Tacoma Power Conservation Potential Assessment 2022-2041

Prepared for: Tacoma Power

By: Applied Energy Group, Inc.

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NOTE TO THE READER

On October 13, 2021, the Tacoma Public Utilities board adopted a ten-year 2022-2031 conservation potential and a two-year 2022-2023 conservation target based on the results of this 2021 Conservation Potential Assessment. Subsequently, while preparing this report, Applied Energy Group (AEG) identified an error that resulted in a 4% under-estimation of the ten-year achievable conservation potential. To most accurately reflect the final results of AEG's analysis, this report has been updated to present the final study results. As such, results presented in this report are slightly different than those used by Tacoma Power in establishing its 2022-2031 conservation forecast and 2022-2023 conservation target. A comparison of the filed and final 10-year achievable potential by sector is provided in the table below.

Comparison of Filed Target and Revised Potential – 10-Year Cumulative Achievable Potential

Sector	Potential in October 2021	Revised Potential	Change (MWh)	% Change
Residential	52,712	55,756	3,044	5.8%
JBLM Residential	1,133	1,210	77	6.8%
Commercial	87,574	94,171	6,597	7.5%
JBLM Commercial	8,932	9,474	542	6.1%
Industrial	58,151	57,062	-1,089	-1.9%
Street Lighting	1,931	1,931	0	0.0%
Distribution	6,570	6,570	0	0.0%
Total	**217,003**	**226,174**	**9,171**	**4.2%**

EXECUTIVE SUMMARY

Applied Energy Group (AEG) has successfully partnered with Tacoma Power (Tacoma) to perform prior Conservation Potential Assessments (CPAs) in 2014, 2016, and 2019, following the methodology of the Northwest Power and Conservation Council's (Council's) then-current Power Plans.[1] The new CPA builds on the background material established in those earlier studies, but includes updates to the latest available customer data from Tacoma Power, best and most recent market data from the Northwest Energy Efficiency Alliance's (NEEA's) regional market assessments (RBSA, CBSA, and IFSA), and updated technical data from the Regional Technical Forum, NEEA, and US Department of Energy.

To produce a reliable and transparent estimate of conservation resource potential, the AEG team performed the following tasks to meet Tacoma's key objectives:

- Used information and data from Tacoma, as well as secondary data sources, to describe how customers currently use energy by sector, segment, end use and technology.
- Developed a baseline projection of how customers are likely to use electricity in absence of future conservation programs; this defines the metric against which future program savings are measured. This projection used up-to-date technology data, modeling assumptions, and energy baselines that reflect both current and anticipated federal, state, and local energy efficiency legislation that will impact energy conservation potential.
- Estimated Technical, Achievable Technical, and Economic Achievable potential consistent with Council methodologies as well as Washington's Energy Independence Act.[2]AEG estimated energy efficiency potential at the measure within the Tacoma service territory over the 2022 to 2041 planning horizon, including energy savings on an hourly basis for each year in the study.

In summary, the potential study provides a solid foundation for the development of Tacoma Power's 2022-2023 biennial savings targets. The results were also prepared for Tacoma's Integrated Resource Planning (IRP) team, who use the estimated program costs and the hourly measure-level savings estimates as inputs to their long-term planning model.

Table ES-1 summarizes the high-level results of this study. AEG analyzed potential for the residential, commercial, industrial, street lighting, and Joint Base Lewis-McChord (JBLM) market sectors as well as for substation distribution efficiency improvements. The ten-year potential in 2031, is 226,174 MWh, or 26.9 aMW.

Table ES-1 Economic Achievable Potential in 2031

Market Sector	2031 Economic Achievable Potential (MWh)	% of Total Potential	Average MW (aMW)
Residential	55,756	24.7%	7.2
JBLM Residential	1,210	0.5%	0.2
Commercial	94,171	41.6%	11.2
JBLM Commercial	9,474	4.2%	1.1
Industrial	57,062	25.2%	6.2
Street Lighting	1,931	0.9%	0.3
Distribution Efficiency	6,570	2.9%	0.7
Total	**226,174**	**100.0%**	**26.9**

[1] "Sixth Northwest Conservation and Electric Power Plan". Northwest Power & Conservation Council, February 1, 2010. https://www.nwcouncil.org/energy/previous-energy-plans/6/sixth-northwest-conservation-and-electric-power-plan-0

"Seventh Northwest Conservation and Electric Power Plan." Northwest Power & Conservation Council, February 10, 2016. http://www.nwcouncil.org/energy/powerplan/7/plan/

[2] Energy Independence Act (I-937). http://www.commerce.wa.gov/growing-the-economy/energy/energy-independence-act/

Key opportunities for savings include the continuation of LED lighting programs, implementation of strategic energy management initiatives in the large commercial sectors, efficient HVAC technologies, industrial motor VFDs, compressed air system upgrades, and motor and process optimization in the Industrial sector.

Comparison with Prior Study

Compared to the prior CPA, which estimated potential for the 2020-2021 biennium, several key assumptions and methodologies used in the region have been updated. These include:

- Updates to Regional Technical Forum (RTF) unit energy savings (UES) measures and standard protocols – two additional years of analysis
- Updates to Tacoma customer data, including a refresh of customer floor space and presence of electric heat
- Updates to Tacoma Power programs – most recent results from Tacoma's implementation database
- Updates to the avoided cost of energy

Compared to the previous study, TRC Economic Achievable potential has decreased by about 15%. Differences in potential affect are noticeable in all sectors and are mainly due to:

- The continuing impacts of the EISA lighting standard that took effect in 2020 and resulting related market transformation have dramatically reduced the opportunity for lighting replacements, particularly in the residential sector. The most recent data from the US Department of Energy and used by the NWPCC Regional Technical Forum expects that the market baseline for general service lighting replacement will reach 100% LED within a few years.
- Updated building stock efficiency in the Residential sector. In addition to the more efficient average building shells from the 2016 NEEA Residential Building Stock Assessment used in the previous study, this study accounts for the impacts of the 2018 Washington State Energy Code which took effect in 2021. This new more efficient code further lowers consumption in new construction homes, which reduces the opportunity for claimed savings above code. Table ES-2 compares 10-year potential between the two studies at a sector level.

Table ES-2 Comparing Economic Achievable Potential in 10th year

Market Sector	Current Study: 2022-2031 Potential (MWh)	*Prior Study: 2020-2029 Potential (MWh)*	Difference
Residential	55,756	*55,827*	-71
JBLM Residential	1,210	*1,413*	-203
Commercial	94,171	*89,279*	4,892
JBLM Commercial	9,474	*8,361*	1,113
Industrial	57,062	*62,700*	-5,638
Street Lighting	1,931	*2,713*	-782
Distribution Efficiency	6,570	*10,548*	-3,978
Total	**226,174**	***230,841***	**-4,667**

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INTRODUCTION

This report documents the results of the Tacoma Power 2021 Conservation Potential Assessment (CPA) as well as the steps followed in its completion. Throughout this study, AEG worked with Tacoma Power staff to understand the baseline characteristics of their service territory, including a detailed understanding of energy consumption in the territory, the assumptions and methodologies used in Tacoma's official load forecast, and recent programmatic accomplishments. Using methodologies consistent with the Northwest Power and Conservation Council's (Council's) 2021 Power Plan,[3] AEG then developed an independent estimate of available conservation potential within Tacoma Power's service territory between 2022 and 2041.

Photo: Getty Images

Goals of the 2022-2041 CPA

The primary objective of this CPA was to assist in developing Tacoma Power's 2022-2023 biennial conservation target under the State of Washington's Energy Independence Act,[4] also known as I-937. To satisfy this requirement, AEG followed the methodologies set forth in the Washington Administrative Code (WAC) 194-37-070, as described later in this document.

Additionally, this study was developed to provide conservation inputs into Tacoma Power's Integrated Resource Planning process. To this end, AEG developed hourly Economic Achievable Potential inputs by program for input into Tacoma Power's Integrated Resource Plan (IRP) model. AEG also identified impacts not captured in Tacoma Power's official econometric forecast, including the effects of known future federal standards and variation in customer growth rates by housing type. These impacts were provided in hourly format for use in the IRP and account for the differences between AEG's end-use projection and Tacoma Power's official forecast.

Finally, the CPA is intended to support the design of programs to be implemented by Tacoma Power during the following two years. Using regional sources, supplemented by well-vetted nationwide data when appropriate,

[3] NWPCC 2021 Power Plan: https://www.nwcouncil.org/2021-northwest-power-plan

[4] Energy Independence Act (I-937). http://www.commerce.wa.gov/growing-the-economy/energy/energy-independence-act/

AEG developed a comprehensive summary of measures. This summary documents input assumptions and sources on a per-unit basis, program applicability and achievability, and potential results (units, incremental potential, and cumulative potential). This summary was developed in collaboration with Tacoma Power and refined throughout the project.

Project Background

AEG has successfully partnered with Tacoma Power's to perform prior Conservation Potential Assessments in 2014, 2016, and again in 2019, following the methodology of the Northwest Power and Conservation Council's (Council's) then-current Power Plans[5]. The new CPA builds on the background material established in those earlier studies, but includes updates to the latest available customer data from Tacoma Power, best and most recent market data from Northwest Energy Efficiency Alliance's (NEEA's) regional market assessments (RBSA, CBSA, and IFSA), and updated technical data from the Regional Technical Forum, NEEA, and US Department of Energy.

Report Contents

This report is divided into six chapters and four appendices, summarizing the approach, assumptions, and results of Tacoma Power's 2022-2041 CPA. We describe each section below:

- **Analysis Approach and Data Development**. Detailed description of AEG's approach to conducting Tacoma Power's 2022-2041 CPA and documentation of primary and secondary sources used.
- **Market Characterization and Market Profiles**. Characterization of Tacoma Power's service territory in the base period of the study, which comprises 12 complete months from October 2019 through September 2020.[6] This characterization includes total consumption, number of customers and market units, and energy intensity. This also includes a breakdown of the energy consumption for the residential, commercial, industrial, street lighting, and JBLM residential and commercial use by end use and technology.
- **Baseline Projection**. Projection of baseline energy consumption under a frozen-efficiency case, described at the end-use level (see Chapter 4). The LoadMAP models were first aligned with Tacoma Power's official econometric forecast and then varied to include the impacts of future federal standards and residential growth assumptions. Note that this reference baseline assumes business-as-usual regarding customer equipment preferences, not a driven electrification scenario.
- **Overall Conservation Potential**. Summary of conservation potential for Tacoma Power's entire service territory for selected years between 2022 and 2041, including territory-wide supply curves and potential estimates for each sector and distribution efficiency.
- **Sector-Level Conservation Potential**. Summary of conservation potential for each market sector within Tacoma Power's service territory, including residential, JBLM residential, commercial, JBLM commercial, industrial, street lighting, and distribution efficiency. This section includes a more detailed breakdown of potential by measure type, vintage, market segment, and end use. Potential is also analyzed for level of risk based on its RTF workbook status and cost-effectiveness ratio. Supply curves by market sector are also provided.
- **Comparison with Prior Study**. Detailed comparison of changes between the prior and current CPA.

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[5] "Seventh Northwest Conservation and Electric Power Plan." Northwest Power & Conservation Council, February 10, 2016. http://www.nwcouncil.org/energy/powerplan/7/plan/ and "Sixth Northwest Conservation and Electric Power Plan." Northwest Power & Conservation Council, February 1, 2010. https://www.nwcouncil.org/energy/previous-energy-plans/6/sixth-northwest-conservation-and-electric-power-plan-0

[6] While previous CPAs have used a true calendar year (January through December) for the base period, at the time this study commenced full calendar year data for 2020 was not available. This methodology is still consistent with a calendar year of use and serves as reasonable grounds for the rest of the study.

Appendices:

- **Consistency with Council Methodology**. Documentation of how AEG's approach in conducting the 2022-2041 CPA aligns with the 2021 Power Plan under WAC 194-37-070.
- **Market Profiles**. Detailed market profiles for each non-industrial market sector. Includes equipment saturation, unit energy consumption or energy usage index, energy intensity, and total consumption.
- **Customer Adoption Factors**. Documentation of the ramp rates used in this analysis. A majority were applied directly from the Seventh Plan conservation workbooks. In addition, AEG developed custom behavioral and street lighting ramp rates to reflect Tacoma Power's current implementation plans for these measures.
- **Measure List**. List of measures, along with example baseline definitions and efficiency options by market sector analyzed. Distribution efficiency was not included in this list since it is a single measure.

Abbreviations and Acronyms

Throughout the report we use a number abbreviations and acronyms. Table 1-1 shows the abbreviation or acronym, along with an explanation.

Table 1-1 Explanation of Abbreviations and Acronyms

Acronym	Explanation
aMW	Average Megawatt, obtained by dividing Megawatt-hours by 8760
AEO	Annual Energy Outlook forecast developed by EIA
B/C Ratio	Benefit to Cost Ratio
BEST	AEG's Building Energy Simulation Tool
BPA	Bonneville Power Administration
C&I	Commercial and Industrial
Council	Northwest Power and Conservation Council (NWPCC)
DSM	Demand-Side Management
EE	Energy Efficiency
EIA	Energy Information Administration
EUL	Effective Useful Life
EUI	Energy Usage Intensity
GWh	Gigawatt Hour
HVAC	Heating Ventilation and Air Conditioning
IRP	Integrated Resource Plan
LED	Light Emitting Diode lamp
LoadMAP	AEG's Load Management Analysis and Planning™ tool
MW	Megawatt
NPV	Net Present Value
NEEA	Northwest Energy Efficiency Alliance
O&M	Operations and Maintenance
RTF	Regional Technical Forum
TRC	Total Resource Cost test
UCT	Utility Cost Test
UEC	Unit Energy Consumption
UES	Unit Energy Savings
WAC	Washington Administrative Code

2

ANALYSIS APPROACH AND DATA DEVELOPMENT

This section describes the analysis approach taken for the study and the data sources used to develop the potential estimates.

Overview of Analysis Approach

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

1. Performed a market characterization to describe sector-level electricity use for the residential, commercial, industrial, street lighting, and JBLM sectors for the base period. This included using Tacoma data and other secondary data sources such as NEEA's 2016 RBSA and recently updated 2019 CBSA and publications by the U.S. Energy Information Administration (EIA).
2. Developed a baseline projection of energy consumption by sector, segment, end use, and technology for 2021 through 2041.
3. Defined and characterized several hundred energy conservation measures (ECMs) to be applied to all sectors, segments, and end uses.
4. Estimated Technical, Achievable Technical, and Economic Achievable potential energy savings at the measure level for 2022-2041.

LoadMAP Model

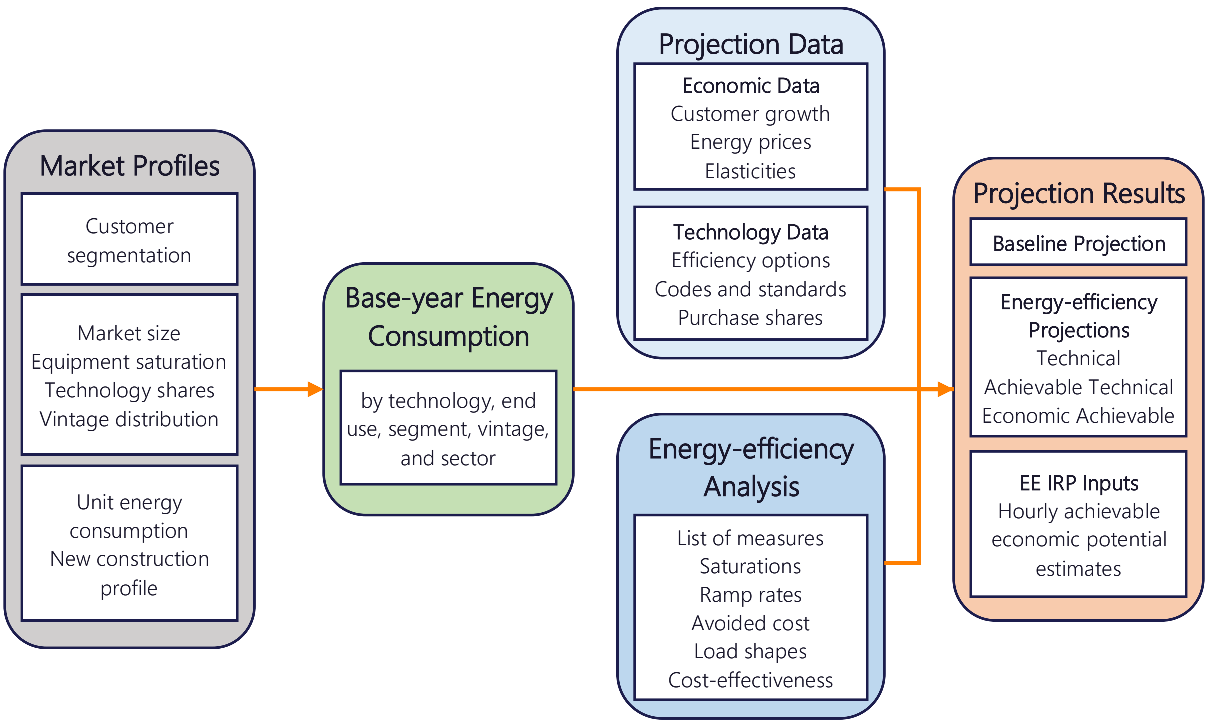
For this analysis, AEG used its Load Management Analysis and Planning tool (LoadMAP™) to develop both the baseline projection and the estimates of potential. AEG developed LoadMAP in 2007 and has enhanced it over time, using it for the EPRI National Potential Study and numerous utility-specific forecasting and potential studies since. Built in Excel, the LoadMAP framework (see Figure 2-1) is both accessible and transparent and has the following key features.

- Embodies the basic principles of rigorous end-use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life and appliance vintage distributions defined by the user.
- Balances the competing needs of simplicity and robustness by incorporating important modeling details related to equipment saturations, efficiencies, vintage, and the like, where market data are available, and treats end uses separately to account for varying importance and availability of data resources.
- Isolates new construction from existing equipment and buildings and treats purchase decisions for new construction and existing buildings separately.
- Uses a simple logic for appliance and equipment decisions. Other models available for this purpose embody complex decision choice algorithms or diffusion assumptions, and the model parameters tend to be difficult to estimate or observe and sometimes produce anomalous results that require calibration or even overriding. The LoadMAP approach allows the user to drive the appliance and equipment choices year by year directly in the model. This flexible approach allows users to import the results from diffusion models or to input individual assumptions. The framework also facilitates sensitivity analysis.

- Includes appliance and equipment models customized by end use. For example, the logic for lighting is distinct from refrigerators and freezers.
- Can accommodate various levels of segmentation. Analysis can be performed at the sector level (e.g., total residential) or for customized segments within sectors (e.g., housing type or income level).
- Natively outputs model results in a detailed line-by-line summary file, allowing for review of input assumptions, cost-effectiveness results, and potential estimates at a granular level.

Consistent with the segmentation scheme and the market profiles we describe below, the LoadMAP model provides projections of baseline energy use by sector, segment, end use, and technology for existing and new buildings. It also provides forecasts of total energy use and energy-efficiency savings associated with the various types of potential. [7]

Figure 2-1 LoadMAP Analysis Framework



Types of Potential Included in the Study

AEG market potential studies typically analyze three types of potential: technical, achievable technical and achievable economic. Utilities can customize this analysis to best suit their needs and align with regulatory requirements in reporting energy efficiency potential. Chapter 5 provides more detail on each type of potential and what data informed potential scenarios for this study.

[7] The model computes energy and peak-demand forecasts for each type of potential for each end use as an intermediate calculation. Annual-energy and peak-demand savings are calculated as the difference between the value in the baseline projection and the value in the potential forecast (e.g., the technical potential forecast).

Table 2-1 Levels of Potential

Potential Type	Definition
Technical	Everyone chooses the most efficient option regardless of cost at time of equipment replacement or measure adoption, limited only by the presence of applicable equipment or space.
Achievable Technical	A modified technical potential that accounts for likely measure adoption within the market over the study timeline
Achievable Economic	A subset of achievable technical potential that includes only cost-effective measures

Market Characterization

In order to estimate the savings potential from energy-efficient measures, it is necessary to first understand how much energy is used today and what equipment is currently in service. This market characterization begins with a segmentation of Tacoma's electricity footprint to quantify energy use by sector, segment, end-use application, and the current set of technologies in operation. For this we rely primarily on information from Tacoma, augmenting with secondary sources as necessary.

Segmentation for Modeling Purposes

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

Table 2-2 Overview of Tacoma Analysis Segmentation Scheme

Segmentation Variable	Description
Sector	Residential, commercial, industrial, JBLM residential, JBLM commercial, street lighting
Segment	Residential: single family, single family 2-4 units, low-rise multifamily, high-rise multifamily, and mobile homes Commercial: office, retail, college, school, grocery, hospital, other health, lodging, restaurant, assembly, warehouse, data center, multifamily common area, street lighting, classified miscellaneous, and unclassified miscellaneous Industrial: key industrial segments and other/misc. Street Lighting: rate class
Vintage	Existing and new construction
End uses	Cooling, lighting, water heating, motors, etc. (as appropriate by sector)
Appliances/end uses and technologies	Technologies such as lamp type, air conditioning equipment, motors by application, etc.
Equipment efficiency levels for new purchases	Baseline and higher-efficiency options as appropriate for each technology

With the segmentation scheme defined, we then performed a high-level market characterization of electricity sales in the base period. We used detailed Tacoma billing and customer data with minimal augmentation from secondary sources to allocate energy use and customers to the various sectors and segments such that the total customer count and energy consumption matched the Tacoma system totals from 2020-2021 billing data. This information provided control totals at a sector level for calibrating the LoadMAP model to known data for the base year.

Market Profiles

The market profile is a base-year snapshot of an entire sector, summarizing energy use for each segment in the study and apportioning the annual energy into the various end uses and technologies. The market profile serves as the foundation for the baseline projection by defining the count of stock units that are available, and what the consumption of those units looks like in each segment. Chapter 3 provides detail on the key market profile elements.

Baseline Projection

The next step was to develop the baseline projection of annual electricity use for 2021 through 2041 by customer segment and end use without new utility conservation programs. The baseline projection is the foundation for the analysis of savings in future conservation cases and scenarios as well as the metric against which potential savings are measured. AEG developed the reference baseline in alignment with Tacoma Power's long-term demand forecast, but some modifications to account for known future conditions were also made.

Inputs to the baseline projection include:

- Customer growth projections
- Trends in fuel shares and equipment saturations
- Existing and approved changes to building codes and equipment standards

It should also be noted that this reference baseline does **not** include the following:

- Future DSM program impacts
- Legislation-driven electrification of end uses – as legislation that would drive this change is not yet established in Washington. If such legislation passes in the future, it may constitute a significant difference in projected baseline sales
- Climate change projections – to remain consistent with the Tacoma Power official load forecast, these projections assume normal weather conditions

We present the baseline projection results for the system as a whole and for each sector in Chapter 4.

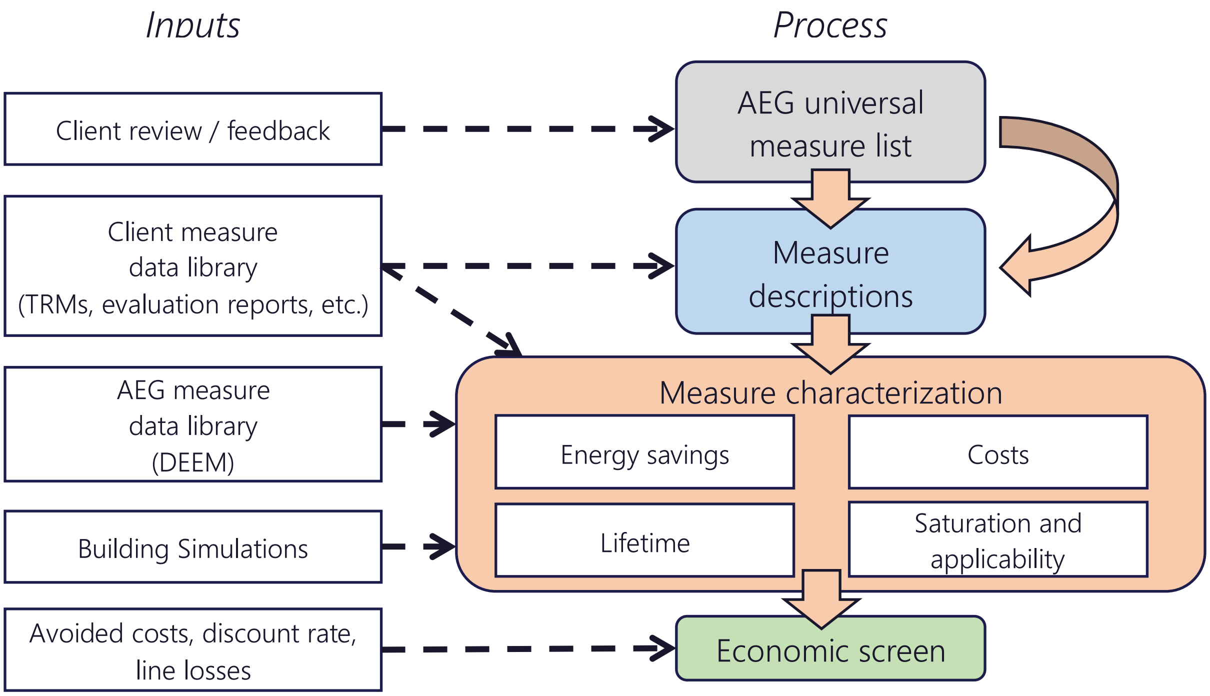
Energy Conservation Measure Development

This section describes the framework used to assess the savings, costs, and other attributes of energy conservation measures (ECMs). These characteristics form the basis for measure-level cost-effectiveness analyses as well as for determining measure-level savings.

Figure 2-2 outlines the framework for ECM analysis. The framework for assessing savings, costs, and other attributes of ECMs involves identifying the list of ECMs to include in the analysis, determining their applicability to each market sector and segment, fully characterizing each measure, and performing cost-effectiveness screening. Tacoma Power provided feedback during each step of the process to ensure measure assumptions and results aligned with programmatic experience.

AEG compiled a robust list of ECMs for each customer sector, primarily from Regional Technical Forum (RTF) measure workbooks, but also drawing upon Tacoma program experience, AEG's own measure databases and building simulation models, and secondary sources. This universal list of measures covers all major types of end-use equipment, as well as devices and actions to reduce energy consumption. While this list may ultimately not be exhaustive of every possible intervention, it presents a wide array of reasonable and possible options with sufficient data for modeling and applying in Tacoma Power's territory. If considered today, some of these measures would not pass the economic screens, but may pass in future years as a result of lower projected equipment costs or higher avoided cost benefits.

Figure 2-2 Approach for ECM Assessment



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

- **Equipment measures** represent efficient energy-consuming pieces of equipment that save energy by providing the same service with a lower energy requirement than a standard unit. For example, an ENERGY STAR refrigerator replacing a standard refrigerator. For equipment measures, many efficiency levels may be available for a given technology, ranging from the baseline unit (often determined by code or standard) up to the most efficient product commercially available. For instance, in the case of central air conditioners, this list begins with the current federal standard (SEER 13) unit and spans a broad spectrum up to a maximum efficiency of a SEER 24 unit. These measures are applied on a stock-turnover basis, and in general, are referred to as lost opportunity (LO) measures by the Council since once a purchase decision is made, there will not be another opportunity to improve the efficiency of that equipment item until the lifetime expires again.
- **Non-equipment measures** save energy by reducing the need for delivered energy, but do not involve the replacement or purchase of major end-use equipment (such as a refrigerator or air conditioner). Since measure installation is not tied to a piece of equipment reaching end of useful life, these are generally categorized as "retrofit" measures. An example would be a wi-fi-enabled thermostat that is pre-set to run heating and cooling systems only when people are home. Non-equipment measures can apply to more than one end use. For instance, the addition of wall insulation will affect the energy use of both space heating and cooling equipment. Non-equipment measures typically fall into one of the following categories:
    - Building shell (windows, insulation, roofing material)
    - Equipment controls (thermostat, integrated lighting fixture controls)
    - Whole-building design (zero-net energy, passive solar lighting)
    - Displacement measures (ceiling fan to reduce use of central air conditioners)
    - Retro-commissioning

- Residential behavioral programs
- Energy Management programs

AEG developed a preliminary list of efficient measures, which was distributed to the Tacoma project team for review. The list was finalized after incorporating comments and is presented in the final appendix to this volume with measure-level detail. Once the list of measures to assess was finalized, the project team fully characterized each measure in terms of energy savings, incremental cost, effective useful life, and other performance factors.

Calculation of Energy Conservation Potential

The approach used to calculate conservation potential adheres to the approaches and conventions outlined in the most recent Washington Administrative Code (WAC) 194-37-070(5), the Northwest Power & Conservation Council's 2021 Power Plan, and the National Action Plan for Energy-Efficiency (NAPEE) Guide for Conducting Potential Studies.[8] These documents represent credible and comprehensive industry best practices for specifying conservation potential. Additional information on WAC 194-37 compliance is provided in Appendix A. As described in the Executive Summary, three types of potential were developed as part of this effort: Technical potential, Achievable Technical potential, and Achievable Economic potential. The calculation of Technical potential is a straightforward algorithm which, as described above, assumes that all customers adopt all feasible measures regardless of their cost.

Estimating Customer Adoption

Once the Technical potential is established, estimates for the market adoption rates for each measure are applied, specifying the percentage of customers assumed to install the measure or select the chosen efficient option. This phases potential in over a realistic time frame that considers barriers such as imperfect information, supplier constraints, technology availability, and individual customer preferences. The intent of market adoption rates is to establish a path to full market maturity for each measure or technology group and ensure that resource planning does not overstep acquisition capabilities. Market adoption rates for each measure are based on 2021 Power Plan ramp rates for comparable measures. Applying these ramp rates to the Technical potential leads directly to the Achievable Technical potential.

Screening Measures for Cost-Effectiveness

With Achievable Technical potential established, the final step is to apply an economic screen to arrive at the subset of measures that are both achievable and cost-effective and ultimately included in Achievable Economic potential. LoadMAP performs an economic screen for each individual measure in each year of the planning horizon. This study uses the Total Resource Cost (TRC) test as the cost-effectiveness metric, which compares the lifetime hourly energy benefits and monetized non-energy impacts of each applicable measure with its cost. The lifetime benefits are calculated by multiplying the annual energy savings for each measure by Tacoma Power's hourly weighted wholesale market avoided cost[9], discounting the dollar savings to the present value equivalent. Final avoided costs for each measure also include some non-energy values and the WA Conservation credit, as described in table X. Lifetime costs represent incremental measure cost and annual O&M costs, also discounted to present value. The analysis uses each measure's values for savings, costs, and lifetimes that were developed as part of the measure characterization process described above.

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

[9] Avoided costs are calculated for each measure by multiplying its normalized 8760 load shape and the provided hourly energy costs from Tacoma Power. In this way, the seasonality of a measure is reflected in its avoided energy cost.

Table 2-3 Overview of Non-Energy Impacts in the CPA

Modeling Component	Included Non-Energy Impacts/Adders
Avoided Costs	Wind Avoided REC Carbon Dioxide Adder Energy-related Capacity value Energy-related T&D Deferral 10% WA Conservation Credit
Measure Characterization	As applicable: Water Savings Detergent Savings Deferred O&M benefits Any other impacts consistent with RTF workbooks and Council methodology

The LoadMAP model performs this screening dynamically, taking into account changing savings and cost data over time. Thus, some measures pass the economic screen for some — but not all — of the years in the forecast.

It is important to note the following about the economic screen:

- The economic evaluation of every measure in the screen is conducted relative to a baseline condition. For instance, in order to determine the kilowatt-hour (kWh) savings potential of a measure, kWh consumption with the measure applied must be compared to the kWh consumption of a baseline condition.
- The economic screening was conducted only for measures that are applicable to each building type and vintage; thus, if a measure is deemed to be irrelevant to a building type and vintage, it is excluded from the respective economic screen.
- Savings and cost effectiveness are considered in relation to the average customer case, characterized across the population.

This constitutes the Achievable Economic potential and includes every program-ready opportunity for conservation savings. Potential results are presented in Chapters 4 and 5. Measure-level detail is available in Appendix D of this report.

Data Development

This section details the data sources used in this study, followed by a discussion of how these sources were applied. In general, data were adapted to local conditions, for example, by using local sources for measure data and local weather for building simulations.

Data Sources

The data sources are organized into the following categories:

- Tacoma Power data
- Northwest regional data
- AEG's databases and analysis tools
- Other secondary data and reports

Tacoma Data

The highest priority data sources for this study were those that were specific to Tacoma.

- **Tacoma customer account database.** Tacoma provided billing data for development of customer counts and energy use for each sector. This included a detailed database of customer building classifications which was instrumental in the development of segmentation. In addition, the account database included the following information which was instrumental to informing the CPA.
    - Presence of electric heat study
    - County Assessor data
    - Conservation accomplishment data
    - Tacoma also provided equipment saturation surveys
- **Load forecasts.** Tacoma provided forecasts by sector of energy consumption, customer counts, and exogenous forecasting variables such as economic activity.
- **Economic information.** Tacoma provided a discount rate as well as avoided cost forecasts and line loss factors on an 8,760-hour basis.
- **Tacoma program data.** Tacoma provided information about past and current programs, including program descriptions, goals, and measure achievements to date.
- **On-site survey of JBLM military base.** The U.S. Military's Joint Base Lewis-McChord is one of the larger electricity consumers in Tacoma Power's service territory, and hosts both army and air force operations, personnel, and their families. Results of the onsite surveys conducted by AEG for Tacoma Power at JBLM as part of the 2014 study were used to generate JBLM-specific assumptions.
- **Hourly load shape data.** Select industrial customers and load profiles.

Northwest Regional Data

The study utilized a variety of local data and research, including research performed by the Northwest Energy Efficiency Alliance (NEEA) and analyses conducted by the Council. Most important among these are:

- **Regional Technical Forum (RTF) workbooks.** The Regional Technical Forum maintains regularly updated technical workbooks on measure data for use within the region, including Washington state. This was used as a primary data source when Tacoma Power-specific program data was not available.
- **Northwest Power and Conservation Council Draft 2021 Power Plan** To develop its Power Plan, the Council maintains workbooks with detailed information about measures, frequently based on the RTF workbooks, but also including data for some measures not covered by the RTF, such as detailed Industrial Motors analysis. Where the 2021 Power Plan data was the most current and relevant, this was used.
- **Northwest Energy Efficiency Alliance, 2016-2017 Residential Building Stock Assessment II,** https://neea.org/data/residential-building-stock-assessment
- **Northwest Energy Efficiency Alliance, 2011 Residential Building Stock Assessment,** https://neea.org/resources/washington-state-report
- **Northwest Energy Efficiency Alliance, 2019 Commercial Building Stock Assessment,** https://neea.org/resources/cbsa-4-2019-final-report
- **Northwest Energy Efficiency Alliance, 2014 Commercial Building Stock Assessment,** https://neea.org/resources/2014-cbsa-final-report
- **Northwest Energy Efficiency Alliance, 2014 Industrial Facilities Site Assessment,** https://neea.org/resources/2014-ifsa-final-report

The NEEA surveys were used extensively to develop base saturation and applicability assumptions for many of the non-equipment measures within the study. Legacy surveys (RBSA 2011 and CBSA 2014) are included because they often provide different granularity of data and/or valuable trend insight when combined with the more recent surveys.

AEG Data

AEG maintains several databases and modeling tools that we use for forecasting and potential studies. Relevant data from these tools has been incorporated into the analysis and deliverables for this study.

- **AEG Energy Market Profiles.** For more than 10 years, AEG staff has maintained profiles of end-use consumption for the residential, commercial, and industrial sectors. These profiles include market size, fuel shares, unit consumption estimates, and annual energy use by fuel (electricity and natural gas), customer segment and end use for 10 regions in the U.S. The Energy Information Administration surveys (RECS, CBECS and MECS) as well as state-level statistics and local customer research provide the foundation for these regional profiles.
- **Building Energy Simulation Tool (BEST)**. AEG's BEST is a derivative of the DOE 2.2 building simulation model, used to estimate base-year UECs and EUIs, as well as measure savings for the HVAC-related measures.
- **AEG's Database of Energy Efficiency Measures (DEEM).** AEG maintains an extensive database of measure data for our studies. Our database draws upon reliable sources including the California Database for Energy Efficient Resources (DEER), the EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, RS Means cost data, and Grainger Catalog Cost data**.**
- **Recent studies**. AEG has conducted numerous studies of energy efficiency potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies, which include PacifiCorp, Avista, Idaho Power, and numerous studies from across the U.S.

Other Secondary Data and Reports

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

- **Annual Energy Outlook**. The Annual Energy Outlook (AEO), conducted each year by the U.S. Energy Information Administration (EIA), presents yearly projections and analysis of energy topics. For this study, we used data from the 2019 AEO.
- **Local Weather Data**. Weather from NOAA's National Climatic Data Center for Tacoma, WA (specifically from the MChord Air Force Base) was used where applicable.
- **EPRI End-Use Models (REEPS and COMMEND)**. These models provide the energy-use elasticities we apply to electricity prices, household income, home size and heating and cooling.
- **Database for Energy Efficient Resources (DEER).** The California Energy Commission and California Public Utilities Commission (CPUC) sponsor this database, which is designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) for the state of California. We used the DEER database to cross check the measure savings we developed using BEST and DEEM.
- **Other relevant resources:** These include reports from the Consortium for Energy Efficiency, the EPA, and the American Council for an Energy-Efficient Economy.

Application of Data to the Analysis

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

Data Application for Market Characterization

To construct the high-level market characterization of electricity consumption and market size units (households for residential, floor space for commercial, employees for industrial, and fixtures for street lighting), we primarily used Tacoma billing data as well as secondary data from AEG's Energy Market Profiles database.

Data Application for Market Profiles

The specific data elements for the market profiles, together with the key data sources, are shown in Table 2-4. To develop the market profiles for each segment, we used the following approach:

1. Developed control totals for each segment. These include market size, segment-level annual electricity use, and annual intensity. Tacoma's customer account database, which includes estimates on square footage as well as consumption, was used as the primary data point for the calculation of intensities. These calculations were then compared with other regional sources and prior AEG studies in the region for reasonableness. Adjustments to customer segmentation and intensity were then made as necessary.
2. Used Tacoma's 2018 Energy Use and Conservation Survey, the 2016 RBSA, 2014 and 2019 CBSA, 2014 IFSA, DOE's RECS 2015 and CBECS 2012, and AEG's Energy Market Profiles database to develop existing appliance saturations, appliance and equipment characteristics, and building characteristics.
3. Ensured calibration to control totals for annual electricity sales in each sector and segment.
4. Compared and cross-checked with other recent AEG studies.
5. Worked with Tacoma staff to vet the data against their knowledge and experience.

Table 2-4 Data Applied for the Market Profiles

Model Inputs	Description	Key Sources
Market size	Base-year residential dwellings, commercial floor space, and industrial employment	Tacoma account database Tacoma Load Forecasting AEO 2019
Annual intensity	Residential: Annual use per household Commercial: Annual use per square foot Industrial: Annual use per employee	Tacoma account database 2016 RBSA, 2014/2019 CBSA, and 2014 IFSA AEG's Energy Market Profiles AEO 2019 Other recent studies
Appliance/equipment saturations	Fraction of dwellings with an appliance/technology Percentage of C&I floor space/employment with equipment/technology	Tacoma's 2018 Energy Use and Conservation Survey 2016 RBSA, 2014/2019 CBSA, and 2014 IFSA American Community Survey AEG's Energy Market Profiles Tacoma Load Forecasting
UEC/EUI for each end-use technology	UEC: Annual electricity use in homes and buildings that have the technology EUI: Annual electricity use per square foot/employee for a technology in floor space that has the technology	HVAC uses: BEST simulations using prototypes developed for Tacoma Engineering analysis AEG DEEM Recent AEG studies
Appliance/equipment age distribution	Age distribution for each technology	Recent AEG studies
Efficiency options for each technology	List of available efficiency options and annual energy use for each technology	NWPCC workbooks, RTF AEG DEEM AEO 2019 DEER Recent AEG studies
Load Shapes	Share of technology energy use that occurs during each hour of the year	NWPCC's Generalized load shapes, as updated for the 2021 Power Plan Tacoma Power metered industrial and solar PV shapes (for street lighting)

Data Application for Baseline Projection

Table 2-5 summarizes the LoadMAP model inputs required for the baseline projection. These inputs are required for each segment within each sector, as well as for new construction and existing dwellings/buildings.

Table 2-5 Data Applied for the Baseline Projection in LoadMAP

Model Inputs	Description	Key Sources
Customer growth forecasts	Forecasts of new construction in residential and C&I sectors	Tacoma load forecast AEO 2017 economic growth forecast
Equipment purchase shares for baseline projection	For each equipment/technology, purchase shares for each efficiency level; specified separately for existing equipment replacement and new construction	Shipments data from AEO and ENERGY STAR AEO 2017 regional forecast assumptions[10] Appliance/efficiency standards analysis Tacoma program results and evaluation reports RTF UES workbooks for measures with a market baseline
Electricity prices	Forecast of monthly average real retail price	Tacoma load forecast
Utilization model parameters	Price elasticities, elasticities for other variables (income, weather)	Tacoma econometric coefficients EPRI's REEPS and COMMEND models

In addition, assumptions were incorporated for known future equipment standards as of June 2021, as shown in

Table 2-6 and Table 2-7. The assumptions tables here extend through 2025, after which all standards are assumed to hold steady.

Table 2-6 Residential Electric Equipment Standards[11]

End Use	Technology	2020	2021	2022	2023	2024	2025
Cooling	Central AC	SEER 13.0				SEER 14.0	
	Room AC	EER 10.8					
Cooling/ Heating	Air-Source Heat Pump	SEER 14.0 / HSPF 8.2				SEER 15.0 / HSPF 8.8 ENERGY STAR (5.0)	
Water Heating	Water Heater (<=55 gallons)	EF 0.95					
	Water Heater (>55 gallons)	EF 2.0 (Heat Pump Water Heater)					
Lighting	General Service	Advanced Incandescent (~45 lm/W)					
	Linear Fluorescent	T8 (92.5 lm/W lamp)					
Appliances	Refrigerator	25% more efficient than the 1997 Final Rule (62 FR 23102)					
	Freezer						
	Clothes Washer	IMEF 1.84 / WF 4.7					
	Clothes Dryer	3.73 Combined EF					

[10] We developed baseline purchase decisions using the Energy Information Agency's *Annual Energy Outlook* report (2017), which utilizes the National Energy Modeling System (NEMS) to produce a self-consistent supply and demand economic model. We calibrated equipment purchase options to match distributions/allocations of efficiency levels to manufacturer shipment data for recent years and then held values constant for the study period.

[11] The assumptions tables here extend through 2025, after which all standards are assumed to hold steady.

Miscellaneous	Furnace Fans	ECM

Table 2-7 Nonresidential (C&I) Electric Equipment Standards[12]

End Use	Technology	2020	2021	2022	2023	2024	2025
Cooling	Chillers	2007 ASHRAE 90.1					
	RTUs	EER 11.9/11.2					
	PTAC	EER 9.8	EER 11.0				
Cooling/ Heating	Heat Pump	EER 11.4/ COP 3.3					
	PTHP	EER 10.4/COP 3.1					
Ventilation	All	Constant Air Volume/Variable Air Volume					
Lighting	General Service	Advanced Incandescent (~45 lumens/watt)					
	Linear Lighting	T8 (82.5 lm/W lamp)					
	High Bay	51.2 lm/W					
Refrigeration	Walk-In	COP 6.1					
	Reach-In	32 kWh/sqft					
	Glass Door	12-28% more efficient than EPACT 2005					
	Open Display	1,453 kWh/ft					
	Icemaker	6.1 kWh/100 lbs.					
Food Service	Pre-Rinse	1.0 GPM					
Motors	All	Expanded EISA 2007					

[12] The assumptions tables here extend through 2025, after which all standards are assumed to hold steady.

Conservation Measure Data Application

Table 2-8 details the energy-efficiency data inputs to the LoadMAP model. It describes each input and identifies the key sources used in the Tacoma analysis.

Table 2-8 Data Needs for the Measure Characteristics in LoadMAP

Model Inputs	Description	Key Sources
Energy Impacts	The annual reduction in consumption attributable to each specific measure. Savings were developed as a percentage of the energy end use that the measure affects.	NWPCC workbooks, RTF BEST AEG DEEM AEO 2017 CA DEER Other secondary sources
Peak Demand Impacts	Savings during the peak demand periods are specified for each electric measure. These impacts relate to the energy savings and depend on the extent to which each measure is coincident with the system peak. Note that peak data are based on normal weather, not climate change or extreme scenarios.	8,760 Hourly load shapes developed from Council's GLS database
Costs	Equipment Measures: Includes the full cost of purchasing and installing the equipment on a per-household, per-square-foot, or per employee basis for the residential, commercial, and industrial sectors, respectively. Non-Equipment Measures: Existing buildings – full installed cost. New Construction - the costs may be either the full cost of the measure, or as appropriate, it may be the incremental cost of upgrading from a standard level to a higher efficiency level.	NWPCC workbooks, RTF Tacoma Power program data for some measure costs and all administrative costs AEG DEEM AEO 2017 CA DEER RS Means Other secondary sources
Measure Lifetimes	Estimates derived from the technical data and secondary data sources that support the measure demand and energy savings analysis.	NWPCC workbooks, RTF AEG DEEM AEO 2017 CA DEER Other secondary sources
Applicability	Estimate of the percentage of dwellings in the residential sector, square feet in the commercial sector, or employees in the industrial sector where the measure is applicable and where it is technically feasible to implement.	NWPCC workbooks, RTF AEG DEEM CA DEER Other secondary sources
On Market and Off Market Availability	Expressed as years for equipment measures to reflect when the equipment technology is available or no longer available in the market.	AEG appliance standards and building codes analysis

Data Application for Cost-Effectiveness Screening

To perform the cost-effectiveness screening, a number of economic assumptions were needed. All cost and benefit values were analyzed in real 2020 dollars and using a real discount rate of 3% as provided by Tacoma Power. All impacts in this report are presented at the customer meter, but electric energy delivery losses were provided by Tacoma to estimate impacts at the generator for economic analysis. Tacoma provided hourly avoided cost values, which AEG converted into end-use specific annual avoided costs using the Council's end-use load shapes.

Estimates of Customer Adoption

To estimate the timing and rate of customer adoption in the potential forecasts, two sets of parameters are needed:

- **Technical diffusion curves for non-equipment measures**. Equipment measures are installed when existing units fail. Non-equipment measures do not have this natural periodicity, so rather than installing all available non-equipment measures in the first year of the projection (instantaneous potential), they are phased in according to adoption schedules that generally align with the diffusion of similar equipment measures. For this analysis, we used the Council's retrofit ramp rates, applied before the achievability adjustment.
- **Customer adoption rates**, also referred to as take rates or ramp rates, are applied to measures on a year-by-year basis. These rates represent customer adoption of measures when delivered through a best-practice portfolio of well-operated efficiency programs under a reasonable policy or regulatory framework. Information channels are assumed to be established and efficient for marketing, educating consumers, and coordinating with trade allies and delivery partners. The primary barrier to adoption reflected in this case is customer preferences. Again, these are based on the ramp rates from the Northwest Power and Conservation Council's 2021 Power Plan.

The customer adoption rates used in this study are available in Appendix C.

3

MARKET CHARACTERIZATION AND MARKET PROFILE

In this section, we describe how customers in the Tacoma Power service territory use electricity in the base period of the study[13]. It begins with a high-level summary of energy use across all sectors and then delves into each sector in more detail.

EAch market profile includes the following elements:

- **Market size** is a representation of the number of customers in the segment. For the residential sector, the unit we use is number of households. In the commercial sector, it is floor space measured in square feet. For the industrial sector, it is number of employees. Street lighting is accounted for as number of lighting fixtures.
- **Saturations** define the fraction of homes and square feet with the various technologies. (e.g., percent of homes with electric space heating).
- **UEC (unit energy consumption) or EUI (energy-use index)** describes the amount of energy consumed in the base year by a specific technology in buildings that have the technology. UECs are expressed in kWh/household for the residential sector, and EUIs are expressed in kWh/square foot or kWh/employee for the commercial and industrial sectors, respectively.
- **Annual energy intensity** for the residential sector represents the average energy use for the technology across all homes in 2017. It is computed as the product of the saturation and the UEC and is defined as kWh/household for electricity. For the commercial and industrial sectors, intensity, computed as the product of the saturation and the EUI, represents the average use for the technology across all floor space or all employees in the base year.
- **Annual usage** is the annual energy used by each end-use technology in the segment. It is the product of the market size and intensity and is quantified in GWh.

Overall Energy Use Summary

Total electricity consumption for all sectors for Tacoma in the base year was 4,359 GWh. As shown in Figure 3-1 and Table 3-1, the combined civilian residential and JBLM residential sectors account for more than one-third (43.5%) of annual energy use. The combined civilian commercial and JBLM commercial sectors account for

[13] To accommodate available data at the CPA's start, the base period for this study is a non-calendar year; twelve complete months from October 2019 through September 2020. "Base Year" and "base period" are used to refer to this time frame throughout this report.

34.2% of annual energy use. The industrial sector accounts for 21.9% while street lighting accounts for the remaining 0.3% of usage.

Within the Residential sector, civilian usage accounts for 42.5% of overall usage while JBLM residential accounts for 1.0%. Within the commercial sector, civilian usage accounts for 28.2% of overall usage while JBLM commercial accounts for 6.0%.

Figure 3-1 Sector-Level Electricity Use in Base Year (Percent)

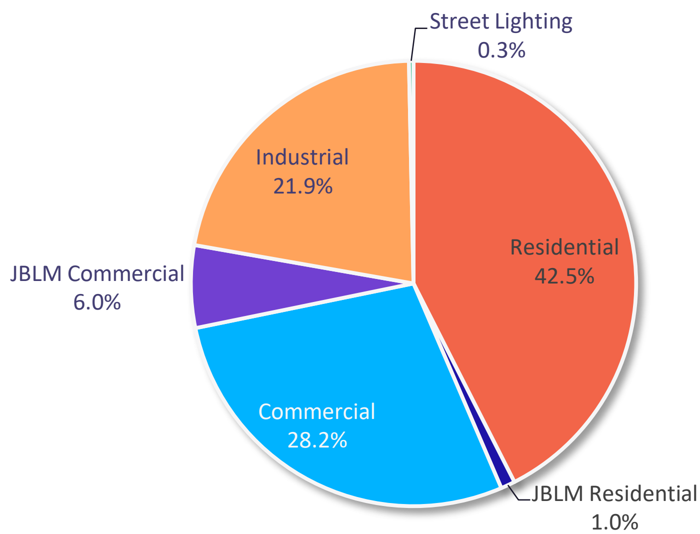


Table 3-1 Tacoma Sector Control Totals (2020)

Sector	Number of Customers/Buildings	Annual Electricity Use (GWh)	% of Annual Use
Residential	166,350	1,853	42.5%
JBLM Residential	4,428	45	1.0%
Commercial	15,788	1,231	28.2%
JBLM Commercial	5,525	261	6.0%
Industrial	911	955	21.9%
Street Lighting	41,368	14	0.3%
Total	**234,370**	**4,359**	**100.0%**

Residential Sector

The total number of households and electricity sales for the service territory were obtained from Tacoma's customer database. In 2020, there were over 162 thousand households in the Tacoma territory that used a total of 1,853 GWh. Average use per customer (or household) at 11,395 kWh is slightly higher than other regions of the country, reflecting relatively high penetrations of electric heat in the Pacific Northwest. These averages include both electric and non-electric heat. Individual household consumption may vary based on house size, age, and presence of natural gas or secondary heat. We allocated these totals into five residential segments and the values are shown in Table 3-2.

Table 3-2 Residential Sector Control Totals (2020)

Segment	Number of Customers	Electricity Use (GWh)	% of Annual Use	Annual Use/Customer (kWh/HH)
Single Family	107,276	1,345	73%	12,540
Single Family 2-4 units	8,917	89	5%	9,945
Low-Rise Multifamily	35,005	281	15%	8,037
High-Rise Multifamily	5,189	35	2%	6,653
Manufactured Home	6,243	103	6%	16,563
Total	**162,629**	**1,853**	**100%**	**11,395**

As described in the previous chapter, the market profiles provide the foundation for development of the baseline projection and the potential estimates. The average market profile for the residential sector is presented in Table 3-3. Segment-specific market profiles are presented in Appendix B.

Figure 3-2 shows the average distribution of annual electricity use by end use for all residential customers. Three main electricity end uses — space heating, water heating, and appliances — account for 71% of total use. Appliances include refrigerators, freezers, stoves/ovens, clothes washers, clothes dryers, dishwashers, microwaves, dehumidifiers, and air purifiers. The remainder of the energy falls into the electronics, lighting, cooling and the miscellaneous category – which is comprised of furnace fans, pool pumps, and other "plug" loads (all other usage not covered by those listed in Table 3-3 such as hair dryers, power tools, coffee makers, etc.). This reflects average consumption and is used to describe consumption residential consumption for the entire service territory. These graphics would look significantly different between gas and electrically heated homes. Approximately 56.9% of homes within Tacoma Power's service territory are primarily heated by electricity. Approximately 55% of single family homes are electrically heated whereas approximately 59% of multifamily homes are electrically heated.

Figure 3-3 presents the electricity intensities by end use and housing type. Manufactured homes have the highest use per customer at 16,563 kWh/year, reflecting less efficient construction and equipment options as well as a higher saturation of electric space heating.

Photo: Getty Images

Figure 3-2 Residential Electricity Use by End Use (2020)

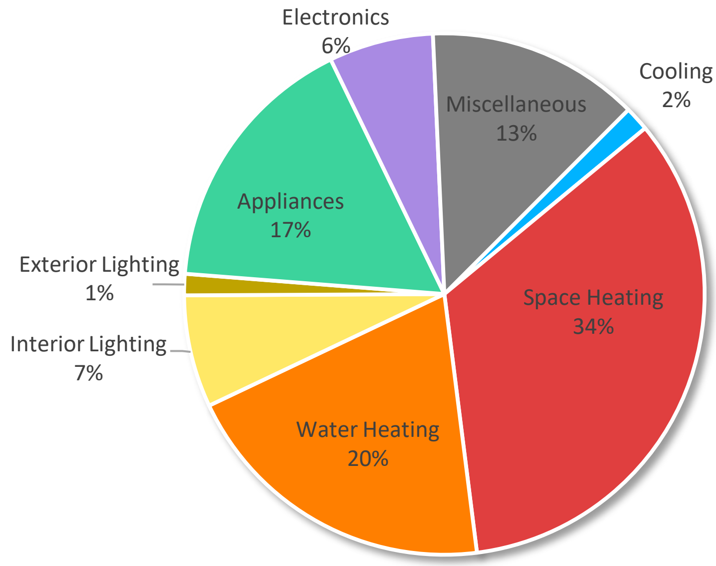


Figure 3-3 Residential Energy Intensity by End Use and Segment (Annual kWh/HH, 2020)

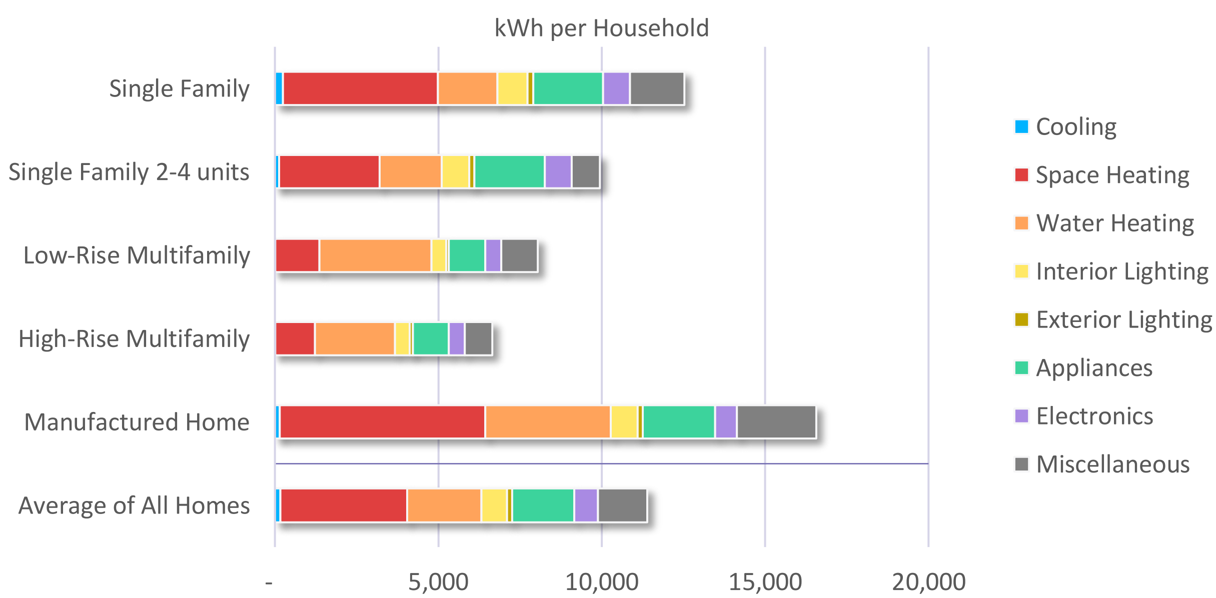


Table 3-3 Average Market Profile for the Residential Sector, 2020

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/HH)	Usage (GWh)
Cooling	Central AC	6.4%	558	36	5.8
	Room AC	24.1%	358	86	14.0
	Air-Source Heat Pump	7.9%	575	45	7.3
	Ductless Mini Split Heat Pump	5.3%	183	10	1.6
Space Heating	Electric Room Heat	29.9%	5,941	1,779	289.4
	Electric Furnace	13.9%	9,948	1,380	224.4
	Air-Source Heat Pump	7.9%	5,752	452	73.4
	Ductless Mini Split Heat Pump	5.3%	2,554	135	21.9
	Secondary Heating	19.7%	1,744	344	55.9
Water Heating	Water Heater (<= 55 Gal)	62.4%	3,387	2,114	343.9
	Water Heater (> 55 Gal)	4.7%	3,390	160	26.1
Interior Lighting	General Service Lighting	100.0%	454	454	73.8
	Linear Lighting	100.0%	107	107	17.5
	Exempted Lighting	100.0%	232	232	37.7
Exterior Lighting	General Service Lighting	100.0%	151	151	24.5
Appliances	Clothes Washer	84.6%	46	39	6.3
	Clothes Dryer	75.9%	761	578	94.0
	Dishwasher	79.5%	83	66	10.7
	Refrigerator	99.1%	529	524	85.3
	Freezer	30.3%	483	147	23.9
	Second Refrigerator	28.4%	821	233	37.9
	Stove/Oven	70.6%	156	110	17.9
	Microwave	105.9%	115	122	19.8
	Dehumidifier	4.3%	766	33	5.3
	Air Purifier	11.4%	321	36	5.9
Electronics	Personal Computers	65.7%	124	81	13.2
	Monitor	131.5%	53	70	11.4
	Laptops	54.1%	33	18	2.9
	TVs	189.9%	126	239	38.8
	Printer/Fax/Copier	98.6%	37	37	6.0
	Set-top Boxes/DVRs	225.4%	88	198	32.2
	Devices and Gadgets	100.0%	97	97	15.7
Miscellaneous	Electric Vehicle Supply Equipment	0.6%	2,538	16	2.6
	Pool Pump	0.4%	1,558	6	1.0
	Hot Tub / Spa	0.5%	1,455	7	1.1
	Furnace Fan	52.6%	1,375	723	117.6
	Bathroom Exhaust Fan	31.4%	46	14	2.3
	Well pump	1.5%	552	8	1.4
	Miscellaneous	100.0%	509	509	82.8
Total				**11,395**	**1,853**

JBLM Residential Sector

Tacoma Power has previously curated discussions, data exchange, and on-site survey assessments of energy consumption and conservation opportunities at the U.S. Military's Joint Base Lewis-McChord (JBLM) to facilitate customized treatment of these facilities in this analysis. This detailed data was deemed still current for the purposes of this CPA. JBLM has a substantial housing sector for residential customers as well as several large commercial and industrial facilities, which we have combined into a single "JBLM commercial" section for purposes of this analysis. JBLM has its own unique energy practices and characteristics, in general being more efficient with energy codes, construction practices, and technology procurement; but dealing with longer lead times and higher administrative costs related to new projects and adoption of new market practices. A brief summarizing this assessment and the associated findings is included in the 2014 study.

The total number of residential households for JBLM were obtained from billing data provided by Equity Residential, the previous property management company responsible for housing at JBLM, during the 2014 study. Energy consumption was updated from prior study values by looking at the difference in JBLM annual consumption between 2017 and 2020. In 2020, there were 4,428 households at JBLM with a total consumption of 44,909 MWh. The average use per customer (or household) at 10,141 kWh is lower than the civilian residential sector. We allocated the control totals into two residential segments for single family and multifamily households and the values are shown in Table 3-4.

Table 3-4 JBLM Residential Sector Control Totals (2020)

Segment	Number of Customers	Electricity Use (MWh)	% of Annual Use	Annual Use/Customer (kWh/HH)
Single Family	3,564	40,267	90%	11,297
Multifamily	864	4,643	10%	5,373
Total	**4,428**	**44,909**	**100%**	**10,141**

Figure 3-4 shows the distribution of annual electricity use by end use for all customers. Like the civilian residential sector, three main end uses — space heating, appliances, and water heating— account for the majority of use (70%). Appliances include refrigerators, freezers, stoves/ovens, clothes washers, clothes dryers, dishwashers, microwaves, dehumidifiers, and air purifiers. The remainder of the energy falls into the cooling, electronics, lighting, and the miscellaneous category – which is comprised of furnace fans, bathroom exhaust fans, and other "plug" loads (all other usage not covered by those listed in Table 3-5 such as hair dryers, power tools, coffee makers, etc.).

Figure 3-5 presents the electricity intensities by end use and housing type. Single-family homes have the highest use per customer at 11,297 kWh/year, which reflects a higher saturation of electric heating and a larger home size.

Figure 3-4 JBLM Residential Electricity Use by End Use (2020)

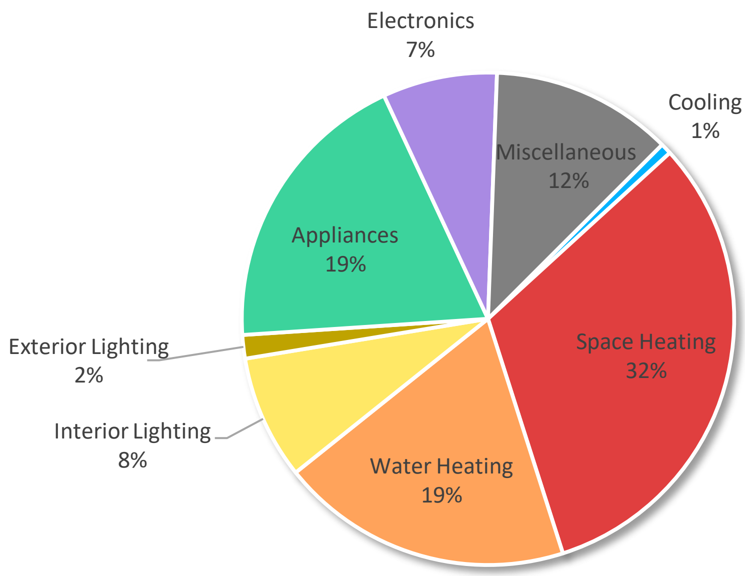


Figure 3-5 JBLM Residential Energy Intensity by End Use and Segment (Annual kWh/HH, 2020)

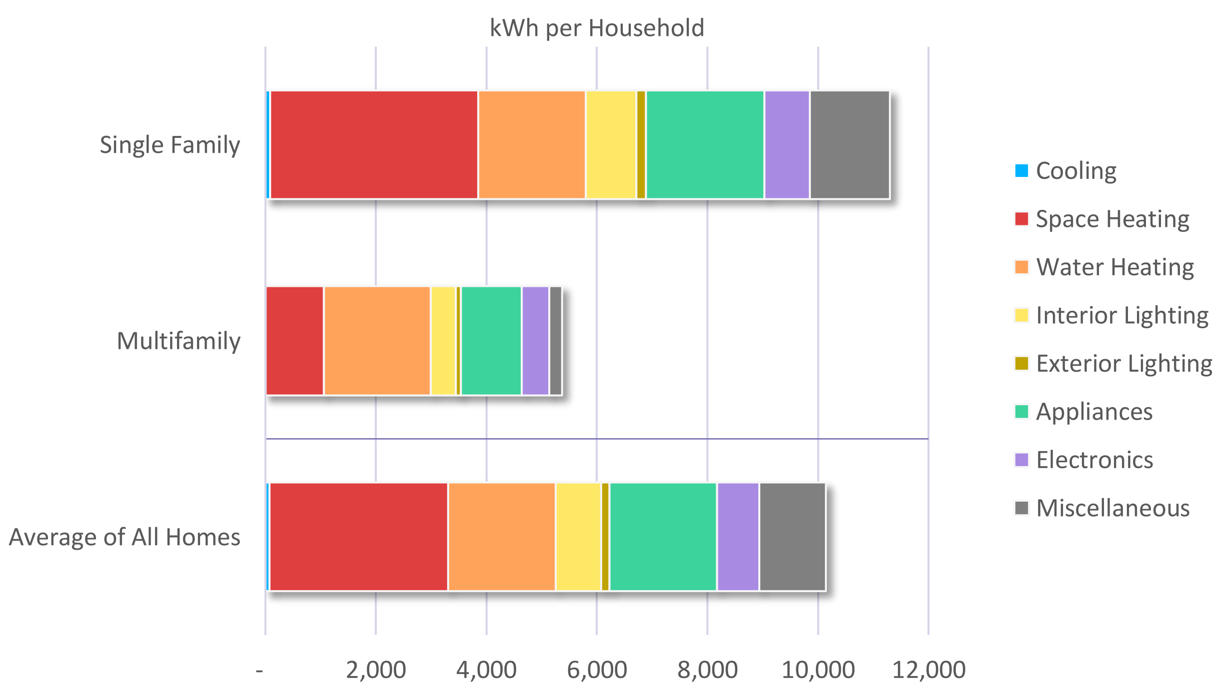


Table 3-5 shows the average market profile for electricity of the JBLM residential sector as a whole, representing a composite of both single family and multifamily homes. Market profiles for each segment are presented in the appendix to this volume.

Table 3-5 Average Market Profile for the JBLM Residential Sector, 2020

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/HH)	Usage (GWh)
Cooling	Room AC	4.1%	383	16	0.1
	Air-Source Heat Pump	8.1%	591	48	0.2
Space Heating	Electric Room Heat	29.1%	4,678	1,362	6.0
	Electric Furnace	15.3%	7,365	1,126	5.0
	Air-Source Heat Pump	8.1%	4,154	337	1.5
	Secondary Heating	23.7%	1,299	308	1.4
Water Heating	Water Heater (<= 55 Gal)	30.5%	2,677	816	3.6
	Water Heater (> 55 Gal)	39.6%	2,853	1,130	5.0
Interior Lighting	General Service Lighting	100.0%	471	471	2.1
	Linear Lighting	100.0%	110	110	0.5
	Exempted Lighting	100.0%	245	245	1.1
Exterior Lighting	General Service Lighting	100.0%	157	157	0.7
Appliances	Clothes Washer	87.3%	45	40	0.2
	Clothes Dryer	77.9%	757	590	2.6
	Dishwasher	80.8%	84	68	0.3
	Refrigerator	99.6%	535	533	2.4
	Freezer	32.1%	484	155	0.7
	Second Refrigerator	30.6%	822	252	1.1
	Stove/Oven	68.7%	152	105	0.5
	Microwave	106.7%	116	124	0.5
	Dehumidifier	4.4%	783	34	0.2
	Air Purifier	11.7%	328	38	0.2
Electronics	Personal Computers	68.3%	124	84	0.4
	Monitor	137.3%	53	73	0.3
	Laptops	56.6%	33	19	0.1
	TVs	194.7%	126	245	1.1
	Printer/Fax/Copier	98.6%	37	37	0.2
	Set-top Boxes/DVRs	237.4%	88	209	0.9
	Devices and Gadgets	100.0%	97	97	0.4
Miscellaneous	Hot Tub / Spa	0.5%	10,298	54	0.2
	Furnace Fan	57.1%	1,473	841	3.7
	Bathroom Exhaust Fan	31.4%	46	14	0.1
	Well pump	1.6%	561	9	0.0
	Miscellaneous	100.0%	290	290	1.3
Total				**10,035**	**44.4**

Commercial Sector

The total electric energy consumed by commercial customers in Tacoma's service area in 2020 was 1,231 GWh. Tacoma billing data, forecast results and secondary data were used to allocate this energy usage among fifteen commercial segments and to develop estimates of energy intensity (annual kWh/square foot). AEG utilized Tacoma Power's detailed customer account database to classify each account into a market segment. Buildings with multiple accounts were classified based on the largest electric customer account in the building. Accounts that have yet to be classified were grouped into a "Miscellaneous - Unclassified" segment at Tacoma Power's request. The Miscellaneous – Classified group includes accounts classified by Tacoma which do not fit into the standard building types, such as flower shops, fire stations, and the Tacoma Dome. When available in the account database, AEG extracted floor space information, which is the unit of analysis in LoadMAP for the commercial sector. When floor space data was unavailable, AEG utilized electricity consumption and intensity estimates to infer floor space. The values are shown in Table 3-6.

Table 3-6 Commercial Sector Control Totals (2020)

Segment	Electricity Sales (GWh)	Intensity (Annual kWh/SqFt)	Floor Space (Million SqFt)
Office	206	15.5	13.3
Retail	127	11.1	11.5
Restaurant	44	22.1	2.0
Grocery	91	35.2	2.6
Hospital	101	31.1	3.2
Other Health	105	38.2	2.7
College	33	15.4	2.2
School	49	5.2	9.6
Lodging	62	26.4	2.4
Assembly	44	8.1	5.5
Warehouse	94	7.4	12.6
Data Center	37	96.9	0.4
MF Common Area	53	10.1	5.3
Misc - Classified	59	15.7	3.7
Misc - Unclassified	125	7.5	16.6
Total	**1,231**	**13.2**	**93.5**

Figure 3-6 shows the distribution of annual electricity consumption by end use across all commercial buildings. Most consumption is associated with lighting and HVAC usage, which comprise 64% of annual electricity usage.

Figure 3-7 presents the electricity intensities by end use and segment. Data centers have the highest use per square foot at 96.9 kWh/SqFt and are thus presented on a larger axis. Table 3-7 shows the average market profile for the commercial sector as a whole, representing a composite of all segments and buildings. Market profiles for each segment are presented in Appendix B of this volume.

Figure 3-6 Commercial Electricity Consumption by End Use (2020)

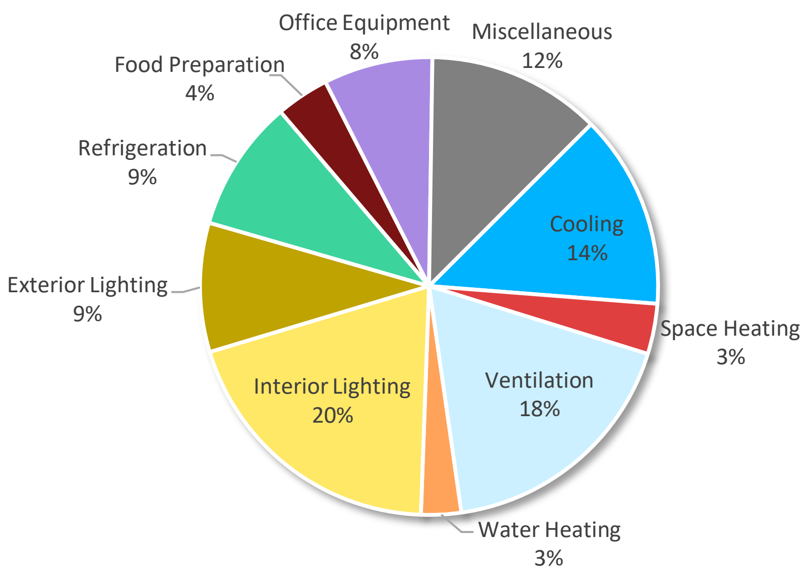


Figure 3-7 Commercial Energy Intensity by End Use and Segment (Annual kWh/SqFt, 2020)

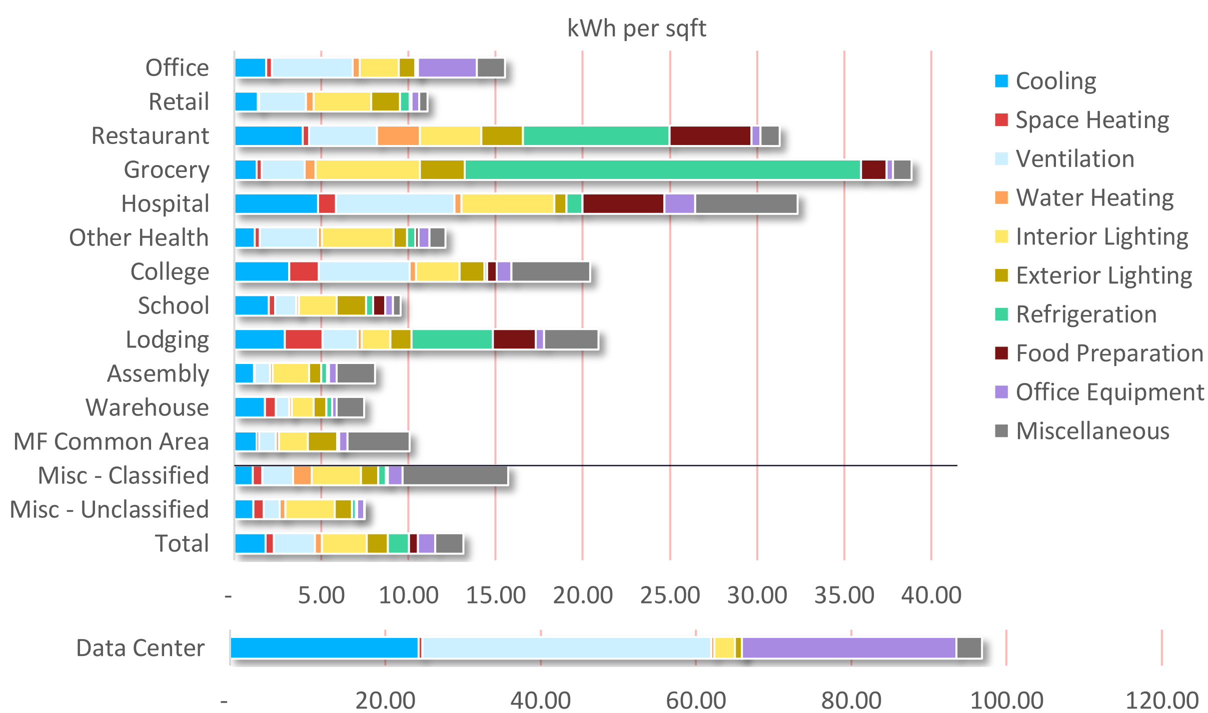


Table 3-7   Average Electric Market Profile for the Commercial Sector, 2020

End Use	Technology	Saturation	EUI (kWh/SqFt)	Intensity (kWh/SqFt)	Usage (GWh)
Cooling	Air-Cooled Chiller	8.6%	2.06	0.18	16.5
	Water-Cooled Chiller	3.8%	4.12	0.16	14.6
	RTU	52.7%	1.90	1.00	93.9
	PTAC	7.6%	2.03	0.15	14.5
	PTHP	3.3%	2.30	0.08	7.1
	Air-Source Heat Pump	7.6%	2.30	0.17	16.3
	Geothermal Heat Pump	3.1%	2.12	0.07	6.2
Space Heating	Electric Furnace	2.1%	2.75	0.06	5.5
	Electric Room Heat	9.4%	2.20	0.21	19.4
	PTHP	3.3%	1.41	0.05	4.3
	Air-Source Heat Pump	7.6%	1.51	0.11	10.7
	Geothermal Heat Pump	3.1%	1.32	0.04	3.8
Ventilation	Ventilation	100.0%	2.36	2.36	220.9
Water Heating	Water Heater	32.1%	1.16	0.37	34.8
Interior Lighting	General Service Lighting	100.0%	0.41	0.41	38.0
	Exempted Lighting	100.0%	0.10	0.10	9.5
	High-Bay Lighting	100.0%	0.34	0.34	32.1
	Linear Lighting	100.0%	1.75	1.75	163.9
Exterior Lighting	General Service Lighting	100.0%	0.43	0.43	40.0
	Area Lighting	100.0%	0.47	0.47	44.0
	Linear Lighting	100.0%	0.30	0.30	28.3
Refrigeration	Walk-in Refrigerator/Freezer	7.7%	0.94	0.07	6.8
	Reach-in Refrigerator/Freezer	15.1%	0.42	0.06	6.0
	Glass Door Display	9.7%	1.59	0.15	14.4
	Open Display Case	9.7%	5.12	0.50	46.5
	Icemaker	39.0%	0.82	0.32	29.8
	Vending Machine	39.0%	0.31	0.12	11.1
Food Preparation	Oven	32.0%	0.09	0.03	2.7
	Fryer	35.0%	0.56	0.20	18.3
	Dishwasher	30.8%	0.25	0.08	7.3
	Hot Food Container	32.8%	0.08	0.03	2.6
	Steamer	28.2%	0.30	0.08	7.9
	Griddle	27.8%	0.29	0.08	7.5
Office Equipment	Desktop Computer	100.0%	0.32	0.32	30.1
	Laptop	99.0%	0.04	0.04	3.4
	Server	86.6%	0.60	0.52	48.9
	Monitor	100.0%	0.06	0.06	5.3
	Printer/Copier/Fax	100.0%	0.05	0.05	4.8
	POS Terminal	60.7%	0.04	0.03	2.4
Miscellaneous	Non-HVAC Motors	54.8%	0.27	0.15	13.9
	Pool Pump	5.7%	0.03	0.00	0.2
	Pool Heater	1.7%	0.05	0.00	0.1
	Electric Vehicle Supply Equipment	12.7%	0.05	0.01	0.6
	Clothes Washer	11.7%	0.02	0.00	0.3
	Clothes Dryer	8.4%	0.08	0.01	0.6
	Other Miscellaneous	100.0%	1.45	1.45	135.3
Total				**13.16**	**1,231**

JBLM Commercial Sector

The total non-residential square footage and electricity sales for JBLM were obtained from Tacoma and adjusted from values used in the prior study. We relied on the onsite surveys conducted by AEG during the 2014 study to tailor assumptions unique to JBLM and capture differences with the civilian commercial sector. In 2020, the analysis shows about 17.5 million square feet of floor space on JBLM and a total consumption of 261 GWh.

Base-year consumption, floor space, and energy intensity, by segment, are shown in Table 3-8. Using information collected during onsite surveys of JBLM and facility information collected from JBLM staff, we kept the new "Mixed Use" market segment added during the 2014 CPA, which represents newer facilities where office, recreation, storage, and assembly spaces are combined into one facility. JBLM staff indicated that buildings undergo substantial reconfigurations throughout the years to fit the military's needs, which may result in variations between segments in later years.

Table 3-8 JBLM Commercial Sector Control Totals (2020)

Segment	Electricity Sales (GWh)	Intensity (Annual kWh/SqFt)	Floor Space (Million SqFt)
Office	46	15.5	3.0
Retail	4	11.1	0.3
Restaurant	11	31.3	0.4
Grocery	3	38.9	0.1
School	8	9.5	0.9
Lodging	48	20.9	2.3
Warehouse	27	7.4	3.7
Data Center	12	96.9	0.1
Health	53	32.3	1.6
Hangar	11	7.4	1.5
Mixed Use	19	15.7	1.2
Other	16	7.5	2.1
Industrial	3	7.4	0.3
Total	**261**	**14.9**	**17.5**

Figure 3-8 shows the distribution of annual electricity consumption by end use across all commercial buildings. The distribution by end use is similar to the civilian commercial sector in that lighting and HVAC comprise the lion's share (61%), but JBLM also includes more industrial-style facilities with mechanical, motor, and process usage that is classified in the larger Miscellaneous end use of the commercial template used to model this sector.

Figure 3-9 presents the electricity intensities by end use and segment. Data centers have the highest use per square foot at 97 kWh/SqFt. Table 3-9 Average Electric Market Profile for the JBLM Commercial Sector, 2020

End Use	Technology	Saturation	EUI (kWh/SqFt)	Intensity (kWh/SqFt)	Usage (GWh)
Cooling	Air-Cooled Chiller	6.36%	2.25	0.14	2.5
	Water-Cooled Chiller	3.96%	5.74	0.23	4.0
	RTU	45.14%	2.48	1.12	19.6
	PTAC	10.98%	2.99	0.33	5.7
	PTHP	3.97%	3.54	0.14	2.5
	Air-Source Heat Pump	7.48%	3.02	0.23	4.0
	Geothermal Heat Pump	3.27%	2.84	0.09	1.6
Space Heating	Electric Furnace	1.52%	4.15	0.06	1.1
	Electric Room Heat	10.18%	3.72	0.38	6.6
	PTHP	3.97%	2.62	0.10	1.8
	Air-Source Heat Pump	7.48%	2.17	0.16	2.8
	Geothermal Heat Pump	3.27%	1.90	0.06	1.1
Ventilation	Ventilation	100.00%	2.61	2.61	45.7
Water Heating	Water Heater	35.73%	1.03	0.37	6.4
Interior Lighting	General Service Lighting	100.00%	0.38	0.38	6.7
	Exempted Lighting	100.00%	0.09	0.09	1.7
	High-Bay Lighting	100.00%	0.38	0.38	6.7
	Linear Lighting	100.00%	1.45	1.45	25.3
Exterior Lighting	General Service Lighting	100.00%	0.27	0.27	4.7
	Area Lighting	100.00%	0.47	0.47	8.3
	Linear Lighting	100.00%	0.25	0.25	4.3
Refrigeration	Walk-in Refrigerator/Freezer	12.88%	0.70	0.09	1.6
	Reach-in Refrigerator/Freezer	15.93%	0.55	0.09	1.5
	Glass Door Display	9.72%	0.46	0.05	0.8
	Open Display Case	9.72%	1.49	0.15	2.5
	Icemaker	40.00%	1.51	0.61	10.6
	Vending Machine	40.00%	0.53	0.21	3.7
Food Preparation	Oven	27.36%	0.21	0.06	1.0
	Fryer	37.02%	0.99	0.37	6.4
	Dishwasher	28.54%	0.52	0.15	2.6
	Hot Food Container	33.39%	0.16	0.05	1.0
	Steamer	22.86%	0.63	0.14	2.5
	Griddle	23.38%	0.63	0.15	2.6
Office Equipment	Desktop Computer	100.00%	0.36	0.36	6.2
	Laptop	99.84%	0.05	0.04	0.8
	Server	88.69%	0.75	0.67	11.7
	Monitor	100.00%	0.06	0.06	1.1
	Printer/Copier/Fax	100.00%	0.06	0.06	1.1
	POS Terminal	59.76%	0.03	0.02	0.3
Miscellaneous	Non-HVAC Motors	60.76%	0.42	0.25	4.4
	Pool Pump	11.12%	0.06	0.01	0.1
	Pool Heater	3.73%	0.08	0.00	0.1
	Electric Vehicle Supply Equipment	14.31%	0.07	0.01	0.2
	Clothes Washer	18.38%	0.03	0.01	0.1
	Clothes Dryer	11.33%	0.11	0.01	0.2
	Other Miscellaneous	100.00%	1.96	1.96	34.3
Total				**14.89**	**260.70**

shows the average market profile for electricity of the JBLM commercial sector as a whole, representing a composite of all segments and buildings. Market profiles for each segment are presented in Appendix B of this volume.

Figure 3-8 JBLM Commercial Electricity Consumption by End Use (2020)

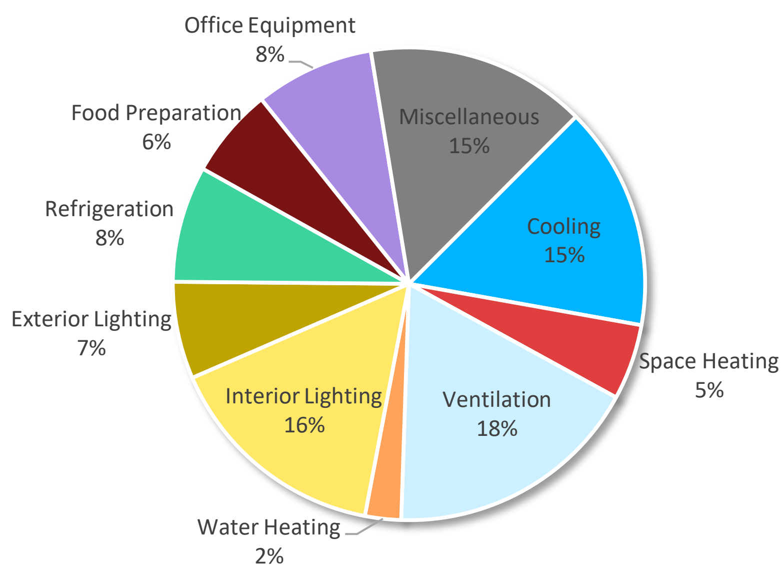


Figure 3-9 JBLM Commercial Energy Intensity by End Use and Segment (Annual kWh/SqFt, 2020)

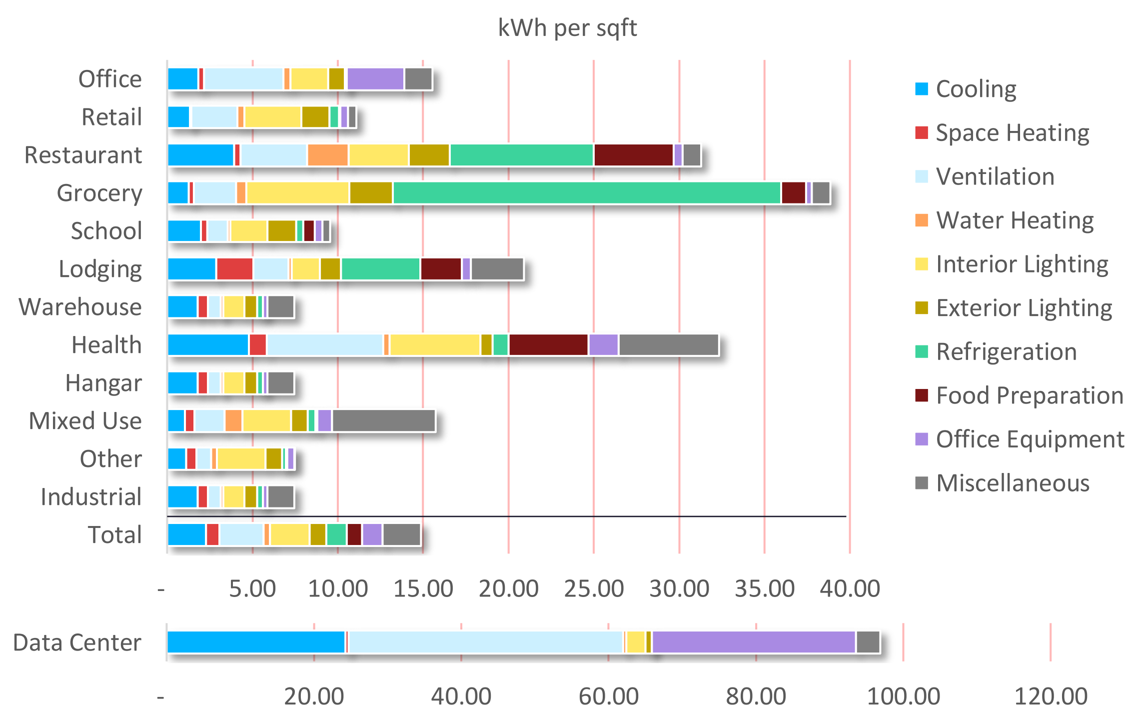


Table 3-9 Average Electric Market Profile for the JBLM Commercial Sector, 2020

End Use	Technology	Saturation	EUI (kWh/SqFt)	Intensity (kWh/SqFt)	Usage (GWh)
Cooling	Air-Cooled Chiller	6.36%	2.25	0.14	2.5
	Water-Cooled Chiller	3.96%	5.74	0.23	4.0
	RTU	45.14%	2.48	1.12	19.6
	PTAC	10.98%	2.99	0.33	5.7
	PTHP	3.97%	3.54	0.14	2.5
	Air-Source Heat Pump	7.48%	3.02	0.23	4.0
	Geothermal Heat Pump	3.27%	2.84	0.09	1.6
Space Heating	Electric Furnace	1.52%	4.15	0.06	1.1
	Electric Room Heat	10.18%	3.72	0.38	6.6
	PTHP	3.97%	2.62	0.10	1.8
	Air-Source Heat Pump	7.48%	2.17	0.16	2.8
	Geothermal Heat Pump	3.27%	1.90	0.06	1.1
Ventilation	Ventilation	100.00%	2.61	2.61	45.7
Water Heating	Water Heater	35.73%	1.03	0.37	6.4
Interior Lighting	General Service Lighting	100.00%	0.38	0.38	6.7
	Exempted Lighting	100.00%	0.09	0.09	1.7
	High-Bay Lighting	100.00%	0.38	0.38	6.7
	Linear Lighting	100.00%	1.45	1.45	25.3
Exterior Lighting	General Service Lighting	100.00%	0.27	0.27	4.7
	Area Lighting	100.00%	0.47	0.47	8.3
	Linear Lighting	100.00%	0.25	0.25	4.3
Refrigeration	Walk-in Refrigerator/Freezer	12.88%	0.70	0.09	1.6
	Reach-in Refrigerator/Freezer	15.93%	0.55	0.09	1.5
	Glass Door Display	9.72%	0.46	0.05	0.8
	Open Display Case	9.72%	1.49	0.15	2.5
	Icemaker	40.00%	1.51	0.61	10.6
	Vending Machine	40.00%	0.53	0.21	3.7
Food Preparation	Oven	27.36%	0.21	0.06	1.0
	Fryer	37.02%	0.99	0.37	6.4
	Dishwasher	28.54%	0.52	0.15	2.6
	Hot Food Container	33.39%	0.16	0.05	1.0
	Steamer	22.86%	0.63	0.14	2.5
	Griddle	23.38%	0.63	0.15	2.6
Office Equipment	Desktop Computer	100.00%	0.36	0.36	6.2
	Laptop	99.84%	0.05	0.04	0.8
	Server	88.69%	0.75	0.67	11.7
	Monitor	100.00%	0.06	0.06	1.1
	Printer/Copier/Fax	100.00%	0.06	0.06	1.1
	POS Terminal	59.76%	0.03	0.02	0.3
Miscellaneous	Non-HVAC Motors	60.76%	0.42	0.25	4.4
	Pool Pump	11.12%	0.06	0.01	0.1
	Pool Heater	3.73%	0.08	0.00	0.1
	Electric Vehicle Supply Equipment	14.31%	0.07	0.01	0.2
	Clothes Washer	18.38%	0.03	0.01	0.1
	Clothes Dryer	11.33%	0.11	0.01	0.2
	Other Miscellaneous	100.00%	1.96	1.96	34.3
Total				**14.89**	**260.70**

Industrial Sector

The total electricity used in 2020 by Tacoma's industrial customers was 955 GWh. Tacoma billing data, load forecast and secondary sources were used to allocate usage among end uses. Figure 3-10 shows the distribution of annual electricity consumption by end use for all industrial customers. Motors are the largest overall end use for the industrial sector, accounting for 67% of energy use. Note that this end use includes a wide range of industrial equipment, such as air and refrigeration compressors, pumps, conveyor motors, and fans. The process end use accounts for 18% of annual energy use, which includes heating, cooling, refrigeration, and electro-chemical processes. Lighting is the next highest, followed by cooling, miscellaneous, ventilation, and space heating.

Photo: Getty Images

Figure 3-10 Industrial Electricity Use by End Use (2020), All Industries

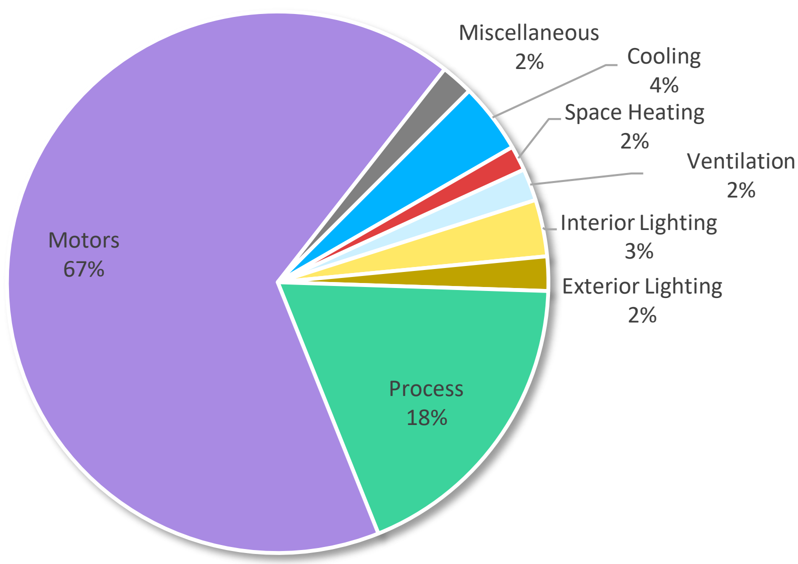


Table 3-10 shows the composite market profile for the industrial sector. Segment-level detail was included in the analysis of the industrial sector but excluded from the report to prevent disclosure of data that may be sensitive for some of Tacoma's larger customers.

Table 3-10 Average Electric Market Profile for the Industrial Sector, 2020

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/Empl)	Usage (GWh)
Cooling	Air-Cooled Chiller	1.0%	6,008	63	1.1
	Water-Cooled Chiller	1.0%	12,306	128	2.3
	RTU	43.8%	4,077	1,784	32.2
	Air-Source Heat Pump	5.6%	4,224	237	4.3
	Geothermal Heat Pump	0.0%	1	0	0.0
Space Heating	Electric Furnace	1.1%	8,145	87	1.6
	Electric Room Heat	5.8%	7,758	448	8.1
	Air-Source Heat Pump	5.6%	4,546	256	4.6
	Geothermal Heat Pump	0.0%	1	0	0.0
Ventilation	Ventilation	100.0%	1,014	1,014	18.3
Interior Lighting	General Service Lighting	100.0%	173	173	3.1
	High-Bay Lighting	100.0%	941	941	17.0
	Linear Lighting	100.0%	677	677	12.2
Exterior Lighting	General Service Lighting	100.0%	322	322	5.8
	Area Lighting	100.0%	312	312	5.6
	Linear Lighting	100.0%	451	451	8.1
Motors	Pumps	92.8%	11,411	10,594	191.1
	Fans & Blowers	92.8%	4,084	3,792	68.4
	Compressed Air	92.8%	4,879	4,529	81.7
	Material Handling	100.0%	15,534	15,534	280.1
	Other Motors	87.2%	957	835	15.1
Process	Process Heating	100.0%	3,328	3,328	60.0
	Process Cooling	87.2%	2,385	2,080	37.5
	Process Refrigeration	87.2%	1,675	1,461	26.3
	Process Electrochemical	90.9%	2,164	1,967	35.5
	Process Other	90.9%	1,007	915	16.5
Miscellaneous	Miscellaneous	77.8%	1,308	1,018	18.4
Total				**52,946**	**954.8**

Street Lighting Sector

Tacoma Power has already converted essentially all of its directly-accessible street lighting fixtures to LEDs. As such, the remaining potential in this equipment category is limited to the fixtures not owned by the utility, and therefore more difficult to find and encourage conversion. The totals shown for this sector throughout the document are only for this remaining classification of fixtures not owned by Tacoma Power. The total electric energy consumed by these fixtures in the base period was 14,323 MWh. Inventory of fixtures, wattages, and usage was provided by Tacoma Power. In this study, we divided street lighting into three market segments based on rate class and jurisdiction. We define fixtures as our unit of analysis within LoadMAP, each represented by an average lamp wattage. The values are shown in Table 3-11 and Table 3-12.

Table 3-11 Street Lighting Sector Control Totals (2020)

Segment	Electricity Sales (MWh)	Usage per Fixture (Annual kWh/Fixt.)	Fixture Count
H1 Dusk to Dawn	4,896	874	5,605
H1 - Other Fixtures	1,406	92	15,231
H2 Service - All	8,021	1,018	7,883
Total	**14,324**	**499**	**28,719**

The H1 - Street and Highway fixtures consume an average of 874 kWh and H1 - Other Fixtures consume 92 kWh. While the majority fixtures in both categories are already converted to LEDs, the first group includes more off-streat dusk to dawn type lamps that are harder to access, whereas the Other Fixtures are mainly standard traffic signals and other public facing fixtures, mostly already converted to LED. H2 Service lamps are unmetered fixtures.

Figure 3-11**Error! Reference source not found.** shows the distribution of annual electricity consumption by fixture type across all streetlights.

Figure 3-11 Street Lighting Sector Electricity Consumption by Fixture Type (2020)

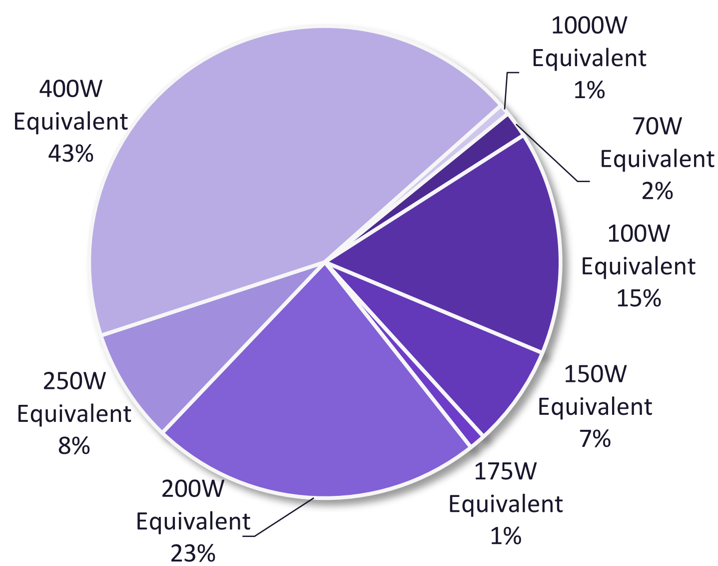


Table 3-12 shows the average market profile for electricity of the street lighting sector, representing a composite of all rate classes (H1 and H2 services). Market profiles for each rate class are presented in the appendix to this volume.

Table 3-12 Average Electric Market Profile for the Street Lighting Sector, 2020

End Use	Technology	Saturation	EUI (kWh)	Fixtures	Usage (MWh)
Street Lighting	70W Equivalent	8.7%	103	2,496	258
	100W Equivalent	40.0%	191	11,482	2,195
	150W Equivalent	17.5%	198	5,036	997
	175W Equivalent	0.8%	678	235	159
	200W Equivalent	17.8%	639	5,100	3,261
	250W Equivalent	3.4%	1157	970	1,123
	400W Equivalent	11.7%	1,859	3,350	6,228
	1000W Equivalent	0.2%	2076	50	104
Total				**28,719**	**14,324**

4

BASELINE PROJECTION

Prior to developing estimates of energy-efficiency potential, AEG developed a baseline end-use projection to quantify what the consumption is likely to be in the future in absence of any conservation or efficiency programs.

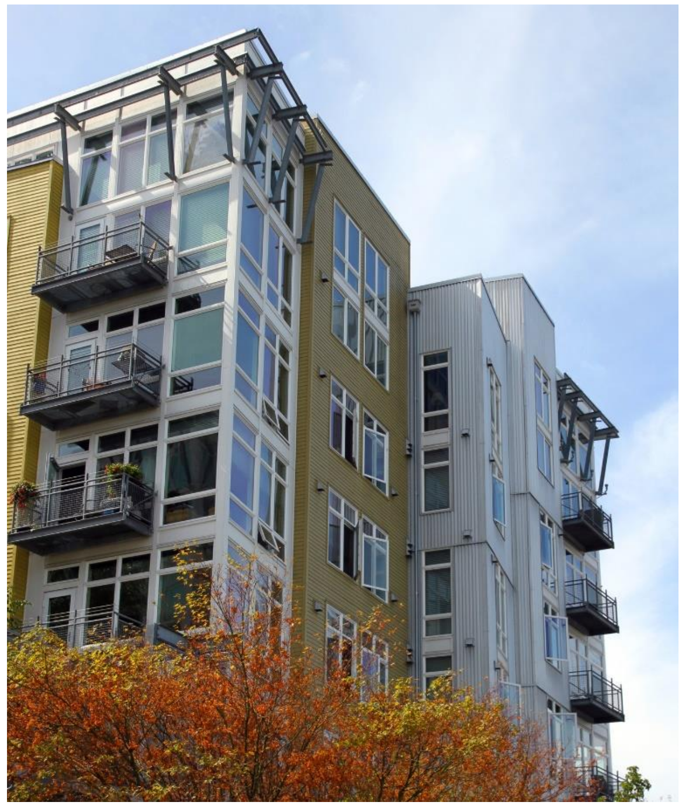


Photo: Getty Images

The first step was to align with Tacoma Power's official forecast. AEG worked with Tacoma Power's load forecasting group to incorporate assumptions and data utilized in the official utility forecast. These data points included customer growth and use-per-customer projections. These assumptions were incorporated into the LoadMAP model, ensuring alignment with the official load forecast.

The end-use projection includes the relatively certain impacts of codes and standards that will unfold over the study timeframe. All such mandates that were defined as of March 2021 are included in the baseline, including the impacts of the 2018 Washington State Energy Code (WSEC) which took effect in 2021. The baseline projection does not include any naturally occurring conservation that might take place in the potential forecast period (2022 and beyond). This creates a frozen efficiency baseline consistent with Council methodology. As such, the baseline projection is the foundation for the analysis of savings from future efficiency cases and scenarios as well as the metric against which potential savings are measured.

Inputs to the baseline projection include:

- An integrated database provided by Tacoma Power which includes energy consumption and account data, county assessor building characteristics, previous conservation accomplishment, and electric heat scoring
- Current economic growth forecasts (i.e., customer growth, income growth)
- Electricity price forecasts
- Trends in fuel shares and equipment saturations
- Existing and approved changes to building codes and equipment standards
- Incorporation of the RTF's market baseline assumptions for measures such as general service lighting.

Although it aligns closely, the baseline projection is not Tacoma's official load forecast. Rather it was developed as an integral component of AEG's modeling construct to serve as the metric against which conservation potentials are measured. This chapter presents the baseline projections we developed for this study.

Below, we present the baseline projections for each sector, which include projections of annual use in GWh. We also present a summary across all sectors.

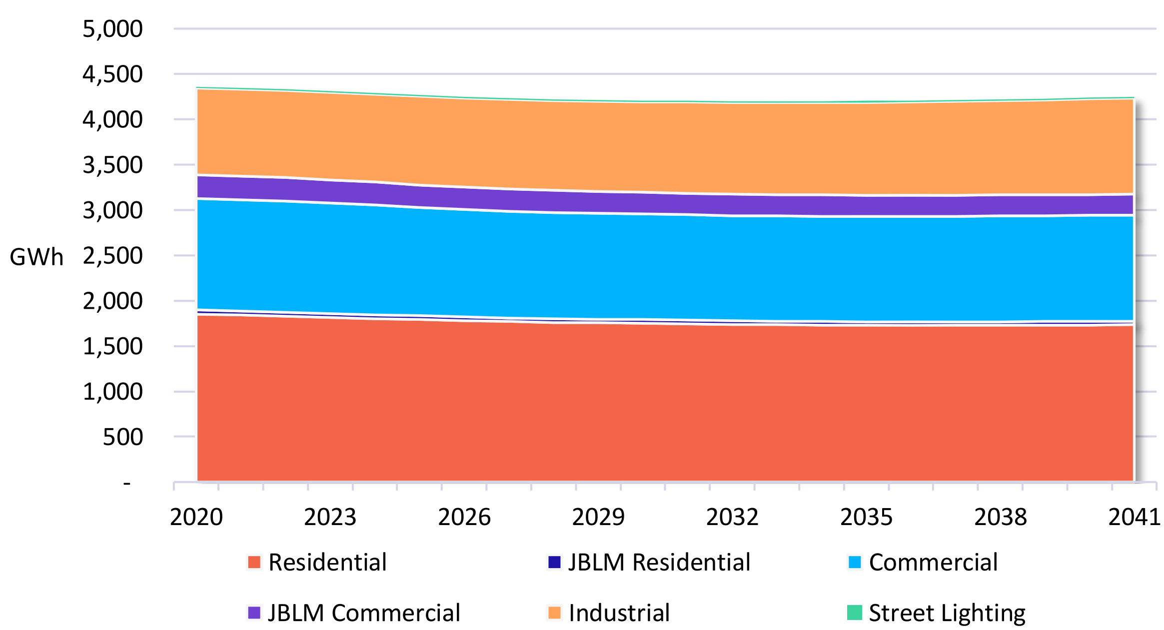
Summary of Baseline Projections Across Sectors

Table 4-1 and Figure 4-1 provide a summary of the baseline projection for annual use by sector for the entire Tacoma service territory. Overall, the forecast shows relatively modest growth in electricity use, driven primarily by customer growth forecasts and moderated by the effects of future codes and standards that have already been enacted.

Table 4-1 Baseline Projection Summary (GWh)

Sector	2022	2023	2024	2026	2031	2041	% Change ('20-'41)	Avg. Annual Growth Rate ('20-'41)
Residential	1,829	1,816	1,804	1,779	1,744	1,735	-6.4%	-0.3%
JBLM Residential	44	43	43	41	39	37	-16.5%	-0.9%
Commercial	1,226	1,219	1,209	1,185	1,163	1,173	-4.7%	-0.2%
JBLM Commercial	258	255	253	247	239	230	-11.6%	-0.6%
Industrial	963	966	970	979	1,003	1,058	10.8%	0.5%
Street Lighting	14	14	14	14	14	14	0.0%	0.0%
Total	**4,334**	**4,314**	**4,292**	**4,247**	**4,203**	**4,249**	**-2.5%**	**-0.1%**

Figure 4-1 Baseline Projection Summary (GWh)



Residential Sector Baseline Projection

Table 4-2 and

End Use	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	28	28	28	28	28	29	3.4%
Space Heating	615	607	600	586	555	504	-19.9%
Water Heating	365	362	358	352	342	345	-6.8%
Interior Lighting	122	117	113	103	89	80	-37.9%
Exterior Lighting	24	23	23	21	19	16	-35.8%
Appliances	309	310	311	314	322	339	10.3%
Electronics	119	118	118	118	123	138	14.6%
Miscellaneous	249	251	253	257	267	285	16.4%
Total	**1,829**	**1,816**	**1,804**	**1,779**	**1,744**	**1,735**	**-6.4%**

Figure 4-2 present AEG's independent baseline projection for electricity at the end-use level for the residential sector as a whole. Overall, residential use decreases from 1,853 GWh in 2020 to 1,735 GWh in 2041, a decrease of 6.4%. presents the baseline projection of annual electricity use per household. Most noticeable is that lighting use decreases throughout the time period due to the impacts of the Washington state lighting standard.

Table 4-2 Residential Baseline Projection by End Use (GWh)

End Use	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	28	28	28	28	28	29	3.4%
Space Heating	615	607	600	586	555	504	-19.9%
Water Heating	365	362	358	352	342	345	-6.8%
Interior Lighting	122	117	113	103	89	80	-37.9%
Exterior Lighting	24	23	23	21	19	16	-35.8%
Appliances	309	310	311	314	322	339	10.3%
Electronics	119	118	118	118	123	138	14.6%
Miscellaneous	249	251	253	257	267	285	16.4%
Total	**1,829**	**1,816**	**1,804**	**1,779**	**1,744**	**1,735**	**-6.4%**

Figure 4-2 Residential Baseline Projection by End Use (GWh)

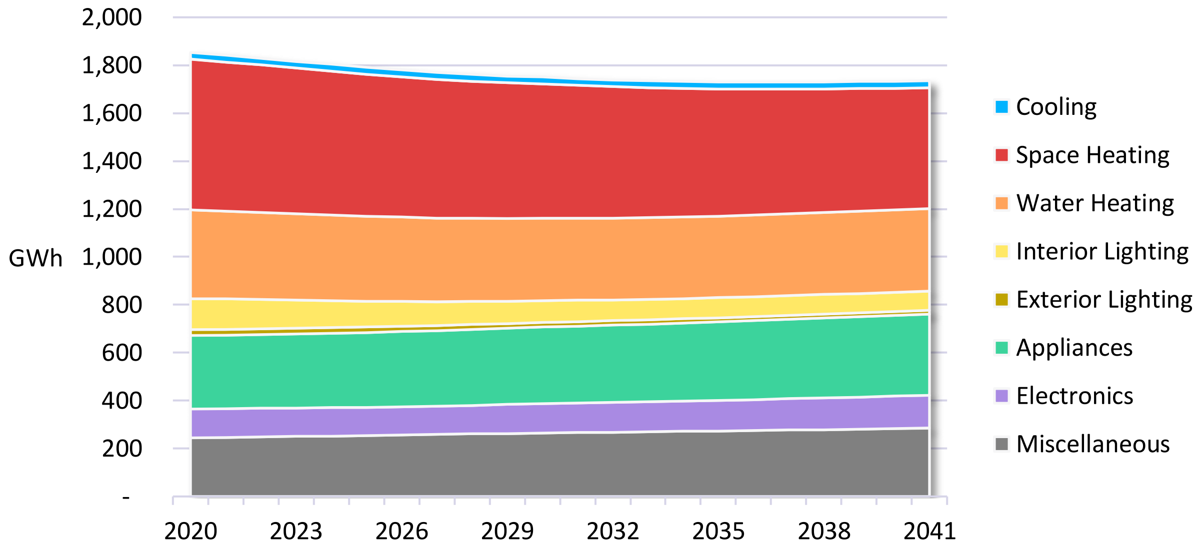


Figure 4-3 Residential Baseline Projection by End Use – Annual Use per Household

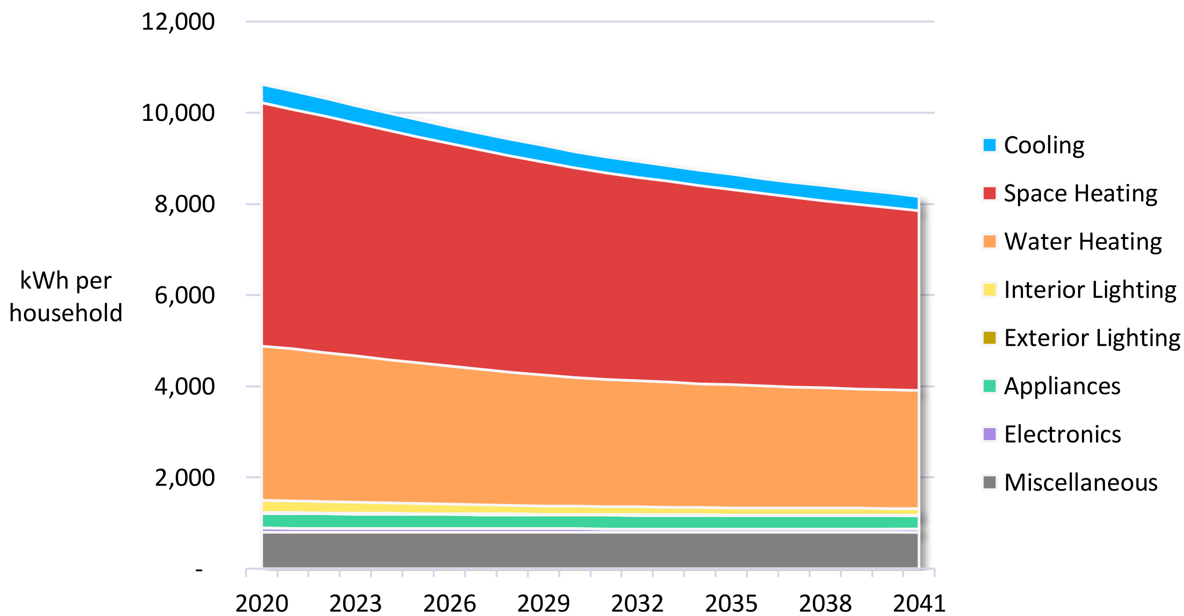


Table 4-3 shows the end-use forecast at the technology level for select years. This projection is in general alignment with Tacoma's residential load forecast. Specific observations include:

1. Lighting use declines as a result of the state lighting standard (which was original based on phase two of the federal EISA lighting standards), and market baseline impacts savings for lighting measures.
2. Appliance energy use experiences significant efficiency gains from new standards, but this is offset by customer growth.
3. Growth in electronics is substantial and reflects an increase in the saturation of electronics and the trend toward higher-powered computers. Growth in other miscellaneous use is also substantial. This end use

has grown consistently in the past and we incorporate future growth assumptions that are consistent with the Annual Energy Outlook.

4. Electric vehicle growth is very high due to projections in the recent AEO studies.

Table 4-3 Residential Baseline Projection by End Use and Technology (GWh)

End Use	Technology	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	Central AC	6	6	6	7	8	10	70.0%
	Room AC	14	13	13	13	12	11	-22.8%
	Air-Source Heat Pump	7	7	7	7	7	6	-8.3%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
	Ductless Mini Split Heat Pump	2	2	2	2	2	2	44.3%
Space Heating	Electric Room Heat	265	261	258	251	235	213	-22.1%
	Electric Furnace	205	201	197	189	170	141	-33.9%
	Air-Source Heat Pump	71	71	71	72	74	74	6.4%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
	Secondary Heating	52	51	51	50	47	42	-19.7%
	Ductless Mini Split Heat Pump	22	23	24	25	28	34	62.4%
Water Heating	Water Heater (<= 55 Gal)	340	338	336	331	325	330	-4.1%
	Water Heater (> 55 Gal)	25	24	23	21	18	15	-42.5%
Interior Lighting	Exempted Lighting	32	28	25	18	10	8	-79.9%
	General Service Lighting	72	71	70	67	60	53	-28.6%
	Linear Lighting	18	18	18	18	19	20	13.6%
Exterior Lighting	General Service Lighting	24	23	23	21	19	16	-35.8%
Appliances	Air Purifier	6	6	6	7	7	8	39.8%
	Clothes Dryer	96	97	98	100	106	117	24.8%
	Clothes Washer	6	6	6	7	7	7	11.1%
	Dehumidifier	6	6	6	6	6	7	40.0%
	Dishwasher	11	11	12	12	14	15	37.1%
	Freezer	24	24	24	24	25	25	6.0%
	Microwave	21	21	22	23	25	29	47.9%
	Refrigerator	84	84	84	83	83	84	-2.0%
	Second Refrigerator	36	36	35	33	30	26	-31.4%
	Stove/Oven	18	18	18	18	19	20	9.5%
Electronics	Devices and Gadgets	16	16	16	16	17	18	14.0%
	Laptops	3	3	3	3	4	4	43.0%
	Monitor	10	10	9	9	8	7	-39.5%
	Personal Computers	12	12	12	12	11	11	-13.3%
	Printer/Fax/Copier	6	6	6	6	7	8	26.9%
	Set-top Boxes/DVRs	32	32	32	32	34	41	25.9%
	TVs	39	39	39	39	42	49	26.7%
Miscellaneous	Bathroom Exhaust Fan	2	2	2	2	3	3	20.4%
	Electric Vehicle Chargers	3	3	3	3	3	3	4.3%
	Furnace Fan	120	121	122	124	129	136	15.3%
	Hot Tub/Spa	8	8	8	8	8	10	22.7%
	Pool Heater	0	0	0	0	0	0	0.0%
	Pool Pump	1	1	1	1	1	0	-72.4%
	Well Pump	1	1	1	1	1	1	5.0%
	Miscellaneous	114	115	116	117	123	132	18.2%
Total		**1,829**	**1,816**	**1,804**	**1,779**	**1,744**	**1,735**	**-6.4%**

JBLM Residential Sector Baseline Projection

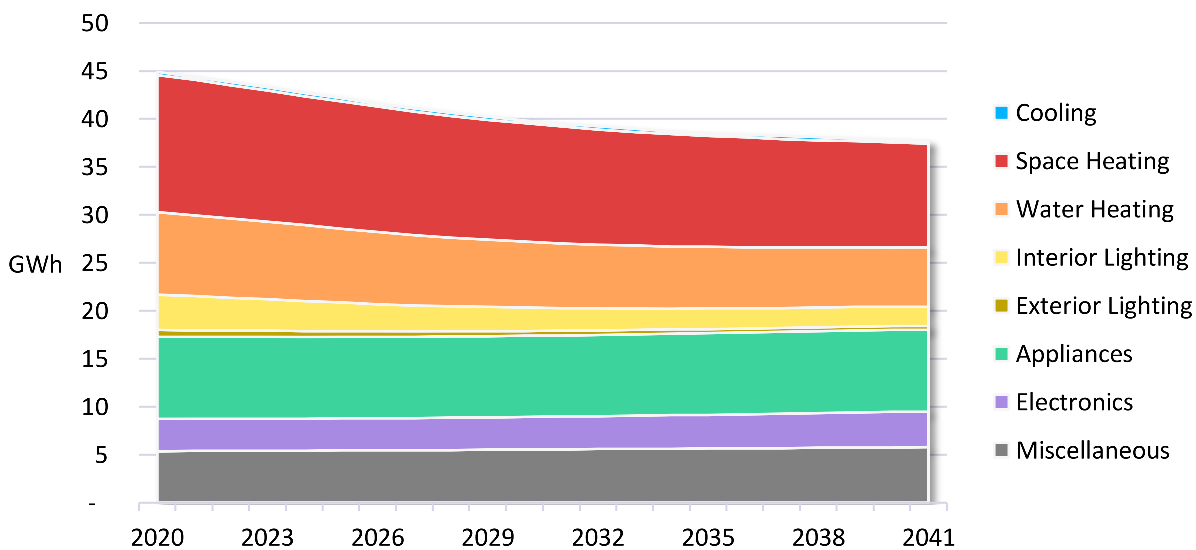
Annual electricity consumption in the JBLM residential sector declines during the overall forecast horizon, starting at 44,909 MWh in 2020 decreasing to 37,711 MWh in 2041, a decrease of 16%. Table 4-4 presents the JBLM residential sector annual forecast by technology for select years. Like non-JBLM residential, lighting use decreases throughout the time period as the Washington State lighting standard affects the market baseline. Water heating and space heating consumption decreases as well.

Figure 4-4 and Figure 4-5 present the baseline projection at the end-use level for the sector as a whole. Table 4-5 shows the end-use forecast at the technology level for select years.

Table 4-4 JBLM Residential Baseline Projection by End Use (MWh) [14]

End Use	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	320	317	314	308	295	281	-13.6%
Space Heating	13,884	13,677	13,472	13,076	12,178	10,819	-24.4%
Water Heating	8,278	8,089	7,894	7,509	6,747	6,165	-28.4%
Interior Lighting	3,419	3,273	3,126	2,825	2,345	2,007	-45.1%
Exterior Lighting	665	649	632	587	497	398	-42.7%
Appliances	8,534	8,521	8,507	8,483	8,457	8,543	-0.4%
Electronics	3,355	3,344	3,337	3,340	3,422	3,714	9.9%
Miscellaneous	5,390	5,408	5,427	5,464	5,558	5,784	8.1%
Total	**43,845**	**43,278**	**42,709**	**41,591**	**39,499**	**37,711**	**-16.0%**

Figure 4-4 JBLM Residential Baseline Projection by End Use (GWh)



[14] Values in this table have been converted to MWh as the JBLM Residential sector is comparatively smaller than others.

Figure 4-5 JBLM Residential Baseline Projection by End Use – Annual Use per Household

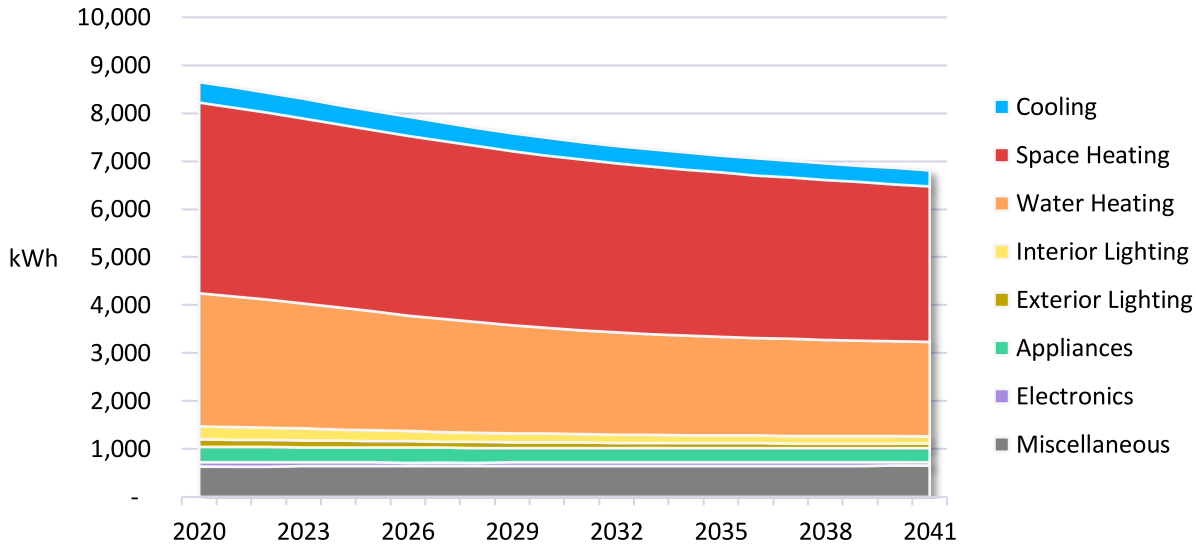


Table 4-5 JBLM Residential Baseline Projection by End Use and Technology (MWh) [15]

End Use	Technology	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	Central AC	0	0	0	0	0	0	0.0%
	Room AC	68	67	63	59	56	54	-23.6%
	Air-Source Heat Pump	209	207	200	190	183	179	-15.6%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
	Ductless Mini Split Heat Pump	43	44	45	46	47	48	12.9%
Space Heating	Electric Room Heat	5,844	5,751	5,486	5,095	4,780	4,531	-24.9%
	Electric Furnace	4,789	4,692	4,413	3,990	3,629	3,318	-33.4%
	Air-Source Heat Pump	1,489	1,486	1,474	1,456	1,447	1,446	-3.2%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
	Secondary Heating	1,326	1,307	1,255	1,173	1,097	1,028	-24.6%
	Ductless Mini Split Heat Pump	436	439	449	465	480	496	15.4%
Water Heating	Water Heater (<= 55 Gal)	3,588	3,574	3,532	3,472	3,431	3,403	-5.8%
	Water Heater (> 55 Gal)	4,690	4,514	3,977	3,276	2,926	2,762	-44.8%
Interior Lighting	Exempted Lighting	916	811	515	273	217	200	-81.6%
	General Service Lighting	2,018	1,977	1,824	1,585	1,420	1,321	-36.7%
	Linear Lighting	486	486	486	487	487	486	0.2%
Exterior Lighting	General Service Lighting	665	649	587	497	437	398	-42.7%
Appliances	Air Purifier	173	175	181	191	201	212	25.0%
	Clothes Dryer	2,644	2,660	2,707	2,799	2,908	2,976	13.9%
	Clothes Washer	176	176	176	176	176	176	0.3%
	Dehumidifier	156	157	162	171	181	190	25.0%
	Dishwasher	310	316	333	355	359	364	21.6%
	Freezer	687	686	685	683	682	680	-1.0%
	Microwave	566	575	602	644	683	720	31.7%
	Refrigerator	2,299	2,280	2,225	2,148	2,099	2,069	-12.3%
	Second Refrigerator	1,064	1,037	955	841	768	723	-35.2%
	Stove/Oven	460	459	455	449	441	433	-6.6%
Electronics	Devices and Gadgets	428	428	428	428	428	428	0.0%
	Laptops	84	85	88	94	100	107	29.2%
	Monitor	294	278	238	205	189	178	-45.0%
	Personal Computers	349	339	319	304	298	295	-21.2%
	Printer/Fax/Copier	165	166	169	173	178	182	11.3%
	Set-top Boxes/DVRs	932	936	952	1,004	1,072	1,150	24.4%
	TVs	1,103	1,113	1,146	1,214	1,291	1,375	26.9%
Miscellaneous	Bathroom Exhaust Fan	64	64	65	67	69	71	11.2%
	Electric Vehicle Chargers	0	0	0	0	0	0	0.0%
	Furnace Fan	3,760	3,778	3,832	3,923	4,016	4,112	10.4%
	Hot Tub/Spa	242	243	244	245	259	279	16.4%
	Miscellaneous	1,284	1,284	1,284	1,284	1,284	1,284	0.0%
	Pool Heater	0	0	0	0	0	0	0.0%
	Pool Pump	0	0	0	0	0	0	0.0%
	Well Pump	39	39	39	39	39	39	0.0%
Total		**43,845**	**43,278**	**41,591**	**39,499**	**38,356**	**37,711**	**-16.0%**

[15] Values in this table have been converted to MWh as the JBLM Residential sector is comparatively smaller than others.

Commercial Sector Baseline Projection

Annual electricity usage in the commercial sector declines 4.7% during the overall forecast horizon, starting at 1,231 GWh in 2020, and declining to 1,173 by 2041. Table 4-6 and Figure 4-6 present the baseline projection at the end-use level for the commercial sector as a whole. Usage in lighting is declining throughout the forecast, due largely to the phasing in of codes and standards such as the state lighting standards, as well as embedded market practices of stocking and purchasing high efficiency lamps. Usage in commercial ventilation decreases even though cooling and heating increase, due to market trends in fan efficiency and controls. Growth in miscellaneous use is substantial and has grown consistently in the past and we incorporates future growth assumptions consistent with the Annual Energy Outlook.

Table 4-6 Commercial Baseline Projection by End Use (GWh)

End Use	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	171	171	172	173	175	180	6.4%
Space Heating	44	44	45	45	46	48	10.1%
Ventilation	215	212	209	203	192	184	-16.6%
Water Heating	35	35	35	36	37	39	11.0%
Interior Lighting	241	238	234	224	212	205	-15.8%
Exterior Lighting	112	109	105	96	86	85	-24.3%
Refrigeration	115	115	115	116	118	123	7.6%
Food Preparation	46	46	46	46	47	49	6.6%
Office Equipment	94	93	93	91	91	92	-2.6%
Miscellaneous	152	153	154	156	159	168	11.0%
Total	**1,226**	**1,219**	**1,209**	**1,185**	**1,163**	**1,173**	**-4.7%**

Figure 4-6 Commercial Baseline Projection by End Use

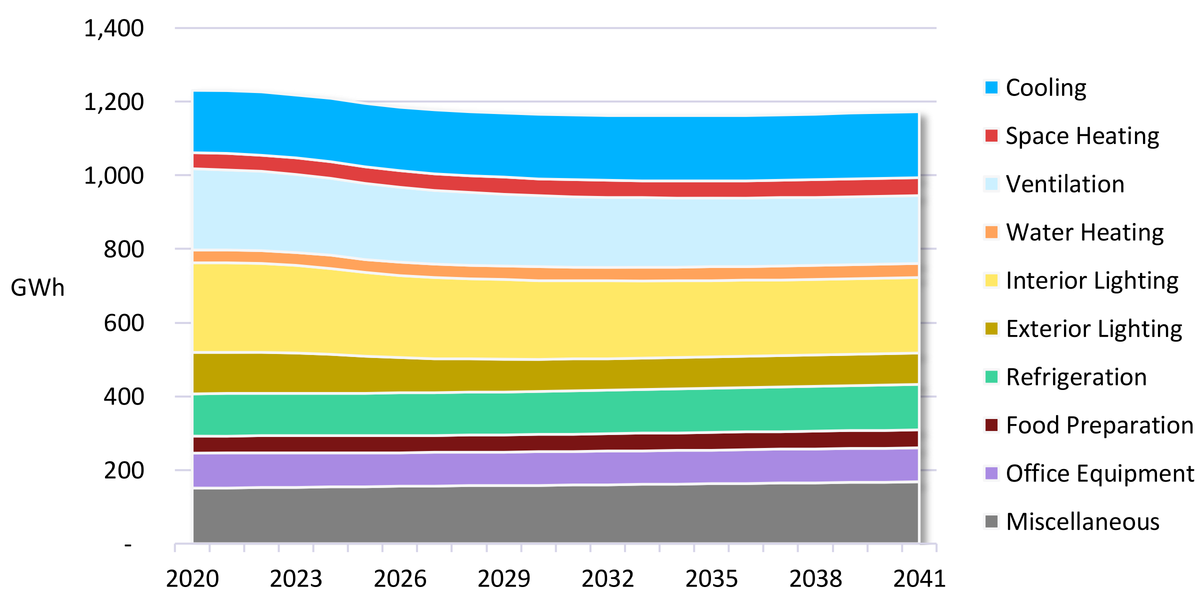


Table 4-7 presents the commercial sector annual forecast by technology for select years. General service and exempted lighting technologies decrease significantly over the forecast period as a result of efficiency standards. The effects of the T12 linear lighting standard are already embedded in the 2020 baseline.

Table 4-7 Commercial Baseline Projection by End Use and Technology (GWh)

End Use	Technology	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	Air-Source Heat Pump	16	16	16	16	16	16	-2.0%
	Geothermal Heat Pump	6	6	6	6	6	6	-4.4%
	Air-Cooled Chiller	17	17	17	17	17	18	6.3%
	Water-Cooled Chiller	16	16	17	18	20	23	56.4%
	RTU	94	94	94	94	94	94	-0.4%
	Packaged Terminal AC	15	15	15	15	15	16	11.0%
	Packaged Terminal HP	7	7	7	7	7	8	11.0%
Space Heating	Electric Room Heat	20	20	20	20	21	22	11.0%
	Electric Furnace	6	6	6	6	6	6	11.0%
	Air-Source Heat Pump	11	11	11	11	11	12	8.5%
	Geothermal Heat Pump	4	4	4	4	4	4	7.8%
	Packaged Terminal HP	4	4	4	4	5	5	11.0%
Ventilation	Ventilation	215	212	209	203	192	184	-16.6%
Water Heating	Water Heater	35	35	35	36	37	39	11.0%
Interior Lighting	General Service Lighting	37	36	33	26	18	15	-60.3%
	Exempted Lighting	8	6	5	4	3	2	-77.2%
	Linear Lighting	164	164	164	163	160	156	-4.5%
	High-Bay Lighting	32	32	32	32	31	31	-2.8%
Exterior Lighting	General Service Lighting	39	36	31	21	11	8	-79.2%
	Linear Lighting	29	29	29	29	29	30	6.2%
	Area Lighting	44	45	45	45	46	47	6.0%
Refrigeration	Walk-in Refrigerator/Freezer	6	6	5	5	4	4	-46.6%
	Reach-in Refrig./Freezer	6	6	6	6	6	7	11.0%
	Glass Door Display	15	15	15	15	15	16	11.0%
	Open Display Case	47	47	47	48	49	52	11.0%
	Icemaker	30	30	30	31	31	33	11.0%
	Vending Machine	11	11	11	11	12	12	11.0%
Food Preparation	Dishwasher	7	7	7	8	8	8	11.0%
	Oven	3	3	3	3	3	3	11.0%
	Fryer	18	18	18	18	18	19	3.7%
	Hot Food Container	3	3	3	3	3	3	11.0%
	Steamer	8	8	8	8	8	8	1.7%
	Griddle	8	8	8	8	8	8	11.0%
Office Equipment	Monitor	5	5	5	5	5	6	8.4%
	Desktop Computer	29	28	27	25	23	20	-33.1%
	Laptop	3	3	3	3	4	4	26.8%
	Server	49	50	50	50	52	54	11.0%
	Printer/Copier/Fax	5	5	5	5	5	5	11.0%
	POS Terminal	2	2	2	2	3	3	11.0%
Miscellaneous	Clothes Dryer	1	1	1	1	1	1	11.0%
	Clothes Washer	0	0	0	0	0	0	11.0%
	Electric Vehicle Chargers	1	1	1	1	1	1	11.0%
	Miscellaneous	137	137	138	139	143	150	11.0%
	Pool Heater	0	0	0	0	0	0	11.0%
	Pool Pump	0	0	0	0	0	0	11.0%
	Non-HVAC Motors	14	14	14	14	15	15	11.0%
Total		**1,226**	**1,219**	**1,209**	**1,185**	**1,163**	**1,173**	**-4.7%**

JBLM Commercial Sector Baseline Projection

Annual electricity usage in the JBLM commercial sector declines during the overall forecast horizon, starting at 261 GWh in 2020, and decreasing to 255 GWh in 2041, a decline of 2.1%. Table 4-8 and Figure 4-7 present the baseline projection at the end-use level for the JBLM commercial sector as a whole.

Table 4-8 JBLM Commercial Baseline Projection by End Use (GWh)

End Use	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	40	41	41	41	42	43	8.2%
Space Heating	14	14	14	14	14	15	10.3%
Ventilation	44	44	43	42	40	38	-16.3%
Water Heating	7	7	7	7	7	7	11.0%
Interior Lighting	40	39	39	37	35	33	-17.2%
Exterior Lighting	17	17	17	16	15	14	-16.4%
Refrigeration	21	21	21	21	21	22	6.7%
Food Preparation	16	16	16	16	16	17	6.7%
Office Equipment	21	21	21	21	21	21	-2.0%
Miscellaneous	40	40	40	41	42	44	11.0%
Total	**260**	**259**	**257**	**254**	**251**	**255**	**-2.1%**

Figure 4-7 JBLM Commercial Baseline Projection by End Use

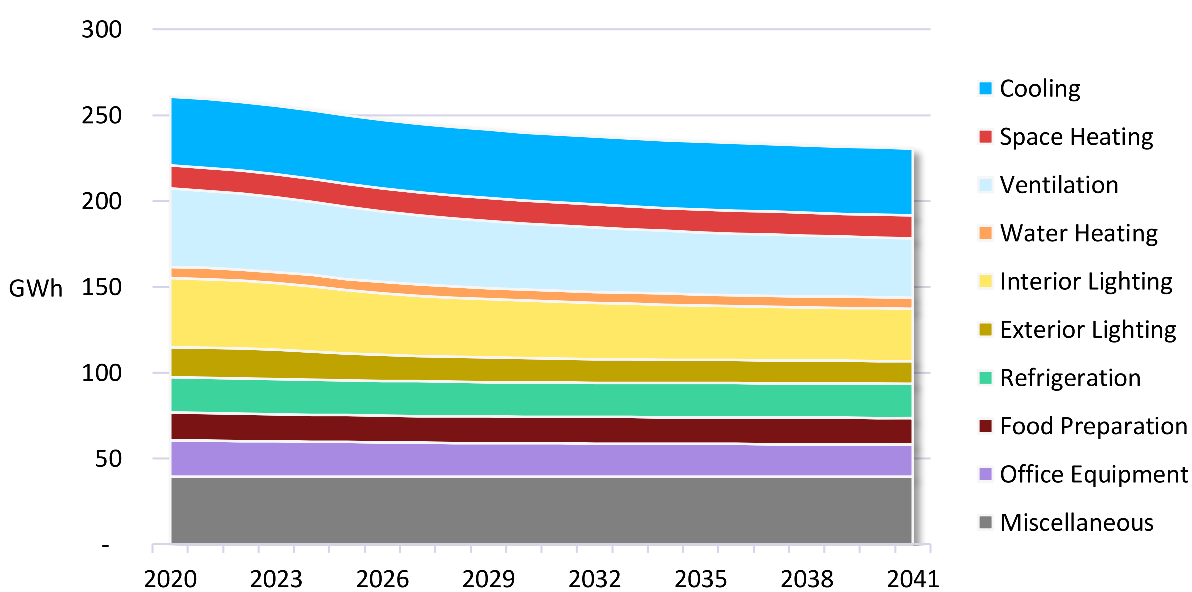


Table 4-9 presents the JBLM commercial sector annual forecast by technology for select years. Screw-in lighting technologies decrease significantly over the forecast period as a result of efficiency standards. The effects of the T12 linear lighting standard are already embedded in the 2020 baseline.

Table 4-9 JBLM Commercial Baseline Projection by End Use and Technology (GWh)

End Use	Technology	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	Air-Source Heat Pump	4	4	4	4	4	4	-1.9%
	Geothermal Heat Pump	2	2	2	2	2	2	-4.4%
	Air-Cooled Chiller	3	3	3	3	3	3	8.6%
	Water-Cooled Chiller	4	4	5	5	5	6	59.1%
	RTU	20	20	20	20	20	20	-0.4%
	Packaged Terminal AC	6	6	6	6	6	6	11.0%
	Packaged Terminal HP	2	2	3	3	3	3	11.0%
Space Heating	Electric Room Heat	7	7	7	7	7	7	11.0%
	Electric Furnace	1	1	1	1	1	1	11.0%
	Air-Source Heat Pump	3	3	3	3	3	3	8.5%
	Geothermal Heat Pump	1	1	1	1	1	1	7.8%
	Packaged Terminal HP	2	2	2	2	2	2	11.0%
Ventilation	Ventilation	44	44	43	42	40	38	-16.3%
Water Heating	Water Heater	7	7	7	7	7	7	11.0%
Interior Lighting	General Service Lighting	7	6	6	5	3	3	-59.7%
	Exempted Lighting	1	1	1	1	0	0	-76.9%
	Linear Lighting	25	25	25	25	25	24	-5.8%
	High-Bay Lighting	7	7	7	7	7	7	-3.0%
Exterior Lighting	General Service Lighting	5	4	4	3	1	1	-78.3%
	Linear Lighting	4	4	4	4	5	5	6.7%
	Area Lighting	8	8	8	9	9	9	6.6%
Refrigeration	Walk-in Refrigerator/Freezer	1	1	1	1	1	1	-46.6%
	Reach-in Refrigerator/Freezer	2	2	2	2	2	2	11.0%
	Glass Door Display	1	1	1	1	1	1	11.0%
	Open Display Case	3	3	3	3	3	3	11.0%
	Icemaker	11	11	11	11	11	12	11.0%
	Vending Machine	4	4	4	4	4	4	11.0%
Food Preparation	Dishwasher	3	3	3	3	3	3	11.0%
	Oven	1	1	1	1	1	1	11.0%
	Fryer	6	6	6	6	6	7	3.7%
	Hot Food Container	1	1	1	1	1	1	11.0%
	Steamer	3	2	2	2	2	3	1.7%
	Griddle	3	3	3	3	3	3	11.0%
Office Equipment	Monitor	1	1	1	1	1	1	8.4%
	Desktop Computer	6	6	6	5	5	4	-34.9%
	Laptop	1	1	1	1	1	1	28.5%
	Server	12	12	12	12	12	13	11.0%
	Printer/Copier/Fax	1	1	1	1	1	1	11.0%
	POS Terminal	0	0	0	0	0	0	11.0%
Miscellaneous	Clothes Dryer	0	0	0	0	0	0	11.0%
	Clothes Washer	0	0	0	0	0	0	11.0%
	Electric Vehicle Chargers	0	0	0	0	0	0	11.0%
	Miscellaneous	35	35	35	35	36	38	11.0%
	Pool Heater	0	0	0	0	0	0	11.0%
	Pool Pump	0	0	0	0	0	0	11.0%
	Non-HVAC Motors	4	4	5	5	5	5	11.0%
Total		**260**	**259**	**257**	**254**	**251**	**255**	**-2.1%**

Industrial Sector Baseline Projection

Annual industrial usage grows modestly throughout the forecast. Table 4-10 and Figure 4-8 present the projection at the end-use level. Overall, industrial annual electricity use increases from 955 GWh in 2020 to 1,058 GWh in 2041. This comprises an overall increase of 10.8% over the study period.

Table 4-10 Industrial Baseline Projection by End Use (GWh)

End Use	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	40	40	41	41	41	42	5.1%
Space Heating	14	14	15	15	15	16	10.2%
Ventilation	18	18	17	17	16	16	-13.2%
Interior Lighting	32	31	31	31	31	31	-5.1%
Exterior Lighting	19	18	17	16	16	16	-19.9%
Process	178	179	179	181	186	195	11.0%
Motors	643	646	649	656	672	707	11.0%
Miscellaneous	20	20	21	22	27	37	99.7%
Total	**963**	**966**	**970**	**979**	**1,003**	**1,058**	**10.8%**

Figure 4-8 Industrial Baseline Projection by End Use (GWh)

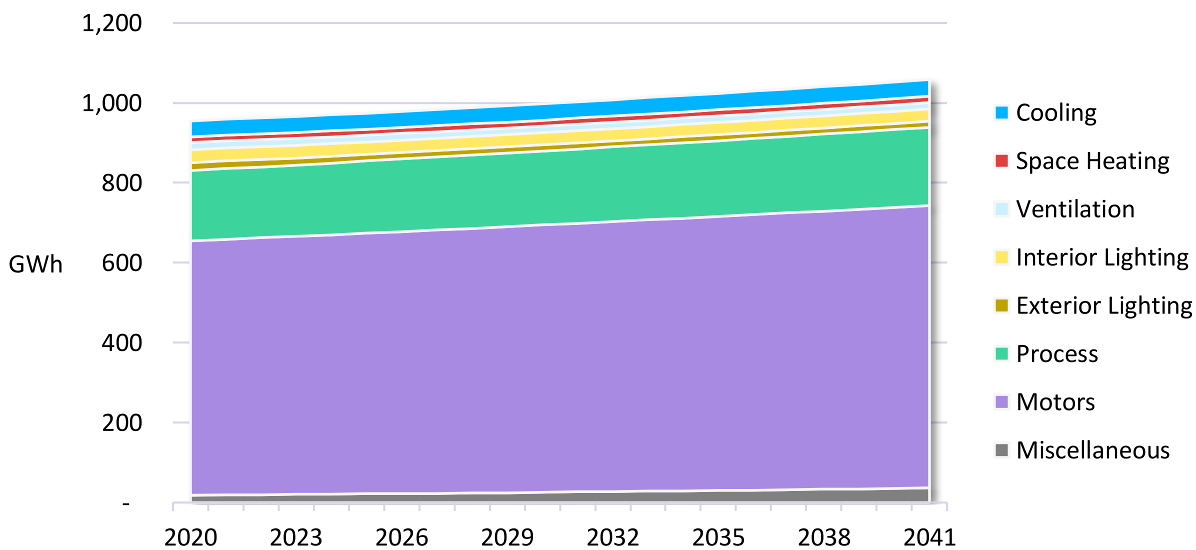


Table 4-11 presents the industrial sector annual forecast by technology for select years. General service lighting technologies decrease significantly over the forecast period as a result of efficiency standards. The effects of the T12 linear lighting standard are already embedded in the 2020 baseline.

Table 4-11 Industrial Baseline Projection by End Use and Technology (GWh)

End Use	Technology	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
Cooling	Air-Source Heat Pump	4	4	4	4	4	4	-1.9%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
	Air-Cooled Chiller	1	1	1	1	1	2	45.0%
	Water-Cooled Chiller	3	3	3	3	3	4	74.1%
	RTU	32	32	32	32	32	32	-0.3%
Space Heating	Electric Room Heat	8	8	8	8	9	9	11.0%
	Electric Furnace	2	2	2	2	2	2	11.0%
	Air-Source Heat Pump	5	5	5	5	5	5	8.5%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
Ventilation	Ventilation	18	18	17	17	16	16	-13.2%
Interior Lighting	General Service Lighting	3	2	2	2	1	1	-60.6%
	Linear Lighting	12	12	12	12	12	12	-2.1%
	High-Bay Lighting	17	17	17	17	17	17	3.0%
Exterior Lighting	General Service Lighting	5	4	3	2	2	2	-73.3%
	Linear Lighting	8	8	8	8	8	8	-1.4%
	Area Lighting	6	6	6	6	6	6	8.4%
Process	Process Heating	61	61	61	62	63	67	11.0%
	Process Cooling	38	38	38	39	40	42	11.0%
	Process Refrigeration	27	27	27	27	28	29	11.0%
	Process Electrochemical	36	36	36	37	37	39	11.0%
	Process Other	17	17	17	17	17	18	11.0%
Motors	Pumps	193	194	195	197	202	212	11.0%
	Fans & Blowers	69	69	70	70	72	76	11.0%
	Compressed Air	83	83	83	84	86	91	11.0%
	Material Handling	283	284	286	289	296	311	11.0%
	Other Motors	15	15	15	16	16	17	11.0%
Miscellaneous	Miscellaneous	20	20	21	22	27	37	99.7%
Total		**963**	**966**	**970**	**979**	**1,003**	**1,058**	**10.8%**

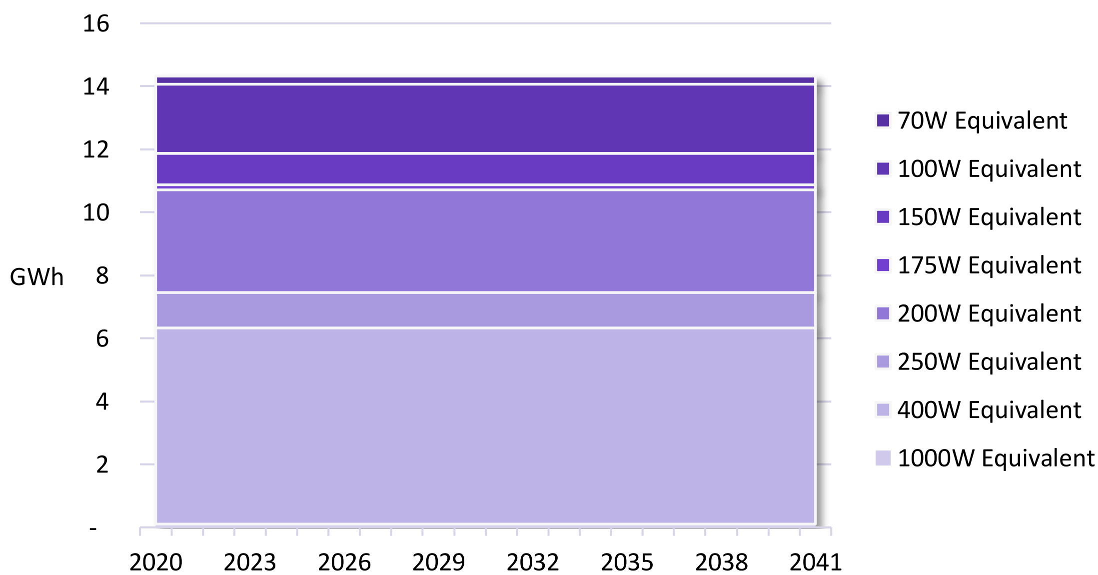
Street Lighting Sector Baseline Projection

Annual electricity use in the street lighting sector is assumed to remain flat throughout forecast horizon at 14,324 MWh. Table 4-12 and Figure 4-9 present the baseline projection at the fixture level for the street lighting sector as a whole. The street lighting baseline projection assumes no street lighting fixture growth over the study period. As discussed in the previous chapter, street lighting fixtures are already mostly LEDs in the baseline. Because of this, there is no meaningful change in consumption as units are replaced due to age.

Table 4-12 Street Lighting Baseline Projection by End Use (MWh) [16]

End Use	2022	2023	2024	2026	2031	2041	% Change ('20-'41)
70W Equivalent	258	258	258	258	258	258	0.0%
100W Equivalent	2,195	2,195	2,195	2,195	2,195	2,195	0.0%
150W Equivalent	997	997	997	997	997	997	0.0%
175W Equivalent	159	159	159	159	159	159	0.0%
200W Equivalent	3,261	3,261	3,261	3,261	3,261	3,261	0.0%
250W Equivalent	1,123	1,123	1,123	1,123	1,123	1,123	0.0%
400W Equivalent	6,228	6,228	6,228	6,228	6,228	6,228	0.0%
1000W Equivalent	104	104	104	104	104	104	0.0%
Total	**14,324**	**14,324**	**14,324**	**14,324**	**14,324**	**14,324**	**0.0%**

Figure 4-9 Street Lighting Baseline Projection by End Use (GWh)



[16] Values in this table have been converted to MWh as Street Lighting is comparatively smaller than other sectors.

5

OVERALL CONSERVATION POTENTIAL

This chapter presents the measure-level energy conservation potential across all sectors. This includes every possible measure that is considered in the measure list, regardless of program implementation concerns. Year-by-year savings for annual energy usage are available in the LoadMAP model, which was provided to Tacoma at the conclusion of the study. Please note that all savings are provided at the customer meter. This section includes potential from the residential, JBLM residential, commercial, JBLM commercial, industrial, and street lighting sectors as well as distribution efficiency improvements.

Summary of Overall Conservation Potential

Table 5-1 and Figure 5-1 summarize the conservation savings in terms of annual impacts of all measures for three levels of potential relative to the baseline projection.

Figure 5-2 displays the conservation forecasts. Savings are represented in cumulative terms, which reflect the effects of persistent savings in prior years in addition to new savings. This allows for the reporting of annual savings impacts as they actually impact each year of the forecast.

- **Technical Potential** reflects the adoption of all conservation measures regardless of cost-effectiveness or market barriers. In this potential case, all equipment goes to the most efficient, technically feasible option (e.g. highest tier heat pump water heaters) even when costs may be prohibitive. All retrofit measures are also installed, regardless of actual achievability. 2022 first-year savings are 92 GWh, or 2.1% of the baseline projection. Cumulative savings in 2031 are 895 GWh, or 21.3% of the baseline. By 2041, cumulative savings reach 1,381 GWh, or 32.5% of the baseline.
- **Achievable Technical Potential** refines technical potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and other factors that affect market penetration of conservation measures. For the 2022-2041 CPA, unadjusted ramp rates from the Council's Draft 2021 Power Plan were applied. For all Power Plan measures, the ramp rate assigned by the Council was applied directly. For additional measures, ramp rates were assigned based on similar technologies present in the Power Plan. Assumed ramp rates may are provided in Appendix C. 2022 first-year achievable technical potential is 60 GWh, or 1.4% of the baseline projection. Cumulative savings in

2031 are 599 GWh, or 14.2% of the baseline. By 2041 cumulative savings reach 973 GWh, or 22.9% of the baseline.

- **Achievable Economic Potential** further refines Achievable Technical potential by applying a cost-effectiveness screen. In this analysis, the cost-effectiveness is measured by the total resource cost (TRC) test, which compares lifetime energy and capacity benefits to the total customer and utility costs of delivering the measure through a utility program, including monetized non-energy impacts. Avoided costs of energy as well as avoided transmission and distribution and generation capacity costs were provided by Tacoma Power. A 10% conservation credit was applied to these costs, consistent with Council methodology. Additional details on alignment with Council methodology can be found in Appendix A. 2022 first-year Achievable Economic potential are 19 GWh, or 0.4% of the baseline projection. Cumulative net savings in 2031 are 226 GWh, or 5.4% of the baseline. By 2041 cumulative savings reach 391 GWh, or 9.2% of the baseline.

Table 5-1 Summary of Conservation Potential (Annual Energy, GWh)

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	4,336	4,316	4,294	4,248	4,205	4,251
Cumulative Savings (GWh)						
Economic Achievable Potential	19	41	64	107	226	391
Achievable Technical Potential	60	124	187	308	599	973
Technical Potential	92	190	288	474	895	1,381
Energy Savings (% of Baseline)						
Economic Achievable Potential	0.4%	1.0%	1.5%	2.5%	5.4%	9.2%
Achievable Technical Potential	1.4%	2.9%	4.3%	7.3%	14.2%	22.9%
Technical Potential	2.1%	4.4%	6.7%	11.2%	21.3%	32.5%

Figure 5-1 Summary of Conservation Potential as % of Baseline Projection (Annual Energy)

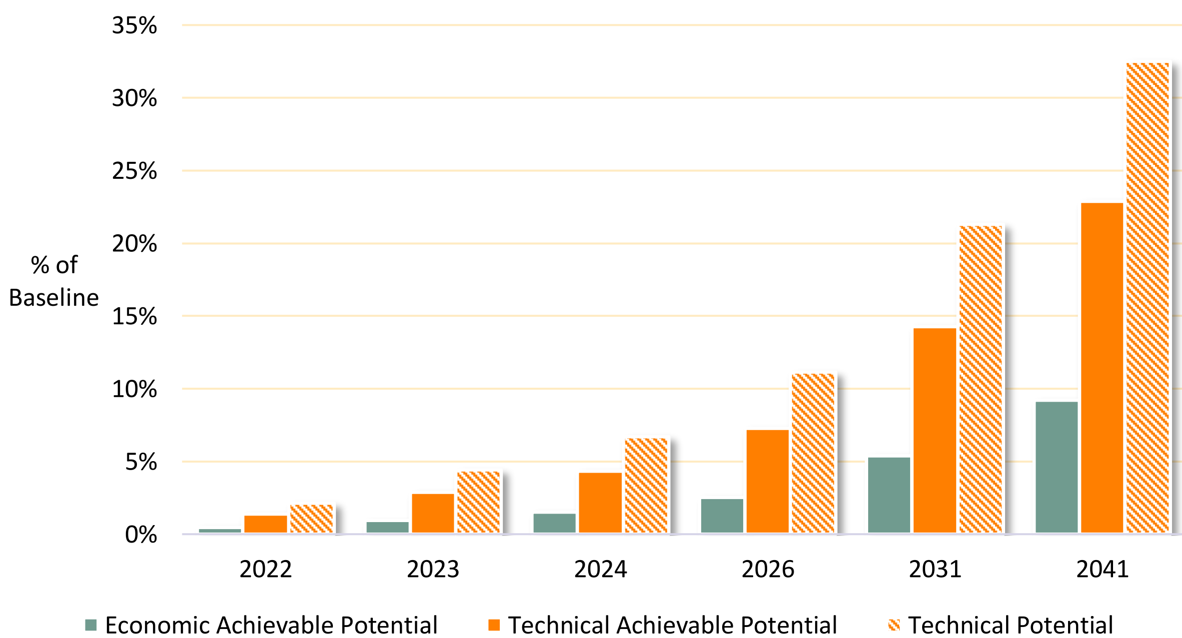


Figure 5-2 Baseline Projection and Conservation Forecast Summary (Annual Energy, GWh)

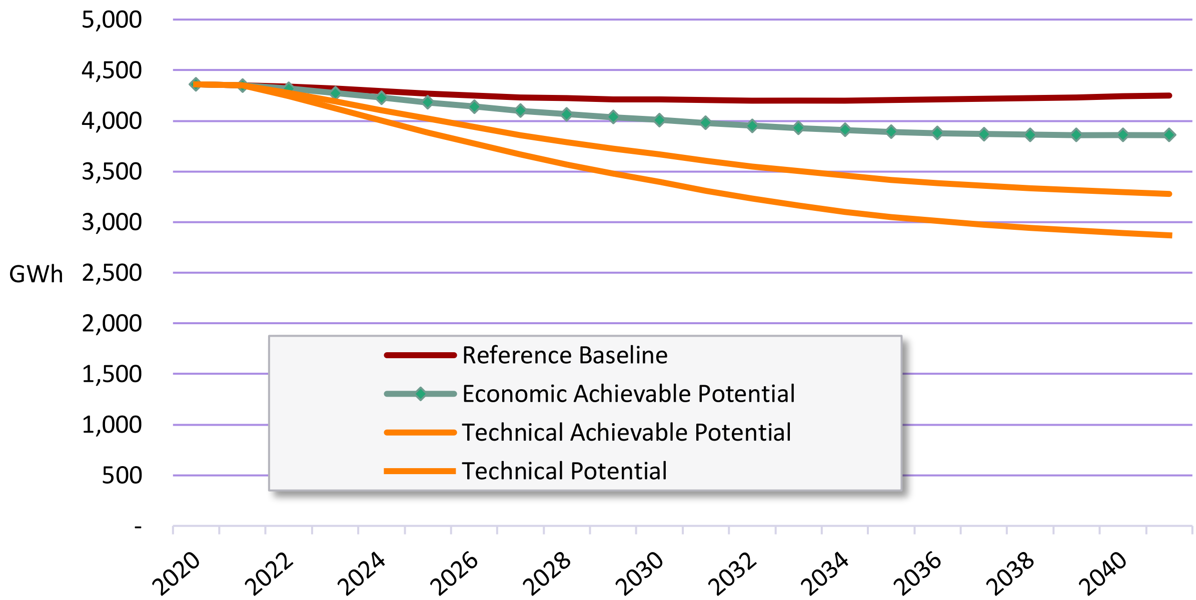


Figure 5-3 and Figure 5-4 show the supply curve of levelized cost of conserved energy ($/MWh) vs. the 10-year cumulative Achievable Technical potential for all sectors in 2031. The Achievable Technical curve represents the universe of measures evaluated for this study in the residential, commercial, industrial, JBLM, street lighting, and distribution models. These levelized costs per MWh represent the TRC cost, including incremental measure cost, programmatic costs, and non-electric benefits or costs associated with each measure.

The dotted blue line represents the cost-effectiveness threshold, determined through a measure-by-measure TRC economic screen utilizing Tacoma Power's adjusted wholesale price forecast to assign monetary value to the energy savings. Savings on the curve to the left of this point reflect the Achievable Economic potential, or the subset of measures that pass the cost-effectiveness screen.

Note that the first tranche of savings up to around 60 GWh have levelized costs that are zero or negative. This is because incremental costs for some measures, particularly LED replacements, are negative when considering the long lifetime and the multiple low-efficiency units that would have otherwise been installed in the baseline scenario.

Figure 5-3 Supply Curve, All Sectors in 2031 (Annual Energy, MWh)

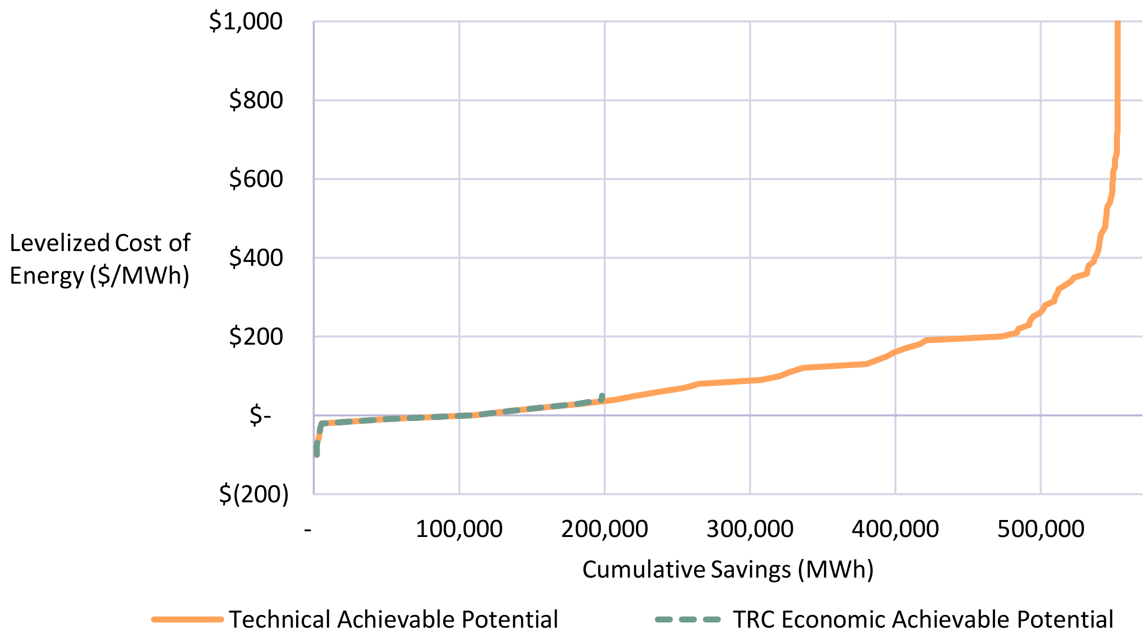
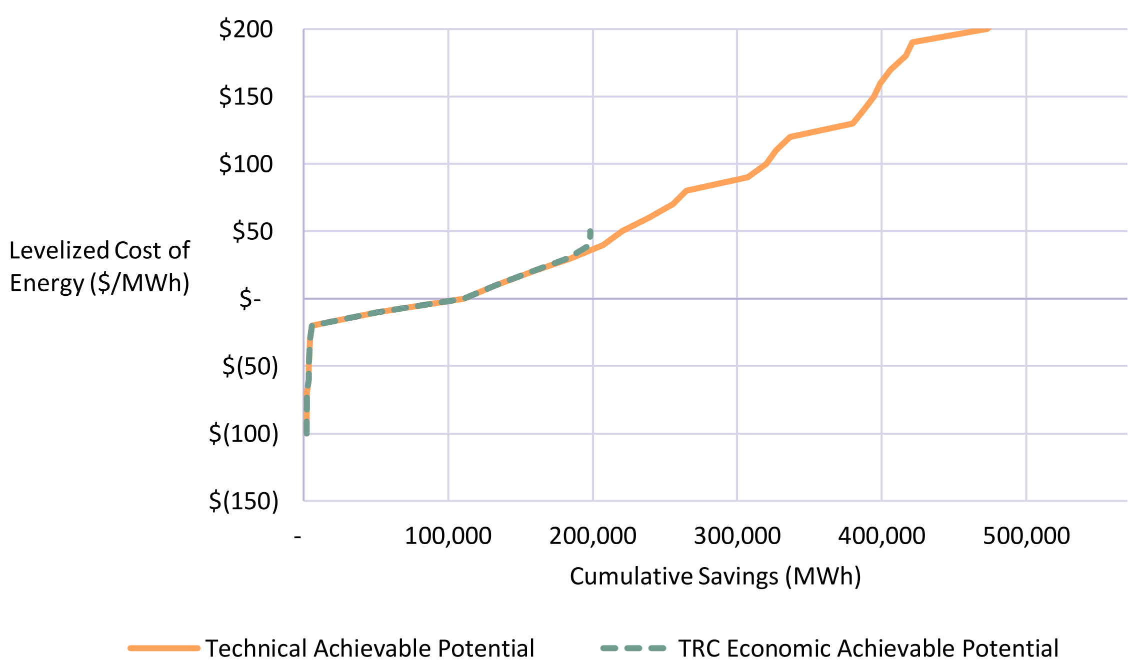


Figure 5-4 Supply Curve, All Sectors in 2031, Limited Axis (Annual Energy, MWh)



Overview of Savings by Sector

Table 5-2 summarizes Achievable Economic potential by market sector for selected years. In 2031, the commercial sector represents the largest share of potential, followed by industrial, then residential. Distribution efficiency, street lighting, and JBLM round out the mix.

Table 5-2 Economic Achievable Potential by Sector, Selected Years (GWh)

	2022	2023	2024	2026	2031	2041
Achievable Economic Potential	19.1	41.5	64.3	106.8	226.2	391.0
Residential	7.9	17.3	24.2	33.4	55.8	90.2
JBLM Residential	0.1	0.2	0.4	0.6	1.2	1.9
Commercial	6.4	14.0	22.8	41.3	94.2	174.9
JBLM Commercial	0.6	1.4	2.2	4.1	9.5	17.4
Industrial	4.0	7.7	13.0	23.8	57.1	89.7
Street Lighting	0.1	0.2	0.3	0.6	1.9	5.2
Distribution Efficiency	0.0	0.7	1.5	2.9	6.6	11.7

Achievable Economic vs. Achievable Technical Potential

Figure 5-5 illustrates the relationship between Achievable Economic Potential and Achievable Technical Potential by sector. Notably, residential sector savings are most affected by the economic screen.

Figure 5-5 TRC Economic vs. Achievable Technical Cumulative Savings (GWh) by Sector

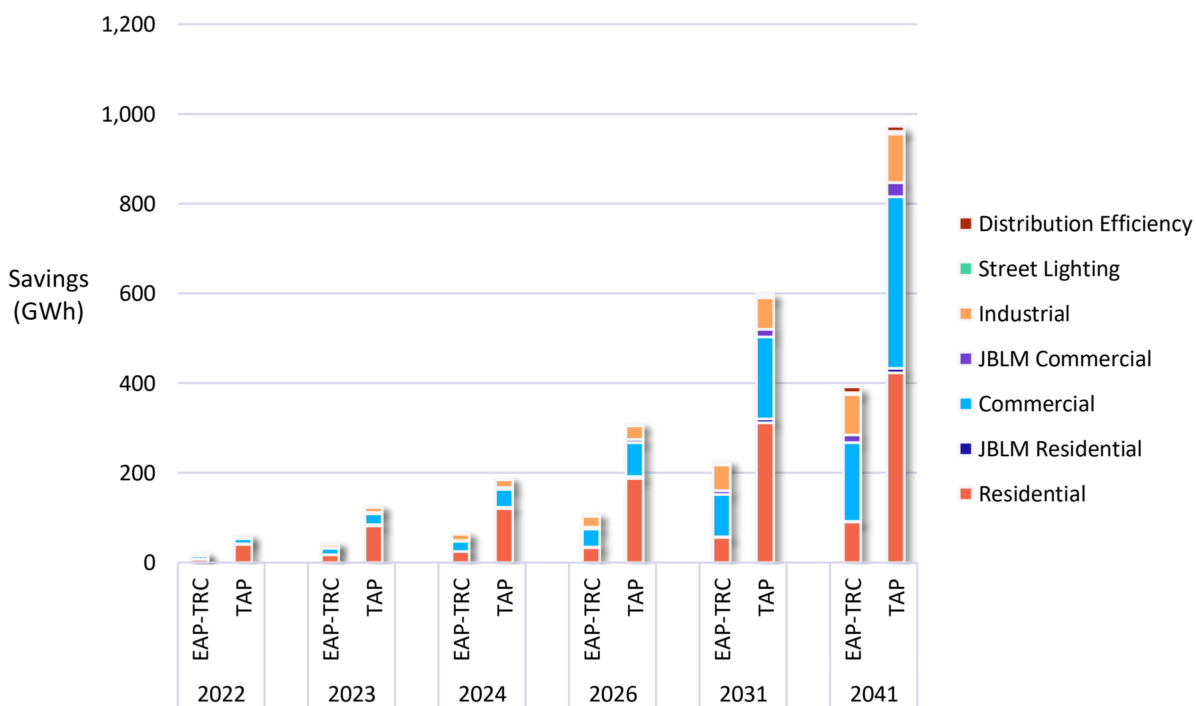
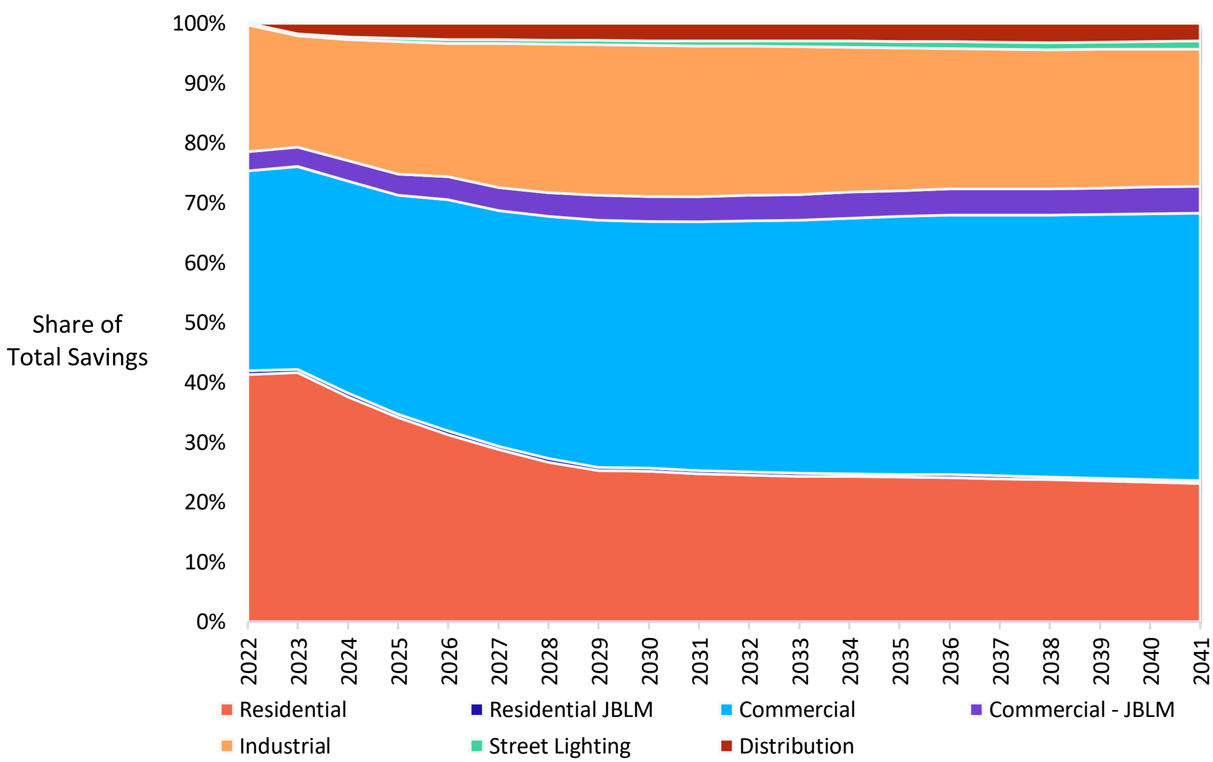


Figure 5-6 shows the cumulative Achievable Economic potential by sector for the full timeframe of the analysis as a percent of total savings. While the precise distribution of savings among sectors shifts slightly over the course of the study, in general residential and commercial potential are well balanced. Since industrial sales customer consumption represents a small percentage of the baseline, potential for this sector makes up a lower percentage of the total. While residential and commercial potential ramps up, industrial potential is mainly retrofit in nature, and is much flatter. This is because process equipment is highly custom and most potential comes from controls modifications or process adjustments rather than high-efficiency equipment upgrades. Additionally, we model retrocommissioning to phase in evenly over the next twenty years. This measure has a maintenance component, and not all existing facilities may be old enough to require the tune-up immediately but will be eligible at some point over the course of the study.

Figure 5-6 Cumulative TRC Achievable Economic Potential by Sector (% of Total)



6

SECTOR-LEVEL CONSERVATION POTENTIAL

The previous section provided a summary of potential for the territory as a whole. In this section, we provide details for each sector.

For each sector, savings are shown in several tables and charts that summarize potential in different ways:

- Total potential by case (Technical, Achievable Technical, and Achievable Economic) and comparison to the reference baseline
- Top measures within the sector, ranked by achievable economic savings over the first 10 years
- The supply curve for the sector, showing 10-year potential savings available at increasing levels of cost ($/MWh)
- Achievable Economic potential broken down by vintage (existing vs. new construction), replacement type (lost opportunity vs. retrofit) and by end use

The final entry for each sector summarizes potential according to its level of risk. Risk was categorized in two ways. The first was by risk level, which rates measures by marginally cost-effective TRC ratios, an RTF workbook sunset within two years, or both. RTF category was also used; Proven measures are assumed to be the least risky, followed by planning. Small savers come third since the lower potential lowers the research and documentation requirements in the RTF work products. Finally, measures with no category or from other sources are grouped.

Residential Potential

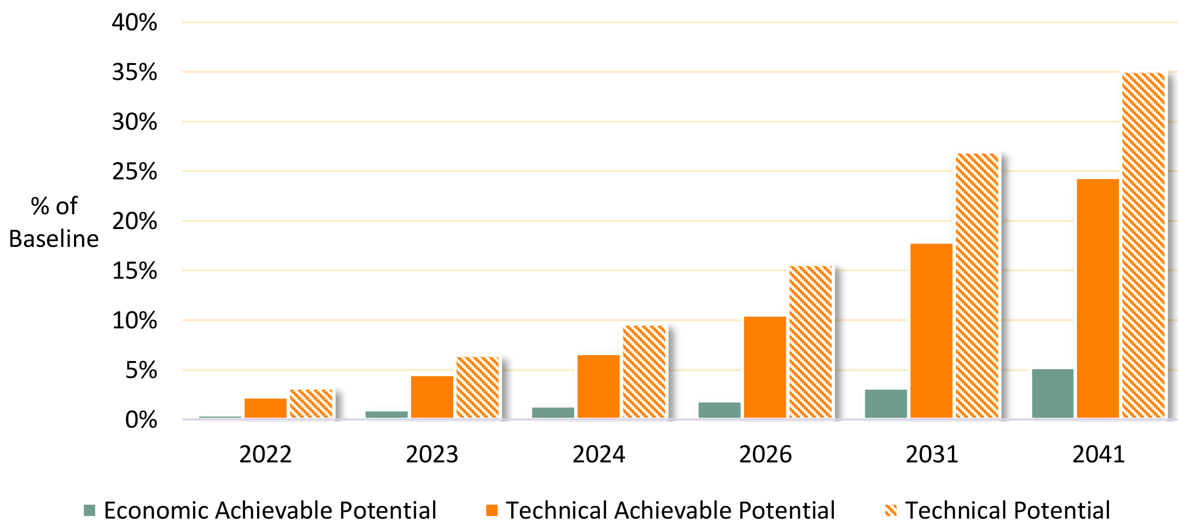
Table 6-1 and Figure 6-1 present estimates for measure-level conservation potential for the residential sector. In 2031, Achievable Economic potential represents slightly over one sixth of Achievable Technical potential. Achievable Economic potential is lower than in the prior study due to the impacts of new general service lighting standards that took effect in 2020 This, along with additional LEDs present in the base-year of the study and throughout the next few years due to RTF market baseline assumptions, lowers lighting potential. In addition, updated RTF workbooks for weatherization and the continued impacts of the strict Washington building code reflected in the newest update to the NEEA Residential Building Stock Assessment have decreased available potential from housing building shell measures.

Photo: Getty Images

Table 6-1 Residential Conservation Potential (Annual Energy, GWh)

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	1,829	1,816	1,804	1,779	1,744	1,735
Cumulative Savings (GWh)						
Economic Achievable Potential	8	17	24	33	56	90
Achievable Technical Potential	41	82	120	187	312	423
Technical Potential	58	117	174	278	470	608
Energy Savings (% of Baseline)						
Economic Achievable Potential	0.4%	0.9%	1.3%	1.9%	3.2%	5.2%
Achievable Technical Potential	2.2%	4.5%	6.7%	10.5%	17.9%	24.4%
Technical Potential	3.2%	6.5%	9.6%	15.6%	27.0%	35.1%

Figure 6-1 Residential Savings as a % of the Baseline Projection (Annual Energy)



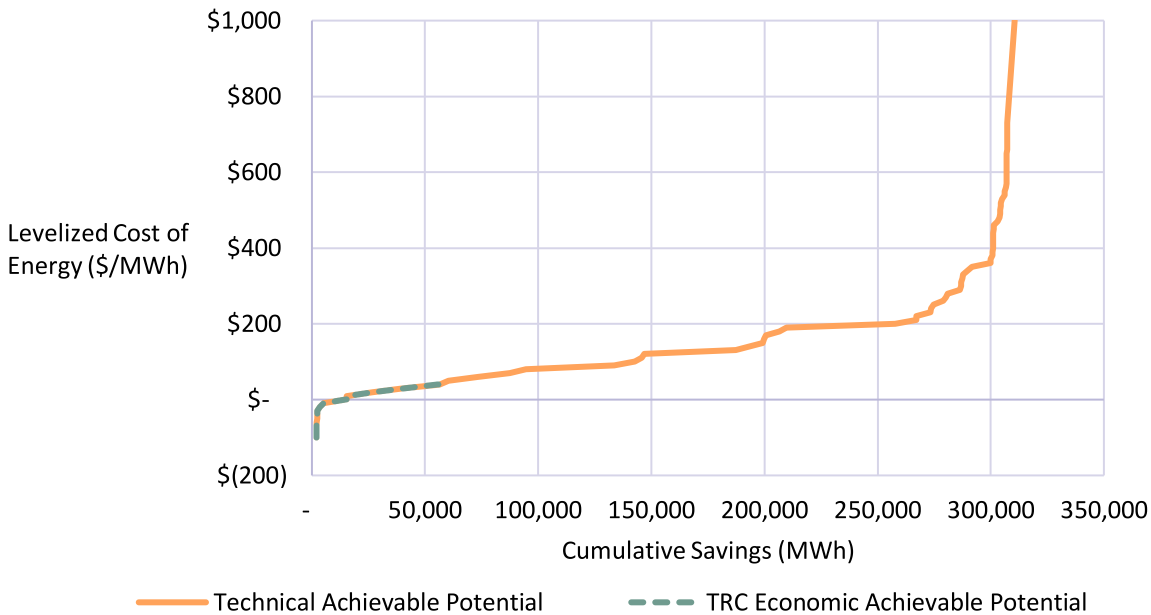


Figure 6-3 present the supply curve of levelized cost per MWh vs. cumulative Achievable Technical potential for the residential sector in 2031. Weatherization measures comprise the majority of cost-effective savings. HVAC and water heating equipment replacements were found not to be cost-effective under the TRC test due to a combination of lower savings and high equipment costs.

Figure 6-2 Supply Curve, Residential Sector in 2031 (Annual Energy, MWh)

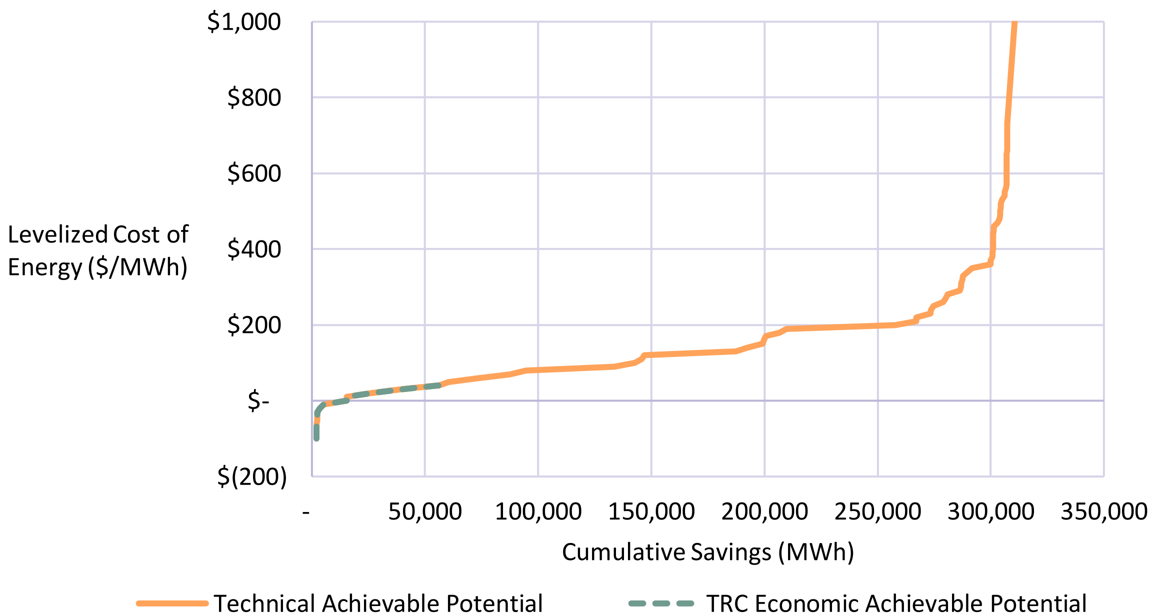


Figure 6-3 Supply Curve, Residential Sector in 2031, Limited Axis (Annual Energy, MWh)

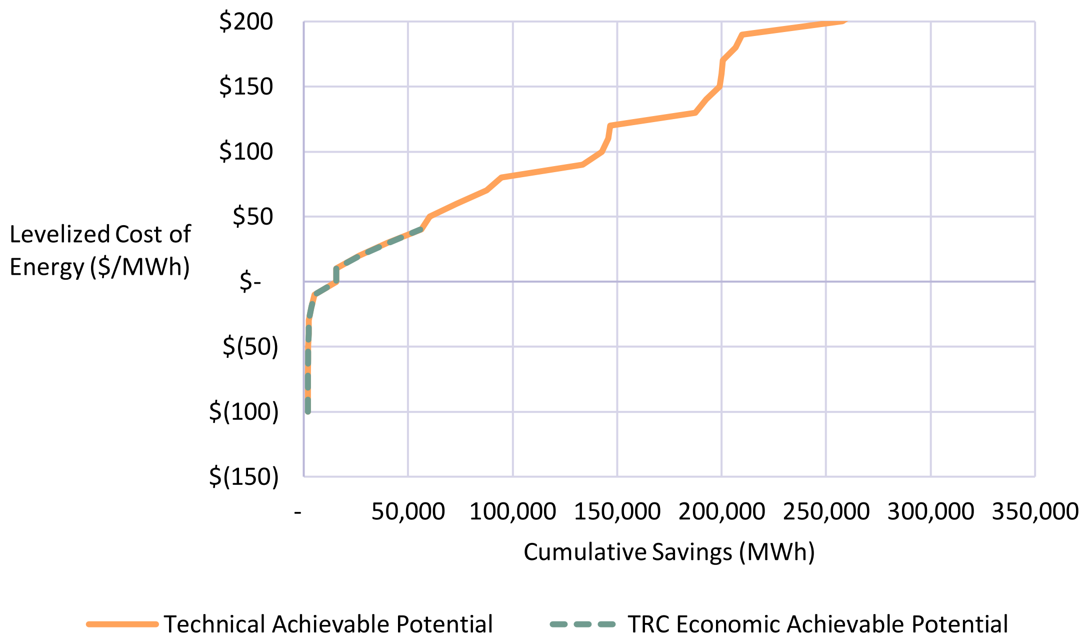


Table 6-2 identifies the top 20 residential measures by cumulative 2031 Achievable Economic potential. Consistent with the previous study, the top two measures are weatherization measures – installation of new wall cavity insulation and ducting repair and sealing. Combined, weatherization measures provide 51.2% of cost-effective savings in 2031. As detailed above, LED lamp potential is lower than in the past, due to higher LED saturations in the baseline and the implementation of EISA 2007's second phase in the first year of potential. With the decline of lighting, residential electronics such as set-top boxes/DVRs and TVs have climbed their way into the top 20.

Table 6-2 Residential Top Measures in 2031 (Annual Energy, MWh)

Rank	Measure / Technology	2031 Achievable Economic Cumulative Savings (MWh)	% of Total
1	Insulation - Wall Cavity Installation	7,338	13.2%
2	Ducting - Repair and Sealing	6,293	11.3%
3	Building Shell - Whole-Home Aerosol Sealing	5,846	10.5%
4	Insulation - Ceiling Installation	5,688	10.2%
5	Set-top Boxes/DVRs	4,205	7.5%
6	Clothes Washer - ENERGY STAR (8.0)	3,589	6.4%
7	Connected Thermostat - Line-Voltage	3,369	6.0%
8	TVs	3,241	5.8%
9	Water Heater - Drainwater Heat Recovery	2,365	4.2%
10	Linear Lighting	2,240	4.0%
11	Insulation - Wall Cavity Installation - LI	1,791	3.2%
12	General Service Lighting	1,668	3.0%
13	Printer/Fax/Copier	1,585	2.8%
14	Insulation - Ceiling Installation - LI	1,469	2.6%
15	Exempted Lighting	1,357	2.4%
16	Personal Computers	963	1.7%
17	Hot Tub/Spa	905	1.6%
18	Water Heater - Pipe Insulation	540	1.0%
19	Laptops	261	0.5%
20	Room AC - Recycling	212	0.4%
	Total	**54,923**	**98.5%**
	Total Savings in 2031	**55,756**	**100.0%**

Figure 6-4 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Interior lighting savings account for a substantial portion of the savings throughout the forecast horizon. This share remains fairly steady, as the potential begins after the major impacts of EISA phase two and the baseline uptake of LEDs are already present. Heating represents the largest portion of savings potential early on, though its proportion steadily wanes through 2041 as the potential for electronics increases. Space heating potential comes mostly from weatherization measures, such as wall cavity insulation, duct repair and sealing, and whole-home aerosol sealing.

Figure 6-4 Residential Achievable Economic Case – Cumulative Savings by End Use (% of Total and Annual MWh)

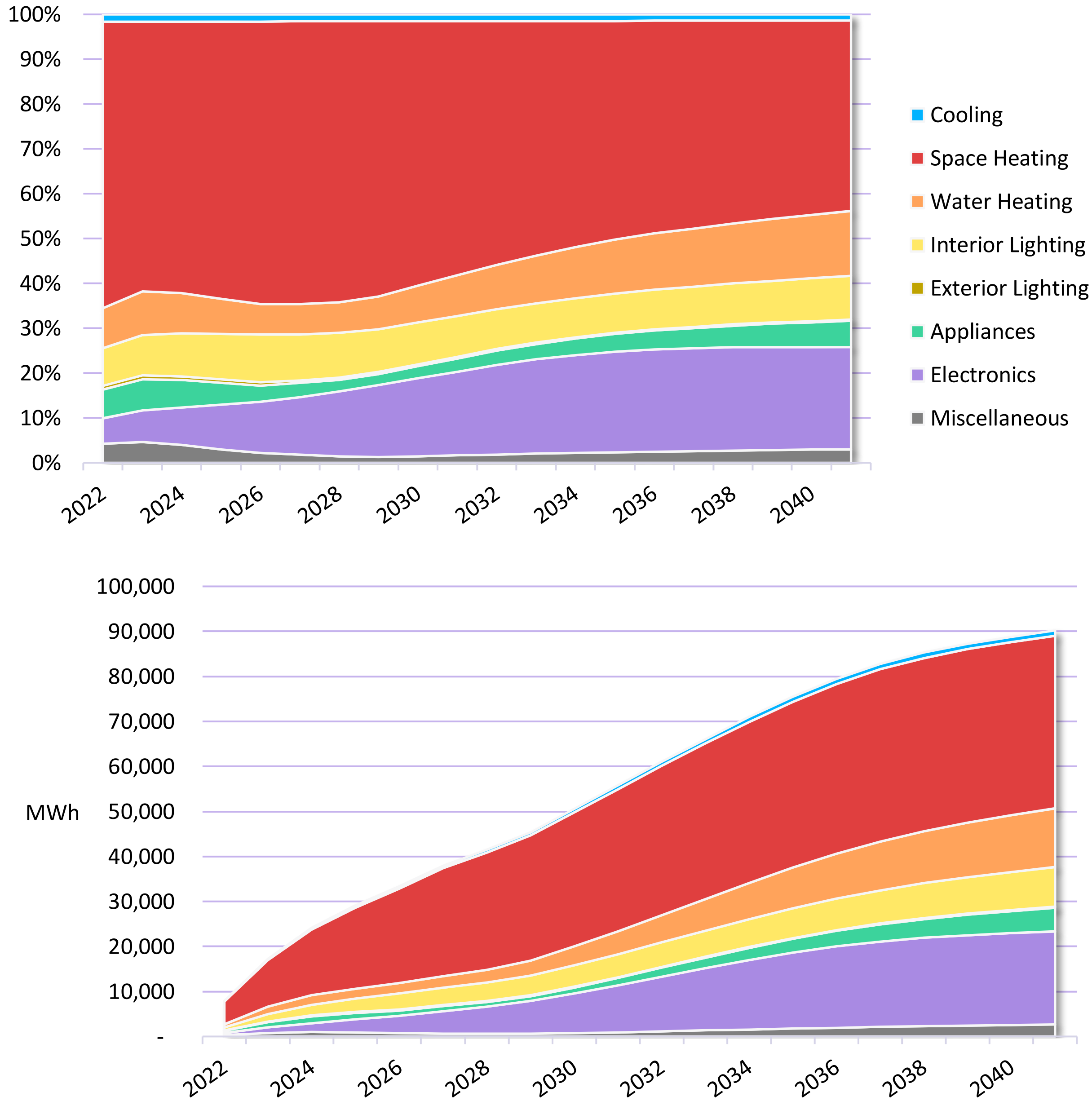


Table 6-3,

Segment	Vintage	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Single Family	Existing	4,313	8,900	13,712	23,915	44,996	69,369
	New	56	133	226	468	1,249	2,584
Single Family 2-4 units	Existing	161	349	560	1,054	2,426	4,501
	New	6	14	26	56	182	575
Low-Rise Multifamily	Existing	135	324	558	1,138	2,535	4,771
	New	33	79	136	293	935	2,799
High-Rise Multifamily	Existing	21	50	86	173	379	708
	New	5	12	20	43	150	464
Manufactured Home	Existing	283	577	882	1,530	2,860	4,320
	New	2	4	7	15	44	126
Total Residential	**Existing**	**4,913**	**10,200**	**15,797**	**27,810**	**53,196**	**83,669**
	New	**101**	**242**	**415**	**875**	**2,560**	**6,547**

Table 6-4, and

Segment	Replacement Type	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Single Family	Lost Opportunity	609	1,570	2,806	5,958	14,769	30,725
	Retrofit	3,760	7,464	11,132	18,424	31,476	41,228
Single Family 2-4 units	Lost Opportunity	45	117	214	470	1,254	2,844
	Retrofit	122	246	372	640	1,354	2,232
Low-Rise Multifamily	Lost Opportunity	120	309	555	1,202	3,113	7,167
	Retrofit	47	93	139	229	358	403
High-Rise Multifamily	Lost Opportunity	19	48	86	182	477	1,113
	Retrofit	7	14	21	34	53	58
Manufactured Home	Lost Opportunity	26	70	127	284	732	1,528
	Retrofit	258	512	762	1,261	2,172	2,918
Total Residential	**Lost Opportunity**	**819**	**2,114**	**3,787**	**8,097**	**20,344**	**43,378**
	Retrofit	**4,195**	**8,328**	**12,424**	**20,588**	**35,412**	**46,839**

Table 6-5 summarize Residential sector savings by vintage, replacement type, and end use respectively.

Table 6-3 Residential Achievable Economic Potential by Vintage, Select Years

Segment	Vintage	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Single Family	Existing	4,313	8,900	13,712	23,915	44,996	69,369
	New	56	133	226	468	1,249	2,584
Single Family 2-4 units	Existing	161	349	560	1,054	2,426	4,501
	New	6	14	26	56	182	575
Low-Rise Multifamily	Existing	135	324	558	1,138	2,535	4,771
	New	33	79	136	293	935	2,799
High-Rise Multifamily	Existing	21	50	86	173	379	708
	New	5	12	20	43	150	464
Manufactured Home	Existing	283	577	882	1,530	2,860	4,320
	New	2	4	7	15	44	126
Total Residential	**Existing**	**4,913**	**10,200**	**15,797**	**27,810**	**53,196**	**83,669**
	New	**101**	**242**	**415**	**875**	**2,560**	**6,547**

Table 6-4 Residential Achievable Economic Potential by Replacement Type, Select Years

Segment	Replacement Type	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Single Family	Lost Opportunity	609	1,570	2,806	5,958	14,769	30,725
	Retrofit	3,760	7,464	11,132	18,424	31,476	41,228
Single Family 2-4 units	Lost Opportunity	45	117	214	470	1,254	2,844
	Retrofit	122	246	372	640	1,354	2,232
Low-Rise Multifamily	Lost Opportunity	120	309	555	1,202	3,113	7,167
	Retrofit	47	93	139	229	358	403
High-Rise Multifamily	Lost Opportunity	19	48	86	182	477	1,113
	Retrofit	7	14	21	34	53	58
Manufactured Home	Lost Opportunity	26	70	127	284	732	1,528
	Retrofit	258	512	762	1,261	2,172	2,918
Total Residential	**Lost Opportunity**	**819**	**2,114**	**3,787**	**8,097**	**20,344**	**43,378**
	Retrofit	**4,195**	**8,328**	**12,424**	**20,588**	**35,412**	**46,839**

Table 6-5 Residential Achievable Economic Potential by End Use, 2031

End Use	Single Family	Single Family 2-4 units	Low-Rise Multifamily	High-Rise Multifamily	Manufactured Home	Total Residential
Cooling	777	41	0	0	16	834
Space Heating	28,557	1,128	0	0	1,905	31,590
Water Heating	3,604	321	715	108	339	5,087
Interior Lighting	3,685	266	799	125	186	5,063
Exterior Lighting	147	11	32	5	6	202
Appliances	1,135	104	245	38	138	1,659
Electronics	7,472	661	1,678	254	315	10,379
Miscellaneous	867	77	0	0	0	943
Total	**46,244**	**2,608**	**3,470**	**530**	**2,904**	**55,756**

Table 6-6 summarizes the risk level of Achievable Economic potential in 2031 for the residential sector. Most of the savings from RTF measures is in measures with a sunset date before 2022. Few cost-effective measures have a TRC < 1.2 however.

Table 6-6 Residential Economic Achievable Potential by Risk and RTF Category, 2031

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	22,579	3,369	3,596	19,278	48,822
1 - TRC B/C Ratio <1.2	3,674	0	0	3,260	6,934
2 - RTF Sunset before 2022	0	0	0	0	0
3 – Higher Risk (combined)	0	0	0	0	0
Total	**26,253**	**3,369**	**3,596**	**22,538**	**55,756**

JBLM Residential Potential

The Joint-Base Lewis-McChord (JBLM) is one of the largest users of energy in Tacoma Power's service territory, and hosts both army and air force operations, personnel, and their families. The residential facilities at JBLM consist mainly of single family and low-rise multifamily homes. The properties are managed by Lincoln Military Housing. For this study, AEG assumed that efficient homes will be built and maintained, similar to the previous study. As a result, many existing buildings have undergone substantial energy efficiency retrofits, and the accelerated replacement of older, inefficient homes has increased the amount of newer, more efficient homes at JBLM. Accordingly, overall potential in the JBLM residential sector is significantly lower than in other parts of the service territory.

Table 6-7 and

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	43.8	43.2	42.6	41.5	39.3	37.5
Cumulative Savings (GWh)						
Achievable Economic Potential	0.1	0.2	0.4	0.6	1.2	1.9
Achievable Technical Potential	1.1	2.2	3.2	5.0	8.0	10.0
Technical Potential	1.5	3.0	4.4	7.1	11.4	13.9
Energy Savings (% of Baseline)						
Achievable Economic Potential	0.2%	0.5%	0.8%	1.5%	3.1%	5.2%
Achievable Technical Potential	2.5%	5.0%	7.4%	12.1%	20.3%	26.8%
Technical Potential	3.4%	6.9%	10.3%	17.0%	29.1%	37.1%

Figure 6-5 present estimates for measure-level conservation potential for the JBLM residential sector.

Table 6-7 JBLM Residential Conservation Potential (Annual Energy, GWh)

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	43.8	43.2	42.6	41.5	39.3	37.5
Cumulative Savings (GWh)						
Achievable Economic Potential	0.1	0.2	0.4	0.6	1.2	1.9
Achievable Technical Potential	1.1	2.2	3.2	5.0	8.0	10.0
Technical Potential	1.5	3.0	4.4	7.1	11.4	13.9
Energy Savings (% of Baseline)						
Achievable Economic Potential	0.2%	0.5%	0.8%	1.5%	3.1%	5.2%
Achievable Technical Potential	2.5%	5.0%	7.4%	12.1%	20.3%	26.8%
Technical Potential	3.4%	6.9%	10.3%	17.0%	29.1%	37.1%

Figure 6-5 JBLM Residential Savings as a % of the Baseline Projection (Annual Energy)

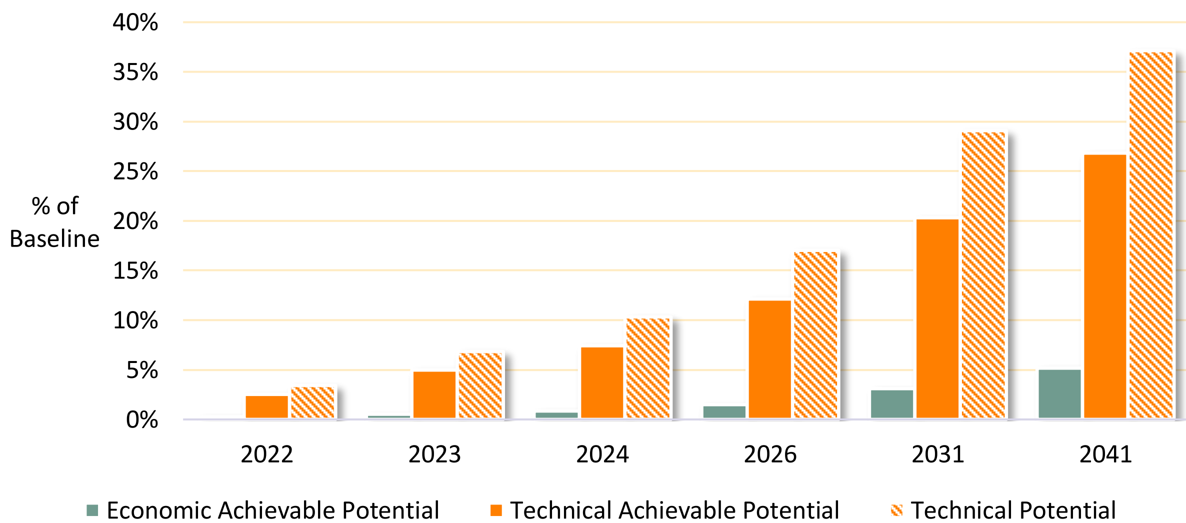


Figure 6-6 and Figure 6-7 show the supply curve of levelized cost per MWh saved vs. cumulative Achievable Technical potential for the JBLM residential sector in 2031. Similar to the civilian residential sector, weatherization measures comprise the majority of cost-effective savings. Compared to the civilian residential sector, Achievable Economic savings are a lower portion of both Achievable Technical potential and the baseline overall. This is due to the significant progress that JBLM and the property management companies have made in retrofitting existing homes and constructing efficient homes under their contract with JBLM. This reflects a higher efficiency baseline.

Figure 6-6 Supply Curve, JBLM Residential Sector in 2031 (Annual Energy, MWh)

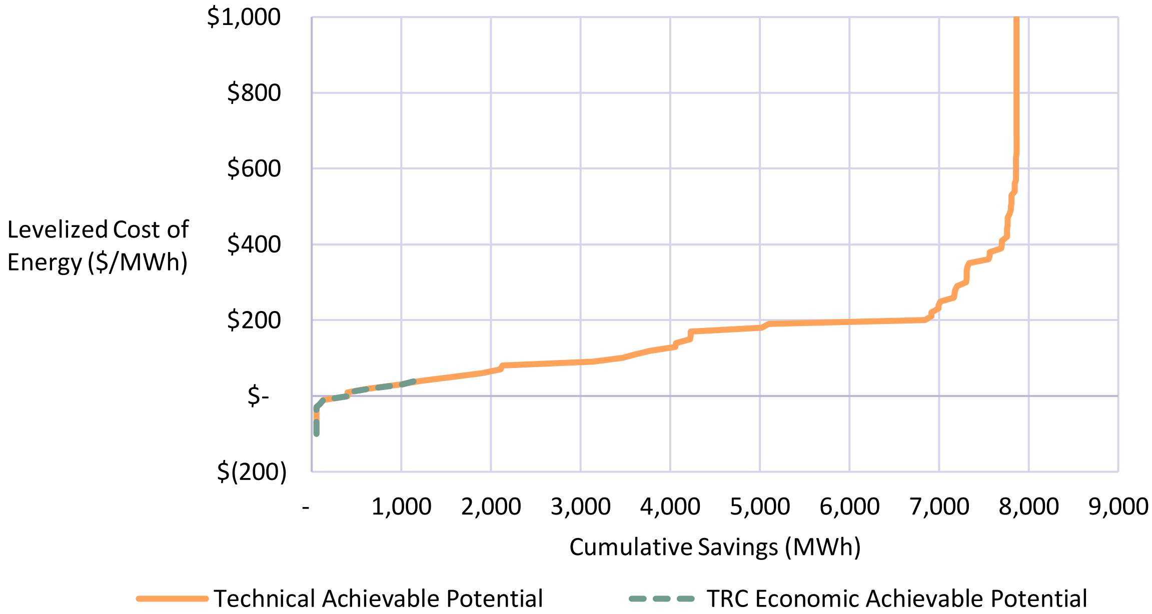


Figure 6-7 Supply Curve, JBLM Residential Sector in 2031, Limited Axis (Annual Energy, MWh)

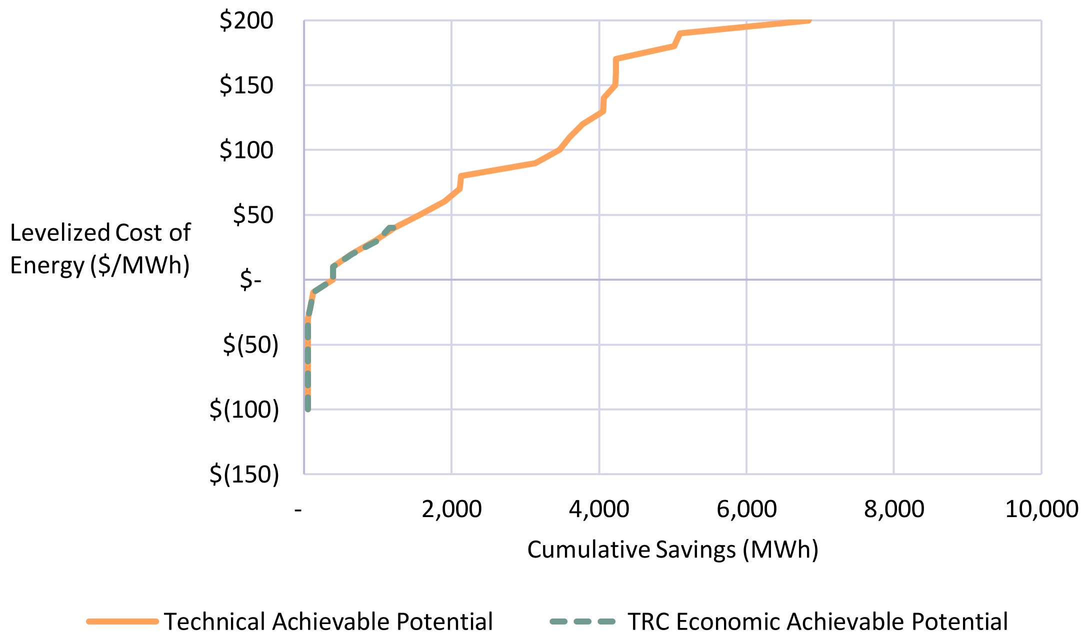


Table 6-8 identifies the top JBLM residential measures in 2031. The list of top measures is similar in most respects to the civilian sector, though some measures have less savings due to differences in presence of equipment between the base and civilian homes.

Table 6-8 JBLM Residential Top Measures in 2031 (Annual Energy, MWh)

Rank	Measure / Technology	2031 Achievable Economic Cumulative Savings (MWh)	% of Total
1	Insulation - Wall Cavity Installation	357	29.5%
2	Insulation - Ceiling Installation	249	20.5%
3	Set-top Boxes/DVRs	112	9.2%
4	Clothes Washer - ENERGY STAR (8.0)	83	6.9%
5	TVs	83	6.9%
6	Connected Thermostat - Line-Voltage	76	6.3%
7	Linear Lighting	53	4.4%
8	General Service Lighting	42	3.5%
9	Printer/Fax/Copier	39	3.2%
10	Exempted Lighting	37	3.1%
11	Hot Tub/Spa	26	2.2%
12	Personal Computers	25	2.1%
13	Water Heater - Pipe Insulation	11	0.9%
14	Laptops	7	0.6%
15	Monitor	3	0.3%
16	Air Purifier	3	0.2%
17	Dehumidifier Recycling	1	0.1%
18	Room AC - Recycling	1	0.1%
19	Dehumidifier	0.33	0.03%
	Total	1,210	100.0%
	Total Savings in 2031	1,210	100.0%

Figure 6-8 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. The distribution of savings across end uses is similar to the civilian sector. Though in the past the more efficient lighting stock on the base caused its lighting savings to be less as a portion of overall savings compared to the civilian sector, the civilian market has transformed to the point that the differences are now minimal.

Figure 6-8 JBLM Residential Achievable Economic Case – Cumulative Savings by End Use (% of Total and Annual MWh)

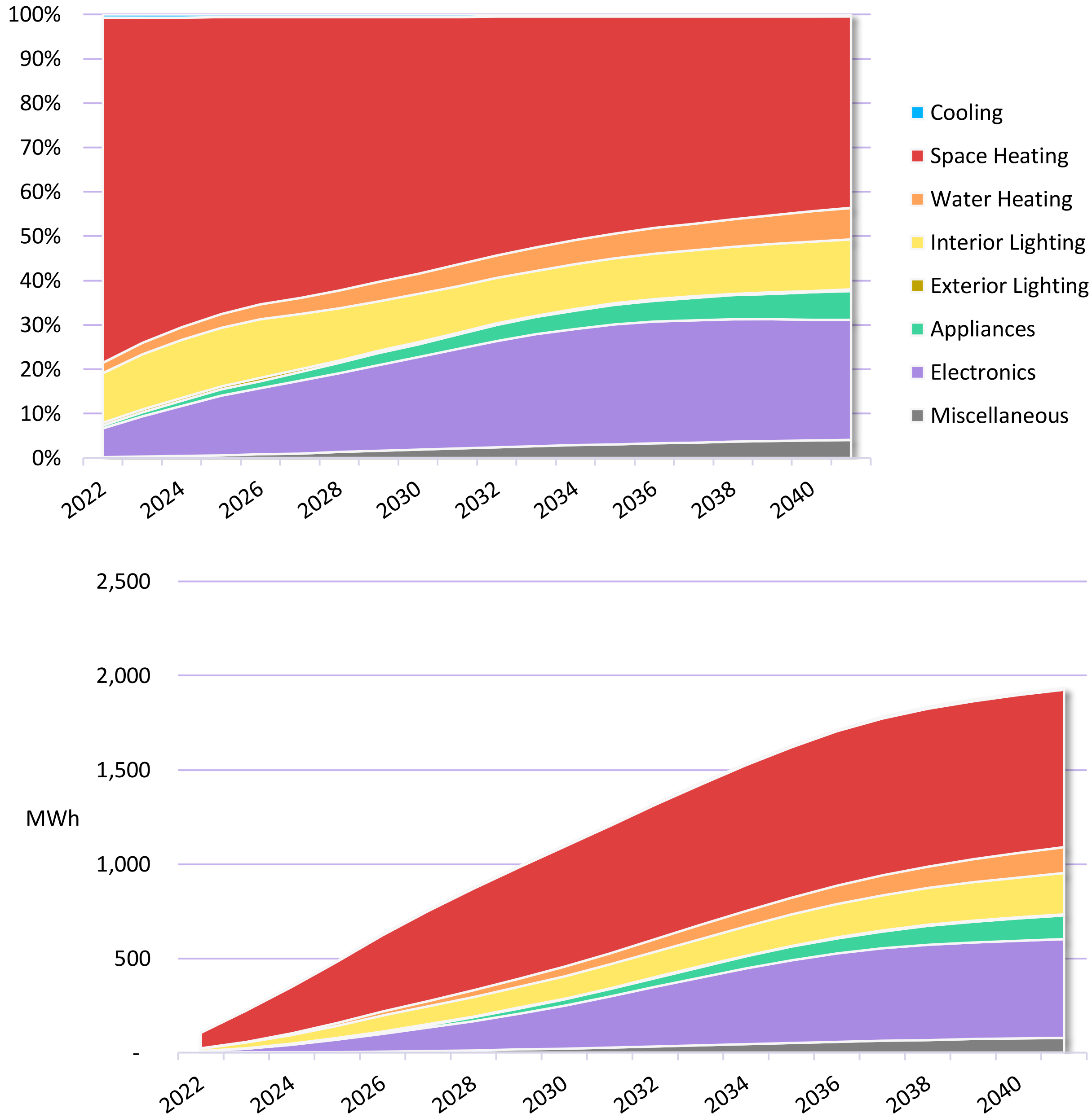


Table 6-9,

Table 6-10, and

Table 6-11 summarize JBLM Residential sector savings by vintage, replacement type, and end use respectively.

Table 6-9 JBLM Residential Achievable Economic Potential by Vintage, Select Years

Segment	Vintage	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Single Family	Existing	97	203	318	564	1,082	1,715
	New	1	1	2	4	13	37
Multifamily	Existing	9	20	32	59	112	171
	New	0	0	1	1	4	11
Total JBLM Residential	**Existing**	**106**	**224**	**350**	**623**	**1,193**	**1,886**
	New	**1**	**2**	**3**	**6**	**16**	**48**

Table 6-10 JBLM Residential Achievable Economic Potential by Replacement Type, Select Years

Segment	Replacement Type	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Single Family	Lost Opportunity	19	49	88	186	458	961
	Retrofit	78	156	232	383	636	792
Multifamily	Lost Opportunity	2	6	11	23	57	117
	Retrofit	7	15	22	36	58	65
Total JBLM Residential	**Lost Opportunity**	**21**	**55**	**98**	**210**	**515**	**1,077**
	Retrofit	**86**	**170**	**254**	**419**	**695**	**857**

Table 6-11 JBLM Residential Achievable Economic Potential by End Use, 2031

End Use	Single Family	Multifamily	Total JBLM Residential
Cooling	7	0	7
Space Heating	625	51	676
Water Heating	47	13	59
Interior Lighting	114	13	127
Exterior Lighting	5	1	5
Appliances	35	4	39
Electronics	237	33	270
Miscellaneous	26	0	26
Total	**1,095**	**115**	**1,210**

Table 6-12 shows the risk level of Achievable Economic potential in 2031 for the JBLM residential sector.

Table 6-12 JBLM Residential Economic Achievable Potential by Risk and RTF Category, 2031

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	554	76	94	325	1,048
1 - TRC B/C Ratio <1.2	135	0	0	27	161
2 - RTF Sunset before 2022	0	0	0	0	0
3 – Higher Risk (combined)	0	0	0	0	0
Total	**689**	**76**	**94**	**351**	**1,210**

Commercial Potential

Table 6-13 and Figure 6-9 present the annual energy savings estimates for the three levels of conservation potential for the commercial sector. Compared to the residential sector, Achievable Economic potential is larger as a percent of the baseline. This is because lighting, an end use with high conservation potential, is a larger percent of baseline. The main reason is that the lighting hours of use in commercial buildings are significantly higher than residential dwellings (approximately three to four times higher on average).

Photo: Getty Images

Table 6-13 Conservation Potential for the Commercial Sector (Energy Savings)

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	1,226	1,219	1,209	1,185	1,163	1,173
Cumulative Savings (GWh)						
Achievable Economic Potential	6	14	23	41	94	175
Achievable Technical Potential	12	25	40	74	183	383
Technical Potential	22	45	71	122	267	523
Energy Savings (% of Baseline)						
Achievable Economic Potential	0.5%	1.2%	1.9%	3.5%	8.1%	14.9%
Achievable Technical Potential	0.9%	2.1%	3.3%	6.3%	15.7%	32.6%
Technical Potential	1.8%	3.7%	5.9%	10.3%	22.9%	44.6%

Figure 6-9 Commercial Savings as a % of the Baseline Projection (Annual Energy)

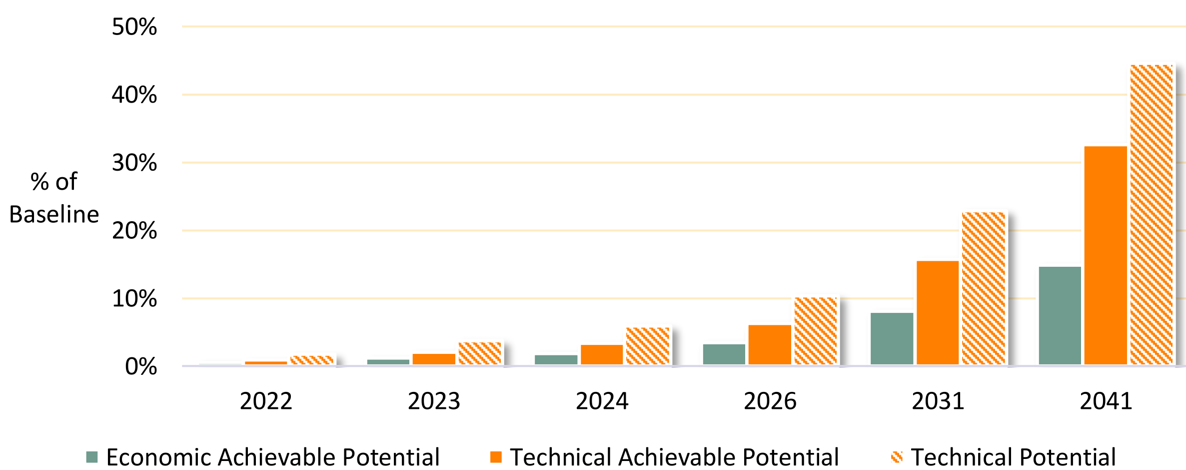


Figure 6-10 and Figure 6-11 show the supply curve of levelized cost per MWh vs. cumulative Achievable Technical potential for the commercial sector in 2031. LED lighting comprises over 50% of cost-effective savings. Due to recent reductions in fixture costs, the price of linear LED panels has been significantly reduced.

This has resulted in LED panels passing the TRC economic screen and contributing highly to the overall potential. In addition, built in control systems bundled with the LED installation increase savings, offsetting the impacts of the market's transformation to LEDs. Strategic energy management in large, targeted buildings results in sizeable Economic Achievable potential. Additionally, HVAC retrofit measures and water heating equipment were also found to be sources of cost-effective potential. Overall, Achievable Economic potential in the commercial sector represents a higher percentage of Achievable Technical potential when compared to residential savings.

Figure 6-10 Supply Curve, Commercial Sector in 2031 (Annual Energy, MWh)

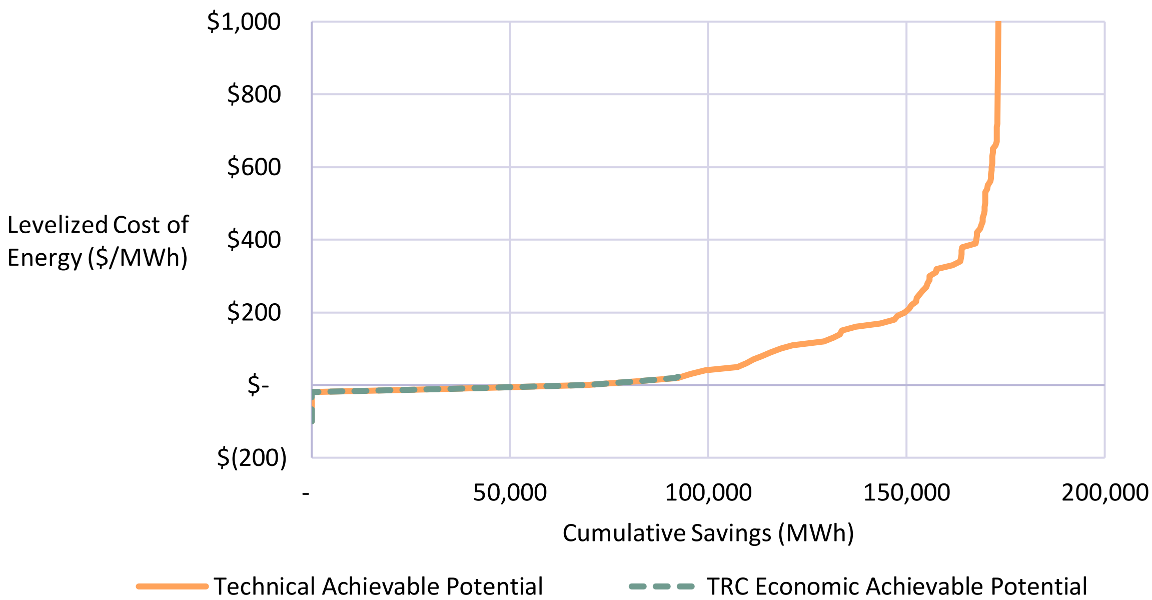


Figure 6-11 Supply Curve, Commercial Sector in 2031, Limited Axis (Annual Energy, MWh)

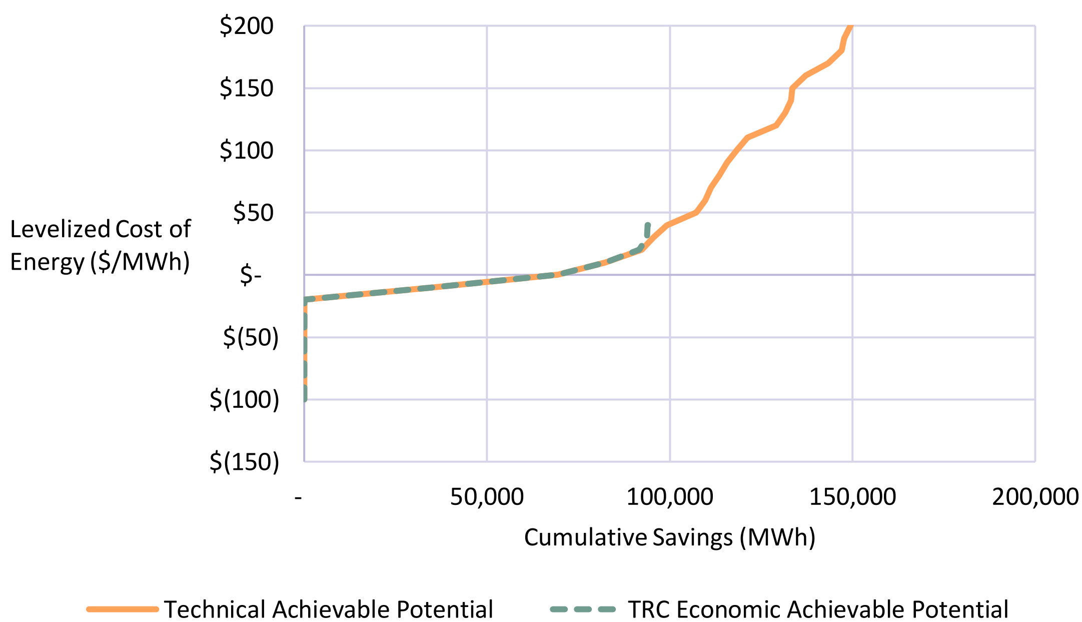


Table 6-14 identifies the top 20 commercial-sector measures in 2031. Three out of four top measures, comprising 54% of total savings, are LED lighting replacements. For Linear lighting and High-Bay replacements, most of these installations (roughly 70% of the savings) include bundled controls that enhance the savings at the time of install. Other measures showing significant potential include high use office servers, HVAC equipment, strategic energy management, and commercial refrigeration equipment.

Table 6-14 Commercial Sector Top Measures in 2031 (Annual Energy, MWh)

Rank	Measure / Technology	2031 Economic Achievable Cumulative Savings (MWh)	% of Total
1	Linear Lighting	34,609	36.8%
2	Area Lighting	11,845	12.6%
3	High-Bay Lighting	7,603	8.1%
4	Refrigeration - Variable Speed Compressor	6,491	6.9%
5	Server	5,187	5.5%
6	Chiller - Variable Flow Chilled Water Pump	3,094	3.3%
7	Strategic Energy Management	2,922	3.1%
8	Water-Cooled Chiller	2,242	2.4%
9	Grocery - Display Case - Anti-Fogging Film	2,171	2.3%
10	Ventilation - Permanent Magnet Synchronous Fan Motor	1,803	1.9%
11	HVAC - Duct Repair and Sealing	1,698	1.8%
12	Grocery - On-Demand Overwrappers	1,317	1.4%
13	Server Room Temperature Set back	1,016	1.1%
14	Ventilation - Nighttime Air Purge	1,012	1.1%
15	Insulation - Wall Cavity	1,001	1.1%
16	Icemaker	980	1.0%
17	Windows - Secondary Glazing Systems	873	0.9%
18	Chiller - Chilled Water Reset	756	0.8%
19	Ventilation	729	0.8%
20	Data Center - Best Practice Measures	713	0.8%
	Total	**88,061**	**93.5%**
	Total Savings in 2031	**94,171**	**100.0%**

Figure 6-12 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Lighting savings from interior and exterior applications account for most of the savings throughout the forecast horizon. This sustained savings is possible due to continuous projected improvements in LED efficacy and the previously mentioned bundled controls. HVAC savings are around 20% of the total potential throughout the forecast, with heating being the smallest portion of those savings. Commercial spaces tend to be heated by natural gas much more commonly than electricity, limiting the available potential in this end use.

Figure 6-12 Commercial Achievable Economic Case – Cumulative Savings by End Use (% of Total and Annual MWh)

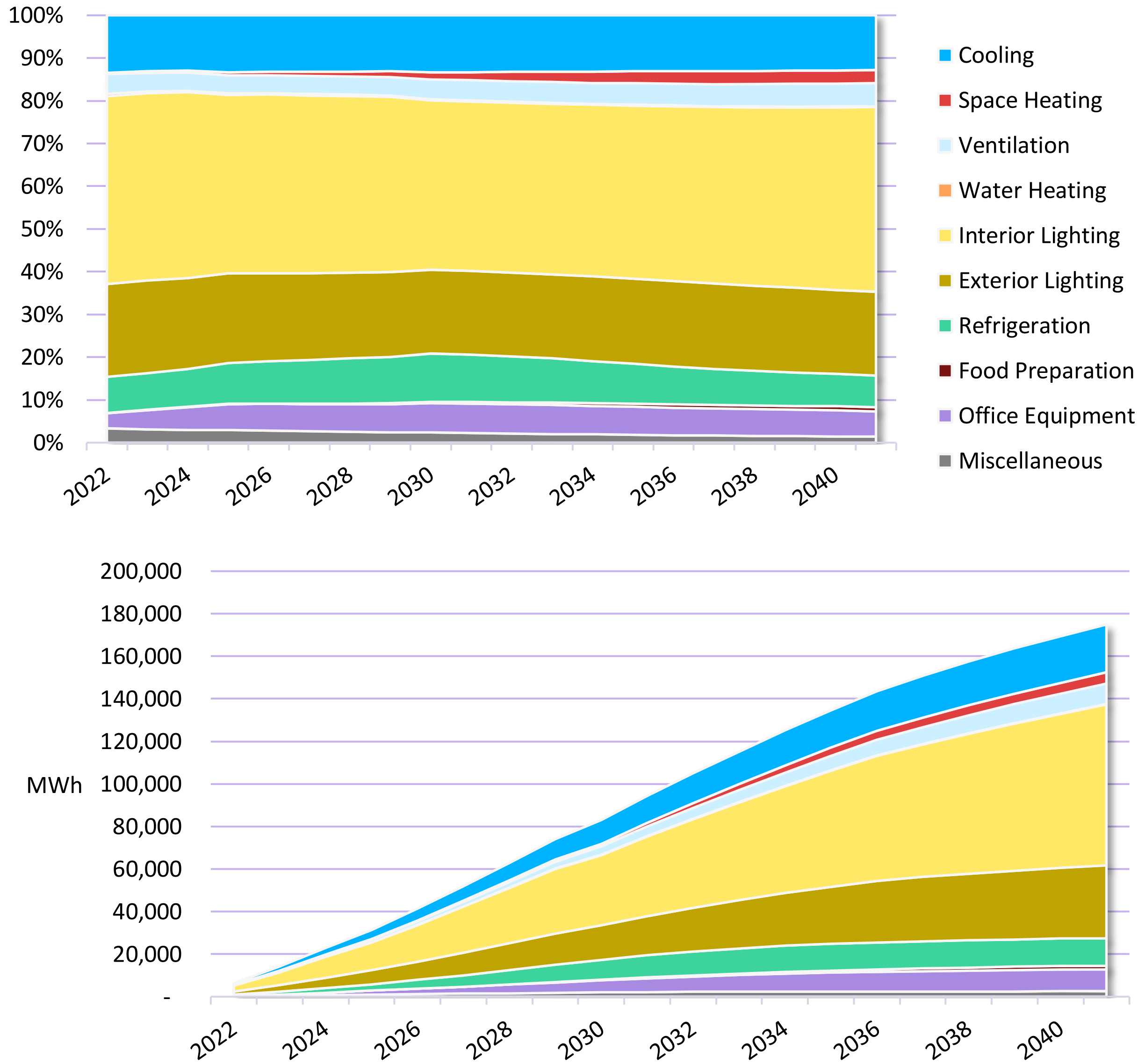


Table 6-15,

Table 6-16, and

Table 6-17 show commercial sector savings by vintage, replacement type, and end use respectively. Most RTF measures have a sunset date before 2020. Very few cost-effective measures have a TRC benefit-to-cost ratio of less than 1.2. The None/Other category includes a substantial number of NWPCC 2021 Power Plan measures which have not been characterized by the RTF.

Table 6-15 Commercial Achievable Economic Potential by Vintage, Select Years

Segment	Vintage	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Office	Existing	623	1,440	2,441	4,664	10,870	19,289
	New	302	646	1,019	1,736	3,904	8,717
Retail	Existing	192	420	681	1,266	2,992	5,063
	New	321	670	1,034	1,635	3,301	6,991
College	Existing	132	286	461	840	1,963	3,806
	New	58	123	194	315	729	1,729
School	Existing	312	689	1,123	2,100	4,788	9,126
	New	233	487	754	1,211	2,485	5,258
Grocery	Existing	529	1,175	1,939	3,700	8,867	12,928
	New	156	333	532	922	2,284	4,041
Hospital	Existing	403	879	1,426	2,663	6,323	11,795
	New	43	104	185	394	1,227	3,248
Other Health	Existing	135	296	481	904	2,127	3,969
	New	63	133	210	356	781	1,667
Lodging	Existing	132	288	470	881	2,059	3,559
	New	34	74	119	210	484	1,101
Restaurant	Existing	149	330	549	1,058	2,513	3,384
	New	64	138	222	398	995	2,044
Assembly	Existing	164	369	610	1,134	2,555	4,598
	New	87	184	289	480	1,011	2,143
Warehouse	Existing	397	868	1,406	2,633	6,107	10,396
	New	67	144	230	423	994	2,000
Data Center	Existing	403	862	1,382	2,497	5,259	8,254
	New	36	89	162	370	1,124	3,388
MF Common Area	Existing	155	354	591	1,083	2,250	3,742
	New	61	130	204	350	757	1,598
Misc - Classified	Existing	131	303	510	946	2,168	4,095
	New	88	184	286	449	927	2,047
Misc - Unclassified	Existing	496	1,152	1,944	3,577	8,363	16,475
	New	384	803	1,241	1,893	3,847	8,471
Total Commercial	**Existing**	**4,352**	**9,710**	**16,015**	**29,947**	**69,202**	**120,480**
	New	**1,996**	**4,244**	**6,680**	**11,141**	**24,853**	**54,443**

Table 6-16 Commercial Achievable Economic Potential by Replacement Type, Select Years

Segment	Replacement Type	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Office	Lost Opportunity	738	1,699	2,860	5,331	12,448	24,405
	Retrofit	188	387	600	1,070	2,326	3,601
Retail	Lost Opportunity	447	952	1,498	2,502	5,294	10,357
	Retrofit	66	138	217	398	1,000	1,698
College	Lost Opportunity	124	275	446	777	1,752	3,708
	Retrofit	65	134	209	379	940	1,827
School	Lost Opportunity	427	935	1,507	2,654	5,890	12,247
	Retrofit	118	241	371	657	1,383	2,138
Grocery	Lost Opportunity	304	669	1,081	1,883	4,155	8,552
	Retrofit	381	839	1,391	2,740	6,997	8,416
Hospital	Lost Opportunity	214	496	841	1,631	4,132	9,215
	Retrofit	232	487	770	1,426	3,418	5,828
Other Health	Lost Opportunity	135	297	480	871	1,975	4,092
	Retrofit	63	133	211	388	934	1,543
Lodging	Lost Opportunity	80	186	313	592	1,440	2,948
	Retrofit	85	176	276	499	1,103	1,712
Restaurant	Lost Opportunity	65	148	247	466	1,150	2,503
	Retrofit	147	320	523	990	2,358	2,926
Assembly	Lost Opportunity	208	463	757	1,360	3,058	6,150
	Retrofit	44	91	142	254	507	591
Warehouse	Lost Opportunity	330	731	1,193	2,240	5,190	9,506
	Retrofit	134	281	443	816	1,910	2,890
Data Center	Lost Opportunity	60	171	334	708	1,908	3,751
	Retrofit	379	781	1,211	2,159	4,474	7,892
MF Common Area	Lost Opportunity	142	332	562	1,024	2,234	4,311
	Retrofit	74	152	234	409	773	1,029
Misc - Classified	Lost Opportunity	199	446	730	1,272	2,764	5,463
	Retrofit	20	42	65	123	331	678
Misc - Unclassified	Lost Opportunity	867	1,922	3,126	5,319	11,439	22,726
	Retrofit	14	32	59	150	771	2,221
Total Commercial	**Lost Opportunity**	**4,339**	**9,721**	**15,975**	**28,629**	**64,829**	**129,932**
	Retrofit	**2,009**	**4,233**	**6,720**	**12,459**	**29,226**	**44,990**

Table 6-17 Commercial Achievable Economic Potential by End Use, 2031

End Use	Office	Retail	College	School	Grocery	Hospital
Cooling	2,033	324	192	1,132	52	1,852
Space Heating	66	21	252	95	2	326
Water Heating	33	32	17	6	15	40
Interior Lighting	5,865	2,372	969	4,255	2,914	2,795
Exterior Lighting	3,345	2,774	634	1,357	1,114	362
Food Preparation	1	11	8	44	52	55
Miscellaneous	0	0	230	1	87	436
Office Equipment	2,775	143	24	83	26	192
Refrigeration	31	405	19	218	6,777	42
Ventilation	626	212	347	82	113	1,449
Total	**14,774**	**6,294**	**2,692**	**7,273**	**11,152**	**7,550**

End Use	Other Health	Lodging	Restaurant	Assembly	Warehouse	Data Center
Cooling	271	690	233	360	467	3,431
Space Heating	48	206	20	5	186	12
Water Heating	13	8	59	8	6	4
Interior Lighting	1,478	270	313	2,112	2,993	190
Exterior Lighting	493	688	336	750	1,962	83
Food Preparation	5	61	114	4	0	0
Miscellaneous	58	182	4	0	1,135	0
Office Equipment	60	28	54	186	138	1,919
Refrigeration	86	286	2,349	106	7	0
Ventilation	397	125	27	33	207	745
Total	**2,909**	**2,543**	**3,508**	**3,565**	**7,101**	**6,383**

End Use	MF Common Area	Misc - Classified	Misc - Unclassified	Total
Cooling	886	278	306	12,507
Space Heating	3	103	446	1,791
Water Heating	7	11	16	274
Interior Lighting	524	1,872	8,303	37,224
Exterior Lighting	1,332	584	2,591	18,405
Food Preparation	0	3	19	378
Miscellaneous	0	6	0	2,139
Office Equipment	200	208	460	6,493
Refrigeration	32	26	58	10,441
Ventilation	24	5	11	4,403
Total	**3,008**	**3,095**	**12,210**	**94,055**

Table 6-18 summarizes the risk level of Achievable Economic potential in 2031 for the commercial sector.

Table 6-18 Commercial Economic Achievable Potential by Risk and RTF Category, 2031

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	1,317	653	2,444	86,837	91,252
1 - TRC B/C Ratio <1.2	0	505	11	2,287	2,804
2 - RTF Sunset before 2022	0	0	0	0	0
3 – Higher Risk (combined)	0	0	0	0	0
Total	**1,317**	**1,158**	**2,455**	**89,125**	**94,055**

JBLM Commercial Potential

The JBLM non-residential facilities are not all that dissimilar from their civilian counterparts, so we began with the same assumptions for customer adoption rates and measure costs. The presence of high security and the additional administrative and logistical requirements of performing work on base, however, led us to apply an adjustment factor to decelerate the measure adoption rates and to increase the measure costs. An example of how this would play out is that the Army Corps of Engineers is required to review every project and contractors typically charge a premium to work on base due to the additional security, badging, etc. These factors reduce the overall Achievable Technical potential at JBLM. AEG reviewed this assumption with Tacoma Power for this CPA cycle and it was deemed to still be accurate.

Table 6-19 and

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	257.7	255.5	252.9	247.1	238.6	230.5
Cumulative Savings (GWh)						
Achievable Economic Potential	0.6	1.4	2.2	4.1	9.5	17.4
Achievable Technical Potential	1.1	2.4	3.9	7.3	17.4	31.4
Technical Potential	4.4	9.1	14.3	24.4	51.1	85.2
Energy Savings (% of Baseline)						
Achievable Economic Potential	0.2%	0.5%	0.9%	1.7%	4.0%	7.5%
Achievable Technical Potential	0.4%	1.0%	1.5%	2.9%	7.3%	13.6%
Technical Potential	1.7%	3.6%	5.7%	9.9%	21.4%	37.0%

Figure 6-13 present estimates for the three levels of conservation potential for the commercial sector.

Table 6-19 Conservation Potential for the JBLM Commercial Sector (Energy Savings)

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	257.7	255.5	252.9	247.1	238.6	230.5
Cumulative Savings (GWh)						
Achievable Economic Potential	0.6	1.4	2.2	4.1	9.5	17.4
Achievable Technical Potential	1.1	2.4	3.9	7.3	17.4	31.4
Technical Potential	4.4	9.1	14.3	24.4	51.1	85.2
Energy Savings (% of Baseline)						
Achievable Economic Potential	0.2%	0.5%	0.9%	1.7%	4.0%	7.5%
Achievable Technical Potential	0.4%	1.0%	1.5%	2.9%	7.3%	13.6%
Technical Potential	1.7%	3.6%	5.7%	9.9%	21.4%	37.0%

Figure 6-13 JBLM Commercial Energy Efficiency Savings (Energy)

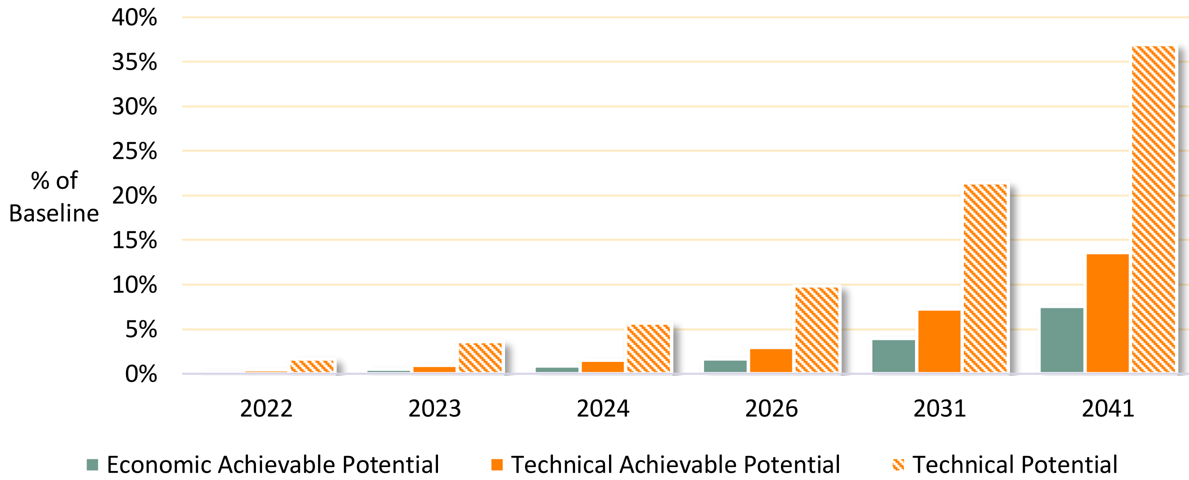


Figure 6-14 and Figure 6-15 show the supply curve of levelized cost per MWh saved vs. cumulative Achievable Technical potential for the JBLM commercial sector in 2031. LED lighting comprises the vast majority of cost-effective savings. Due to recent reductions in fixture costs, the price of linear LED panels has been significantly reduced. This has resulted in LED panels passing the economic screen and contributing highly to the overall potential. In addition, a higher saturation of standard efficiency T8 fixtures was found on base when compared to the civilian sector. This resulted in higher linear LED lighting potential than in the civilian sector. HVAC retrofit measures were also found to be sources of cost-effective potential. Although higher linear LED savings increases potential, overall Economic Achievable potential in the JBLM commercial sector is lower than the civilian commercial sector relative to baseline. This is attributable to less measures passing the TRC screen due to the higher costs of doing business at JBLM.

Figure 6-14 Supply Curve, JBLM Commercial Sector in 2031 (Annual Energy, MWh)

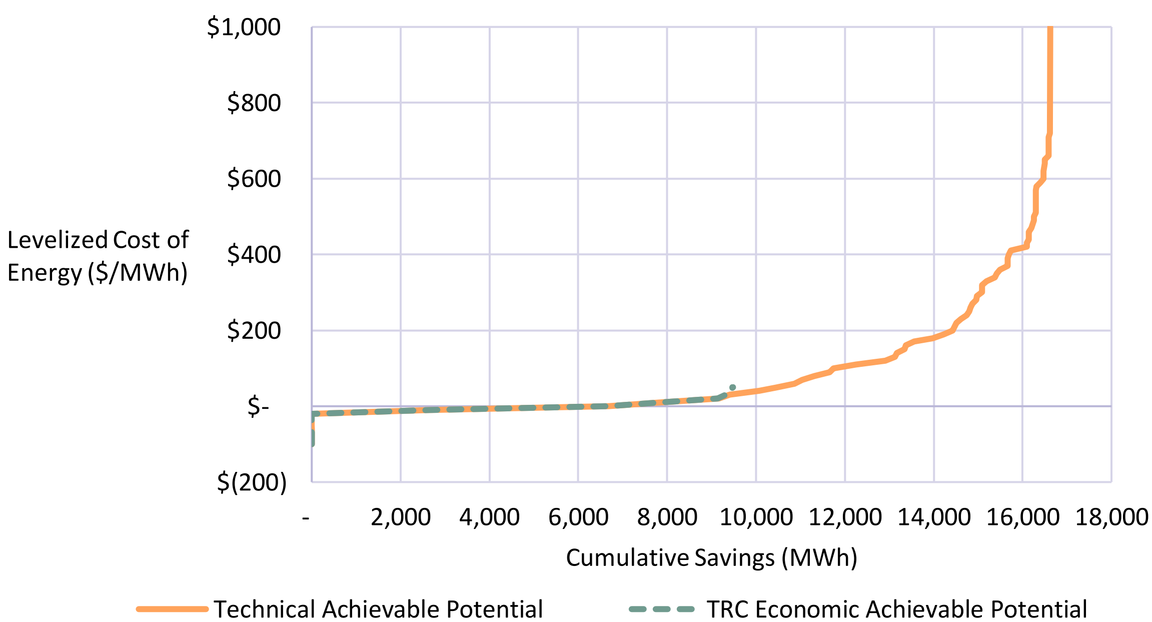


Figure 6-15 Supply Curve, JBLM Commercial Sector in 2031, Limited Axis (Annual Energy, MWh)

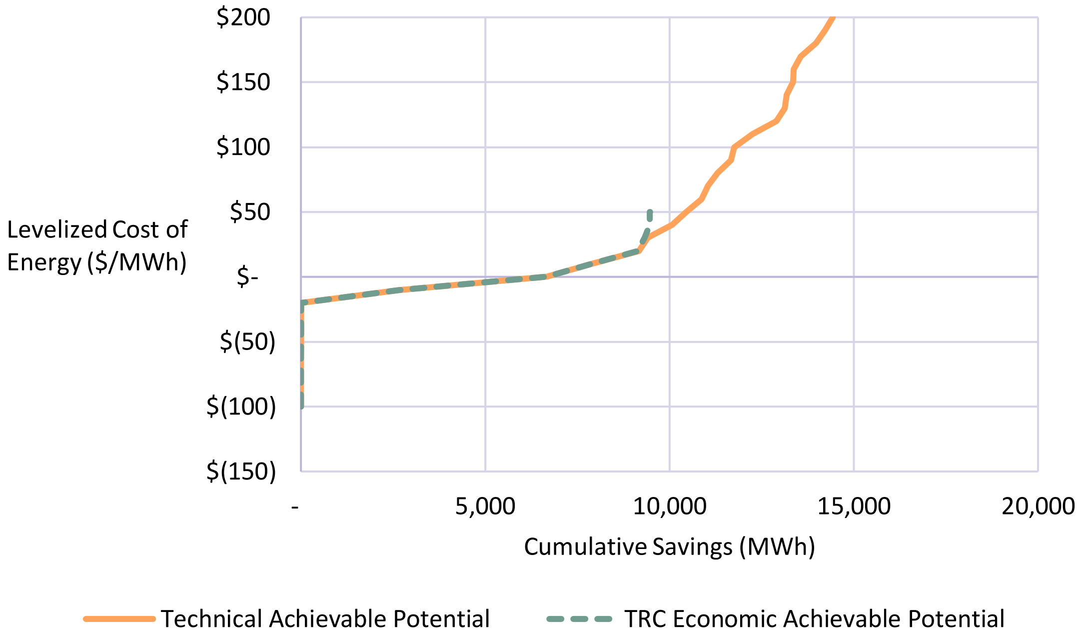


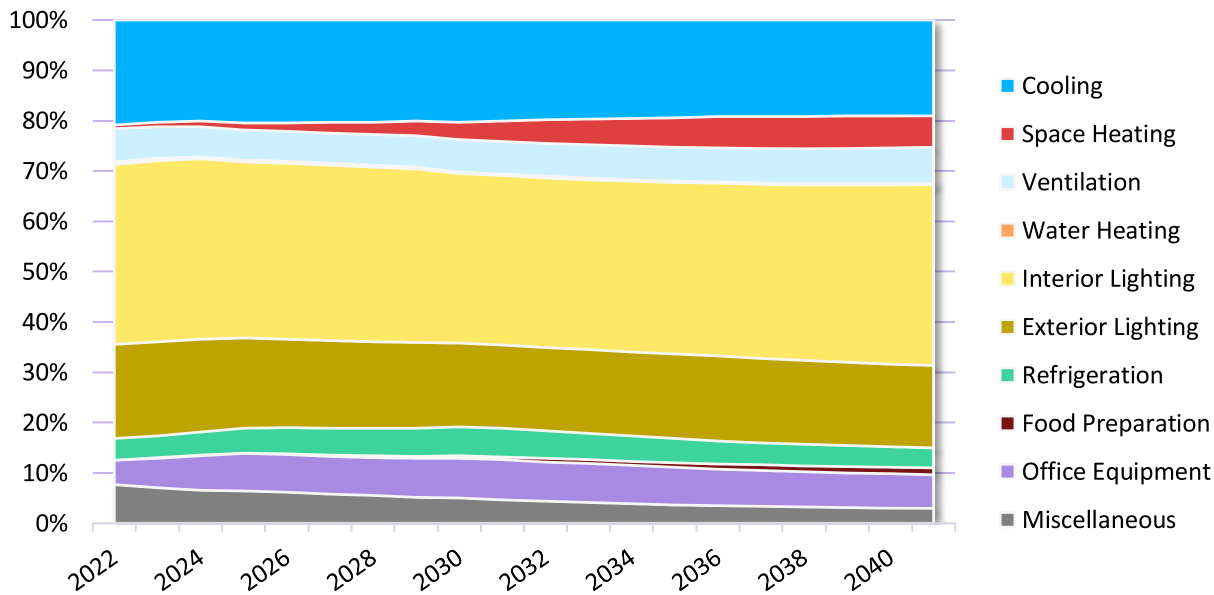
Table 6-20 identifies the top 20 measures in 2031 for the JBLM non-residential sector. Lighting measures make up three out of the top five commercial savings measures. For linear and high-bay lighting, many of these LED replacements include bundled controls that help increase savings for a modest additional cost at time of installation.

Table 6-20 JBLM Commercial Sector Top Measures in 2031 (Annual Energy, MWh)

Rank	Measure / Technology	2031 Achievable Economic Cumulative Savings (MWh)	% of Total
1	Linear Lighting	2,614	27.6%
2	Area Lighting	1,074	11.3%
3	High-Bay Lighting	900	9.5%
4	Server	563	5.9%
5	Strategic Energy Management	504	5.3%
6	Chiller - Variable Flow Chilled Water Pump	370	3.9%
7	Water-Cooled Chiller	355	3.8%
8	Grocery - On-Demand Overwrappers	321	3.4%
9	Refrigeration - Variable Speed Compressor	253	2.7%
10	Insulation - Wall Cavity	239	2.5%
11	Ventilation - Permanent Magnet Synchronous Fan Motor	226	2.4%
12	HVAC - Duct Repair and Sealing	199	2.1%
13	Ventilation - Nighttime Air Purge	181	1.9%
14	Chiller - Chilled Water Reset	156	1.7%
15	Server Room Temperature Set back	155	1.6%
16	Icemaker	151	1.6%
17	Windows - Secondary Glazing Systems	143	1.5%
18	Water-Cooled Chiller - Condenser Water Temperature Reset	114	1.2%
19	Data Center - Best Practice Measures	109	1.1%
20	Ventilation	108	1.1%
	Total	**8,735**	**92.2%**
	Total Savings in 2031	**9,474**	**100.0%**

Figure 6-16 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. About 50% of cost-effective potential is in lighting, with cooling and office equipment following at a distant second and third place respectively.

Figure 6-16 JBLM Commercial Achievable Economic Case – Cumulative Savings by End Use (% of Total and Annual MWh)



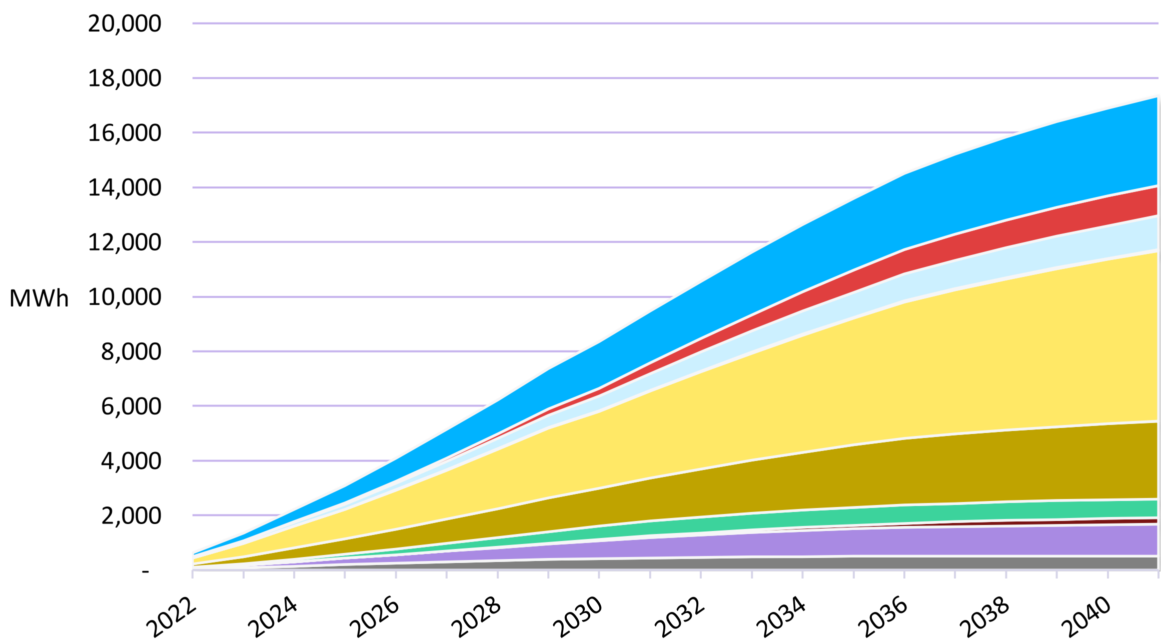


Table 6-21, Table 6-22, and

Table 6-23 summarize JBLM Commercial sector savings by vintage, replacement type, and end use respectively.

Table 6-21 JBLM Commercial Achievable Economic Potential by Vintage, Select Years

Segment	Vintage	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Office	Existing	70	161	274	523	1,219	2,159
	New	26	56	88	149	331	718
Retail	Existing	3	6	10	19	45	75
	New	4	7	11	18	35	72
School	Existing	15	33	53	99	225	418
	New	8	18	27	43	88	180
Grocery	Existing	8	19	30	58	137	198
	New	2	4	6	10	25	45
Lodging	Existing	64	140	228	428	999	1,727
	New	12	27	43	77	191	461
Restaurant	Existing	13	29	47	91	219	295
	New	4	9	15	27	66	134
Warehouse	Existing	58	128	208	393	938	1,642
	New	8	16	26	48	124	278
Data Center	Existing	61	130	209	377	788	1,228
	New	5	12	21	46	123	244
Health	Existing	103	225	365	682	1,621	2,976
	New	9	21	37	79	242	619
Other	Existing	40	91	150	274	614	1,162
	New	20	42	65	101	206	438
Hangar	Existing	20	46	75	145	372	681
	New	8	16	26	45	103	229
Mixed Use	Existing	37	81	131	236	505	864
	New	13	28	44	72	153	318
Industrial	Existing	5	10	17	32	78	142
	New	2	4	6	10	23	49
Total JBLM Commercial	**Existing**	**498**	**1,099**	**1,798**	**3,358**	**7,762**	**13,566**
	New	**121**	**260**	**415**	**726**	**1,712**	**3,787**

Table 6-22 JBLM Commercial Achievable Economic Potential by Replacement Type, Select Years

Segment	Replacement Type	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
Office	Lost Opportunity	75	174	294	552	1,289	2,478
	Retrofit	21	44	68	121	262	398
Retail	Lost Opportunity	5	11	18	30	64	122
	Retrofit	1	2	4	7	16	25
School	Lost Opportunity	17	38	62	110	243	494
	Retrofit	6	12	19	33	70	104
Grocery	Lost Opportunity	4	9	15	26	58	119
	Retrofit	6	13	21	42	104	124
Lodging	Lost Opportunity	35	82	139	265	646	1,296
	Retrofit	41	85	132	240	543	892
Restaurant	Lost Opportunity	5	11	18	34	86	181
	Retrofit	13	27	44	83	200	248
Warehouse	Lost Opportunity	46	102	167	315	730	1,325
	Retrofit	20	42	67	126	332	596
Data Center	Lost Opportunity	9	27	52	111	302	602
	Retrofit	56	115	178	312	610	871
Health	Lost Opportunity	51	119	201	389	979	2,141
	Retrofit	61	127	201	372	884	1,454
Other	Lost Opportunity	50	113	184	321	698	1,382
	Retrofit	10	20	31	55	122	218
Hangar	Lost Opportunity	24	51	83	153	347	638
	Retrofit	5	11	18	37	128	272
Mixed Use	Lost Opportunity	32	72	118	208	457	883
	Retrofit	18	37	57	100	202	299
Industrial	Lost Opportunity	6	12	19	36	81	149
	Retrofit	1	2	3	6	19	42
Total JBLM Commercial	**Lost Opportunity**	**360**	**820**	**1,370**	**2,549**	**5,981**	**11,811**
	Retrofit	**259**	**538**	**843**	**1,535**	**3,493**	**5,542**

Table 6-23 JBLM Commercial Achievable Economic Potential by End Use, 2031

End Use	Office	Retail	School	Grocery	Lodging
Cooling	224	5	51	1	318
Space Heating	7	0	5	0	118
Water Heating	4	0	0	0	4
Interior Lighting	611	26	189	41	122
Exterior Lighting	341	37	51	15	305
Food Preparation	0	0	2	1	28
Miscellaneous	0	0	0	1	86
Office Equipment	293	2	4	0	11
Refrigeration	3	6	10	102	138
Ventilation	68	4	2	0	59
Total	**1,551**	**80**	**313**	**163**	**1,190**

End Use	Restaurant	Warehouse	Data Center	Health	Other
Cooling	21	79	505	442	119
Space Heating	1	74	2	77	27
Water Heating	5	1	0	10	1
Interior Lighting	22	437	27	658	490
Exterior Lighting	23	262	12	108	151
Food Preparation	9	0	0	11	1
Miscellaneous	0	161	0	106	0
Office Equipment	5	19	288	61	28
Refrigeration	198	1	0	44	3
Ventilation	2	29	78	346	1
Total	**286**	**1,062**	**911**	**1,863**	**820**

End Use	Hangar	Mixed Use	Industrial	Total
Cooling	55	70	8	1,898
Space Heating	40	28	7	386
Water Heating	1	4	0	31
Interior Lighting	234	278	53	3,188
Exterior Lighting	109	134	25	1,572
Food Preparation	0	0	0	53
Miscellaneous	0	84	5	443
Office Equipment	8	34	2	754
Refrigeration	18	14	0	538
Ventilation	11	12	0	612
Total	**475**	**659**	**101**	**9,474**

Table 6-24 summarizes the risk level of Achievable Economic potential in 2031 for the JBLM commercial sector. Results are very similar to the civilian commercial sector.

Table 6-24 JBLM Commercial Achievable Economic Potential by Risk and RTF Category, 2031

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	268	168	462	8,231	9,129
1 - TRC B/C Ratio <1.2	53	11	6	276	345
2 - RTF Sunset before 2022	0	0	0	0	0
3 – Higher Risk (combined)	0	0	0	0	0
Total	**321**	**179**	**468**	**8,507**	**9,474**

Industrial Potential

Table 6-25 and

Photo: Getty Images

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	963	966	970	979	1,003	1,058
Cumulative Savings (GWh)						
Economic Achievable Potential	4	8	13	24	57	90
Achievable Technical Potential	5	11	17	30	70	108
Technical Potential	6	14	21	37	83	128
Energy Savings (% of Baseline)						
Economic Achievable Potential	0.4%	0.8%	1.3%	2.4%	5.7%	8.5%
Achievable Technical Potential	0.5%	1.1%	1.8%	3.1%	7.0%	10.2%
Technical Potential	0.6%	1.4%	2.2%	3.8%	8.3%	12.1%

Figure 6-17 present potential estimates at the measure level for the industrial sector. As a percent of the baseline projection, industrial savings are the lowest as a result of stringent motor standards and the challenges of identifying additional opportunities to reduce process energy use. Compared to the other sectors, a larger portion of the Achievable Technical potential is cost-effective. Many of these are control-type measures that affect large energy consuming motors and processes. Compressed air measures, which are on faster ramp rates than measures for other applications, make up a sizeable amount of potential. Additionally, strategic energy management programs, which have recently been gaining significant traction in the region, are a large source of potential.

Table 6-25 Conservation Potential for the Industrial Sector (Annual Energy, GWh)

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	963	966	970	979	1,003	1,058
Cumulative Savings (GWh)						
Economic Achievable Potential	4	8	13	24	57	90
Achievable Technical Potential	5	11	17	30	70	108
Technical Potential	6	14	21	37	83	128
Energy Savings (% of Baseline)						

Economic Achievable Potential	0.4%	0.8%	1.3%	2.4%	5.7%	8.5%
Achievable Technical Potential	0.5%	1.1%	1.8%	3.1%	7.0%	10.2%
Technical Potential	0.6%	1.4%	2.2%	3.8%	8.3%	12.1%

Figure 6-17 Industrial Potential as a % of the Baseline Projection (Annual Energy)

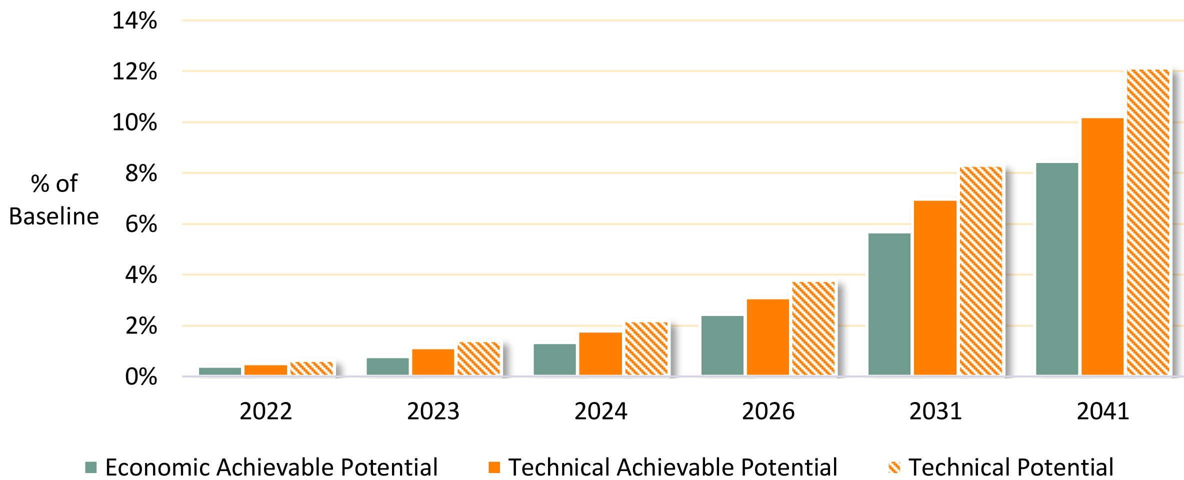


Figure 6-18 and Figure 6-19 show the supply curve of levelized cost per MWh saved vs. cumulative Achievable Technical potential for the industrial sector in 2031. Energy management measures, motor and process controls, and LED lighting make up a majority of the cost-effective savings potential. Although the linear LED cost reduction also applies to industrial spaces, high bay LED applications make up a majority of the fixtures and are highly cost-effective. Overall, Economic Achievable potential in the industrial sector represents an even higher percentage of Achievable Technical potential when compared to both residential and commercial savings. This is mainly due to measures being either highly cost effective or ineffective. This is apparent by the amount of Achievable Technical savings with levelized costs of less than $30/MWh.

Figure 6-18 Supply Curve, Industrial Sector in 2031 (Annual Energy, MWh)

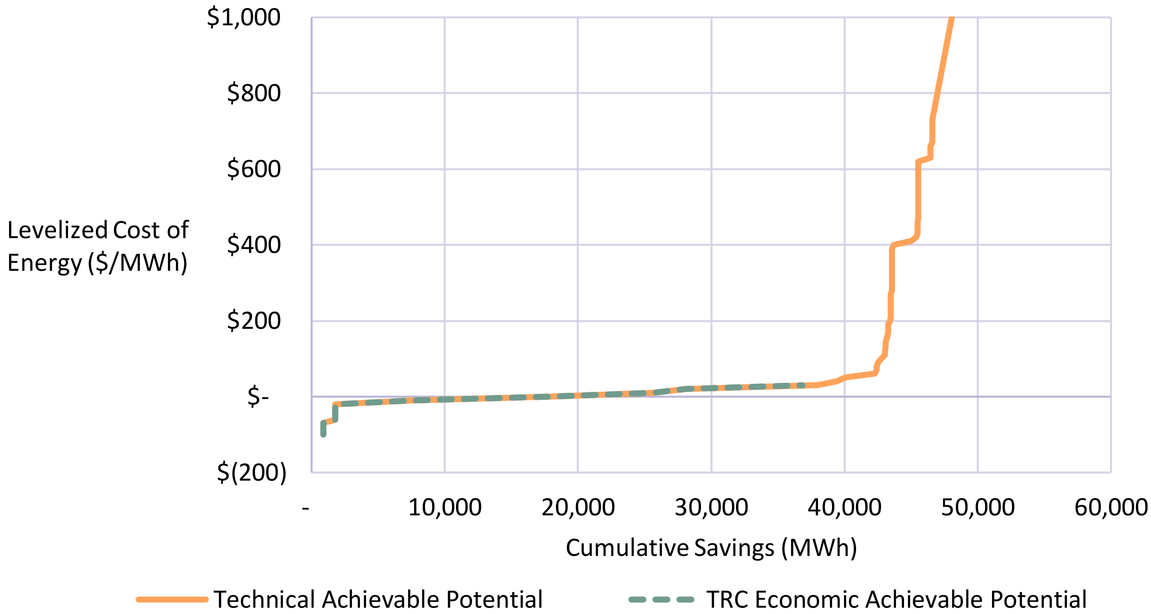


Figure 6-19 Supply Curve, Industrial Sector in 2031, Limited Axis (Annual Energy, MWh)

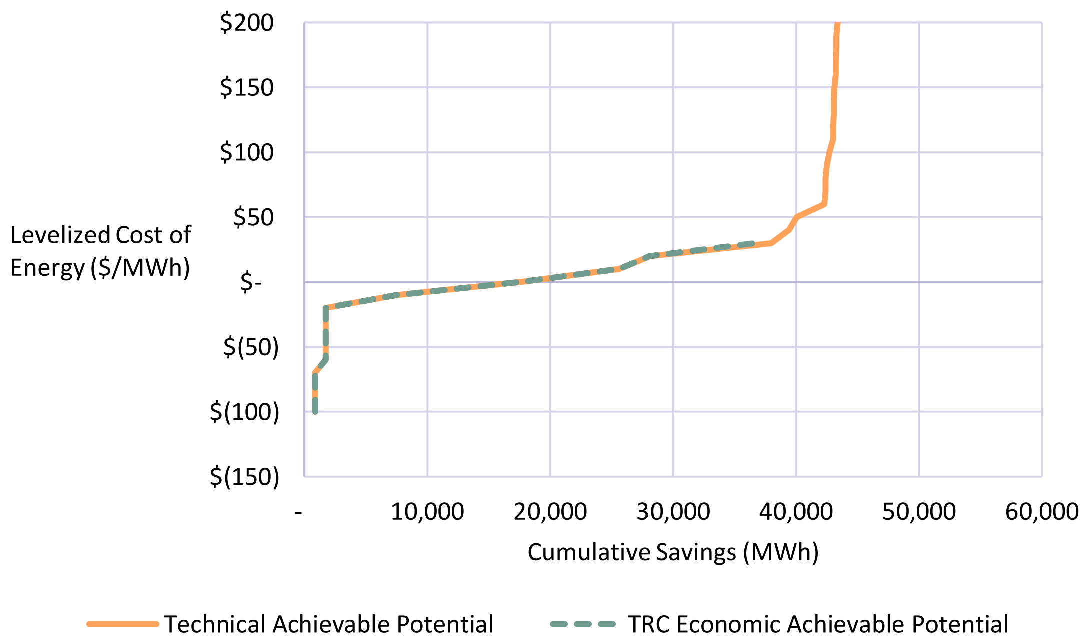


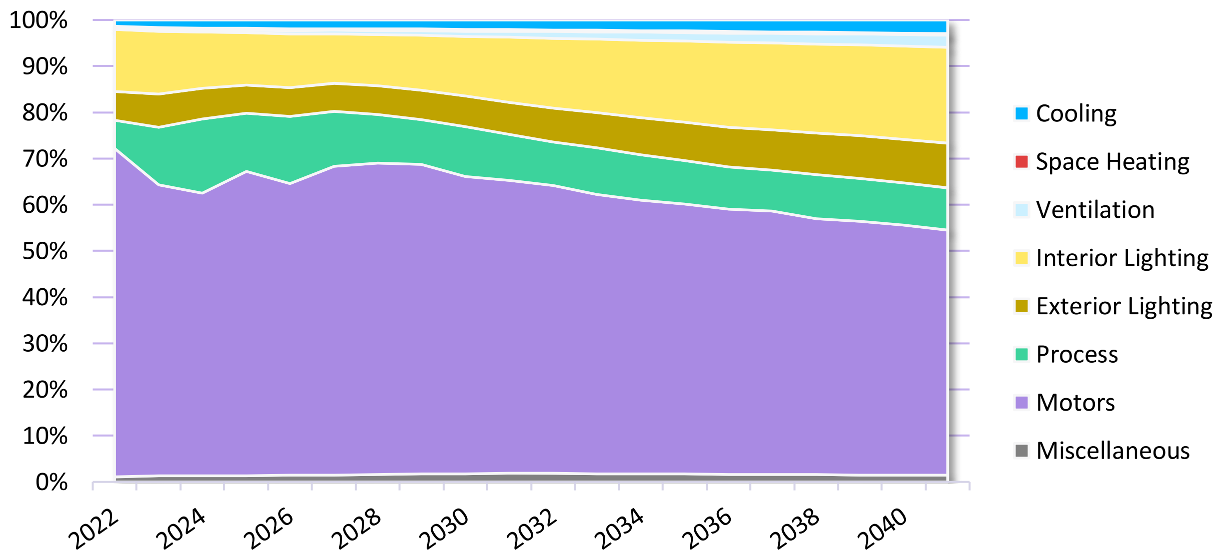
Table 6-26 identifies the top 20 industrial measures in 2031. The top measures are compressed air measures and strategic energy management. Strategic Energy Management encompasses behavioral and low-cost/no-cost opportunities.

Table 6-26 Industrial Sector Top Measures in 2031 (Annual Energy, MWh)

Rank	Measure / Technology	2031 Economic Achievable Cumulative Savings (MWh)	% of Total
1	Advanced Industrial Motors	5,873	16.3%
2	Linear Lighting	5,542	15.4%
3	Strategic Energy Management	5,070	14.1%
4	High-Bay Lighting	4,373	12.2%
5	Fan System - Equipment Upgrade	1,922	5.3%
6	Area Lighting	1,523	4.2%
7	Indoor Agriculture - LED Lighting	1,311	3.6%
8	High Frequency Battery Chargers	1,042	2.9%
9	Pumping System - System Optimization	881	2.5%
10	Pumping System - Variable Speed Drive	708	2.0%
11	Compressed Air - Engineered Nozzles	678	1.9%
12	Compressed Air - System Controls	672	1.9%
13	Motors - Green Rewind (<100 HP)	658	1.8%
14	Ventilation	654	1.8%
15	Compressed Air - Variable Speed Drive	642	1.8%
16	Water-Cooled Chiller	551	1.5%
17	Compressed Air - Zero-Loss Condensate Drain	488	1.4%
18	Switch from Belt Drive to Direct Drive	468	1.3%
19	Motors - Green Rewind (100 HP+)	441	1.2%
20	Wood - Replace Pneumatic Conveyor	423	1.2%
	Total	**33,923**	**94.4%**
	Total Savings in 2031	**35,942**	**100.0%**

Figure 6-20 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Motor-related measures account for most of the savings throughout the forecast horizon. Savings associated with lighting measures are also significant throughout the forecast.

Figure 6-20 Industrial Achievable Economic Case – Cumulative Savings by End Use (% of Total and Annual MWh)



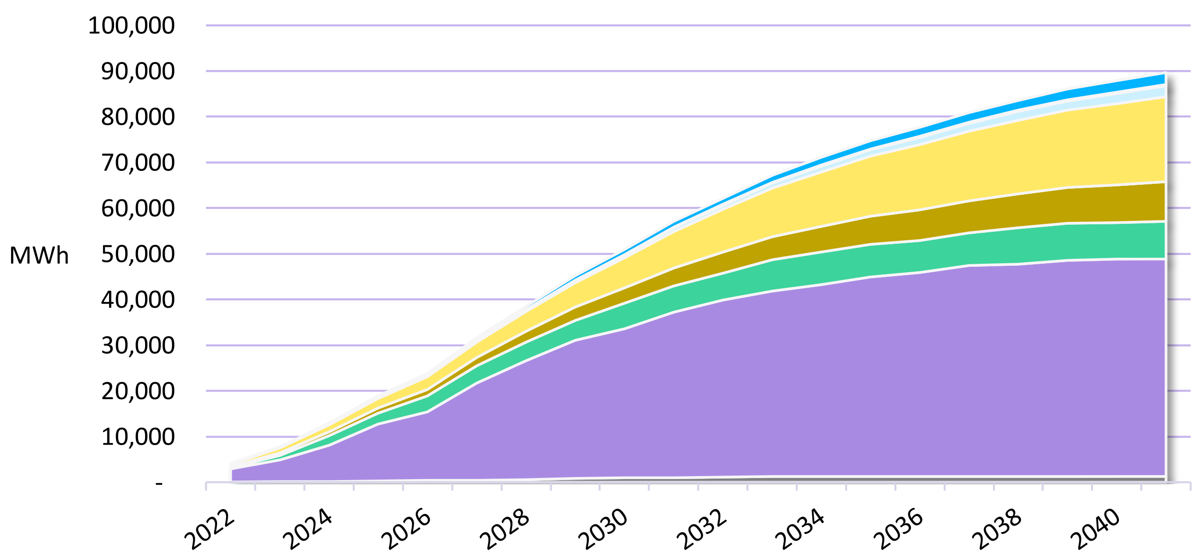


Table 6-29 summarize Industrial sector savings by vintage, replacement type, and end use respectively.

Table 6-27 Industrial Achievable Economic Potential by Vintage, Select Years

Segment	Vintage	2022 Savings (MWh)	2023 Savings (MWh)	2024 Savings (MWh)	2026 Savings (MWh)	2031 l Savings (MWh)	2041 Savings (MWh)
Paper Mfg	Existing	2,144	3,569	6,298	11,041	23,258	34,481
	New	82	174	273	494	1,154	2,379
Chemical Mfg	Existing	361	796	1,312	2,554	6,754	9,865
	New	79	177	296	606	1,809	3,165
Stone Clay Glass Products	Existing	93	206	341	664	1,788	2,569
	New	24	52	87	174	501	843
Petroleum Refining	Existing	166	361	589	1,133	2,909	4,054
	New	25	58	100	213	682	1,118
Lumber Wood Products	Existing	96	214	354	689	1,862	2,847
	New	29	64	106	207	573	1,029
Food Mfg	Existing	105	232	383	745	2,060	3,348
	New	39	85	138	265	701	1,318
Rubber and Plastics	Existing	74	163	268	518	1,601	2,965
	New	46	98	156	288	700	1,361
Other Industrial	Existing	507	1,081	1,722	3,170	8,191	13,446
	New	167	355	564	1,037	2,505	4,883
Total Industrial	**Existing**	**3,545**	**6,623**	**11,268**	**20,512**	**48,422**	**73,573**
	New	**491**	**1,063**	**1,719**	**3,285**	**8,626**	**16,096**

Table 6-28 Industrial Achievable Economic Potential by Replacement Type, Select Years

Segment	Replacement Type	2022 Savings (MWh)	2023 Savings (MWh)	2024 Savings (MWh)	2026 Savings (MWh)	2031 Savings (MWh)	2041 Savings (MWh)
Paper Mfg	Lost Opportunity	131	288	459	835	2,376	5,614
	Retrofit	37	82	140	300	929	1,313
Chemical Mfg	Lost Opportunity	440	973	1,608	3,160	8,564	13,030
	Retrofit	106	234	377	695	1,996	4,789
Stone Clay Glass Products	Lost Opportunity	117	259	428	838	2,289	3,413
	Retrofit	30	65	103	186	560	1,343
Petroleum Refining	Lost Opportunity	191	419	689	1,346	3,590	5,172
	Retrofit	28	60	95	171	519	1,253
Lumber Wood Products	Lost Opportunity	125	278	459	896	2,435	3,875
	Retrofit	42	93	148	272	776	1,848
Food Mfg	Lost Opportunity	143	317	521	1,010	2,761	4,666
	Retrofit	58	128	205	377	1,081	2,584
Rubber and Plastics	Lost Opportunity	120	262	425	806	2,301	4,325
	Retrofit	67	144	228	410	1,242	2,989
Other Industrial	Lost Opportunity	674	1,436	2,286	4,207	10,696	18,328
	Retrofit	241	519	824	1,486	4,494	10,819
Total Industrial	**Lost Opportunity**	**1,942**	**4,231**	**6,874**	**13,097**	**35,013**	**58,424**
	Retrofit	**608**	**1,325**	**2,119**	**3,897**	**11,598**	**26,939**

Table 6-29 Industrial Achievable Economic Potential by End Use, 2031

End Use	Paper Mfg	Chemical Mfg	Stone Clay Glass Products	Petroleum Refining	Lumber Wood Products	Food Mfg	Rubber and Plastics	Other Industrial	Total
Cooling	205	384	27	33	100	190	30	230	1,199
Space Heating	1	44	11	10	7	21	13	91	197
Interior Lighting	1,494	1,123	359	328	439	621	762	2,842	7,968
Exterior Lighting	703	567	183	167	221	313	387	1,443	3,984
Miscellaneous	0	0	57	0	139	114	212	521	1,042
Motors	18,958	5,801	1,414	2,941	1,488	1,099	826	3,665	36,191
Process	2,970	516	204	81	9	340	0	1,594	5,714
Ventilation	81	129	35	32	33	64	72	311	755
Total	24,411	8,564	2,289	3,590	2,435	2,761	2,301	10,696	57,048

Table 6-30 summarizes the risk level of Achievable Economic potential in 2031 for the industrial sector. Since the RTF characterizes very few industrial measures, most potential is in the None/Other category. This includes 2021 Plan Plan measures, strategic energy management, and additional system optimization and controls measures identified by AEG.

Table 6-30 Industrial Achievable Economic Potential by Risk and RTF Category, 2031

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	0	0	1,204	25,681	26,885
1 - TRC B/C Ratio <1.2	0	0	0	9,057	9,057
2 - RTF Sunset before 2022	0	0	0	0	0
3 – Higher Risk (combined)	0	0	0	0	0
Total	**0**	**0**	**1,204**	**34,738**	**35,942**

Street lighting Potential

Table 6-31 and Figure 6-21 present estimates for the three levels of conservation potential for the street lighting sector. Most Achievable Technical potential is cost effective, however the opportunity is slim. As discussed in Chapter 3, lamps under Tacoma Power's direct control have been retrofit to LEDs already. The remaining potential comes from fixtures that Tacoma does not have direct access to and are slower to respond to programs.

Table 6-31 Conservation Potential for the Street Lighting Sector

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	14.3	14.3	14.3	14.3	14.3	14.3
Cumulative Savings (GWh)						
Economic Achievable Potential	0.1	0.2	0.3	0.6	1.9	5.2
Achievable Technical Potential	0.1	0.3	0.6	1.0	2.3	5.6
Technical Potential	0.3	0.7	1.1	1.8	3.6	7.2
Energy Savings (% of Baseline)						
Economic Achievable Potential	0.4%	1.0%	2.0%	4.4%	13.5%	36.5%
Achievable Technical Potential	0.7%	2.3%	4.2%	6.8%	16.3%	39.4%
Technical Potential	2.1%	5.0%	8.0%	12.4%	24.8%	50.2%

Figure 6-21 Street Lighting Energy Efficiency Savings

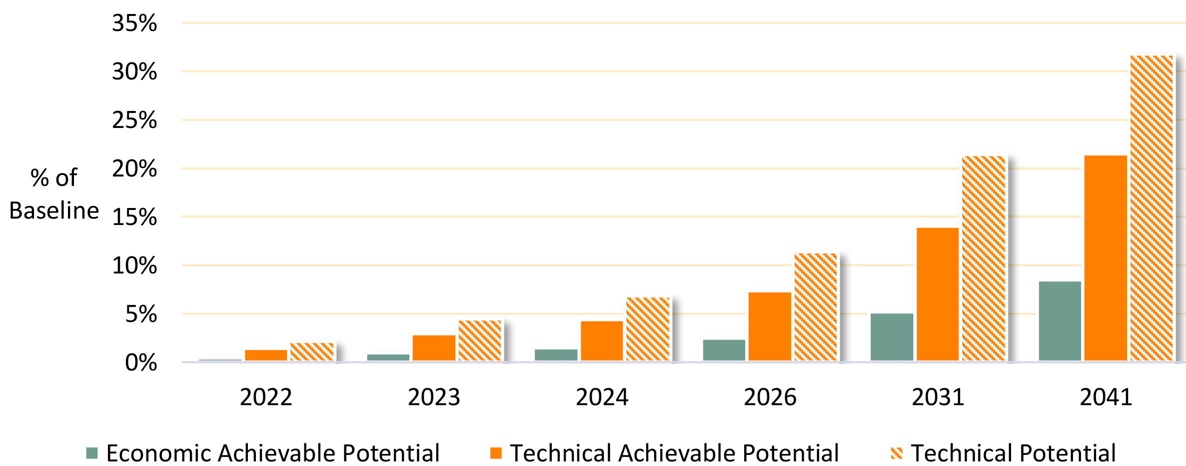


Figure 6-22 shows the supply curve of levelized cost per MWh saved vs. cumulative Achievable Technical potential for the street lighting sector in 2031. Cost-effective potential is mainly attributable to the installation of LED lighting fixtures. Using assumptions provided for labor and O&M of replacing existing high intensity lamps multiple times during the baseline fixture lifetime, LED fixtures become immediately cost-effective before even considering energy savings. These non-energy impacts allow most measures to easily pass and are reflected by the substantial savings that occur with near-zero levelized costs, as shown below.

Figure 6-22 Supply Curve, Street Lighting in 2031 (Annual Energy, MWh)

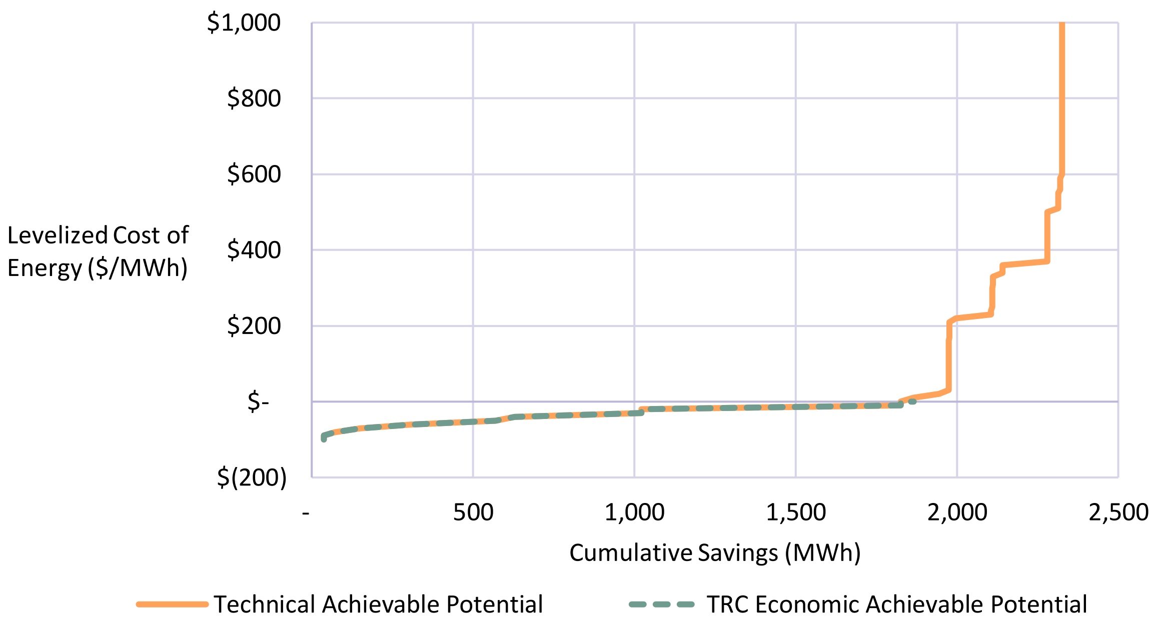


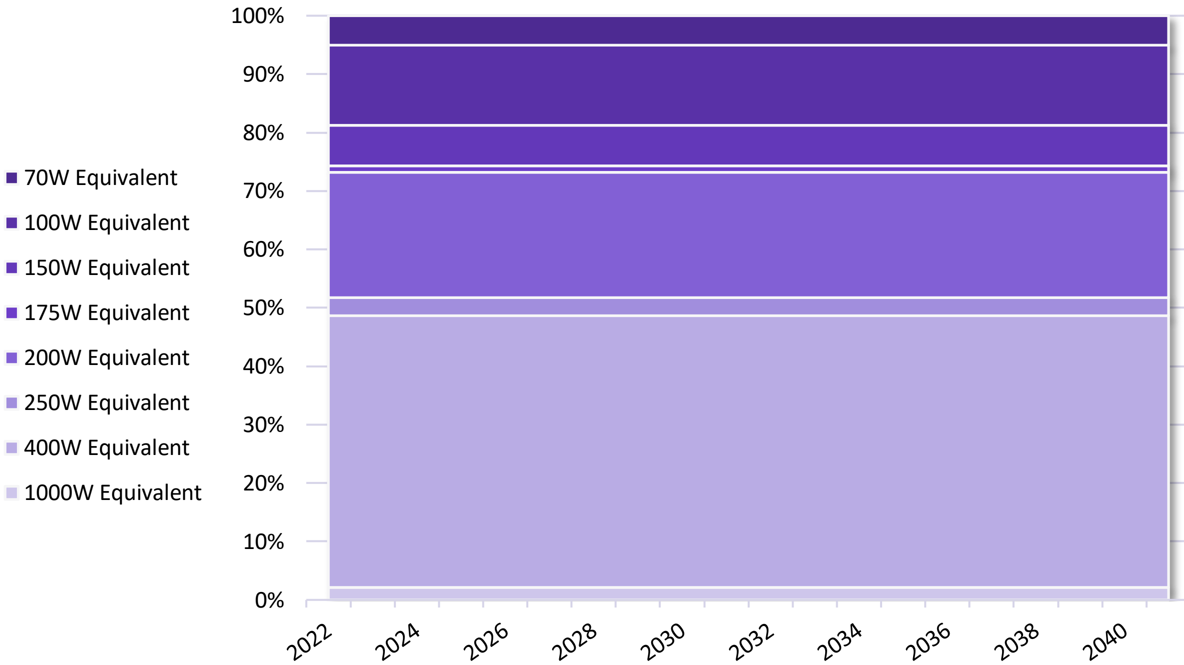
Table 6-32 identifies the top street lighting measures from the perspective of annual energy savings in 2031. A high operations and maintenance cost savings leads to favorable benefit to cost ratios which allows all LED equipment replacement measures to pass the economic screen, along with high use retrofits.

Table 6-32 Street Lighting Sector Top Measures in 2031 (Annual Energy, GWh)

Rank	Measure / Technology	2031 Economic Achievable Cumulative Savings (MWh)	% of Total
1	400W Equivalent	868	46.5%
2	200W Equivalent	400	21.5%
3	100W Equivalent	256	13.7%
4	150W Equivalent	129	6.9%
5	70W Equivalent	94	5.0%
6	250W Equivalent	58	3.1%
7	1000W Equivalent	40	2.1%
8	175W Equivalent	21	1.1%
	Total	**1,866**	**100.0%**
	Total Savings in 2031	**1,866**	**100.0%**

Figure 6-23 presents forecasts of energy savings by street lighting fixture as a percent of total annual savings and cumulative savings. The potential is mainly located in the 100W, 250W, and 400W equivalent fixture sizes.

Figure 6-23 Street Lighting Achievable Economic Case – Cumulative Savings by End Use (% of Total and Annual GWh)



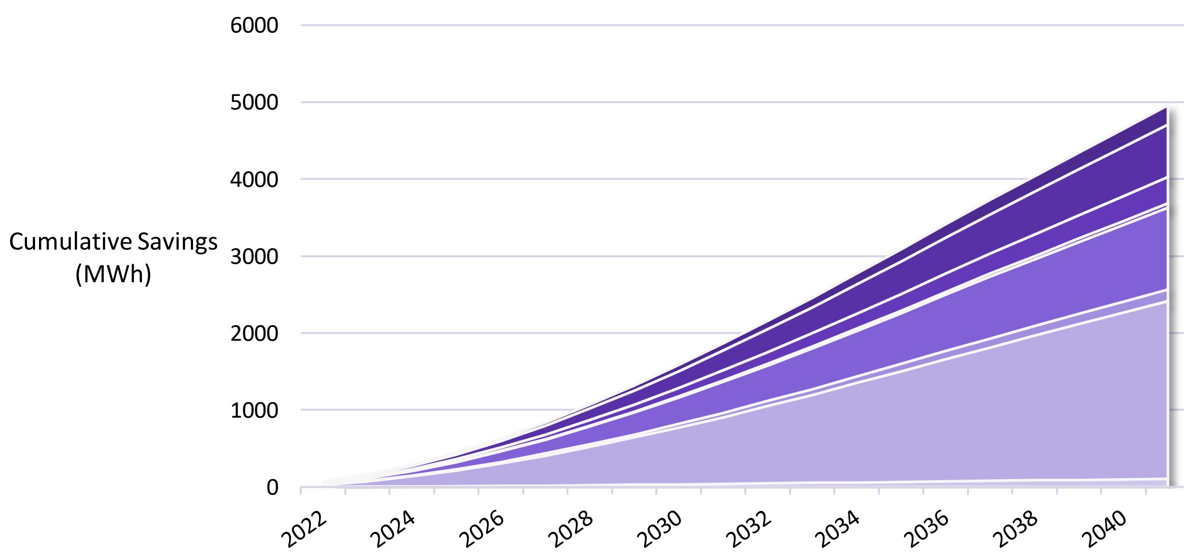


Table 6-33,

Table 6-34, and

Table 6-35 summarize Street Lighting sector savings by vintage, replacement type, and fixture wattage respectively. Street Lighting potential by end use is not reported here as there is only one end use. Although the baseline projection is flat, it assumes that a small percentage of fixtures will turn over in any given year.

Absent a utility program, it is assumed that these fixtures will be replaced with a high-intensity discharge fixture, such as a high-pressure sodium, in the baseline.

Table 6-33 Street Lighting Achievable Economic Potential by Vintage, Select Years

Segment	Vintage	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
H1 Dusk to Dawn	Existing	11	30	57	127	381	1,012
	New	2	5	9	19	51	137
Other H1	Existing	5	13	24	54	163	434
	New	1	2	4	8	22	59
All H2	Existing	31	88	164	366	1,100	2,922
	New	5	14	26	55	148	395
Total Street Lighting	**Existing**	**47**	**132**	**246**	**548**	**1,644**	**4,369**
	New	**8**	**22**	**39**	**82**	**222**	**590**

Table 6-34 Street Lighting Achievable Economic Potential by Replacement Type, Select Years

Segment	Replacement Type	2022 Economic Achievable Savings (MWh)	2023 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2026 Economic Achievable Savings (MWh)	2031 Economic Achievable Savings (MWh)	2041 Economic Achievable Savings (MWh)
H1 Dusk to Dawn	Lost Opportunity	13	35	66	146	432	1,149
	Retrofit	0	0	0	0	0	0
Other H1	Lost Opportunity	5	15	28	63	185	493
	Retrofit	0	0	0	0	0	0
All H2	Lost Opportunity	37	102	190	421	1,248	3,317
	Retrofit	0	0	0	0	0	0
Total Street Lighting	**Lost Opportunity**	**55**	**153**	**285**	**630**	**1,866**	**4,959**
	Retrofit	**0**	**0**	**0**	**0**	**0**	**0**

Table 6-35 Street Lighting Achievable Economic Potential by Fixture Wattage, 2031

End Use	H1 Tacoma	H1 Other	H2 All	Total Street Lighting
70W Equivalent	87	7	0	94
100W Equivalent	37	77	142	256
150W Equivalent	97	32	0	129
175W Equivalent	19	2	0	21
200W Equivalent	34	40	326	400

250W Equivalent	53	4	0	58
400W Equivalent	65	23	780	868
1000W Equivalent	40	0	0	40
Total	**432**	**185**	**1,248**	**1,866**

Risk. Due to the large O&M benefits, all LED street lighting potential is considered low risk.

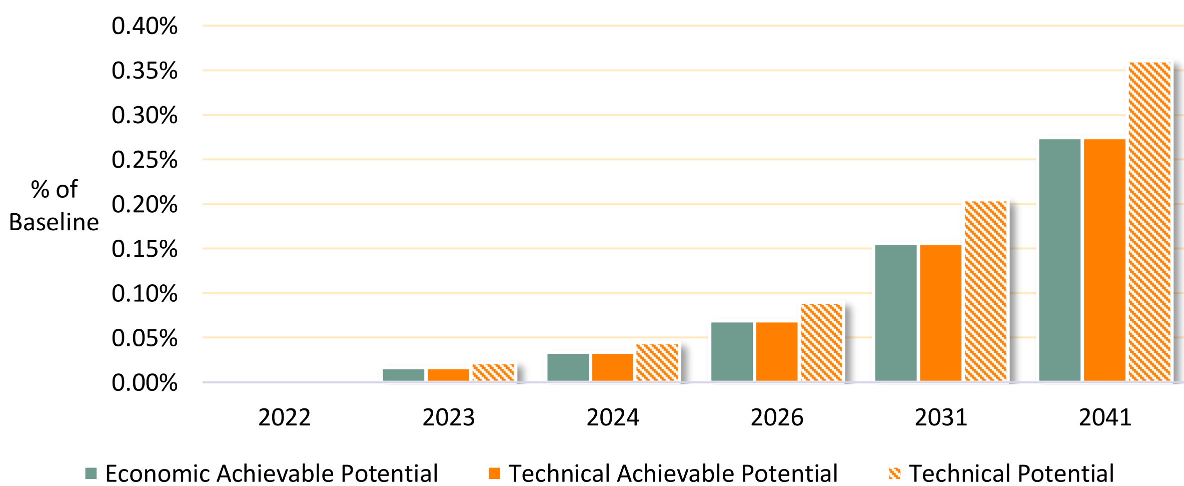
Distribution Efficiency Potential

Table 6-36 and Figure 6-24 present estimates for the three levels of conservation potential for the distribution efficiency analysis. Based on a utility specific three sub-station study conducted by RW Beck for Tacoma Power, this measure set was found to be highly cost effective. For this reason, all Achievable Technical potential is economic as well. The baseline displayed in this section refers to the entire territory since substations often impact more than one market sector at a time. Distribution efficiency assumptions were provided by Tacoma Power based on accomplishment in recent years. To date, Tacoma Power has upgraded 12 substations within the territory and expects to complete the remaining 16 at a rate of roughly one per year through 2038. After this point, potential remains flat.

Table 6-36 Conservation Potential for Distribution Efficiency

Scenario	2022	2023	2024	2026	2031	2041
Baseline Forecast (GWh)	4,336	4,316	4,294	4,248	4,205	4,251
Cumulative Savings (GWh)						
Economic Achievable Potential	0.0	0.7	1.5	2.9	6.6	11.7
Achievable Technical Potential	0.0	0.7	1.5	2.9	6.6	11.7
Technical Potential	0.0	1.0	1.9	3.8	8.6	15.3
Energy Savings (% of Baseline)						
Economic Achievable Potential	0.00%	0.02%	0.03%	0.07%	0.16%	0.27%
Achievable Technical Potential	0.00%	0.02%	0.03%	0.07%	0.16%	0.27%
Technical Potential	0.00%	0.02%	0.04%	0.09%	0.21%	0.36%

Figure 6-24 Distribution Efficiency Energy Efficiency Savings



7

COMPARISON WITH PRIOR STUDY

Compared to the prior CPA, which estimated potential for the 2020-2021 biennium, several key assumptions and methodologies used in the region have been updated. These include:

Table 7-1 Economic Achievable Potential in 2031

Market Sector	Current Study: 2022-2031 Potential (MWh)	*Prior Study: 2020-2029 Potential (MWh)*	Change from Prior Study (MWh)
Residential	55,756	*55,827*	-71
JBLM Residential	1,210	*1,413*	-203
Commercial	94,171	*89,279*	4,892
JBLM Commercial	9,474	*8,361*	1,113
Industrial	57,062	*62,700*	-5,638
Street Lighting	1,931	*2,713*	-782
Distribution	6,570	*10,548*	-3,978
Total	**226,174**	***230,841***	**-4,667**

Residential Sector Comparison

Table 7-2 compares 10-year potential between the current and prior studies for the residential market sector.

Table 7-2 Comparison of Residential Potential with Prior Study

End Use	Current Study: 2022-2031 Potential (MWh)	*Prior Study: 2020-2029 Potential (MWh)*	Change from Prior Study (MWh)
Cooling	834	*239*	-595
Space Heating	31,590	*25,141*	-6,449
Water Heating	5,087	*11,640*	6,553
Interior Lighting	5,063	*11,268*	6,205
Exterior Lighting	202	*1,248*	1,046
Appliances	1,659	*4199*	2,540
Electronics	10,379	*1,306*	-9,073
Miscellaneous	943	*786*	-157
Total	**55,756**	***55,827***	**71**

Commercial Sector Comparison

Table 7-3 compares 10-year potential between the current and prior studies for the commercial market sector.

Table 7-3 Comparison of Commercial Potential with Prior Study

End Use	Current Study: 2022-2031 Potential (MWh)	*Prior Study: 2020-2029 Potential (MWh)*	Change from Prior Study (MWh)
Cooling	12,507	*9,039*	-3,468
Space Heating	1,791	*2,862*	1,071
Ventilation	4,403	*1,665*	-2,738
Water Heating	274	*4,009*	3,735
Interior Lighting	37,340	*47,152*	9,812
Exterior Lighting	18,405	*12,081*	-6,324
Refrigeration	10,441	*4,176*	-6,265
Food Preparation	378	*532*	154
Office Equipment	6,493	*7,624*	1,131
Miscellaneous	2,139	*139*	-2,000
Total	**94,171**	***89,279***	**-4,892**

A

CONSISTENCY WITH COUNCIL METHODOLOGY

This appendix presents information about how the Tacoma Power 2022-2041 conservation potential assessment complies with Washington State Initiative 937.

Background

In mid-2020, Tacoma Power contracted with Applied Energy Group to conduct this Conservation Potential Assessment. A primary objective of the study was to establish Tacoma's 2022-2023 biennium target. The performance of this CPA was in accordance with the utility analysis option, using an analytical methodology consistent with Council procedures, and specified in Washington Administrative Code (WAC) 194-37-070, subsection (5).

Adherence to the Council Analytical Methodology

The CPA completed by AEG for Tacoma Power established a ten-year potential from 2022-2031 using an analytical methodology consistent with the Council procedures outlined in WAC 194-37-070 (5) as filed by Washington Commerce on November 28, 2016.

The Energy Analysis & Planning group at AEG was selected to complete this project because they are familiar with the Council's analytical methodology and with conservation measures and practices common to the Pacific Northwest.

The utility point of contact for the consulting firm was Rich Arneson, Project Director in Power Management, Conservation Planning Research and Evaluation Division.

The development of the CPA and publication of the final report took place from December 2020 through January 2022, with the majority of work completed in 2021. The base year of the study was 12 complete months from October 2019 through September 2020.[17]. The consultant was provided with the following information which was current as of April, 2021:

- Utility customer account billing data – annual consumption for each customer by sector and market segment (residential, commercial, industrial, and street lighting), as well as SIC/NAICS (where available) and building type (where available). This database incorporates county assessor data, conservation accomplishment data, and heating fuel type.
- 2016 Residential Building Stock Assessment (RBSA) and 2016 Residential Appliance Saturation Survey (RASS) reports, residential saturation surveys were used again in this study as the newest survey is still in the field.
- Load forecasts of energy and customer growth by rate class
- Facility information by building for the Joint-Base Lewis-McChord military base was retained from previous study
- Economic parameters: hourly avoided cost and price forecast, energy-related capacity costs, wind RECs, carbon dioxide emission costs, discount rate, and line loss factors (hourly for the residential market sector)

[17] While previous CPAs have used a true calendar year (January through December) for the base period, at the time this study commenced full calendar year data for 2020 was not available. This methodology is still consistent with a calendar year of use and serves as reasonable grounds for the rest of the study.

- A new analysis of time-sensitive value for avoided costs, affecting the value of measures whose impacts on the peak hour are less substantive than at other times.
- Historical data from existing conservation and demand side management programs, including achievements, evaluation results, and program expenditures
- Additional data as necessary, referenced in the main body of this report.

In addition to the data provided by Tacoma Power, AEG also relied heavily on regional data, particularly measure data from the most recent Regional Technical Forum information when available, and the Council's Seventh Power Plan. When a measure was present in both RTF and 2021 Power Plan datasets, we prioritized RTF where it was the more recent source. The notable exception to this was the RTF's most recent Residential Weatherization workbooks, where Tacoma Power's program data is in much greater alignment with older versions of the RTF's input data. Other sources, such as NEEA, BPA, U.S. DOE, and AEG's own internally developed tools and databases, were also utilized, as described in Section 2 of this report.

AEG's modeling approach for the 2022-2041 CPA analysis uses an end-use based, bottom-up analysis that considers individual equipment technologies to create a baseline energy forecast. The forecast is then modified interactively on a measure-by-measure basis to produce integrated forecasts of technical, achievable technical, and achievable economic potential. The analysis is conducted with AEG's Load Management Analysis and Planning (LoadMAP) tool[18].

The CPA was modeled in AEG's Excel-based LoadMAP tool, the current version of which was specifically developed to handle data reporting requirements in the State of Washington and throughout the Northwest. In this version of the model, measure savings, cost-effectiveness, and levelized costs are calculated in straightforward and transparent spreadsheets then directly output into a comprehensive line-by-line measure summary spreadsheet formatted for use in both program and resource planning. At the same time, the rigorous stock-accounting is used to develop the baseline projection and to calculate turnover for lost-opportunity measures.

Quality Control Reviews

Before submitting inputs and information to AEG, Rich Arneson and Conservation Resource Management staff reviewed the data for reasonableness**.** Specifically, he reviewed the input data for each sector, proposed revisions, and collaborated with consultant staff on final solutions. Through regular project meetings and careful review of interim deliverables and multiple drafts of the results and final report, Tacoma Power gained an understanding and satisfactory level of comfort with the approach and modeling software utilized by the consultant.

The final results and values were approved by Rich Arneson.

Tacoma Power staff use the 10-year achievable economic potential results, along with input from the Tacoma Power Integrated Resource Planning process to develop a biennium target for the 2022-2023 period.

Adherence to Procedures in WAC 194-37-070 subsection (5):

Below we describe how AEG satisfied or addressed each methodology used by the Council in its most recently published regional power plan when creating the 2022-2023 conservation target. All four procedures in WAC 194-37-070 (5) (a-d) were followed.

[18] AEG originally developed LoadMAP in 2007 and has since used it for dozens of utility-specific forecasting and potential studies across the U.S. Built in Excel, the LoadMAP framework is both accessible and transparent. LoadMAP develops a bottom-up forecast based on energy use by end use of major energy-consuming equipment. It includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life defined by the user. More detail is provided in Section 2 of this report.

(a) Technical Potential

Determine the amount of conservation that is technically feasible, considering measures and the number of these measures that could physically be installed or implemented, without regard to achievability or cost.

The 2020-2039 CPA assessed technical potential prior to performing any cost-effectiveness screening. Achievability factors were not applied to potential at this point, allowing for 100% of all measures which could be physically installed or implemented to be counted. Results of this analysis may be found on the "Measure Summary" tab of the "LoadMAP Potential" files.

(b) Achievable Technical Potential

Determine the amount of the conservation technical potential that is available within the planning period, considering barriers to market penetration and the rate at which savings could be acquired.

The 2022-2041 CPA applied the 2021 Power Plan's Ramp Rates to the technical potential, assessing achievable conservation potential prior to the application of cost-effectiveness screening. Ramp rates assigned to each measure as well as results of this analysis may be found on the "Measure Summary" tab of the "LoadMAP Potential" files.

(c) Economic Achievable Potential

***Establish the economic achievable potential**, which is the conservation potential that is cost-effective, reliable, and feasible, by comparing the total resource cost of conservation measures to the cost of other resources available to meet expected demand for electricity and capacity. A utility may use either of the following approaches to identify economic achievable potential:*

AEG utilized approach (ii) as described below for the Tacoma Power 2022-2041 CPA.

***(i) Integrated portfolio approach.** A utility may analyze, as a part of its integrated resource plan, the cost-effective potential of conservation resources over a range of potential future outcomes for unknown variables, such as future demand, costs, and resource availability. Economic achievable potential will be based on resource plan that achieves a long-run least-cost and least-risk electric power system considering all power system costs and quantifiable non-energy costs and benefits.*

Not applicable, AEG used approach (ii) below.

***(ii) Benefit-cost ratio approach.** A utility may establish economic achievable potential as those conservation measures or programs that pass a total resource cost test, in which the ratio of total benefits to total costs is one or greater. The benefit-cost calculation must use inputs that incorporate the cost of risks that would otherwise be reflected in an integrated portfolio approach.*

AEG utilized the "Benefit-cost ratio approach" in assessing Economic Achievable Potential in the 2022-2041 CPA. We worked with Tacoma staff to develop comprehensive, hourly avoided cost inputs, incorporating the total resource cost (TRC) test guidance in subsection (5) below.

(d) Total Resource Cost

***In determining economic achievable potential** as provided in (c) of this subsection, perform a life-cycle cost analysis of measures or programs to determine the net levelized cost, as described in this subsection:*

LoadMAP performs this life-cycle cost analysis. Calculations and formulas can be found on the "Economics" tab of the "LoadMAP Baseline" files and "Unstacked NEM Potential" tab of the "LoadMAP Potential" files.

***(ii) Include the incremental savings and incremental costs** of measures and replacement measures where resources or measures have different measure lifetimes;*

The LoadMAP model automatically accounts for savings throughout the lifetime of the selected efficient option. Additionally, LoadMAP monetizes the cost of additional replacements due to measures with varying lifetimes as a cost or benefit in the TRC calculation, depending on whether the baseline or efficient measure has a longer lifetime. This affects measures such as General Service Screw-In Lighting where a halogen or CFL would have to be replaced at some point throughout an LED lamp's lifetime.

***(iii) Calculate the value of the energy saved** based on when it is saved. In performing this calculation, use time differentiated avoided costs to conduct the analysis that determines the financial value of energy saved through conservation;*

AEG applied end use load shapes to the energy savings for each measure considered with the 2022-2041 CPA. These shapes were derived from the RTF's Generalized Load Shape (GLS) database and Tacoma Power billing data where appropriate. These load shapes were also applied to Tacoma's hourly price forecast, to account for the cost of energy, by end use, in each hour of the forecast horizon. Base-year load shapes were adjusted for each future year (2022 through 2041) to ensure like day-types between years (e.g. weekend and holidays are properly reflected within each year). The load shape used for each measure may be found on the "Measure Summary" tab of the "LoadMAP Potential" files.

***(iv) Include the increase or decrease in annual or periodic operations and maintenance** costs due to conservation measures;*

Where these costs have been quantified by the RTF or 2021 Plan in measure workbooks, they have been included in the analysis. Measure cost inputs are found on the "Measure Summary" tab of the "LoadMAP Potential" files.

***(v) Include avoided energy costs equal to a forecast of regional market prices,** which represents the cost of the next increment of available and reliable power supply available to the utility for the life of the energy efficiency measures to which it is compared;*

Tacoma provided AEG with avoided costs to use for the analysis[19]. These costs are based on the cost of the Block product under Tacoma Power's purchase power contract with the Bonneville Power Administration (BPA). Since Tacoma buys and sells energy on the market, costs were shaped at the hourly level to reflect additional market purchases and sales when prices are high and less value when prices are low. This was done by applying a fixed adder ($/MWh) to Tacoma Power's hourly market price forecast until the average hourly price equaled the cost of the BPA Block. This methodology was used as long as Tacoma Power's Net Requirement (NR) was below their High-Water Mark (HWM). In these cases, the raw Mic-C hourly price forecast was used as a basis of the conservation avoided cost. The data are in the "Avoided Costs" tab of each "LoadMAP" file. Newly in this study, the possible contract implications of conservation that does not impact the coincident peak load as strongly are incorporated in the value of a given measure – that is, if a conservation measure on an annual basis lowers the BPA contracted MWh amount but does *not* mitigate the peak load, it can potentially have a negative value for those hours.

***(vi) Include deferred capacity expansion benefits** for transmission and distribution systems;*

Tacoma Power reviewed the basis of utility specific T&D upgrades and that needed work was to address failing and old equipment rather than increasing capacity. Therefore, we determined that conservation would not result in a transmission or distribution system deferral. These costs are included in the avoided costs Tacoma provided for the analysis, available in the "Avoided Costs" tab of each "LoadMAP" file

***(vii) Include deferred generation benefits** consistent with the contribution to system peak capacity of the conservation measure;*

Tacoma Power reviewed the basis of utility specific generation capacity benefits resulting from energy conservation and determined that the existing machine capacity of the utility's resource portfolio well exceeds peak retail demand. Therefore, as a placeholder for this study, Tacoma Power developed this cost based on analysis of a small, short-term capacity contract it has with a neighboring utility. These costs are included in the

[19] A detailed description of the process used by Tacoma Power to define hourly avoided energy costs may be found in Tacoma's "2016 Conservation Avoided Cost Write-Up" document.

avoided costs Tacoma provided for the analysis, available in the “Avoided Costs” tab of each “LoadMAP” file. Tacoma Power plans to continue to investigate market values of generation capacity for use in future CPAs.

(viii) Include the social cost of carbon emissions *from avoided non-conservation resources;*

Tacoma Power provided results from applying the United States Government Inter-Agency Working Group on Social Cost of Carbon, cost assumptions at the 3% discount rate to the Tacoma Power resource portfolio as documented by the California Air Resource Board. These were used in the LoadMAP analysis and can be found on the “Avoided Cost” tab of the “LoadMAP Potential” files. These costs are externalized values.

(ix) Include a risk mitigation credit *to reflect the additional value of conservation, not otherwise accounted for in other inputs, in reducing risk associated with costs of avoided non-conservation resources;*

The value of conservation includes the risk mitigation noted in v, vi, vii, viii and x. We found no other risk mitigation credits to account for at the time of the study.

(x) Include all non-energy impacts *that a resource or measure may provide that can be quantified and monetized;*

Where these costs have been quantified by the RTF or 2021 Plan in measure workbooks, they have been included in the analysis. Measure cost inputs are found on the “Measure Summary” tab of the “LoadMAP Potential” files.

(xi) Include an estimate of program administrative costs;

Tacoma provided administrative costs estimates for each program offered. These were used in the LoadMAP analysis and can be found on the “Measure Summary” tab of the “LoadMAP Potential” files.

(xii) Include the cost of financing measures *using the capital costs of the entity that is expected to pay for the measure;*

At the time of this study, the Tacoma Power financing cost of capital used throughout the organization is 3% real.

(xiii) Discount future costs and benefits *at a discount rate equal to the discount rate used by the utility in evaluating non-conservation resources; and*

Tacoma uses a real discount rate when evaluating all resources which equals our capital financing costs. At this time that rate equals 3%. This value is incorporated in the LoadMAP analysis. This input is entered on the Variables tab of the LoadMAP files.

(xiv) Include a ten percent bonus for the energy and capacity benefits *of conservation measures as defined in 16 U.S.C. § 839a of the Pacific Northwest Electric Power Planning and Conservation Act.*

Tacoma Power applied the ten percent bonus to the value of energy related avoided costs (v, vi and vii above). The bonus plus avoided costs Tacoma were used in the analysis. The specific values are available in the “Avoided Costs” tab of each “LoadMAP” file.

B

MARKET PROFILES

As described in Chapter 1 of this study, market profiles describe electricity use by sector, segment, end use and technology in the base year of the study (2020). The market profiles are given for average, existing buildings.

Chapter 2 includes market profiles for sectors as a whole, but this workbook contains segment-level detail within each sector. This appendix presents the following market profiles:

- Residential market profiles by segment (Table C-1 through C-5)
- JBLM Residential market profiles by segment (Table C-6 and C-7)
- Commercial market profiles by building type (Table C-8 through C-22)
- Industrial market profiles by segment have not been included in this report. Segment-level detail was included in the analysis of the industrial sector but excluded from the report to prevent disclosure of data that may be sensitive for some of Tacoma's larger customers.
- JBLM Commercial market profiles (Table C-23 through C-35)
- Street Lighting market profiles (Table C-36 through C-38)

Tacoma Power 2021
Market Profiles.xlsx

C

CUSTOMER ADOPTION FACTORS

As described in Chapter 2, to estimate the rate at which measures are phased into the study given market barriers such as customer preference, imperfect information, and commercial availability of technologies; we apply a set of customer adoption factors. These are also referred to as ramp rates or take rates. The values are the factors applied to the technical potential for a given measure in a given year to arrive at the Achievable Technical potential. These factors may be found in Table C-1 below.

Measures are divided into two categories, each of which has its own timing and achievability considerations:

- Lost Opportunity potential occurs at the time of equipment burnout. 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. These "LO" ramp rate factors increase over time to values of either 85% or 55% and apply only to the subset of units which turn over in any given year.
- Retrofit potential is 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. Since these ramp rates apply to all units in the market, "Retro" ramp rates instead sum to either 85% or 55% and are intended to phase in potential throughout the study period. The faster ramp rates (e.g. summing up to 85% sooner) will phase potential in over a shorter timeframe.

Table C-1 Ramp Rates used in CPA Analysis (2021 Power Plan)

Ramp Rate	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2039	2040	2041
Retro12Med	10.9%	10.9%	10.9%	10.9%	10.9%	9.8%	7.9%	6.3%	5.0%	4.0%	3.2%	2.6%	2.1%	1.7%	1.3%	1.1%	0.0%	0.0%
Retro5Med	4.3%	5.3%	6.5%	7.5%	8.6%	10.0%	11.0%	11.2%	10.6%	9.1%	7.0%	4.7%	2.7%	1.3%	0.6%	0.2%	0.1%	0.0%
Retro1Slow	0.3%	0.5%	0.9%	1.5%	2.2%	3.2%	4.4%	5.7%	7.0%	8.3%	9.3%	9.9%	9.9%	9.4%	8.2%	6.8%	5.2%	3.6%
Retro50Fast	45.0%	21.0%	14.0%	9.0%	6.0%	3.0%	1.3%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Retro20Fast	22.1%	15.5%	10.7%	8.4%	7.3%	6.3%	5.4%	4.6%	3.9%	3.3%	2.7%	2.1%	1.7%	1.3%	1.0%	0.9%	0.7%	0.6%
RetroEven20	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Retro3Slow	0.6%	0.9%	1.7%	3.0%	4.7%	6.6%	8.4%	9.8%	10.6%	10.6%	9.9%	8.7%	7.1%	5.5%	4.1%	2.9%	1.9%	1.2%
LO12Med	10.9%	21.9%	32.8%	43.7%	54.7%	64.5%	72.4%	78.7%	83.7%	87.8%	91.0%	93.6%	95.6%	97.3%	98.6%	99.7%	99.7%	99.7%
LO5Med	4.3%	9.6%	16.0%	23.5%	32.1%	42.1%	53.1%	64.3%	74.8%	83.9%	90.9%	95.8%	98.7%	100.0%	100.0%	100.0%	100.0%	100.0%
LO1Slow	0.5%	0.8%	1.7%	3.2%	5.4%	8.6%	13.0%	18.7%	25.7%	34.0%	43.3%	53.1%	63.1%	72.4%	80.6%	87.3%	92.3%	96.0%
LO50Fast	45.0%	66.0%	80.0%	89.0%	95.0%	97.9%	99.3%	99.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
LO20Fast	22.1%	37.6%	48.4%	56.7%	64.0%	70.4%	75.8%	80.4%	84.3%	87.6%	90.3%	92.4%	94.1%	95.4%	96.4%	97.1%	97.7%	98.4%
LOEven20	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%	35.0%	40.0%	45.0%	50.0%	55.0%	60.0%	65.0%	70.0%	75.0%	80.0%	85.0%	90.0%
LO3Slow	0.6%	1.4%	3.2%	6.2%	10.9%	17.6%	26.0%	35.8%	46.4%	57.0%	66.9%	75.6%	82.7%	88.3%	92.3%	95.2%	97.1%	98.3%
LO80Fast	76.0%	83.0%	88.0%	92.0%	95.0%	97.0%	98.0%	99.0%	99.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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MEASURE LIST

Here we summarize the list of measures evaluated in the 2022-2041 CPA

The data are presented in eight tables, separated by sector and modeling type (equipment or non-equipment)[20].

Tacoma Power 2021
CPA - Measure List.x

[20] See Chapter 2 for an explanation of equipment vs non-equipment measures in the LoadMAP framework

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