Applied Energy Group

TACOMA POWER CONSERVATION POTENTIAL ASSESSMENT, 2020-2039

June 1, 2019

Report prepared for:
TACOMA POWER

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EXECUTIVE SUMMARY

In mid-2016, Tacoma Power (Tacoma) contracted with Applied Energy Group (AEG) to conduct this Conservation Potential Assessment (CPA) in support of its conservation and resource planning activities. This report documents this effort and provides estimates of the potential reductions in annual energy usage for electricity customers in the Tacoma Power service territory from energy conservation efforts in the time period of 2020 to 2039.

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 the technical, Technical Achievable, and Economic Achievable potential at the measure level for energy efficiency within the Tacoma service territory over the 2020 to 2039 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 2020-2021 Biennium 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-1-1 summarizes the results of this study at a high level. AEG analyzed potential for the residential, commercial, industrial, street lighting, and JBLM market sectors as well as for substation distribution efficiency improvements. The ten-year potential, in 2029, is 233,660 MWh, or 26.7 aMW.

Table ES-1-1 Economic Achievable Potential in 2029

Market Sector	Economic Achievable Potential (MWh)	% of Total Potential	Average Megawatts (aMW)
Residential	55,827	23.9%	6.4
JBLM Residential	1,737	0.7%	0.2
Commercial	89,125	38.1%	10.2
JBLM Commercial	11,242	4.8%	1.3
Industrial	62,468	26.7%	7.1
Street Lighting	2,713	1.2%	0.3
Distribution Efficiency	10,548	4.5%	1.2
Total	**233,660**	**100.0%**	**26.7**

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, and compressed air system upgrades.

Comparison with Prior Study

Compared to the prior CPA, which estimated potential for the 2018-2019 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 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:

- EISA 2007 phase two is in effect in the first year of potential. This eliminates the forward momentum of cumulative previous savings able to build up in the prior study.
- Increased saturation of efficient technologies in the baseline. For example, updated RTF guidelines expect 80%-90% transformation of the lighting market to LEDs in the baseline within the study horizon, even above the EISA 2007 phase two impact.
- Updated building stock efficiency in the Residential sector. NEEA released the completed data sets from its 2014 Residential Building Stock Assessment, which showed continuing improvements in the shell of average homes as a result of Washington's strict building codes. Lower home usage means less available potential for savings.
- In the Commercial sector, the lighting reduction is offset by new bundled controls for LED fixtures.

Table ES-1-2 compares 10-year potential between the two studies at a sector level.

Table ES-1-2 Economic Achievable Potential in 2029

Market Sector	Current Study: 2020-2029 Potential (MWh)	*Prior Study: 2018-2027 Potential (MWh)*	*Change from Prior Study (MWH)*
Residential	55,827	*99,164*	*-43,337*
JBLM Residential	1,737	*1,477*	*260*
Commercial	89,125	*87,880*	*1,245*
JBLM Commercial	11,242	*7,068*	*4,174*
Industrial	62,468	*57,569*	*4,899*
Street Lighting	2,713	*8,582*	*-5,869*
Distribution	10,548	*15,800*	*-5,252*
Total	**233,660**	***277,540***	***-43,880***

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INTRODUCTION

This report documents the results of the Tacoma Power 2020-2039 Conservation Potential Assessment (CPA) as well as the steps followed in its completion. Throughout this study, AEG worked with Tacoma Power 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) Seventh Power Plan[1], AEG then developed an independent estimate of achievable, economic conservation potential within Tacoma Power's service territory between 2020 and 2039.

Goals of the 2020-2039 CPA

The primary objective of this CPA was to assist in developing Tacoma Power's 2020-2021 Biennium conservation target under the State of Washington's Energy Independence Act[2], 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 (IRP) process. To this end, AEG developed hourly Economic Achievable conservation inputs by program for input into Tacoma Power's 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 also 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, and well-vetted nationwide data when appropriate, AEG developed a comprehensive summary of measures. This summary documents input assumptions and sources on a per-unit value, 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

Between 2016 and 2017, AEG successfully completed Tacoma Power's 2020-2039 Conservation Potential Assessment, following the methodology of the Council's then-current Sixth Power Plan. In the two years since, the Council has published their Seventh Power Plan, which includes updated measure assumptions, new measures, and a new suite of achievability Ramp Rates. Between studies, NEEA also finalized the 2016 Residential Building Stock Assessment (RBSA), which AEG incorporated into the current CPA.

In addition to updates in Council methodology, AEG updated the base-year of the potential study from 2017 to 2017 and incorporated two additional years of conservation accomplishments into the baseline. Tacoma Power also provided an updated load forecasts, new avoided costs, and updated measure data

[1] "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/

(such as weatherization assumptions and commercial SEM eligible accounts). AEG then developed modeling assumptions independent of the prior study to estimate potential between 2020 and 2039 using the most up-to-date data available.

Report Contents

This report is divided into six chapters and four appendices, summarizing the approach, assumptions, and results of Tacoma Power's 2020-2039 CPA. We describe each section below:

- Analysis Approach and Data Development. Detailed description of AEG's approach to conducting Tacoma Power's 2020-2039 CPA and documentation of primary and secondary sources used.
- Market Characterization and Market Profiles. Characterization of Tacoma Power's service territory in the base year of the study, 2017, including 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 by end use and technology.
- Baseline Projection. Projection of baseline energy consumption under a frozen-efficiency case, described at the end-use level. 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.
- Overall Conservation Potential. Summary of conservation potential for Tacoma Power's entire service territory for selected years between 2020 and 2039. Includes 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, end use, and risk. Supply curves by market sector are also provided.
- Comparison with Prior Study. Detailed comparison of changes between prior CPA and current study.

Appendices:

- Consistency with Seventh Plan Methodology. Documentation of how AEG's approach in conducting the 2020-2039 CPA aligns with the Seventh 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 several 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)
CFL	Compact Fluorescent Lamp
DHW	Domestic Hot Water
DSM	Demand Side Management
EE	Energy Efficiency
EIA	Energy Information Administration
EUL	Estimated 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
WH	Water Heater

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 year, 2017. This included using Tacoma data and other secondary data sources such as the Energy Information Administration (EIA).
2. Developed a baseline projection of energy consumption by sector, segment, end use, and technology for 2017 through 2039.
3. Defined and characterized several hundred energy conservation measures (ECMs) to be applied to all sectors, segments, and end uses.
4. Estimated technical, Technical Achievable, and Economic Achievable potential energy savings at the measure level for 2020-2039.

LoadMAP Model

For this analysis, AEG used its Load Management Analysis and Planning tool (LoadMAP™) version 5.0 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.

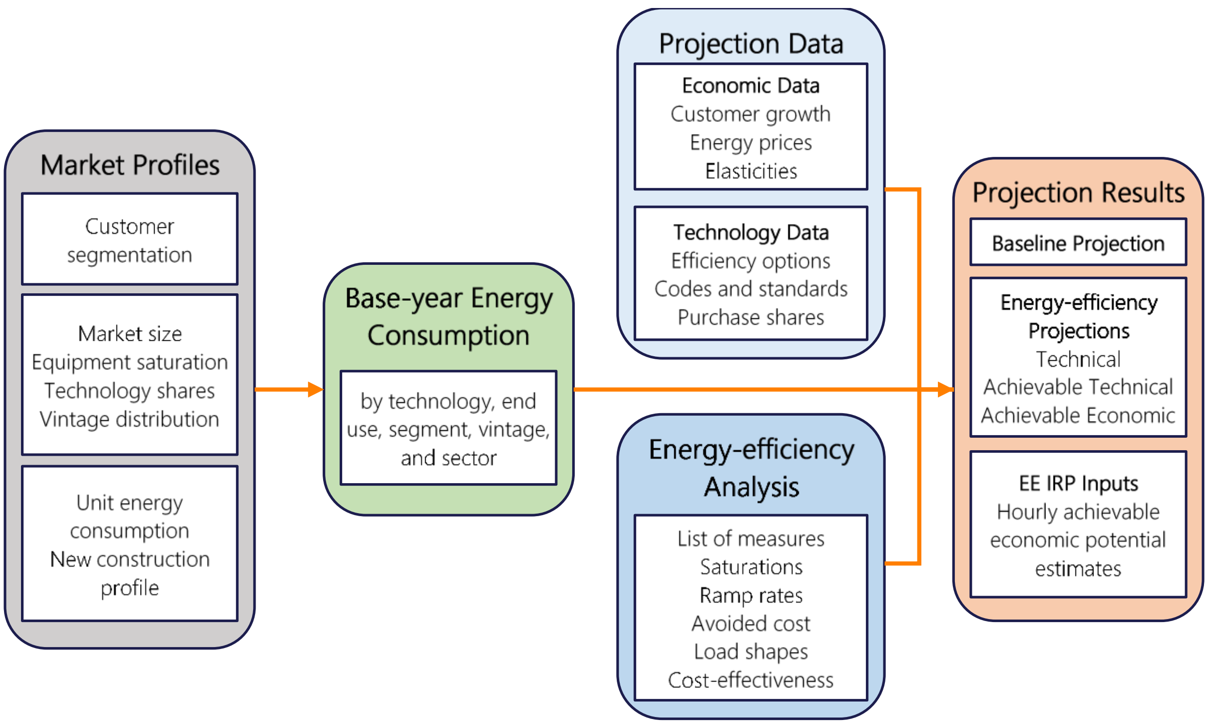
- Embodies the basic principles of rigorous end-use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced 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. [3]

Figure 2-1 LoadMAP Analysis Framework



Definitions of Potential

Before we delve into the details of the analysis approach, it is important to define what we mean when discussing conservation potential. In this study, the savings estimates are developed for three types of potential: technical potential, Technical Achievable potential, and Economic Achievable potential. These are developed at the measure level, and results are provided as hourly savings impacts over the 20-year forecasting horizon. The various levels are described below.

[3] 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).

- Technical Potential is defined as the theoretical upper limit of conservation potential. It assumes that customers adopt all feasible measures regardless of their cost. At the time of existing equipment failure, customers replace their equipment with the most efficient option available. In new construction, customers and developers also choose the most efficient equipment option.

  Technical potential also assumes the adoption of every other available measure, where applicable. For example, it includes installation of high-efficiency windows in all new construction opportunities and air conditioner maintenance in all existing buildings with central and room air conditioning. These retrofit measures are phased in over several years to align with the stock turnover of related equipment units, rather than modeled as immediately available all at once.
- Technical Achievable 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. The customer adoption rates used in this study were the ramp rates developed for the Northwest Power & Conservation Council's Seventh Plan.
- Economic Achievable Potential further refines Technical Achievable potential by applying an economic 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 costs of delivering the measure through a utility program, including monetized non-energy impacts. These costs are the incremental cost of the given efficiency measure relative to the relevant baseline course of action, plus any administrative costs that are incurred by the program to deliver and implement the measure. If the benefits outweigh the costs (that is, if the TRC ratio is greater than 1.0), a given measure is included in the economic potential.

Market Characterization

Now that we have described the modeling tool and provided the definitions of the potential cases, the first step in the actual analysis approach is market characterization. In order to estimate the savings potential from energy-efficient measures, it is necessary to understand how much energy is used today and what equipment is currently in service. This 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 used. 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 2-1.

Table 2-1 Overview of Tacoma Analysis Segmentation Scheme

Dimension	Segmentation Variable	Description
1	Sector	Residential, commercial, industrial, JBLM residential, JBLM commercial, street lighting
2	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
3	Vintage	Existing and new construction
4	End uses	Cooling, lighting, water heating, motors, etc. (as appropriate by sector)
5	Appliances/end uses and technologies	Technologies such as lamp type, air conditioning equipment, motors by application, etc.
6	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 year, 2017. 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 2017 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 next step was to develop market profiles for each sector, customer segment, end use, and technology. A 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.

The market characterization results and the market profiles are presented in Chapter 3 and Appendix B.

Baseline Projection

The next step was to develop the baseline projection of annual electricity use for 2017 through 2039 by customer segment and end use without new utility conservation programs.

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, changes in retail rates, and unemployment projections. These assumptions, along with econometric coefficients, were incorporated into the LoadMAP model, ensuring alignment with the official load forecast. When aligning with the official forecast, AEG excluded the impacts of future federal standards as well as differing customer growth rates between market segments. AEG also backed future conservation impacts out of the official forecast using data provided by Tacoma Power.

We then updated the end-use projection for use in the CPA. With guidance from Tacoma Power, we included additional impacts that were not captured by the official econometric model. This includes the impacts of future federal standards, which drive energy consumption down through the study period. Of particular interest is the second phase of the EISA 2007 general service lighting standard which will be going into effect in 2020. Additionally, per discussions with Tacoma Power, we varied the customer growth rate in the residential market sector. Based on recent large construction projects in the territory, a large majority of new construction is estimated to occur in the multifamily market segments. To account for this, AEG varied growth rates by segment, allocating 90% of customer growth to the multifamily segments, 9% to the single-family segments, and 1% to manufactured homes. Since multifamily dwellings tend to consume less energy, this had the effect of lowering the baseline projection.

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 December 2016 are included in the baseline. This includes the impacts of 2017 Washington State Energy Code (WSEC). The baseline projection does not include any naturally occurring conservation that might take place in the potential forecast period (2020 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 which includes 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

We present the baseline-projection results for the system as a whole and for each sector in Chapter 3.

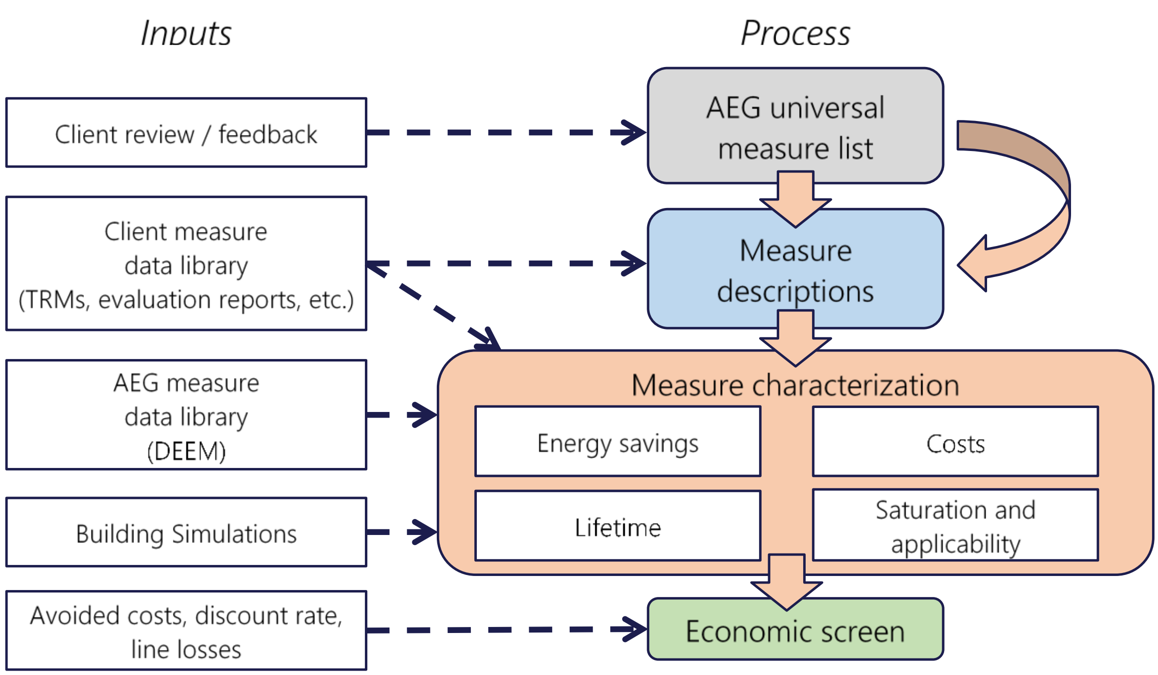
Energy Conservation Measure Development

This section describes the framework used to assess the savings, costs, and other attributes of energy conservation measures (ECM). These characteristics form the basis for measure-level cost-effectiveness analyses as well as for determining measure-level savings. For all measures, AEG assembled information to reflect equipment performance, incremental costs, and equipment lifetimes. We used this information along with Tacoma's avoided cost data in the economic screen to determine economically feasible measures.

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 lined up with programmatic experience.

We compiled a robust list of ECMs for each customer sector, drawing upon Tacoma program experience, AEG's own measure databases and building simulation models, and secondary sources, primarily Regional Technical Forum (RTF) measure spreadsheets. This universal list of measures covers all major types of end-use equipment, as well as devices and actions to reduce energy consumption. If considered today, some of these measures would not pass the economic screens initially 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 are efficient energy-consuming pieces of equipment that save energy by providing the same service with a lower energy requirement than a standard unit. An example is an ENERGY STAR refrigerator that replaces a standard efficiency 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 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, 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 (building orientation, passive solar lighting)
    - Displacement measures (ceiling fan to reduce use of central air conditioners)
    - Retro-commissioning
    - Residential behavioral programs
    - Energy Management programs

We 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 we assembled the list of measures, the project team assessed their energy-saving characteristics. For each measure, we also characterized incremental cost, service life, and other performance factors. Following the measure characterization, we performed an economic screening of each measure, which serves as the basis for developing the economic and achievable potential.

Representative Measure Data Inputs

To provide an example of the energy-efficiency measure data, Table 2-2 and Table 2-3 present examples of the detailed data inputs behind both equipment and non-equipment measures, respectively, for the case of residential Central Air Conditioning (CAC) in single-family homes. Table 2-2 displays the various efficiency levels available as equipment measures, as well as the corresponding useful life, energy usage, and cost estimates. The columns labeled On Market and Off Market reflect equipment availability due to codes and standards or the entry of new products to the market.

Table 2-2 Example Equipment Measures for Central AC – Single-Family Home

Efficiency Level	Useful Life	Equipment Cost	Energy Usage (kWh/yr)	On Market	Off Market
SEER 13	15	$2,097	542	2017	n/a
SEER 14	15	$2,505	504	2017	n/a
SEER 15	15	$2,913	470	2017	n/a
SEER 16	15	$3,321	441	2017	n/a
SEER 18	15	$4,140	392	2017	n/a
SEER 20	15	$4,955	353	2017	n/a

Table 2-3 lists some of the non-equipment measures applicable to zonal electric resistance heating in an existing single-family home. All measures are evaluated for cost-effectiveness based on the lifetime benefits relative to the cost of the measure. The total savings, costs, and monetized non-energy impacts are calculated for each year of the study and depend on the base year saturation of the measure, the applicability[4] of the measure, and the savings as a percentage of the relevant energy end uses.

Table 2-3 Example Non-Equipment Measures – Single Family Home, Existing

End Use	Measure	Saturation in 2017[5]	Applicability	Life (yrs.)	Measure Installed Cost per Unit	Energy Savings per Unit (kWh/yr)	Unit of Measure
Heating	Insulation - Ceiling Installation	16%	19%	45	$1.80	2.2	Square foot of roof
Heating	Ductless Mini Split Heat Pump (Zonal)	5%	61%	15	$3,610	1,819	Household
Heating	Windows - High Efficiency (SP to CI30)	15%	21%	45	$22.19	10.8	Square foot of window
Heating	Windows - High Efficiency (SP to CI22)	2%	3%	45	$26.62	11.6	Square foot of window

4 The applicability factors take into account whether the measure is applicable to a particular building type and whether it is feasible to install the measure. For instance, attic fans are not applicable to homes where there is insufficient space in the attic or there is no attic at all.

5 Note that saturation levels reflected for the base year change over time as more measures are adopted.

Table 2-4 summarizes the number of measures evaluated for each segment within each sector.

Table 2-4 Number of Measures Evaluated

Sector	Total Measures	Measure Permutations w/ 2 Vintages	Measure Permutations w/ All Segments
Residential	104	208	1,035
JBLM Residential	103	206	412
Commercial	120	240	3,585
JBLM Commercial	119	238	3,094
Industrial	107	214	1,689
Street Lighting	41	82	114
Distribution	1	1	1
Total Measures Evaluated	**595**	**1,189**	**9,930**

Calculation of Energy Conservation Potential

The approach we used for this study to calculate the 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 Seventh Plan, and the National Action Plan for Energy-Efficiency (NAPEE) Guide for Conducting Potential Studies.[6] These documents represent credible and comprehensive industry best practices for specifying conservation potential. Additional information on WAC 194-37 compliance may be found in Appendix A. As described in the Executive Summary, three types of potential were developed as part of this effort: technical potential, Technical Achievable potential, and Economic Achievable potential. The calculation of technical potential is a straightforward algorithm which, as described above, assumes that 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 that specify the percentage of customers that will select the highest–efficiency economic option. This phases potential in over a more 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. We used the Northwest Power and Conservation Council's Seventh Plan ramp rates to develop these achievability factors for each measure. Applying these ramp rates as factors leads directly to the Technical Achievable potential.

Screening Measures for Cost-Effectiveness

With Technical Achievable potential established, the final step is to apply an economic screen and arrive at the subset of measures that are cost-effective and ultimately included in Economic Achievable potential.

LoadMAP performs an economic screen for each individual measure in each year of the planning horizon. This study uses the TRC test as the cost-effectiveness metric, which compares the lifetime hourly energy

[6] 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.

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, discounting the dollar savings to the present value equivalent. 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.

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.

This constitutes the Economic Achievable 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 the final appendix to 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 data
- Northwest regional data
- AEG's databases and analysis tools
- Other secondary data and reports

Tacoma Data

Our 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 very 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.
    - o Presence of electric heat study
    - o 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:

- Northwest Power and Conservation Council Seventh Plan and Regional Technical Forum workbooks. To develop its Power Plan, the Council maintains workbooks with detailed information about measures. This was used as the primary data source when Tacoma-specific program data was not available. The most recent data and workbooks available were used at the time of this study.
- Northwest Power and Conservation Council Generalized Least Squares (GLS) Load Shapes. September 29, 2016. https://rtf.nwcouncil.org/work-products/supporting-documents
- Bonneville Power Administration Implementation Manual. Select measures
- Northwest Energy Efficiency Alliance, Residential Building Stock Assessment II, Single-Family Homes Report 2016-2017, https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Single-Family-Homes-Report-2016-2017.pdf
- Northwest Energy Efficiency Alliance, Residential Building Stock Assessment II, Manufactured Homes Report 2016-2017, https://neea.org/img/uploads/Residential-Building-Stock-Assessment-II-Manufactured-Homes-Report-2016-2017.pdf
- Northwest Energy Efficiency Alliance, Residential Building Stock Assessment II, Multifamily Buildings Report 2016-2017, https://neea.org/img/documents/Residential-Building-Stock-Assessment-II-Multifamily-Homes-Report-2016-2017.pdf
- Northwest Energy Efficiency Alliance, 2014 Commercial Building Stock Assessment, December 16, 2014, http://neea.org/docs/default-source/reports/2014-cbsa-final-report_05-dec-2014.pdf?sfvrsn=12.
- Northwest Energy Efficiency Alliance, 2014 Industrial Facilities Site Assessment, December 29, 2014, http://neea.org/resource-center/regional-data-resources/industrial-facilities-site-assessment

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 EE potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies, which include Seattle City Light, PacifiCorp, Avista and numerous studies from across the U.S. In addition, we used the information about impacts of building codes and appliance standards from recent reports for the Edison Electric Institute[7].

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 2017 AEO.
- American Community Survey. The US Census American Community Survey is an ongoing survey that provides data every year on household characteristics. Data for Tacoma were available for this study. http://www.census.gov/acs/www/
- Local Weather Data. Weather from NOAA's National Climatic Data Center for Tacoma, WA 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.

[7] AEG staff has prepared three white papers on the topic of factors that affect U.S. electricity consumption, including appliance standards and building codes. Links to all three white papers are provided:
http://www.edisonfoundation.net/IEE/Documents/IEE_RohmundApplianceStandardsEfficiencyCodes1209.pdf
http://www.edisonfoundation.net/iee/Documents/IEE_CodesandStandardsAssessment_2010-2025_UPDATE.pdf.
http://www.edisonfoundation.net/iee/Documents/IEE_FactorsAffectingUSElecConsumption_Final.pdf

- 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 2-5. 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 2011 Energy Use and Conservation Survey, the 2016 RBSA, 2014 CBSA, 2014 IFSA, DOE's RECS 2009, the American Housing Survey, 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 2-5 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 2017
Annual intensity	Residential: Annual use per household Commercial: Annual use per square foot Industrial: Annual use per employee	Tacoma account database 2016 RBSA, 2014 CBSA, and 2014 IFSA AEG's Energy Market Profiles AEO 2017 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 2011 Energy Use and Conservation Survey 2016 RBSA, 2014 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 2017 DEER Recent AEG studies
Load Shapes	Share of technology energy use that occurs during each hour of the year	NWPCC's Generalized Least Square (GLS) load shapes, as updated for the Seventh Plan Tacoma Power metered industrial and solar PV shapes (for street lighting)

Data Application for Baseline Projection

Table 2-6 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 2-6 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[8] Appliance/efficiency standards analysis Tacoma program results and evaluation reports
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 September 2016, as shown in Table 2-7, Table 2-8 and Table 2-9. The assumptions tables here extend through 2025, after which all standards are assumed to hold steady.

[8] 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.

Table 2-7 Residential Electric Equipment Standards [9]

<table>
<tr><th>End Use</th><th>Technology</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="2">Cooling</td><td>Central AC</td><td colspan="9">SEER 13.0</td></tr>
<tr><td>Room AC</td><td colspan="9">EER 10.8</td></tr>
<tr><td>Cooling/ Heating</td><td>Air-Source Heat Pump</td><td colspan="9">SEER 14.0 / HSPF 8.2</td></tr>
<tr><td rowspan="2">Water Heating</td><td>Water Heater (<=55 gallons)</td><td colspan="9">EF 0.95</td></tr>
<tr><td>Water Heater (>55 gallons)</td><td colspan="9">EF 2.0 (Heat Pump Water Heater)</td></tr>
<tr><td rowspan="2">Lighting</td><td>General Service</td><td colspan="2">Advanced Incandescent (~20 lumens/watt)</td><td colspan="7">Advanced Incandescent (~45 lumens/watt)</td></tr>
<tr><td>Linear Fluorescent</td><td>T8 (89 lm/W lamp)</td><td colspan="8">T8 (92.5 lm/W lamp)</td></tr>
<tr><td rowspan="4">Appliances</td><td>Refrigerator</td><td colspan="9" rowspan="2">25% more efficient than the 1997 Final Rule (62 FR 23102)</td></tr>
<tr><td>Freezer</td></tr>
<tr><td>Clothes Washer</td><td colspan="9">IMEF 1.84 / WF 4.7</td></tr>
<tr><td>Clothes Dryer</td><td colspan="9">3.73 Combined EF</td></tr>
<tr><td>Miscellaneous</td><td>Furnace Fans</td><td>Conventional</td><td colspan="8">ECM</td></tr>
</table>

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

Table 2-8 Commercial Electric Equipment Standards [10]

<table>
<tr><th>End Use</th><th>Technology</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td rowspan="3">Cooling</td><td>Chillers</td><td colspan="9">2007 ASHRAE 90.1</td></tr>
<tr><td>RTUs</td><td colspan="9">EER 11.9/11.2</td></tr>
<tr><td>PTAC</td><td colspan="4">EER 9.8</td><td colspan="5">EER 11.0</td></tr>
<tr><td rowspan="2">Cooling/ Heating</td><td>Heat Pump</td><td colspan="2">EER 11.0/
COP 3.3</td><td colspan="7">EER 11.4/
COP 3.3</td></tr>
<tr><td>PTHP</td><td colspan="9">EER 10.4/COP 3.1</td></tr>
<tr><td>Ventilation</td><td>All</td><td colspan="9">Constant Air Volume/Variable Air Volume</td></tr>
<tr><td rowspan="3">Lighting</td><td>General Service</td><td colspan="3">Advanced Incandescent
(~20 lumens/watt)</td><td colspan="6">Advanced Incandescent
(~45 lumens/watt)</td></tr>
<tr><td>Linear Lighting</td><td colspan="9">T8 (82.5 lm/W lamp)</td></tr>
<tr><td>High Bay</td><td>51.2 lm/W</td><td colspan="8">Metal Halide (55.6 lm/W)</td></tr>
<tr><td rowspan="5">Refrigeration</td><td>Walk-In</td><td colspan="2">COP 3.2</td><td colspan="7">COP 6.1</td></tr>
<tr><td>Reach-In</td><td colspan="9">32 kWh/sqft</td></tr>
<tr><td>Glass Door</td><td colspan="9">12-28% more efficient than EPACT 2005</td></tr>
<tr><td>Open Display</td><td colspan="3">1,537 kWh/ft</td><td colspan="6">1,453 kWh/ft</td></tr>
<tr><td>Icemaker</td><td colspan="9">6.1 kWh/100 lbs.</td></tr>
<tr><td>Food Service</td><td>Pre-Rinse</td><td colspan="2">1.6 GPM</td><td colspan="7">1.0 GPM</td></tr>
<tr><td>Motors</td><td>All</td><td colspan="9">Expanded EISA 2007</td></tr>
</table>

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

Table 2-9 Industrial Electric Equipment Standards [11]

End Use	Technology	2017	2018	2019	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 11.0/ COP 3.3		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 (~20 lumens/watt)			Advanced Incandescent (~45 lumens/watt)					
	Linear Lighting	T8 (82.5 lm/W lamp)								
	High Bay	51.2 lm/W	Metal Halide (55.6 lm/W)							
Motors	All	Expanded EISA 2007								

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

Conservation Measure Data Application

Table 2-10 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 2-10 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.	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 as real 2018 dollars. We applied a discount rate of 3% in real dollars. 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 values, which were converted into annual values 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, "Retro", applied before the 85% 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 Seventh Plan.

The customer adoption rates used in this study are available in the appendix.

3

MARKET CHARACTERIZATION AND MARKET PROFILES

In this section, we describe how customers in the Tacoma Power service territory use electricity in the base year of the study, 2017. It begins with a high-level summary of energy use across all sectors and then delves into each sector in more detail.

Figure 3-1 Tacoma Skyline (courtesy of Rob Green)

Overall Energy Use Summary

Total electricity consumption for all sectors for Tacoma in 2017 was 4,707 GWh. As shown in Figure 3-2 and Table 3-1, the combined civilian residential and JBLM residential sectors account for more than one-third (41.7%) of annual energy use. The combined civilian commercial and JBLM commercial sectors account for 34.7% of annual energy use. The industrial sector accounts for 23.1% while street lighting accounts for the remaining 0.4% of usage.

Within the Residential sector, civilian usage accounts for 40.7% of overall usage while JBLM residential accounts for 1.0%. Within the commercial sector, civilian usage accounts for 28.3% of overall usage while JBLM commercial accounts for 6.4%.

Figure 3-2 Sector-Level Electricity Use in Base Year 2017 (Annual GWh, Percent)

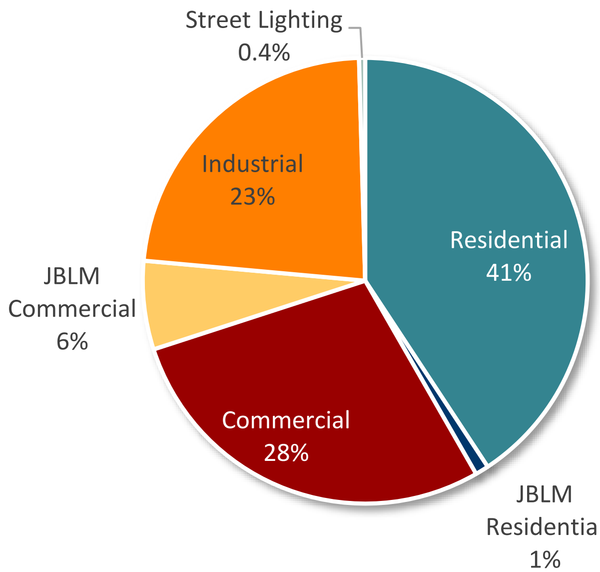


Table 3-1 Tacoma Sector Control Totals (2017)

Sector	Number of Customers/Buildings	Annual Electricity Use (GWh)	% of Annual Use
Residential	158,439	1,917	40.7%
JBLM Residential	4,420	46	1.0%
Commercial	20,058	1,333	28.3%
JBLM Commercial	5,525	302	6.4%
Industrial	872	1,088	23.1%
Street Lighting	41,368	21	0.4%
Total	**228,120**	**4,707**	**100.0%**

Residential Sector

The total number of households and electricity sales for the service territory were obtained from Tacoma's customer database. In 2017, there were over 158 thousand households in the Tacoma territory that used a total of 1,917 GWh. Average use per customer (or household) at 12,097 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 (2017)

Segment	Number of Customers	Electricity Use (GWh)	% of Annual Use	Annual Use/Customer (kWh/HH)
Single Family	113,941	1,465	76%	12,855
Single Family 2-4 units	5,835	96	5%	16,501
Low-Rise Multifamily	27,687	68	4%	2,442
High-Rise Multifamily	5,547	244	13%	44,040
Manufactured Home	5,429	44	2%	8,048
Total	**158,439**	**1,917**	**100%**	**12,097**

As we describe 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 3-3 shows the average distribution of annual electricity use by end use for all customers. Three main electricity end uses — space heating, water heating, and appliances — account for 74% of total use. Appliances include refrigerators, freezers, stoves, clothes washers, clothes dryers, dishwashers, and microwaves. 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 58.6% of homes within Tacoma Power's service territory contain some form of electric space heating. Approximately 45% of single family homes are electrically heater whereas approximately 90% of multifamily homes are electrically heated.

Figure 3-4 presents the electricity intensities by end use and housing type. Manufactured homes have the highest use per customer at 15,761 kWh/year, reflecting less efficient construction and equipment options as well as a higher saturation of electric space heating.

Figure 3-3 Residential Electricity Use by End Use (2017)

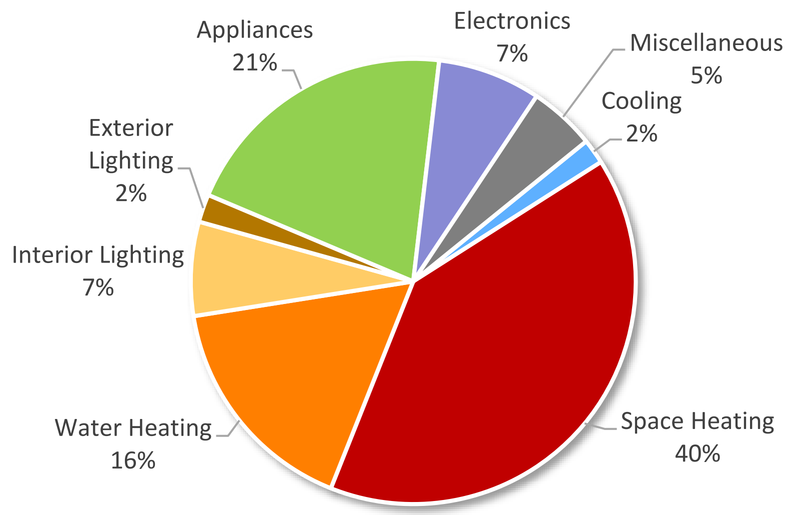


Figure 3-4 Residential Energy Intensity by End Use and Segment (Annual kWh/HH, 2017)

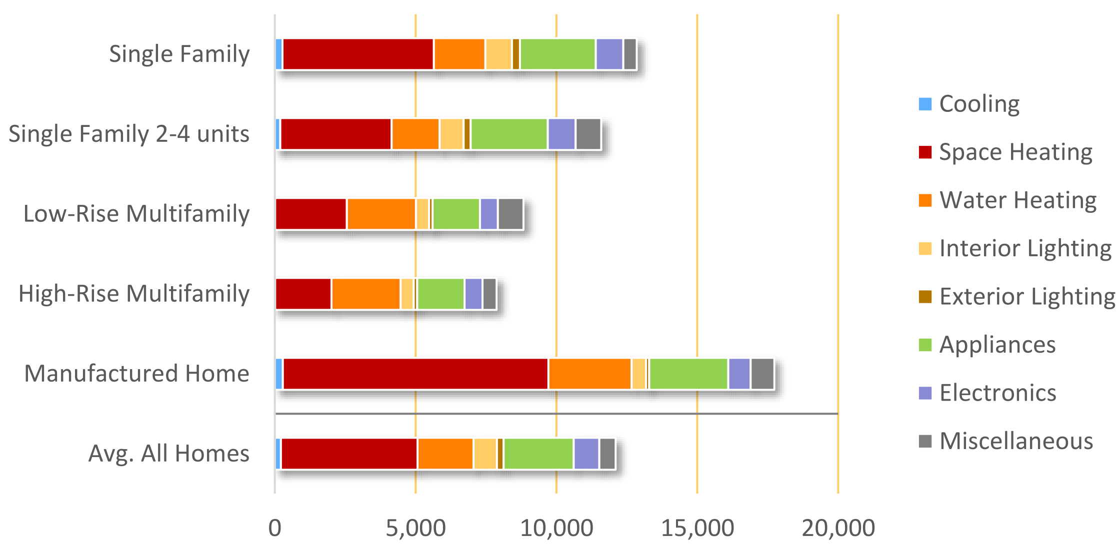


Table 3-3 Average Market Profile for the Residential Sector, 2017

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/HH)	Usage (GWh)
Cooling	Central AC	6.6%	579	38	6.0
	Room AC	24.6%	383	94	15.0
	Air-Source Heat Pump	14.9%	580	86	13.7
	Geothermal Heat Pump	0.3%	540	1	0.2
Heating	Electric Room Heat	35.5%	5,648	2,008	318.1
	Electric Furnace	15.6%	9,832	1,537	243.5
	Air-Source Heat Pump	14.9%	5,723	852	135.0
	Geothermal Heat Pump	0.3%	2,735	7	1.1
	Secondary Heating	23.1%	1,906	441	69.9
Water Heating	Water Heater (<= 55 Gal)	60.7%	3,009	1,826	289.4
	Water Heater > 55 Gal	5.0%	3,336	165	26.2
Interior Lighting	General Service Screw-in	100.0%	673	673	106.6
	Linear Lighting	100.0%	102	102	16.2
	Exempted Screw-In	100.0%	51	51	8.1
Exterior Lighting	Screw-in	100.0%	245	245	38.8
Appliances	Clothes Washer	86.4%	77	66	10.5
	Clothes Dryer	77.5%	730	565	89.6
	Dishwasher	80.2%	376	302	47.9
	Refrigerator	99.4%	704	700	110.9
	Freezer	31.6%	564	178	28.2
	Second Refrigerator	29.6%	819	242	38.4
	Stove/Oven	69.8%	426	297	47.1
	Microwave	104.8%	124	131	20.7
Electronics	Personal Computers	67.3%	161	108	17.2
	Monitor	134.6%	61	83	13.1
	Laptops	55.3%	42	23	3.7
	TVs	192.9%	114	219	34.7
	Printer/Fax/Copier	118.2%	42	50	7.9
	Set-top Boxes/DVRs	320.0%	99	316	50.0
	Devices and Gadgets	100.0%	108	108	17.1
Miscellaneous	Electric Vehicles	0.7%	3,943	26	4.1
	Pool Pump	0.4%	3,500	14	2.2
	Hot Tub / Spa	0.5%	2,032	10	1.6
	Furnace Fan	63.5%	186	118	18.7
	Well pump	1.6%	553	9	1.4
	Miscellaneous	100.0%	405	405	64.1
Total				**12,097**	**1,916.6**

JBLM Residential Sector

Tacoma Power 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. 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 Appendix B.

The total number of residential households for JBLM were obtained from billing data provided by Equity Residential, the property management company responsible for housing at JBLM, during the prior study. Energy consumption was updated from prior study values by looking at the difference in JBLM annual JBLM consumption between 2015 and 2017. In 2017, there were 4,420 households at JBLM with a total consumption of 45,904 MWh. The average use per customer (or household) at 10,384 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 (2017)

Segment	Number of Customers	Electricity Use (MWh)	% of Annual Use	Annual Use/Customer (kWh/HH)
Single Family	3,604	41,159	90%	11,419
Multifamily	816	4,746	10%	5,815
Total	**4,420**	**45,904**	**100%**	**10,384**

Figure 3-5 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 (76%). Lighting is significantly lower than civilian homes due to JBLM policies that are already in place to procure exclusively high efficiency screw-in lamps. Appliances include refrigerators, freezers, stoves, clothes washers, clothes dryers, dishwashers, and microwaves. The remainder of the energy falls into the cooling, electronics, lighting, 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 Figure 2-4 such as hair dryers, power tools, coffee makers, etc.).

Figure 3-6 presents the electricity intensities by end use and housing type. Single-family homes have the highest use per customer at 11,419 kWh/year, which reflects a higher saturation of electric heating and a larger home size.

Figure 3-5 JBLM Residential Electricity Use by End Use (2017)

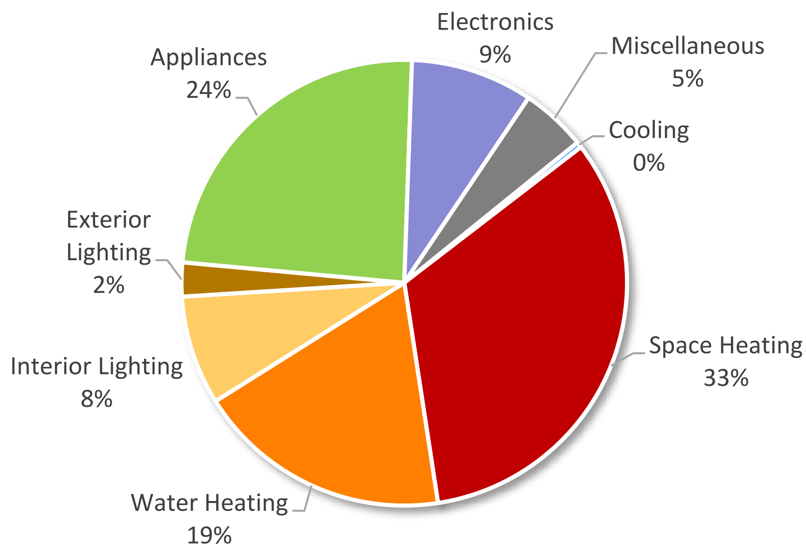


Figure 3-6 JBLM Residential Energy Intensity by End Use and Segment (Annual kWh/HH, 2017)

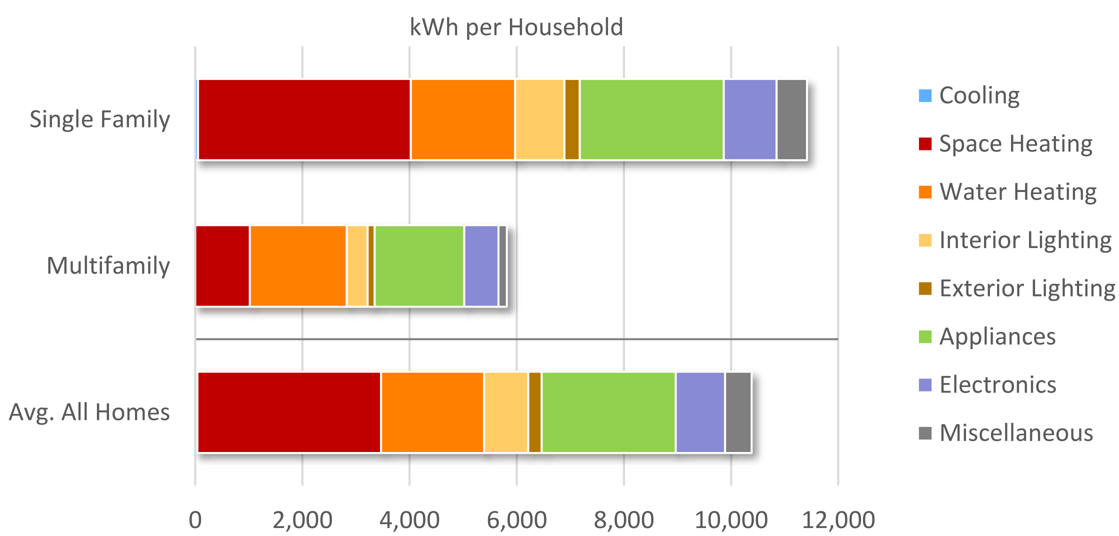


Table 3-5 shows the average market profile for electricity of the JBLM residential sector as a whole, representing a composite of both single and multi-family homes. Market profiles for each segment are presented in the appendix to this volume.

Table 3-5 Average Market Profile for the JBLM Residential Sector, 2017

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/HH)	Usage (GWh)
Cooling	Central AC	0.0%	0	0	0.0
	Room AC	4.2%	252	10	0.0
	Air-Source Heat Pump	8.2%	395	32	0.1
	Geothermal Heat Pump	0.0%	0	0	0.0
Heating	Electric Room Heat	28.7%	5,031	1,445	6.4
	Electric Furnace	15.4%	7,906	1,221	5.4
	Air-Source Heat Pump	8.2%	4,795	394	1.7
	Geothermal Heat Pump	0.0%	0	0	0.0
	Secondary Heating	23.8%	1,536	366	1.6
Water Heating	Water Heater (<= 55 Gal)	30.3%	2,651	804	3.6
	Water Heater > 55 Gal	39.5%	2,828	1,117	4.9
Interior Lighting	General Service Screw-in	100.0%	664	664	2.9
	Linear Lighting	100.0%	107	107	0.5
	Exempted Screw-In	100.0%	52	52	0.2
Exterior Lighting	Screw-in	100.0%	256	256	1.1
Appliances	Clothes Washer	87.8%	77	68	0.3
	Clothes Dryer	78.4%	725	568	2.5
	Dishwasher	81.0%	376	305	1.3
	Refrigerator	99.7%	704	702	3.1
	Freezer	32.4%	564	183	0.8
	Second Refrigerator	30.9%	822	254	1.1
	Stove/Oven	68.6%	424	291	1.3
	Microwave	105.0%	124	131	0.6
Electronics	Personal Computers	68.7%	161	111	0.5
	Monitor	138.2%	61	85	0.4
	Laptops	56.9%	42	24	0.1
	TVs	195.5%	114	222	1.0
	Printer/Fax/Copier	120.4%	42	51	0.2
	Set-top Boxes/DVRs	325.8%	99	321	1.4
	Devices and Gadgets	100.0%	108	108	0.5
Miscellaneous	Electric Vehicles	0.0%	0	0	0.0
	Pool Pump	0.0%	0	0	0.0
	Hot Tub / Spa	0.5%	2,032	11	0.0
	Furnace Fan	65.8%	189	125	0.6
	Well pump	1.6%	561	9	0.0
	Miscellaneous	100.0%	348	348	1.5
Total				**10,384**	**45.9**

Commercial Sector

The total electric energy consumed by commercial customers in Tacoma's service area in 2017 was 1,329 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 (2017)

Segment	Electricity Sales (GWh)	Intensity (Annual kWh/SqFt)	Floor Space (Million SqFt)
Office	194	16.3	11.9
Retail	152	11.6	13.2
Restaurant	67	44.1	1.5
Grocery	104	44.5	2.3
Hospital	107	27.4	3.9
Other Health	36	14.1	2.5
College	49	20.4	2.4
School	101	9.2	11.0
Lodging	49	25.4	1.9
Assembly	46	8.1	5.7
Warehouse	71	6.3	11.2
Data Center	39	96.9	0.4
MF Common Area	58	6.9	8.3
Misc. - Classified	75	13.2	5.7
Misc. - Unclassified	186	8.3	22.4
Total	**1,333**	**12.8**	**104.5**

Figure 3-7 shows the distribution of annual electricity consumption by end use across all commercial buildings. Most of consumption is associated with lighting and HVAC usage, which comprises 58% of annual electricity usage.

Figure 3-8 presents the electricity intensities by end use and segment. Data centers have the highest use per square foot at 96.9 kWh/SqFt. We present the higher intensity segments, restaurants, grocery stores, and data centers on a larger axis. Table 3-7 shows the average market profile for electricity of the commercial sector as a whole, representing a composite of all segments and buildings. Market profiles for each segment are presented in the appendix to this volume.

Figure 3-7 Commercial Sector Electricity Consumption by End Use (2017)

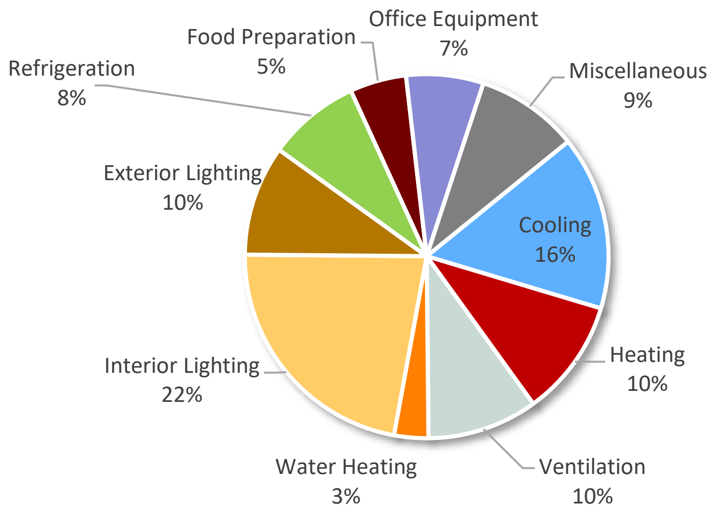


Figure 3-8 Commercial Energy Intensity by End Use and Segment (Annual kWh/SqFt, 2017)

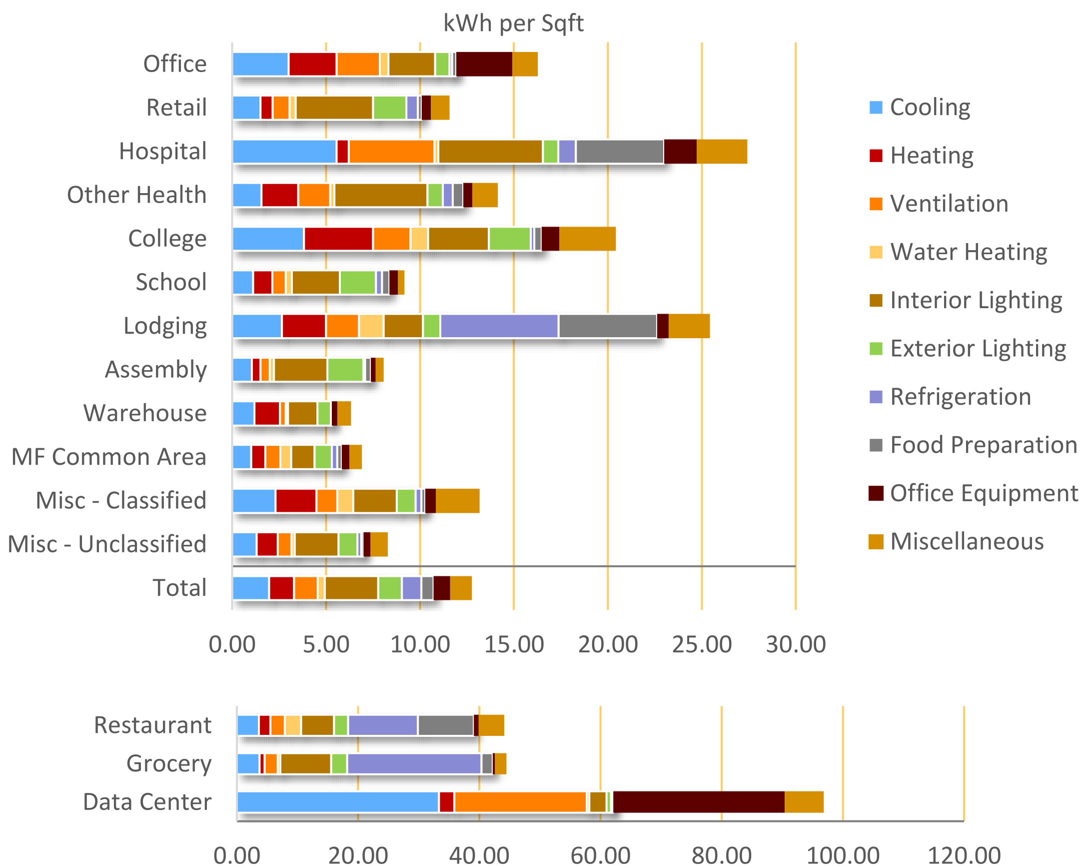


Table 3-7 Average Electric Market Profile for the Commercial Sector, 2017

End Use	Technology	Saturation	EUI (kWh/sq.ft)	Intensity (kWh/sq.ft)	Usage (GWh)
Cooling	Air-Cooled Chiller	8.3%	3.15	0.26	27.4
	Water-Cooled Chiller	6.3%	5.55	0.35	36.5
	RTU	43.7%	2.30	1.00	105.0
	PTAC	4.4%	2.03	0.09	9.4
	PTHP	2.2%	2.03	0.05	4.7
	Air-Source Heat Pump	6.4%	2.74	0.18	18.4
	Geothermal Heat Pump	2.6%	1.71	0.04	4.7
Heating	Electric Furnace	3.2%	6.09	0.19	20.2
	Electric Room Heat	10.7%	5.66	0.61	63.6
	PTHP	2.2%	4.76	0.11	11.0
	Air-Source Heat Pump	6.4%	4.95	0.32	33.3
	Geothermal Heat Pump	2.6%	3.90	0.10	10.7
Ventilation	Ventilation	100.0%	1.25	1.25	130.6
Water Heating	Water Heater	29.3%	1.32	0.39	40.5
Interior Lighting	Screw-in	100.0%	0.51	0.51	53.3
	Specialty	100.0%	0.14	0.14	14.3
	High-Bay Fixtures	100.0%	0.87	0.87	90.8
	Linear Lighting	100.0%	1.32	1.32	138.3
Exterior Lighting	Screw-in	100.0%	0.44	0.44	45.6
	Area Lighting	100.0%	0.49	0.49	50.8
	Linear Lighting	100.0%	0.33	0.33	34.2
Refrigeration	Walk-in Refrigerator/Freezer	8.8%	1.20	0.11	11.0
	Reach-in Refrigerator/Freezer	13.4%	0.32	0.04	4.5
	Glass Door Display	39.8%	0.45	0.18	18.8
	Open Display Case	6.1%	8.67	0.52	54.8
	Icemaker	28.8%	0.51	0.15	15.4
	Vending Machine	17.7%	0.27	0.05	5.0
Food Preparation	Oven	15.4%	0.61	0.09	9.8
	Fryer	4.9%	1.91	0.09	9.7
	Dishwasher	27.9%	1.42	0.40	41.4
	Steamer	2.6%	1.43	0.04	3.9
	Hot Food Container	10.2%	0.21	0.02	2.2
Office Equipment	Desktop Computer	100.0%	0.29	0.29	30.0
	Laptop	99.2%	0.03	0.03	3.4
	Server	68.2%	0.62	0.42	44.0
	Monitor	100.0%	0.05	0.05	5.3
	Printer/Copier/Fax	100.0%	0.07	0.07	7.0
	POS Terminal	39.2%	0.05	0.02	1.9
Miscellaneous	Non-HVAC Motors	10.0%	0.29	0.03	3.0
	Pool Pump	29.9%	0.02	0.01	0.7

	Pool Heater	0.9%	0.09	0.00	0.1
	Clothes Washer	16.4%	0.06	0.01	1.0
	Clothes Dryer	10.0%	0.20	0.02	2.1
	Other Miscellaneous	100.0%	1.10	1.10	114.4
Total				**12.76**	**1,333.0**

JBLM Commercial Sector

The total non-residential square footage and electricity sales for the 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 prior study to tailor assumptions unique to JBLM and capture differences with the civilian commercial sector. In 2017, the analysis shows just over 21 million square feet of floor space on JBLM which used a total consumption of 302 GWh.

The values 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 market segment added during the prior CPA, "Mixed Use", 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 (2017)

Segment	Electricity Sales (GWh)	Intensity (Annual kWh/SqFt)	Floor Space (Million SqFt)
Office	53	16.3	3.3
Retail	4	11.6	0.4
Restaurant	13	44.1	0.3
Grocery	4	44.5	0.1
School	10	9.2	1.1
Lodging	56	25.4	2.2
Warehouse	32	6.3	5.0
Data Center	13	96.9	0.1
Health	61	27.4	2.2
Hangar	13	8.1	1.6
Mixed Use	22	6.9	3.2
Other	18	13.2	1.4
Industrial	3	8.3	0.4
Total	**302**	**14.2**	**21.3**

Figure 3-9 shows the distribution of annual electricity consumption by end use across all commercial buildings. The electric usage looks like the civilian commercial sector in that lighting and HVAC comprise the lion's share (66%), 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 3-10 presents the electricity intensities by end use and segment. Data centers have the highest use per square foot at 175 kWh/SqFt.

Table 3-9 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 the appendix to this volume.

Figure 3-9 JBLM Commercial Sector Electricity Consumption by End Use (2017)

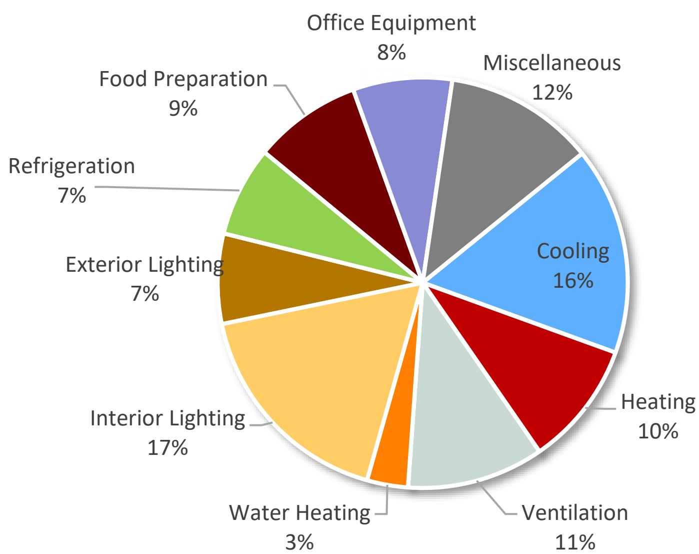
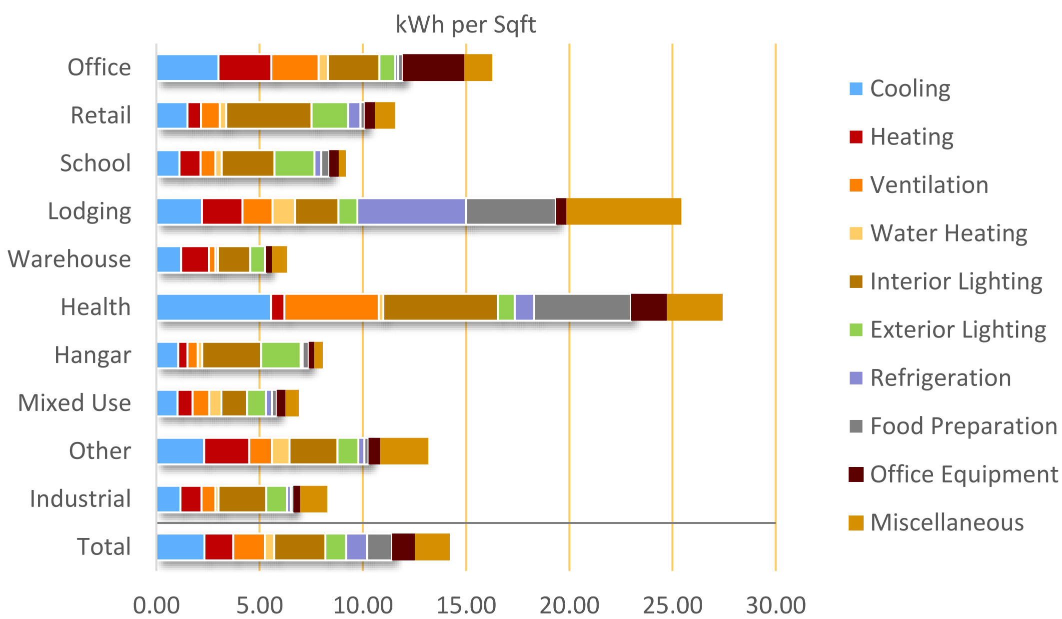


Figure 3-10 JBLM Commercial Energy Intensity by End Use and Segment (Annual kWh/SqFt., 2017)



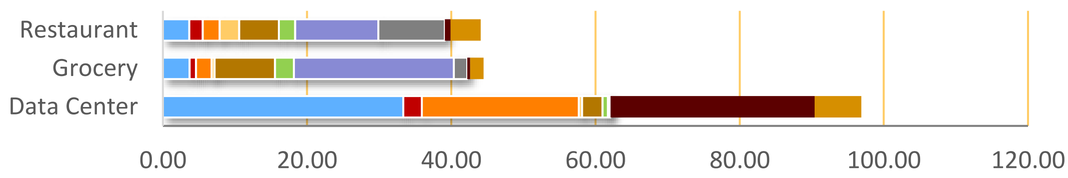


Table 3-9 Average Electric Market Profile for the JBLM Commercial Sector, 2017

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/SqFt)	Usage (GWh)
Cooling	Air-Cooled Chiller	7.4%	3.71	0.27	5.8
	Water-Cooled Chiller	10.7%	6.36	0.68	14.5
	RTU	34.2%	2.56	0.88	18.6
	PTAC	8.2%	2.13	0.18	3.7
	PTHP	3.1%	2.23	0.07	1.5
	Air-Source Heat Pump	6.0%	3.19	0.19	4.1
	Geothermal Heat Pump	2.7%	2.09	0.06	1.2
Heating	Electric Furnace	2.1%	7.97	0.17	3.6
	Electric Room Heat	11.5%	5.58	0.64	13.6
	PTHP	3.1%	5.20	0.16	3.4
	Air-Source Heat Pump	6.0%	5.52	0.33	7.1
	Geothermal Heat Pump	2.7%	3.51	0.10	2.0
Ventilation	Ventilation	100.0%	1.53	1.53	32.6
Water Heating	Water Heater	32.3%	1.42	0.46	9.8
Interior Lighting	Screw-in	100.0%	0.38	0.38	8.1
	Specialty	100.0%	0.09	0.09	2.0
	High-Bay Fixtures	100.0%	0.83	0.83	17.5
	Linear Lighting	100.0%	1.17	1.17	24.9
Exterior Lighting	Screw-in	100.0%	0.27	0.27	5.7
	Area Lighting	100.0%	0.49	0.49	10.4
	Linear Lighting	100.0%	0.25	0.25	5.4
Refrigeration	Walk-in Refrigerator/Freezer	7.4%	2.00	0.15	3.1
	Reach-in Refrigerator/Freezer	8.0%	0.42	0.03	0.7
	Glass Door Display	43.8%	0.37	0.16	3.5
	Open Display Case	5.2%	5.00	0.26	5.6
	Icemaker	26.3%	1.15	0.30	6.4
	Vending Machine	17.6%	0.58	0.10	2.2
Food Preparation	Oven	11.9%	1.38	0.16	3.5
	Fryer	4.6%	3.24	0.15	3.2
	Dishwasher	35.0%	2.30	0.80	17.1
	Steamer	3.4%	1.92	0.07	1.4
	Hot Food Container	6.6%	0.41	0.03	0.6
Office Equipment	Desktop Computer	100.0%	0.32	0.32	6.8
	Laptop	99.9%	0.04	0.04	0.9

	Server	73.1%	0.81	0.59	12.5
	Monitor	100.0%	0.06	0.06	1.2
	Printer/Copier/Fax	100.0%	0.09	0.09	1.8
	POS Terminal	34.0%	0.04	0.01	0.3
Miscellaneous	Non-HVAC Motors	9.0%	0.38	0.03	0.7
	Pool Pump	18.3%	0.12	0.02	0.5
	Pool Heater	0.4%	0.47	0.00	0.0
	Clothes Washer	26.8%	0.07	0.02	0.4
	Clothes Dryer	14.8%	0.18	0.03	0.6
	Other Miscellaneous	100.0%	1.58	1.58	33.6
Total				**14.21**	**302.2**

Industrial Sector

The total electricity used in 2017 by Tacoma's industrial customers was 1,087 GWh. Tacoma billing data, load forecast and secondary sources were used to allocate usage among end uses. Figure 3-11 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 62% 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 19% of annual energy use, which includes heating, cooling, refrigeration, and electro-chemical processes. Lighting is the next highest, followed by cooling, miscellaneous, space heating, and ventilation.

Figure 3-11 Industrial Electricity Use by End Use (2017), All Industries

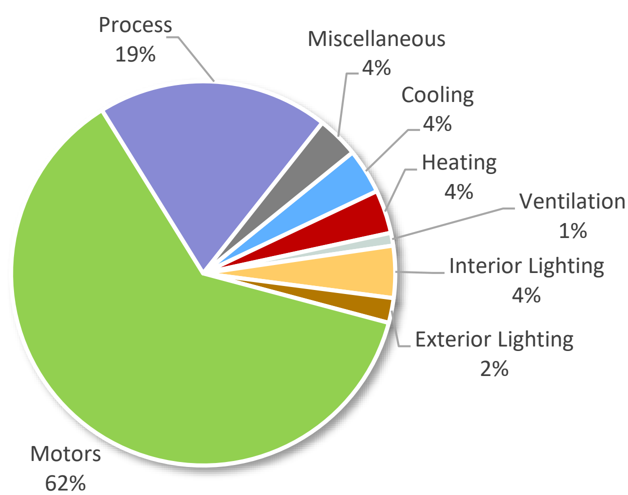


Table 3-10 shows the composite market profile for the industrial sector. Segment-level detail was included in the analysis of the industrial sector, but excluded from the report to prevent disclosure of data that may be sensitive for some of Tacoma's larger customers.

Table 3-10 Average Electric Market Profile for the Industrial Sector, 2017

End Use	Technology	Saturation	EUI (kWh)	Intensity (kWh/Empl)	Usage (GWh)
Cooling	Air-Cooled Chiller	2.5%	6,241	156	2.8
	Water-Cooled Chiller	2.5%	7,426	186	3.4
	RTU	38.8%	4,436	1,719	31.4
	Air-Source Heat Pump	4.7%	4,282	201	3.7
	Geothermal Heat Pump	0.0%	2,856	0	0.0
Heating	Air-Source Heat Pump	1.1%	19,806	214	3.9
	Geothermal Heat Pump	5.8%	18,863	1,103	20.1
	Electric Furnace	4.7%	18,263	856	15.6
	Electric Room Heat	0.0%	12,182	0	0.0
Ventilation	Ventilation	100.0%	642	642	11.7
Interior Lighting	Screw-in/Hard-wire	100.0%	305	305	5.6
	Linear Lighting	100.0%	1,531	1,531	28.0
	High-Bay Fixtures	100.0%	773	773	14.1
Exterior Lighting	Screw-in/Hard-wire	100.0%	366	366	6.7
	Linear Lighting	100.0%	459	459	8.4
	Area Lighting	100.0%	418	418	7.6
Motors	Pumps	100.0%	9,642	9,642	176.1
	Fans & Blowers	100.0%	5,938	5,938	108.5
	Compressed Air	100.0%	4,731	4,731	86.4
	Material Handling	100.0%	15,736	15,736	287.4
	Other Motors	100.0%	818	818	14.9
Process	Process Heating	100.0%	5,457	5,457	99.7
	Process Cooling	100.0%	1,608	1,608	29.4
	Process Refrigeration	100.0%	1,608	1,608	29.4
	Process Electrochemical	100.0%	2,040	2,040	37.3
	Process Other	100.0%	898	898	16.4
Miscellaneous	Other Miscellaneous	100.0%	2,094	2,094	38.3
Total				**59,497**	**1,086.7**

Street Lighting Sector

The total electric energy consumed by street lighting in Tacoma's service area in 2017 was 20,906 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. Tacoma Power is planning to upgrade the city-owned H1 fixtures, so those are isolated to capture this potential. 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.

Table 3-11 Street Lighting Sector Control Totals (2017)

Segment	Electricity Sales (MWh)	Usage per Fixture (Annual kWh/Fixt.)	Fixture Count
H1 - Tacoma Street and Highway	10,110	462	21,903
H1 - Other Fixtures	4,081	295	13,849
H2 Service - All	6,715	1,196	5,616
Total	**20,906**	**505**	**41,368**

The H1 - Tacoma Street and Highway fixtures consume an average of 505 kWh and H1 - Other Fixtures consume 331 kWh. This is due to the Tacoma fixtures being mostly high-intensity discharge lamps whereas the Other Fixtures are mainly LEDs. H2 Service lamps are unmetered fixtures.

Figure 3-12 shows the distribution of annual electricity consumption by fixture type across all street lights.

Figure 3-12 Street Lighting Sector Electricity Consumption by Fixture Type (2017)

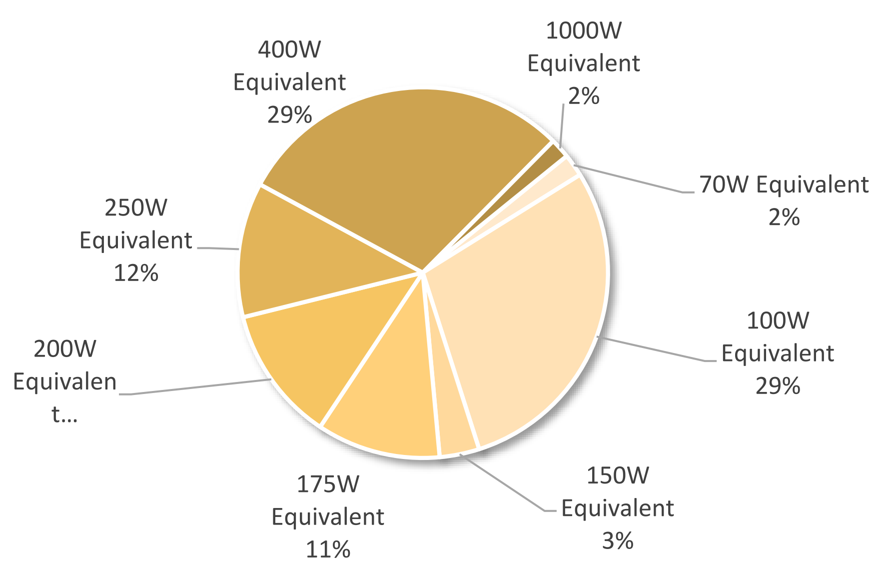


Table 3-12 shows the average market profile for electricity of the street lighting sector, representing a composite of all rate classes (H1 and H2 services). Market profiles for each rate class are presented in the appendix to this volume.

Table 3-12 Average Electric Market Profile for the Street Lighting Sector, 2017

End Use	Technology	Saturation	EUI (kWh)	Fixtures	Usage (GWh)
Street Lighting	70W Equivalent	4.4%	226	1,829	0.4
	100W Equivalent	50.8%	291	21,011	6.1
	150W Equivalent	3.3%	531	1,364	0.7
	175W Equivalent	7.8%	701	3,221	2.3
	200W Equivalent	7.5%	789	3,120	2.5
	250W Equivalent	12.3%	487	5,090	2.5
	400W Equivalent	13.7%	1,091	5,656	6.2
	1000W Equivalent	0.2%	4,760	76	0.4
Total				**41,368**	**21.0**

4

BASELINE PROJECTION

Prior to developing estimates of energy-efficiency potential, we 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. The savings from past programs are embedded in the forecast, but the baseline projection assumes that those past programs cease to exist in the future. Thus, the potential analysis captures all possible savings from future programs.

Figure 4-1 Apartment Buildings at the Theas Landing Marina (courtesy of Rob Green)

The baseline projection incorporates assumptions about:

- 2017 account data classified by sector and building types and rate classes
- Customer population and economic growth
- Appliance/equipment standards and building codes already mandated (see Chapter 2)
- Appliance/equipment purchase decisions frozen at contemporary levels throughout (except where superseded by a code or standard)
- Forecasts of future electricity prices
- Tacoma Power load forecast by rate class, updated in June 2018
- Residential, commercial, and industrial building stock assessments
- Trends in fuel shares and appliance saturations and assumptions about miscellaneous electricity growth

AEG removed the impacts of future DSM programs from Tacoma's official load forecast prior to aligning. This was done at the sector-level using load forecast documentation provided by Tacoma. Although it aligns closely, the baseline projection is not Tacoma's official load forecast. Rather it was developed as an integral component of our modeling construct to serve as the metric against which conservation potentials are measured. This chapter presents the baseline projections we developed for this study.

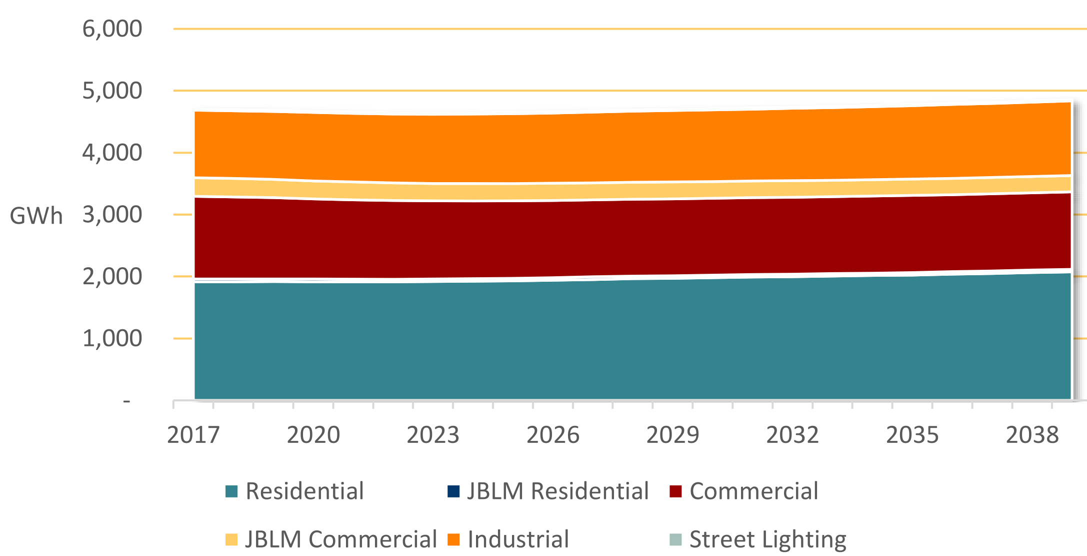
Below, we present the baseline projections for each sector, which include projections of annual use in GWh. We also present a summary across all sectors. Summary of Baseline Projections Across Sectors

Table 4-1 and Figure 4-2 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 will be enacted per all current legislation.

Table 4-1 Baseline Projection Summary (GWh)

Sector	2020	2021	2022	2024	2029	2039	% Change ('17-'39)	Avg. Growth Rate
Residential	1,915	1,914	1,914	1,923	1,972	2,075	8.4%	0.4%
JBLM Residential	45	44	44	43	42	41	-7.3%	-0.4%
Commercial	1,294	1,280	1,269	1,255	1,242	1,251	-3.3%	-0.2%
JBLM Commercial	292	289	285	281	272	263	-9.9%	-0.5%
Industrial	1,103	1,108	1,113	1,124	1,151	1,209	9.6%	0.5%
Street Lighting	21	21	21	21	21	21	0.0%	0.0%
Total	**4,669**	**4,656**	**4,647**	**4,646**	**4,700**	**4,860**	**4.1%**	**0.2%**

Figure 4-2 Baseline Projection Summary (GWh)



Residential Sector Baseline Projection

Table 4-2 and Figure 4-4 present AEG's independent baseline projection for electricity at the end-use level for the residential sector as a whole. Overall, residential use increases from 1,917 GWh in 2017 to 2,075 GWh in 2039, an increase of 8.4%. Figure 4-5 presents the baseline projection of annual electricity use per household. Most noticeable is that lighting use decreases throughout the time period as the lighting standards from EISA come into effect.

Figure 4-3 Townhomes Under Construction (courtesy of Tacoma Power)

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 phase two of the EISA lighting standards coming online in 2020.
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 4-2 Residential Baseline Projection by End Use (GWh)

End Use	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	35	35	36	36	37	38	9.3%
Heating	779	783	788	796	818	847	10.4%
Water Heating	308	306	305	304	307	326	3.2%
Interior Lighting	113	104	96	84	68	60	-54.1%
Exterior Lighting	32	30	28	25	20	17	-55.4%
Appliances	394	395	396	399	408	425	8.1%
Electronics	150	153	155	160	172	187	30.5%
Miscellaneous	104	109	113	123	147	178	93.5%
Total	**1,916**	**1,915**	**1,916**	**1,926**	**1,977**	**2,079**	**8.5%**

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

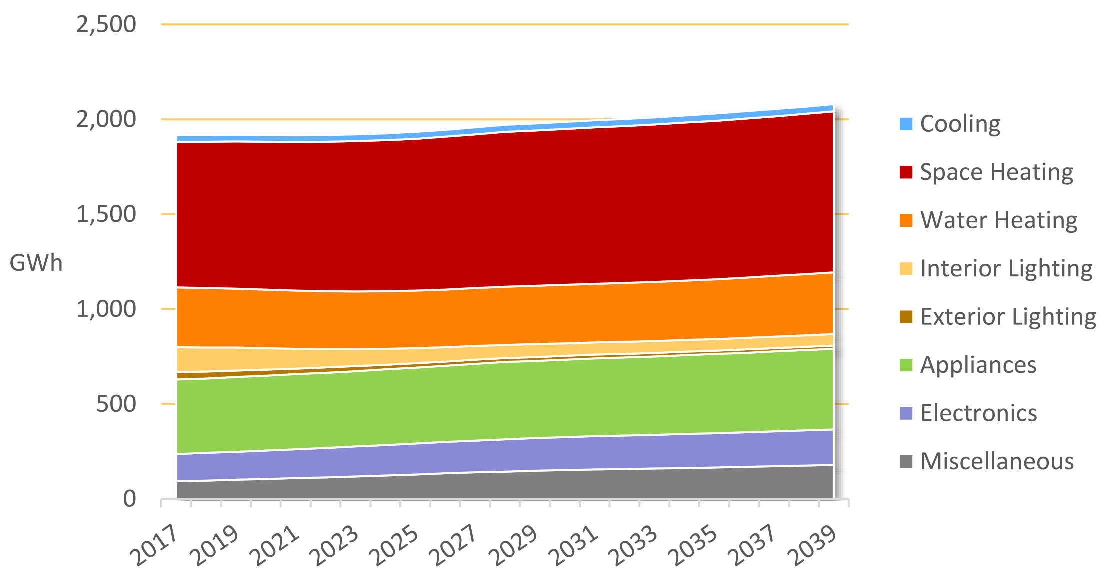


Figure 4-5 Residential Baseline Projection by End Use – Annual Use per Household

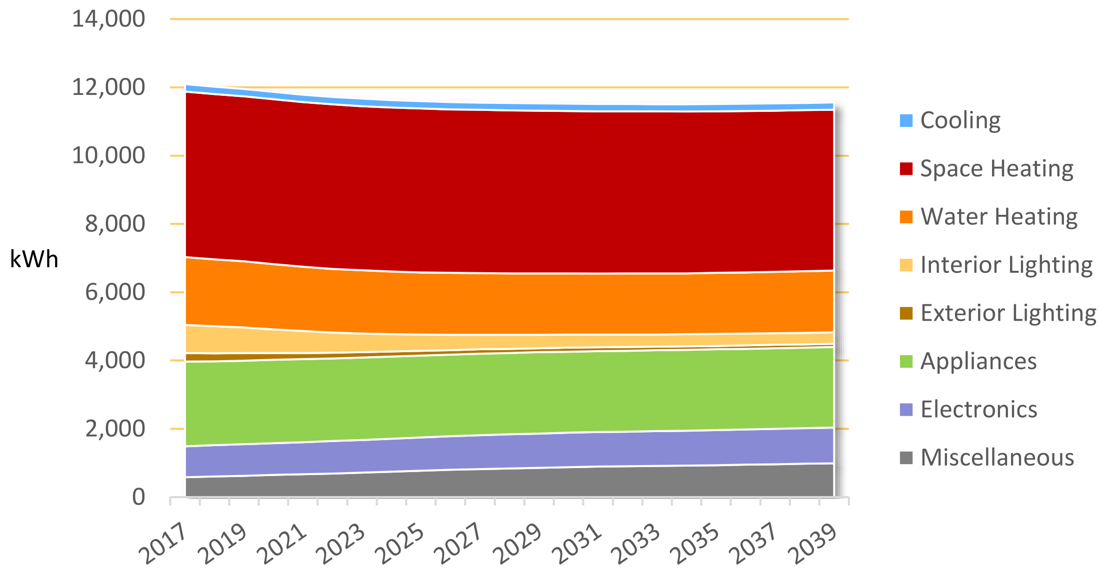


Table 4-3 Residential Baseline Projection by End Use and Technology (GWh)

End Use	Technology	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	Central AC	6	6	6	6	6	6	2.1%
	Room AC	15	15	15	15	16	16	4.5%
	Air-Source Heat Pump	14	14	14	14	15	16	17.9%
	Geothermal Heat Pump	0	0	0	0	0	0	3.9%
Heating	Electric Room Heat	323	325	327	330	340	355	11.8%
	Electric Furnace	245	245	246	247	249	247	1.3%
	Air-Source Heat Pump	139	141	143	146	154	170	25.6%
	Geothermal Heat Pump	1	1	1	1	1	1	3.9%
	Secondary Heating	71	71	71	72	73	74	6.5%
Water Heating	Water Heater (<= 55 Gal)	285	285	284	285	292	313	8.2%
	Water Heater > 55 Gal	23	22	21	19	16	13	-52.0%
Interior Lighting	General Service Screw-in	89	81	73	62	47	40	-62.4%
	Linear Lighting	16	16	16	16	16	16	-0.8%
	Exempted Screw-In	8	7	7	6	4	4	-52.2%
Exterior Lighting	Screw-in	32	30	28	25	20	17	-55.4%
Appliances	Clothes Washer	11	11	11	11	11	12	12.4%
	Clothes Dryer	92	93	94	95	100	107	19.0%
	Dishwasher	50	50	51	52	56	61	27.9%
	Refrigerator	108	108	107	106	105	106	-4.5%
	Freezer	27	27	26	26	24	23	-18.3%
	Second Refrigerator	38	38	38	38	38	38	-1.2%
	Stove/Oven	48	49	49	50	52	56	19.4%
	Microwave	20	20	20	21	21	22	8.3%
Electronics	Personal Computers	17	18	18	18	18	19	9.4%
	Monitor	13	13	13	13	14	14	7.5%
	Laptops	4	4	4	4	5	6	63.4%
	TVs	37	37	38	39	43	49	41.0%
	Printer/Fax/Copier	8	8	9	9	10	11	41.2%
	Set-top Boxes/DVRs	52	52	53	54	56	60	20.4%
	Devices and Gadgets	19	20	21	23	27	28	65.9%
Miscellaneous	Electric Vehicles	8	9	10	13	22	43	946.1%
	Pool Pump	2	2	2	2	2	2	5.4%
	Hot Tub / Spa	2	2	2	2	2	2	9.6%
	Furnace Fan	19	18	18	18	17	16	-15.6%
	Well pump	1	1	1	1	1	1	5.1%
	Miscellaneous	73	76	79	87	103	114	78.2%
Total		**1,916**	**1,915**	**1,916**	**1,926**	**1,977**	**2,079**	**8.5%**

JBLM Residential Sector Baseline Projection

Annual electricity consumption in the JBLM residential sector declines during the overall forecast horizon, starting at 45,904 MWh in 2017 decreasing to 41,373 MWh in 2039, a decrease of 9.9%. 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 lighting standards from EISA come into effect. Heating, water heating, and appliance consumption decreases as well.

Figure 4-6 and Figure 4-7 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) [12]

End Use	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	190	190	190	191	193	203	7.1%
Heating	15,165	15,173	15,180	15,196	15,244	15,370	1.5%
Water Heating	7,764	7,489	7,252	6,866	6,172	5,632	-33.7%
Interior Lighting	3,134	2,895	2,671	2,317	1,839	1,586	-56.4%
Exterior Lighting	984	923	874	794	665	562	-50.3%
Appliances	10,887	10,852	10,818	10,756	10,653	10,652	-3.7%
Electronics	4,162	4,194	4,226	4,293	4,442	4,602	13.0%
Miscellaneous	2,332	2,385	2,440	2,558	2,783	2,766	27.1%
Total	**44,618**	**44,100**	**43,652**	**42,971**	**41,992**	**41,373**	**-9.9%**

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

Figure 4-6 JBLM Residential Baseline Projection by End Use (GWh)

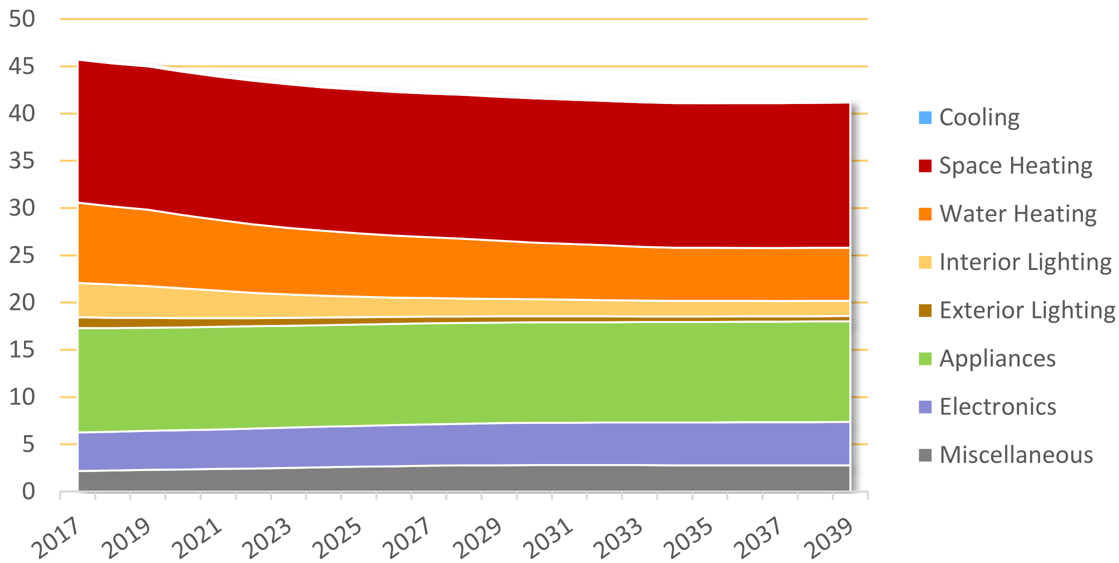


Figure 4-7 JBLM Residential Baseline Projection by End Use – Annual Use per Household

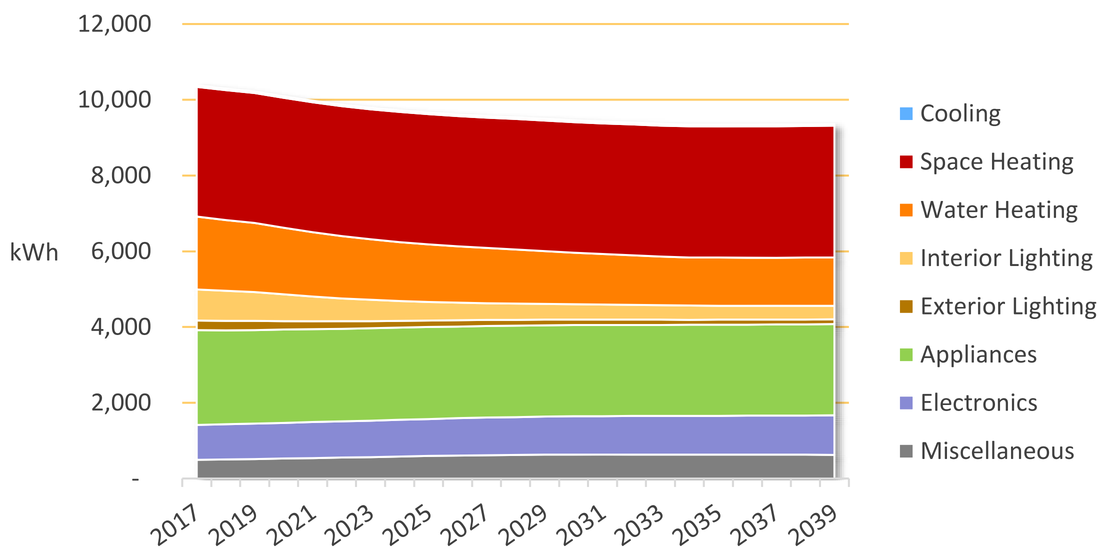


Table 4-5 JBLM Residential Baseline Projection by End Use and Technology (MWh) [13]

End Use	Technology	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	Central AC	0	0	0	0	0	0	0.0%
	Room AC	46	46	46	46	46	46	-0.5%
	Air-Source Heat Pump	144	144	144	145	147	157	9.6%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
Heating	Electric Room Heat	6,390	6,391	6,392	6,394	6,398	6,408	0.3%
	Electric Furnace	5,381	5,376	5,370	5,359	5,333	5,279	-2.2%
	Air-Source Heat Pump	1,775	1,787	1,798	1,823	1,892	2,059	18.1%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
	Secondary Heating	1,619	1,620	1,620	1,620	1,621	1,624	0.3%
Water Heating	Water Heater (<= 55 Gal)	3,470	3,448	3,429	3,400	3,368	3,409	-4.1%
	Water Heater > 55 Gal	4,294	4,040	3,823	3,466	2,804	2,223	-55.0%
Interior Lighting	General Service Screw-in	2,443	2,211	1,996	1,669	1,243	1,013	-65.5%
	Linear Lighting	473	472	472	471	469	466	-1.6%
	Exempted Screw-In	219	212	202	177	127	107	-53.6%
Exterior Lighting	Screw-in	984	923	874	794	665	562	-50.3%
Appliances	Clothes Washer	299	299	299	299	299	300	0.7%
	Clothes Dryer	2,534	2,542	2,550	2,566	2,606	2,687	7.0%
	Dishwasher	1,368	1,375	1,382	1,396	1,432	1,505	11.7%
	Refrigerator	2,981	2,951	2,920	2,862	2,746	2,628	-15.3%
	Freezer	765	751	738	714	665	618	-23.5%
	Second Refrigerator	1,097	1,089	1,081	1,067	1,043	1,028	-8.6%
	Stove/Oven	1,293	1,295	1,298	1,302	1,313	1,335	3.7%
	Microwave	550	550	550	550	550	550	-4.7%
Electronics	Personal Computers	489	489	489	489	489	489	0.0%
	Monitor	375	375	375	375	375	375	0.0%
	Laptops	111	112	114	117	126	145	37.3%
	TVs	1,008	1,018	1,027	1,045	1,094	1,197	22.0%
	Printer/Fax/Copier	231	233	235	240	252	279	24.5%
	Set-top Boxes/DVRs	1,421	1,421	1,421	1,421	1,421	1,421	0.0%
	Devices and Gadgets	528	546	566	606	685	696	46.1%
Miscellaneous	Electric Vehicles	0	0	0	0	0	0	0.0%
	Pool Pump	0	0	0	0	0	0	0.0%

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

	Hot Tub / Spa	48	48	48	48	48	48	0.0%
	Furnace Fan	538	532	525	512	481	430	-21.8%
	Well pump	40	40	40	40	40	40	0.0%
	Miscellaneous	1,706	1,766	1,828	1,958	2,215	2,248	46.1%
Total		**44,618**	**44,100**	**43,652**	**42,971**	**41,992**	**41,373**	**-9.9%**

Commercial Sector Baseline Projection

Annual electricity use in the commercial sector grows 2.9% during the overall forecast horizon, starting at 1,310 GWh in 2017, and increasing to 1,348 in 2039. Table 4-6 and Figure 4-8 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 EISA 2007 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. This end use has grown consistently in the past and we incorporate future growth assumptions that are consistent with the Annual Energy Outlook.

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

End Use	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	202	200	199	195	188	181	-10.4%
Heating	137	137	137	136	135	135	-1.9%
Ventilation	127	126	125	123	120	121	-4.7%
Water Heating	41	41	41	41	42	44	8.6%
Interior Lighting	286	281	277	272	269	272	-4.9%
Exterior Lighting	116	111	107	103	102	101	-12.4%
Refrigeration	106	105	104	102	100	102	-3.6%
Food Preparation	65	65	64	64	65	67	3.5%
Office Equipment	92	92	92	92	93	93	1.7%
Miscellaneous	123	124	125	126	129	136	9.9%
Total	**1,294**	**1,281**	**1,270**	**1,256**	**1,243**	**1,252**	**-3.2%**

Figure 4-8 Commercial Baseline Projection by End Use

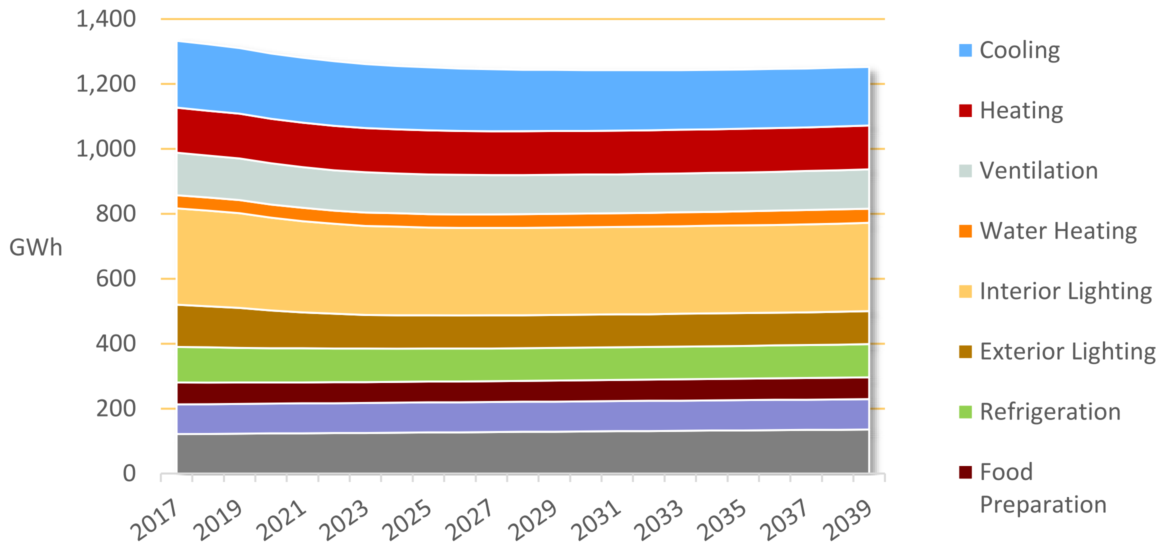


Table 4-7 presents the commercial sector annual forecast by technology for select years. General service and exempted lighting technologies decrease significantly over the forecast period as a result of efficiency standards. The effects of the T12 linear lighting standard are already embedded in the 2017 baseline.

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

End Use	Technology	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	Air-Cooled Chiller	27	27	26	26	26	25	-6.8%
	Water-Cooled Chiller	35	35	35	34	33	32	-13.5%
	RTU	104	103	103	101	97	91	-13.4%
	PTAC	9	9	8	8	8	8	-17.7%
	PTHP	5	5	5	5	4	4	-7.6%
	Air-Source Heat Pump	18	18	18	17	17	16	-12.4%
	Geothermal Heat Pump	5	5	4	4	4	4	-11.3%
Heating	Electric Room Heat	64	64	64	64	64	65	1.5%
	Electric Furnace	20	20	20	20	20	20	-2.7%
	PTHP	11	11	11	11	11	10	-6.2%
	Air-Source Heat Pump	32	32	32	31	30	29	-11.6%
	Geothermal Heat Pump	11	11	11	11	11	11	2.2%
Ventilation	Ventilation	127	126	125	123	120	121	-7.6%
Water Heating	Water Heater	41	41	41	41	42	44	9.3%
Interior Lighting	General Service Lighting	42	37	33	27	22	20	-62.5%
	Exempted Lighting	12	11	11	9	8	8	-46.4%
	Linear Lighting	140	141	142	143	145	147	6.6%
	High-Bay Lighting	92	92	92	93	94	97	6.8%
Exterior Lighting	General Service Lighting	29	25	20	16	14	13	-71.2%
	Linear Lighting	35	35	35	35	36	37	7.3%

End Use	Technology	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
	Area Lighting	51	51	52	52	52	51	1.1%
Refrigeration	Walk-in Refrigerator/Freezer	10	9	9	8	6	5	-51.7%
	Reach-in Refrigerator/Freezer	4	4	4	4	4	5	0.5%
	Glass Door Display	18	18	18	18	18	19	0.5%
	Open Display Case	54	53	53	53	52	53	-3.5%
	Icemaker	15	15	15	15	15	15	0.7%
	Vending Machine	5	5	5	5	5	5	0.5%
Food Preparation	Oven	10	10	9	9	9	10	0.5%
	Fryer	9	9	9	9	9	10	0.5%
	Dishwasher	40	40	40	40	40	42	0.5%
	Hot Food Container	2	2	2	2	2	2	1.5%
	Steamer	4	4	4	4	4	4	2.1%
Office Equipment	Desktop Computer	29	29	29	28	27	24	-21.6%
	Laptop	4	4	4	4	4	5	47.4%
	Monitor	5	5	5	5	6	6	11.6%
	Server	45	45	45	46	47	49	11.6%
	Printer/Copier/Fax	7	7	7	7	7	8	11.6%
	POS Terminal	2	2	2	2	2	2	11.6%
Miscellaneous	Clothes Dryer	2	2	2	2	2	2	11.6%
	Clothes Washer	1	1	1	1	1	1	11.6%
	Non-HVAC Motors	3	3	3	3	3	3	11.6%
	Pool Pump	1	1	1	1	1	1	11.6%
	Pool Heater	0	0	0	0	0	0	11.6%
	Other Miscellaneous	116	117	117	119	122	128	11.6%
Total		**1,294**	**1,281**	**1,270**	**1,256**	**1,243**	**1,252**	**-6.1%**

JBLM Commercial Sector Baseline Projection

Annual electricity use in the JBLM commercial sector grows during the overall forecast horizon, starting at 293 GWh in 2017, and increasing to 304 GWh in 2039, an increase of 3.7%. The increase corresponds to internal JBLM projections provided by Tacoma Power. Table 4-8 and Figure 4-9 present the baseline projection at the end-use level for the JBLM commercial sector as a whole. Refer to Appendix B for additional information on how the JBLM baseline projection was constructed.

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

End Use	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	48	47	46	45	43	39	-20.8%
Heating	29	29	29	28	28	26	-10.9%
Ventilation	31	31	30	30	28	27	-18.0%
Water Heating	10	9	9	9	9	9	-6.3%
Interior Lighting	51	50	49	48	47	45	-13.9%
Exterior Lighting	20	19	18	18	17	16	-24.1%
Refrigeration	20	20	20	19	18	18	-17.7%
Food Preparation	25	24	24	24	23	23	-9.8%
Office Equipment	24	24	24	23	23	23	-1.6%
Miscellaneous	36	36	36	36	36	36	0.0%
Total	**292**	**289**	**285**	**281**	**272**	**263**	**-13.0%**

Figure 4-9 JBLM Commercial Baseline Projection by End Use

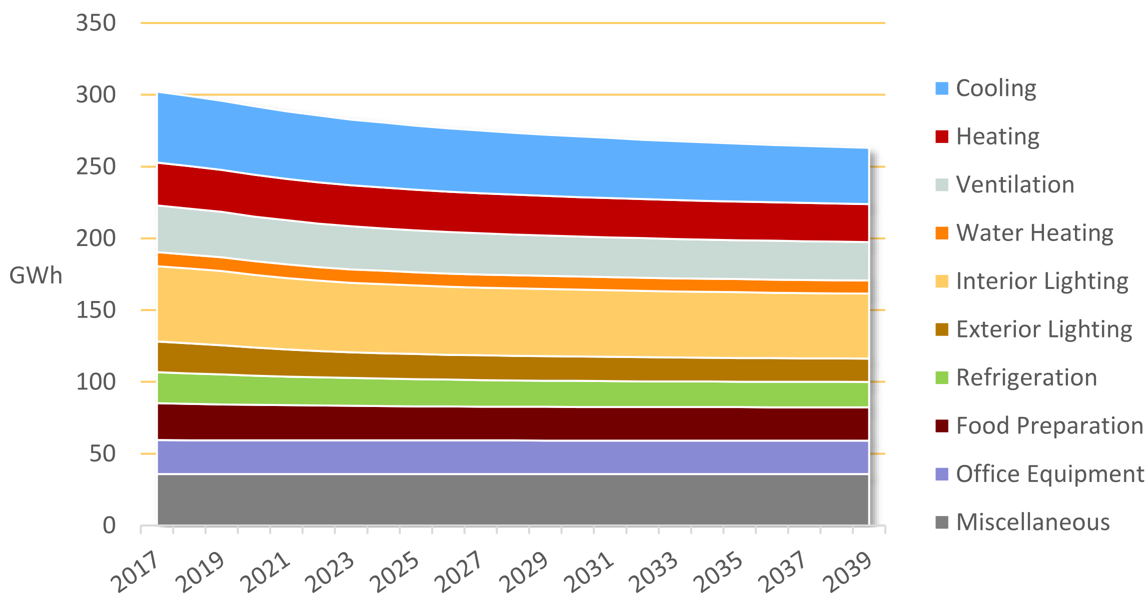


Table 4-9 presents the JBLM commercial sector annual forecast by technology for select years. Screw-in lighting technologies decrease significantly over the forecast period as a result of efficiency standards. The effects of the T12 linear lighting standard are already embedded in the 2017 baseline.

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

End Use	Technology	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	Air-Cooled Chiller	6	6	6	5	5	5	-15.9%
	Water-Cooled Chiller	14	14	13	13	12	11	-23.3%
	RTU	18	18	18	17	16	15	-20.4%
	PTAC	3	3	3	3	3	3	-25.2%
	PTHP	1	1	1	1	1	1	-14.4%
	Air-Source Heat Pump	4	4	4	4	4	3	-18.8%
	Geothermal Heat Pump	1	1	1	1	1	1	-20.1%
Heating	Electric Room Heat	13	13	13	13	13	13	-6.9%
	Electric Furnace	4	4	4	3	3	3	-9.0%
	PTHP	3	3	3	3	3	3	-13.1%
	Air-Source Heat Pump	7	7	7	6	6	6	-19.4%
	Geothermal Heat Pump	2	2	2	2	2	2	-7.9%
Ventilation	Ventilation	31	31	30	30	28	27	-18.0%
Water Heating	Water Heater	10	9	9	9	9	9	-6.3%
Interior Lighting	General Service Lighting	7	6	5	4	4	3	-60.7%
	Exempted Lighting	2	2	1	1	1	1	-49.2%
	Linear Lighting	25	25	25	25	25	24	-3.3%
	High-Bay Lighting	17	17	17	17	17	17	-3.4%
Exterior Lighting	General Service Lighting	4	3	3	2	2	2	-72.5%
	Linear Lighting	5	5	5	5	5	5	-2.8%
	Area Lighting	10	10	10	10	10	9	-8.8%
Refrigeration	Walk-in Refrigerator/Freezer	3	3	2	2	2	1	-56.7%
	Reach-in Refrigerator/Freezer	1	1	1	1	1	1	-9.9%
	Glass Door Display	3	3	3	3	3	3	-9.9%
	Open Display Case	5	5	5	5	5	5	-13.8%
	Icemaker	6	6	6	6	6	6	-9.7%
	Vending Machine	2	2	2	2	2	2	-9.9%
Food Preparation	Oven	3	3	3	3	3	3	-9.9%
	Fryer	3	3	3	3	3	3	-9.9%
	Dishwasher	16	16	16	16	16	15	-9.9%
	Hot Food Container	1	1	1	1	1	1	-9.0%
	Steamer	1	1	1	1	1	1	-8.3%
Office Equipment	Desktop Computer	7	7	7	7	7	6	-6.5%
	Laptop	1	1	1	1	1	1	7.4%
	Monitor	1	1	1	1	1	1	0.0%
	Server	13	13	13	13	13	13	0.0%
	Printer/Copier/Fax	2	2	2	2	2	2	0.0%
	POS Terminal	0	0	0	0	0	0	0.0%
Miscellaneous	Clothes Dryer	1	1	1	1	1	1	0.0%
	Clothes Washer	0	0	0	0	0	0	0.0%
	Non-HVAC Motors	1	1	1	1	1	1	0.0%

	Pool Pump	0	0	0	0	0	0	0.0%
	Pool Heater	0	0	0	0	0	0	0.0%
	Other Miscellaneous	34	34	34	34	34	34	0.0%
Total		**292**	**289**	**285**	**281**	**272**	**263**	**-13.0%**

Industrial Sector Baseline Projection

Annual industrial use increases significantly by 2019 then remains relatively flat throughout the remainder of the forecast horizon. The load forecast primarily associates this near-term increase with the addition of a small group of large customers who are moving into the area or expanding their operations considerably. Table 4-10 and Figure 4-10 present the projection at the end-use level. Overall, industrial annual electricity use increases from 1,050 GWh in 2017 to 1,324 GWh in 2039. This comprises an overall increase of 26.1% over the 23-year period. The projection grows sharply in 2018 and 2019 as a result of a few large customers who are planned to come online during that timeframe.

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

End Use	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	42	42	43	43	43	45	7.9%
Heating	40	40	40	41	41	43	9.4%
Ventilation	12	12	12	12	12	13	8.1%
Interior Lighting	49	49	49	50	52	55	14.6%
Exterior Lighting	21	21	20	20	20	21	-7.4%
Motors	685	688	692	699	717	753	11.6%
Process	215	216	217	220	225	237	11.6%
Miscellaneous	39	39	39	40	41	43	11.6%
Total	**1,103**	**1,108**	**1,113**	**1,124**	**1,151**	**1,209**	**11.1%**

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

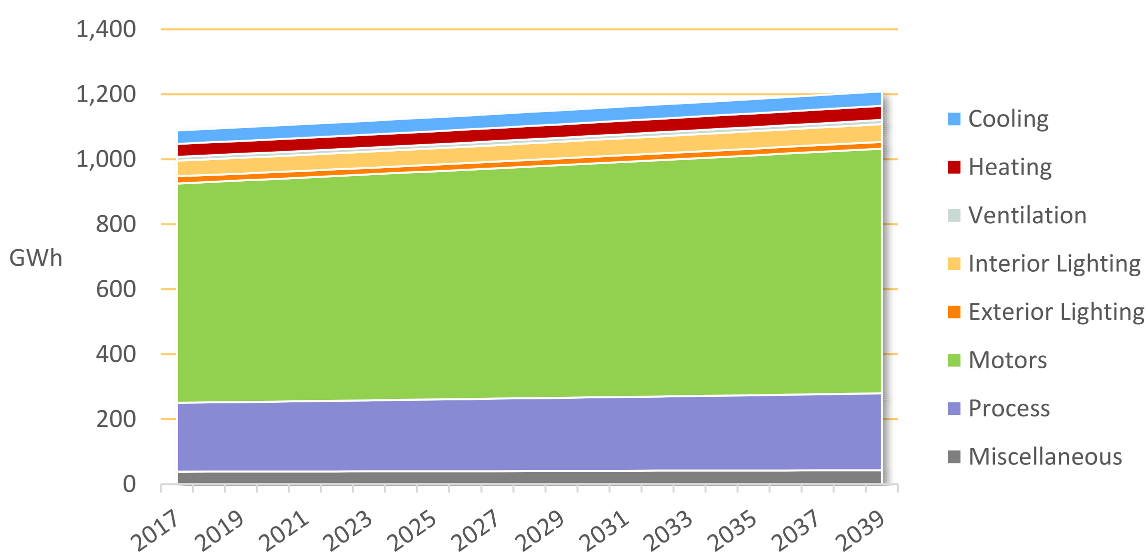


Table 4-11 presents the industrial sector annual forecast by technology for select years. Screw-in lighting technologies decrease significantly over the forecast period as a result of efficiency standards. The effects of the T12 linear lighting standard are already embedded in the 2017 baseline.

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

End Use	Technology	2020	2021	2022	2024	2029	2039	% Change ('17-'39)
Cooling	Air-Cooled Chiller	3	3	3	3	3	3	9.8%
	Water-Cooled Chiller	3	3	3	3	4	4	7.9%
	RTU	32	32	33	33	33	34	8.0%
	Air-Source Heat Pump	4	4	4	4	4	4	5.8%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
Heating	Air-Source Heat Pump	16	16	16	16	16	17	5.9%
	Geothermal Heat Pump	0	0	0	0	0	0	0.0%
	Electric Room Heat	20	21	21	21	21	22	11.6%
	Electric Furnace	4	4	4	4	4	4	11.6%
Ventilation	Ventilation	12	12	12	12	12	13	8.1%
Interior Lighting	General Service Lighting	5	5	4	4	4	3	-40.8%
	Linear Lighting	14	14	14	14	14	14	1.0%
	High-Bay Lighting	30	30	31	32	34	37	32.6%
Exterior Lighting	General Service Lighting	5	4	4	4	3	3	-51.7%
	Linear Lighting	8	8	8	8	8	8	8.7%
	Area Lighting	9	9	9	9	9	9	13.4%
Motors	Pumps	179	180	181	182	187	197	11.6%
	Fans & Blowers	110	111	111	112	115	121	11.6%
	Compressed Air	88	88	89	89	92	96	11.6%
	Material Handling	293	295	296	299	307	322	11.6%
	Other Motors	15	15	15	15	16	17	11.6%
Process	Process Heating	101	102	102	103	106	111	11.6%
	Process Cooling	30	30	30	30	31	33	11.6%
	Process Refrigeration	30	30	30	30	31	33	11.6%
	Process Electrochemical	38	38	38	39	40	42	11.6%
	Process Other	17	17	17	17	17	18	11.6%
Miscellaneous	Miscellaneous	39	39	39	40	41	43	11.6%
Total		**1,103**	**1,108**	**1,113**	**1,124**	**1,151**	**1,209**	**11.1%**

Street Lighting Sector Baseline Projection

Annual electricity use in the street lighting sector remains flat throughout forecast horizon at 20,906 MWh. Table 4-12 and

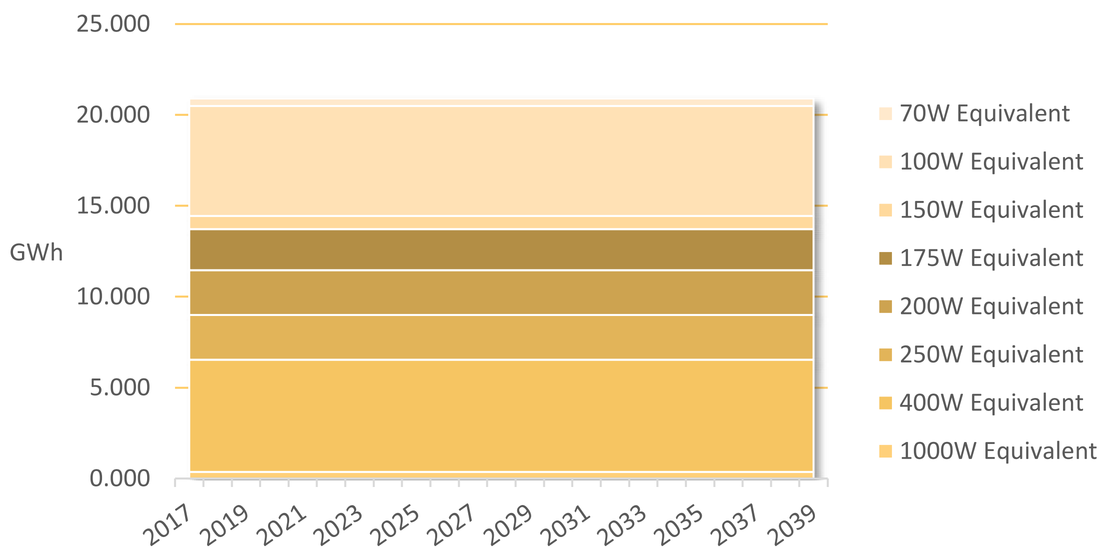
Figure 4-11 present the baseline projection at the fixture level for the street lighting sector as a whole. The street lighting baseline projection assumes no street lighting fixture growth over the study period. As discussed in the previous chapter, non-City of Tacoma fixtures are already mostly LEDs in the baseline and City-owned fixture are mostly high intensity discharge (HID) lamps. Due to these factors as well as the "frozen efficiency" baseline assumption, there is no meaningful change in consumption.

Table 4-12 Street Lighting Baseline Projection by End Use (MWh) [14]

End Use	2020	2021	2022	2025	2029	2039	% Change ('15-'37)
70W Equivalent	413	413	413	413	413	413	0.0%
100W Equivalent	6,048	6,048	6,048	6,048	6,048	6,048	0.0%
150W Equivalent	725	725	725	725	725	725	0.0%
175W Equivalent	2,259	2,259	2,259	2,259	2,259	2,259	0.0%
200W Equivalent	2,463	2,463	2,463	2,463	2,463	2,463	0.0%
250W Equivalent	2,462	2,462	2,462	2,462	2,462	2,462	0.0%
400W Equivalent	6,173	6,173	6,173	6,173	6,173	6,173	0.0%
1000W Equivalent	362	362	362	362	362	362	0.0%
Total	**20,906**	**20,906**	**20,906**	**20,906**	**20,906**	**20,906**	**0.0%**

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

Figure 4-11 Street Lighting Baseline Projection by End Use (GWh)



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, street lighting, and distribution analyses.

Summary of Overall Conservation Potential Table 5-1 and

Figure 5-1 summarize the conservation savings in terms of annual energy use for 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. 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 installed, regardless of achievability. 2020 first-year net savings are 81 GWh, or 1.7% of the baseline projection. Cumulative net savings in 2029 are 671 GWh, or 14.3% of the baseline. By 2039, cumulative savings reach 979 GWh, or 20.1% of the baseline.
- Technical Achievable 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 2020-2039 CPA, unadjusted ramp rates from the Seventh Power Plan were applied. For all Seventh 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 Plan. These ramp rates may be found in Appendix C. 2020 first-year net savings are 46 GWh, or 1.0% of the baseline projection. Cumulative net savings in 2029 are 460 GWh, or 9.8% of the baseline. By 2039 cumulative savings reach 775 GWh, or 15.9% of the baseline.
- Economic Achievable Potential further refines Technical Achievable potential by applying an economic 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 per the power act. Additional details can be found in Appendix A. 2020 first-year net savings are 24 GWh, or 0.5% of the baseline projection. Cumulative net savings in 2029 are 460 GWh, or 9.8% of the baseline. By 2039 cumulative savings reach 387 GWh, or 8.0% of the baseline.

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

	2020	2021	2024	2029	2039
Baseline Forecast (GWh)	4,669	4,656	4,646	4,700	4,860
Cumulative Savings (GWh)					
Economic Achievable Potential	24	49	124	234	387
Technical Achievable Potential	46	92	233	460	775
Technical Potential	81	159	371	671	979
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.5%	1.0%	2.7%	5.0%	8.0%
Technical Achievable Potential	1.0%	2.0%	5.0%	9.8%	15.9%
Technical Potential	1.7%	3.4%	8.0%	14.3%	20.1%

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

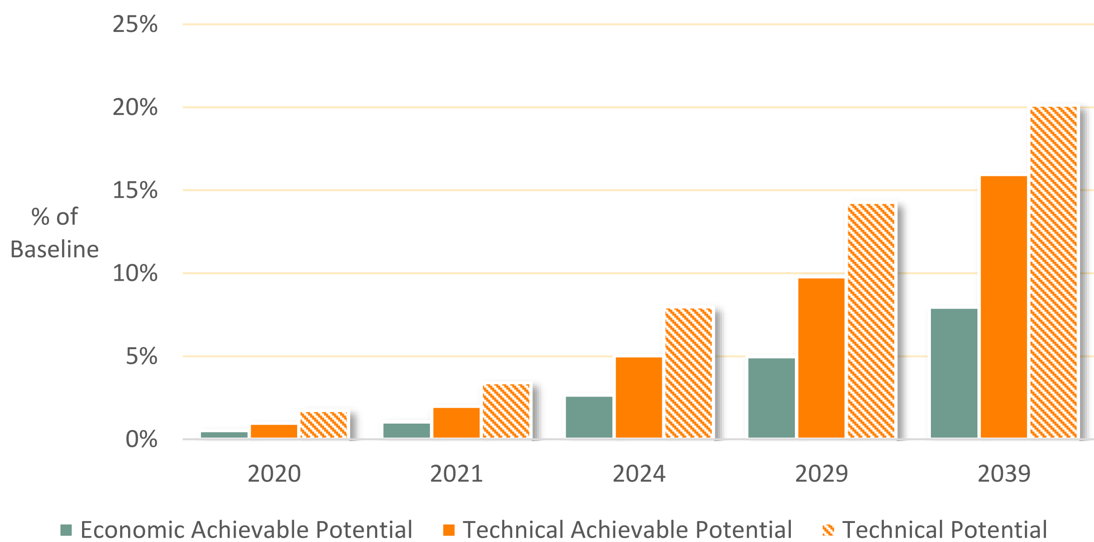


Figure 5-2 Baseline Projection and Conservation Forecast Summary (Annual Energy, GWh)

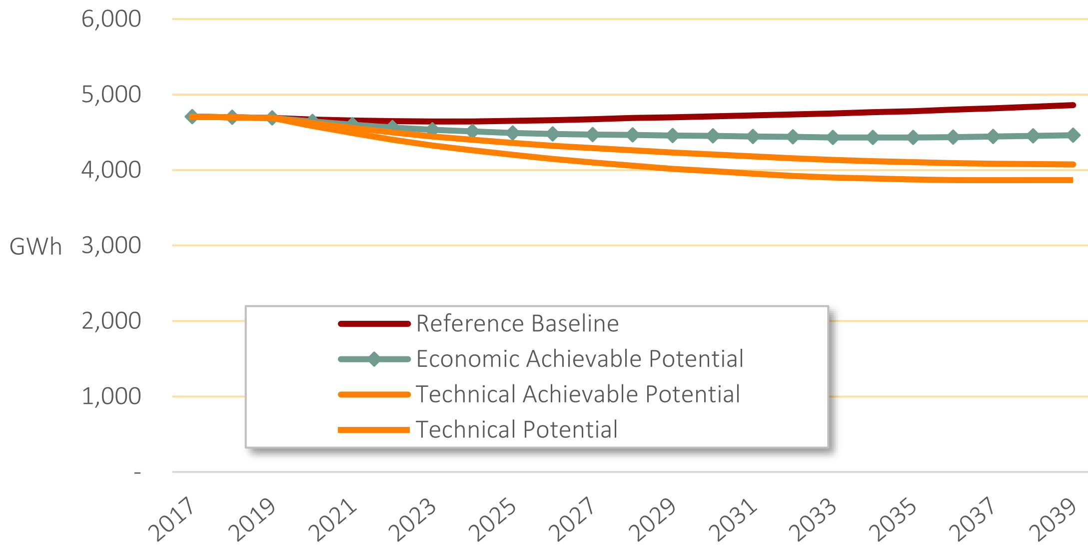


Figure 5-3 and Figure 5-4 show the supply curve of levelized cost per kWh vs. the 10-year cumulative Technical Achievable potential for all sectors in 2029. The Technical Achievable curve represents the universe of measures evaluated for this study in the residential, commercial, industrial, JBLM, street 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 Economic Achievable 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 lifetime energy costs that are zero or negative. This is because lifetime 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. Also, note that while a measure with a high levelized cost could pass the TRC, the utility is ultimately limited to offer incentives no higher than the forecast avoided wholesale cost of power for the measure. This is especially relevant for measures with high non-electric benefits.

Figure 5-3 Supply Curve, All Sectors in 2029 (Annual Energy, MWh)

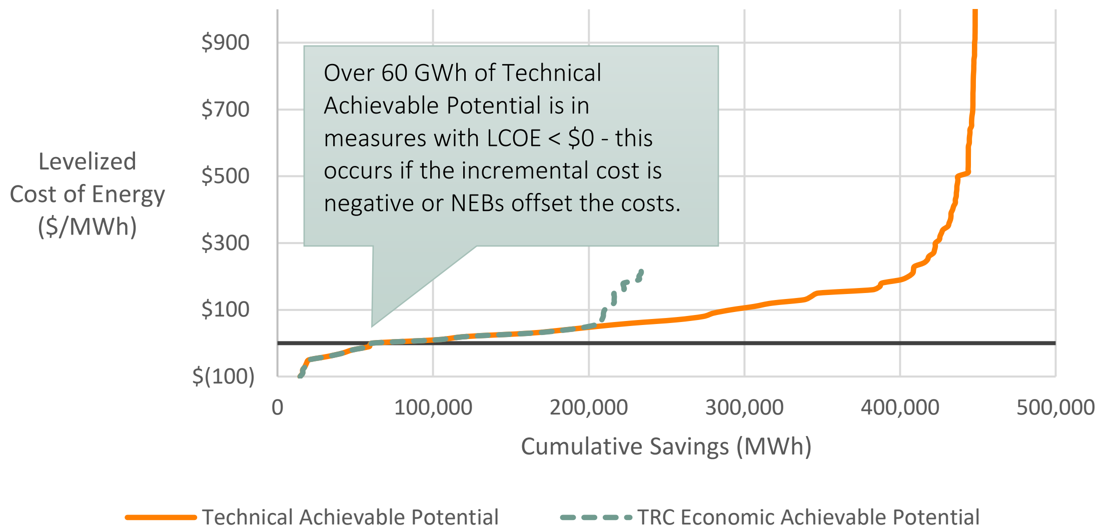


Figure 5-4 Supply Curve, All Sectors in 2029, Limited Axis (Annual Energy, MWh)

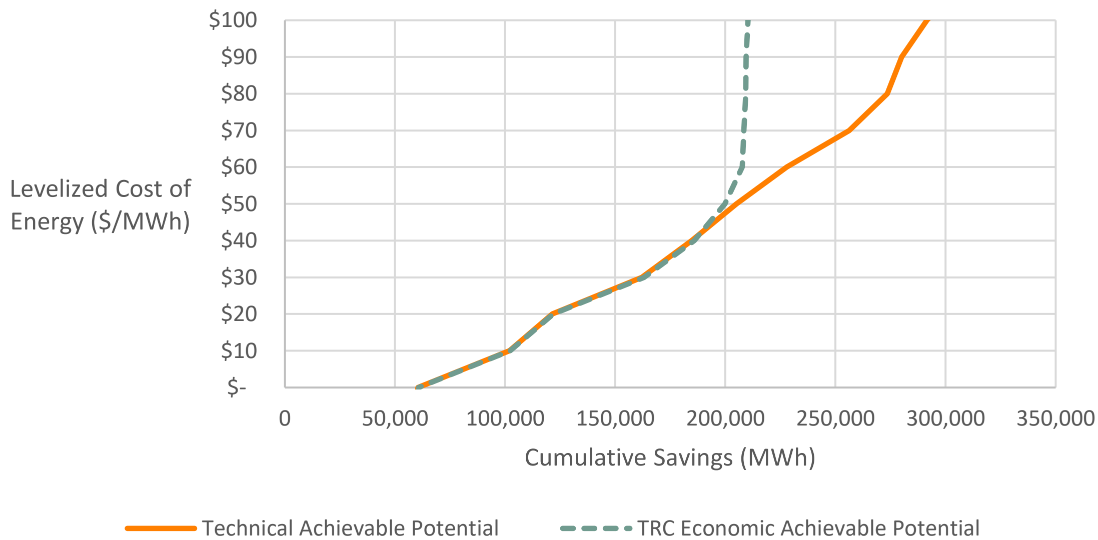


Table 5-2 summarizes Economic Achievable potential by market sector for selected years. In 2029, the commercial sector bears the largest share of potential, followed by industrial, then residential. Distribution efficiency, street lighting, and JBLM round out the mix.

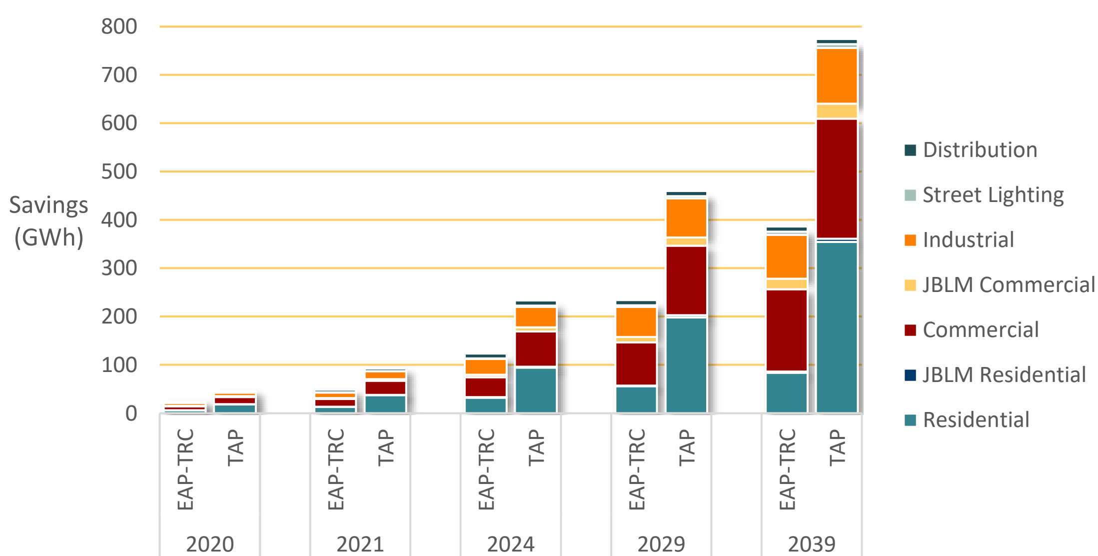
Table 5-2 Economic Achievable Potential by Sector, Selected Years (GWh)

	2020	2021	2024	2029	2039
Economic Achievable Potential	**24.2**	**48.5**	**123.8**	**233.7**	**386.3**
Residential	6.3	13.2	32.4	55.8	84.0
JBLM Residential	0.2	0.4	0.9	1.4	2.1
Commercial	8.1	15.9	41.5	89.3	170.5
JBLM Commercial	0.9	1.8	5.0	11.2	21.6
Industrial	6.1	11.7	32.5	62.7	91.0
Street Lighting	0.1	0.2	1.1	2.7	6.5
Distribution Efficiency	2.6	5.3	10.5	10.5	10.5

Economic vs. Technical Achievable Potential

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

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



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.

Residential Potential

Table 6-1 and

Figure 6-2 present estimates for measure-level conservation potential for the residential sector. In 2029, Economic Achievable potential represents slightly less than one third of Technical Achievable potential. Economic Achievable potential is lower than in the prior study. Since the potential forecast period begins in 2020, phase two of the EISA 2007 general service lighting standard is already in place in the first year of potential. This, along with additional LEDs present in the base-year of the study, 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, and in some cases – such as Class 30 windows – caused them to no longer be cost effective.

Figure 6-1 Residential Home Weatherization (courtesy of Tacoma Power)

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

	2020	2021	2024	2029	2039
Baseline Forecast (GWh)	1,916	1,915	1,926	1,977	2,079
Cumulative Savings (GWh)					
Economic Achievable Potential	6	13	32	56	84
Technical Achievable Potential	18	37	94	199	355
Technical Potential	34	68	163	311	448
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.3%	0.7%	1.7%	2.8%	4.0%
Technical Achievable Potential	1.0%	1.9%	4.9%	10.0%	17.1%
Technical Potential	1.8%	3.6%	8.5%	15.7%	21.5%

Figure 6-2 Residential Savings as a % of the Baseline Projection (Annual Energy)

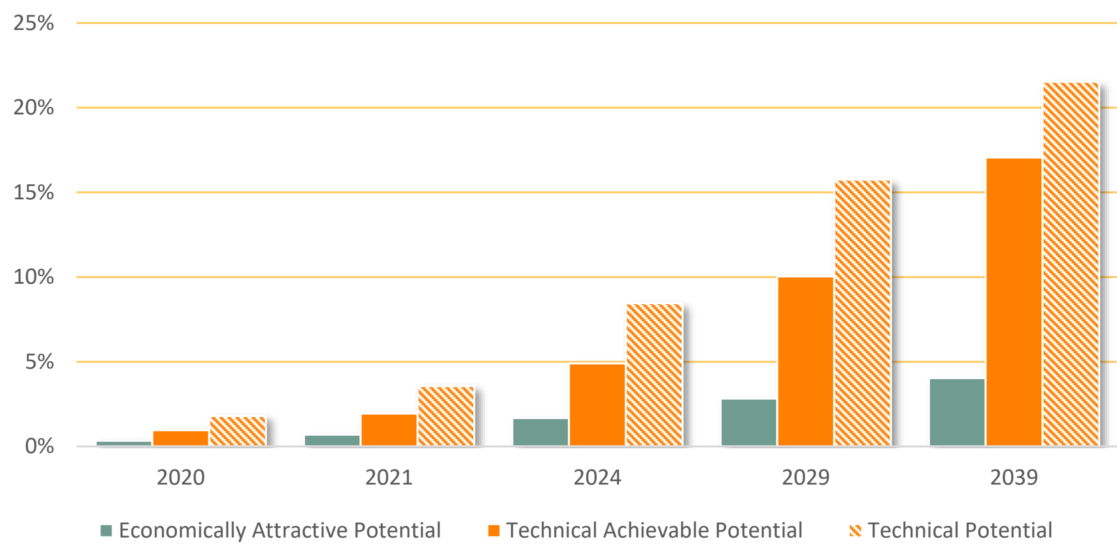


Figure 6-3 and Figure 6-4 show the supply curve of levelized TRC cost per MWh vs. cumulative Technical Achievable potential for the residential sector in 2029. Interior and exterior LED lighting and weatherization measures comprise the majority of cost-effective savings. HVAC and water heating equipment replacements were found not to be cost effective under the TRC due to a combination of relatively low savings and high equipment costs.

Figure 6-3 Supply Curve, Residential Sector in 2029 (Annual Energy, MWh)

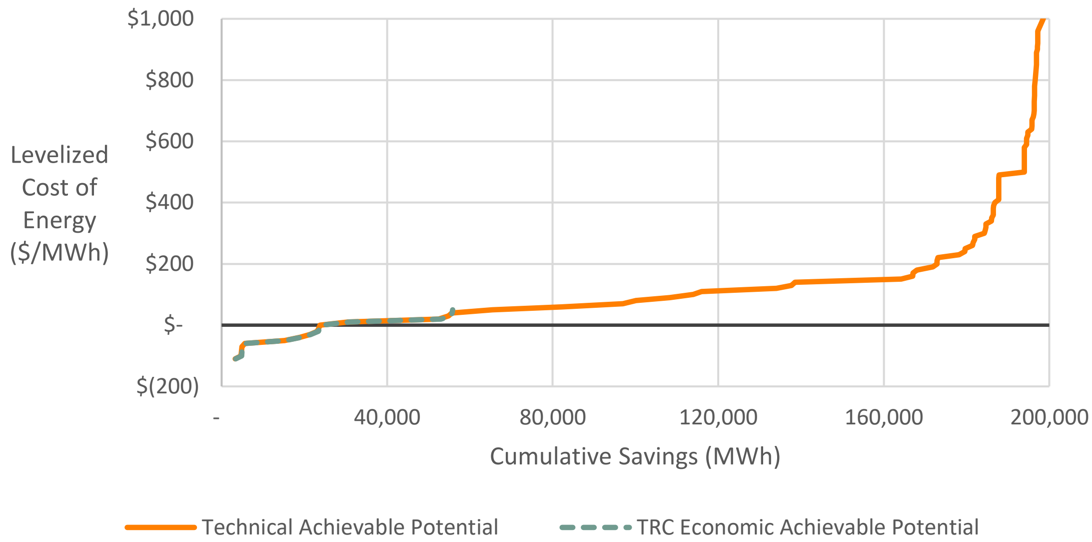


Figure 6-4 Supply Curve, Residential Sector in 2029, Limited Axis (Annual Energy, MWh)

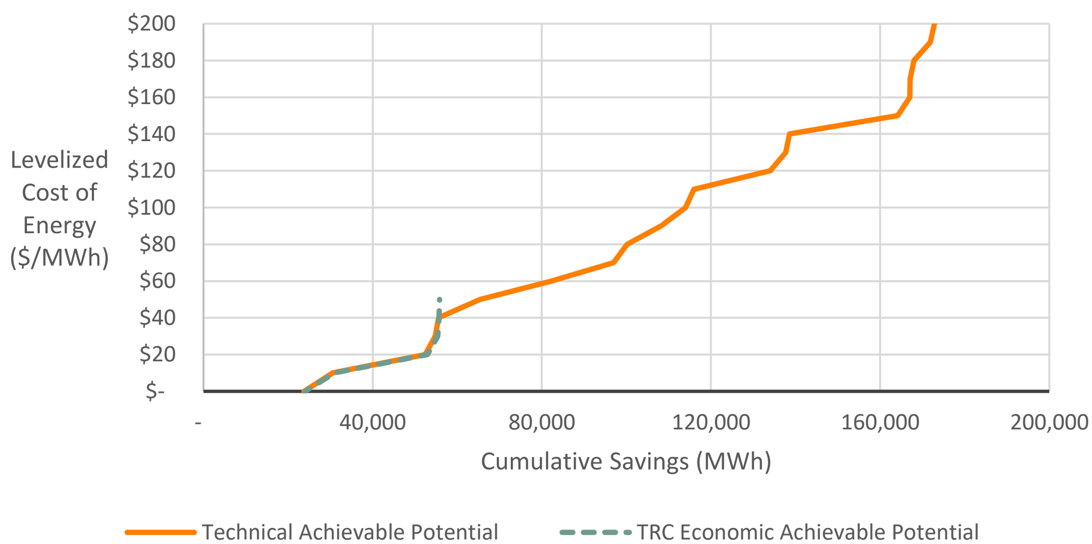


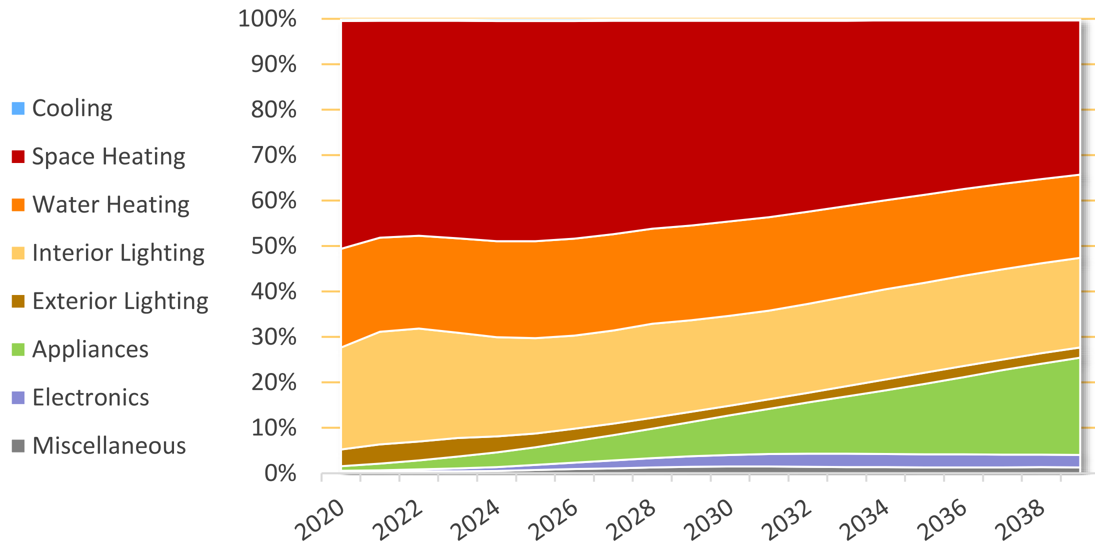
Table 6-2 identifies the top 20 residential measures by cumulative 2029 savings. In a change from prior studies, the top two measures are weatherization measures – installation of new wall cavity insulation and ducting repair and sealing. Combined, weatherization measures provide 44% of cost-effective savings in 2029. 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 appliances such as ENERGY STAR clothes washers, dishwashers, and pool pumps have climbed their way into the top 20.

Table 6-2 Residential Top Measures in 2029 (Annual Energy, MWh)

Rank	Measure / Technology	2029 Economic Achievable Cumulative Savings (MWh)	% of Total
1	Insulation - Wall Cavity Installation	9,179	16.4%
2	Ducting - Repair and Sealing	8,109	14.5%
3	General Service Screw-in – LEDs	7,133	12.8%
4	Water Heater - Pipe Insulation	4,923	8.8%
5	ENERGY STAR Clothes Washers	4,430	7.9%
6	Insulation - Wall Cavity Installation - LI	3,435	6.2%
7	Insulation - Ceiling Installation	2,652	4.7%
8	Linear Lighting – LEDs	2,374	4.3%
9	Exempted Lighting – LEDs	1,761	3.2%
10	Water Heater - Low-Flow Showerheads (1.5 GPM)	1,678	3.0%
11	Water Heater - Thermostatic Shower Restriction Valve	1,592	2.9%
12	Advanced Power Strips - Load or Occupancy	1,253	2.2%
13	Exterior Screw-in – LEDs	1,248	2.2%
14	Dishwasher – CEE Tier 1	1,190	2.1%
15	Water Heater - Low-Flow Showerheads (1.75 GPM)	1,083	1.9%
16	Insulation - Ceiling Installation - LI	991	1.8%
17	Pool Pump – ENERGY STAR Variable Speed	786	1.4%
18	Water Heater - Faucet Aerators	534	1.0%
19	Ducting - Repair and Sealing - Aerosol	401	0.7%
20	Water Heater - Low-Flow Showerheads (2.0 GPM)	393	0.7%
	Total	**55,145**	**98.8%**
	Total Savings in 2029	**55,827**	**100.0%**

Figure 6-5 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 2039 as the potential for appliances increases. Space heating potential comes mostly from weatherization measures, such as wall cavity insulation, duct repair and sealing, and high efficiency windows.

Figure 6-5 Residential Economic Achievable Case – Cumulative Savings by End Use (% of Total and Annual GWh)



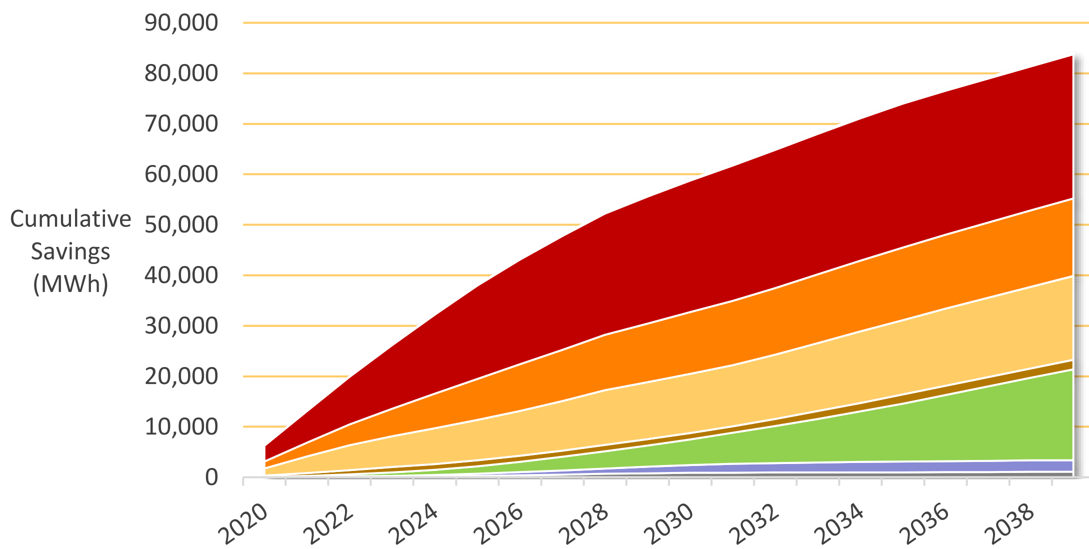


Table 6-3,

Segment	Vintage	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
Single Family	Existing	4,622	9,729	23,571	39,869	58,988
	New	92	211	643	1,540	2,909
Single Family 2-4 units	Existing	157	337	820	1,436	2,307
	New	9	21	66	178	484
Low-Rise Multifamily	Existing	891	1,821	4,446	7,394	10,112
	New	36	84	267	848	2,639
High-Rise Multifamily	Existing	169	347	846	1,410	1,945
	New	7	17	54	192	611
Manufactured Home	Existing	309	632	1,638	2,928	3,934
	New	1	3	11	33	100
Total Residential	**Existing**	**6,148**	**12,867**	**31,321**	**53,036**	**77,286**
	New	**147**	**336**	**1,041**	**2,791**	**6,743**

Table 6-4, and Table 6-5 summarize Residential sector savings by vintage, replacement type, and end use respectively.

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

Segment	Vintage	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
Single Family	Existing	4,622	9,729	23,571	39,869	58,988
	New	92	211	643	1,540	2,909
Single Family 2-4 units	Existing	157	337	820	1,436	2,307
	New	9	21	66	178	484
Low-Rise Multifamily	Existing	891	1,821	4,446	7,394	10,112
	New	36	84	267	848	2,639
High-Rise Multifamily	Existing	169	347	846	1,410	1,945
	New	7	17	54	192	611
Manufactured Home	Existing	309	632	1,638	2,928	3,934
	New	1	3	11	33	100
Total Residential	**Existing**	**6,148**	**12,867**	**31,321**	**53,036**	**77,286**
	New	**147**	**336**	**1,041**	**2,791**	**6,743**

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

Segment	Replacement Type	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
Single Family	Lost Opportunity	1,459	3,462	8,133	15,240	31,802
	Retrofit	3,256	6,477	16,080	26,170	30,095
Single Family 2-4 units	Lost Opportunity	72	171	411	813	1,835
	Retrofit	94	188	475	801	957
Low-Rise Multifamily	Lost Opportunity	170	401	981	2,084	5,607
	Retrofit	757	1,504	3,733	6,157	7,144
High-Rise Multifamily	Lost Opportunity	34	80	197	439	1,204
	Retrofit	143	283	703	1,163	1,352
Manufactured Home	Lost Opportunity	27	65	177	400	1,022
	Retrofit	291	581	1,488	2,576	3,012
Total Residential	**Lost Opportunity**	**1,762**	**4,179**	**9,899**	**18,975**	**41,471**
	Retrofit	**4,541**	**9,033**	**22,478**	**36,867**	**42,559**

Table 6-5 Residential Economic Achievable Potential by End Use, 2029

End Use	Single Family	Single Family 2-4 units	Low-Rise Multifamily	High-Rise Multifamily	Manufactured Home	Total Residential
Cooling	206	9	8	1	15	239
Space Heating	18,935	439	3,221	574	1,971	25,141
Water Heating	7,230	371	2,878	579	582	11,640
Interior Lighting	9,156	470	1,197	250	195	11,268
Exterior Lighting	1,009	52	141	30	15	1,248
Appliances	3,209	184	550	117	139	4,199
Electronics	919	49	246	50	42	1,306
Miscellaneous	745	41	0	0	0	786
Total	**41,409**	**1,614**	**8,242**	**1,602**	**2,960**	**55,827**

Table 6-6 summarizes the risk level of Economic Achievable potential in 2029 for the residential sector. 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. Most RTF measures have a sunset date before 2020. About one-third of this subset has a TRC benefit-to-cost ratio of less than 1.2.

Table 6-6 Residential Economic Achievable Potential by Risk and RTF Category, 2029

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	0	7,586	0	17,372	24,959
1 - TRC B/C Ratio <1.2	0	12	0	12,904	12,916
2 - RTF Sunset before 2020	12,451	3,806	0	0	16,257
3 – Higher Risk (combined)	1,695	0	0	0	1,695
Total	**14,147**	**11,404**	**0**	**30,276**	**55,827**

JBLM Residential Potential

The Joint-Base Lewis-McChord (JBLM) is the largest user 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 Equity Residential. As part of the contract, the homes are required to be maintained at strict energy efficiency standards. 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

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

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

	2020	2021	2024	2029	2039
Baseline Forecast (GWh)	44.6	44.1	43.0	42.0	41.4
Cumulative Savings (GWh)					
Economic Achievable Potential	0.2	0.4	0.9	1.4	2.1
Technical Achievable Potential	0.5	0.9	2.2	4.3	6.8
Technical Potential	0.7	1.5	3.4	6.3	8.5
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.4%	0.8%	2.0%	3.4%	5.0%
Technical Achievable Potential	1.0%	2.1%	5.1%	10.3%	16.4%
Technical Potential	1.7%	3.3%	8.0%	15.1%	20.6%

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

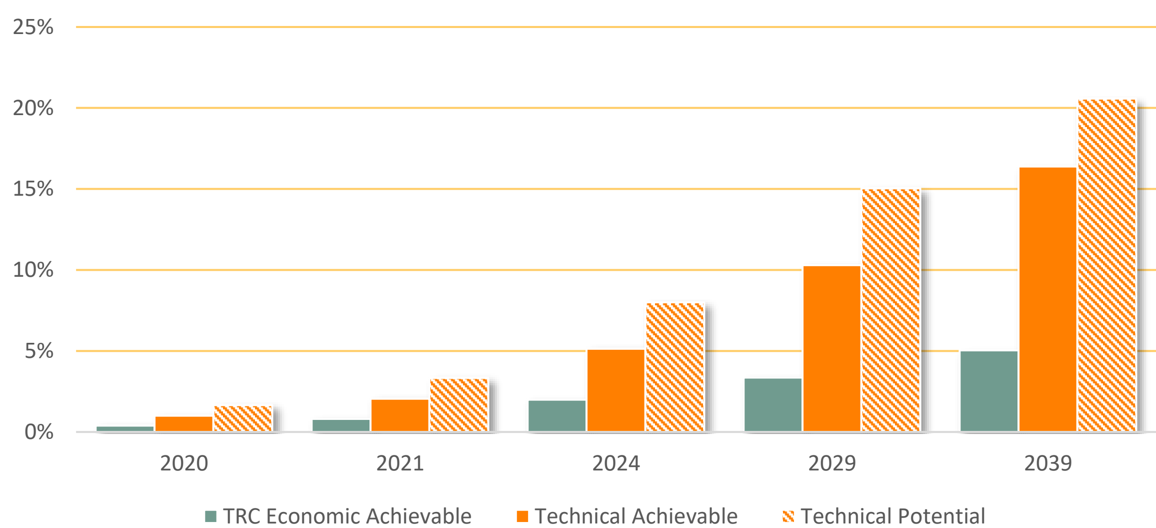


Figure 6-7 and Figure 6-8 show the supply curve of levelized TRC cost per MWh saved vs. cumulative Technical Achievable potential for the JBLM residential sector in 2025. Similar to the civilian residential sector, interior LED lighting and weatherization measures comprise the majority of cost effective savings. Compared to the civilian residential sector, Economic Achievable savings are a lower portion of both Technical Achievable potential and the baseline overall. This is due to the significant progress that Equity has made in retrofitting existing homes and constructing efficient homes under their contract with JBLM. This reflects a higher efficiency baseline.

Figure 6-7 Supply Curve, JBLM Residential Sector in 2029 (Annual Energy, MWh)

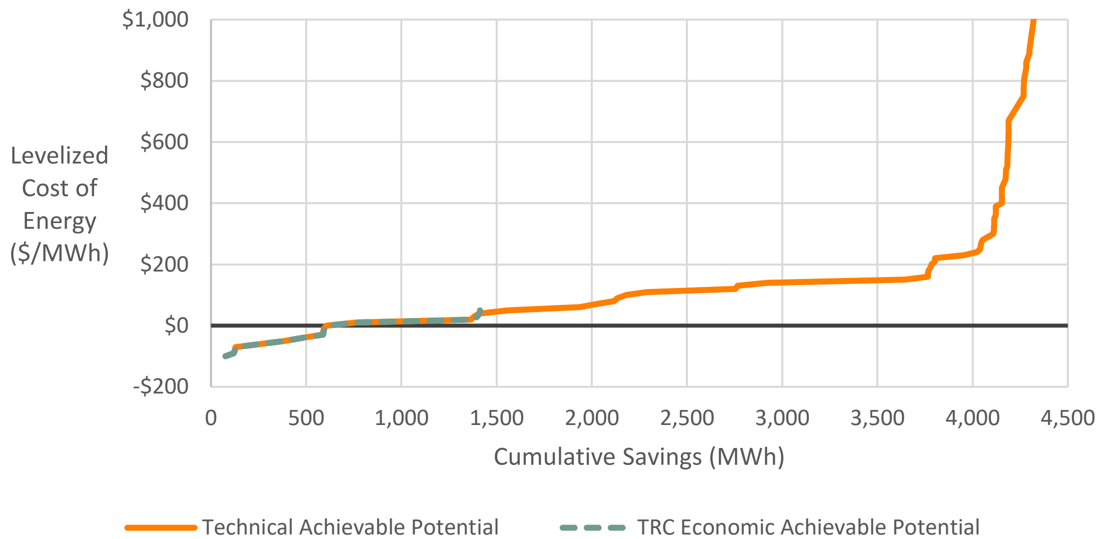


Figure 6-8 Supply Curve, JBLM Residential Sector in 2029, Limited Axis (Annual Energy, MWh)

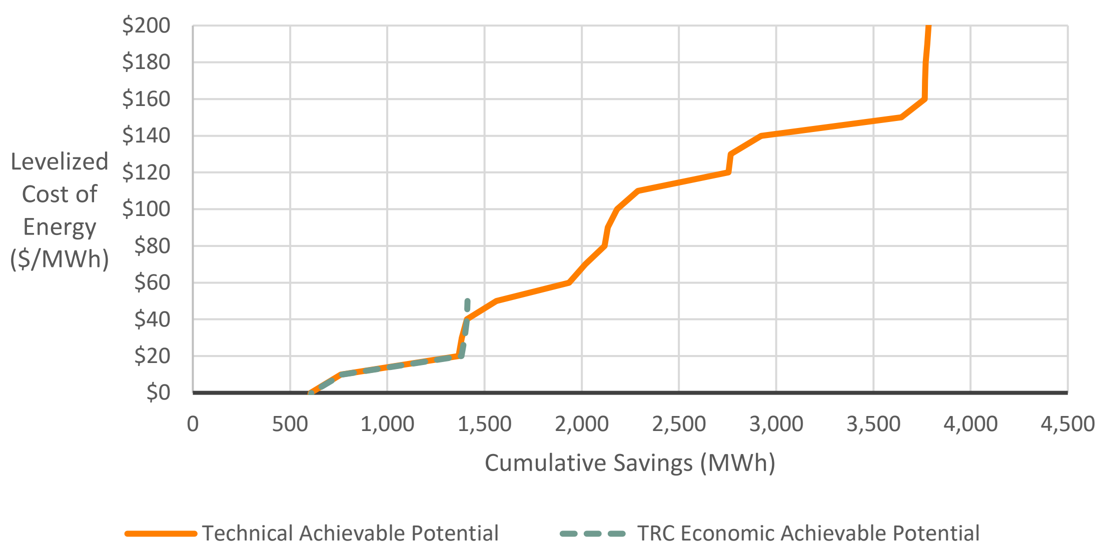


Table 6-8 identifies the top 20 JBLM residential measures in 2029. The list of top measures is similar in most respects to the civilian sector, though some measures have less savings due to differences in presence of equipment between the base and civilian homes.

Table 6-8 JBLM Residential Top Measures in 2029 (Annual Energy, MWh)

Rank	Measure / Technology	2029 Economic Achievable Cumulative Savings (MWh)	% of Total
1	Insulation - Wall Cavity Installation	246	17.4%
2	Ducting - Repair and Sealing	235	16.6%
3	General Service Screw-in	183	13.0%
4	Water Heater - Pipe Insulation	117	8.3%
5	ENERGY STAR Clothes Washers	104	7.3%
6	Insulation - Wall Cavity Installation - LI	79	5.6%
7	Insulation - Ceiling Installation	71	5.0%
8	Linear Lighting	66	4.7%
9	Exempted Lighting	50	3.5%
10	Screw-in	41	2.9%
11	Water Heater - Low-Flow Showerheads (1.5 GPM)	39	2.8%
12	Water Heater - Thermostatic Shower Restriction Valve	37	2.6%
13	Advanced Power Strips - Load or Occupancy	33	2.3%
14	Dishwasher	29	2.1%
15	Water Heater - Low-Flow Showerheads (1.75 GPM)	25	1.8%
16	Insulation - Ceiling Installation - LI	22	1.5%
17	Water Heater - Faucet Aerators	13	0.9%
18	Water Heater - Low-Flow Showerheads (2.0 GPM)	9	0.6%
19	Insulation - Floor Installation	8	0.6%
20	Windows - High Efficiency (SP to CI22) - LI	3	0.2%
	Total	**1,409**	**99.7%**
	Total Savings in 2029	**1,413**	**100.0%**

Figure 6-9 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 6-9 JBLM Residential Economic Achievable Case – Cumulative Savings by End Use (% of Total and Annual GWh)

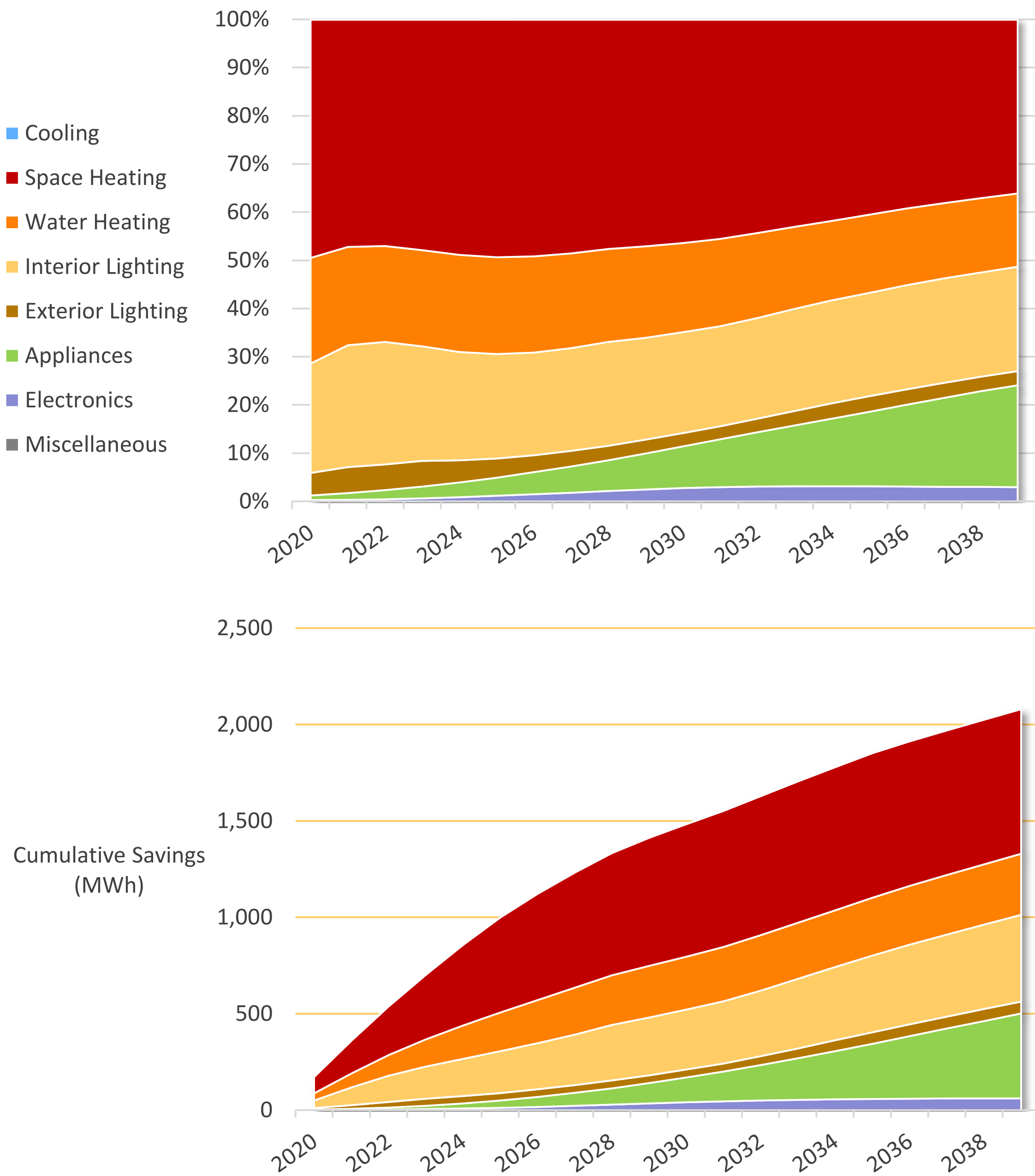


Table 6-9, Table 6-10 and Table 6-11 summarize JBLM Residential sector savings by vintage, replacement type, and end use respectively.

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

Segment	Vintage	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
Single Family	Existing	149	312	744	1,221	1,792
	New	1	2	6	15	38
Multifamily	Existing	22	45	106	173	240
	New	0	0	1	4	10
Total JBLM Residential	**Existing**	**171**	**356**	**850**	**1,394**	**2,033**
	New	**1**	**2**	**7**	**18**	**48**

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

Segment	Replacement Type	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
Single Family	Lost Opportunity	45	107	245	431	922
	Retrofit	105	207	505	805	909
Multifamily	Lost Opportunity	5	11	24	43	99
	Retrofit	18	34	84	134	151
Total JBLM Residential	**Lost Opportunity**	**50**	**118**	**269**	**474**	**1,021**
	Retrofit	**122**	**241**	**588**	**939**	**1,060**

Table 6-11 JBLM Residential Economic Achievable Potential by End Use, 2029

End Use	Single Family	Multifamily	Total JBLM Residential
Cooling	1	0	1
Heating	596	68	664
Water Heating	206	62	268
Interior Lighting	272	27	299
Exterior Lighting	38	3	41
Appliances	95	11	105
Electronics	28	6	35
Miscellaneous	0	0	0
Total	**1,236**	**177**	**1,413**

Table 6-12 summarizes the risk level of Economic Achievable potential in 2029 for the JBLM residential sector. 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. Similar to the civilian residential sector, most RTF measures have a sunset date before 2020. In this case, over one-half of this subset has a TRC benefit-to-cost ratio of less than 1.2, higher than in the civilian residential sector.

Table 6-12 JBLM Residential Economic Achievable Potential by Risk and RTF Category, 2029

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	0	142	0	539	682
1 - TRC B/C Ratio <1.2	0	0	0	332	332
2 - RTF Sunset before 2020	348	0	0	0	348
3 – Higher Risk (combined)	51	0	0	0	51
Total	**399**	**142**	**0**	**871**	**1,413**

Commercial Potential

Table 6-13 and Figure 6-11 present the annual energy savings estimates for the three levels of conservation potential for the commercial sector. Compared to the residential sector, Economic Achievable 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).

Figure 6-10 Lighting at the LeMay - America's Car Museum (courtesy of Tacoma Power)

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

	2020	2021	2024	2029	2039
Baseline Forecast (GWh)	1,294	1,281	1,256	1,243	1,252
Cumulative Savings (GWh)					
Economic Achievable Potential	8	16	41	89	170
Technical Achievable Potential	15	29	75	150	262
Technical Potential	30	57	126	219	333
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.6%	1.2%	3.3%	7.2%	13.6%
Technical Achievable Potential	1.2%	2.3%	5.9%	12.0%	21.0%
Technical Potential	2.3%	4.4%	10.0%	17.6%	26.6%

Figure 6-11 Commercial Savings as a % of the Baseline Projection (Annual Energy)

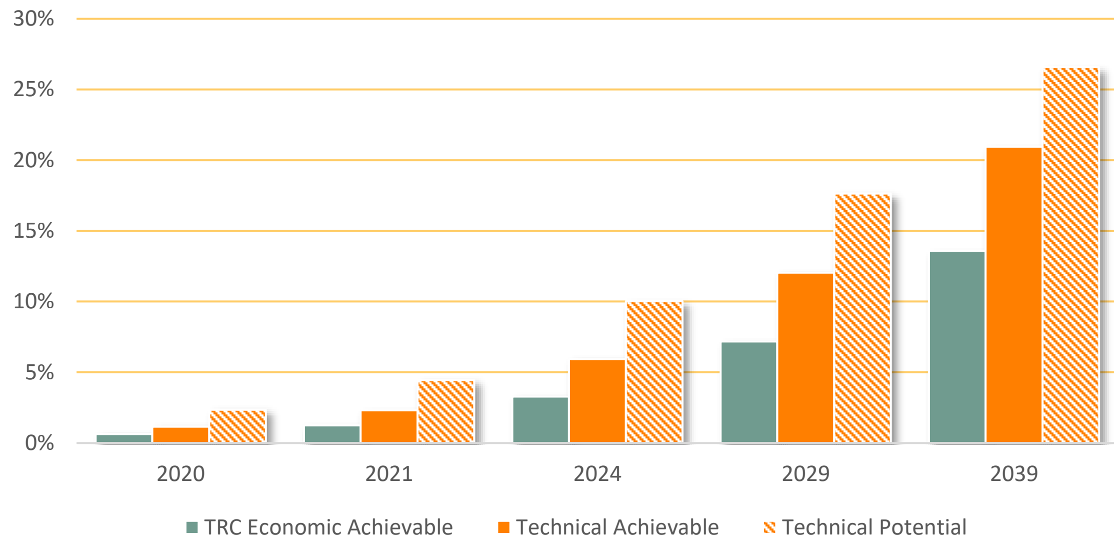


Figure 6-12 and

Figure 6-13 show the supply curve of levelized TRC cost per MWh vs. cumulative Technical Achievable potential for the commercial sector in 2029. LED lighting comprises over 60% 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, retrofit HVAC measures and water heating equipment were also found to be sources of cost-effective potential. Overall, Economic Achievable potential in the commercial sector represents a higher percentage of Technical Achievable potential when compared to residential savings.

Figure 6-12 Supply Curve, Commercial Sector in 2029 (Annual Energy, MWh)

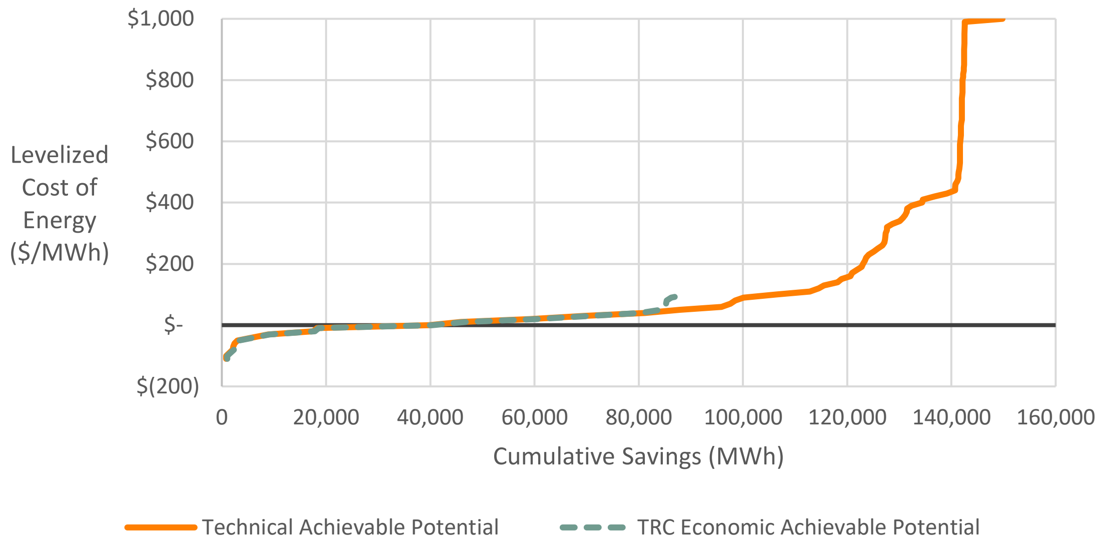


Figure 6-13 Supply Curve, Commercial Sector in 2029, Limited Axis (Annual Energy, MWh)

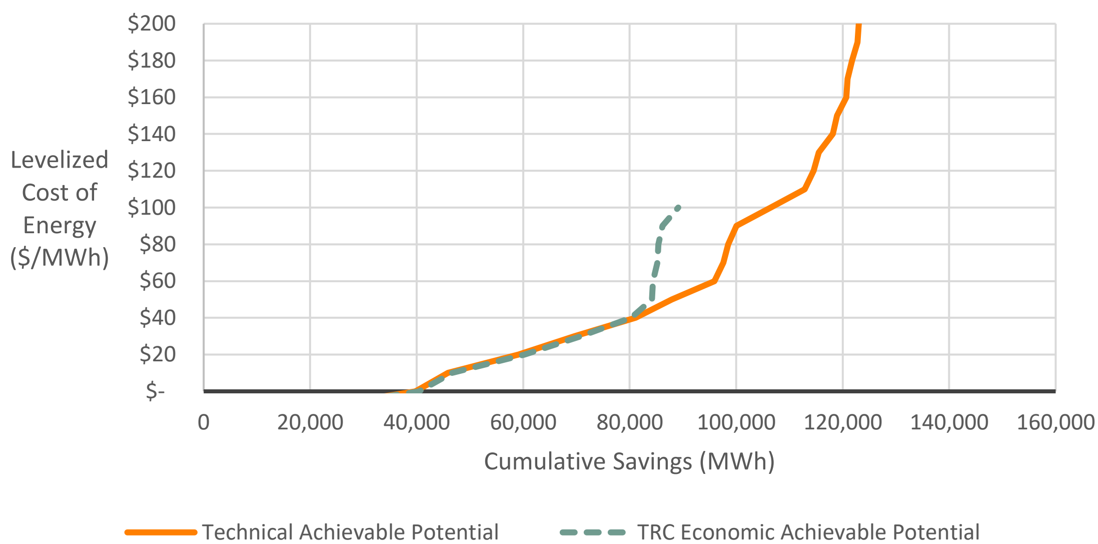


Table 6-14 identifies the top 20 commercial-sector measures in 2029. The top three measures, comprising 58% of total savings, are LED lighting replacements. For Linear lighting and High-Bay replacements, most of these installations (roughly 70% of the savings) include bundled controls that enhance the 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 2029 (Annual Energy, MWh)

Rank	Measure / Technology	2029 Economic Achievable Cumulative Savings (MWh)	% of Total
1	Linear Lighting	27,535	30.9%
2	High-Bay Lighting	20,149	22.6%
3	Area Lighting	5,605	6.3%
4	Server	4,602	5.2%
5	Water-Cooled Chiller	3,103	3.5%
6	General Service Lighting	2,866	3.2%
7	Strategic Energy Management	2,631	3.0%
8	Refrigeration - Replace Single-Compressor with Subcooled Multiplex	1,662	1.9%
9	Retrocommissioning	1,608	1.8%
10	Air-Cooled Chiller	1,572	1.8%
11	Destratification Fans (HVLS)	1,538	1.7%
12	Ventilation - Nighttime Air Purge	1,370	1.5%
13	Water Heater - Pre-Rinse Spray Valve	1,353	1.5%
14	Desktop Computer	1,297	1.5%
15	HVAC - Dedicated Outdoor Air System (DOAS)	1,184	1.3%
16	Water Heating - High Efficiency Circulation Pump	931	1.0%
17	Open Display Case	881	1.0%
18	Exempted Lighting	862	1.0%
19	Interior Fluorescent - Delamp and Install Reflectors	751	0.8%
20	Data Center - Best Practice Measures	734	0.8%
	Total	**82,234**	**92.3%**
	Total Savings in 2029	**89,120**	**100.0%**

Figure 6-14 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. Cooling and heating savings together make up roughly 15% of the total savings potential in 2020 but taper off by 2039 as lighting continues to grow. This sustained savings is possible due to continuous projected improvements in LED efficacy and the previously mentioned bundled controls.

Figure 6-14 Commercial Economic Achievable Case – Cumulative Savings by End Use (% of Total and Annual GWh)

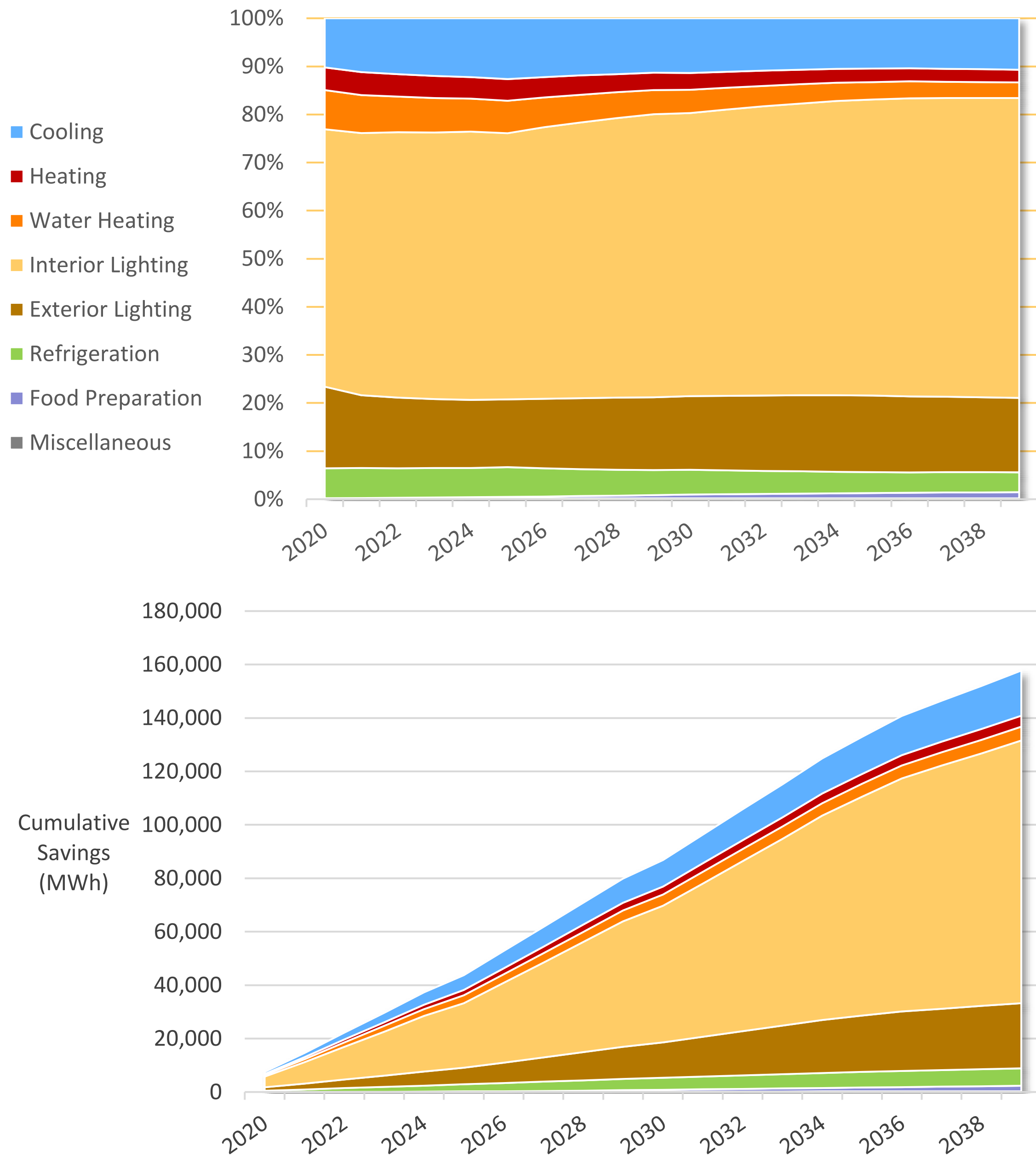


Table 6-15, Table 6-16, and Table 6-17 summarize Commercial sector savings by vintage, replacement type, and end use respectively.

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

Segment	Vintage	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
Office	Existing	723	1,499	4,114	8,926	15,342
	New	162	360	1,170	3,273	8,324
Retail	Existing	918	1,577	3,560	7,034	11,949
	New	225	445	1,233	2,794	6,556
College	Existing	291	583	1,461	2,743	4,384
	New	61	134	407	944	2,212
School	Existing	612	1,232	3,244	7,038	12,546
	New	186	398	1,172	2,898	7,408
Grocery	Existing	606	1,185	2,946	5,720	9,365
	New	118	253	770	1,890	4,573
Hospital	Existing	445	909	2,344	4,663	8,056
	New	119	263	811	1,980	4,862
Other Health	Existing	179	360	904	1,845	3,225
	New	58	124	359	830	2,000
Lodging	Existing	177	344	832	1,619	2,863
	New	18	39	120	319	897
Restaurant	Existing	275	526	1,229	2,312	3,764
	New	46	98	292	698	1,666
Assembly	Existing	264	536	1,463	3,410	6,386
	New	92	198	584	1,471	3,886
Warehouse	Existing	542	1,070	2,715	5,305	8,314
	New	102	217	638	1,573	3,902
Data Center	Existing	188	405	1,226	2,748	3,729
	New	21	52	219	696	1,413
MF Common Area	Existing	222	430	1,118	2,414	4,118
	New	52	112	343	896	2,201
Misc - Classified	Existing	265	488	1,143	2,277	3,897
	New	56	117	341	865	2,194
Misc - Unclassified	Existing	816	1,473	3,394	7,036	12,562
	New	198	402	1,142	2,900	7,520
Total Commercial	**Existing**	**6,524**	**12,618**	**31,693**	**65,093**	**110,500**
	New	**1,514**	**3,211**	**9,601**	**24,027**	**59,613**

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

Segment	Replacement Type	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
Office	Lost Opportunity	551	1,219	3,827	9,980	21,139
	Retrofit	334	641	1,457	2,220	2,527
Retail	Lost Opportunity	1,007	1,763	4,219	8,958	17,500
	Retrofit	137	259	574	870	1,005
College	Lost Opportunity	173	368	1,049	2,374	4,963
	Retrofit	179	349	819	1,314	1,633
School	Lost Opportunity	602	1,252	3,554	8,536	18,091
	Retrofit	196	378	861	1,400	1,862
Grocery	Lost Opportunity	359	728	2,054	4,982	10,784
	Retrofit	365	711	1,661	2,628	3,154
Hospital	Lost Opportunity	403	862	2,467	5,671	12,033
	Retrofit	161	310	688	971	885
Other Health	Lost Opportunity	202	414	1,101	2,427	4,946
	Retrofit	36	69	161	248	280
Lodging	Lost Opportunity	67	132	363	938	2,288
	Retrofit	128	251	589	1,000	1,472
Restaurant	Lost Opportunity	156	312	832	1,948	4,128
	Retrofit	165	312	689	1,062	1,302
Assembly	Lost Opportunity	320	664	1,889	4,641	9,993
	Retrofit	36	70	158	241	279
Warehouse	Lost Opportunity	355	725	2,041	4,874	9,973
	Retrofit	289	562	1,312	2,004	2,243
Data Center	Lost Opportunity	56	147	617	1,894	3,444
	Retrofit	152	310	828	1,550	1,697
MF Common Area	Lost Opportunity	186	370	1,047	2,632	5,419
	Retrofit	88	172	414	678	900
Misc - Classified	Lost Opportunity	203	376	955	2,277	4,921
	Retrofit	119	229	529	866	1,170
Misc - Unclassified	Lost Opportunity	770	1,404	3,458	8,157	17,647
	Retrofit	244	470	1,078	1,779	2,434
Total Commercial	**Lost Opportunity**	**5,410**	**10,737**	**29,474**	**70,291**	**147,269**
	Retrofit	**2,629**	**5,092**	**11,819**	**18,829**	**22,845**

Table 6-17 Commercial Economic Achievable Potential by End Use, 2029

End Use	Office	Retail	College	School	Grocery	Hospital
Cooling	1,523	178	659	602	144	1,716
Heating	530	42	393	113	15	20
Ventilation	525	48	180	74	41	249
Water Heating	589	397	211	313	64	92
Interior Lighting	4,969	6,927	1,568	6,119	3,630	3,619
Exterior Lighting	1,240	1,736	518	2,325	723	392
Refrigeration	17	128	11	80	2,928	36
Food Preparation	184	0	10	0	0	89
Office Equipment	2,623	373	122	308	60	418
Miscellaneous	0	0	15	1	5	12
Total	**12,200**	**9,828**	**3,688**	**9,936**	**7,610**	**6,643**

End Use	Other Health	Lodging	Restaurant	Assembly	Warehouse	Data Center
Cooling	116	337	61	207	766	981
Heating	0	76	15	12	1,228	13
Ventilation	43	74	20	11	78	107
Water Heating	64	276	394	127	99	19
Interior Lighting	2,061	508	1,296	3,295	3,490	226
Exterior Lighting	247	196	412	1,102	1,027	34
Refrigeration	34	319	590	0	1	0
Food Preparation	7	55	129	10	1	6
Office Equipment	73	82	92	110	184	2,056
Miscellaneous	30	14	1	7	5	1
Total	**2,675**	**1,937**	**3,010**	**4,881**	**6,878**	**3,444**

End Use	MF Common Area	Misc. - Classified	Misc. - Unclassified	Total
Cooling	368	411	971	9,039
Heating	31	97	275	2,862
Ventilation	10	47	157	1,665
Water Heating	532	462	371	4,009
Interior Lighting	1,305	1,597	6,382	46,993
Exterior Lighting	765	270	1,093	12,081
Refrigeration	0	7	24	4,176
Food Preparation	17	7	18	532
Office Equipment	264	233	627	7,624
Miscellaneous	18	13	18	139
Total	**3,310**	**3,142**	**9,936**	**89,120**

Table 6-18 summarizes the risk level of Economic Achievable potential in 2029 for the commercial sector. 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. 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, lower than in the residential sector. The None/Other category includes a substantial number of Seventh Plan measures which have not been characterized by the RTF.

Table 6-18 Commercial Economic Achievable Potential by Risk and RTF Category, 2029

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	0	21	888	59,528	60,437
1 - TRC B/C Ratio <1.2	6	532	22	27,646	28,206
2 - RTF Sunset before 2020	0	118	514	0	632
3 – Higher Risk (combined)	0	8	2	0	10
Total	**6**	**678**	**1,426**	**87,174**	**89,284**

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 Technical Achievable potential at JBLM. There is evidence that this effect may decline in future years, lowering overall costs and increasing measure penetration. AEG recommends revisiting this assumption when assessing potential for the 2020-2021 biennium.

Table 6-19 and Figure 6-15 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)

	2018	2019	2022	2029	2039
Baseline Forecast (GWh)	291.9	288.6	280.6	272.3	263.0
Cumulative Savings (GWh)					
Economic Achievable Potential	0.7	1.4	3.8	8.4	15.4
Technical Achievable Potential	1.4	2.8	7.4	15.1	26.4
Technical Potential	4.8	9.2	20.7	36.9	56.6
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.2%	0.5%	1.4%	3.1%	5.9%
Technical Achievable Potential	0.5%	1.0%	2.6%	5.6%	10.0%
Technical Potential	1.7%	3.2%	7.4%	13.6%	21.5%

Figure 6-15 JBLM Commercial Energy Efficiency Savings (Energy)

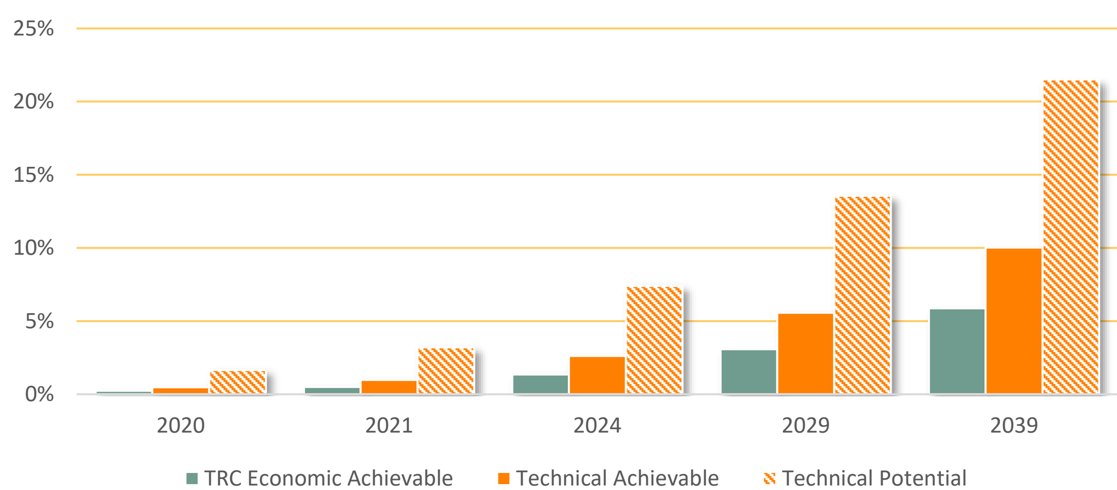


Figure 6-16 and Figure 6-17 show the supply curve of levelized TRC cost per MWh saved vs. cumulative Technical Achievable potential for the JBLM commercial sector in 2029. LED lighting comprises the vast majority of cost-effective savings. Due to recent reductions in fixture costs, the price of linear LED panels has been significantly reduced. This has resulted in LED panels passing the TRC 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. Retrofit HVAC 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 6-16 Supply Curve, JBLM Commercial Sector in 2029 (Annual Energy, MWh)

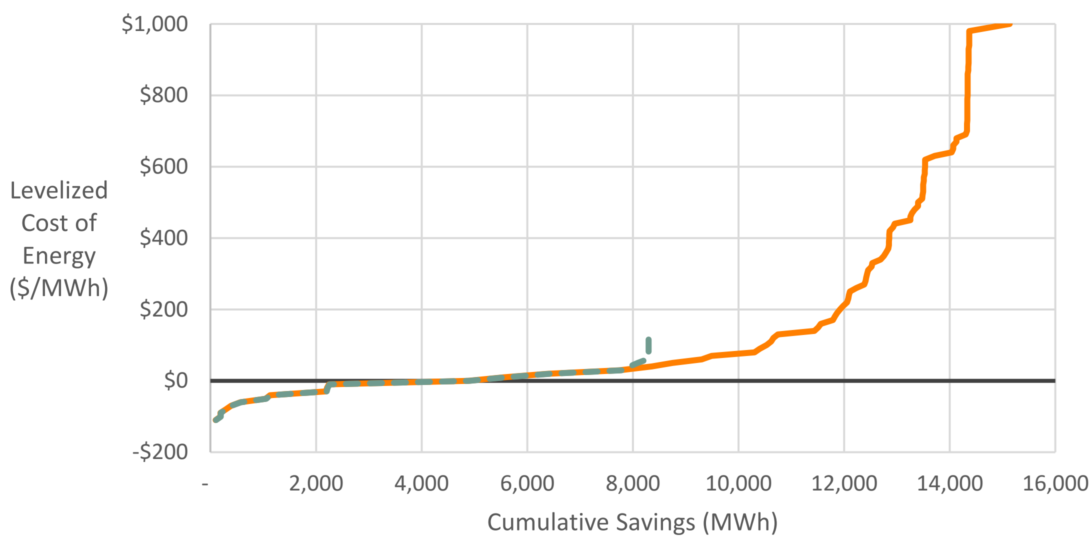


Figure 6-17 Supply Curve, JBLM Commercial Sector in 2029, Limited Axis (Annual Energy, MWh)

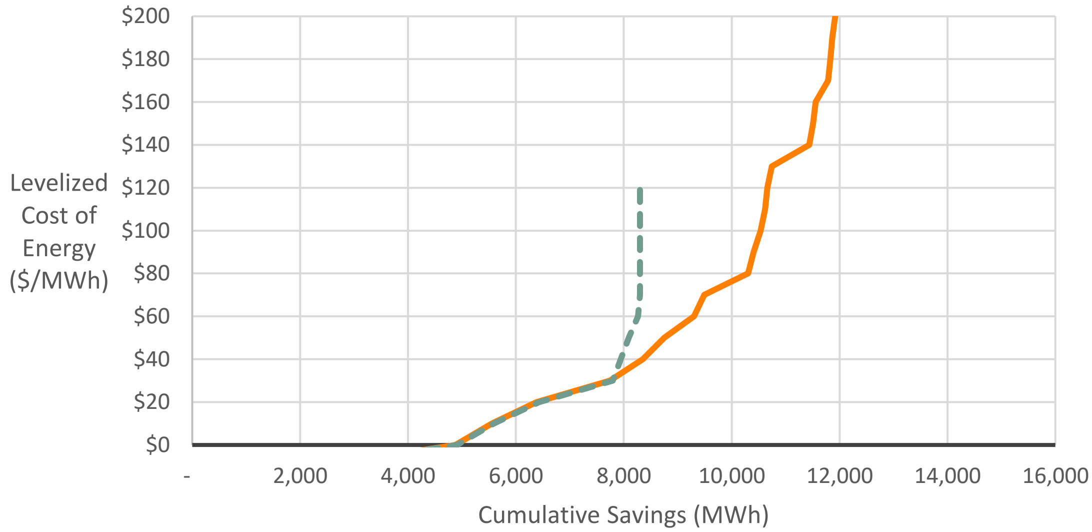


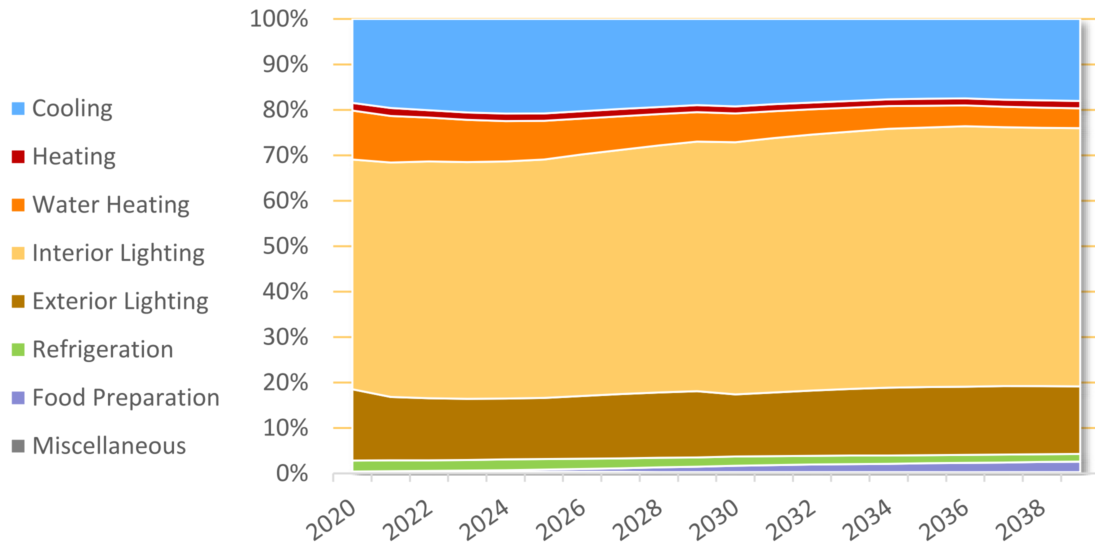
Table 6-20 identifies the top 20 commercial-sector measures in 2029. Lighting measures make up three out of the top five commercial savings measures. For linear and high-bay lighting, many of these LED replacements include bundled controls that help increase savings for a modest additional cost at time of installation.

Table 6-20 JBLM Commercial Sector Top Measures in 2029 (Annual Energy, MWh)

Rank	Measure / Technology	2029 Economic Achievable Cumulative Savings (MWh)	% of Total
1	Linear Lighting	2,280	27.3%
2	High-Bay Lighting	1,726	20.6%
3	Server	615	7.4%
4	Area Lighting	577	6.9%
5	Water-Cooled Chiller	518	6.2%
6	Strategic Energy Management	376	4.5%
7	General Service Lighting	219	2.6%
8	Chiller - Variable Speed Fans	164	2.0%
9	Ventilation - Nighttime Air Purge	161	1.9%
10	Water Heater - Pre-Rinse Spray Valve	160	1.9%
11	Air-Cooled Chiller	143	1.7%
12	Data Center - Best Practice Measures	127	1.5%
13	Water-Cooled Chiller - Condenser Water Temperature Reset	107	1.3%
14	Chiller - Chilled Water Reset	105	1.3%
15	Water Heating - High Efficiency Circulation Pump	105	1.3%
16	Commercial Laundry - Alternative Dry-Cleaning Methods	94	1.1%
17	Refrigeration - Replace Single-Compressor with Subcooled Multiplex	86	1.0%
18	Steamer	85	1.0%
19	Interior Fluorescent - Delamp and Install Reflectors	67	0.8%
20	Water Heater - Faucet Aerators/Low Flow Nozzles	63	0.8%
	Total	**7,779**	**93.0%**
	Total Savings in 2029	**8,361**	**100.0%**

Figure 6-18 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Nearly 70% of cost-effective potential is in lighting, with cooling and water heating following at a distant second a third place respectively.

Figure 6-18 JBLM Commercial Economic Achievable Case – Cumulative Savings by End Use (% of Total and Annual GWh)



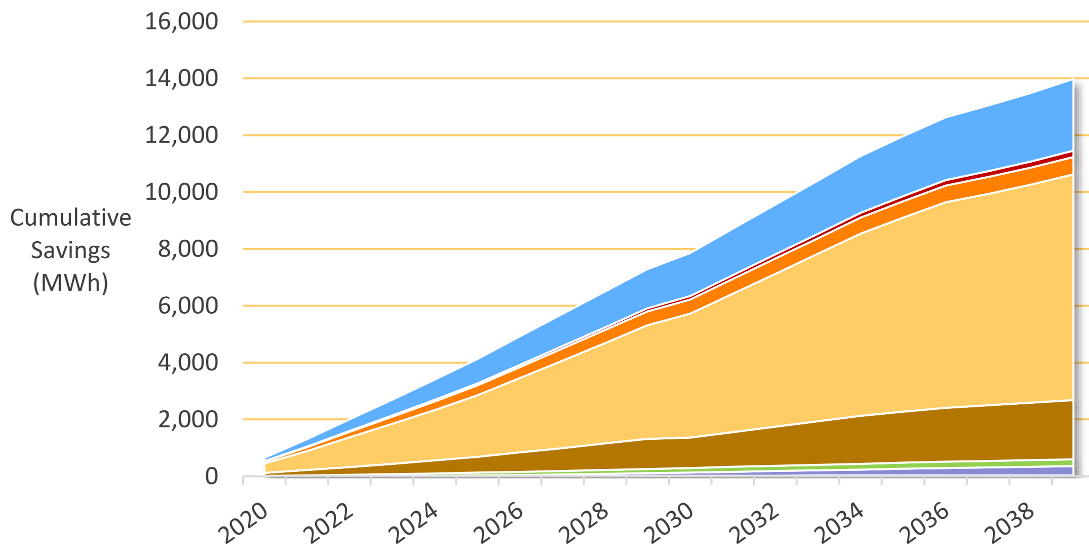


Table 6-21, Table 6-22, and Table 6-23 summarize JBLM Commercial sector savings by vintage, replacement type, and end use respectively.

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

Segment	Vintage	2020 Economic Achievable Potential (MWh)	2021 Economic Achievable Potential (MWh)	2024 Economic Achievable Potential (MWh)	2029 Economic Achievable Potential (MWh)	2039 Economic Achievable Potential (MWh)
Office	Existing	79.9	166.5	466.6	1,073.1	1,881.0
	New	16.8	37.3	119.7	327.2	801.1
Retail	Existing	11.5	19.2	41.9	86.2	156.2
	New	2.0	3.9	10.5	24.9	62.0
School	Existing	28.4	57.1	151.1	334.3	600.4
	New	6.9	14.7	42.7	104.1	254.4
Grocery	Existing	9.0	17.8	45.1	90.8	156.1
	New	1.5	3.2	9.7	23.8	57.3
Lodging	Existing	51.8	100.5	250.4	520.3	855.7
	New	7.1	15.1	45.9	118.3	279.7
Restaurant	Existing	25.3	48.5	114.5	214.7	344.4
	New	3.4	7.3	21.7	51.2	117.2
Warehouse	Existing	70.8	140.7	373.5	835.0	1,494.6
	New	17.4	36.9	107.6	262.1	637.4
Data Center	Existing	30.3	65.7	201.4	462.0	642.9
	New	2.5	6.3	27.0	86.4	174.2
Health	Existing	167.7	338.9	858.3	1,666.2	2,818.1
	New	26.7	58.9	179.9	427.8	1,000.9
Other	Existing	33.9	62.7	147.0	287.1	464.1
	New	5.5	11.2	32.6	78.0	165.8
Hangar	Existing	36.0	73.1	200.2	471.3	874.8
	New	9.8	21.0	61.4	152.3	382.2
Mixed Use	Existing	43.0	83.5	216.8	469.5	796.3
	New	7.5	16.2	49.1	125.5	299.8
Industrial	Existing	6.4	11.4	26.1	52.9	88.6
	New	1.2	2.5	6.8	16.2	34.7
Total JBLM Commercial	**Existing**	**594.0**	**1,185.5**	**3,092.7**	**6,563.4**	**11,173.3**
	New	**108.3**	**234.4**	**714.6**	**1,797.9**	**4,266.6**

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

Segment	Replacement Type	2020 Economic Achievable Potential (MWh)	2021 Economic Achievable Potential (MWh)	2024 Economic Achievable Potential (MWh)	2029 Economic Achievable Potential (MWh)	2039 Economic Achievable Potential (MWh)
Office	Lost Opportunity	66.9	147.2	459.3	1,202.6	2,440.5
	Retrofit	29.8	56.6	127.0	197.7	241.6
Retail	Lost Opportunity	11.8	19.9	45.2	100.0	205.1
	Retrofit	1.7	3.2	7.2	11.1	13.2
School	Lost Opportunity	26.6	55.0	154.8	372.3	756.9
	Retrofit	8.6	16.7	39.0	66.1	97.8
Grocery	Lost Opportunity	5.6	11.2	31.4	76.3	162.8
	Retrofit	5.0	9.8	23.4	38.4	50.5
Lodging	Lost Opportunity	34.8	68.0	181.7	456.8	912.7
	Retrofit	24.1	47.6	114.6	181.8	222.8
Restaurant	Lost Opportunity	14.1	28.1	73.9	172.2	355.5
	Retrofit	14.6	27.8	62.3	93.7	106.0
Warehouse	Lost Opportunity	73.4	148.9	413.9	984.2	1,965.0
	Retrofit	14.8	28.7	67.1	112.9	167.0
Data Center	Lost Opportunity	8.2	21.7	93.4	291.4	521.7
	Retrofit	24.6	50.2	135.0	257.0	295.5
Health	Lost Opportunity	105.1	223.4	631.7	1,452.2	3,014.2
	Retrofit	89.4	174.3	406.5	641.8	804.7
Other	Lost Opportunity	23.1	42.3	105.6	241.0	450.7
	Retrofit	16.3	31.6	73.9	124.1	179.2
Hangar	Lost Opportunity	41.8	86.4	244.3	596.7	1,224.1
	Retrofit	4.0	7.7	17.3	26.9	32.9
Mixed Use	Lost Opportunity	33.7	66.7	186.9	467.1	929.2
	Retrofit	16.8	33.0	79.0	127.8	167.0
Industrial	Lost Opportunity	5.8	10.3	24.7	55.3	103.1
	Retrofit	1.8	3.5	8.2	13.8	20.2
Total JBLM Commercial	**Lost Opportunity**	**450.9**	**929.2**	**2,646.9**	**6,468.2**	**13,041.4**
	Retrofit	**251.4**	**490.8**	**1,160.4**	**1,893.1**	**2,398.5**

Table 6-23 JBLM Commercial Economic Achievable Potential by End Use, 2029

End Use	Office	Retail	School	Grocery	Lodging
Cooling	197	2	22	2	87
Heating	35	1	6	0	0
Ventilation	4	1	4	1	12
Water Heating	77	5	14	1	116
Interior Lighting	604	75	274	57	241
Exterior Lighting	156	22	104	10	90
Refrigeration	2	1	4	42	17
Food Preparation	23	0	0	0	23
Office Equipment	302	4	11	1	39
Miscellaneous	0	0	0	0	14
Total	**1,400**	**111**	**438**	**115**	**639**

End Use	Restaurant	Warehouse	Data Center	Health	Other
Cooling	4	73	162	687	51
Heating	0	29	2	12	17
Ventilation	0	3	17	96	8
Water Heating	36	21	3	30	55
Interior Lighting	113	724	30	1,003	174
Exterior Lighting	36	213	5	109	32
Refrigeration	58	0	0	25	1
Food Preparation	11	0	1	23	1
Office Equipment	8	33	328	108	25
Miscellaneous	0	0	0	2	1
Total	**266**	**1,097**	**548**	**2,094**	**365**

End Use	Hangar	Mixed Use	Industrial	Total
Cooling	20	68	5	1,382
Heating	2	7	2	112
Ventilation	1	2	1	148
Water Heating	17	97	3	476
Interior Lighting	426	234	45	4,000
Exterior Lighting	142	134	8	1,063
Refrigeration	0	0	0	151
Food Preparation	1	3	0	85
Office Equipment	14	47	4	923
Miscellaneous	0	3	0	21
Total	**624**	**595**	**69**	**8,361**

Table 6-24 summarizes the risk level of Economic Achievable potential in 2029 for the JBLM commercial sector. 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. Results are very similar to the civilian commercial sector. 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 Seventh Plan measures which have not been characterized by the RTF.

Table 6-24 JBLM Commercial Economic Achievable Potential by Risk and RTF Category, 2029

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	0	3	94	7,960	8,056
1 - TRC B/C Ratio <1.2	0	58	0	3,083	3,141
2 - RTF Sunset before 2020	0	2	43	0	45
3 – Higher Risk (combined)	0	0	0	0	0
Total	**0**	**62**	**137**	**11,043**	**11,242**

Industrial Potential

Table 6-25 and Figure 6-20 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 Technical Achievable 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.

Figure 6-19 WestRock Pulp Mill (courtesy of Rob Green)

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

	2018	2019	2022	2029	2039
Baseline Forecast (GWh)	1,103	1,108	1,124	1,151	1,209
Cumulative Savings (GWh)					
Economic Achievable Potential	6	11	32	62	91
Technical Achievable Potential	7	16	42	81	115
Technical Potential	10	20	51	95	133
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.5%	1.0%	2.8%	5.4%	7.5%
Technical Achievable Potential	0.7%	1.5%	3.7%	7.0%	9.6%
Technical Potential	0.9%	1.8%	4.5%	8.3%	11.0%

Figure 6-20 Industrial Potential as a % of the Baseline Projection (Annual Energy)

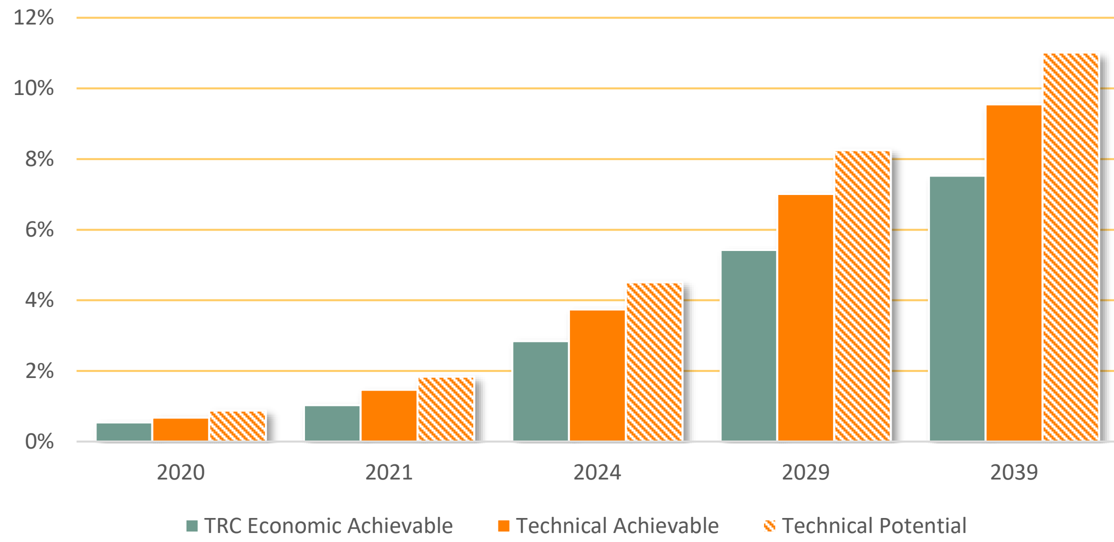


Figure 6-21 and Figure 6-22 show the supply curve of levelized TRC cost per MWh saved vs. cumulative Technical Achievable potential for the industrial sector in 2029. Energy management measures, motor and process controls, and LED lighting make up a majority of the cost-effective savings potential. Although 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 Technical Achievable 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 Technical Achievable savings with levelized costs of less than $30/MWh.

Figure 6-21 Supply Curve, Industrial Sector in 2029 (Annual Energy, MWh)

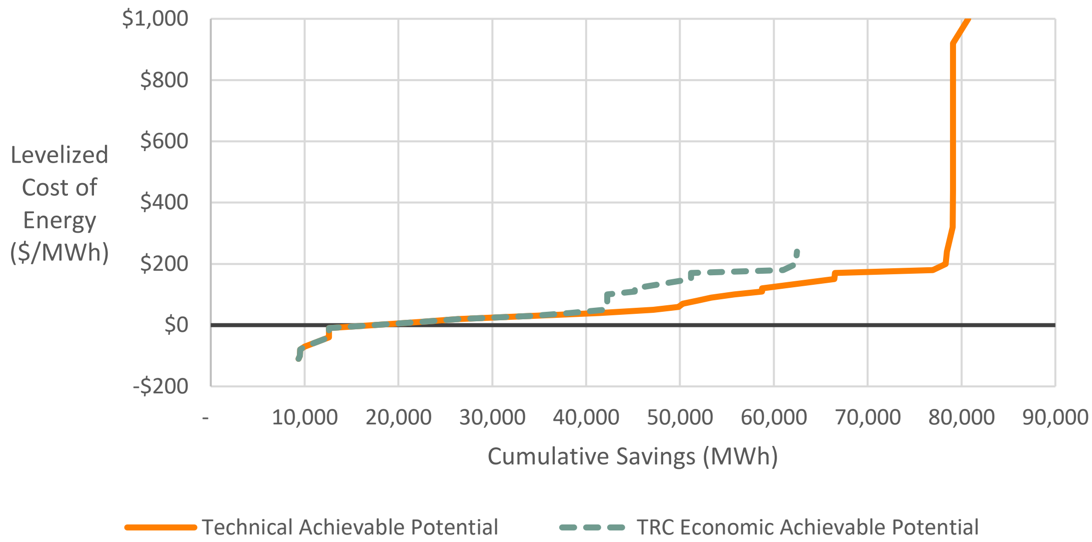


Figure 6-22 Supply Curve, Industrial Sector in 2029, Limited Axis (Annual Energy, MWh)

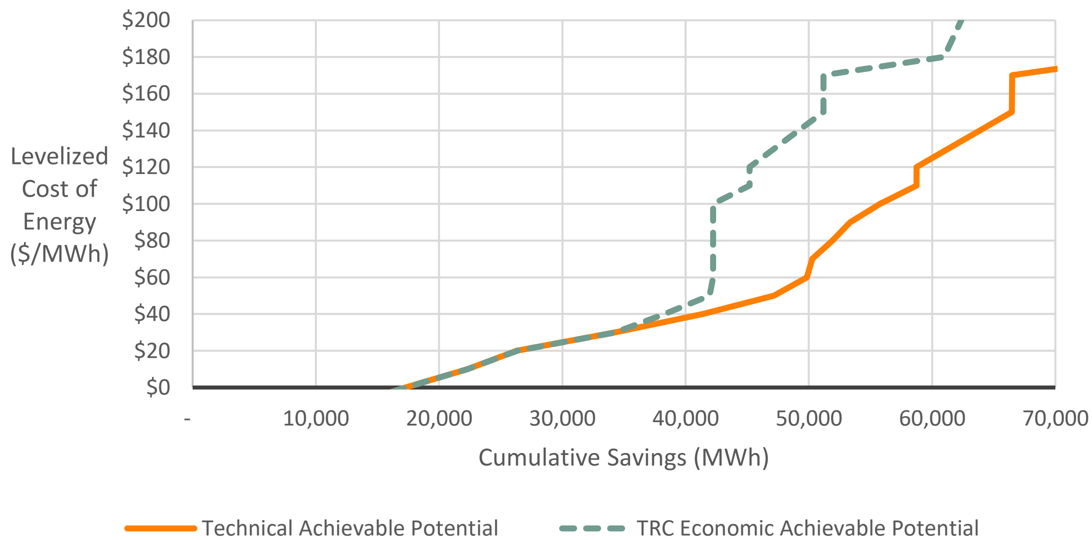


Table 6-26 identifies the top 20 industrial measures in 2029. The top measures are compressed air measures and strategic energy management. Strategic Energy Management encompasses behavioral and low-cost/no-cost opportunities. Interior high bay and exterior area lighting are the eighth and ninth highest measure savings options in the industrial sector.

Table 6-26 Industrial Sector Top Measures in 2029 (Annual Energy, MWh)

Rank	Measure / Technology	2029 Economic Achievable Cumulative Savings (MWh)	% of Total
1	Motor VFDs	9,152	14.7%
2	High-Bay Lighting	7,573	12.1%
3	Controls & Optimization	5,999	9.6%
4	Linear Lighting	4,030	6.5%
5	Compressed Air - Equipment Upgrade	3,537	5.7%
6	Compressed Air - Raise Compressed Air Dryer Dewpoint	3,440	5.5%
7	Compressed Air - End Use Optimization	3,111	5.0%
8	Process Equipment	2,946	4.7%
9	Impeller Trim	2,908	4.7%
10	Pumping System - System Optimization	2,596	4.2%
11	Pumping System - Equipment Upgrade	2,461	3.9%
12	Compressed Air - Leak Management Program	2,443	3.9%
13	Strategic Energy Management	2,407	3.9%
14	Area Lighting	1,486	2.4%
15	Fan System - Equipment Upgrade	1,133	1.8%
16	Compressed Air - System Controls	942	1.5%
17	Fan System - Flow Optimization	662	1.1%
18	Ventilation	550	0.9%
19	Compressed Air - Outside Air Intake	526	0.8%
20	Motors - Green Rewind (100 HP+)	505	0.8%
	Total of top 20 measures	**58,406**	**93.5%**
	Total Savings in 2029	**62,468**	**100.0%**

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

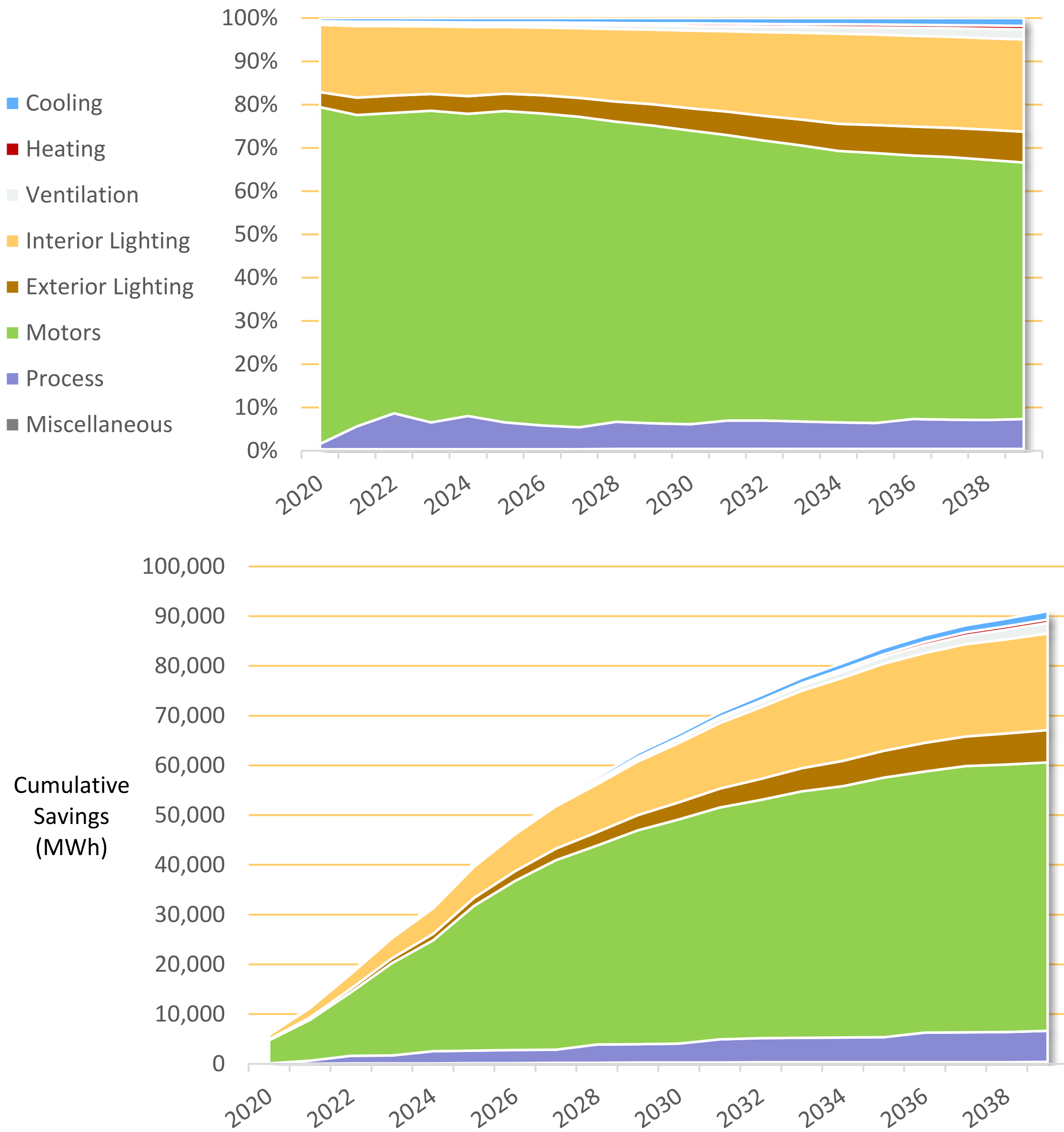


Table 6-27, Table 6-28 and Table 6-29 summarize Industrial sector savings by vintage, replacement type, and end use respectively.

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

Segment	Vintage	2020 Economic Achievable Potential (MWh)	2021 Economic Achievable Potential (MWh)	2024 Economic Achievable Potential (MWh)	2029 Economic Achievable Potential (MWh)	2039 Economic Achievable Potential (MWh)
Paper Mfg.	Existing	2,208	3,679	11,182	22,565	32,015
	New	15	35	118	292	488
Chemical Mfg.	Existing	1,010	2,022	5,021	8,366	10,007
	New	98	227	769	1,702	2,506
Stone Clay & Glass Products	Existing	220	459	1,230	2,465	3,672
	New	41	93	293	705	1,384
Petroleum Refining	Existing	488	982	2,480	4,308	5,227
	New	42	99	343	799	1,075
Lumber & Wood Products	Existing	220	456	1,217	2,411	3,367
	New	35	79	253	618	1,100
Food Mfg.	Existing	296	610	1,594	3,055	4,434
	New	50	115	359	836	1,602
Rubber & Plastics	Existing	240	488	1,244	2,229	3,007
	New	32	73	237	544	974
Other Industrial	Existing	761	1,598	4,262	8,534	13,540
	New	188	424	1,299	3,040	6,600
Total Industrial	**Existing**	**5,444**	**10,293**	**28,230**	**53,933**	**75,270**
	New	**502**	**1,143**	**3,672**	**8,535**	**15,729**

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

Segment	Vintage	2020 Economic Achievable Potential (MWh)	2021 Economic Achievable Potential (MWh)	2024 Economic Achievable Potential (MWh)	2029 Economic Achievable Potential (MWh)	2039 Economic Achievable Potential (MWh)
Paper Mfg.	Lost Opportunity	18	39	111	247	483
	Retrofit	2,206	3,675	11,189	22,610	32,020
Chemical Mfg.	Lost Opportunity	110	243	698	1,567	3,110
	Retrofit	998	2,005	5,092	8,501	9,402
Stone Clay Glass Products	Lost Opportunity	100	220	629	1,405	2,759
	Retrofit	162	332	894	1,765	2,298
Petroleum Refining	Lost Opportunity	33	72	206	462	916
	Retrofit	498	1,008	2,617	4,645	5,387
Lumber Wood Products	Lost Opportunity	75	164	464	1,029	1,985
	Retrofit	180	370	1,006	1,999	2,482
Food Mfg.	Lost Opportunity	116	257	733	1,637	3,209
	Retrofit	230	467	1,221	2,254	2,827
Rubber and Plastics	Lost Opportunity	59	131	376	840	1,653
	Retrofit	213	430	1,105	1,932	2,328
Other Industrial	Lost Opportunity	524	1,161	3,326	7,461	14,784
	Retrofit	425	861	2,236	4,113	5,356
Total Industrial	**Lost Opportunity**	**1,035**	**2,288**	**6,542**	**14,648**	**28,900**
	Retrofit	**4,911**	**9,148**	**25,360**	**47,820**	**62,099**

Table 6-29 Industrial Economic Achievable Potential by End Use, 2029

End Use	Paper Mfg.	Chemical Mfg.	Stone Clay Glass Products	Petroleum Refining	Lumber Wood Products
Cooling	11	73	62	26	29
Heating	5	25	29	12	14
Ventilation	9	70	52	17	15
Interior Lighting	286	1,117	1,031	338	790
Exterior Lighting	53	318	295	97	226
Motors	19,463	8,430	1,570	4,575	1,889
Process	3,027	27	113	37	40
Miscellaneous	4	8	17	6	26
Total	**22,858**	**10,068**	**3,170**	**5,107**	**3,028**

End Use	Food Mfg.	Rubber and Plastics	Other Industrial	Total
Cooling	74	41	423	739
Heating	36	20	204	345
Ventilation	60	34	346	604
Interior Lighting	1,210	616	5,403	10,792
Exterior Lighting	347	176	1,547	3,058
Motors	1,961	1,827	3,251	42,966
Process	168	48	256	3,716
Miscellaneous	34	10	144	248
Total	**3,891**	**2,773**	**11,574**	**62,468**

Table 6-30 summarizes the risk level of Economic Achievable potential in 2029 for the industrial sector. 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. Since the RTF characterizes very few industrial measures, most potential is in the None/Other category. This includes Seventh Plan measures, strategic energy management, and additional system optimization and controls measures identified by AEG.

Table 6-30 Industrial Economic Achievable Potential by Risk and RTF Category, 2029

Risk Level	Proven	Planning	Small Saver	None/Other	Total
0 - Lower Risk	0	16	1	39,431	39,448
1 - TRC B/C Ratio <1.2	0	0	0	23,103	23,103
2 - RTF Sunset before 2020	0	0	149	0	149
3 – Higher Risk (combined)	0	0	0	0	0
Total	**0**	**16**	**150**	**62,534**	**62,700**

Street Lighting Potential

Table 6-31 and Figure 6-25 present estimates for the three levels of conservation potential for the street lighting sector from the perspective of annual energy savings. In 2029, Economic Achievable potential represents roughly half of Technical Achievable potential. The majority of lamps under Tacoma Power's direct control (the H1 – Tacoma Street and Highway segment) have been retrofit to LEDs already. The remaining potential comes from the H1 and H2 fixtures that Tacoma does not have direct access to, and are slower to respond to programs.

Figure 6-24 Tacoma Street Lights (courtesy of Rob Green)

Table 6-31 Conservation Potential for the Street Lighting Sector

	2020	2021	2025	2029	2039
Baseline Forecast (GWh)	20.9	20.9	20.9	20.9	20.9
Cumulative Savings (GWh)					
Economic Achievable Potential	0.1	0.2	1.4	2.7	6.5
Technical Achievable Potential	0.1	0.2	2.8	4.2	7.8
Technical Potential	0.5	1.0	4.6	6.5	10.8
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.4%	1.2%	6.6%	13.0%	31.2%
Technical Achievable Potential	0.4%	1.2%	13.5%	20.3%	37.5%
Technical Potential	2.3%	4.7%	21.8%	31.0%	51.7%

Figure 6-25 Street Lighting Energy Efficiency Savings

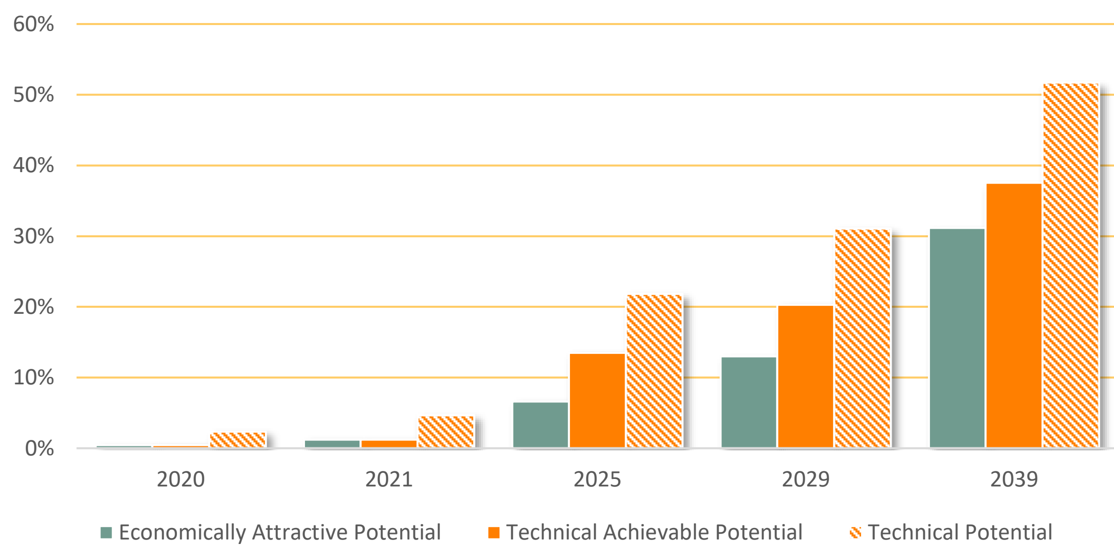


Figure 6-26 shows the supply curve of levelized TRC cost per MWh saved vs. cumulative Technical Achievable potential for the street lighting sector in 2029. Cost effective potential is mainly attributable to the installation of LED lighting fixtures. Using assumptions provided for labor and O&M of replacing 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 6-26 Supply Curve, Industrial Sector in 2029 (Annual Energy, MWh)

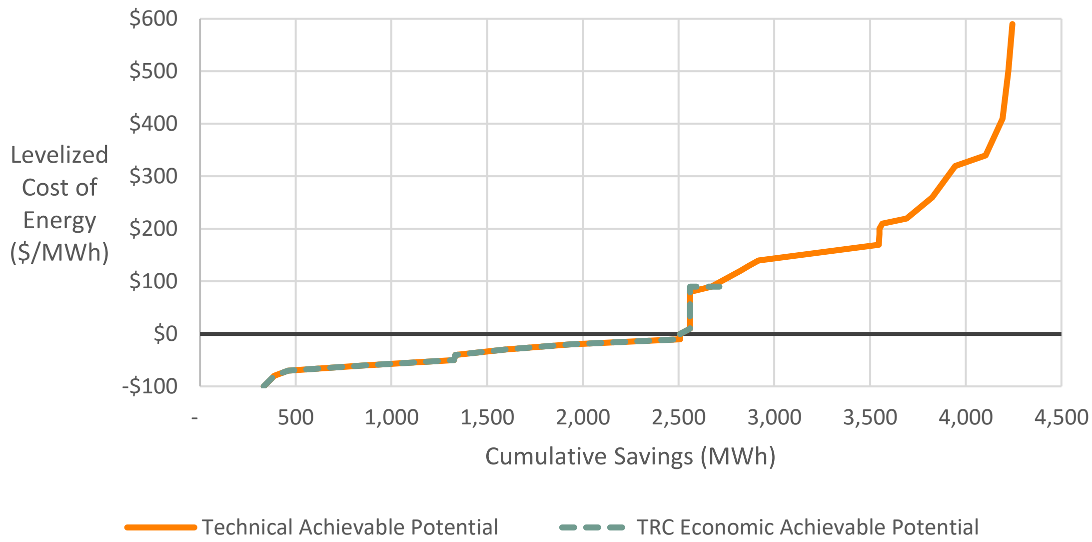


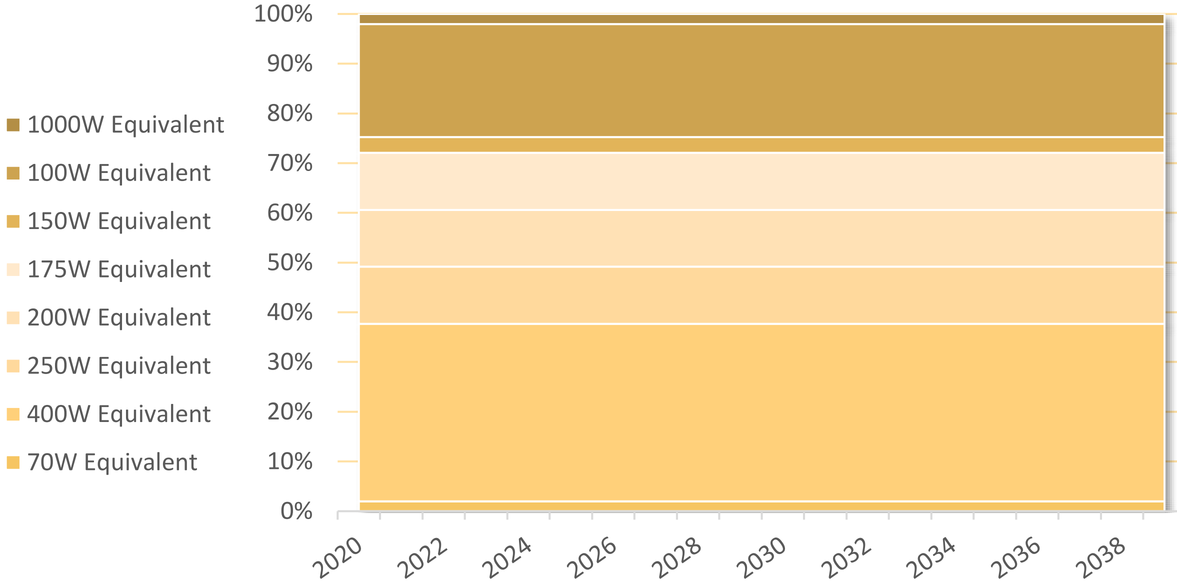
Table 6-32 identifies the top street lighting measures from the perspective of annual energy savings in 2029. A high operations and management savings leads to favorable benefit to cost ratios which allows all LED equipment measures to pass.

Table 6-32 Street Lighting Sector Top Measures in 2029 (Annual Energy, GWh)

Rank	Measure / Technology	2029 Economic Achievable Cumulative Savings (GWh)	% of Total
1	400W Equivalent	914	33.7%
2	100W Equivalent	582	21.4%
3	250W Equivalent	295	10.9%
4	175W Equivalent	294	10.8%
5	200W Equivalent	292	10.8%
6	H1 Retrofit - Flood - 1000W Equivalent	87	3.2%
7	150W Equivalent	81	3.0%
8	H1 Retrofit - Other - 1000W Equivalent	66	2.4%
9	1000W Equivalent	52	1.9%
10	70W Equivalent	51	1.9%
	Total	**2,713**	**100.0%**
	Total Savings in 2029	**2,713**	**100.0%**

Figure 6-27 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 6-27 Street Lighting Economic Achievable Case – Cumulative Savings by End Use (% of Total and Annual GWh)



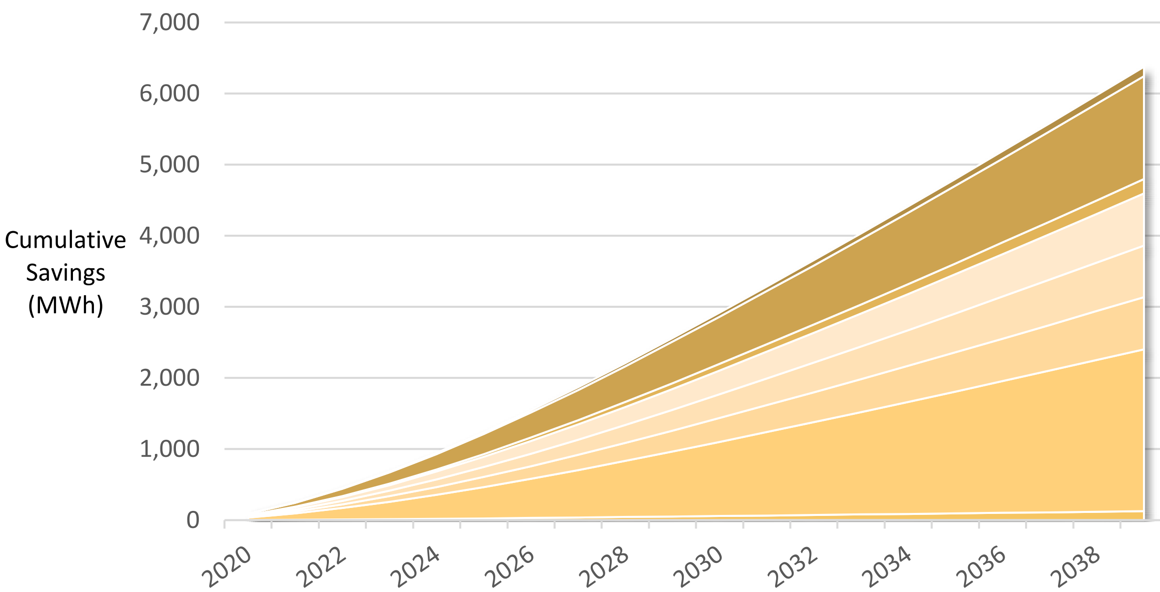


Table 6-33Error! Reference source not found., Table 6-34, and

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 Economic Achievable Potential by Vintage, Select Years

Segment	Vintage	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
H1 Tacoma	Existing	46	124	605	1,420	3,259
	New	6	16	65	171	457
Other H1	Existing	5	15	55	149	367
	New	1	2	7	19	53
All H2	Existing	31	82	312	844	2,076
	New	4	11	41	110	300
Total Street Lighting	**Existing**	**82**	**221**	**973**	**2,413**	**5,703**
	New	**11**	**29**	**113**	**300**	**811**

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

Segment	Replacement Type	2020 Economic Achievable Savings (MWh)	2021 Economic Achievable Savings (MWh)	2024 Economic Achievable Savings (MWh)	2029 Economic Achievable Savings (MWh)	2039 Economic Achievable Savings (MWh)
H1 Tacoma	Lost Opportunity	52	140	532	1,437	3,579
	Retrofit	0	0	139	153	137
Other H1	Lost Opportunity	6	16	62	169	420
	Retrofit	0	0	0	0	0
All H2	Lost Opportunity	35	93	353	954	2,377
	Retrofit	0	0	0	0	0
Total Street Lighting	**Lost Opportunity**	**93**	**250**	**948**	**2,560**	**6,376**
	Retrofit	**0**	**0**	**139**	**153**	**137**

Table 6-35 Street Lighting Economic Achievable Potential by Fixture Wattage, 2029

End Use	H1 Tacoma	H1 Other	H2 All	Total Street Lighting
70W Equivalent	44	7	0	51
100W Equivalent	333	71	178	582
150W Equivalent	74	6	0	81
175W Equivalent	277	18	0	294
200W Equivalent	56	7	229	292
250W Equivalent	264	31	0	295
400W Equivalent	338	28	547	914
1000W Equivalent	**205**	**0**	**0**	**205**
Total	**1,590**	**169**	**954**	**2,713**

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

Distribution Efficiency Potential

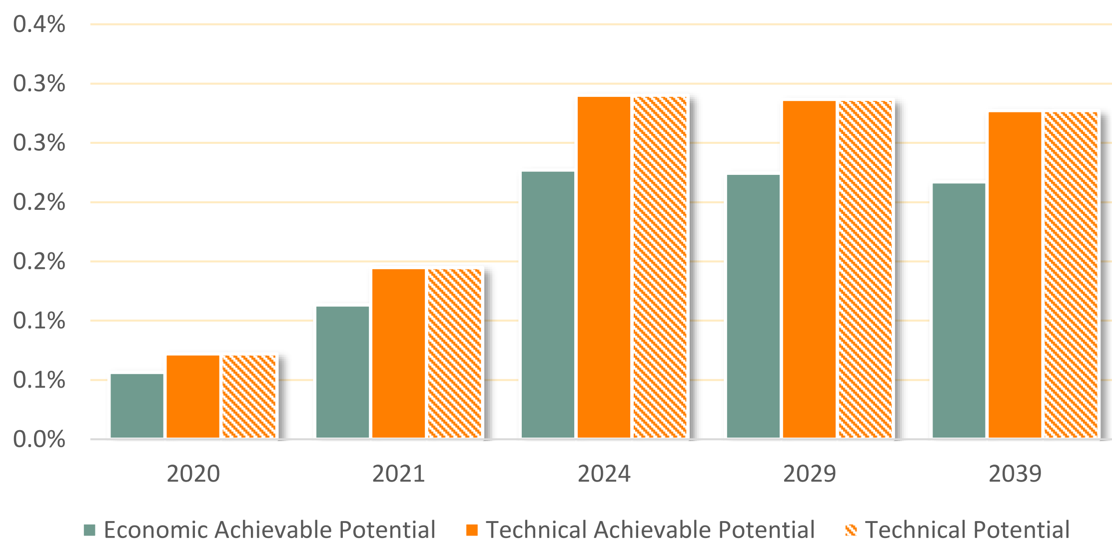
Table 6-36 and Figure 6-29 present estimates for the three levels of conservation potential for the distribution efficiency analysis from the perspective of annual energy savings. In earlier CPA studies, distribution efficiency was based on a utility specific three sub-station study conducted by RW Beck for Tacoma Power, this measure set was found to be highly cost effective. With more than five years' experience implementing distribution efficiency, Tacoma now uses the average of measured savings for actual projects which is 25% lower than initial estimates. Given the relatively low incremental cost for these measures, all Technical Achievable 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. Through 2018, Tacoma Power has upgraded eight substations within the territory with ongoing plans to upgrade additional substations each biennium. To estimate potential and acquisition ramp, AEG assumed that 18 out of the remaining 20 substations could be achievably upgraded over the next six years

Figure 6-28 Electrical Substation in Tacoma (courtesy of Tacoma Power)

Table 6-36 Conservation Potential for Distribution Efficiency

	2020	2021	2024	2029	2039
Baseline Forecast (GWh)	4,669	4,656	4,646	4,700	4,860
Cumulative Savings (GWh)					
Economic Achievable Potential	2.6	5.3	10.5	10.5	10.5
Technical Achievable Potential	3.4	6.7	13.5	13.5	13.5
Technical Potential	3.4	6.7	13.5	13.5	13.5
Cumulative Savings as a % of Baseline					
Economic Achievable Potential	0.1%	0.1%	0.2%	0.2%	0.2%
Technical Achievable Potential	0.1%	0.1%	0.3%	0.3%	0.3%
Technical Potential	0.1%	0.1%	0.3%	0.3%	0.3%

Figure 6-29 Distribution Efficiency Energy Efficiency Savings



7

COMPARISON WITH PRIOR STUDY

Compared to the prior CPA, which estimated potential for the 2018-2019 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 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:

- EISA 2007 phase two is in effect in the first year of potential. This eliminates the forward momentum of cumulative previous savings able to build up in the prior study.
- Increased saturation of efficient technologies in the baseline. For example, updated RTF guidelines expect 80%-90% transformation of the lighting market to LEDs in the baseline within the study horizon, even above the EISA 2007 phase two impact.
- Updated building stock efficiency in the Residential sector. NEEA released the completed data sets from its 2014 Residential Building Stock Assessment, which showed continuing improvements in the shell of average homes as a result of Washington's strict building codes. Lower home usage means less available potential for savings.
- In the Commercial sector, the lighting reduction is offset by new bundled controls for LED fixtures.

Table 7-1 compares 10-year potential between the two studies at a sector level.

Table 7-1 Comparison of 10-Year Economic Achievable Potential with Prior Study (excl. Distribution Efficiency)

Market Sector	Current Study: 2020-2029 Potential (MWh)	*Prior Study: 2018-2027 Potential (MWh)*	Change from Prior Study (MWh)
Residential	55,827	*99,164*	-43,337
JBLM Residential	1,737	*1,477*	260
Commercial	89,125	*87,880*	1,245
JBLM Commercial	11,242	*7,068*	4,174
Industrial	62,468	*57,569*	4,899
Street Lighting	2,713	*8,582*	-5,869
Total	**233,660**	***277,540***	**-43,880**

A more detailed explanation of differences between the two studies is presented below.

Residential Sector Comparison

Table 7-2 compares 10-year potential between the current and prior studies for the residential market sector. The largest differences are in the space heating and interior lighting end uses. Lower avoided costs and revised savings values for many heating measures apply constraints from both ends, lowering the cost effectiveness of potential.

Differences are also significant in interior lighting due to combined impacts from baseline LED penetration and the second EISA 2007 general service standard starting right away in 2020. Exterior lighting is not affected by EISA, but does reflect the trend in baseline lighting efficiency.

Note that these space heating and lighting trends do not affect the JBLM residential sector in the same way. Homes on the base are built to meet higher efficiency requirements than the civilian sector, and have seen less of a shock from the new standards effects, simply because there wasn't as much room in the first place.

Water heating measures have also fallen in the new study, due to updates to the relevant RTF workbooks for water savings measures like low flow showerheads and faucets. Revisions to both costs and savings have tightened the window of cost-effective savings.

Table 7-2 Comparison of Residential Potential with Prior Study

End Use	Current Study: 2020-2029 Potential (MWh)	*Prior Study: 2018-2027 Potential (MWh)*	Change from Prior Study (MWh)
Cooling	239	1,337	-1,098
Space Heating	25,141	41,426	-16,285
Water Heating	11,640	18,431	-6,790
Interior Lighting	11,268	24,020	-12,752
Exterior Lighting	1,248	12,581	-11,333
Appliances	4,199	109	4,090
Electronics	1,306	1,259	47
Miscellaneous	786	2	784
Total	**55,827**	**99,164**	**-43,337**

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: 2020-2029 Potential (MWh)	*Prior Study: 2018-2027 Potential (MWh)*	Change from Prior Study (MWh)
Cooling	9,039	11,612	-2,573
Heating	2,862	3,075	-213
Ventilation	1,665	2,480	-815
Water Heating	4,009	929	3,080
Interior Lighting	46,993	35,277	11,716
Exterior Lighting	12,081	18,358	-6,276
Refrigeration	4,176	6,789	-2,614
Food Preparation	532	1,815	-1,284
Office Equipment	7,624	7,141	483
Miscellaneous	139	405	-265
Total	**89,120**	**87,880**	**1,240**

Lighting faces similar challenges as in the Residential sectors, however in Commercial the additional option for linear, high-bay, and area lighting is to bundle controls at the time of install, improving savings for a small additional cost. About 70% of C&I LED lighting retrofits are bundled with controls in the potential shown above.

As buildings become more efficient and the building code has been on the books longer, potential for savings from economizers on HVAC systems has reduced. Although these measures still have potential, the applicable market has been decreasing over time.

The JBLM commercial market is affected in similar ways to the civilian market, but differences are more pronounced. The first issue is that measures have a more difficult time achieving cost effectiveness due to costs of doing business on base and low cooling usage. This means that any measures that were marginally cost effective in the civilian commercial sector will not pass for JBLM.

A

DOWNTOWN DEFERRAL ANALYSIS

Separate from the 2020-2039 CPA process, Tacoma Power asked AEG to investigate the possibility of using energy efficiency to defer additional investment in the transmission and distribution infrastructure of the downtown Tacoma region, which expects significant, concentrated growth in the commercial sector, along with some residential high-rise additions. Tacoma Power is concerned that aggressive growth may overtax the existing infrastructure in the future, particularly during the coldest parts of the winter season, during which near-peak load conditions persist for many hours a day and for several days at a time. This means short-duration targeted DR programs are not sufficient to relieve the stress and overheating on the lines feeding the area.

Rather than a completely independent CPA for the region in question, this was developed as a "scoping study" to estimate the level of impact of growth and energy efficiency potential, and gain clarity on the specific data needs for a more comprehensive approach in the future. The downtown CPA scoping study assumptions and results were not be incorporated into the regular CPA. The viability of the deferral and decision process is not completed at this time. If Tacoma Power proceeds with strategic conservation for deferral and results indicate that deferral is plausible, downtown avoided cost assumptions will be incorporated into a future CPA study

Preliminary Downtown Region Potential Results

These estimates do not include any cost-effectiveness screening, which would likely cause some high cost potential to fall out. Table A-1 and Error! Reference source not found. summarize preliminary results of the downtown deferral micro-study.

Table A-1 Preliminary Downtown Deferral Study Potential (All Sectors)

	2021	2023	2028	2033	2039
Reference Baseline (GWh)	442	444	462	473	462
Cumulative Savings (GWh)					
Technical Achievable Potential	10	19	45	66	82
Technical Potential	19	35	69	92	106
Energy Savings (% of Baseline)					
Technical Achievable Potential	2.2%	4.4%	9.8%	14.0%	17.7%
Technical Potential	4.2%	7.8%	14.9%	19.5%	22.9%

Next Steps

Continued study and pilot testing is required determine the viability of a downtown deferral. Among the key factors which require further study include:

- Further Clarity on New Growth. Tacoma is currently in the process of a detailed analysis of all land parcels in its territory to assess the most likely growth scenario. This will directly inform the growth assumptions on the downtown feeder region, with greater clarity than the estimates used here.
- Develop Avoided Costs for Deferral. Cost-effectiveness cannot be fully performed on the downtown region's specific needs until full avoided T&D costs are quantified.
- Further Research on Cold Climate Heat Pumps. Research on the possible peak demand savings from cold-climate optimized heat pumps is still very limited. If impacts from these measures can be reasonably quantified, it could increase the magnitude of the available opportunity for peak reduction.

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 (2013). 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 (Error! Reference source not found. through Error! Reference source not found.)
- JBLM Residential market profiles by segment (Error! Reference source not found. through Error! Reference source not found.)
- Commercial market profiles by building type (Error! Reference source not found. through Error! Reference source not found.)
- 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 (Error! Reference source not found. through Error! Reference source not found.)
- Street Lighting market profiles (Error! Reference source not found. through Error! Reference source not found.)

Tacoma 2018-2019
CPA Market Profiles.

C

CUSTOMER ADOPTION FACTORS

As described in Chapter 1, 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 Technical Achievable 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.

Note that the "CustomBehav" ramp rate was developed with guidance from Tacoma Power and is intended to reflect deployment of a pilot program in year 1 and full implementation in year 2.

Table C-1 Ramp Rates used in CPA Analysis

Ramp Rate	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2039
LO12Med	9%	19%	28%	37%	47%	55%	62%	67%	71%	75%	78%	80%	82%	83%	84%	85%	85%	85%	85%	85%
LO5Med	4%	8%	13%	20%	27%	35%	45%	54%	63%	71%	76%	81%	83%	84%	85%	85%	85%	85%	85%	85%
LO1Slow	0%	1%	1%	3%	5%	7%	11%	16%	22%	29%	37%	46%	54%	62%	69%	75%	79%	82%	84%	85%
LO50Fast	38%	56%	68%	76%	81%	83%	84%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%
LO20Fast	19%	32%	42%	49%	55%	61%	65%	69%	72%	75%	78%	79%	81%	82%	83%	84%	84%	84%	85%	85%
LOEven20	4%	9%	13%	17%	21%	26%	30%	34%	38%	43%	47%	51%	55%	60%	64%	68%	72%	77%	81%	85%
LOMax60	1%	3%	5%	8%	12%	16%	20%	24%	28%	31%	34%	37%	40%	42%	45%	47%	49%	51%	53%	55%
LO3Slow	0%	1%	3%	5%	9%	15%	22%	31%	40%	49%	57%	65%	71%	75%	79%	81%	83%	84%	85%	85%
Retro12Med	9%	9%	9%	9%	9%	8%	7%	5%	4%	3%	3%	2%	2%	1%	1%	1%	0%	0%	0%	0%
Retro5Med	4%	4%	5%	6%	7%	8%	9%	9%	9%	8%	6%	4%	2%	1%	1%	0%	0%	0%	0%	0%
Retro1Slow	0%	0%	1%	1%	2%	3%	4%	5%	6%	7%	8%	8%	9%	8%	7%	6%	4%	3%	2%	1%
Retro50Fast	38%	18%	12%	8%	5%	3%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Retro20Fast	19%	13%	9%	7%	6%	5%	5%	4%	3%	3%	2%	2%	1%	1%	1%	1%	1%	0%	0%	0%
RetroEven20	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
RetroMax60	1%	2%	3%	3%	4%	4%	4%	4%	4%	3%	3%	3%	3%	3%	2%	2%	2%	2%	2%	2%
Retro3Slow	0%	1%	1%	3%	4%	6%	7%	8%	9%	9%	8%	7%	6%	5%	3%	2%	2%	1%	1%	0%
CustomBehav[15]	53%	32%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

[15] Since behavioral programs are deployed by the utility and not a traditional energy efficiency measure, achievability is not constrained to traditional participation curves. Through discussions with Tacoma Power staff on the design of both pilot and full-scale behavioral programs, it was determined that if the program was cost-effective, it could be effectively deployed within the 2020-2021 biennium period.

D

MEASURE LIST

Here we summarize the list of measures evaluated in the 2020-2039 CPA. These tables include sample baseline definitions and efficient options from a selected large segment. Full details may be found in the "Measure Summary" spreadsheets in any of the "LoadMAP Results" files provided to Tacoma Power alongside this report.

Table D-1 summarizes the residential equipment measures analyzed in this study. The civilian and JBLM residential market sectors share a common measure list.

Table D-1 Residential Equipment Measures, Single Family

End Use	Measure	Baseline Definition	Efficient Definition (in 2029)
Cooling	Central AC	SEER 14.0	SEER 15.0
Cooling	Room AC	CEER 10.9	CEER 12.0 (ENERGY STAR)
Cooling/Space Heating	Air-Source Heat Pump	Heat Pump Upgrade to 9.0 HSPF/14 SEER	SEER 18.0 / HSPF 12.0 Variable Capacity (CEE)
Cooling/Space Heating	Geothermal Heat Pump	EER 13.4 / COP 3.1	EER 14.2 / COP 3.2
Water Heating	Water Heater (<= 55 Gal)	EF 0.95 (2020)	NEEA Tier 3 Heat Pump (UEF 2.6)
Water Heating	Water Heater (> 55 Gal)	EF 2.00 - Federal Standard	NEEA Tier 1 Heat Pump (UEF 2.2)
Interior Lighting	General Service Screw-in	EISA Compliant (45 lm/W)	LED 2025 (111 lm/W)
Interior Lighting	Linear Lighting	T8 - F32 (69.0 lm/W lm/W system)	LED 2025 (142 lm/W system)
Interior Lighting	Exempted Lighting	Incandescent (9.7 lm/W)	LED 2025 (108 lm/W)
Exterior Lighting	Screw-in	EISA Compliant (45 lm/W)	LED 2025 (104 lm/W)
Appliances	Clothes Dryer	UCEF 2.44 - RTF Conventional Baseline	UCEF 3.3 - Heat Pump
Appliances	Dishwasher	Standard 2013 (180-307 kWh)	CEE Tier 1 (180-295 kWh, 0.75 min EF)
Appliances	Refrigerator	Standard 2014	CEE Tier 1 (10% above standard)
Appliances	Freezer	Standard 2014	ENERGY STAR
Appliances	Second Refrigerator	Standard 2014	CEE Tier 1 (10% above standard)
Appliances	Stove/Oven	Standard	High Efficiency
Appliances	Microwave	2016 Code	2016 Efficient (Level 4)
Electronics	Personal Computers	Standard	ENERGY STAR (6.1)
Electronics	Monitor	Standard	ENERGY STAR (7.0)
Electronics	Laptops	Standard	ENERGY STAR (6.1)
Electronics	TVs	Standard	ENERGY STAR (7.0)
Electronics	Printer/Fax/Copier	Standard	ENERGY STAR (2.0)
Electronics	Set-top Boxes/DVRs	2017 Agreement	2017 Agreement
Miscellaneous	Electric Vehicles	Level 1 Future	Level 2 Future
Miscellaneous	Pool Pump	Standard	ENERGY STAR Variable Speed
Miscellaneous	Pool Heater	Electric Resistance	Heat Pump

End Use	Measure	Baseline Definition	Efficient Definition (in 2029)
Miscellaneous	Hot Tub/Spa	Standard	Efficient Pumps
Miscellaneous	Furnace Fan	Blower Motor Upgrade	Blower Motor Upgrade
Miscellaneous	Well pump	Standard (40% EF)	High Efficiency (60% EF)

Table D-2 summarizes the residential non-equipment measures analyzed in this study. Many of the weatherization and heat pump measures have both regular and low-income permutations.

Table D-2 Residential Non-Equipment Measures, Single Family

End Use	Measure	Baseline Definition	Efficient Definition
Cooling/Space Heating	Insulation - Ceiling Installation	R-0	R-30, R-38, or R-49
Cooling/Space Heating	Insulation - Ceiling Upgrade	R-11	R-30 or R-49
Cooling/Space Heating	Insulation - Radiant Barrier	None	Installed
Cooling/Space Heating	Insulation - Wall Cavity Installation	R-0	R-11
Cooling/Space Heating	Insulation - Wall Sheathing	None	Install R-5 Rigid
Cooling/Space Heating	Insulation - External Wall Sheathing - Insulated Vinyl Siding	None	Insulated Vinyl Siding, between R-2 and R-2.7
Cooling/Space Heating	Insulation - Floor Installation	R-0	R-22 or R-30
Cooling/Space Heating	Insulation - Floor Upgrade	R-11	R-22
Cooling/Space Heating	Insulation - Foundation	R-0	R-10
Cooling/Space Heating	Insulation - Insulated Concrete Forms	R-0	R-17 to R-26
Cooling/Space Heating	Insulation - Ducting	R-4	R-8
Cooling/Space Heating	Ducting - Repair and Sealing	20% Leakage	Sealed
Cooling/Space Heating	Ducting - Repair and Sealing - Aerosol	20% Leakage	G.17 Aerosol Duct Sealing
Cooling/Space Heating	Building Shell - Infiltration Control	None	0.1 ACH Reduction
Cooling/Space Heating	Building Shell - Whole-Home Aerosol Sealing	Leaky Building	Building Sealed
Cooling/Space Heating	Building Shell - Liquid-Applied Weather-Resistive Barrier	None	Liquid-Applied Weather-Resistant Barrier

End Use	Measure	Baseline Definition	Efficient Definition
Cooling/Space Heating	Windows - High Efficiency (SP to Cl30)	Single Pane	Class 30
Cooling/Space Heating	Windows - High Efficiency (SP to Cl22)	Single Pane	Class 22
Cooling/Space Heating	Windows - High Efficiency (DP to Cl30)	Double Pane	Class 30
Cooling/Space Heating	Windows - High Efficiency (DP to Cl22)	Double Pane	Class 22
Cooling/Space Heating	Windows - Low-e Storm Addition	Single or Double Pane	Low-e Storm Window
Cooling	Windows - Install Reflective Film	No Film Installed	Film Installed
Cooling/Space Heating	Windows - Cellular Shades	No Shades	Insulated Cellular Shades
Cooling/Space Heating	Doors - Storm and Thermal	R-2.5 Door	R-5 Door
Cooling/Space Heating	Ductless Mini Split Heat Pump (Zonal)	None	Installed
Cooling/Space Heating	Ductless Mini Split Heat Pump (Ducted Forced Air)	None	Installed
Space Heating	Space Heating - Heat Recovery Ventilator	None	Installed
Space Heating	Furnace - Conversion to Air-Source Heat Pump	Central Forced Air Furnace	Central Air-Source Heat Pump
Cooling	Room AC - Removal of Second Unit	Unit Installed	Unit Removed
Cooling	Central AC - Maintenance and Tune-Up	Standard Unit	Tuned Up Unit
Cooling/Space Heating	Central Heat Pump - Controls and Commissioning	Standard Unit	Properly Sized and Installed Unit
Cooling/Space Heating/Water Heating	Integrated Heat Pump - Combination HVAC and DHW	Degraded Unit	3-Function Heat Pump: Hot Water, Space Heating and Cooling
Cooling	Ceiling Fan - ENERGY STAR	Standard Unit	ENERGY STAR Unit
Cooling	Whole-House Fan - Installation	None	Installed
Cooling/Space Heating	Thermostat - Connected	Programmable Thermostat	Networked Thermostat Installed

End Use	Measure	Baseline Definition	Efficient Definition
Cooling/Space Heating/Interior Lighting/Exterior Lighting/Miscellaneous	Connected Home Control System	No Controls	Networked Controls Installed
Water Heating	Water Heater - Drainwater Heat Recovery	None	Installed
Water Heating	Water Heater - Faucet Aerators	2.5 GPM Faucet	1.0-1.5 GPM Faucet
Water Heating	Water Heater - Low-Flow Showerheads (2.0 GPM)	2.5 GPM Faucet	2 GPM Showerhead
Water Heating	Water Heater - Low-Flow Showerheads (1.75 GPM)	2.5 GPM Faucet	1.75 GPM Showerhead
Water Heating	Water Heater - Low-Flow Showerheads (1.5 GPM)	2.5 GPM Faucet	1.5 GPM Showerhead
Water Heating	Water Heater - Pipe Insulation	Uninsulated Pipe	R-3.5 Insulation Installed
Water Heating	Water Heater - Desuperheater	None	Installed
Water Heating	Water Heater - Temperature Setback	Water Set at 135°F	Water Set at 120°F
Water Heating	Water Heater - Thermostatic Shower Restriction Valve	None	Installed
Water Heating	Water Heater - Solar System	Standard Electric Unit	SEF 2.5 Solar Unit
Water Heating/Space Heating	Circulation Pump - High Efficiency	Standard Unit	Bronze or stainless steel pump; ≤1/30 horsepower (≤50 Max watts); ; Aquastat run-hours control
Interior Lighting	Interior Lighting - Occupancy Sensors	Manual Controls	Occupancy-Based Controls
Exterior Lighting	Exterior Lighting - Photosensor Control	Manual Controls	Light-Sensing Controls
Exterior Lighting	Exterior Lighting - Photovoltaic Installation	None	Solar-Powered Unit Installed
Exterior Lighting	Exterior Lighting - Timeclock Installation	Manual Controls	Motion-Sensing Controls

End Use	Measure	Baseline Definition	Efficient Definition
Appliances	Refrigerator - Decommissioning and Recycling	Unit Installed	Unit Removed
Appliances	Freezer - Decommissioning and Recycling	Unit Installed	Unit Removed
Electronics	Advanced Power Strips - Load or Occupancy	Standard Unit	Tier 1 - Load Sensing
Electronics	Advanced Power Strips - IR Sensing	Standard Unit	Tier 2 - Occupancy Sensing
Water Heating/Appliances	ENERGY STAR Clothes Washers	MEF 1.87	Energy Star Washer
Miscellaneous	Pool Pump - Timer	Manual Controls	Scheduled Controls
Miscellaneous	Pool Heater - Solar Water Heating System	Standard Electric Unit	Passive Solar Unit
Miscellaneous	Pool Cleaner - Robotic	Standard Pool Cleaner	Advanced Pool Cleaner
Exterior Lighting	LED Pool and Spa Lighting	100W Incandescent	15.5 W LED Pool Lamp
Cooling/Space Heating/Water Heating/Interior Lighting	ENERGY STAR Home Design	Code-Compliant Home Design	ENERGY STAR Home Design
All	Advanced New Construction Design - Zero Net Energy	Standard New Construction Home	ZNE-Ready Home
All	Behavioral Programs	None	Program Participation
Cooling/Space Heating	Insulation - Ceiling Installation - LI	R-0	R-30, R-38, or R-49
Cooling/Space Heating	Insulation - Ceiling Upgrade - LI	R-11	R-30 or R-49
Cooling/Space Heating	Insulation - Wall Cavity Installation - LI	R-0	R-11
Cooling/Space Heating	Insulation - Floor Installation - LI	R-0	R-22 or R-30
Cooling/Space Heating	Insulation - Floor Upgrade - LI	R-11	R-22
Cooling/Space Heating	Windows - High Efficiency (SP to Cl30) - LI	Single Pane	Class 30
Cooling/Space Heating	Windows - High Efficiency (SP to Cl22) - LI	Single Pane	Class 22

End Use	Measure	Baseline Definition	Efficient Definition
Cooling/Space Heating	Windows - High Efficiency (DP to CI30) - LI	Double Pane	Class 30
Cooling/Space Heating	Windows - High Efficiency (DP to CI22) - LI	Double Pane	Class 22
Cooling/Space Heating	Ductless Mini Split Heat Pump (Zonal) - LI	None	Installed
Cooling/Space Heating	Ductless Mini Split Heat Pump (Ducted Forced Air) - LI	None	Installed
Interior Lighting	T12 to T8 Retrofit Savings Booster	T12 - 40W Fixture	T8-32W Fixture

Table D-3 summarizes the commercial equipment measures analyzed in this study. The civilian and JBLM commercial market sectors share a common measure list.

Table D-3 Commercial Equipment Measures, Office

End Use	Measure	Baseline Definition	Efficient Definition
Cooling	Air-Cooled Chiller	COP 3.11 (EER 10.6)	COP 4.40 (EER 15.0)
Cooling	Water-Cooled Chiller	COP 5.78 (0.61 kW/ton)	COP 12.13 (0.29 kW/ton)
Cooling	RTU	EER 12.4	EER 13.9, VRF
Cooling	PTAC	EER 11.0	EER 12.0
Cooling/Heating	PTHP	EER 10.4 / COP 3.1	EER 11.7 / COP 3.4
Cooling/Heating	Air-Source Heat Pump	EER 12.0 / COP 3.40	EER 12.0 / COP 3.40
Cooling/Heating	Geothermal Heat Pump	EER 15.5 / COP 3.20	EER 25.5 / COP 3.98
Ventilation	Ventilation	Constant Volume	Variable Air Volume
Water Heating	Water Heater	Resistance Heater, Standard Standby Wattage	Resistance Heater, Reduced Standby Wattage
Interior Lighting	General Service Lighting	EISA Compliant (45 lm/W)	LED 2025 (111 lm/W)
Interior Lighting	Exempted Lighting	EISA Compliant (17.4 lm/W)	LED 2025 (111 lm/W)
Interior Lighting	Linear Lighting	T8 - F32 Standard (69.0 lm/W lm/W system)	LED 2025 (142 lm/W system) w/ Controls
Interior Lighting	High-Bay Lighting	Metal Halide (55.6 lm/W)	LED 2025 (138 lm/W) w/ Controls

End Use	Measure	Baseline Definition	Efficient Definition
Exterior Lighting	General Service Lighting	EISA Compliant (45 lm/W)	LED 2025 (111 lm/W)
Exterior Lighting	Linear Lighting	T8 - F32 Standard (69.0 lm/W lm/W system)	LED 2025 (142 lm/W system)
Exterior Lighting	Area Lighting	Metal Halide (55.6 lm/W)	LED 2025 (120 lm/W)
Refrigeration	Reach-in Refrigerator/Freezer	Current Standard	ENERGY STAR
Refrigeration	Glass Door Display	2017 Standard	ENERGY STAR v4.0
Refrigeration	Open Display Case	1453 kWh/ft	1345 kWh/ft
Refrigeration	Icemaker	Current Standard	ENERGY STAR
Refrigeration	Vending Machine	Standard	ENERGY STAR
Food Preparation	Oven	Standard	ENERGY STAR
Food Preparation	Fryer	Standard	ENERGY STAR
Food Preparation	Dishwasher	Standard	ENERGY STAR
Food Preparation	Hot Food Container	Standard	ENERGY STAR
Food Preparation	Steamer	Standard	ENERGY STAR
Office Equipment	Desktop Computer	Standard	ENERGY STAR
Office Equipment	Laptop	Standard	ENERGY STAR
Office Equipment	Monitor	Standard	ENERGY STAR
Office Equipment	Server	Standard	ENERGY STAR
Office Equipment	Printer/Copier/Fax	Standard	ENERGY STAR
Office Equipment	POS Terminal	Standard	ENERGY STAR
Miscellaneous	Non-HVAC Motors	Standard (NEMA Premium)	Standard (NEMA Premium)
Miscellaneous	Pool Pump	Standard	Dual Speed

End Use	Measure	Baseline Definition	Efficient Definition
Miscellaneous	Pool Heater	Electric Resistance	Heat Pump
Miscellaneous	Clothes Washer	MEF 1.87	MEF 1.87

Table D-4 summarizes the commercial non-equipment measures analyzed in this study.

Table D-4 Commercial Non-Equipment Measures, Office

End Use	Measure	Baseline Definition	Efficient Definition
Cooling/Heating/Ventilation	Insulation - Ceiling	R-13	R-38
Cooling/Heating/Ventilation	Insulation - Ducting	R-4	R-8
Cooling/Heating/Ventilation	Insulation - Wall Cavity	R-9	Absorbptivity 0.45
Cooling/Heating/Ventilation	HVAC - Duct Repair and Sealing	20% Leakage	Sealed
Cooling/Heating/Ventilation	Windows - High Efficiency Glazing	Single Glaze	High Efficiency Glaze
Cooling	Chiller - Chilled Water Reset	None	Enabled
Cooling	Chiller - Variable Flow Chilled Water Pump	Constant Flow	Variable Flow
Cooling	Chiller - Variable Speed Fans	On/Off Operation	Part-Load Operation
Cooling	Water-Cooled Chiller - Variable Flow Condenser Water Pump	To be filled in	To be filled in
Cooling	Water-Cooled Chiller - Condenser Water Temperature Reset	Constant Temperature	Variable Temperature
Cooling	HVAC - Economizer	None	Installed
Cooling	Ventilation - Nighttime Air Purge	Normal operation	Nighttime purge
Heating	Space Heating - Heat Recovery Ventilator	None	Installed
Ventilation	Ventilation - ECM on VAV Boxes	None	Installed
Ventilation	Ventilation - Permanent Magnet Synchronous Fan Motor	Standard Motors	Permanent Magnet Synchonous Fan Motor
Ventilation	Ventilation - Fan Drive Improvements	Standard Motors	Impvroved Drive
Ventilation	Ventilation - Variable Speed Control	None	Installed
Ventilation	Ventilation - Demand Controlled	Standard	Demand-Controlled Fans
Heating/Ventilation	HVAC - Dedicated Outdoor Air System (DOAS)	Normal operation	Outdoor air system installed
Cooling/Heating	Destratification Fans (HVLS)	None	Installed
Cooling	RTU - Maintenance	Standard Unit	Tuned Up Unit

End Use	Measure	Baseline Definition	Efficient Definition
Cooling	RTU - Advanced Controls	RTU with Constant Speed Fan	Advanced Rooftop Controller
Cooling/Heating	Ductless Mini Split Heat Pump	None	Installed
Cooling/Heating/Ventilation	Thermostat - Connected	Standard Unit	Smart/WiFi Enabled Unit
Water Heating	Water Heater - Faucet Aerators/Low Flow Nozzles	1.39 GPM Average Baseline	0.94 GPM Unit
Water Heating	Water Heater - Low-Flow Showerheads	2.2 GPM Showerhead	1.5 GPM Showerhead
Water Heating	Water Heater - Thermostatic Shower Restriction Valve	No valve	Tx valve installed
Water Heating	Water Heating - High Efficiency Circulation Pump	Standard Efficiency Pump	High Efficiency Pump
Water Heating	Water Heater - Pipe Insulation	Uninsulated Pipe	1" Insulation
Water Heating	Water Heater - Pre-Rinse Spray Valve	1.33 GPM Kitchen Spray Valve	0.81-1.00 GPM Kitchen Spray Valve
Water Heating	Water Heater - Solar System	Heat Pump Water Heater	SEF 3.0 Solar Unit
Water Heating	Commercial Laundry - Ozone Treatment	Standard Laundry	Ozone cleaning method
Water Heating/Miscellaneous/Miscellaneous	Commercial Laundry - ENERGY STAR Washer	Standard Laundry	ENERGY STAR Unit
Water Heating/Miscellaneous	Commercial Laundry - Alternative Dry-Cleaning Methods	Standard Laundry	Alternative methods
Interior Lighting	Interior Lighting - Embedded Fixture Controls	Standard Controls	Enhanced Controls
Interior Lighting	Interior Lighting - Networked Fixture Controls	Standard Controls	Enhanced Controls
Interior Lighting	Interior Lighting - LEC Exit Lighting	Baseline LED Sign	Light Emitting Capacitor Sign
Interior Lighting	Interior Lighting - Photoluminescent Exit Lighting	Standard light fixture	Photoluminescent fixture
Interior Lighting	Interior Lighting - Skylights	None	Installed
Interior Lighting	Interior Fluorescent - Delamp and Install Reflectors	Overlit Fixture	Properly Lit Fixture, 1 Lamp Removed
Interior Lighting	Interior Fluorescent - Bi-Level Stairwell Fixture	Single Level Lighting Controls	Two Level Lighting Controls
Exterior Lighting	Exterior Lighting - Bi-Level Parking Garage Fixture	Single Level Lighting Controls	Two Level Lighting Controls

End Use	Measure	Baseline Definition	Efficient Definition
Exterior Lighting	Exterior Lighting - Enhanced Controls	Standard Controls	Photocell and/or Motion Based Controls
Exterior Lighting	Exterior Lighting - Photovoltaic Installation	Grid-Tied LED Lighting System	Solar Powered Area LED Lighting
Refrigeration	Refrigeration - Anti-Sweat Heater Controls	No Anti-Sweat Heater Controls	Anti Sweat Heater Controls
Refrigeration	Refrigeration - Door Gasket Replacement	Leaky Case Doors	Sealed Case Doors
Refrigeration	Refrigeration - Floating Head Pressure	Fixed Discharge Pressure Controls	Wetbulb Reset Controls
Refrigeration	Refrigeration - Strip Curtain	No Strip Curtains	Strip Curtains Installed
Refrigeration	Refrigeration - High Efficiency Compressor	Standard Efficiency Compressor	High Efficiency Compressor
Refrigeration	Refrigeration - Variable Speed Compressor	Inefficient Compressor Loading	Variable Speed Compressor Loading
Refrigeration	Refrigeration - ECM Compressor Head Fan Motor	Standard compressor	ECM Compressor
Refrigeration	Refrigeration - Evaporative Condenser	Standard compressor	Evaporative Condenser installed
Refrigeration	Refrigeration - Replace Single-Compressor with Subcooled Multiplex	Single compressor	sub-cooled multiplex
Refrigeration	Refrigeration - ECM Evaporator Fan Motor	Standard Motors	ECM Motors
Refrigeration	Refrigeration - Permanent Magnet Synchronous Fan Motor	Standard Motors	Permanent Magnet Synchonous Fan Motor
Refrigeration	Refrigeration - Evaporator Fan Controls	Standard Controls	Load-Based Fan Controls
Refrigeration	Refrigeration - Demand Defrost	Timed Defrost Control	Ice-Based Defrost Control
Refrigeration	Refrigeration - Automatic Door Closer	Manual Controls	Automatic
Refrigeration	Refrigeration - Low-Heat/No-Heat Doors	Standard Doors	Low-heat/no-heat doors
Refrigeration	Grocery - Display Case - LED Lighting	Fluorescent Case Lighting	LED Case Lighting
Refrigeration	Grocery - Display Case Motion Sensors	Manual Controls	Motion Based Controls

End Use	Measure	Baseline Definition	Efficient Definition
All	Grocery - Open Display Case - Night Covers	No Covers	Night Covers
All	Grocery - On Demand Overwrappers	Always-on machine	On-demand operation
Refrigeration	Vending Machine - Occupancy Sensor	None	Lighting and Compressor Controls
Ventilation	Cooking - Exhaust Hoods with Sensor Control	Constant Speed Hoods	Demand-Controlled Hoods
Cooling/Heating	Lodging - Guest Room Controls	Manual Controls	Occupancy Controls
Office Equipment	Office Equipment - Advanced Power Strips	Standard Unit	Load Sensing Strip
Office Equipment	Data Center - Best Practice Measures	Baseline Data Center	Best Practice Measures Installed
Cooling/Ventilation/Office Equipment	Data Center - Commercially Available Measures	Baseline Data Center	Commercially Available Measures Installed
Office Equipment	Data Center - Cutting Edge Measures	Baseline Data Center	Cutting Edge Measures Installed
Ventilation	Optimized Variable Volume Lab Hood Design	Constant Speed Hoods	Demand-Controlled Hoods
Refrigeration	ENERGY STAR Ultra-Low Temperature Freezer	Standard Low-temp freezer	ENERGY STAR Unit
Miscellaneous	Pool Pump - Timer	Manual Controls	Scheduled Controls
Miscellaneous	Pool Heater - Night Covers	No Covers	Covers
Miscellaneous	ENERGY STAR Water Cooler	Standard Unit	ENERGY STAR Unit
Miscellaneous	Miscellaneous - Improved Vertical Lift Technology	Standard lift	Efficient lift
Cooling/Heating/Ventilation/Water Heating/Interior Lighting/Exterior Lighting	Advanced New Construction Designs	Standard Building Practices	LEED Average Design
Cooling/Heating/Ventilation/Water Heating/Interior Lighting/Exterior Lighting/Refrigeration/Office Equipment	Strategic Energy Management	None	Implemented
Cooling/Heating/Ventilation/Water Heating/Interior Lighting/Exterior Lighting/Refrigeration	Retrocommissioning	None	Commissioned
Miscellaneous	LED Signage	Fluorescent fixture	LED fixture
Interior Lighting	T12 to T8 Retrofit Savings Booster	T12 - 40W Fixture	T8-32W Fixture

Table D-5 summarizes the industrial equipment measures analyzed in this study.

Table D-5 Industrial Equipment Measures, All

End Use	Measure	Baseline Definition	Efficient Definition
Cooling	Air-Cooled Chiller	COP 3.11 (EER 10.6)	COP 4.40 (EER 15.0)
Cooling	Water-Cooled Chiller	COP 5.78 (0.61 kW/ton)	COP 12.13 (0.29 kW/ton)
Cooling	RTU	EER 11.2	EER 11.7
Cooling/Heating	Air-Source Heat Pump	EER 11.4 / COP 3.35	EER 12.0 / COP 3.40
Cooling/Heating	Geothermal Heat Pump	EER 15.5 / COP 3.20	EER 25.5 / COP 3.98
Ventilation	Ventilation	Constant Volume	Variable Air Volume
Interior Lighting	General Service Lighting	EISA Compliant (45 lm/W)	LED 2019/2020 (97 lm/W)
Interior Lighting	High-Bay Lighting	Metal Halide (55.6 lm/W)	LED 2019/2020 (121 lm/W) w/Controls
Interior Lighting	Linear Lighting	T8 - F32 Standard (69.0 lm/W lm/W system)	LED 2019/2020 (123 lm/W system) w/Controls
Exterior Lighting	General Service Lighting	EISA Compliant (45 lm/W)	LED 2019/2020 (97 lm/W)
Exterior Lighting	Area Lighting	Metal Halide (51.2 lm/W)	LED 2019/2020 (105 lm/W) w/Controls
Exterior Lighting	Linear Lighting	T8 - F32 Standard (69.0 lm/W lm/W system)	LED 2019/2020 (123 lm/W system) w/Controls

Table D-6 summarizes the industrial non-equipment measures analyzed in this study.

Table D-6 Industrial Non-Equipment Measures, All

End Use	Measure	Baseline Definition	Efficient Definition
Cooling/Heating/Ventilation	Insulation - Ceiling	R-13	R-38
Cooling/Heating/Ventilation	Insulation - Ducting	R-4	R-8
Cooling/Heating/Ventilation	Insulation - Wall Cavity	R-9	Absorbptivity 0.45
Cooling/Heating/Ventilation	HVAC - Duct Repair and Sealing	20% Leakage	Sealed
Cooling	Chiller - Chilled Water Reset	None	Enabled
Cooling	Chiller - Variable Flow Chilled Water Pump	Constant Flow	Variable Flow
Cooling	Chiller - Variable Speed Fans	On/Off Operation	Part-Load Operation
Cooling	Water-Cooled Chiller - Variable Flow Condenser Water Pump	To be filled in	To be filled in
Cooling	Water-Cooled Chiller - Condenser Water Temperature Reset	Constant Temperature	Variable Temperature
Cooling	HVAC - Economizer	None	Installed
Ventilation	Ventilation - Demand Controlled	Standard	Demand-Controlled Fans
Cooling/Heating	Destratification Fans (HVLS)	None	Installed
Cooling	RTU - Maintenance	Standard Unit	Tuned Up Unit
Cooling/Heating/Ventilation	Thermostat - Connected	Standard Unit	Smart/WiFi Enabled Unit
Interior Lighting	Interior Lighting - Embedded Fixture Controls	Standard Controls	Enhanced Controls
Interior Lighting	Interior Lighting - Networked Fixture Controls	Standard Controls	Enhanced Controls
Interior Lighting	Interior Lighting - LEC Exit Lighting	Baseline LED Sign	Light Emitting Capacitor Sign
Interior Lighting	Interior Lighting - Photoluminescent Exit Lighting	Standard light fixture	Photoluminescent fixture
Interior Lighting	Interior Lighting - Skylights	None	Installed
Interior Lighting	Interior Fluorescent - Delamp and Install Reflectors	Overlit Fixture	Properly Lit Fixture, 1 Lamp Removed
Interior Lighting	Interior Fluorescent - Bi-Level Stairwell Fixture	Single Level Lighting Controls	Two Level Lighting Controls
Exterior Lighting	Exterior Lighting - Bi-Level Parking Garage Fixture	Single Level Lighting Controls	Two Level Lighting Controls
Exterior Lighting	Exterior Lighting - Enhanced Controls	Standard Controls	Photocell and/or Motion Based Controls
Exterior Lighting	Exterior Lighting - Photovoltaic Installation	Grid-Tied LED Lighting System	Solar Powered Area LED Lighting
Miscellaneous	High Efficiency Battery Chargers	Standard charger	High efficiency charger
Process	Refrigeration - Floating Head Pressure	Fixed Discharge Pressure Controls	Wetbulb Reset Controls

End Use	Measure	Baseline Definition	Efficient Definition
Process	Refrigeration - System Optimization	Normal operation	Optimized
Motors	Pumping System - Equipment Upgrade	Existing equipment	Premium equipment
Motors	Pumping System - System Optimization	Normal operation	Optimized
Motors	Pumping System - Variable Speed Drive	Standard Motors	VSD Motors
Motors	Fan System - Equipment Upgrade	Existing equipment	Premium equipment
Motors	Fan System - Flow Optimization	Normal operation	Optimized
Motors	Fan System - Variable Speed Drive	Standard Motors	VSD Motors
Motors	Compressed Air - Equipment Upgrade	Standard Equipment	High Efficiency Equipment
Motors	Compressed Air - Heat of Compression Dessicant Dryer	Unheated dessicant dryer	Heated dessicant dryer
Motors	Compressed Air - Refrigerated Cycling Dryers	Non-Cycling Refrigerated Dryer	Cycling Refrigerated Dryer
Motors	Compressed Air - Raise Compressed Air Dryer Dewpoint	Standard operation	Raised dewpoint
Motors	Compressed Air - System Controls	Standard Controls	Advanced Controls and Sequencing
Motors	Compressed Air - Leak Management Program	No Annual Leak Detection Program	Annual Leak Detection Program
Motors	Compressed Air - Variable Speed Drive	Standard Motor Starter	Variable Frequency Drive
Motors	Compressed Air - Low Pressure-Drop Filters	Standard Filters	Low Pressure-Drop Filters
Motors	Compressed Air - Zero-Loss Condensate Drain	Timed Drains	Zero-Loss Drains
Motors	Compressed Air - Outside Air Intake	Engine Room Air	Outside Air
Motors	Compressed Air - Receiver Capacity Addition	Undersized Receivers	Oversized Receivers
Motors	Compressed Air - End Use Optimization	Normal operation	Optimized
Motors	Material Handling - Variable Speed Drive	Standard Motor Starter	Variable Frequency Drive
Motors	Motors - Green Rewind (<100 HP)	Standard Motor Rewind	Green Motor Rewind
Motors	Motors - Green Rewind (100 HP+)	Standard Motor Rewind	Green Motor Rewind
Motors	Switch from Belt Drive to Direct Drive	Belt Drive	Direct Drive
Motors	Motors - Synchronous Belts	Standard Belts	Synchronous Belts
Miscellaneous	Engine Block Heater Controls	No controls	Controls in operation
Miscellaneous	Circulating Engine Block Heater	Normal operation	Circulating heater
Motors	Agriculture - Efficient Stock Watering Tanks	Standard tank	Efficient tank
Miscellaneous	Agriculture - Stock Tank De-Icer	Standard de-icer	Efficient de-icer
Miscellaneous	Agriculture - Thermostatically Controlled Outlets	Standard operation	Thermostatic control
Process	Dairy - Milk Precoolers	No Precooler	Precooler Installed
Miscellaneous	Dairy - Heat Recovery from Refrigeration	Normal operation	Heat recovery installed on coils
Motors	Dairy - Variable Speed Milk Vacuum Pump	Normal motors	Variable speed system
Motors	Automatic Milker Takeoffs	Manual operation	Automatic system
Process	Clean Room: Change Filter Strategy	Standard	Installed

End Use	Measure	Baseline Definition	Efficient Definition
Process	Clean Room: Chiller Optimize	Standard	Installed
All	Clean Room: Clean Room HVAC	Standard	Installed
All	Elec Chip Fab: Solidstate Chiller	Standard	Solid state chiller
Process	Elec Chip Fab: Eliminate Exhaust	Standard	Installed
Process	Elec Chip Fab: Alternative Exhaust Injector	Standard operation	Alternative exhaust system
Process	Elec Chip Fab: Reduce Process Gas Pressure	Standard operation	Reduced pressure
Motors	Panel: Hydraulic Press	Standard	Installed
Motors	Wood: Replace Pneumatic Conveyor	Standard	Installed
Process	Metal: New Arc Furnace	Existing equipment	Installed
Process	Paper: Premium Control Large Material	Standard	Installed
Process	Paper: Efficient Pulp Screen	Standard	Installed
Process	Kraft: Effluent Treatment System	Standard	Installed
Motors	Kraft: Efficient Agitator	Standard	Installed
Process	Mech Pulp: Premium Process	Standard operation	Premium process
Motors	Mech Pulp: Refiner Plate Improvement	Standard operation	Premium process
All	Transformer - High Efficiency	Standard Transformer	High Efficiency Transformer
All	Strategic Energy Management	None	Implemented
All	Retrocommissioning	None	Commissioned
Motors	Municipal Sewage Treatment - Optimization	Normal operation	Optimized
Motors	Municipal Water Supply Treatment - Optimization	Normal operation	Optimized
Motors	Municipal Water Treatment - Pulsed Air Mixing	Standard operation	Premium process
Process	Food Processing - Radio Frequency Defrosting	Standard heating	Use RF to defrost
Interior Lighting	T12 to T8 Retrofit Savings Booster	T12 - 40W Fixture	T8-32W Fixture

Table D-7 summarizes the street lighting measures analyzed in this study. Note that there were multiple permutations of the LED measure based on fixture type (ornamental, cobra head, shoebox, wallpack, flood, and other), which affected measure costs.

Table D-7 Street Lighting Measures, All

End-Use	Measure	2018 Baseline Definition	2018 Efficient Option
Street Lighting	70W Equivalent	HID	LED
Street Lighting	100W Equivalent	HID	LED
Street Lighting	150W Equivalent	HID	LED
Street Lighting	175W Equivalent	HID	LED
Street Lighting	200W Equivalent	HID	LED
Street Lighting	250W Equivalent	HID	LED
Street Lighting	400W Equivalent	HID	LED
Street Lighting	1000W Equivalent	HID	LED

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