, behavioral DR programs typically neither offer any financial incentives for customers to reduce their energy use nor require the installation of expensive technology at a customer's premise. As with HER programs, behavioral DR programs are most cost-effective when run on an opt-out basis due to their relatively modest per-customer impacts and the low marginal cost of sending out additional emails and communications. One source estimates the cost of targeted behavioral DR messaging at $68 per kW-year.[24]

Recommendation: AEG recommends exploring the inclusion of Targeted Behavioral Demand Response Messaging as a Demand-Side Rate measure in future CPAs to target capacity reductions for the PacifiCorp service territory.

Real-Time Home Energy Use Feedback

Real-Time Home Energy Use Feedback uses AMI data to generate real-time home energy use information, which the customer receives via a Web interface or a smartphone. The Web interface (or smartphone) displays: interval consumption graphs, various overlays and comparisons (incl. temperature overlay and comparison to similar homes nearby), and projections/forecasts. Customers can typically view how much energy use and costs occur at peak, mid-peak, and off-peak times. Additionally, the tool allows users to set up alerts for specific thresholds. Several utilities provide real-time home energy use feedback to their residential customers through a web portal, with primary examples being PG&E, SCE, SDG&E, SMUD, BC Hydro, DTE, Hawaiian Electric, and CPS Energy. PacifiCorp also provides this feedback in states where they have AMI deployed but has not claimed savings to date. Impact evaluations for DTE (Michigan) and several California utilities demonstrate annual energy savings of 1.6-2.6% and capacity reductions of 3% (or 0.08-1.0 kW per participant). The lifetime for this measure is one year.

The savings values for real-time residential feedback programs are similar to those for Home Energy Reports (HERs),[25] and this measure could be thought of as a more advanced, interactive version of HERs. For example, Rocky Mountain Power's HER program in Idaho achieved energy savings of 1.3% and 1.6% in 2018 and 2019, respectively.[26] In Washington, the HER savings for 2018 and 2019 ranged from 0.5% to 2.6%, depending on how long the customers had participated in the HER program.

[24] Beth Fitzgerald, Utility Behavioral Demand Response Programs, October 2017. Presented at the BECC 2017. URL: https://beccconference.org/wp-content/uploads/2017/10/fitzjarrald_presentation.pdf

[25] HERs are an energy efficiency resource included separately in the Energy Efficiency/Class 2 DSM potential model.

[26] Cadmus, Evaluation Report of 2018-2019 Home Energy Reports Program. Prepared for PacifiCorp. December 8, 2020.

Recommendation: AEG recommends that future HER evaluations examine impacts from Real-Time Home Energy Use Feedback in PacifiCorp's current programs to see if it increases savings from treatment with just HERs. Just like PacifiCorp, many utilities are increasingly combining HERs delivered by regular or electronic mail with access to a web portal where customers can view details and insights about their near-real-time home energy use.

Building Operator Certification

Building Operator Certification (BOC) is a competency-based training and certification for building operators. The curriculum teaches participants how to improve building comfort and efficiency by optimizing a building's systems. BOC Level 1 training ("Building Systems Maintenance") emphasizes energy-efficient building operation and maintenance practices. BOC Level 2 training ("Equipment Troubleshooting & Maintenance") targets preventive maintenance and troubleshooting equipment. Each BOC level typically involves 16 half-days of training. The cost is approximately $1,000 per training level.

Various state and utility-sponsored BOC programs show annual energy savings ranging from 14 to 300 kWh per 1,000 sq. ft. total building floor area per participant with a lifetime in the range of 3-5 years (see Table N-3). A NEEA report documents the highest yearly energy savings value (300 kWh/1,000 sq. ft.). There may be several reasons for the significant variation in energy savings across the various sources, including:

- The California data show energy savings differ significantly by commercial segment. For example, BOC-trained operators in California achieved higher energy savings in restaurants (154 kWh per 1,000 sq. ft.) than in warehouses (14 kWh per 1,000 sq. ft.).
- It is critical to separate behavior-related savings from equipment-upgrade savings to prevent overestimating the BOC-related savings. While the NEEA report breaks out the behavior-related savings, the contractor used an engineering-based algorithm to convert questionnaire responses from BOC participants to energy savings which may have induced errors.
- The NEEA study did not consistently gather the building square feet that each BOC participant oversaw. As such, the NEEA report may have inflated energy savings.

BOC overlaps with Strategic Energy Management (SEM), which is included as a measure in the Energy Efficiency DSM Potential Study, to some degree. SEM is a comprehensive approach to aligning energy efficiency with business practices and goals in a facility. While SEM targets groups of employees at a commercial or industrial facility to collectively nurture a conservation and continuous energy improvement culture, BOC targets commercial building operators responsible for energy-using building equipment and day-to-day building operation. Because commercial building operators are often responsible for multiple buildings, BOC program participation offers opportunities to achieve behavioral-related savings in several buildings.

Recommendation: AEG recommends continuing to explore the potential of BOC in future programs. Specifically, we recommend that PacifiCorp carefully evaluate the energy savings associated with BOC training in the Pacific Northwest. We recommend normalizing the energy savings per square foot and developing savings values for different commercial building segments. Table N-3 shows that the savings ranges for BOC are relatively wide and based on impact evaluation results from an array of US utilities, jurisdictions, and customer segments. Because the climate zones and customer characteristics in other utility service territories may differ from those of PacifiCorp, we recommend that PacifiCorp conduct additional analyses to firm up the savings before incorporating BOC into a future program.

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