Applied Energy Group

2020 CASCADE NATURAL GAS CONSERVATION POTENTIAL ASSESSMENT

Phase 2 Final Report – Volume 1

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Report prepared for:
CASCADE NATURAL GAS CORPORATION

Energy Solutions. Delivered.

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EXECUTIVE SUMMARY

In the summer of 2020, Cascade Natural Gas Corporation (Cascade) contracted with Applied Energy Group (AEG) to conduct this update to Cascade's 2018 Conservation Potential Assessment (CPA) in support of their conservation and resource planning activities. This report documents this effort and provides estimates of the potential reductions in annual energy usage for natural gas customers in Cascade's Washington service territory from energy conservation efforts from 2021 to 2040.

Phase 1, which was completed in 2020, focused on the market characterization and baseline projections underlying the potential estimates while effectively preserving the characterization of energy-efficient measures used in the 2017 CPA. Phase 2, described in this document, was designed to accomplish the following goals:

- Update the baseline projection from Phase 1 to reflect 2020 actual consumption
- Comprehensive update to assumptions for measures not updated in Phase 1
- Update non-energy impacts (NEIs) and revisit proxy assumptions for Resource Value Test sensitivity
- Perform additional analysis to understand Cascade residential customer distribution and energy consumption by income level
- Revise the Washington CPA residential market characterization and potential to include income level analysis

In addition to the goals above, AEG worked with Cascade to consider the landscape of energy efficiency potential for natural gas over the coming years, including the possible impacts of new legislation, newly implemented building codes, and the challenges associated with assessing potential from non-residential transport-only customers. These are described briefly here and in more detail in Sections 1 and Section 4.

- Legislative Environment. Because no new laws explicitly affecting the future consumption of natural gas have currently been passed, potential impacts of this type of legislation have not been considered in the baseline projection or the energy efficiency estimates provided in this report. In future studies, it will be essential to review the legislative landscape to determine whether adjustments to the baseline or applicability of energy efficiency measures are required.
- Building Code Impacts. Through conversations with NEEA, Cascade, and via AEG's other work in the WA region, we developed a set of assumptions regarding how builders were likely to modify their choices. The adjustments to new construction equipment saturation relative to existing homes are documented in Section 4
- Considering Transport Customers. Though there have been regional conversations surrounding potential for transport customers, there are additional data needs in estimating this potential and challenges in acquiring it. Assessing the cost-effective potential for transport customers would require different avoided costs, more visibility into the kinds of customers on these rates and their end uses, and an understanding of how these customers view energy savings and might participate in future programs since there is no history on which to draw. In addition, the incentive mechanism for these customers would need to be determined, as they do not currently pay into the tariff that supports the rebates and incentives to core customers.

Results Overview

In summary, the potential study provided a solid foundation for the development of Cascade's energy savings targets. Table ES-1-1 summarizes the results of this study at a high level. AEG analyzed the potential for the residential, commercial, and industrial market sectors. The first-year utility cost test (UCT) achievable economic potential is 765 thousand therms. This increases to a cumulative total of 1,630 thousand therms in the second year and 15,610 thousand therms by the tenth year. As part of this study, AEG also estimated achievable economic potential using the total resource cost (TRC) test, with the focus of fully balancing non-energy impacts. This includes the use of full measure costs as well as quantified and monetizable non-energy impacts and non-gas fuel impacts (e.g., electric cooling or wood secondary heating) consistent with methodology within the Northwest Power and Conservation Council's Draft 2021 Power Plan (2021 Plan).

Table ES-1-1 Conservation Potential by Case, Selected Years (thousand therms)

Scenario	2021	2022	2023	2024	2025	2030	2040
Baseline Projection (thousand therms)	246,225	248,892	251,569	255,494	256,840	268,912	292,401
Cumulative Savings (thousand therms)							
TRC Achievable Economic Potential	434	915	1,534	2,325	3,311	10,789	22,091
UCT Achievable Economic Potential	765	1,630	2,694	3,550	4,954	15,610	33,053
Achievable Technical Potential	1,678	3,486	5,544	7,473	9,955	25,538	48,416
Technical Potential	5,496	10,399	15,612	19,781	25,104	53,337	90,258
Cumulative Savings (% of Baseline)							
TRC Achievable Economic Potential	0.2%	0.4%	0.6%	0.9%	1.3%	4.0%	7.6%
UCT Achievable Economic Potential	0.3%	0.7%	1.1%	1.4%	1.9%	5.8%	11.3%
Achievable Technical Potential	0.7%	1.4%	2.2%	2.9%	3.9%	9.5%	16.6%
Technical Potential	2.2%	4.2%	6.2%	7.7%	9.8%	19.8%	30.9%

While opportunities are reduced by the impact of new building codes (see Section 4), there remain substantial savings in residential furnaces, commercial boilers and water heaters. Weatherization retrofits continue to see opportunities, and continued technology improvements have made some measures cost effective that previously were not, such as ENERGY STAR Clothes Washers, and increasing emphasis on smart/adaptive thermostats over standard programmable models.

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INTRODUCTION

This report documents the methodology and results of the Cascade Natural Gas Corporation (Cascade) 2021-2040 Conservation Potential Assessment (CPA). This study was performed in two phases, with the first phase focused on capturing changes to the baseline consumption projection and completed in late 2020. Phase 2, the focus of this report, builds on the results of Phase 1 and accomplishes the objectives described below.

Throughout this study, AEG worked with Cascade to understand the baseline characteristics of their Washington service territory, including a detailed understanding of energy consumption in the territory, the assumptions and methodologies used in Cascade's official load forecast, and recent programmatic accomplishments. Adapting methodologies consistent with the Northwest Power and Conservation Council's (Council's) Draft 2021 Power Plan[1] for natural gas studies, AEG then developed an independent estimate of achievable, cost-effective energy efficiency potential within Cascade's Washington service territory between 2021 and 2040.

Conservation Potential Assessment Objectives

The first primary objective of this study was to develop independent and credible estimates of energy efficiency potential available within Cascade's service territory using accepted regional inputs and methodologies. This included estimating technical, achievable technical, then achievable economic potential[2], using the Council's ramp rates as the starting point for all achievability assumptions, leveraging Northwest Energy Efficiency Alliance's (NEEA's) market research initiatives, and utilizing assumptions consistent with Draft 2021 Plan supply curves, and Regional Technical Forum (RTF) measure workbooks where appropriate for use in natural gas planning studies.

The second primary objective was to deliver a fully configured end-use model for Cascade to use in future energy efficiency planning initiatives. AEG has customized its LoadMAP end-use planning tool with data specific to Cascade's territory and the Northwest. This includes a detailed snapshot of how Cascade's customers use energy in the base year of the study, 2019, assumptions on future customer growth provided by Cascade's load forecasting team, and measure assumptions using Cascade primary data, regional research, and well-vetted sources from around the nation.

Thirdly, the CPA is intended to support the design of programs to be implemented by Cascade during the upcoming years. One output of the LoadMAP model is a comprehensive summary of measures, documenting input assumptions and sources on a per-unit basis, program applicability and achievability (ramp rates), and potential results (units, incremental potential, and cumulative potential), as well as cost-effectiveness under the Total Resource Cost (TRC) test, Utility Cost Test (UCT), and proxy Resource Value Test (RVT)[3]. This summary was developed in collaboration with Cascade and refined throughout the project.

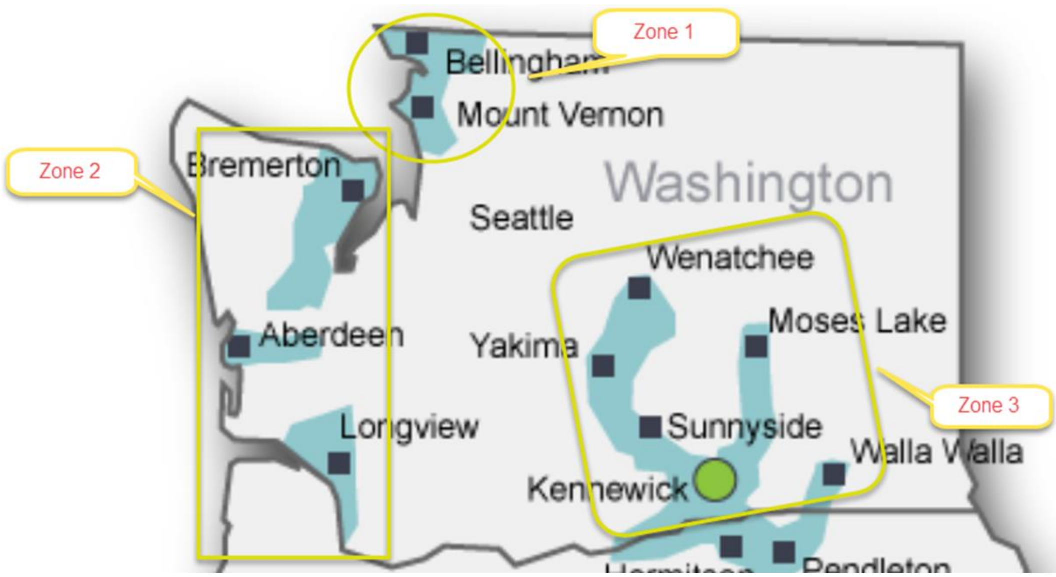
[1] "The 2021 Northwest Power Plan." Northwest Power & Conservation Council. https://www.nwcouncil.org/2021-northwest-power-plan/

[2] Levels of potential are described in chapter 2

[3] Components of the various cost-effectiveness tests are described in chapter 2

Finally, this study was developed to provide energy efficiency inputs into Cascade's Integrated Resource Planning (IRP) process. To this end, AEG developed detailed achievable economic potential inputs by measure for use in Cascade's SENDOUT planning model. These inputs are highly customizable and provide potential estimates at the Washington-territory level, Cascade climate zone, and city-gate level. We present a map of Cascade's Washington climate zones in Figure 1-1 to summarize the terms we reference throughout this study.

Figure 1-1 Cascade's Washington Service Territory and Climate Zones (courtesy Cascade)



Specific Goals of Phase 2

As discussed above, this CPA was performed in two phases. Phase 1, which was completed in 2020, focused on the market characterization and baseline projections underlying the potential estimates while largely preserving the characterization of energy-efficient measures used in the 2017 CPA. Phase 2, described in this document, was designed to accomplish the following goals:

- Update the baseline projection from Phase 1 to reflect 2020 actual consumption
- Comprehensive update to assumptions for measures not updated in Phase 1
- Update non-energy impacts (NEIs) and revisit proxy assumptions for Resource Value Test sensitivity
- Perform additional analysis to understand Cascade residential customer distribution and energy consumption by income level
- Revise the Washington CPA residential market characterization and potential to include income level analysis

Study Considerations

Below, AEG notes a number of items that came up during the development of this study based on feedback from stakeholders or state policy considerations. These items are discussed throughout the remainder of the report and are summarized here for the benefit of the reader.

- Alignment with Regional Methodology: Because there is no established regional methodology for conducting natural gas CPAs in the Northwest, AEG based the analysis on the methodology established by the Northwest Power and Conservation Council for assessing electric energy efficiency potential. While AEG used a methodology consistent with the Council, certain Council assumptions, particularly ramp rates, were modified to better represent natural gas markets.

- Potential Assessment vs. Program and Portfolio Design: By nature, CPAs rely on the best information available to assess the average cost and impacts of energy efficiency measures for a given group of customers. For example, because it is not possible to get data on the building shell characteristics of each single-family home in Cascade's territory, the CPA makes assumptions about the characteristics of the average single family home and the resulting applicability of energy efficiency upgrades. Because of this, the CPA is able to estimate the total opportunity for a given measure and its average cost-effectiveness but then makes a binary choice whether to include a measure in the economic potential based on this average cost-effectiveness.

  Energy efficiency programs operate differently, often offering prescriptive incentives for measures expected to be cost-effective on average, and a custom measure path for those that may only be cost-effective in certain applications. As such, the CPA can provide a guide for which measures to consider for inclusion in programs, particularly for prescriptive programs, but the identified cost-effective potential should not be viewed as exhaustive of all program opportunities.

- Treatment of Non-Residential Transport Customers: Non-residential transport-only customers were excluded from consideration in this study, as they are not currently eligible for participation in Cascade's energy efficiency programs. Though there have been regional conversations surrounding potential for transport customers, there are additional data needs in estimating this potential and challenges in acquiring it. Assessing the cost-effective potential for transport customers would require different avoided costs, more visibility into the kinds of customers on these rates and their end uses, and an understanding of how these customers view energy savings and might participate in future programs since there is no past history on which to draw.

- Potential Impacts of Current or Future Legislation: At the time of publication of this report, there is significant activity in the Washington Legislature regarding carbon policy, electrification, and related topics that could impact on future natural gas energy efficiency opportunities. For example, House Bill 1084 would have eliminated the use of natural gas for space and water heating in new construction in 2027, also eliminating associated natural gas energy efficiency opportunities.

  Because no new laws explicitly affecting the future consumption of natural gas have currently been passed, potential impacts of this type of legislation have not been considered in the baseline projection or the energy efficiency estimates provided in this report. In future studies, it will be important to review the legislative landscape to determine whether adjustments to the baseline or applicability of energy efficiency measures are required.

- Deeper Insight into Energy Efficiency Potential by Residential Customer Income Level: In the previous CPAs performed for Cascade, AEG estimated energy efficiency potential based on average customer profiles without differentiation by household income. By estimating energy efficiency potential based on Cascade's average customer, previous CPAs have inherently captured energy efficiency potential in low-income homes. However, given the increased interest in the low-income customer segment specifically, Phase 2 of this CPA expanded its scope to include income level analysis for the residential sector, allowing AEG to present results separately for low, moderate, and above-median income groups.

- Assessing Potential Under a Resource Value Test (RVT): At the time of the 2017 CPA, Washington Utilities and Transportation Commission (WUTC) staff was considering the development of a Resource

Value Test to assess the cost-effectiveness of energy efficiency measures. To investigate the impacts on the potential of including benefits not captured in the total resource cost test, AEG performed a review of treatment in other jurisdictions, ultimately adopting a 20% benefit adder for the purpose of the sensitivity analysis.

On April 12, 2021, Cascade and AEG met with WUTC staff and interested stakeholders to review the current state of RVT development in Washington and assumptions for this study. During that meeting, WUTC staff communicated that the formal process to consider adopting an RVT had not commenced, although it was expected to later in 2021. As such, the group determined that it was still appropriate for AEG to include a proxy RVT scenario in Cascade's 2020 CPA by applying percentage adders to benefits. As an enhancement for this study, AEG varied these percentage adders by customer income to reflect additional potential benefits for low-income customers.

- Application of the Updated Washington State Energy Code: A new consideration for Phase 2 of the CPA is the impact of WSEC 2018 code changes on the baseline and potential, which took effect starting in 2021. Through conversations with NEEA, Cascade, and via AEG's other work in the WA region, we developed a set of assumptions regarding how builders were likely to modify their choices. The adjustments to new construction equipment saturation relative to existing homes are documented in Section 4.

Summary of Report Contents

The document is divided into five chapters, summarizing the approach, assumptions, and results of the EE potential analysis, with additional detail provided in Volume 2 appendices:

Volume 1, Final Report:

- Analysis Approach and Data Development. A detailed description of AEG's approach to conducting Cascade's 2021-2040 CPA and documentation of primary and secondary sources used.
- Market Characterization and Market Profiles. Characterization of Cascade's Washington service territory in the base year of the study, 2019, including total consumption, number of customers and market units, and energy intensity. This also includes a breakdown of the energy consumption for residential, commercial, and core industrial customers by end use and technology.
- Baseline Projection. Projection of baseline energy consumption under a naturally occurring efficiency case described at the end-use level. The LoadMAP models were first aligned with actual sales and Cascade's official, weather-normalized econometric forecast and then varied to include the impacts of future federal standards, the 2018 Washington State Energy Code on new construction, which took effect starting in 2021, and future technology purchasing decisions.
- Overall Energy Efficiency Potential. Summary of energy efficiency potential for Cascade's entire Washington service territory for selected years between 2021 and 2040.
- Sector-Level Energy Efficiency Potential. Summary of energy efficiency potential for each market sector within Cascade's service territory, including residential, commercial, core industrial customers. This section includes a more detailed breakdown of potential by measure type, vintage, market segment, end use, and Cascade climate zone in the case of residential.

Volume 2, Appendices:

- Alignment with the Council's Methodology. Discussion on how this study aligns with Council electric-centric methodologies, including ramp rates, regional data, and measure assumptions.

- Market Profiles. Detailed market profiles for each market segment. Including 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. These were adapted from the 2021 Power Plan electric conservation supply curve workbooks for use in the estimation of achievable natural gas potential.
- Measure List. Contained in a separate spreadsheet accompanying delivery of this report. List of measures, along with example baseline definitions and efficiency options by market sector analyzed.
- Potential by Segment. Contained in a separate spreadsheet accompanying delivery of this report. Breaks down the potential by customer segment, including income levels for residential and business type for commercial and industrial.
- Proxy RVT Potential Results. Presented in summary and by sector with comparison to UCT and TRC results.
- Detailed Measure Assumptions. Contained in a separate spreadsheet accompanying delivery of this report. This dataset provides input assumptions, measure characteristics, cost-effectiveness results, and potential estimates for each measure permutation analyzed within the study.

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
AEO	Annual Energy Outlook forecast developed by EIA
AFUE	Annual Fuel Utilization Efficiency
B/C Ratio	Benefit to Cost Ratio
BEST	AEG's Building Energy Simulation Tool
BPA	Bonneville Power Administration
C&I	Commercial and Industrial
CBSA	NEEA's Commercial Building Stock Assessment
CEF	Combined Energy Factor
Council	Northwest Power and Conservation Council (NWPCC)
DHW	Domestic Hot Water
DSM	Demand-Side Management
EIA	Energy Information Administration
EUL	Estimated Useful Life
EUI	Energy Usage Index
HVAC	Heating Ventilation and Air Conditioning
IFSA	NEEA's Industrial Facilities Site Assessment
IRP	Integrated Resource Plan
LoadMAP	AEG's Load Management Analysis and Planning™ tool
NEEA	Northwest Energy Efficiency Alliance
O&M	Operations and Maintenance
RBSA	NEEA's Residential Building Stock Assessment
RTF	Regional Technical Forum
RVT	Resource Value Test
TE	Thermal Efficiency
TRC	Total Resource Cost
UCT	Utility Cost Test
UEC	Unit Energy Consumption
UEF	Uniform Energy Factor
UES	Unit Energy Savings
WSEC	Washington State Energy Code

2

ANALYSIS APPROACH AND DATA DEVELOPMENT

This section describes AEG's analysis approach and the data sources used to develop the potential estimates in this study.

Overview of Analysis Approach

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

1. Performed a market characterization to describe sector-level natural gas use for the residential, commercial, and industrial sectors for the base year 2019. This included extensive use of Cascade data and other secondary data sources from NEEA and the Energy Information Administration (EIA).
2. Developed a baseline projection of energy consumption by sector, segment, end use, and technology for 2021 through 2040.
3. Defined and characterized several hundred EE measures to be applied to all sectors, segments, and end uses.
4. Estimated technical, achievable technical, and achievable economic energy savings at the measure level for 2021-2040. Achievable economic potential was assessed using both the UCT and TRC screens.

Comparison with Northwest Power & Conservation Council Methodology

Cascade's Washington Conservation Advisory Group (CAG) strongly recommended the Council's methodology to assess potential and develop ramp rates. It is important to note that the Council's methodology was developed for, and used in, electric DSM resource planning. Natural gas impacts are typically assessed when they overlap with electricity measures (e.g., gas water heating impacts in an electrically heated "Built Green Washington" home). Beyond the potential for utility programs, the Council's ramp rates and achievability assumptions also implicitly include market transformation impacts, where NEEA has a much longer history of working on electric market transformation initiatives than natural gas. For these reasons, AEG adapted the Council methodology in some cases rather than using the direct assumptions developed by the Council for electric studies. This is especially relevant in the development of ramp rates when achievability was determined not to be applicable to a specific natural gas measure or program. We discuss this further in Appendix A of Volume 2 of this report.

Among other aspects, this approach involves using consistent:

- Data sources: regional surveys, market research, and assumptions
- Measures and assumptions: Draft 2021 Plan supply curves and RTF work products
- Potential factors: Draft 2021 Plan ramp rates
- Levels of potential: Technical, Achievable Technical, and Achievable Economic
- Cost-effectiveness approaches: assessed potential under the UCT as well as the Council's TRC test, including non-energy impacts which may be quantified and monetized and O&M impacts within the TRC
- Conservation credits: applied a 10% conservation credit to avoided energy costs for energy benefits

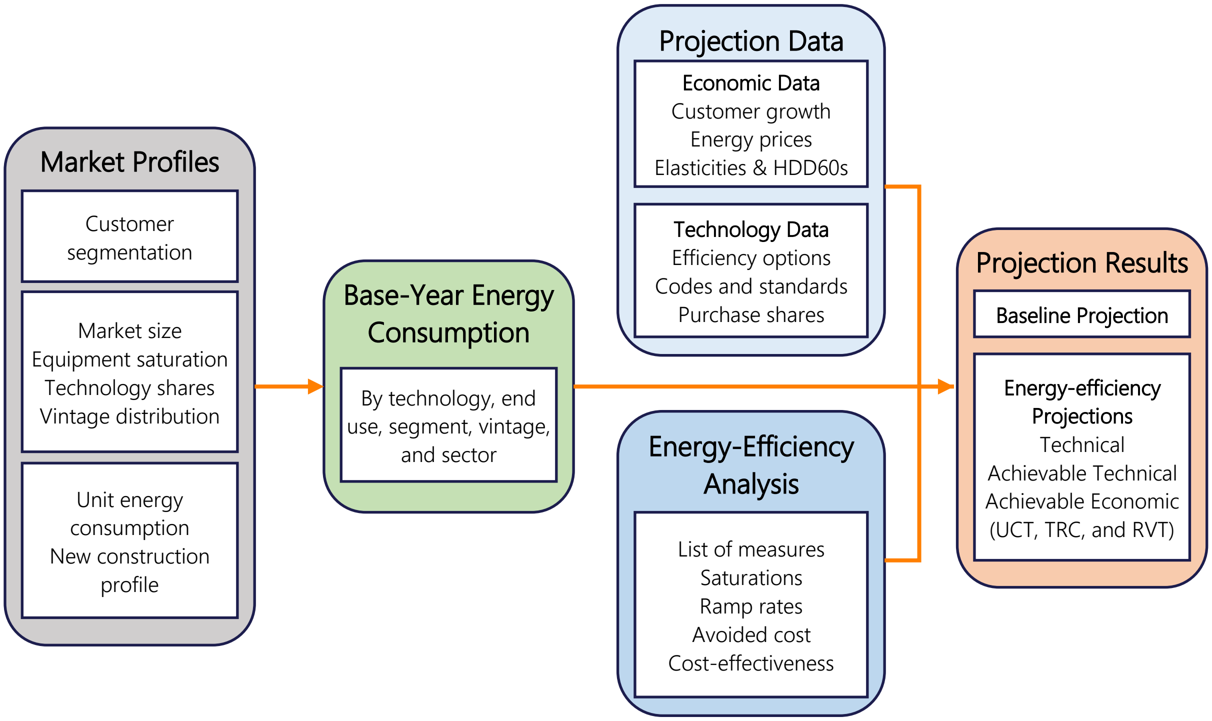
LoadMAP Model

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 Electric Power Research Institute (EPRI) National Potential Study and numerous utility-specific forecasting and potential studies since. Built in Microsoft 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 Residential End-Use Energy Planning System (REEPS) and Commercial End-Use Planning System (COMMEND)) but in a simplified, more 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. This is especially relevant in the state of Washington, where the 2018 WSEC substantially enhances the efficiency of the new construction market.
- Uses a simple logic for appliance and equipment decisions. Other models available for this purpose embody complex customer 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 will enable 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 water heating is distinct from furnaces and fireplaces.
- 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, climate zone, 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. It also allows for the development of IRP supply curves, both at the achievable technical and achievable economic potential levels.

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. [4]

Figure 2-1 LoadMAP Analysis Framework



Definitions of Potential

Before we delve into the details of the analysis approach, it is essential to define what we mean when discussing energy efficiency potential. In this study, savings estimates are developed for three types of potential ('cases'): technical, achievable technical, and achievable economic. These are developed at the measure level, and results are provided as savings impacts over the forecasting horizon. The various levels are described below.

- Technical Potential is defined as the *theoretical* upper limit of energy efficiency potential. It assumes 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 technically feasible. For example, it includes the installation of high-efficiency windows in all new construction opportunities and furnace maintenance in all existing buildings with installed furnaces. These retrofit measures are phased in over a number of years to align with the stock turnover of related equipment units, rather than modeled as immediately available all at once.

- Achievable Technical Potential refines technical potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and other factors that affect market penetration of conservation measures. The customer adoption rates used

[4] The model computes energy forecasts for each type of potential for each end use as an intermediate calculation. Annual-energy 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).

in this study were based on the ramp rates developed for the Council's 2021 Plan and adjusted to reflect differences between electric and natural gas energy efficiency resources and Cascade's program experience.

- UCT Achievable Economic Potential further refines achievable technical potential by applying an economic cost-effectiveness screen. In this analysis, primary cost-effectiveness is measured by the utility cost test (UCT), which assesses cost-effectiveness from the utility's perspective. This test compares lifetime energy benefits to the costs of delivering the measure through a utility program, excluding monetized non-energy impacts. These costs are the assumed incentive, represented as a percent of the incremental cost of the given efficiency measure, relative to the relevant baseline course of action (e.g. federal standard for lost opportunity and no action for retrofits), plus any non-incentive costs that are incurred by the program to deliver and implement the measure. If the benefits outweigh the costs, a given measure is included in the economic potential. Note that we set the measure-level cost-effectiveness threshold at 0.9 for this analysis since Cascade may include non-cost-effective measures as long as the entire portfolio is cost-effective. This is important because a portfolio considers more than just energy savings. Cascade may include popular measures that are on the cusp of cost-effectiveness, accommodate variance between climate zones, maintain a robust portfolio, or include a measure that improves customer outreach and communication. It also supports the inclusion of borderline cost-effective measures, increasing overall savings through energy efficiency offerings.
- TRC Achievable Economic Potential is similar to UCT's achievable economic potential in that it refines achievable technical potential through cost-effectiveness analysis. However, it sues the total resource cost (TRC) test as the screening criterion. The TRC test assesses cost-effectiveness from a combined utility and customer perspective. As such, this test includes full measure costs but also includes non-energy impacts realized by the customer if quantifiable and monetized. In addition to non-energy impacts, we assessed the impacts of non-gas impacts following Council methodology. This includes a calibration credit for space heating equipment consumption to account for secondary heating equipment present in an average home as well as other electric end-use impacts such as cooling and interior lighting as applicable on a measure-by-measure basis. As a secondary screen, we include TRC results for comparative purposes.
- Proxy RVT Achievable Economic Potential is similar to the UCT and TRC achievable economic potential but assesses cost-effectiveness using a proxy for a Resource Value Test (RVT). The RVT reframes the analysis around accomplishing a jurisdiction's regional policy goals and includes hard-to-quantify impacts through quantitative or qualitative approaches. This test allows jurisdictions to define policy goals that may include additional impacts beyond the traditional utility-customer TRC approach. In May of 2017, the National Efficiency Screening Project (NESP) released a National Standard Practice Manual[5] (2017 NSPM), which details an approach for conducting screening measures under the RVT. Because the Washington Utilities and Transportation Commission (WUTC) is still considering the adoption and application of an RVT, AEG used proxy adders to investigate the sensitivity of achievable economic potential to the inclusion of additional benefits. Proxy RVT assumptions and results are provided in Appendix C of Volume 2 of this report.

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. To estimate the savings potential from

[5] National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources, May 18, 2017 https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf

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 Cascade's natural gas footprint to quantify energy use by sector, segment, end-use application, and the current set of technologies in use. For this, we rely primarily on information from Cascade, augmenting with secondary sources as necessary.

Segmentation for Modeling Purposes

This assessment first defined the market segments (climate zones, building types, end uses, and other dimensions) that are relevant in Cascade's service territory. The segmentation scheme for this project is presented in Table 2-1.

Table 2-1 Overview of Cascade Analysis Segmentation Scheme

Dimension	Segmentation Variable	Description
1	Sector	Residential, Commercial, Industrial (core customers only)
2	Segment	Residential: Climate Zones 1 through 3 Single Family, Climate Zones 1 through 3 Multifamily; further divided according to income analysis (see chapter 3) Commercial: Office, Retail, Restaurant, Grocery, Education, Healthcare, Lodging, Warehouse, Miscellaneous Industrial: Food Products, Agriculture, Primary Metals, Stone Clay & Glass, Petroleum, Paper & Printing, Instruments, Wood & Lumber Products, Other Industrial
3	Vintage	Existing and new construction
4	End uses	Heating, secondary heating, water heating, food preparation, process, and miscellaneous (as appropriate by sector)
5	Appliances/end uses and technologies	Technologies such as furnaces, water heaters, and process heating 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 natural gas sales in the base year, 2019. We used detailed Cascade billing and customer data with minimal augmentation from secondary sources to allocate energy use and customers to the various sectors and segments. The total customer count and energy consumption matched Cascade's system totals in 2019. This information provided control totals at a sector level for calibrating the LoadMAP model to known data for the base year. Please note that due to a meager number of mobile homes with natural gas service in Cascade's territory, as identified from billing data and supported by regional surveys, we included consumption for these dwellings within the single-family market segment.

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 the number of households. In the commercial sector, it is floor space measured in square feet. For the industrial sector, it is the number of employees.

- Saturations indicate the share of the market that is served by a particular end-use technology. Three types of saturation definitions are commonly used:
  - The conditioned space approach accounts for a fraction of each building that is conditioned by the end-use. This applies to cooling and heating end uses.
  - The whole-building approach measures shares of space in a building with an end use regardless of the portion of each building that is served by the end use. Examples are commercial refrigeration and foodservice and domestic water heating and appliances.
  - The 100% saturation approach applies to end uses that are generally present in every building or home and are simply set to 100% in the base year.
- UEC (Unit Energy Consumption) or EUI (Energy Usage Index) define consumption for a given technology. UEC represents the amount of energy a given piece of equipment is expected to use in one year. EUI is a UEC indexed to a non-building market unit, such as per square foot or per employee)
  - These are indices that refer to a measure of average annual energy use per market unit (home, floor space, or employee in the residential, commercial, and industrial sector, respectively) that are served by an end-use technology. UECs and EUIs embody an average level of service and average equipment efficiency for the market segment.
- Annual energy intensity for the residential sector represents the average energy use for the technology across all homes in 2019. It is computed as the product of the saturation and the UEC and is defined as therms/household for natural gas. 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 therms or thousand therms.

The market characterization results and the market profiles are presented in Section 3 and Appendix E.

Baseline Projection

The next step was to develop the baseline projection of annual natural gas use for 2020 through 2040 by customer segment and end use in the absence of new utility energy efficiency programs.

We first aligned with Cascade's official forecast. AEG worked with Cascade's load forecasting group to incorporate assumptions and data utilized in the official utility forecast. Cascade's heating degree days (base 60°F) were incorporated into the LoadMAP model to align the baseline projection with the official utility forecast. The end-use projection includes impacts of future federal standards that were effective as of July 2020, which drive energy consumption down through the study period.

Naturally occurring energy conservation, that is, energy conservation that is realized within the service area independent of utility-sponsored programs, is incorporated into the baseline projection consistent with the US Energy Information Administration's Annual Energy Outlook for the Pacific region. Results of the primary market research were used to calibrate these assumptions to ensure the secondary sources were relevant to Cascade customers. For example, some customers will purchase and install energy conservation measures that are available in the market without a utility incentive. Please note that this is not the "Frozen Efficiency" case defined by the Council, which is used for comparison with electricity savings from the Seventh Plan. After discussions with the Cascade team and review of the load forecast, AEG determined that a naturally occurring baseline is appropriate and would align better with the official forecast, whose econometric approach includes impacts of naturally occurring efficiency embedded within natural gas sales for the last few years.

As such, the baseline projection is the foundation for the analysis of savings in future conservation cases and scenarios, as well as the metric against which potential savings are measured.

Inputs to the baseline projection include:

- Current economic growth forecasts (i.e., customer growth, changes in weather (Heating Degree Day, base-60°F (HDD60) normalization))
- 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 Section 4.

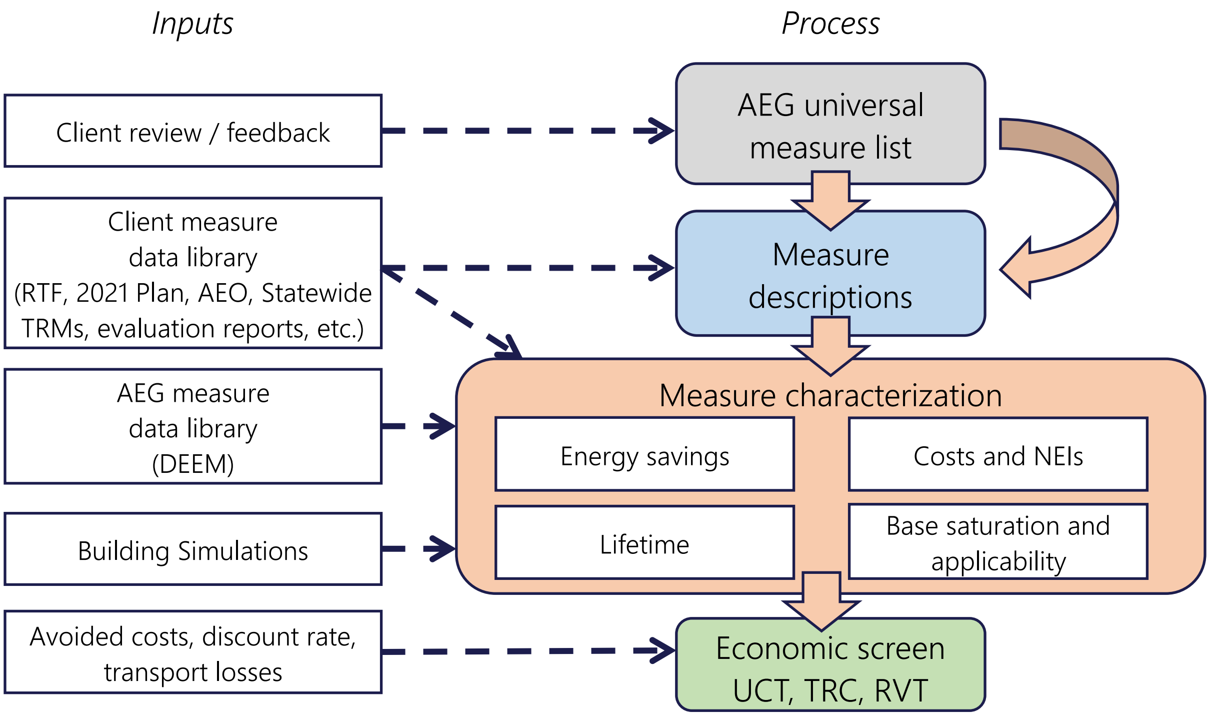
Energy Efficiency Measure Development

This section describes the framework used to assess the savings, costs, and other attributes of energy efficiency measures. 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. Combined with Cascade's avoided cost data, this information informs the economic screens that determine economically feasible measures. In this section, AEG would like to acknowledge the work of the Cascade team in analyzing actual implementation data to provide territory-specific costs for many of the measures assessed within this CPA.

Figure 2-2 outlines the framework for measure characterization analysis. First, the list of measures is identified; each measure is then assigned an applicability for each market sector and segment and characterized with appropriate savings, costs, and other attributes; then the cost-effectiveness screening is performed. Cascade 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 conservation measures for each customer sector, drawing upon Cascade's program experience, AEG's own measure databases and building simulation models, and secondary sources, primarily the Regional Technical Forum's (RTF's) UES measure workbooks and the 2021 Power Plan's electric power conservation supply curves. This universal list of measures covers all major types of end-use equipment, as well as devices and actions to reduce energy consumption, as well as emerging technologies that can be sufficiently characterized for modeling.

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 a tankless residential water heater (UEF 0.91) that replaces a standard efficiency storage water heater (UEF 0.58). For equipment measures, many efficiency levels may be available for a given technology, ranging from the baseline unit (often determined by a code or standard) up to the most efficient product commercially available. These measures are applied on a stock-turnover basis, and in general, are referred to as lost opportunity (LO) measures by the Council because once a purchase decision is made, there will not be another opportunity to improve the efficiency of that equipment item until its end of useful life (EUL) is reached once 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 furnace or water heater). Measure installation is not tied to a piece of equipment reaching the end of useful life, so these are generally categorized as "retrofit" measures. An example would be insulation that modifies a household's space heating consumption but does not change the efficiency of the furnace. The existing insulation can be upgraded without waiting for any existing equipment to malfunction and saves energy used by the furnace. Non-equipment measures typically fall into one of the following categories:
    - Building shell (windows, insulation, roofing material)
    - Equipment controls (smart thermostats, water heater setback)
    - Whole-building design (Built Green homes)
    - Retrocommissioning

AEG developed a preliminary list of efficient measures, which was distributed to Cascade's project team for review and Cascade's nonresidential implementer, TRC Companies, Inc. Once we assembled the list of measures, the AEG team assessed their energy-saving characteristics. For each measure, we also characterized incremental cost, service life, non-energy impacts, and other performance factors. Over 150 unique energy savings measures were considered in the CPA, with permutations across vintage and segment adding up to over 4,000 variations.

While Phase 1 of this CPA updated the baseline and estimated potential using the characterizations developed in the 2017 CPA, this phase updated information for all measures to the latest available data appropriate for Cascade's territory.

Following the measure characterization, we performed an economic screening of each measure, which serves as the basis for developing the economic and achievable potential scenarios.

Calculation of Energy Efficiency Potential

The approach we used for this study to calculate the energy efficiency potential adheres to the approaches and conventions outlined in the National Action Plan for Energy-Efficiency (NAPEE) *Guide for Conducting Energy Efficiency Potential Studies*.[6] This document represents credible and comprehensive industry best practices for specifying energy conservation potential. Three types of potential were developed as part of this effort: technical potential, achievable technical potential, and achievable economic potential (using UCT, TRC, and proxy RVT tests). The calculation of technical potential is a straightforward algorithm that, as described above, assumes that customers adopt all feasible measures regardless of their cost.

Stacking of Measures and Interactive Effects

An important factor when estimating potential is to consider interactions between measures when they are applied within the same space. This is important to avoid double counting and could feasibly result in savings at greater than 100% of equipment consumption if not properly accounted for.

This occurs at the population- or system- level, where multiple DSM actions must be stacked or layered on top of each other in succession, rather than simply summed arithmetically. These interactions are automatically handled within the LoadMAP models where measure impacts are stacked on top of each other, modifying the baseline for each subsequent measure. We first compute the total savings of each measure on a standalone basis, then also assign a stacking priority, based on levelized cost, to the measures such that "integrated" or "stacked" savings will be calculated as a percent reduction to the running total of baseline energy remaining in each end use after the previous measures have been applied. This ensures that the available pie of baseline energy shrinks in proportion to the number of DSM measures applied, as it would in reality. The loading order is based on the levelized cost of conserved energy, such that the more economical measures that are more likely to be selected from a resource planning perspective will be the first to be applied to the modeled population.

We also account for the exclusivity of certain measure options when defining measure assumptions. For instance, if an AFUE 95% furnace is installed in a single-family home, the model will not allow that same home to install an AFUE 98% furnace, or any other furnace, until the newly installed AFUE 95% option has reached its end of useful life. For non-equipment measures, which do not have a native applicability limit, we define base saturations and applicabilities such that measures do not overlap. For example, we model two applications of ceiling insulation: the first assumes the installation of insulation where there previously was none, while the second upgrades pre-existing insulation if it falls under a certain threshold. We used

[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.

regional market research data to ensure the exclusivity of these two options. NEEA's RBSA II contains information on average R-values of insulation installed. The AEG team used these data to define the percent of homes that could install one measure but not the other.

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 potential phases 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 resource planning does not overstep acquisition capabilities. We adapted the Northwest Power and Conservation Council's 2021 Plan ramp rates to develop these achievability factors for each measure. Applying these ramp rates as factors leads directly to the achievable technical potential. More details on this process can be found in Appendix A of Volume 2 of this report.

Screening Measures for Cost-Effectiveness

With achievable technical 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 achievable economic potential.

LoadMAP performs an economic screen for each individual measure in each year of the planning horizon. This study uses the UCT test as the primary cost-effectiveness metric, which compares the lifetime hourly energy benefits of each applicable measure with the incentive and administrative costs incurred by the utility. The lifetime benefits are calculated by multiplying the annual energy savings for each measure by Cascade's avoided costs and discounting the dollar savings to the present value equivalent. 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, considering 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 therm savings potential of a measure, consumption with the measure applied must be compared to the 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 economic screen.

This constitutes the achievable economic potential and includes every program-ready energy efficiency opportunity. Potential results are presented in Chapters 4 and 5. Measure-level detail is available in Excel format, presented as Appendix G 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:

- Cascade-provided data
- Northwest regional data
- AEG's databases and analysis tools
- Other secondary data and reports

Cascade Data

Our highest priority data sources for this study were those that were specific to Cascade, including the primary market research conducted specifically for this study. These data are specific to Cascade's service territory and are an important consideration when customizing the model for Cascade's market. This is best practice when developing CPA baselines when the data are available.

- Cascade customer account database. Cascade provided billing data for the 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. This also included equipment flags, identifying the presence of a substantial number of gas-consuming technologies. These data were very useful in developing a detailed estimate of energy consumption within Cascade's service territory.
- Load forecasts. Cascade provided forecasts, by sector and climate zone, of energy consumption, customer counts, weather actuals for 2019, as well as weather-normal HDD60s.
- Economic information. Cascade provided a discount rate as well as avoided cost forecasts and transportation loss factors.
    - Avoided Costs represent the total value of energy saved each year and include (but are not limited to) the cost of the fuel itself, storage, distribution and transport, avoided cost of carbon emissions, the Social Cost of Carbon, and the Washington Conservation Credit. The latter two are applied as percent adders that increase the value of energy savings for cost-effectiveness testing.
- Cascade program data. Cascade provided information about past and current programs, including program descriptions, goals, and measure achievements to date. Cascade also provided a comprehensive list of measure costs, developed from measure installations within actual Cascade conservation programs.

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 Draft 2021 Plan and Regional Technical Forum workbooks. To develop its Power Plan, the Council maintains workbooks with detailed information about measures. Though electric savings have been the primary focus in the past, more workbooks are conducting analysis of natural gas measures as well. This was used as a primary data source when Cascade-specific program data was not available, and the data was determined to be applicable to natural gas conservation measures. The most recent data and workbooks available were used at the time of this study.

- Northwest Energy Efficiency Alliance, 2016-2017 Residential Building Stock Assessment II, https://neea.org/data/residential-building-stock-assessment
- Northwest Energy Efficiency Alliance, 2011 Residential Building Stock Assessment, https://neea.org/resources/washington-state-report
- Northwest Energy Efficiency Alliance, 2019 Commercial Building Stock Assessment, https://neea.org/resources/cbsa-4-2019-final-report
- Northwest Energy Efficiency Alliance, 2014 Commercial Building Stock Assessment, https://neea.org/resources/2014-cbsa-final-report
- Northwest Energy Efficiency Alliance, 2014 Industrial Facilities Site Assessment, https://neea.org/resources/2014-ifsa-final-report

Since Cascade's billing data included information on appliance saturations at the customer level, the NEEA surveys were used more for benchmarking and comparative purposes rather than as a primary source of data. The NEEA surveys were used extensively to develop base saturation and applicability assumptions for many of the non-equipment measures within the study.

AEG Data

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

- AEG Energy Market Profiles. For more than ten 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 (natural gas and electricity), 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 more than 60 studies of EE potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies, both within the region and across the country.

Other Secondary Data and Reports

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

- Annual Energy Outlook. The Annual Energy Outlook (AEO), conducted each year by the U.S. Energy Information Administration (EIA), presents yearly projections and analysis of energy topics. For this study, we used data from the 2019 AEO.

- American Community Survey (US Census). The US Census American Community Survey is an ongoing survey that provides data every year on household characteristics. http://www.census.gov/acs/www/
- Local Weather Data. Cascade provided both actual and normal heating degree days (HDD) for Bellingham (Cascade climate zone 1), Hoquiam (Cascade climate zone 2), and Yakima (Cascade climate zone 3), which were used where applicable. For the commercial and industrial sectors, where analysis was not done at the climate zone-level, we used a weighted average of the three weather stations based on Cascade's billing data within each zone.
- EPRI End-Use Models (REEPS and COMMEND). These models provide the energy-use elasticities we apply to prices, household income, home size, heating, and cooling.
- Database for Energy Efficient Resources (DEER). The California Energy Commission and California Public Utilities Commission (CPUC) sponsor this database, which is designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) for the state of California. We used the DEER database to cross-check the measure savings we developed using BEST and DEEM.
- Other relevant resources: These include reports from the Consortium for Energy Efficiency, the EPA, and the American Council for an Energy-Efficient Economy. This also includes technical reference manuals (TRMs) from other states. When using data from outside the region, especially weather-sensitive data, AEG adapted assumptions for use within Cascade's Washington territory.

Application of Data to the Analysis

Data Application for Market Characterization

To construct the high-level market characterization of natural gas consumption and market size units (households for residential, floor space for commercial, and employees for industrial), we primarily used Cascade's billing data as well as secondary data from AEG's Energy Market Profiles database. We also performed an analysis of US Census data in the American Community Survey (ACS) to inform residential segmentation by income, described in Chapter 3.

Data Application for Market Profiles

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

1. Develop control totals for each segment. These include market size, segment-level annual natural gas use, and annual intensity. Control totals were based on Cascade's actual sales and customer-level information found in Cascade's customer billing database.
2. Develop existing appliance saturations and the energy characteristics of appliances, equipment, and buildings using equipment flags within Cascade's billing data, NEEA's 2016 RBSA, 2019 CBSA, and 2014 IFSA, DOE's 2015 RECS, the 2019 edition of the Annual Energy Outlook, AEG's Energy Market Profile (EMP) for the Pacific region, and the American Housing Survey.
3. Ensure calibration to Cascade control totals for annual natural gas sales in each sector and segment.
4. Compare and cross-check with other recent AEG studies.
5. Work with Cascade staff to verify the data aligns with their knowledge and experience.

Table 2-2 Data Applied for the Market Profiles

Model Inputs	Description	Key Sources
Market size	Base-year residential dwellings, commercial floor space, and industrial employment	Cascade 2019 actual sales Cascade customer account database US Census data (for income analysis)
Annual intensity	Residential: Annual use per household Commercial: Annual use per square foot Industrial: Annual use per employee	Cascade customer account database AEG's Energy Market Profiles AEO 2019 – Pacific Region 2016 RBSA (for income analysis) Other recent studies
Appliance/equipment saturations	Fraction of dwellings with an appliance/technology Percentage of C&I floor space/employment with equipment/technology	Cascade equipment flags in customer account database 2016 RBSA, 2019 CBSA and 2014 IFSA 2018 American Community Survey AEG's Energy Market Profiles
UEC/EUI for each end-use technology	UEC: Annual natural gas use in homes and buildings that have the technology EUI: Annual natural gas use per square foot/employee for a technology in floor space that has the technology	HVAC uses: BEST simulations using prototypes developed for Cascade Engineering analysis AEG DEEM AEO 2019 – Pacific Region Recent AEG studies
Appliance/equipment age distribution	Age distribution for each technology	2011 RBSA, 2014 CBSA, and recent AEG studies
Efficiency options for each technology	List of available efficiency options and annual energy use for each technology	Cascade current program offerings AEG DEEM AEO 2019 CA DEER Recent AEG studies

Data Application for Baseline Projection

Table 2-3 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 2-3 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	Cascade load 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 2019 regional forecast assumptions[7] Appliance/efficiency standards analysis
Utilization model parameters	Price elasticities, elasticities for other variables (income, weather)	EPRI's REEPS and COMMEND models

- *Equipment Codes & Standards.* Assumptions were incorporated for known future equipment standards as of July 2020, as shown in Table 2-4 and Table 2-5. The assumptions tables here extend through 2025, after which all standards are assumed to hold steady.
- *Building Codes for New Construction.* This CPA assumed new construction would comply with the mandatory portions of the 2018 Washington State Energy Code. However, builders must also select from a list of possible additional energy-efficient elements to meet a minimum number of credits. Through conversations with Cascade, NEEA, and AEG's other clients in the region, we developed a set of assumptions regarding likely credit choices for new construction compliance, which are documented in Chapter 4.

[7] We developed baseline purchase decisions using the Energy Information Agency's *Annual Energy Outlook* report (2020), 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.

Table 2-4 Residential Natural Gas Equipment Federal Standards[8]

End Use	Technology	2019	2020	2021	2022	2023	2024	2025
Space Heating	Furnace – Direct Fuel	AFUE 80%					AFUE 92%*	
	Boiler – Direct Fuel	AFUE 82%	AFUE 84%					
Secondary Heating	Fireplace	N/A						
Water Heating	Water Heater <= 55 gal.	UEF 0.58						
	Water Heater > 55 gal.	UEF 0.76						
Appliances	Clothes Dryer	CEF 3.30						
	Stove/Oven	N/A						
Miscellaneous	Pool Heater	TE 0.82						
	Miscellaneous	N/A						

* This standard was originally set to take effect in 2021 but exempts smaller systems. The comment period lasted through 2017 with the standard not expected to take effect until at least 5 years after that time. There has been no update since the comment period expired, so the analysis retains the previous assumption that this standard will come online officially in 2024.

Table 2-5 Commercial and Industrial Natural Gas Equipment Standards

End Use	Technology	2019	2020	2021	2022	2023	2024	2025
Space Heating	Furnace	AFUE 80% / TE 0.80						
	Boiler	Average around AFUE 80% / TE 0.80 (varies by size)						
	Unit Heater	Standard (intermittent ignition and power venting or automatic flue damper)						
Water Heater	Water Heating	TE 0.80						

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

Energy Conservation Measure Data Application

Table 2-6 details the energy-efficiency data inputs to the LoadMAP model. It describes each input and identifies the key sources used in the Cascade analysis.

Table 2-6 Data Inputs 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.	Cascade program data NWPCC workbooks, RTF AEG BEST AEG DEEM AEO 2020 CA DEER Other secondary sources
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.	Cascade program data NWPCC workbooks, RTF AEG DEEM AEO 2020 EIA 2018 Reference case 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 2020 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.	2011/2016 RBSA, 2014/2019 CBSA; 2021 Plan applicability guidelines 2018 WSEC and NEEA research for limitations on new construction AEG DEEM CA DEER Other secondary sources
On Market and Off Market Availability	Expressed as years for equipment measures to reflect when the equipment technology is available or no longer available in the market.	AEG appliance standards and building codes analysis

Data Application for Cost-Effectiveness Screening

To perform the cost-effectiveness screening, a number of economic assumptions were needed. All cost and benefit values were analyzed in real (2019) dollars. The analysis applied Cascade's long-term real discount rate of 3.40%. This rate was based on the average 30-year mortgage value rather than the weighted average cost of capital (WACC) to maintain consistency with the IRP. LoadMAP is configured to vary this by market sector (e.g., residential and commercial) if Cascade develops alternative values in the future. All impacts in this report are presented at the customer meter, but transportation losses were provided by Cascade and were included for cost-effectiveness screening.

Estimates of Customer Adoption

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

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

The ramp rates referenced above were adapted for use for assessing natural gas measure potential, as described in Appendix A of Volume 2. The customer adoption rates used in this study are available in Appendix F.

3

MARKET CHARACTERIZATION AND MARKET PROFILES

In this section, we describe how customers in Cascade's Washington service territory use natural gas in the base year of the study, 2019, beginning with a high-level summary of energy use across all sectors and then delving into each sector in more detail.

Overall Energy Use Summary

Total natural gas consumption for core customers across all sectors for Cascade in 2019 was 244,473 thousand therms. As shown in Figure 3-1 and Table 3-1, the residential sector accounts for the largest share of annual energy use at 52%, followed by the commercial sector at 38%. Core customers[9] within the industrial sector (non-transport) account for 10% of usage.

Figure 3-1 Sector-Level Natural Gas Use in Base Year 2019 (annual therms, percent)

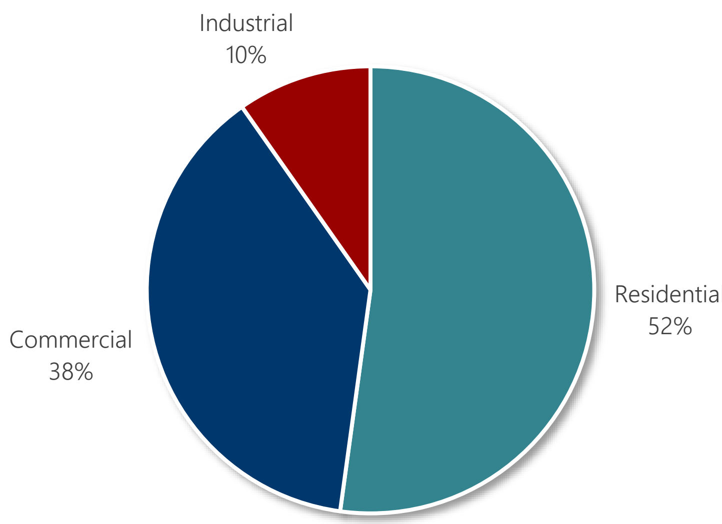


Table 3-1 Cascade Sector Control Totals, 2019

Sector	Number of Customers/Buildings	Natural Gas Use (thousand therms)
Residential	212,827	127,538
Commercial	25,039	93,122
Industrial	450	23,814
Total	**238,316**	**244,473**

[9] See "Addressing Transport Customers" below

Considerations for Transport Customers

Non-residential transport-only customers were excluded from consideration in this study, as they are not currently eligible for participation in energy efficiency programs. Though there has been regional conversation surrounding potential for transport customers, there are additional data needs in estimating this potential and challenges in acquiring it. Assessing cost-effective potential for transport customers would require different avoided costs, more visibility into the kinds of customers on these rates and their end uses, and an understanding of how these customers view energy savings and might participate in future programs since there is no past history on which to draw. In addition, the incentive mechanism for these customers would need to be determined, as they do not currently pay into the tariff that supports the rebates and incentives to core customers.

Residential Sector

The total number of households and gas sales for the service territory were obtained from Cascade's actual sales for 2019. Details, including the number of households and 2019 natural gas consumption for the residential sector, can be found in Table 3-2 below. In 2019, there were over 200,000 households in the Cascade territory that used a total of over 127 million therms, resulting in an average use per household of 599 therms per year. This is an important number for the calibration process.

One adjustment made to Cascade customer counts was in the multifamily segments. A common trend in billing data is master accounts that represent multiple units within the same floor or building. When natural gas usage is shared in that way, we do not use the data directly. To account for this, we used 2016 RBSA data on multifamily usage per customer, then scaled it based on the relative usage within the three climate zones. For example, multifamily homes used comparatively more natural gas in climate zone 1 compared to zone 3, so the RBSA intensities were scaled upward in zone[10] 1 and downward in zone 3. In future updates to the LoadMAP model, Cascade may substitute the RBSA data for a more targeted local source if additional research is done into this topic.

These values have been weather normalized to account for differences in the actual heating degree days for 2019 compared to normal weather. Degree days for the conversion were provided by Cascade's forecast department.

Table 3-2 Residential Sector Control Totals, 2019

Segment	Households	Natural Gas Sales (thousand therms)	Avg. Use / Household (therms)
CZ1 - Single Family	71,590	51,737	723
CZ1 - Multi Family	27,076	8,487	313
CZ2 - Single Family	37,443	25,519	682
CZ2 - Multi Family	4,736	1,267	267
CZ3 - Single Family	57,136	36,151	633
CZ3 - Multi Family	14,846	4,377	295
Total	**212,827**	**127,538**	**599**

[10] Refer to Chapter 1 for the geographic definition of CNGC climate zones

Figure 3-2 Residential Natural Gas Use by Segment, 2019

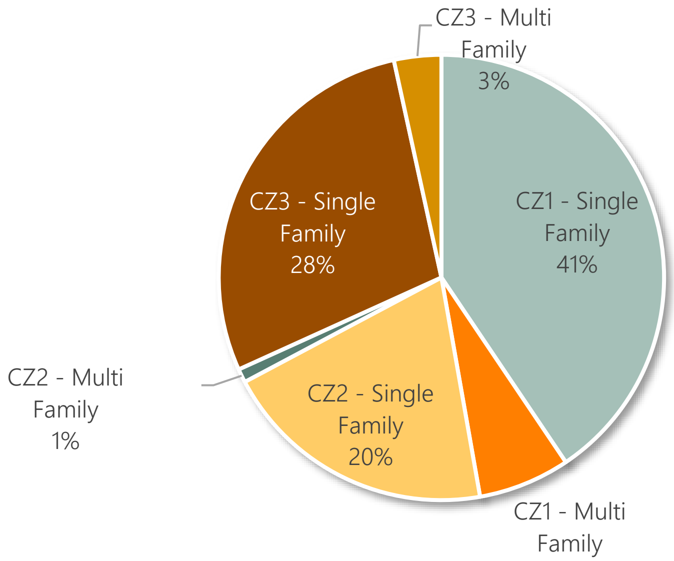
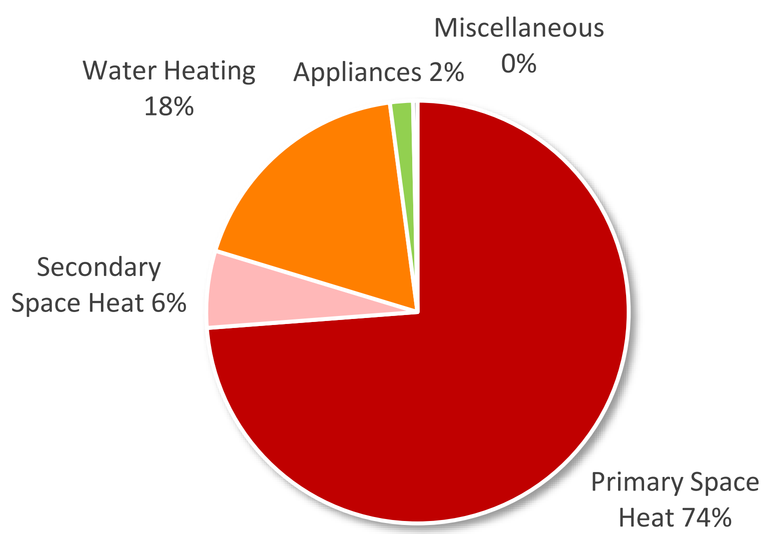


Figure 3-3 shows the distribution of annual natural gas consumption by end use for an average residential household. Space heating (primary and secondary) comprises a majority of the load at 80% followed by water heating at 18%. Miscellaneous loads make up a very small portion of the total. This is expected for a natural gas profile as there are few miscellaneous technologies. One example is natural gas barbecues.

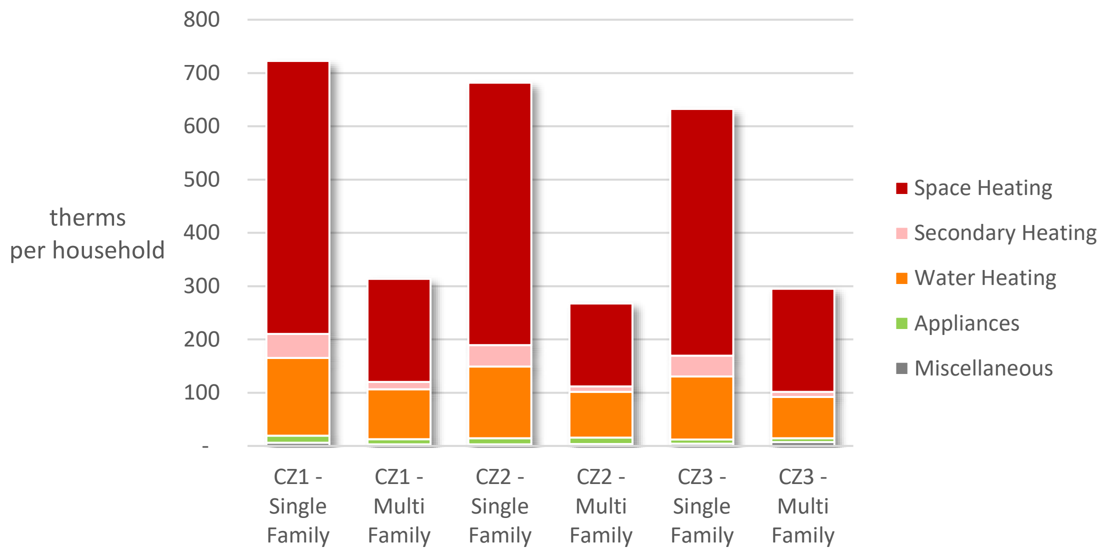
Figure 3-3 Residential Natural Gas Use by End Use, 2019



Equipment flags within Cascade's billing data-informed estimates of the saturation of key equipment types, which were used to distribute usage at the technology and end use level.

Figure 3-4 presents average natural gas intensities by end use and housing type. Single-family homes consume substantially more energy in space heating, primarily due to two factors. The first is that single-family homes are larger. The second is that more walls are exposed to the outside environment, compared to multifamily dwellings with many shared walls. This increases heat transfer, resulting in greater heating loads. Water heating consumption is higher in single-family homes as well. This is due to a greater number of occupants, which increases the demand for hot water.

Figure 3-4 Residential Energy Intensity by End Use and Segment, 2019 (Annual Therms/HH)



The market profile for an average home in the residential sector is presented in Table 3-3 below. An important step in the profile development process is model calibration. All consumption within an average home must sum up to the intensity extracted from billing data. This is necessary so estimates of consumption for a piece of equipment do not exceed the actual usage in a home.

Table 3-3 Average Market Profile for the Residential Sector, 2019

End Use	Technology	Saturation	UEC (therms)	Intensity (therms/HH)	Usage (thousand therms)
Primary Space Heat	Furnace - Direct Fuel	82.8%	502	416	88,530
	Boiler - Direct Fuel	2.1%	428	9	1,893
Second. Space Heat	Fireplace	29.1%	121	35	7,508
Water Heating	Water Heater <= 55 gal.	64.7%	165	107	22,710
	Water Heater > 55 gal.	10.3%	165	17	3,619
Appliances	Clothes Dryer	9.4%	21	2	427
	Stove/Oven	27.6%	31	9	1,816
Miscellaneous	Pool Heater	1.0%	106	1	232
	Miscellaneous	100%	4	4	804
Total				**599**	**127,538**

Residential Income Group Analysis

In the previous CPAs performed for Cascade, AEG estimated energy efficiency potential based on average customer profiles without differentiation by household income. By estimating energy efficiency potential based on Cascade's average customer, previous CPAs have inherently captured energy efficiency potential in low-income homes. However, given the increased interest in the low-income customer segment specifically, Phase 2 of this CPA expanded its scope to include income level analysis for the residential sector. To protect customer privacy, data on Cascade's specific customers were limited to anonymized street addresses and household natural gas use.

This additional analysis allows Cascade to review goal setting and their portfolio structure to adapt to this more granular understanding of their customer base.

Income Group Definitions

AEG worked with Cascade to develop suitable definitions of each income group to align with program eligibility and other state guidance. The thresholds of household income for Low and Moderate Income designations are shown in Table 3-4 below. The Low-Income threshold corresponds with 200% of the Federal Poverty Level (FPL), which is also the eligibility cutoff for the Washington low-income weatherization assistance program. Households in the Moderate income group are above the 200% FPL level but below the Washington state median income by household size. Households with income above the Washington state median income were included in a third "Above Median Income" group.

Table 3-4 Definitions of Income Groups by Household Size (up to)

HH Size (persons)	Low Income	Moderate Income
1	$25,520	$28,931
2	$34,480	$57,863
3	$43,440	$86,794
4	$52,400	$115,725
5	$61,360	$144,657
6	$70,320	$173,588
7	$79,280	$202,520
8	$88,240	$231,451

Customer Segmentation by Income Group

To estimate the number of Cascade customers in each of the income groups, AEG mapped address data or Cascade residential accounts back to corresponding geographic "blocks" in the census data. Each of these blocks was then processed to analyze average household size and income, producing a distribution of households into income buckets for places where Cascade customers reside. These distributions by housing type and income level serve to split apart the housing types from the original 2019 market profile.

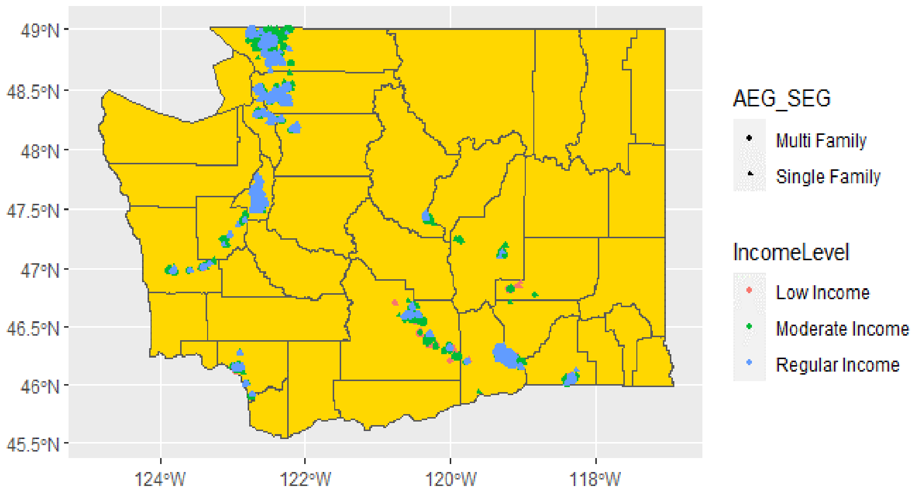
As shown in Table 3-5 below, nearly 60% of Cascade's Washington customers fall into either the low or moderate income grouping, with the majority of these in the moderate-income range. In fact, the moderate-income group is the largest group of customers overall, with nearly half of Cascade's customers falling into this designation, followed by 41% of customers above the median income for the state of Washington.

Table 3-5 Customer Distribution by Income Groupings and Housing Type (% of households)

Overall by Housing Type	Above Median	Moderate	Low Income	Low/Moderate Combined
Single Family	42%	47%	11%	58%
Multifamily	35%	51%	14%	65%
Total	**41%**	**47%**	**11%**	**59%**

The map in Figure 3-5 plots the geographic points used for the US Census demographic analysis against the state of Washington. The data points follow Cascade's distribution infrastructure as only data from geoblocks corresponding with Cascade's customers were used for this analysis. On the map, the color of the dot corresponds to income level, while the shape of each dot denotes whether the information assessed at that point was for single or multifamily homes.

Figure 3-5 Map of Income Analysis Data Points



Energy Consumption by Income Group

AEG then performed an integrated analysis of data from the American Community Survey and 2016-2017 RBSA combined with household location information from Cascade's billing data.

Once the percent of customers in each housing type and income group was known, AEG used RBSA data for gas-using customers in Washington to investigate differences in home characteristics and energy consumption by these same groupings. This allowed AEG to compare natural gas usage per household across categories. AEG was also able to identify some adjustments to the base market profile and building assumptions to reflect differences by income level, including:

- Low-income customers have a lower presence of gas water heat but the greater presence of gas space heat compared to moderate or above median income customers.
- Low- and moderate-income homes are smaller than above median income homes. However, use per square foot of the home is similar across all three categories, despite RBSA data showing that low- and moderate-income homes have lower insulation values and would be expected to use more energy (per square foot) to maintain similar levels of comfort in the home. This suggests that while the home size is a factor in reduced consumption, it is not the sole explanation.
- Income level does not appear to correlate with the age of the home.

Combining the geographic/demographic analysis with RBSA data on usage differences by income level, AEG was able to produce an expanded residential profile with data-driven variation by income group.

Table 3-6 shows the residential control totals from above after distributing base-year households and natural gas consumption based on the income group analysis. Totals by climate zone and housing type (single-family/multifamily) match those in Table 3-2 above.

Table 3-6 Residential Income-Level Totals, 2019

Segment	Income Group	Households	Natural Gas Use (thousand therms)	Use per Household (therms/HH)
CZ1 - Single Family	Above Median	32,019	24,957	779
	Moderate Income	35,256	24,361	691
	Low Income	4,315	2,419	561
CZ1 - Multi Family	Above Median	10,457	3,566	341
	Moderate Income	14,800	4,475	302
	Low Income	1,819	446	245
CZ2 - Single Family	Above Median	16,746	12,310	735
	Moderate Income	18,440	12,016	652
	Low Income	2,257	1,193	529
CZ2 - Multi Family	Above Median	1,829	532	291
	Moderate Income	2,589	668	258
	Low Income	318	67	209
CZ3 - Single Family	Above Median	29,098	19,811	681
	Moderate Income	22,917	13,832	604
	Low Income	5,122	2,508	490
CZ3 - Multi Family	Above Median	5,001	1,650	330
	Moderate Income	7,094	2,075	292
	Low Income	2,751	653	237
Total	**Above Median**	**95,150**	**62,826**	**660**
	Moderate Income	**101,095**	**57,426**	**568**
	Low Income	**16,583**	**7,286**	**439**
Grand Total		**212,827**	**127,538**	**599**

Commercial Sector

The total number of non-residential accounts and natural gas sales for the service territory were obtained from Cascade's customer account database. AEG first separated the commercial accounts from industrial by analyzing the SIC codes and rate codes assigned in the company's billing system. Prior to using the data, AEG inspected individual accounts to confirm the proper assignment. This was done on the top accounts within each segment but also via spot checks when reviewing the database. By doing this, AEG was able to positively classify about 90% of energy use from non-residential (core) customers. Energy use from accounts where the customer type could not be identified were distributed proportionally to all C&I segments.

Once the billing data was analyzed, the final segment control totals were derived by distributing the total 2019 non-residential load to the sectors and segments according to the proportions in the billing data.

Table 3-7 below shows the final allocation of energy to each segment in the commercial sector, as well as the energy intensity on a square-foot basis. Intensities for each segment were derived from a combination of the 2019 CBSA and equipment saturations extracted from Cascade's database. The CBSA intensities corresponded to spaces with slightly lower natural gas saturations than Cascade's database, so AEG increased intensities proportionally based on the additional presence of natural gas-consuming equipment documented in Cascade's higher saturations.

Table 3-7 Commercial Sector Control Totals, 2019

Segment	Description	Intensity (therms/Sq Ft)	2019 Natural Gas Use (thousand therms)
Office	Traditional office-based businesses including finance, insurance, law, government buildings, etc.	0.25	11,279
Retail	Department stores, services, boutiques, strip malls etc.	0.40	16,068
Restaurant	Sit-down, fast food, coffee shop, food service, etc.	2.74	14,653
Grocery	Supermarkets, convenience stores, market, etc.	1.83	5,383
Education	College, university, trade schools, etc.as well as day care, pre-school, elementary, secondary schools	0.34	15,154
Health	Health practitioner office, hospital, urgent care centers, etc.	1.84	6,567
Lodging	Hotel, motel, bed and breakfast, etc.	1.38	5,095
Warehouse	Large storage facility, refrigerated/unrefrigerated warehouse	0.21	4,709
Miscellaneous	Catchall for buildings not included in other segments, includes churches, recreational facilities, public assembly, correctional facilities, etc.	0.49	14,212
Total		**0.47**	**93,122**

Figure 3-6 shows each segment's natural gas consumption as a percentage of the entire commercial sector energy consumption. The four segments with the highest natural gas usage in 2019 were retail, education, restaurant, and miscellaneous, in descending order. As expected, the highest intensity segment is restaurant, reflecting the high presence of food preparation equipment.

Figure 3-6 Commercial Natural Gas Use by Segment, 2019

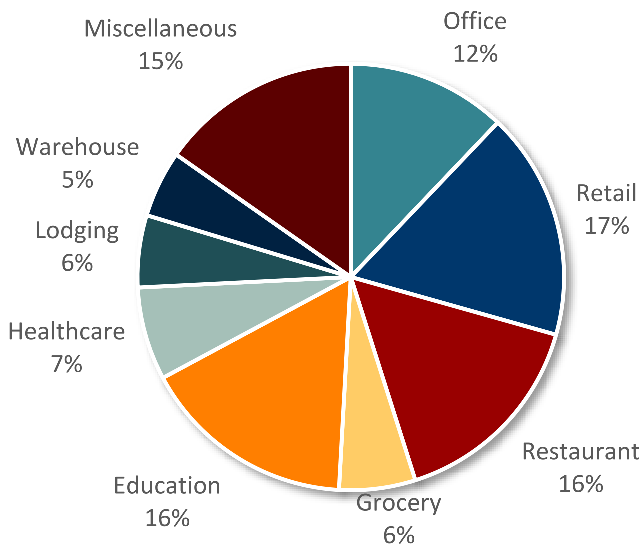


Figure 3-7 shows the distribution of natural gas consumption by end use for the entire commercial sector. Space heating is the largest end use, followed closely by water heating and food preparation. The miscellaneous end use is quite small, as expected given the limited applications for natural gas that do not fall into the other three categories.

Figure 3-7 Commercial Sector Natural Gas Use by End Use, 2019

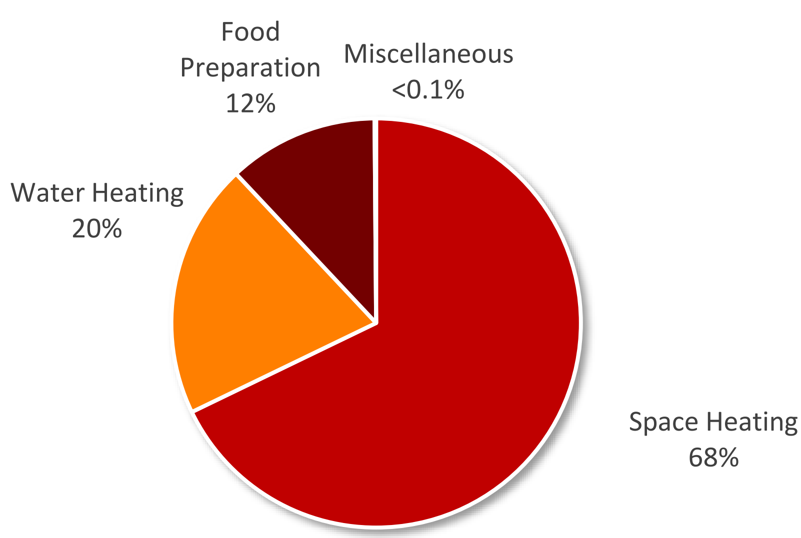
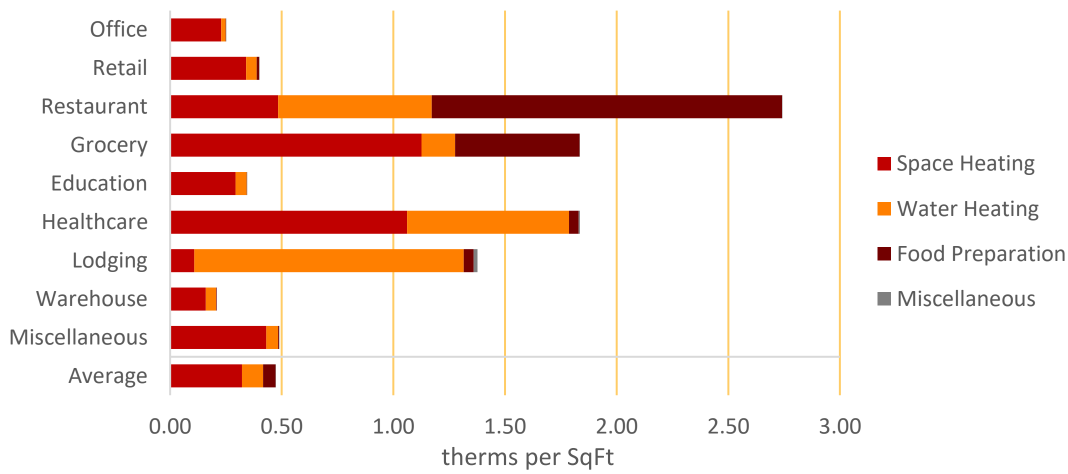


Figure 3-8 presents average natural gas intensities by segment and end use.

Figure 3-8 Commercial Energy Usage Intensity by Segment and End Use, 2019 (Annual Therms/Sq. Ft)



The total market profile for an average building in the commercial sector is presented in Table 3-8 below. Cascade customer account data informed the market profile by providing information on saturation of key equipment types. Secondary data was used to develop estimates of energy intensity and square footage and to fill in saturations for any equipment types not included in the database.

Table 3-8 Average Market Profile for the Commercial Sector, 2019

End Use	Technology	Saturation	EUI (therms/ Sq Ft)	Intensity (therms/ Sq Ft)	Usage (thousand therms)
Heating	Furnace	68.5%	0.19	0.13	25,572
	Boiler	23.0%	0.46	0.11	20,803
	Unit Heater	23.7%	0.36	0.09	16,790
Water Heating	Water Heater	49.5%	0.19	0.10	18,790
Food Preparation	Oven	3.8%	0.09	0.00	663
	Conveyor Oven	1.9%	0.15	0.00	567
	Double Rack Oven	1.9%	0.23	0.00	862
	Fryer	6.7%	0.26	0.02	3,446
	Broiler	2.3%	0.26	0.01	1,152
	Griddle	3.7%	0.17	0.01	1,249
	Range	11.5%	0.10	0.01	2,297
	Steamer	2.0%	0.12	0.00	474
	Commercial Food Prep Other	2.1%	0.08	0.00	341
Miscellaneous	Pool Heater	2.4%	0.01	0.00	42
	Miscellaneous	100.0%	0.00	0.00	73
Total				**0.47**	**93,122**

Industrial Sector

The total sum of natural gas used in 2019 by Cascade's core industrial customers was 23,814 thousand therms. The industrial sector's total natural gas usage does not include transport-only customers as they are not currently eligible to participate in Cascade's energy efficiency programs. As in the commercial sector, customer account data were used to allocate usage among segments. Energy intensity was derived from AEG's Energy Market Profiles database. We cross-referenced this data with Bureau of Labor Statistics employment data by industry. The number of employees is calculated by dividing total usage by intensity. For the industrial sector, the unit of measure chosen is employment. This is because the floor area is not as indicative of process loads, which may be constrained to one portion of a larger warehouse/storage facility. We chose to capture usage on an employment basis rather than customer since NEEA's 2014 IFSA reports in a similar metric, and it allows us to compare intensities with those estimated for the region as a whole. Most industrial measures are installed through custom programs, where the unit of measure is not as necessary to estimate potential.

Table 3-9 Industrial Sector Control Totals, 2019

Segment	Intensity (therms/employee)	Natural Gas Usage (thousand therms)	Employees
Food Products	3,055	7,243	2,371
Agriculture	215	3,721	17,279
Primary Metals	10,135	2,780	274
Stone, Clay, and Glass	6,298	2,223	353
Petroleum	75,573	1,454	19
Paper and Printing	6,854	429	63
Instruments	246	1,831	7,458
Wood and Lumber Products	1,029	854	830
Other Industrial	215	3,278	15,222
Total	**543**	**23,814**	**43,869**

Figure 3-9 summarizes core-customer industrial natural gas consumption by industry type.

Figure 3-9 Industrial Natural Gas Use by Segment, 2019

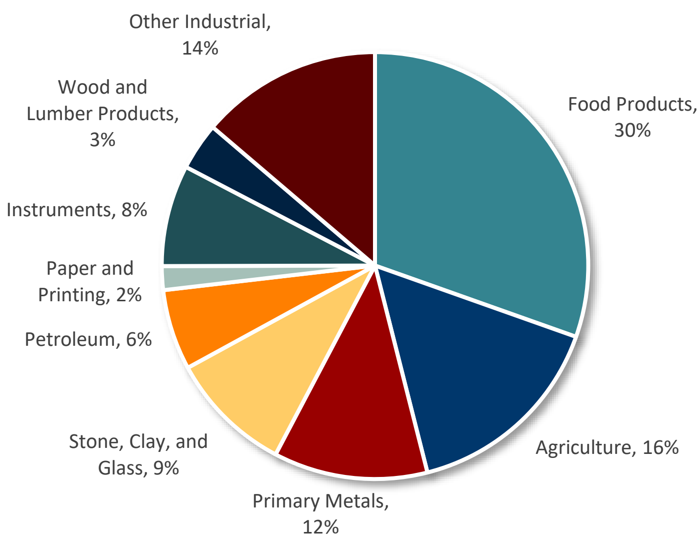


Figure 3-10 shows the distribution of annual natural gas consumption by end use for all industrial customers. Two major sources were used to develop this consumption profile. The first was AEG's analysis of warehouse usage as part of the commercial sector. We begin with this prototype as a starting point to represent non-process loads. We then added in process loads using our Energy Market Profiles database, which summarizes usage by end use and process type. Accordingly, process is the largest overall end use for the industrial sector, accounting for 80% of energy use. Heating is the second largest end use, and miscellaneous, non-process industrial uses round out consumption.

Figure 3-10 Industrial Natural Gas Use by End Use, 2019, All Industries

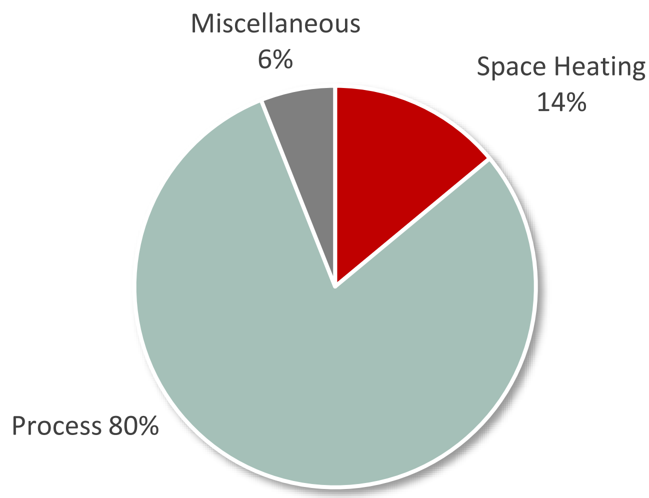


Figure 3-11 summarizes industrial energy intensities by industry type. Petroleum is presented on a separate axis due to the much higher per-employee usage estimate.

Figure 3-11 Industrial Energy Usage Intensity by End Use and Segment, 2019 (Annual Therms/Employee)

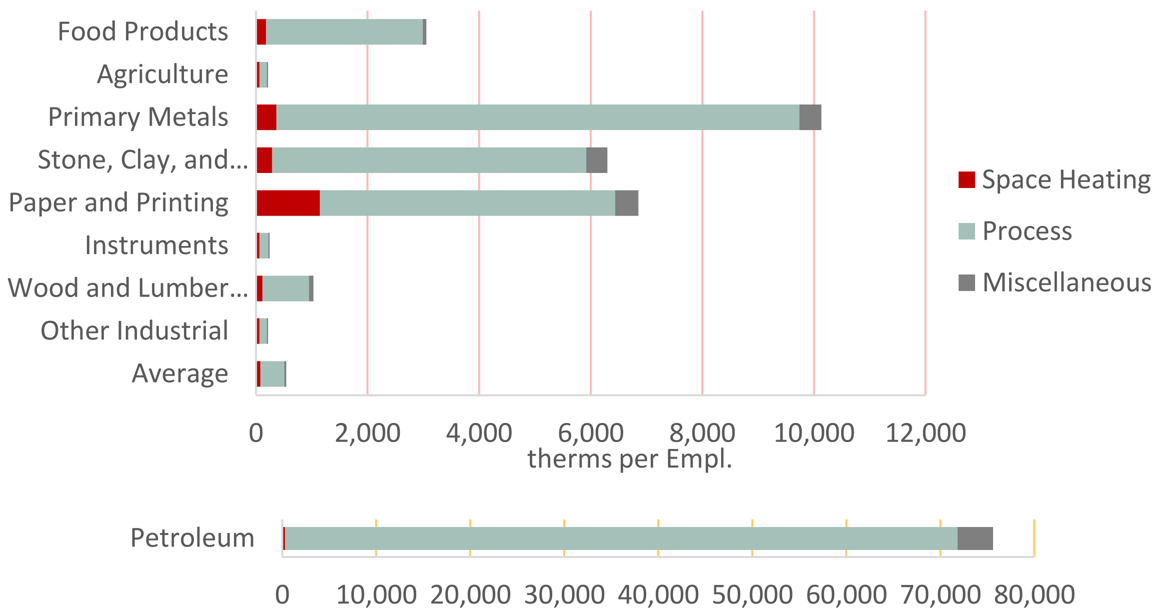


Table 3-10 shows the composite market profile for the industrial sector. Process cooling is very small and represents technologies such as gas-driven absorption chillers.

Table 3-10 Average Natural Gas Market Profile for the Industrial Sector, 2019

End Use	Technology	Saturation	EUI (therms/ employee)	Intensity (therms/ employee)	Usage (thousand therms)
Heating	Furnace	35.8%	92.63	33.21	1,432
	Boiler	10.6%	57.35	6.10	338
	Unit Heater	31.5%	116.28	36.62	1,704
Process	Process Boiler	100.0%	186.97	186.97	8,202
	Process Heating	100.0%	238.37	238.37	10,457
	Process Cooling	100.0%	0.88	0.88	39
	Other Process	100.0%	8.06	8.06	354
Miscellaneous	Miscellaneous	100.0%	32.63	32.63	1,432
Total				**542.83**	**23,814**

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 the absence of any energy conservation 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.

The baseline projection incorporates assumptions about:

- 2019 energy consumption based on the market profiles
- Customer population growth
- Appliance/equipment standards and building codes already mandated
- Appliance/equipment purchase decisions
- Cascade's customer forecast
- Trends in fuel shares and appliance saturations and assumptions about miscellaneous natural gas growth

BUSINESS AS USUAL

The baseline projection in this document assumes a business-as-usual scenario aside from documented "on-the-books" adjustments like the 2018 WSEC code changes. Crucially, it does *not* assume an electrification scenario such as has been proposed in recent, as yet unpassed, legislation.

Although it aligns closely, the baseline projection is not Cascade's official load forecast. Rather it was developed as an integral component of our modeling construct to serve as the metric against which energy 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 thousand therms. We also present a summary across all sectors.

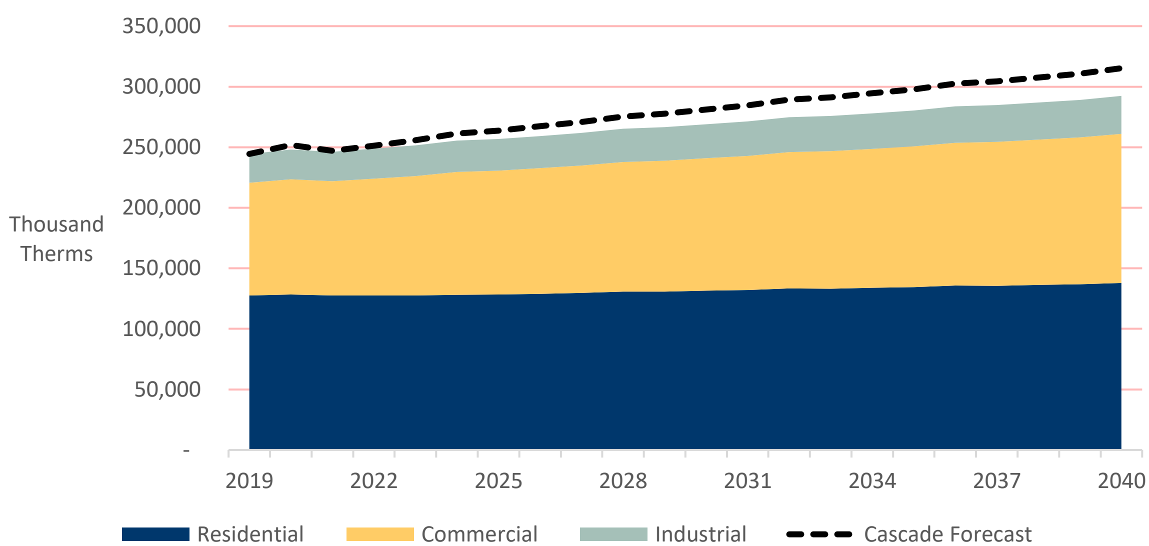
Summary of Overall Baseline Projection

Table 4-1 and Figure 4-1 provide a summary of the baseline projection for annual use by sector for the entire Cascade service territory. Base year (2019) values are weather normalized using HDD data provided by Cascade's load forecast department. 2020 consumption and weather data was updated to actuals provided by Cascade, and include possible effects from the COVID-19 pandemic[11]. Years 2021 forward assume normal weather. Overall, the forecast shows modest growth in natural gas consumption, at an average rate of about 0.9% per year.

Table 4-1 Baseline Projection Summary by Sector, Selected Years (thousand therms)

Sector	2021	2022	2023	2024	2025	2030	2040	% Change ('19-'40)	Avg. Growth
Residential	127,593	127,578	127,551	128,181	128,257	131,448	137,944	8.2%	0.4%
Commercial	94,385	96,529	98,691	101,324	102,343	109,448	123,129	32.2%	1.3%
Industrial	24,247	24,784	25,326	25,989	26,240	28,015	31,329	31.6%	1.3%
Total	**246,225**	**248,892**	**251,569**	**255,494**	**256,840**	**268,912**	**292,401**	**19.6%**	**0.9%**

Figure 4-1 Baseline Projection Summary by Sector (thousand therms)



[11] COVID-19 effects are expected to persist for a few years in the forecast. AEG calibrated these impacts on the baseline forecast to match expectations from Cascade's resource planning team

Residential Sector Baseline Projection

Table 4-3 and Figure 4-2 present the baseline projection for natural gas at the end-use level for the residential sector as a whole. Overall, residential use increases from 127,593 thousand therms in 2021 to 137,944 thousand therms in 2040, an increase of 8.1%. There are two high-level factors affecting growth. The first is a moderate increase in the number of households and customers. The second is a decrease in equipment consumption due to future standards and naturally occurring efficiency improvements (notably the AFUE's upcoming 92% furnace standard). We model gas-fired fireplaces as secondary heating because these units consume energy and may heat a space but are rarely relied on to be a primary heating technology. As such, they are estimated to be more aesthetic and less weather-dependent than gas furnaces. This end use grows faster than others since new homes are more likely to install a unit, increasing fireplace stock. Miscellaneous is a very small end use in natural gas studies and includes technologies with low penetration, such as gas barbeques.

Residential New Construction

A new consideration for Phase 2 of the CPA is the impact of WSEC 2018 code changes on the baseline and potential, which took effect starting in 2021. Through conversations with NEEA, Cascade, and through AEG's other work in the WA region, we developed a set of assumptions regarding how builders were likely to modify their choices in light of the cost implications and changes to credits that can be gleaned from natural gas installations. Feedback from builders suggested that many projects would move away from natural gas for heating, while a greater number would continue with natural gas for space heating. Other end uses, such as natural gas cooking appliances, are seen more as luxury applications and will likely continue to be installed as a desirable feature. The adjustments to new construction equipment saturation relative to existing homes are documented in Table 4-2.

Table 4-2 Residential New Construction Equipment Adjustments

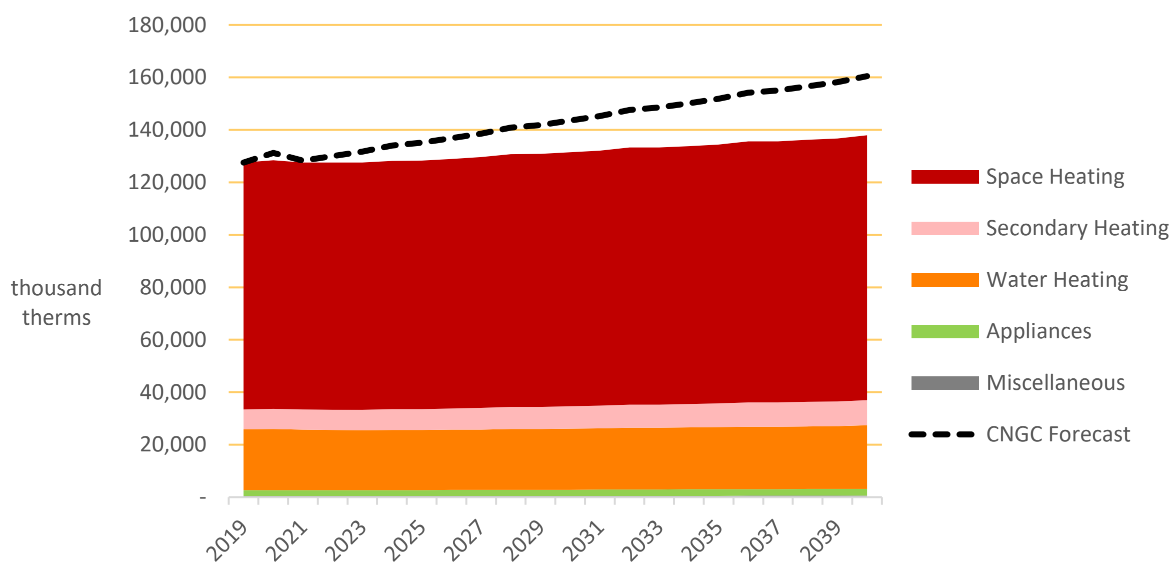
Technology Class	Adjustment relative to Average Existing Saturation
Furnace	Reduced by 50%, a greater share of new builds assumed to choose electric heat pumps for space heating needs
Boiler (for space heat)	Assumed none in new construction
Water Heating	Reduced by 80%, most builders assumed to choose electric heat pump water heaters

The impact of these adjustments produces a difference between the reference baseline for the CPA and Cascade's resource planning forecast (shown below).

Table 4-3 Residential Baseline Projection by End Use (thousand therms)

End Use	2021	2022	2023	2024	2025	2030	2040	% Change ('21-'40)	Avg. Growth
Space Heating	94,213	94,240	94,259	94,672	94,676	96,778	101,010	7.2%	0.4%
Secondary Heating	7,695	7,757	7,813	7,930	8,010	8,554	9,542	24.0%	1.1%
Water Heating	23,012	22,910	22,809	22,887	22,867	23,270	24,209	5.2%	0.3%
Appliances	2,233	2,227	2,223	2,238	2,245	2,354	2,633	17.9%	0.9%
Miscellaneous	440	444	447	454	459	492	550	25.1%	1.2%
Total	**127,593**	**127,578**	**127,551**	**128,181**	**128,257**	**131,448**	**137,944**	**8.1%**	**0.4%**

Figure 4-2 Residential Baseline Projection by End Use



Commercial Sector Baseline Projection

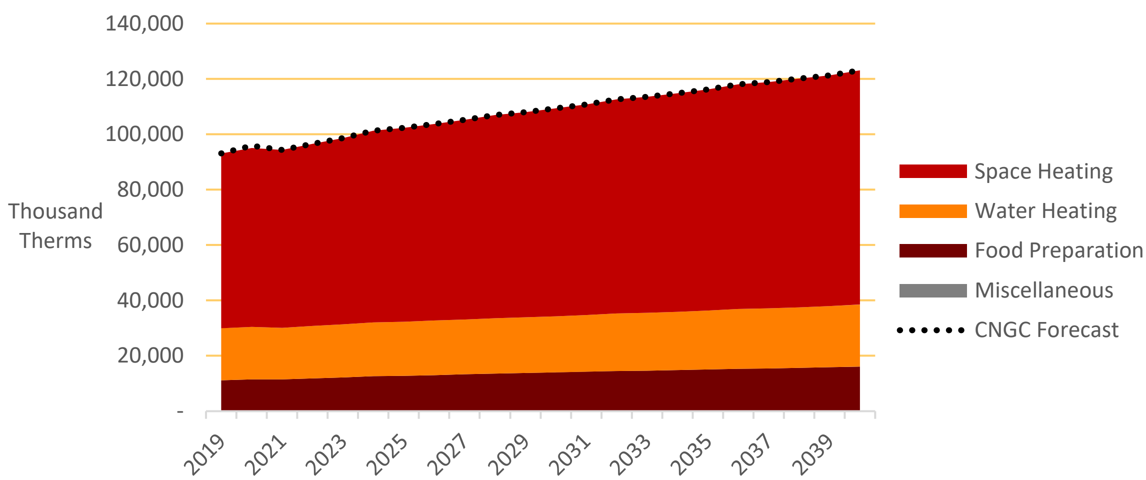
Annual natural gas use in the commercial sector grows 30.5% during the overall forecast horizon, starting at 94,385 thousand therms in 2021, and increasing to 123,129 thousand therms in 2040. Table 4-4 and Figure 4-3 present the baseline projection at the end-use level for the commercial sector, as a whole. Similar to the residential sector, market size is increasing and usage per square foot is decreasing slightly.

Table 4-4 Commercial Baseline Projection by End Use (thousand therms)

End Use	2021	2022	2023	2024	2025	2030	2040	% Change ('21-'40)	Avg. Growth Rate
Heating	64,224	65,772	67,333	69,215	69,991	75,142	84,620	31.8%	1.5%
Water Heating	18,638	18,894	19,151	19,500	19,543	20,295	22,416	20.3%	1.0%

Food Preparation	11,404	11,742	12,082	12,480	12,677	13,868	15,928	39.7%	1.8%
Miscellaneous	119	112	126	130	132	144	166	39.7%	1.8%
Total	**94,385**	**96,529**	**98,691**	**101,324**	**102,343**	**109,448**	**123,129**	**30.5%**	**1.4%**

Figure 4-3 Commercial Baseline Projection by End Use



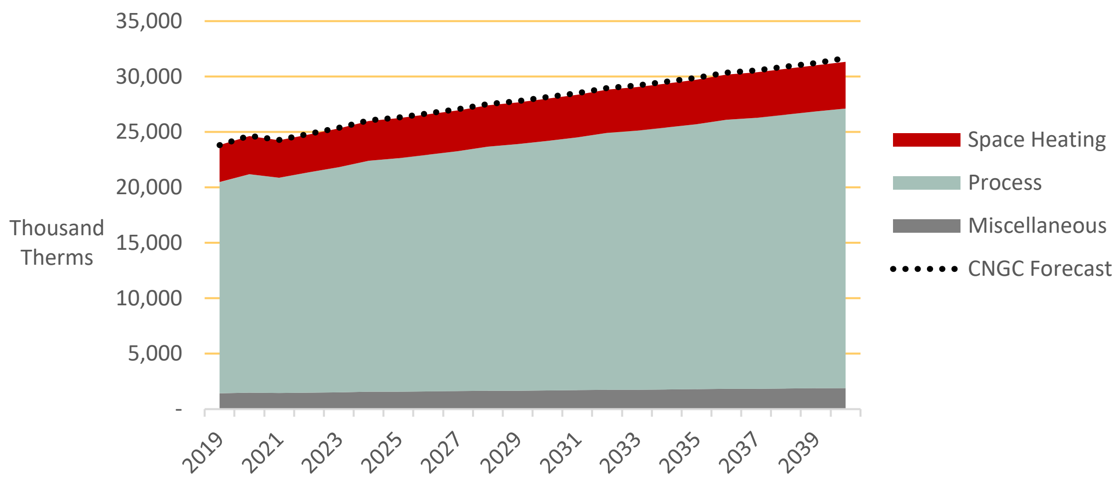
Industrial Sector Baseline Projection

Industrial sector usage increases throughout the planning horizon. Table 4-5 and Figure 4-4 present the projection at the end-use level. Overall, industrial annual natural gas use increases from 24,247 thousand therms in 2021 to 31,329 thousand therms in 2040. Growth in most end uses is consistent at around 1.3% per year but impacts of naturally occurring efficiency lowers consumption slightly in the space heating end use.

Table 4-5 Industrial Baseline Projection by End Use (thousand therms)

End Use	2021	2022	2023	2024	2025	2030	2040	% Change ('21-'40)	Avg. Growth
Space Heating	3,370	3,433	3,497	3,577	3,602	3,806	4,210	24.9%	1.2%
Process	19,418	19,859	20,304	20,846	21,055	22,517	25,223	29.9%	1.4%
Miscellaneous	1,459	1,493	1,526	1,567	1,582	1,692	1,896	29.9%	1.4%
Total	**24,247**	**24,784**	**25,326**	**25,989**	**26,240**	**28,015**	**31,329**	**29.2%**	**1.3%**

Figure 4-4 Industrial Baseline Projection by End Use



5

OVERALL ENERGY EFFICIENCY POTENTIAL

This chapter presents the measure-level energy conservation potential across all sectors: residential, commercial, and industrial. 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 and measure assumption summary, which was provided to Cascade at the conclusion of the study. Note that all savings are provided at the customer site.

Summary of Overall Energy Efficiency Potential

Table 5-1 and Figure 5-1 summarize the energy conservation savings in terms of annual energy use for all measures for four levels of potential relative to the baseline projection. Figure 5-2 displays the energy conservation forecasts. Savings are represented in cumulative terms, reflecting 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, efficient equipment makes up all lost opportunity installations, and all retrofit measures are installed, regardless of achievability. 2021 first-year savings are 5,496 thousand therms, or 2.2% of the baseline projection. Cumulative savings in 2030 are 53,337 thousand therms, or 19.8% of the baseline. By 2040, cumulative savings reach 90,258 thousand therms, or 30.9% of the baseline. Technical potential is useful as a theoretical construct, applying an upper bound to the potential that may be realized in any one year. Other levels of potential are based off this level which makes it an important component in the estimation of potential.
- Achievable Technical Potential refines technical potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and other factors that affect market penetration of conservation measures. For the 2021-2040 CPA, ramp rates from the 2021 Power Plan were customized for use in natural gas programs and applied in a manner similar to the 2017 CPA.[12] Since the 2021 Plan does not explicitly assign ramp rates for the majority of natural gas measures, we assigned these based on similar electric technologies present in the 2021 Plan as a starting point. These ramp rates are provided in Appendix F. 2021 first-year net savings are 1,678 thousand therms, or 0.7% of the baseline projection. Cumulative net savings in 2030 are 25,538 thousand therms, or 9.5% of the baseline. By 2040 cumulative savings reach 48,416 thousand therms, or 16.6% of the baseline.
- UCT Achievable Economic Potential further refines achievable technical potential by applying an economic cost-effectiveness screen. In this analysis, the cost-effectiveness is measured by the utility cost test (UCT), which compares lifetime energy benefits to the total utility costs of delivering the measure through a utility program, excluding monetized non-energy impacts. Avoided costs of energy were provided by Cascade. A 10% conservation credit was applied to these costs per Council methodologies. Additional details can be found in Appendix A. 2021 first-year savings are 765 thousand therms, or 0.3% of the baseline projection. Cumulative savings in 2030 are 15,610 thousand

[12] Note that the 2017 CPA use ramp rates from the Seventh Power Plan, but the methodology is the same

therms, or 5.8% of the baseline. By 2040 cumulative savings reach 33,053 thousand therms, or 11.3% of the baseline.

- TRC Achievable Economic Potential further refines achievable technical 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 benefits to the total customer and utility costs of delivering the measure through a utility program, including monetized non-energy impacts. AEG also applied benefits for non-gas energy savings, such as electric HVAC savings for weatherization and lighting savings for retro-commissioning. We also applied the Council's calibration credit to space heating savings to reflect the fact that additional fuels may be used as a supplemental heat source within an average home and may be accounted for within the TRC. Avoided costs of energy were provided by Cascade. A 10% conservation credit was applied to these costs per the Council methodologies. 2021 first-year savings are 434 thousand therms, or 0.2% of the baseline projection. Cumulative net savings in 2030 are 10,789 thousand therms, or 4.0% of the baseline. By 2040 cumulative savings reach 22,091 thousand therms, or 7.6% of the baseline. Potential under the TRC test is lower than UCT due to the inclusion of full measure costs rather than the utility portion. For most measures, these outweigh the quantified and monetized non-energy impacts included in the TRC.

Table 5-1 Summary of Energy Efficiency Potential (thousand therms)

Scenario	2021	2022	2023	2024	2025	2030	2040
Baseline Projection (thousand therms)	246,225	248,892	251,569	255,494	256,840	268,912	292,401
Cumulative Savings (thousand therms)							
TRC Achievable Economic Potential	434	915	1,534	2,325	3,311	10,789	22,091
UCT Achievable Economic Potential	765	1,630	2,694	3,550	4,954	15,610	33,053
Achievable Technical Potential	1,678	3,486	5,544	7,473	9,955	25,538	48,416
Technical Potential	5,496	10,399	15,612	19,781	25,104	53,337	90,258
Cumulative Savings (% of Baseline)							
TRC Achievable Economic Potential	0.2%	0.4%	0.6%	0.9%	1.3%	4.0%	7.6%
UCT Achievable Economic Potential	0.3%	0.7%	1.1%	1.4%	1.9%	5.8%	11.3%
Achievable Technical Potential	0.7%	1.4%	2.2%	2.9%	3.9%	9.5%	16.6%
Technical Potential	2.2%	4.2%	6.2%	7.7%	9.8%	19.8%	30.9%

Figure 5-1 Summary of Energy Efficiency Potential as % of Baseline Projection (thousand therms)

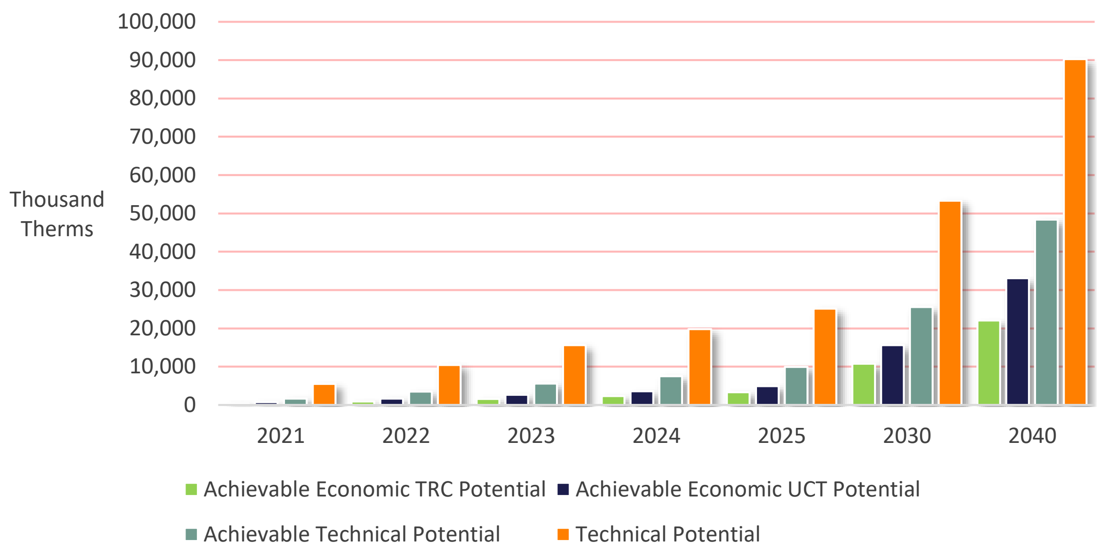
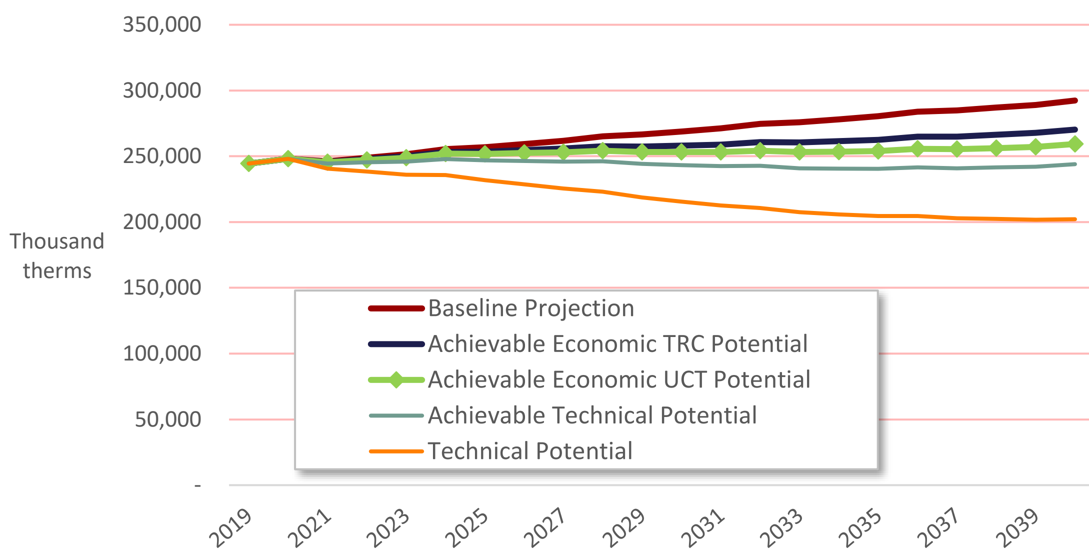


Figure 5-2 Baseline Projection and Energy Efficiency Forecasts (thousand therms)



Summary of Overall UCT Achievable Economic Potential

Figure 5-3 shows the cumulative UCT's achievable potential by sector for the full timeframe of the analysis as a percent of total savings. Table 5-2 summarizes UCT achievable potential by market sector for selected years.

While the precise distribution of savings among sectors shifts slightly over the course of the study, in general, residential and commercial potential are well balanced. Since industrial consumption is such a low percentage of the baseline once large customers have been excluded, potential for this sector makes up a lower percentage of the total. While residential and commercial potential ramps up, industrial potential is mainly retrofit in nature and is much flatter. This is because process equipment is highly custom, and most potential comes from controls modifications or process adjustments rather than high-efficiency equipment upgrades..

There is a notable downtick in residential savings around 2024. This is due to the impacts of the residential forced-air furnace standard, which raises the baseline from AFUE 80% to AFUE 92%, which is a substantial increase when the efficient option is an AFUE 95% of 98% unit.

Figure 5-3 Cumulative UCT Achievable Economic Potential by Sector (% of Total)

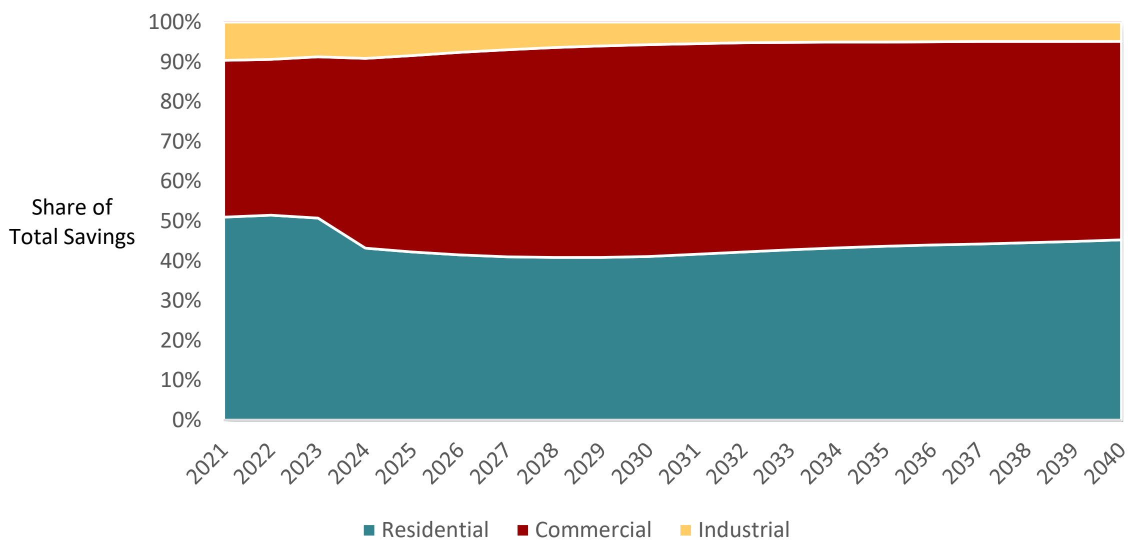


Table 5-2 Cumulative UCT Achievable Economic Potential by Sector, Selected Years (thousand therms)

Sector	2021	2022	2023	2024	2025	2030	2040
Residential	390	840	1,368	1,535	2,095	6,424	14,962
Commercial	301	639	1,091	1,693	2,445	8,304	16,500
Industrial	73	152	234	323	414	881	1,591
Total	**765**	**1,630**	**2,694**	**3,550**	**4,954**	**15,610**	**33,053**

6

SECTOR-LEVEL ENERGY EFFICIENCY POTENTIAL

The previous section provided a summary of potential for Cascade's Washington territory as a whole. This section provides details for each sector.

Residential Sector Potential

Table 6-1 and Figure 6-1 summarize the energy efficiency potential for the residential sector. In 2021, UCT achievable economic potential is 390 thousand therms, or 0.3% of the baseline projection. By 2030, cumulative savings are 6,424 thousand therms, or 4.9% of the baseline.

Potential by income level and housing type is available in the segment-level potential results in Appendix D of Volume 2

Table 6-1 Residential Energy Conservation Potential Summary (thousand therms)

Scenario	2021	2022	2023	2024	2025	2030	2040
Baseline Forecast (thousand therms)	127,593	127,578	127,551	128,181	128,257	131,448	137,944
Cumulative Savings (thousand therms)							
UCT Achievable Economic Potential	390	840	1,368	1,535	2,095	6,424	14,962
TRC Achievable Economic Potential	87	181	292	416	577	1,856	4,091
Achievable Technical Potential	550	1,171	1,890	2,277	3,086	9,274	21,445
Technical Potential	2,868	5,653	8,578	10,251	13,002	28,065	51,468
Energy Savings (% of Baseline)							
UCT Achievable Economic Potential	0.3%	0.7%	1.1%	1.2%	1.6%	4.9%	10.8%
TRC Achievable Economic Potential	0.1%	0.1%	0.2%	0.3%	0.4%	1.4%	3.0%
Achievable Technical Potential	0.4%	0.9%	1.5%	1.8%	2.4%	7.1%	15.5%
Technical Potential	2.2%	4.4%	6.7%	8.0%	10.1%	21.4%	37.3%

Figure 6-1 Residential Energy Conservation by Case (thousand therms)

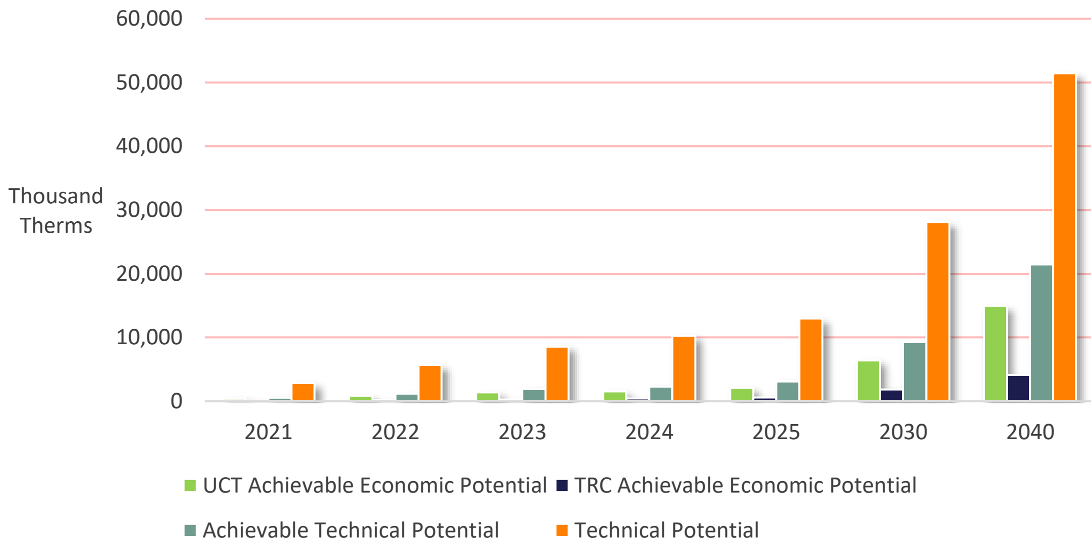
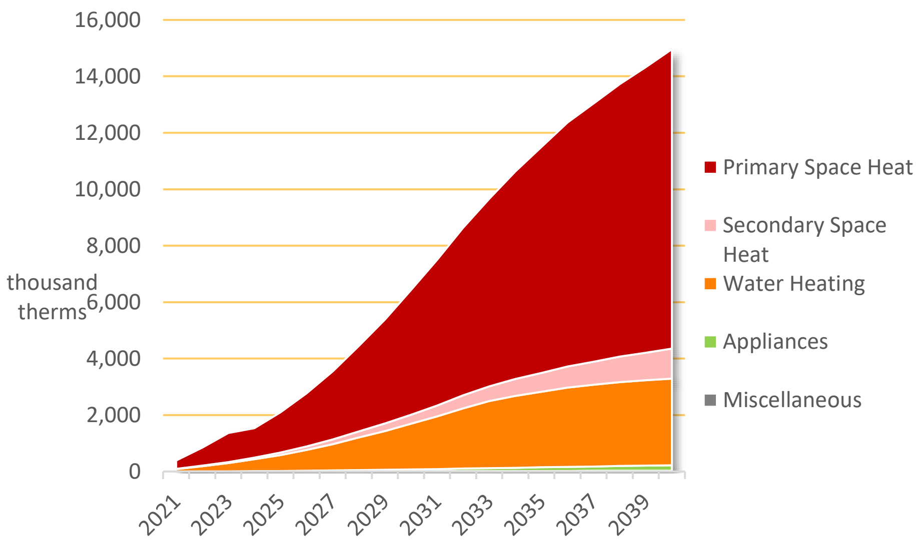


Figure 6-2 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Space heating makes up a majority of potential throughout the study.

Figure 6-2 Residential UCT Achievable Economic Potential – Cumulative Savings by End Use (therms, % of total)



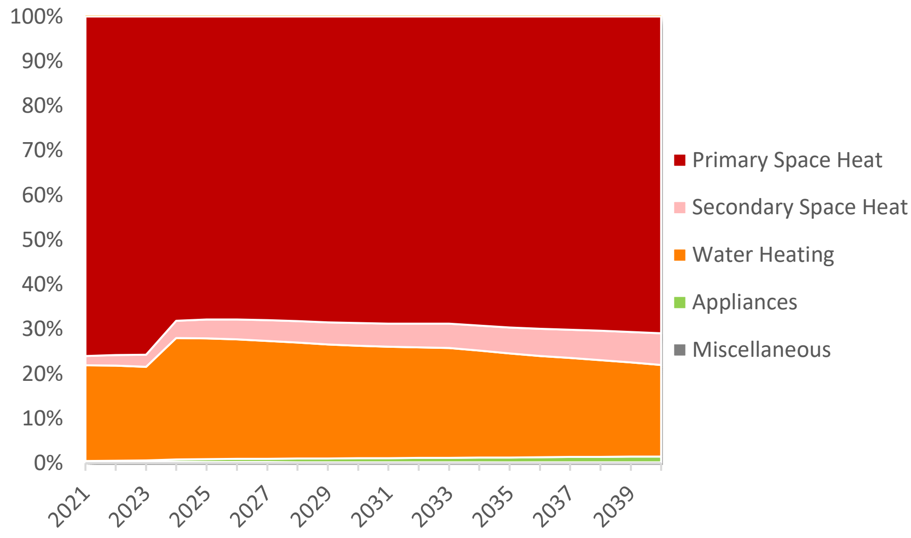


Table 6-2 identifies the top 20 residential measures by cumulative 2022 and 2023 savings. Furnaces, interactive/learning thermostats, tankless water heaters, and weatherization are the top measures. The majority of cost-effective furnace savings are coming from upgrades to AFUE 98% models, which were not cost effective in the prior CPA. These units do not pass in every segment, but where they do pass, they help support furnace savings to a comparable level to past program activity, despite the reduced number of available units in the market. ENERGY STAR clothes washers are a new entry on the top measures list. Though they have not passed cost-effectiveness in past CPAs, improved savings and lower costs compared to previous data are showing as a possible new avenue for savings for Cascade.

It should also be noted that many of the CPA measures are niche applications or may only make sense for certain customer building configurations. While these measures may not be readily characterized for a prescriptive measure, Cascade could consider incentivizing these measures with a more custom approach.

Table 6-2 Residential Top Measures in 2022 and 2023, UCT Achievable Economic Potential (thousand therms)

Rank	Measure / Technology	2022 Cumulative Potential Savings (thousand therms)	% of Total	2023 Cumulative Potential Savings (thousand therms)	% of Total
1	Furnace - Direct Fuel - AFUE 98%	323	23.6%	514	37.6%
2	ENERGY STAR Connected Thermostat - Interactive/learning thermostat (ie, NEST)	137	10.0%	219	16.0%
3	Water Heater <= 55 gal. - UEF 0.91 (Instantaneous Condensing)	115	8.4%	186	13.6%
4	Insulation - Ceiling, Installation - R-49 (Retro only)	87	6.3%	132	9.6%
5	ENERGY STAR Clothes Washers - ENERGY STAR unit	53	3.9%	79	5.8%
6	Fireplace - Tier 1 (70% FE Rating)	20	1.5%	37	2.7%
7	Insulation - Basement Sidewall - R-15	13	0.9%	27	2.0%
8	Ducting - Repair and Sealing - 50% reduction in duct leakage	12	0.9%	26	1.9%
9	Gas Boiler - Pipe Insulation - Pipe insulated throughout home	17	1.2%	25	1.8%
10	Thermostat - Programmable - Programmed thermostat	12	0.9%	19	1.4%
11	Water Heater - Pipe Insulation - Insulated 5' of pipe between unit and conditioned space	7	0.5%	15	1.1%
12	Insulation - Ducting - duct thermal losses reduced 50%	6	0.4%	12	0.9%
13	Windows - U-.22 or better - Double Pane LowE CL22	5	0.4%	11	0.8%
14	Gas Boiler - Hot Water Reset - Reset control installed	6	0.4%	10	0.7%
15	Windows - U-.30 - Double Pane LowE U30	4	0.3%	9	0.7%
16	Insulation - Infiltration Control (Air Sealing) - 20% reduction in ACH50	4	0.3%	8	0.6%
17	Combined Boiler + DHW System (Tankless) - Combined tankless boiler unit for space and DHW	4	0.3%	7	0.5%
18	Combined Boiler + DHW System (Storage Tank) - Combined tankless boiler unit for space and DHW	4	0.3%	7	0.5%
19	Doors - Storm and Thermal - R-5 door	3	0.2%	7	0.5%
20	Built Green homes - Built Green spec (NC Only)	3	0.2%	6	0.4%
Subtotal		**833**	**60.9%**	**1,355**	**99.0%**
Total Savings in Year		**840**	**61.4%**	**1,368**	**100%**

Table 6-3 and Table 6-4 present residential potential summarized by income level and by vintage, respectively. Note that due to the adjustments to the new construction forecast to comply WESC 2018 (described in Section 4 above), New Construction makes up a very small portion of the overall portfolio.

Table 6-3 Cumulative residential potential by income group, selected years (thousand therms)

Cumulative Savings (thousand therms)	2021	2022	2023	2024	2025	2030	2040
Achievable Economic UCT Potential							
Above Median Household Income	193	415	675	750	1,021	3,121	7,317
Moderate Income	177	382	622	703	958	2,920	6,783
Low Income	20	43	71	82	116	384	863
Achievable Economic TRC Potential							
Above Median Household Income	42	88	143	207	288	941	2,050
Moderate Income	41	85	136	193	266	836	1,858
Low Income	4	9	14	16	23	78	183
Achievable Technical Potential							
Above Median Household Income	266	566	913	1,089	1,472	4,416	10,274
Moderate Income	250	532	859	1,040	1,409	4,221	9,747
Low Income	34	72	117	148	205	638	1,424
Technical Potential							
Above Median Household Income	1,410	2,776	4,206	5,002	6,340	13,661	25,162
Moderate Income	1,287	2,541	3,862	4,630	5,875	12,702	23,304
Low Income	171	336	511	619	787	1,703	3,002

Table 6-4 Cumulative Residential potential by Vintage, selected years (thousand therms)

Cumulative Savings (thousand therms)	2021	2022	2023	2024	2025	2030	2040
Achievable Economic UCT Potential							
Existing/Retrofit	358	776	1,268	1,463	1,993	6,083	13,950
New Construction	33	64	100	72	102	342	1,012
Achievable Economic TRC Potential							
Existing/Retrofit	84	177	285	414	573	1,834	4,027
New Construction	2	5	7	2	4	22	64
Achievable Technical Potential							
Existing/Retrofit	516	1,103	1,782	2,192	2,963	8,825	20,106
New Construction	34	67	108	84	122	450	1,339
Technical Potential							
Existing/Retrofit	2,512	5,031	7,690	9,323	11,853	25,716	46,678
New Construction	356	622	888	929	1,149	2,349	4,790

Commercial Sector Potential

Table 6-5 and Figure 6-3 summarize the energy conservation potential for the commercial sector. In 2021, UCT achievable economic potential is 301 thousand therms, or 0.3% of the baseline projection. By 2030, cumulative savings are 8,304 thousand therms, or 7.6% of the baseline.

Table 6-5 Commercial Energy Conservation Potential Summary

Scenario	2021	2022	2023	2024	2025	2030	2040
Baseline Forecast (thousand therms)	94,385	96,529	98,691	101,324	102,343	109,448	123,129
Cumulative Savings (thousand therms)							
UCT Achievable Economic Potential	301	639	1,091	1,693	2,445	8,304	16,500
TRC Achievable Economic Potential	276	579	989	1,542	2,242	7,776	16,118
Achievable Technical Potential	1,032	2,109	3,323	4,722	6,239	14,845	24,733
Technical Potential	2,509	4,479	6,602	8,914	11,293	23,506	36,090
Energy Savings (% of Baseline)							
UCT Achievable Economic Potential	0.3%	0.7%	1.1%	1.7%	2.4%	7.6%	13.4%
TRC Achievable Economic Potential	0.3%	0.6%	1.0%	1.5%	2.2%	7.1%	13.1%
Achievable Technical Potential	1.1%	2.2%	3.4%	4.7%	6.1%	13.6%	20.1%
Technical Potential	2.7%	4.6%	6.7%	8.8%	11.0%	21.5%	29.3%

Figure 6-3 Commercial Energy Conservation by Case

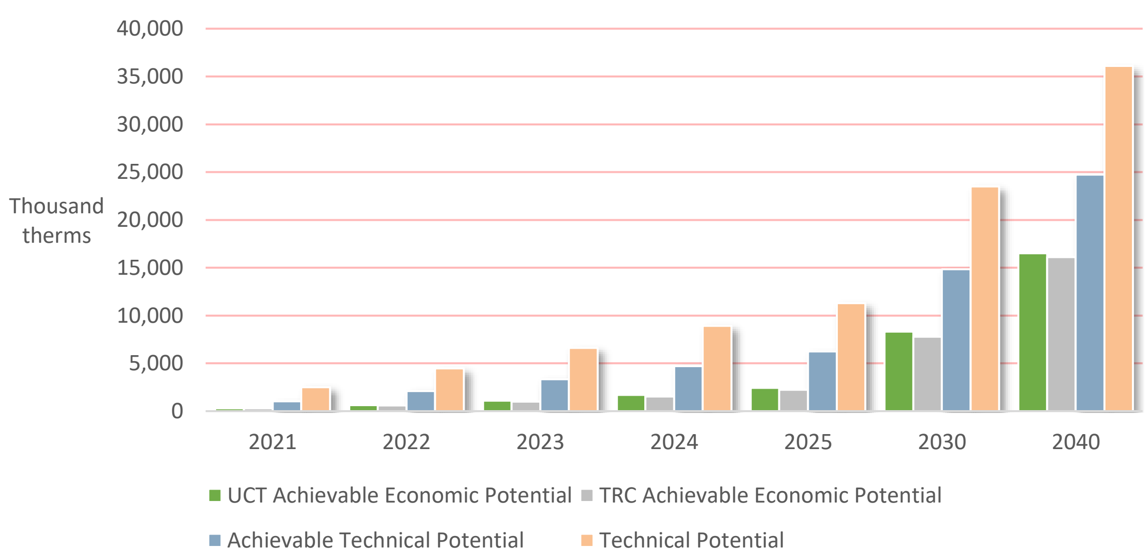
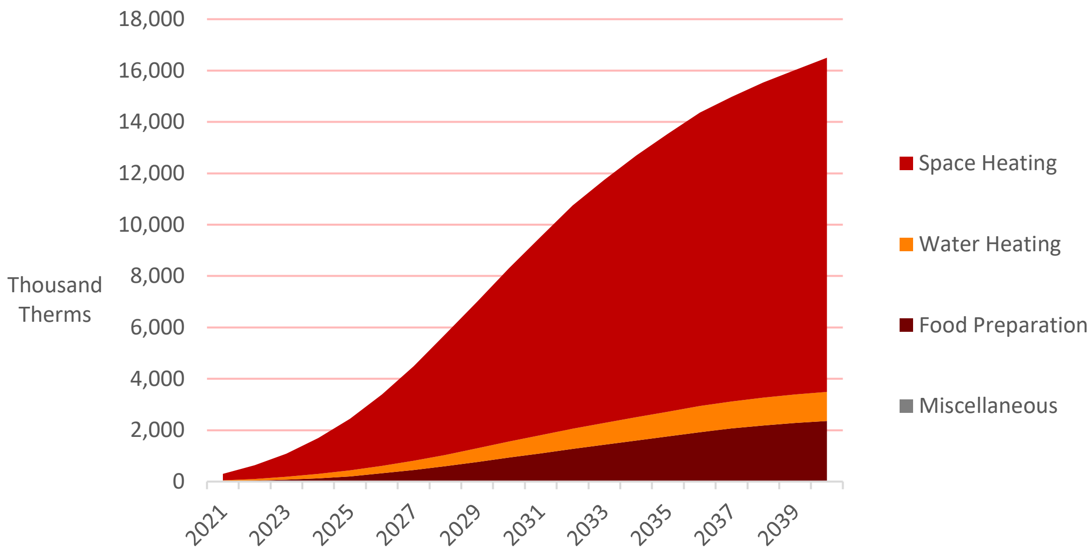


Figure 6-4 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Space heating makes up a majority of the potential early, but food preparation equipment upgrades provide substantial savings opportunities in the later years.

Figure 6-4 Commercial UCT Achievable Economic Potential – Cumulative Savings by End Use (thousand therms, % of total)



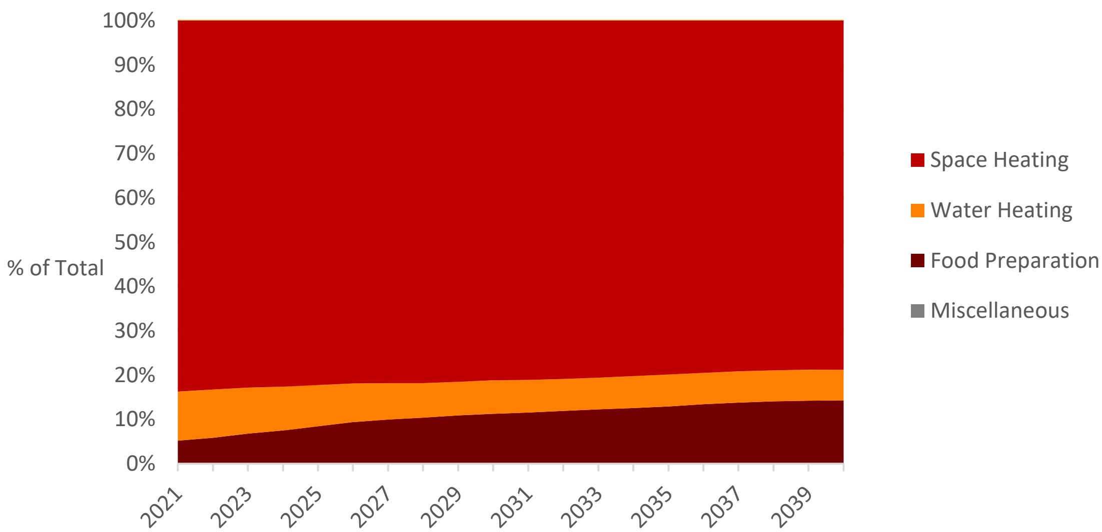


Table 6-6 identifies the top 20 commercial measures by cumulative savings in 2022 and 2023. Boilers are the top measure, followed by weatherization and food preparation equipment replacements. A new entry to the top measures list is Ozone Laundry, which received a recharacterization based on information provided by Cascade's C&I implementer, TRC, who has had substantial success with this measure.

Table 6-6 Commercial Top Measures in 2022 and 2023, UCT Achievable Economic Potential (thousand therms)

Rank	Measure / Technology	2022 Cumulative Potential Savings (thousand therms)	% of Total	2023 Cumulative Potential Savings (thousand therms)	% of Total
1	Boiler - AFUE 97%	126.2	12.4%	198.6	19.4%
2	Insulation - Roof/Ceiling - R-49	57.8	5.7%	127.9	12.5%
3	Gas Boiler - Insulate Hot Water Lines - Insulated water lines	43.7	4.3%	65.6	6.4%
4	Insulation - Wall Cavity - R-21	28.6	2.8%	63.3	6.2%
5	Fryer - ENERGY STAR	23.2	2.3%	43.8	4.3%
6	Water Heater - TE 96%	25.0	2.4%	42.5	4.2%
7	Water Heater - Ozone Laundry - Ozone laundry system	27.6	2.7%	41.8	4.1%
8	Gas Boiler - Hot Water Reset - Reset control installed	24.6	2.4%	41.1	4.0%
9	Gas Boiler - High Turndown - Turndown control installed	25.7	2.5%	38.5	3.8%
10	Furnace - AFUE 96%	20.2	2.0%	37.4	3.7%
11	Kitchen Hood - DCV/MUA - DCV/HUA vent hood	21.3	2.1%	32.4	3.2%
12	ENERGY STAR Connected Thermostat - Wi-Fi/interactive thermostat installed	20.8	2.0%	31.7	3.1%
13	Space Heating - Heat Recovery Ventilator - HRV installed	19.2	1.9%	31.5	3.1%
14	Gas Boiler - Insulate Steam Lines/Condensate Tank - Lines and condensate tank insulated	19.1	1.9%	28.6	2.8%
15	Unit Heater - Infrared Radiant	13.8	1.3%	26.9	2.6%
16	HVAC - Demand Controlled Ventilation - DCV enabled	9.2	0.9%	20.2	2.0%
17	Gas Boiler - Maintenance - General cleaning and maintenance	14.2	1.4%	18.4	1.8%
18	Steam Trap Maintenance - Cleaning and maintenance	11.7	1.1%	17.7	1.7%
19	Water Heater - Pre-Rinse Spray Valve - 2 GPM sprayer nozzle	11.0	1.1%	16.7	1.6%
20	Gas Furnace - Maintenance - General cleaning and maintenance	12.6	1.2%	16.4	1.6%
Subtotal		**555.3**	**92.9%**	**940.9**	**92.1%**
Total Savings in Year		**597.8**	**100%**	**1,021.5**	**100%**

Industrial Sector Potential

Table 6-7 and

Figure 6-5 summarize the energy conservation potential for the core industrial sector. In 2021, UCT's achievable economic potential is 73 thousand therms, or 0.3% of the baseline projection. By

2030, cumulative savings reach 881thousand therms, or 3.1% of the baseline. Industrial potential is a lower percentage of overall baseline compared to the residential and commercial sectors. While large, custom process optimization and controls measures are present in potential, these are not applicable to all applications which limits potential at the technical level. Additionally, since the largest customers were excluded from this analysis due to their status as transport-only customers, making them ineligible to participate in energy efficiency programs for the utility, the remaining customers are smaller and tend to have lower process end-use shares, further lowering industrial potential. As seen in the figure below, industrial potential is substantially lower due to the smaller sector size and process uses.

Table 6-7 Industrial Energy Conservation Potential Summary (thousand therms)

Scenario	2021	2022	2023	2024	2025	2030	2040
Baseline Forecast (thousand therms)	24,247	24,784	25,326	25,989	26,240	28,015	31,329
Cumulative Savings (thousand therms)							
UCT Achievable Economic Potential	73	152	234	323	414	881	1,591
TRC Achievable Economic Potential	71	155	253	367	492	1,157	1,882
Achievable Technical Potential	96	206	331	474	629	1,419	2,238
Technical Potential	119	267	431	616	809	1,766	2,701
Energy Savings (% of Baseline)							
UCT Achievable Economic Potential	0.3%	0.6%	0.9%	1.2%	1.6%	3.1%	5.1%
TRC Achievable Economic Potential	0.3%	0.6%	1.0%	1.4%	1.9%	4.1%	6.0%
Achievable Technical Potential	0.4%	0.8%	1.3%	1.8%	2.4%	5.1%	7.1%
Technical Potential	0.5%	1.1%	1.7%	2.4%	3.1%	6.3%	8.6%

Figure 6-5 Industrial Energy Conservation Potential (thousand therms)

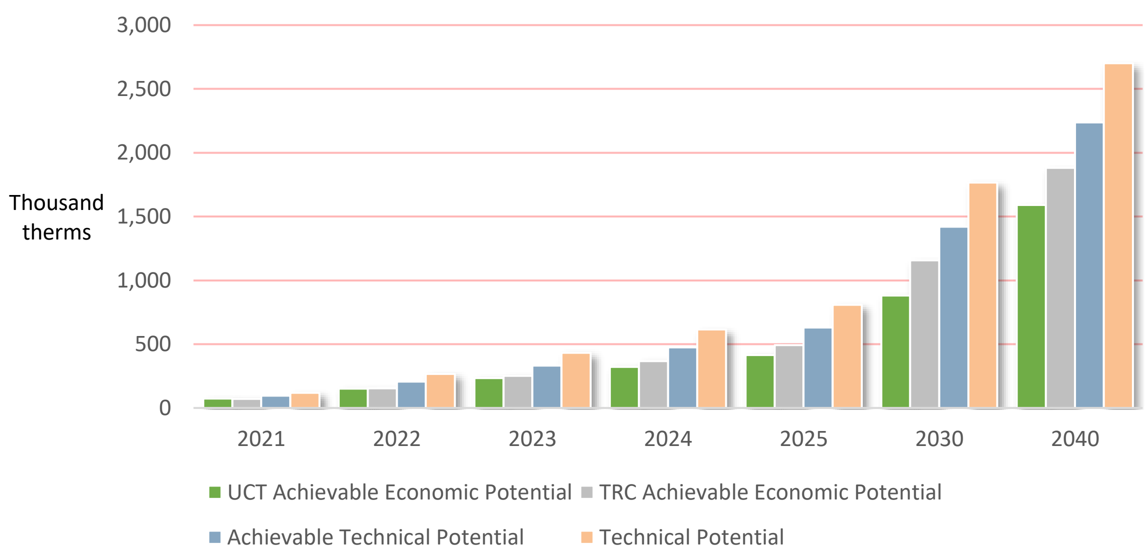
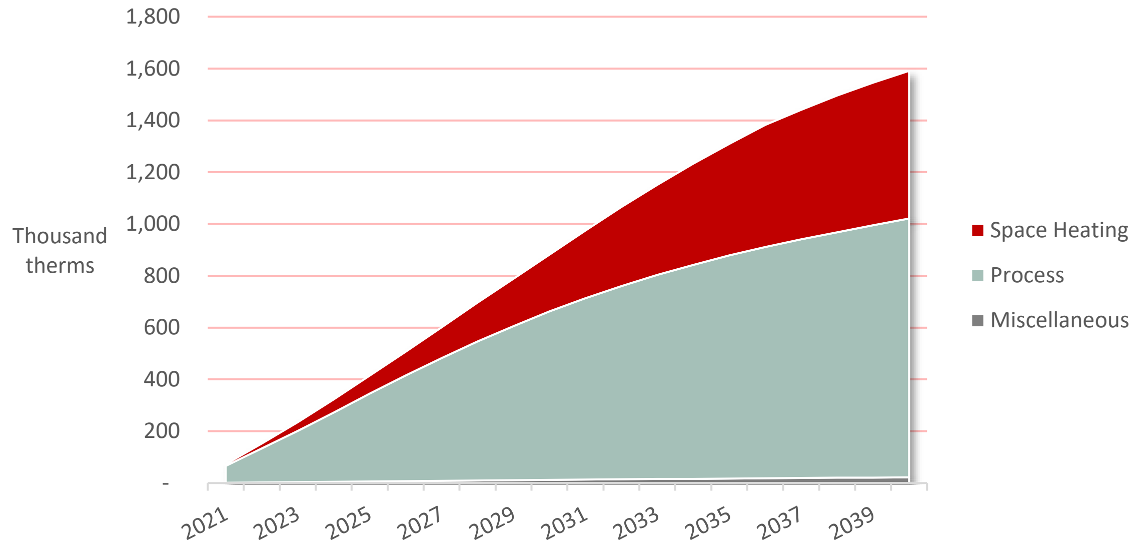


Figure 6-6 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings.

Figure 6-6 Industrial UCT Achievable Economic Potential – Cumulative Savings by End Use (thousand therms, % of total)



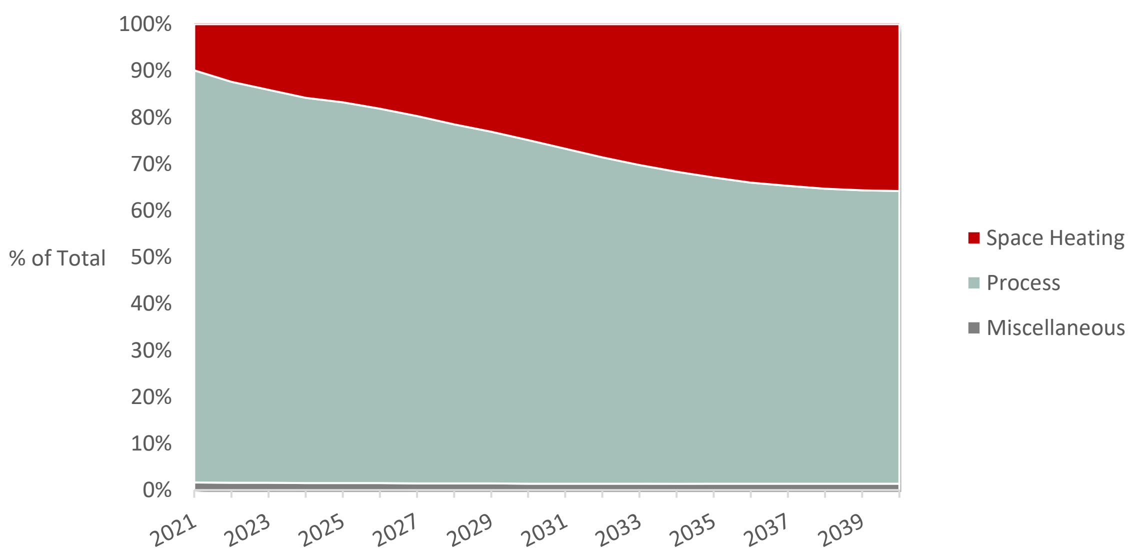


Table 6-8 identifies the top 20 industrial measures by cumulative 2022 and 2023 savings. Strategic energy management of industrial process applications is the highest measure by total savings. For smaller industrial customers, this measure typically involves a cohort of between five to ten customers who form a working group facilitated by an energy management expert. One or more employees at each facility are designated an energy conservation "champion" who work to integrate efficient energy-consuming behavior into the company's culture. Many of these measures are more custom in nature, such as strategic energy management and heat recovery systems. This results in behavior-based and low-cost/no-cost measures but also results in larger custom projects. We estimate that this potential will be captured within these measures/delivery mechanisms.

Table 6-8 Industrial Top Measures in 2022 and 2023, UCT Achievable Potential (thousand therms)

Rank	Measure / Technology	2022 Cumulative Potential Savings (thousand therms)	% of Total	2023 Cumulative Potential Savings (thousand therms)	% of Total
1	Strategic Energy Management - Energy management system installed and programmed	40.2	17.2%	60.9	26.0%
2	Process - Insulate Heated Process Fluids - Insulated process fluid lines	20.9	8.9%	31.6	13.5%
3	Gas Boiler - Insulate Hot Water Lines - Insulated water lines	19.4	8.3%	29.1	12.4%
4	Gas Boiler - Stack Economizer - Economizer installed	18.6	7.9%	28.1	12.0%
5	Process Heat Recovery - HR system installed	9.8	4.2%	14.5	6.2%
6	Gas Boiler - Insulate Steam Lines/Condensate Tank - Lines and condensate tank insulated	8.9	3.8%	13.4	5.7%
7	Gas Boiler - Hot Water Reset - Reset control installed	7.4	3.2%	12.6	5.4%
8	Gas Boiler - High Turndown - Turndown control installed	7.3	3.1%	11.1	4.7%
9	Gas Boiler - Maintenance - General cleaning and maintenance	6.0	2.5%	7.7	3.3%
10	Unit Heater - Infrared Radiant	2.2	0.9%	5.5	2.4%
11	Boiler - AFUE 97%	2.8	1.2%	5.5	2.3%
12	HVAC - Demand Controlled Ventilation - DCV enabled	2.9	1.2%	4.3	1.8%
13	Steam Trap Maintenance - Cleaning and maintenance	2.4	1.0%	3.5	1.5%
14	Building Automation System - Automation system installed and programmed	1.3	0.6%	2.9	1.3%
15	Gas Boiler - Burner Control Optimization - Optimized burner controls	0.7	0.3%	1.7	0.7%
16	Retrocommissioning - Optimized HVAC flow and controls	0.8	0.3%	1.2	0.5%
17	Furnace - AFUE 96%	0.3	0.1%	0.6	0.2%
18	Steam System Efficiency Improvements - Optimized system	0.1	<0.1%	0.2	0.1%
Subtotal		**151.9**	**100%**	**234.4**	**100%**
Total Savings in Year		**151.9**	**100%**	**234.4**	**100%**

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