AEG

2024-2043 Natural Gas Conservation Potential Assessment

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EXECUTIVE SUMMARY

In late 2022, Cascade Natural Gas Corporation (Cascade) contracted with Applied Energy Group (AEG) to conduct this update to Cascade's 2021 Conservation Potential Assessment (CPA) in support of its conservation and resource planning activities. This report documents this effort and provides estimates of the potential reductions in annual energy usage for natural gas customers in Cascade's Washington service territory from energy conservation efforts from 2024 to 2043.

This study was designed to accomplish the following goals:

- Update the baseline projection to align with actual consumption through 2022;
- Consider the impacts of new Washington state legislation and city ordinances on natural gas use and presence of equipment; and
- Thoroughly review measure characterization for a set of high priority measures.

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, which is described in more detail in Sections 1 and Section 4.

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. As part of this study, AEG 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 2021 Power Plan (2021 Plan). This study also includes potential assessed under the utility cost test (UCT) which is useful for Cascade's planning and consistent with prior CPAs

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

Scenario	2024	2025	2028	2033	2038	2043
Baseline Projection (thousand therms)	229,381	225,522	213,715	195,878	181,440	169,938
Cumulative Savings (thousand therms)						
Achievable Economic UCT Potential	815	1,782	5,544	13,241	19,672	23,777
Achievable Economic TRC Potential	669	1,475	4,648	10,899	15,660	18,490
Achievable Technical Potential	1,685	3,540	9,674	20,333	28,372	32,828
Technical Potential	4,621	9,288	23,102	42,998	55,754	62,474
Cumulative Savings (% of Baseline)						
Achievable Economic UCT Potential	0.4%	0.8%	2.6%	6.8%	10.8%	14.0%
Achievable Economic TRC Potential	0.3%	0.7%	2.2%	5.6%	8.6%	10.9%
Achievable Technical Potential	0.7%	1.6%	4.5%	10.4%	15.6%	19.3%
Technical Potential	2.0%	4.1%	10.8%	22.0%	30.7%	36.8%

Key Takeaways

- The new building code is set to dramatically reduce or eliminate the opportunities to incentivize natural gas equipment in new construction (see Section 4).

    - However, while available savings are small, there are cost effective opportunities for AFUE 95% furnace backup units installed with electric heat pumps

- There remain substantial savings in residential and commercial furnaces, infrared radiant heaters (unit heaters) and high efficiency gas water heaters where there is opportunity to replace failing existing natural gas equipment.
- Weatherization retrofits continue to see opportunities, and savings per installation will continue to increase as code requires pushing for higher R-values when projects are undertaken. However, this increased requirement comes with increased costs.

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1 | INTRODUCTION

AEG has previously worked with Cascade Natural Gas (Cascade) to perform their two previous Conservation Potential Assessments (CPAs), the most recent of which covered a forecast range from 2021-2040 and helped to inform the planning for the 2022-2023 biennium planning period. This new iteration of the CPA refreshes key aspects of the 2021 CPA to assist Cascade in planning for the 2024-2025 biennium and to aid in developing the next iteration of the integrated resource plan (IRP).

AEG and Cascade have collaborated through the previous CPAs 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. This study retains that robust characterization but updates a number of assumptions that have changed since the prior studies' completion.

Adapting methodologies consistent with the Northwest Power and Conservation Council's (Council's) 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 2023 and 2042.

Conservation Potential Assessment Objectives

As have the previous rounds of the CPA, this study was developed to meet several primary objectives:

- Develop independent and credible estimates of energy efficiency potential available within Cascade's service territory using accepted regional inputs and methodologies.
- Deliver a fully configured end-use model for Cascade to use in future energy efficiency planning initiatives.
- Support the design of programs to be implemented by Cascade during the upcoming years.
- Provide energy efficiency inputs into Cascade's Integrated Resource Planning (IRP) process

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)

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

Study Considerations

Below, AEG notes a number of items that have come up in this or prior studies 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:** Consistent with previous assessments, 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 average cost and impacts of energy efficiency measures for a given group of customers to estimate the total opportunity for a given measure and its average cost-effectiveness, but make a binary choice whether to include a measure in the economic potential. 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.
- **Impacts of Codes and Legislation:** The past few years have seen several pieces of legislation affecting natural gas use at both the state and municipal level. AEG worked with Cascade to estimate the impacts of state codes and municipal restrictions on natural gas additions on consumption and potential savings. In addition, 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 for new construction code credits based on Washington State Energy Code 2021 (WSEC 2021) which takes effect in July of this year.
- **Assessing Energy Efficiency Potential by Residential Customer Income Level**. This study retains the stratification of Residential energy use and savings potential by household income groups from the analysis performed in the prior CPA. Differentiating presence of equipment and average use by income group allows deeper understanding of how these customers may interact with energy efficiency programs and how cost effectiveness and impacts vary across the groups.

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:

This Volume, Final Report:

- **Analysis Approach and Data Development.** A description of AEG's approach to conducting Cascade's 2024-2043 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 checked against Cascade's official, weather-normalized econometric forecast, but also explicitly includes the impacts of future federal standards, the 2021 Washington State Energy Code, 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 2024 and 2043.
- **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.
- **Appendix A - 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.

Separate Appendices:

The following are provided as Excel workbooks accompanying this report:

- **Appendix B - Market Profiles.** Detailed market profiles for each market segment. Including equipment saturation, unit energy consumption or energy usage index, energy intensity, and total consumption.
- **Appendix C - Detailed Measure List and Results.** This dataset provides input assumptions, measure characteristics, cost-effectiveness results, and potential estimates for each measure permutation analyzed within the study. This database supports cross tabulation of results by any dimension such as customer segment, residential income group, specific end use, or other desired aggregation.
- **Appendix D - 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.

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
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 summarized in this document for brevity, but more in-depth descriptions can be found in AEG's previous CPA reports for Cascade.

1. Retained the robust market characterization developed for the 2021 CPA with an anchor year of 2019
2. Calibrated the baseline projection of energy consumption by sector, segment, end use, and technology to 2022 actual customers and consumption, then continued the projection through 2043.
3. Reviewed 30 high priority residential and commercial measures from the 2021 CPA characterization, updating to the best available data.
4. Estimated technical, achievable technical, and achievable economic energy savings at the measure level for 2024-2043. Achievable economic potential was assessed using the TRC test, however potential under the UCT screen was also evaluated for Cascade's planning benefit.

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. The Council's methodology was developed for, and used in, electric DSM resource planning, and makes ramp rate and achievability assumptions that implicitly include market transformation impacts such as those from NEEA and energy codes. AEG utilized and adapted ramp rates and achievability from the 2021 Power Plan as appropriate for natural gas programs and Cascade. We discuss this further in Appendix A of this report.

Among other aspects, this approach involves using consistent:

- **Data sources**: regional surveys, market research, and assumptions
- **Measures and assumptions**: 2021 Plan supply curves and RTF work products
- **Potential factors**: 2021 Plan ramp rates
- **Levels of potential**: Technical, Achievable Technical, and Achievable Economic
- **Cost-effectiveness approaches**: assessed potential under the TRC test, including non-energy impacts which may be quantified and monetized and O&M impacts within the TRC
    - Supplemental Cost Test: AEG also assessed potential under the UCT test which serves as a useful tool for Cascade in their planning
- **Conservation credits:** applied a 10% conservation credit to avoided energy costs for energy benefits

LoadMAP Model

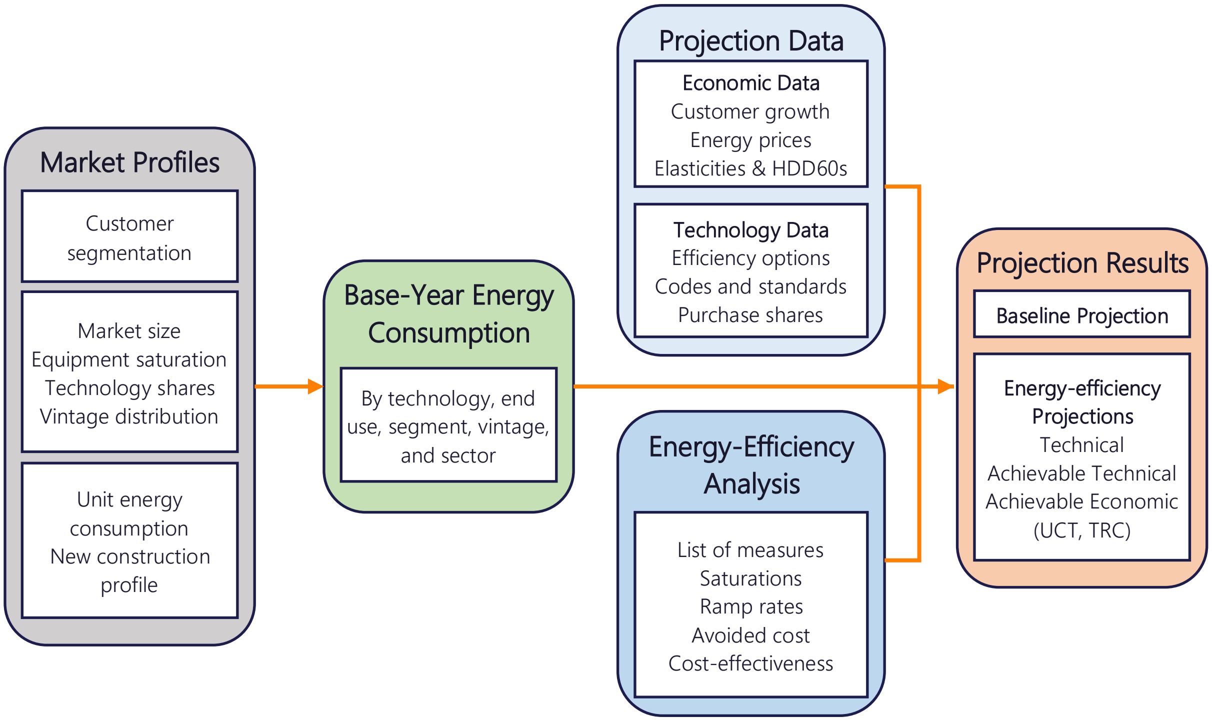
For this analysis, AEG used its Load Management Analysis and Planning tool (LoadMAP™) version 5.0 to develop both the baseline projection and the estimates of potential. AEG developed LoadMAP in 2007 and has enhanced it over time, using it for the Electric Power Research Institute (EPRI) National Potential 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 2021 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. [2]

[2] 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).

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 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 achievable economic potential in that it refines achievable technical potential through cost-effectiveness analysis. However, it uses 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. While prior CPAs for Cascade have focused on the UCT as Cascade's preferred planning cost-effectiveness test, Cascade is now required to use the TRC as the primary cost effectiveness test for estimating potential in the CPA.

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 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.

The following section describes work performed during the 2021 CPA, which was retained for the purposes of this study.

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 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 B provided separately from this document.

Baseline Projection

The next step was to refine the baseline projection of annual natural gas use for 2020 through 2043 from the prior CPA to align with Cascade's 2022 actual totals. The 2021 CPA reference case forecast was updated with the latest iteration of Cascade's IRP customer growth projections and weather data, and market based (naturally occurring) efficient purchase shares were reviewed in light of changes to the efficiency options provided for equipment replacement.

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 |

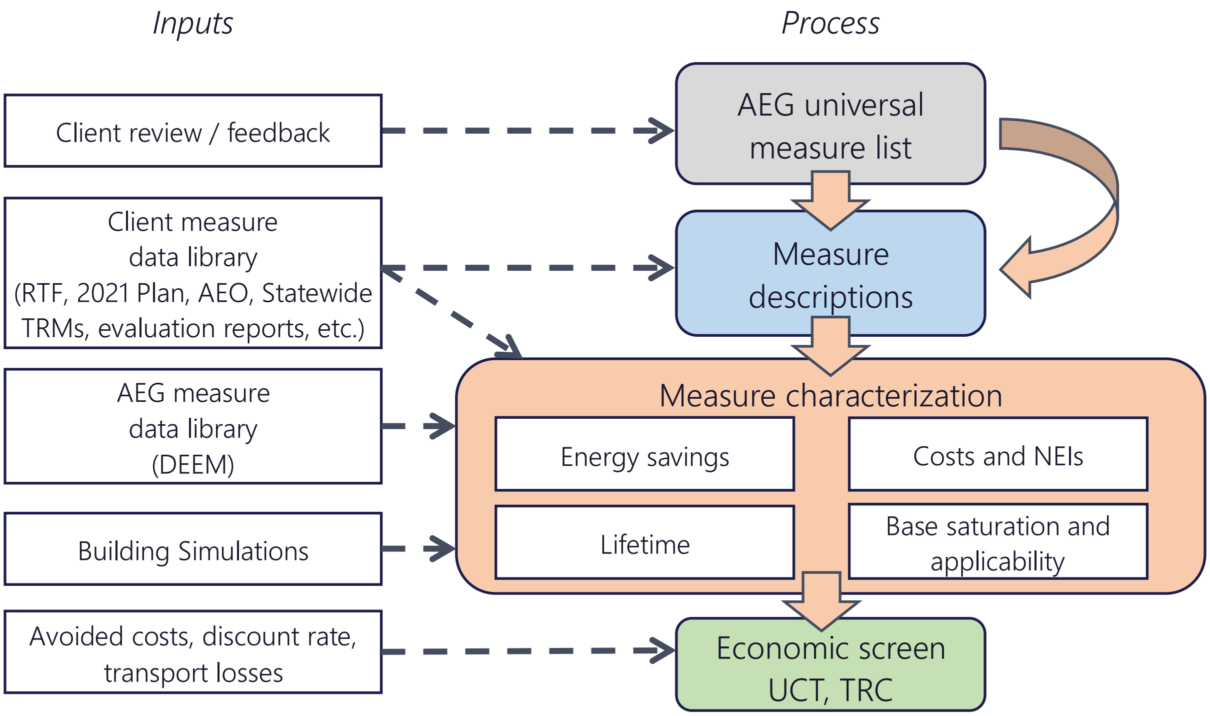
Energy Efficiency Measure Development

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.

For this study, work from the 2021 CPA Phase 2 measure development was retained except for the 30 measures identified by Cascade and AEG as high priority for review and update, shown in Table 2-2 below:

Table 2-2 Priority Measures for Review

Sector	Measure
Residential	Gas Furnaces
	Ceiling Insulation
	Tankless Water Heaters
	Floor Insulation
	Windows
	Gas-driven Heat Pumps for Space Heat
	Gas Furnace as Backup to Electric Heat Pump (Dual Fuel)
	Gas Fireplaces
	Gas Heat Pump Water Heaters
	Prescriptive Air Sealing
	Smart Thermostats
	Clothes Washers - ENERGY STAR
	Duct Repair and Sealing
	Built Green Homes
Commercial	Boilers
	Storage Tank Water Heaters
	Roof/Attic Insulation
	Wall Insulation
	Tankless Water Heaters
	Warm-Air Furnace
	Gas-Driven Heat Pumps and Dual-Fuel
	S.E.M
	Unit Heater (aka Radiant Heating)
	Convection Ovens
	Demand-Controlled Ventilation
	Make-up Air Unit Kitchen Hoods
	Windows
	Boiler Radiator Replacement
	Fryers

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.[3] 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). 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 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 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

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

benefits 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 5 |and 0 Measure-level detail is available in Excel format, presented as Appendix C 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 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 2-3. 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 2-3 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 2-4 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 2-4 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[4] 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 2-5 and Table 2-6. 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 2021 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

Table 2-5 Residential Natural Gas Equipment Federal Standards[5]

End Use	Technology	2019	2020	2021	2022	2023	2024	2025
Space Heating	Furnace – Direct Fuel	AFUE 80%						
	Boiler – Direct Fuel	AFUE 80%		AFUE 82%				
Secondary Heating	Fireplace	50-60% FE Rating						
Water Heating	Water Heater <= 55 gal.	UEF 0.58						
	Water Heater > 55 gal.	UEF 0.76						
Appliances	Clothes Dryer	CEF 3.30						
	Stove/Oven	EF 0.399						
Miscellaneous	Pool Heater	TE 0.82						
	Miscellaneous	N/A						

Table 2-6 Commercial and Industrial Natural Gas Equipment Standards

End Use	Technology	2019	2020	2021	2022	2023	2024	2025

[4] 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.

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

Space Heating	Furnace	AFUE 80% / TE 0.80	AFUE 81% / TE 0.81
	Boiler	~TE 0.80 (varies by size)	~TE 0.84 (varies by size)
	Unit Heater	Standard (intermittent ignition and power venting or automatic flue damper)	
Water Heater	Water Heating	TE 0.80	

Energy Conservation Measure Data Application

Table 2-7 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 2-7 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 2021 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 5.06%. 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 2021 Power Plan.

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

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[6] 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)

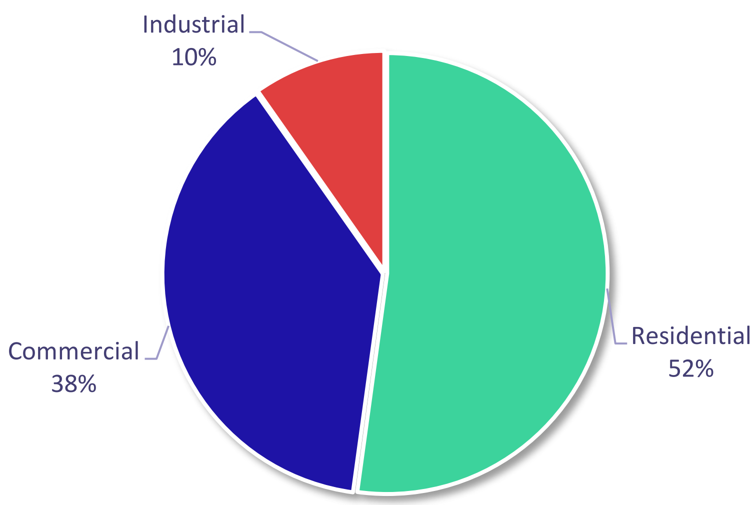


Table 3-1 Cascade Sector Control Totals, 2019

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

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

[6] See "Addressing Transport Customers" below

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[7] 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**

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

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

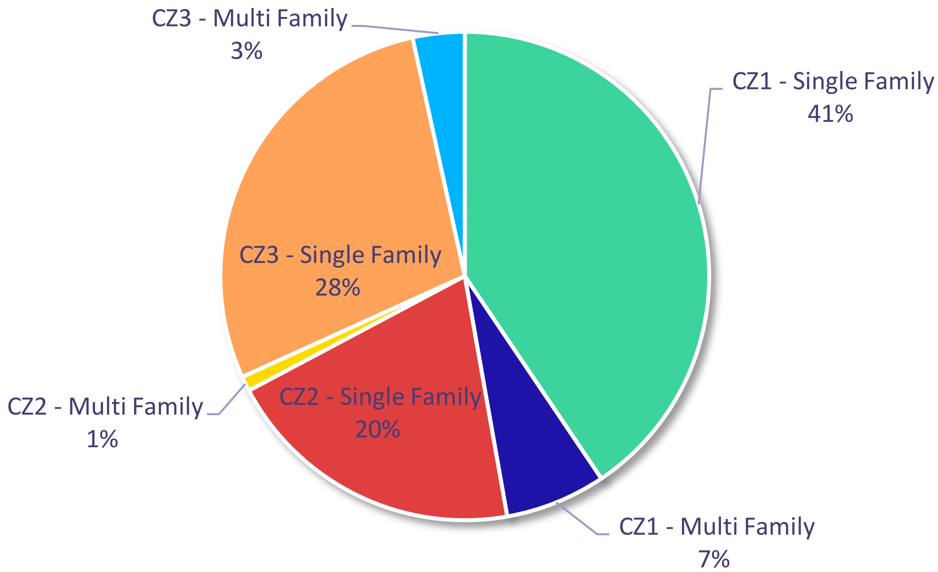
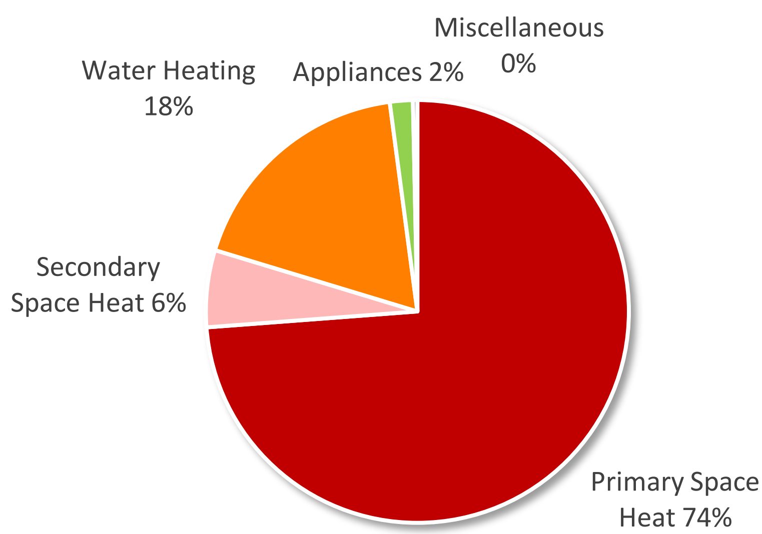


Figure 3-3 shows the distribution of annual natural gas consumption by end use for an average residential household. Space heating (primary and secondary) comprises a majority of the load at 80% followed by water heating at 18%. Miscellaneous loads make up a very small portion of the total. This is expected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

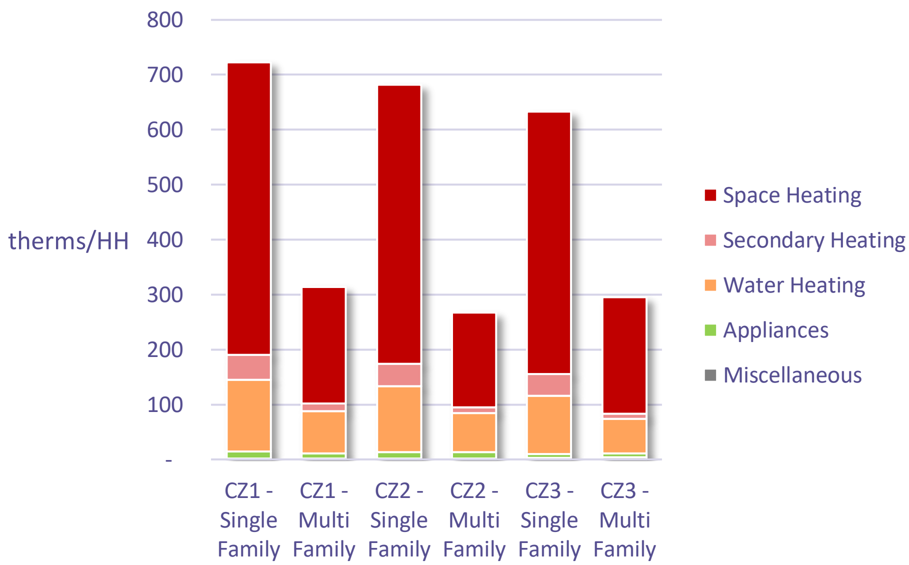
Figure 3-3 Residential Natural Gas Use by End Use, 2019



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.

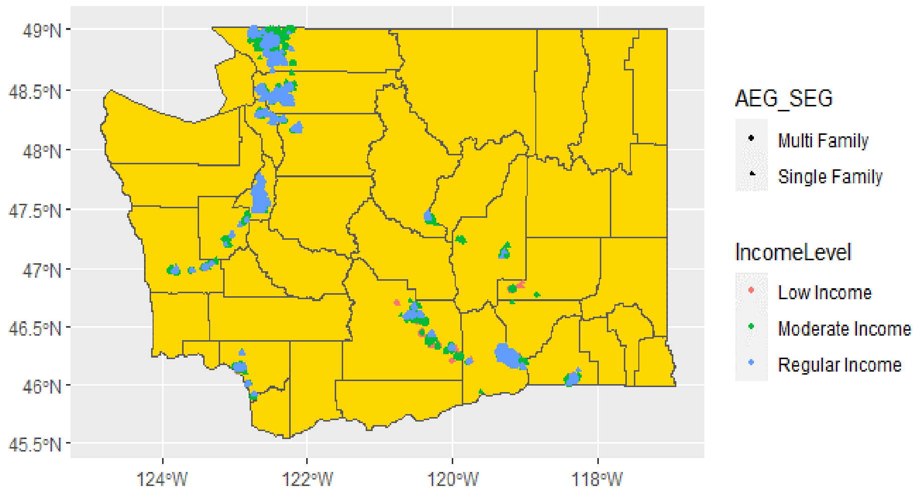
As shown in Table 3-5 below, nearly 60% of Cascade’s Washington customers fall into either the low or moderate income grouping, with the majority of these in the moderate-income range. In fact, the moderate-income group is the largest group of customers overall, with nearly half of Cascade’s customers 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

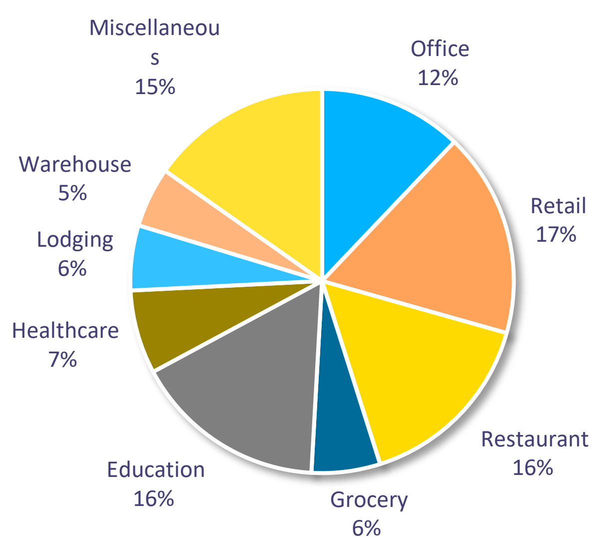


Figure 3-7 shows the distribution of natural gas consumption by end use for the entire commercial sector. Space heating is the largest end use, followed closely by water heating and food preparation. The miscellaneous end use is quite small, as expected given the limited applications for natural gas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

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

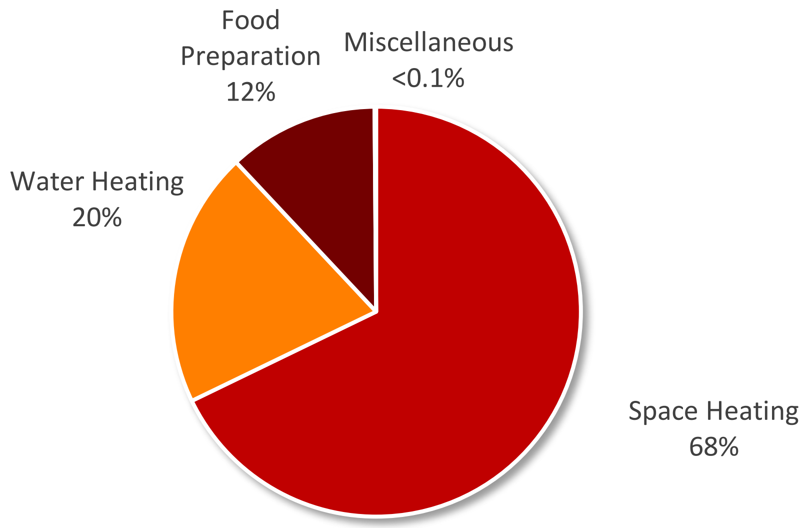
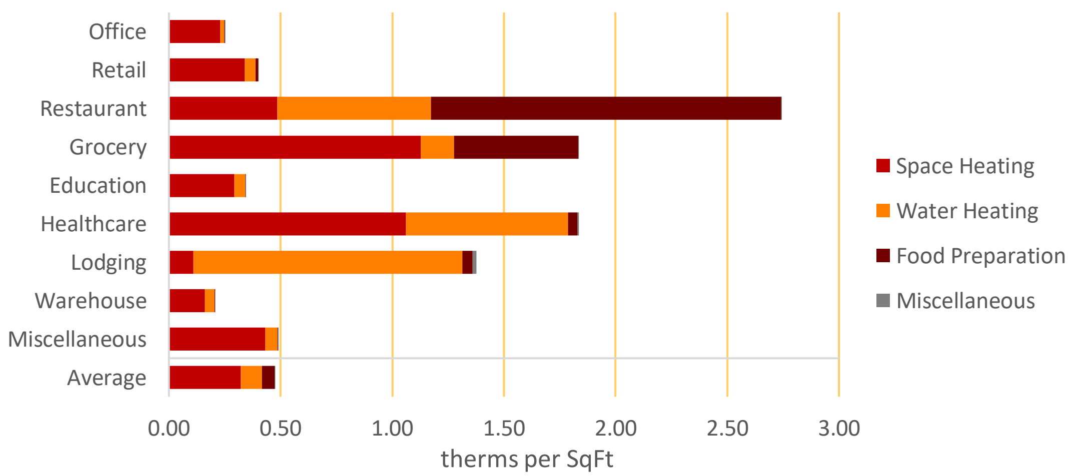


Figure 3-8 presents average natural gas intensities by segment and end use.

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 (Estimated)
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

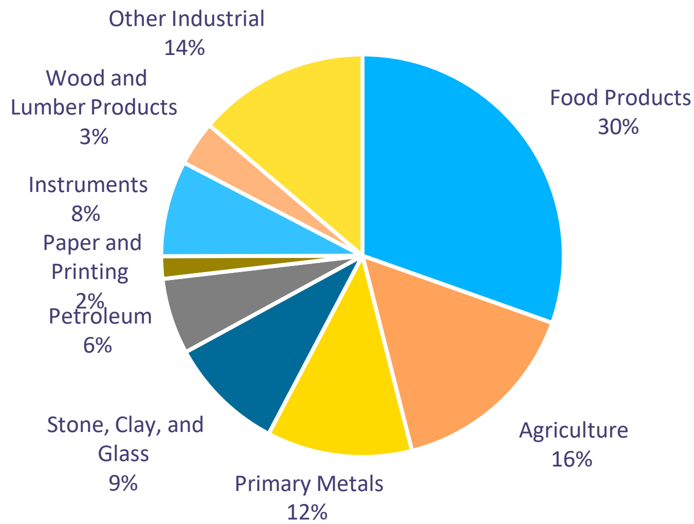


Figure 3-10 shows the distribution of annual natural gas consumption by end use for all industrial customers. Two major sources were used to develop this consumption profile. The first was AEG's analysis of warehouse usage as part of the commercial sector. We begin with this prototype as a starting point 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

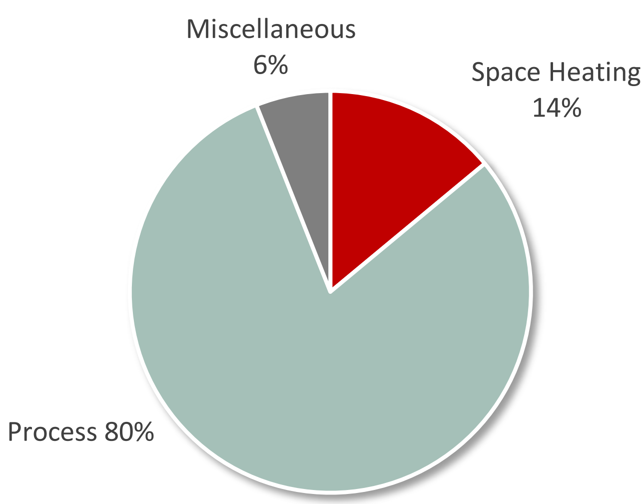


Figure 3-11 summarizes industrial energy intensities by industry type. Petroleum is presented on a separate axis due to the much higher per-employee usage estimate.

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

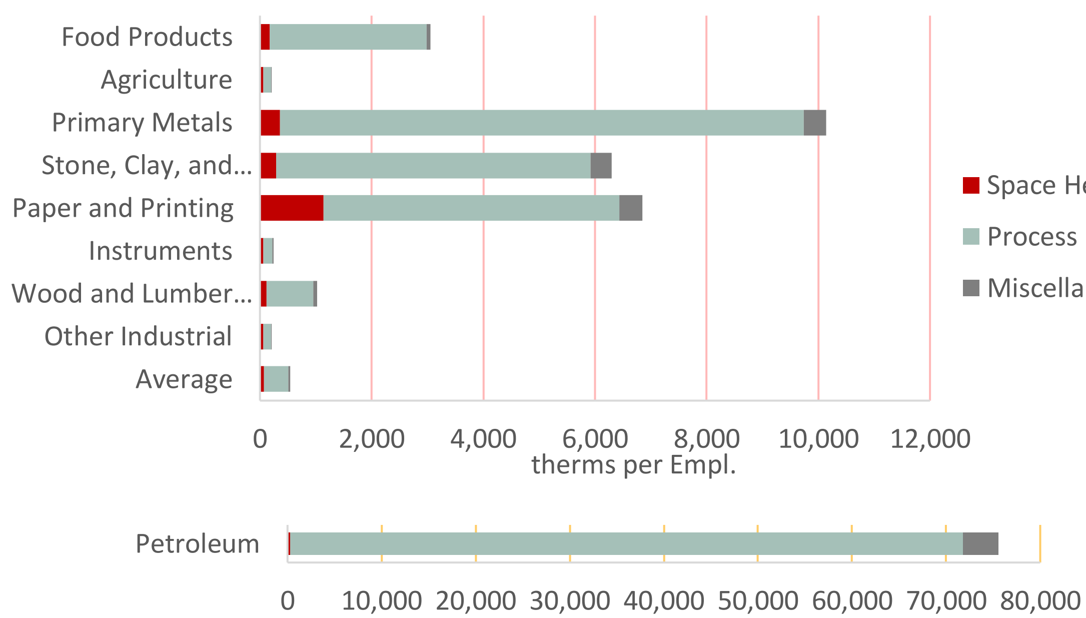


Table 3-10 shows the composite market profile for the industrial sector. Process cooling is very small and represents technologies such as gas-driven absorption chillers.

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, considering the effects of the 2021 WSEC and municipal natural gas ordinances on likely new gas customers
- 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 2021 WSEC code changes. It does *not* assume electrification beyond what is required by code.

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.

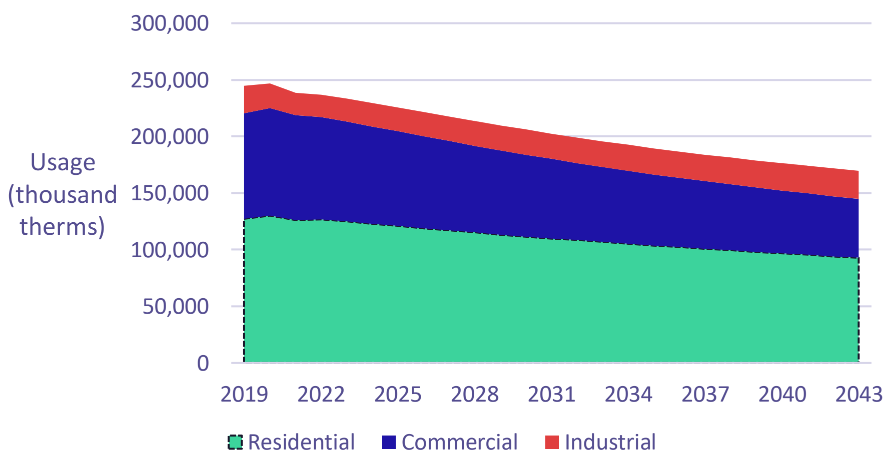
Summary of Overall Baseline Projection

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. 2022 consumption and weather data was updated to actuals provided by Cascade. Years 2023 forward assume normal weather. Overall, the forecast shows a modest decline in natural gas consumption, at an average rate of about 1.58% per year. This decline is due to restrictions on new construction gas loads detailed in the following section.

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

Sector	2024	2025	2028	2033	2038	2043	% Change ('24-'43)	Avg. Growth
Residential	123,075	121,020	115,263	106,878	99,641	93,064	-24.38%	-1.47%
Commercial	85,692	83,581	76,682	66,254	57,956	51,866	-39.47%	-2.64%
Industrial	20,614	20,920	21,770	22,747	23,843	25,008	21.31%	1.02%
Total	**229,381**	**225,522**	**213,715**	**195,878**	**181,440**	**169,938**	**-25.91%**	**-1.58%**

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



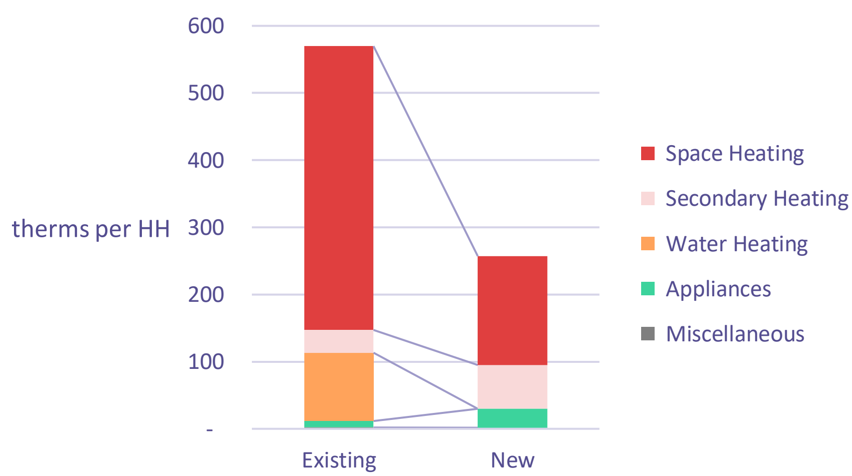
Assumptions Regarding WSEC 2021 and New Construction/Renovation

The newest Washington State Energy Code which takes effect in July 2023 has significant impacts on new construction and renovated buildings. Through conversations with NEEA, Cascade, and through AEG's other work in the WA region, we developed a set of assumptions regarding how code compliance will be achieved, particularly the mandate of electric heat pumps for the majority of space and water heating applications. 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, but in reduced quantity. Data from US DOE RECS 2020 for the state of Washington confirms that there is a subset of natural gas customers that use gas appliances without having gas space heat or water heat. This data and conversation with Cascade formed the basis of the assumptions shown in the following table. The adjustments to new construction equipment saturation relative to existing houses are documented in Table 4-2 and the adjustments for Commercial are shown in Table 4-3 below.

Table 4-2 Residential New Construction Equipment Adjustments

Technology Class	Adjustment relative to Average Existing Saturation
Natural Gas Furnace	Code allows fossil fuel furnaces as a backup unit to a heat pump primary heating system. This configuration is already not uncommon in Cascade's territory, especially in the Eastern part of the state. We retain 20% saturation of furnaces specifically as backup units for CZ 1 & 2, and 50% of homes for CZ 3 due to climactic conditions.
Gas Boiler	Assumed none in new construction
Secondary Heating (Fireplaces)	Assumed 40% of new construction that connects to natural gas will install
Water Heating	Assumed none in new construction[8]
Clothes Dryers & Stoves	Assumed 40% of new construction that connects to natural gas will install

Figure 4-2 Residential New Construction 2023 Intensity

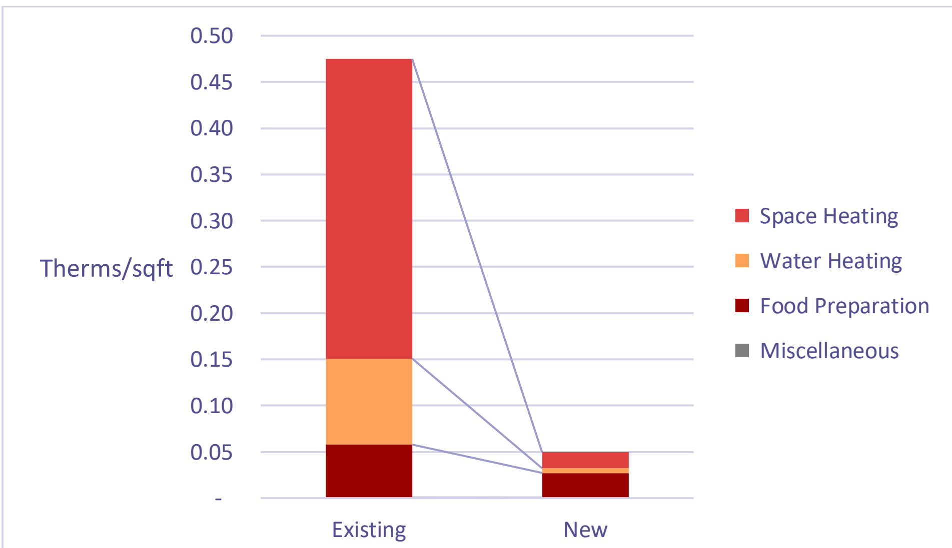


[8] Currently, code credits specify electric heat pump water heaters only. If this changes in the future, it could open the way for gas heat pump water heaters, but as of this study's publication they are unlikely to be selected by builders even if they become widely available in the near future

Table 4-3 Commercial New Construction Equipment Adjustments

Technology Class	Adjustment relative to Average Existing Saturation
Primary Space Heating (Furnace or Boiler)	Assumed none in new construction
Unit Heaters	While these units are often supplemental and cover areas not handled by central systems, very few will be allowed through under the strict space limits of the code. We reduce presence of these units by 80% compared to existing saturations.
Water Heating	Assumed none in new construction for most segments except for restaurants and healthcare/hospitals – HPWH does not reach sufficient temperatures to meet all the needs for these segments, so we assumed a continuing presence of gas water heating, 80% reduced from current saturations.
Food Service Equipment	Assumed new construction will continue some presence of gas food service equipment, at half the rate of existing buildings. However some equipment classes are required to install ENERGY STAR units as minimum code, which preempts program potential in these cases.

Figure 4-3 Commercial New Construction 2023 Intensity



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

Assumptions in the CPA vs Cascade's IRP

Cascade's most recent IRP was developed prior to the finalization of WSEC 2021 and does not contain the same assumptions as about new construction presence of equipment. This produces some differences between Cascade's current official load forecast and the CPA reference baseline. However, this difference has been thoroughly explored with Cascade, and both AEG and Cascade believe the CPA reference case baseline is the most reasonable starting point for future potential given what is currently known.

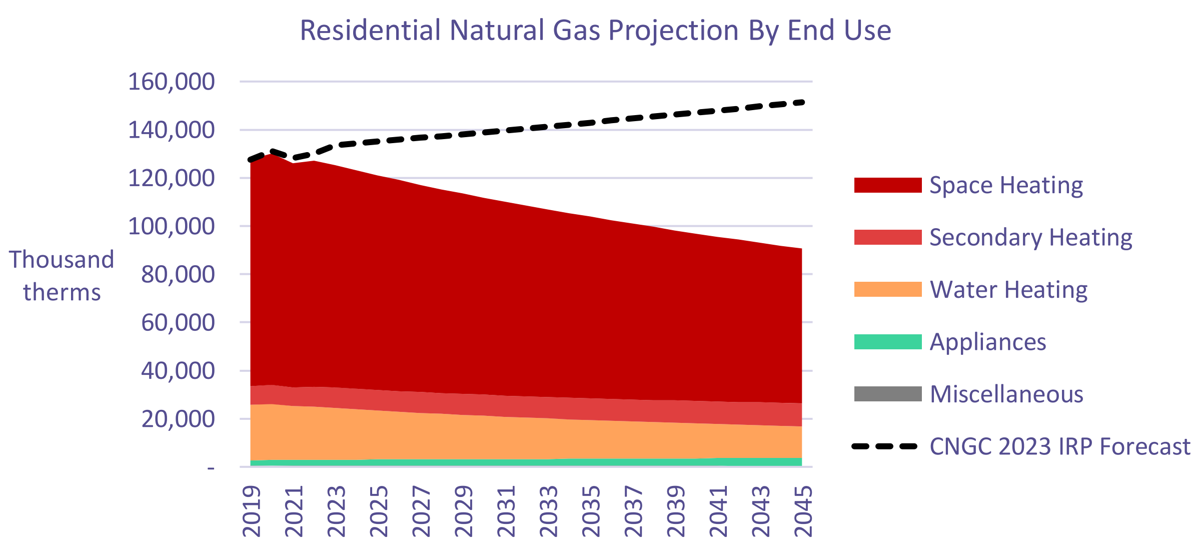
Residential Sector Baseline Projection

Table 4-4 and Figure 4-4 present the baseline projection for natural gas at the end-use level for the residential sector. Overall, residential use decreases from 127,538 thousand therms in 2019 to 93,064 thousand therms in 2043, a decrease of 27%. There are two high-level factors affecting growth. The first is a moderate increase in the number of households and customers, however without the highest load units due to WSEC 2021. The second is a decrease in equipment consumption due to future standards and naturally occurring efficiency improvements targeting existing building replacements and retrofits. 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.

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

End Use	2019	2025	2030	2035	2040	2043	% Change	Avg. Growth Rate
Space Heating	94,119	89,109	81,810	75,417	69,585	66,336	-29.5%	-1.5%
Secondary Heating	7,508	8,512	8,769	9,036	9,312	9,482	26.3%	1.0%
Water Heating	23,242	20,342	17,958	16,046	14,428	13,557	-41.7%	-2.2%
Appliances	2,243	2,626	2,787	2,978	3,178	3,300	47.1%	1.6%
Miscellaneous	427	431	417	404	394	389	-8.8%	-0.4%
Total	**127,538**	**121,020**	**111,741**	**103,882**	**96,898**	**93,064**	**-27.0%**	**-1.3%**

Figure 4-4 Residential Baseline Projection by End Use



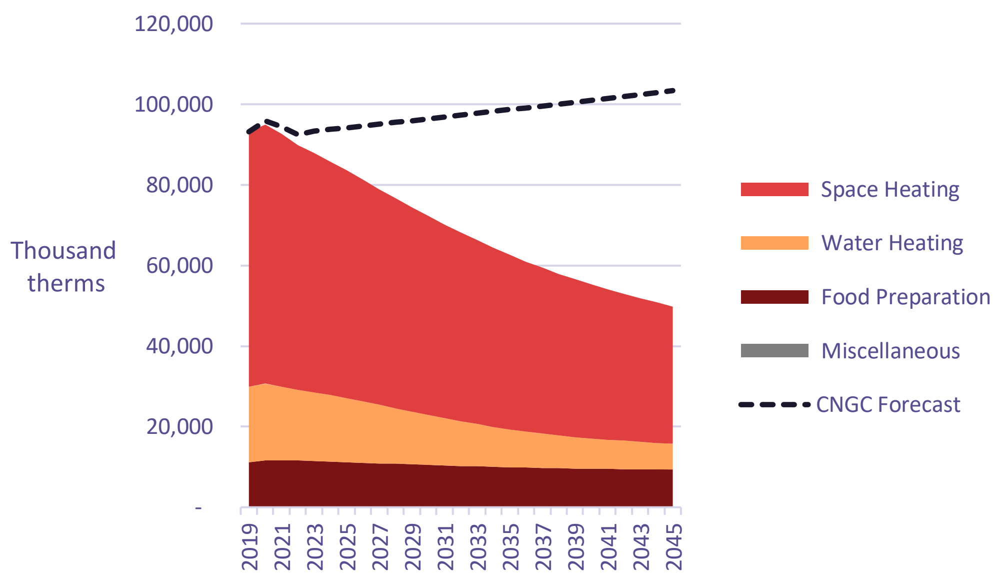
Commercial Sector Baseline Projection

Annual natural gas use in the commercial sector decreases 40.6% during the overall forecast horizon, starting at 93,122 thousand therms in 2019, and decreasing to 55,306 thousand therms in 2043.Table 4-5 Table 4-5 and Figure 4-5 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 over time as a result of existing building bring brought up to code as they age.

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

End Use	2019	2025	2030	2035	2040	2043	% Change ('19 – '43)	Avg. Growth Rate
Space Heating	63,166	64,315	62,663	57,914	50,745	38,251	-39.4%	-2.4%
Water Heating	18,790	18,969	18,311	16,474	13,103	7,478	-60.2%	-4.4%
Food Preparation	11,051	11,547	11,552	11,178	10,487	9,449	-14.5%	-0.7%
Miscellaneous	115	122	124	126	127	129	12.0%	0.5%
Total	**93,122**	**94,953**	**92,650**	**85,692**	**74,462**	**55,306**	**-40.6%**	**-2.5%**

Figure 4-5 Commercial Baseline Projection by End Use



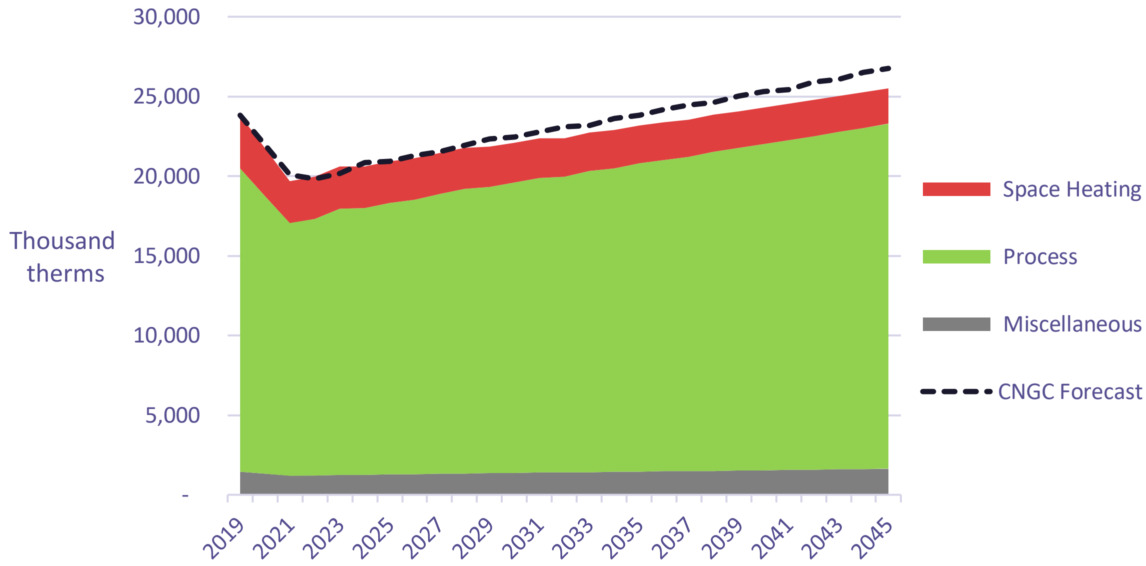
Industrial Sector Baseline Projection

Industrial sector usage increases throughout the planning horizon. Table 4-6 and Figure 4-6 present the projection at the end-use level. Overall, industrial annual natural gas use increases from 23,814 thousand therms in 2019 to 25,503 thousand therms in 2043. Growth of load as a whole is 0.3% per year but impacts of naturally occurring efficiency and code restrictions on equipment lower consumption in the space heating end use.

Table 4-6 Industrial Baseline Projection by End Use (thousand therms)

End Use	2019	2025	2030	2035	2040	2043	% Change ('19-'43)	Avg. Growth Rate
Space Heating	3,330	2,619	2,508	2,386	2,289	2,224	-33.2%	-1.6%
Process	19,051	17,022	18,221	19,337	20,468	21,651	0	0.5%
Miscellaneous	1,432	1,279	1,369	1,453	1,538	1,627	13.6%	0.5%
Total	**23,814**	**20,920**	**22,098**	**23,176**	**24,296**	**25,503**	**7.1%**	**0.3%**

Figure 4-6 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. 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.
    - 2024-2025 total Technical Potential savings are 9,288 thousand therms, or 4.1% of the baseline projection. Cumulative savings in 2033 are 42,998 thousand therms, or 22.0% of the baseline.
- Achievable Technical Potential refines technical potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and other factors that affect market penetration of conservation measures. For the 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.[9] 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 D.
    - 2024 -2025 total Achievable Technical savings are 3,540 thousand therms, or 1.6% of the baseline projection. Cumulative net savings in 2033 are 20,333 thousand therms, or 10.4% 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.
    - 2024-2025 total UCT Achievable Economic savings are 1,782 thousand therms, or 0.8% of the baseline projection. Cumulative savings in 2033 are 13,241 thousand therms, or 6.8% 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

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

was applied to these costs per the Council methodologies. 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.

- 2024-2025 total TRC Achievable Economic savings are 1,475 thousand therms, or 0.7% of the baseline projection. Cumulative net savings in 2033 are 10,899 thousand therms, or 5.6% of the baseline.

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

Scenario	2024	2025	2028	2033	2038	2043
Baseline Projection (thousand therms)	229,381	225,522	213,715	195,878	181,440	169,938
Cumulative Savings (thousand therms)						
UCT Achievable Economic Potential	815	1,782	5,544	13,241	19,672	23,777
TRC Achievable Economic Potential	669	1,475	4,648	10,899	15,660	18,490
Achievable Technical Potential	1,685	3,540	9,674	20,333	28,372	32,828
Technical Potential	4,621	9,288	23,102	42,998	55,754	62,474
Cumulative Savings (% of Baseline)						
UCT Achievable Economic Potential	0.4%	0.8%	2.6%	6.8%	10.8%	14.0%
TRC Achievable Economic Potential	0.3%	0.7%	2.2%	5.6%	8.6%	10.9%
Achievable Technical Potential	0.7%	1.6%	4.5%	10.4%	15.6%	19.3%
Technical Potential	2.0%	4.1%	10.8%	22.0%	30.7%	36.8%

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

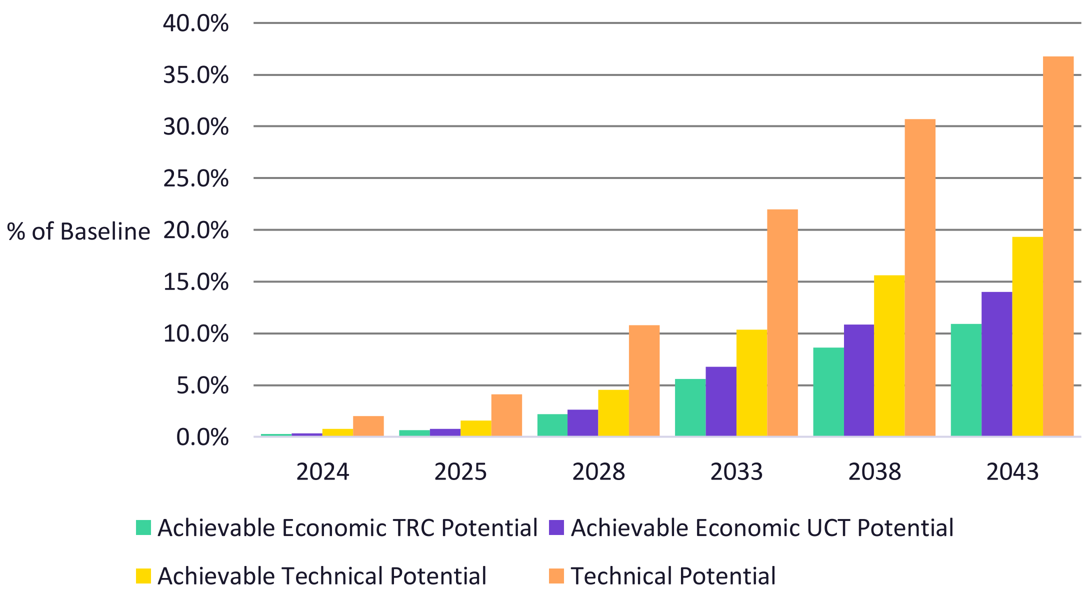
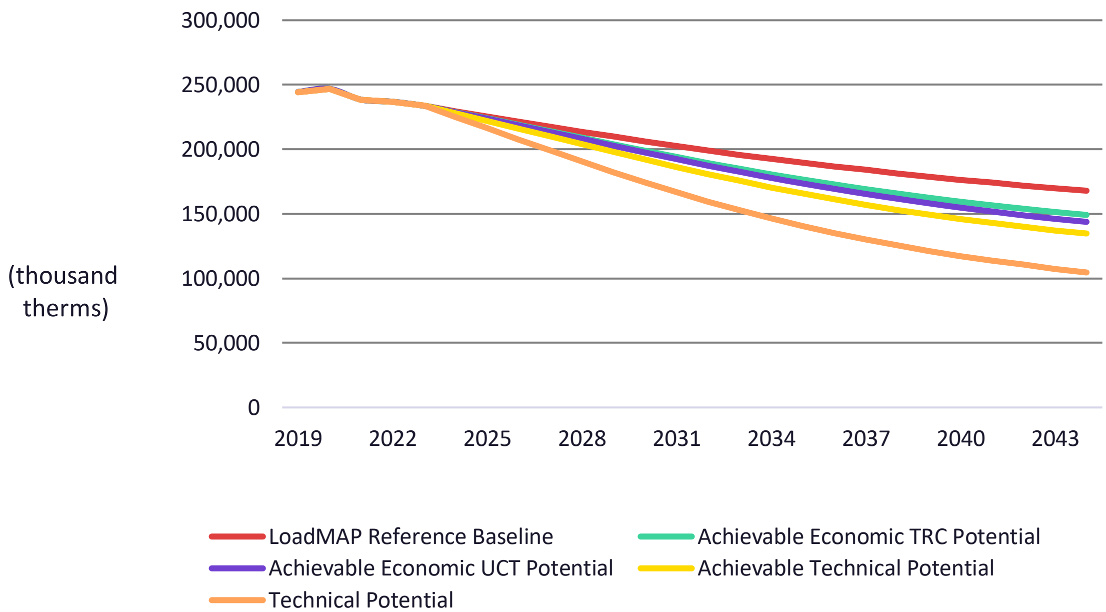


Figure 5-2 Baseline Projection and Energy Efficiency Forecasts (thousand therms)



Summary of 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 TRC 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.

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

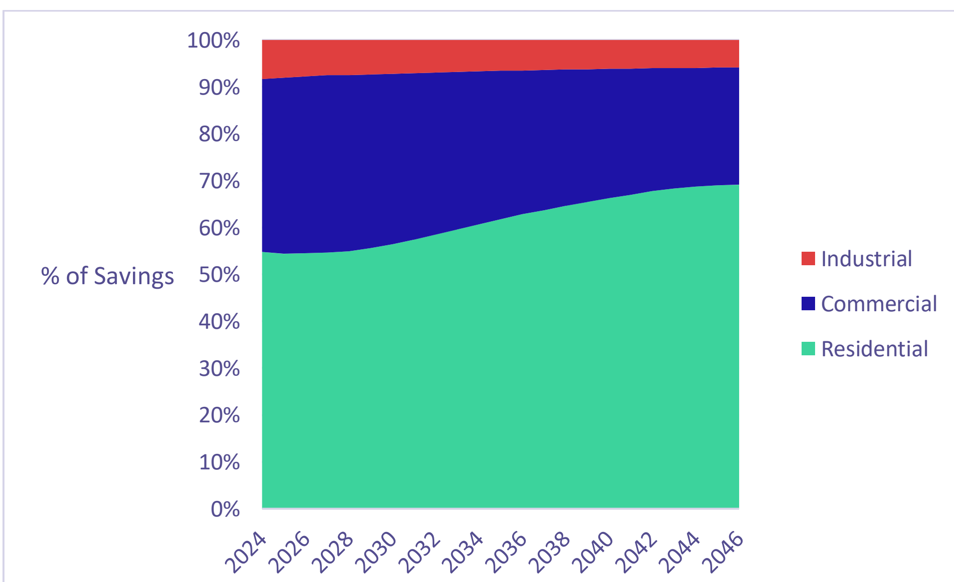


Table 5-2 Cumulative UCT Achievable Economic Potential by Sector, Selected Years (thousand therms)

Sector	2024	2025	2028	2033	2038	2043
Residential	446,143	969,752	3,047,823	7,883,583	12,712,372	16,243,729
Commercial	300,711	670,319	2,084,348	4,457,378	5,722,243	6,104,298
Industrial	67,989	142,141	411,523	899,907	1,237,704	1,428,639
Total	**814,843**	**1,782,211**	**5,543,693**	**13,240,867**	**19,672,319**	**23,776,666**

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 2024, UCT achievable economic potential is 446 thousand therms, or 0.4% of the baseline projection. By 2033, cumulative savings are 7,884 thousand therms, or 7.4% of the baseline.

Potential by income level and housing type is available from the measure level data in Appendix C.

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

Scenario	2024	2025	2028	2033	2038	2043
Baseline Forecast (thousand therms)	123,075	121,020	115,263	106,878	99,641	93,064
Cumulative Savings (thousand therms)						
Achievable Economic UCT Potential	446	970	3,048	7,884	12,712	16,244
Achievable Economic TRC Potential	299	646	2,017	5,204	8,415	10,782
Achievable Technical Potential	563	1,218	3,824	9,981	16,059	20,148
Technical Potential	3,082	6,133	15,032	28,879	39,108	45,067
Energy Savings (% of Baseline)						
Achievable Economic UCT Potential	0.4%	0.8%	2.6%	7.4%	12.8%	17.5%
Achievable Economic TRC Potential	0.2%	0.5%	1.7%	4.9%	8.4%	11.6%
Achievable Technical Potential	0.5%	1.0%	3.3%	9.3%	16.1%	21.6%
Technical Potential	2.5%	5.1%	13.0%	27.0%	39.2%	48.4%

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

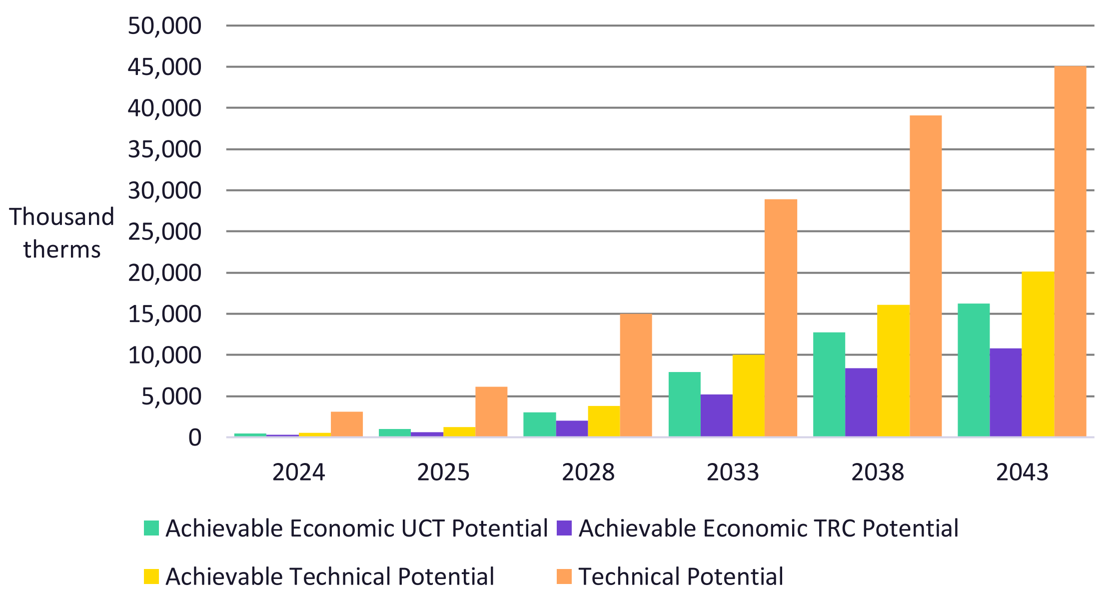


Figure 6-2 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Space heating makes up a majority of potential throughout the study.

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

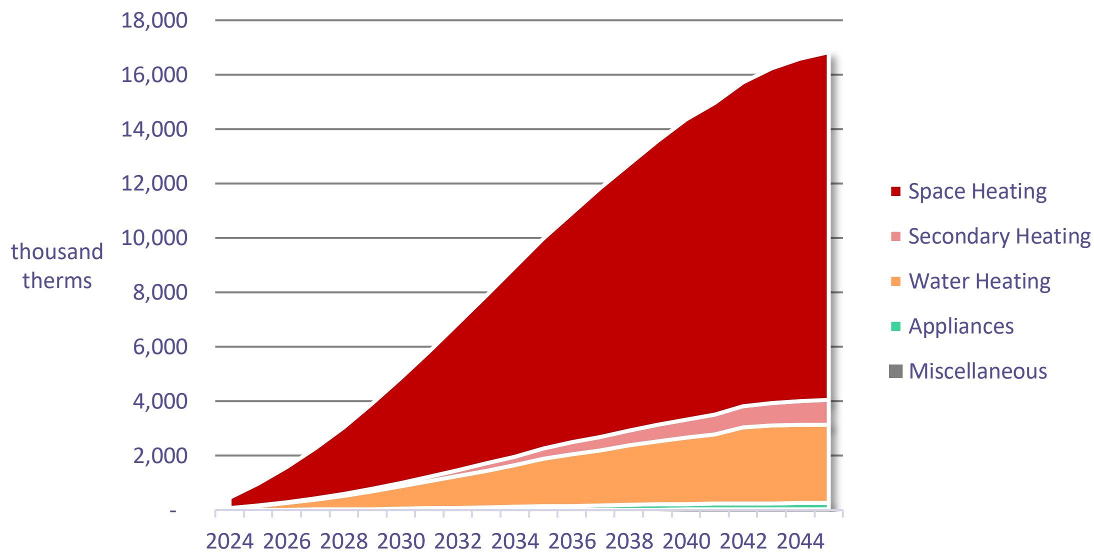


Table 6-2 identifies the top residential measures by cumulative 2024-2025 savings. Ceiling insulation, Furnaces, and tankless water heaters are the top measures. The majority of cost-effective furnace savings are coming from upgrades to AFUE 97%, which in the prior study stopped passing cost effectiveness after a standard change took effect. As that standard was withdrawn without going into effect, this study has a significantly better economic outlook for furnaces replacing expired units.

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 2024 and 2025, UCT Achievable Economic Potential (thousand therms)

Rank	Measure / Technology	2024 Cumulative Savings (thousand therms)	% of Total	2025 Cumulative Savings (thousand therms)	% of Total
1	Insulation - Ceiling, Upgrade - R-49 to R-60 depending on space	115	25.9%	233	24.0%
2	Furnace - Direct Fuel - AFUE 97% (CEE Tier 3)	110	24.6%	241	24.8%
3	Insulation - Wall Cavity, Installation - R-14 to R-21 depending on space	46	10.3%	92	9.5%
4	Insulation - Ceiling, Installation - R-49 to R-60 depending on space	42	9.5%	85	8.8%
5	Water Heater <= 55 gal. - UEF 0.95 (Instantaneous, ENERGY STAR 5.0)	33	7.4%	79	8.2%
6	Ducting - Repair and Sealing - 50% reduction in duct leakage	14	3.1%	35	3.6%
7	Insulation - Basement Sidewall - R-15	13	3.0%	34	3.5%
8	ENERGY STAR Clothes Washers - ENERGY STAR unit	12	2.6%	23	2.4%
9	Water Heater - Pipe Insulation - Insulated 5' of pipe between unit and conditioned space	8	1.7%	19	2.0%
10	Fireplace - Tier 2 (77%+ FE Rating)	7	1.6%	17	1.8%
11	Thermostat - Programmable - Programmed thermostat	7	1.5%	14	1.4%
12	Windows - U-.30 - Double Pane LowE U30	6	1.4%	15	1.6%
13	Insulation - Ducting - duct thermal losses reduced 50%	6	1.2%	14	1.5%
14	Water Heater - Temperature Setback - Setback to 120° F	5	1.1%	12	1.2%
15	Gas Boiler - Hot Water Reset - Reset control installed	4	0.9%	8	0.9%
16	Doors - Storm and Thermal - R-5 door	3	0.7%	8	0.8%
17	Combined Boiler + DHW System (Tankless) - Combined tankless boiler unit for space and DHW	3	0.6%	7	0.7%
18	Combined Boiler + DHW System (Storage Tank) - Combined tankless boiler unit for space and DHW	3	0.6%	7	0.7%
19	Stove/Oven - High Efficiency (730 + 1660 IAEC)	2	0.5%	5	0.6%
20	Windows - U-.22 or better - Double Pane LowE CL22	2	0.5%	5	0.5%
Subtotal		**440**	**98.5%**	**1,036**	**98.4%**
Total Savings in Year		**446**	**100.0%**	**1,053**	**100.0%**

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 2021 (described in Section 4 above), New Construction makes up a very small portion of the overall portfolio, coming from higher efficiency fireplaces and stoves.

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

Cumulative Savings (thousand therms)	2024	2025	2028	2033	2038	2043
Achievable Economic UCT Potential						
Above Median Household Income	231	502	1,577	4,043	6,506	8,269
Moderate Income	105	227	697	1,745	2,744	3,354
Low Income	109	240	774	2,096	3,463	4,620
Achievable Economic TRC Potential						
Above Median Household Income	179	390	1,230	3,190	5,176	6,642
Moderate Income	69	149	453	1,138	1,830	2,329
Low Income	50	107	334	876	1,408	1,810
Achievable Technical Potential						
Above Median Household Income	262	568	1,781	4,607	7,378	9,210
Moderate Income	123	265	823	2,110	3,341	4,062
Low Income	178	386	1,220	3,264	5,340	6,876
Technical Potential						
Above Median Household Income	1,428	2,841	6,958	13,307	17,921	20,576
Moderate Income	652	1,298	3,180	6,094	8,245	9,494
Low Income	1,002	1,994	4,895	9,477	12,942	14,996

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

Cumulative Savings (thousand therms)	2024	2025	2028	2033	2038	2043
Achievable Economic UCT Potential						
Existing/Retrofit	434	943	2,948	7,555	12,032	15,094
New Construction	12	27	99	328	681	1,150
Achievable Economic TRC Potential						
Existing/Retrofit	289	625	1,948	5,010	8,028	10,074
New Construction	9	21	69	194	386	708
Achievable Technical Potential						
Existing/Retrofit	548	1,184	3,688	9,497	15,001	18,402
New Construction	15	34	136	484	1,058	1,746
Technical Potential						
Existing/Retrofit	2,966	5,903	14,454	27,657	37,091	42,419
New Construction	115	230	578	1,222	2,017	2,648

Commercial Sector Potential

Table 6-5 and Figure 6-3 summarize the energy conservation potential for the commercial sector. In 2024, UCT achievable economic potential is 301 thousand therms, or 0.4% of the baseline projection. By 2033, cumulative savings are 4,457 thousand therms, or 6.7% of the baseline.

Table 6-5 Commercial Energy Conservation Potential Summary

Scenario	2024	2025	2028	2033	2038	2043
Baseline Forecast (thousand therms)	85,692	83,581	76,682	66,254	57,956	51,866
Cumulative Savings (thousand therms)						
Achievable Economic UCT Potential	301	670	2,084	4,457	5,722	6,104
Achievable Economic TRC Potential	304	690	2,224	4,796	6,016	6,294
Achievable Technical Potential	1,045	2,162	5,388	9,350	10,941	11,104
Technical Potential	1,445	2,959	7,509	12,916	15,019	15,548
Energy Savings (% of Baseline)						
Achievable Economic UCT Potential	0.4%	0.8%	2.7%	6.7%	9.9%	11.8%
Achievable Economic TRC Potential	0.4%	0.8%	2.9%	7.2%	10.4%	12.1%
Achievable Technical Potential	1.2%	2.6%	7.0%	14.1%	18.9%	21.4%
Technical Potential	1.7%	3.5%	9.8%	19.5%	25.9%	30.0%

Figure 6-3 Commercial Energy Conservation by Case

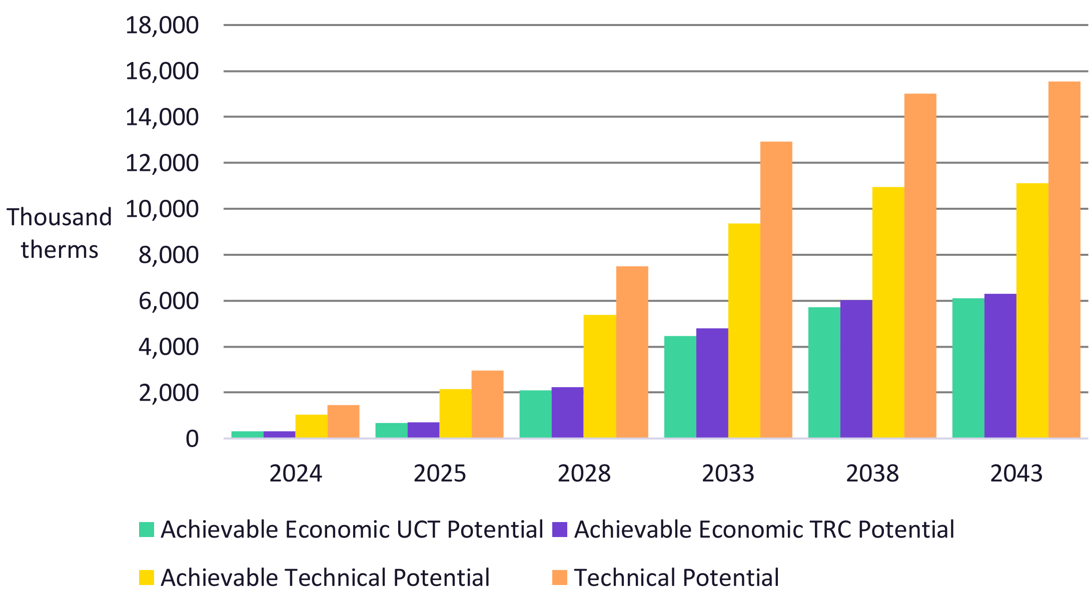


Figure 6-4 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings. Space heating makes up a majority of the potential early, but food preparation equipment upgrades provide some savings opportunities in the later years.

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

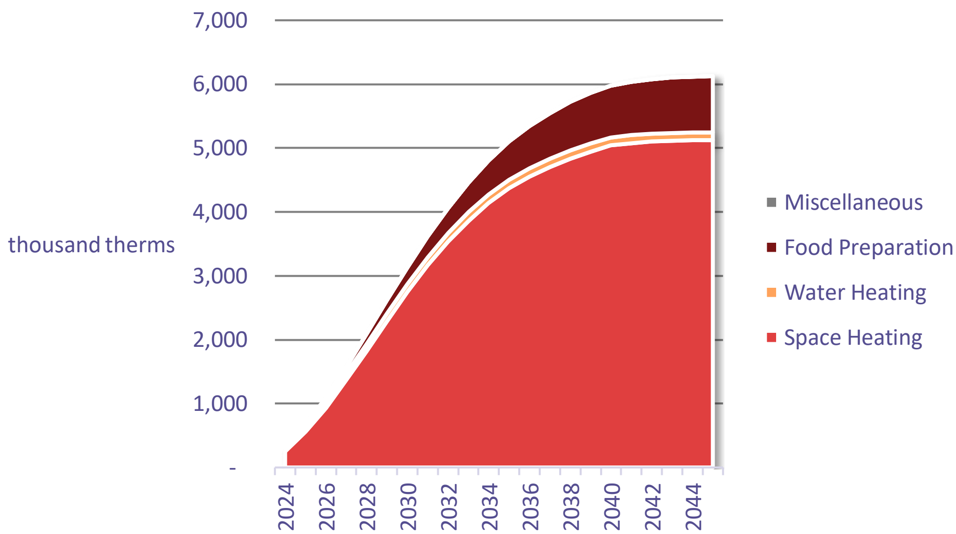


Table 6-6 identifies the top 20 commercial measures by cumulative savings in 2022 and 2023. Weatherization is cost effective but can sometimes be difficult to achieve "on the ground". Additional potential is found in insulation, boilers, water heaters, furnaces, and a long tail of smaller controls and more niche-application component measures.

Table 6-6 Commercial Top Measures in 2024 and 2025, UCT Achievable Economic Potential (thousand therms)

Rank	Measure / Technology	2024 Cumulative Potential Savings (thousand therms)	% of Total	2025 Cumulative Potential Savings (thousand therms)	% of Total
1	Insulation - Roof/Ceiling - R-38	48	15.9%	120	17.9%
2	Insulation - Wall Cavity - R-21	44	14.6%	109	16.3%
3	Gas Boiler - Insulate Hot Water Lines - Insulated water lines	22	7.2%	42	6.3%
4	Gas Boiler - Stack Economizer - Economizer installed	20	6.7%	39	5.9%
5	Gas Boiler - Hot Water Reset - Reset control installed	19	6.3%	40	6.0%
6	Water Heater - TE 94% (ENERGY STAR 2.0)	16	5.4%	34	5.1%
7	Water Heater - Ozone Laundry - Ozone laundry system	12	3.9%	23	3.4%
8	Boiler - TE 98%	12	3.8%	24	3.5%
9	Furnace - AFUE 96%	11	3.8%	26	3.9%
10	Gas Boiler - High Turndown - Turndown control installed	10	3.3%	19	2.9%
11	Gas Boiler - Insulate Steam Lines/Condensate Tank - Lines and condensate tank insulated	9	3.1%	18	2.7%
12	ENERGY STAR Connected Thermostat - Wi-Fi/interactive thermostat installed	9	3.0%	18	2.6%
13	HVAC - Demand Controlled Ventilation - DCV enabled	9	2.9%	24	3.5%
14	Space Heating - Heat Recovery Ventilator - HRV installed	7	2.3%	13	2.0%
15	Unit Heater - Infrared Radiant	6	2.1%	17	2.5%
16	Steam Trap Maintenance - Cleaning and maintenance	6	1.8%	11	1.6%
17	Water Heater - Pre-Rinse Spray Valve - 2 GPM sprayer nozzle	5	1.5%	9	1.3%
18	Range - High Efficiency	5	1.5%	11	1.6%
19	Retrocommissioning - HVAC - Optimized HVAC flow and controls	4	1.5%	9	1.3%
20	Broiler - Infrared Burners	4	1.4%	10	1.5%
Subtotal		**277**	**92.0%**	**617**	**92.0%**
Total Savings in Year		**301**	**100.0%**	**670**	**100.0%**

Industrial Sector Potential

Table 6-7Table 6-7 and Figure 6-5 summarize the energy conservation potential for the core industrial sector. In 2024, UCT achievable economic potential is 68 thousand therms, or 0.3% of the baseline projection. By 2033, cumulative savings reach 900 thousand therms, or 4.0% 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.

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

Scenario	2024	2025	2028	2033	2038	2043
Baseline Forecast (thousand therms)	20,614	20,920	21,770	22,747	23,843	25,008
Cumulative Savings (thousand therms)						
Achievable Economic UCT Potential	68	142	412	900	1,238	1,429
Achievable Economic TRC Potential	67	139	407	899	1,229	1,413
Achievable Technical Potential	77	160	461	1,002	1,372	1,576
Technical Potential	94	195	561	1,203	1,627	1,859
Energy Savings (% of Baseline)						
Achievable Economic UCT Potential	0.3%	0.7%	1.9%	4.0%	5.2%	5.7%
Achievable Economic TRC Potential	0.3%	0.7%	1.9%	4.0%	5.2%	5.7%
Achievable Technical Potential	0.4%	0.8%	2.1%	4.4%	5.8%	6.3%
Technical Potential	0.5%	0.9%	2.6%	5.3%	6.8%	7.4%

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

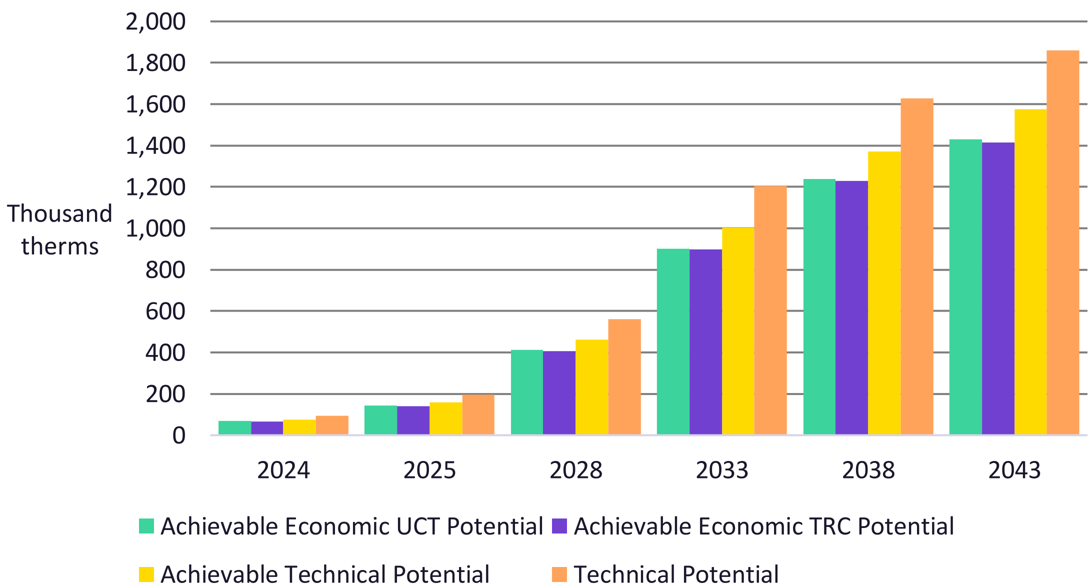


Figure 6-6 presents forecasts of energy savings by end use as a percent of total annual savings and cumulative savings.

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

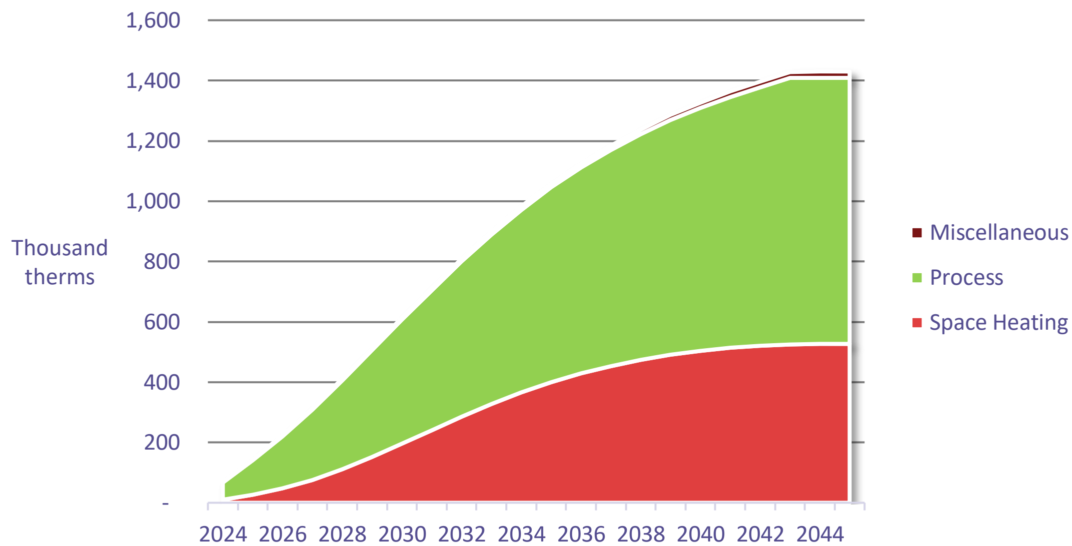


Table 6-8 identifies the top 20 industrial measures by cumulative 2024-2025 savings. Strategic energy management of industrial process applications is one of the highest measures by total savings. For smaller industrial customers, this measure typically involves a cohort of between five to ten businesses 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 2024 and 2025, UCT Achievable Potential (thousand therms)

Rank	Measure / Technology	2024 Cumulative Potential Savings (thousand therms)	% of Total	2025 Cumulative Potential Savings (thousand therms)	% of Total
1	Strategic Energy Management - Energy management system installed and programmed	17	24.9%	34	23.9%
2	Process - Insulate Heated Process Fluids - Insulated process fluid lines	10	14.5%	20	14.0%
3	Gas Boiler - Insulate Hot Water Lines - Insulated water lines	8	12.0%	16	11.5%
4	Gas Boiler - Stack Economizer - Economizer installed	8	11.7%	16	11.2%
5	Insulation - Roof/Ceiling - R-38	5	7.8%	14	10.2%
6	Process Heat Recovery - HR system installed	4	6.6%	9	6.3%
7	Gas Boiler - Insulate Steam Lines/Condensate Tank - Lines and condensate tank insulated	4	5.5%	8	5.3%
8	Gas Boiler - High Turndown - Turndown control installed	3	4.4%	6	4.2%
9	Gas Boiler - Maintenance - General cleaning and maintenance	3	4.3%	5	3.5%
10	Gas Boiler - Hot Water Reset - Reset control installed	3	4.1%	6	4.5%
11	Steam Trap Maintenance - Cleaning and maintenance	1	1.4%	2	1.4%
12	Boiler - Convert to Gas-Fired ASHP	1	1.0%	2	1.2%
13	Building Automation System - Automation system installed and programmed	0	0.5%	1	0.7%
14	Retro commissioning - Optimized HVAC flow and controls	0	0.5%	1	0.5%
15	Gas Boiler - Burner Control Optimization - Optimized burner controls	0	0.3%	1	0.4%
16	Unit Heater - Infrared Radiant	0	0.3%	1	0.6%
17	Steam System Efficiency Improvements - Optimized system	0	0.0%	0	0.1%
18	Furnace - AFUE 96%	0	0.0%	0	0.0%
19	Gas Furnace - Maintenance - General cleaning and maintenance	0	0.0%	0	0.0%
20	Insulation - Ducting - 50% reduction in thermal losses	0	0.0%	0	0.0%
Subtotal		**68**	**100.0%**	141	**99.5%**
Total Savings in Year		**68**	**100.0%**	**142**	**100.0%**

A | COMPARISON TO COUNCIL METHODOLOGY

While developing potential estimates for Cascade's CPA, AEG strove to adapt Northwest Power & Conservation Council's Draft 2021 Conservation and Electric Power Plan methodologies wherever appropriate for gas studies and maintain consistency with analysis procedures within the region. To accomplish this, AEG employed the following approach:

- Estimate technical, achievable technical, and achievable economic potential;
- Utilize regional market baseline data;
- Consider all measures within the 2021 Plan and RTF work products when applicable to gas, utilize or adapt Council and RTF assumptions wherever possible;
- Adapt the 2021 Plan's ramp rates for use in natural gas efficiency programs; and
- Incorporate all quantified and monetized non-energy impacts when developing a fully balanced TRC.

We describe these in more detail below.

Estimate technical, achievable technical, and achievable economic potential

Within the 2021 Plan, the Council estimates three levels of potential, technical, achievable technical, and achievable economic. This is different from best-practice methodology for other parts of the country, where technical, economic, then achievable potential is estimated. The primary advantage of estimating achievable technical potential first is that it allows for a more apples-to-apples comparison with previous studies and other utilities throughout the region. Avoided costs are one of the most likely potential drivers to change and will likely vary by utility, so isolating this impact is important when making comparisons.

Within AEG's LoadMAP model, we estimate potential using the Council's preferred approach of beginning with technical potential, applying ramp rates to estimate achievable technical potential, and finally screening for cost effectiveness to estimate achievable economic potential. Within this study, AEG estimated potential primarily under the UCT, since that is Cascade's primary cost-effectiveness test, but also estimated potential using the Council's preferred test, a fully-balanced TRC, for regulatory reporting, future reference and planning initiatives if necessary.

Utilize regional market baseline data

In addition to Cascade-specific data, which is the best-practice primary source available, AEG relied on NEEA's regional stock and site assessments, the 2016-2017 RBSA, 2014 and 2019 CBSA, and 2014 IFSA. These surveys, which also informed the baseline of the draft 2021 Power Plan, contain detailed home, building, and industrial facility information for customers in the region. While these surveys have primarily been used to inform electric CPAs, AEG identified a list of useful data that is applicable for gas customers in the region as well. For example, AEG utilized detailed home and building shell characteristics to determine the applicable portion of the market for many retrofit opportunities. This included the percentage of customers with no, or very low, ceiling insulation. We also used this to determine baseline window types (e.g. single vs. double pane) and amount of homes with exterior ductwork.

NEEA's surveys were also used to inform commercial and industrial energy intensities on a square foot and employee basis respectively. This data, particularly the consumption per square foot, is invaluable when determining energy consumption in commercial and industrial facilities. Compared to a residential home, which roughly corresponds one-to-one with customer accounts, a commercial facility may be anywhere from a few thousand square feet to over one million. Utilizing NEEA data allowed AEG an additional benchmark upon which to estimate building energy consumption.

Consider all measures within the 2021 Plan and RTF work products when applicable to gas, utilize or adapt Council and RTF assumptions wherever possible

While many of the Council and RTF assumptions were developed with electricity savings in mind, there is data that may be adapted for use in estimating gas potential. For example, weatherization measures may be applied equally to both electric and gas heating systems, so assumptions on lifetime and cost are applicable to both. Additionally, energy savings as percent of baseline consumption may also be adapted if reasonably scrutinized. For example, electric resistance and natural gas direct-fuel furnaces should share similar load shapes and save similar percentages. On the other hand, efficiency of electric air-source heat pumps varies by load and outside temperatures and is not comparable to any commercially available gas technologies and should not be used.

When developing the measure list for this study, AEG began with workbooks from the 2021 Plan and RTF to ensure that all similar measures were captured. We used assumptions from these workbooks when appropriate, and substituted gas-specific details as necessary.

Adapt the 2021 Plan's ramp rates for use in natural gas efficiency programs

Participation rates, also known as ramp rates, are a key driver in estimation of potential. These identify the percentage of an applicable population that will adopt an efficiency measure as part of a utility EE program or other non-utility mechanism within the territory. For CPAs in the Northwest, and particularly the state of Washington, the 2021 Plan's electric ramp rates are a key source of information. While very thorough and straightforward to use, these were developed with electric utilities and electric programs in mind, and reflect assumptions about measure maturity, market acceptance, and existing penetration for electric markets. Because of these embedded assumptions, they may not be appropriate to apply directly to natural gas EE programs or measures.

Figure A-1 Example Power Council Ramp Rates

AEG utilized these ramp rates as a starting point for estimating potential. We adapted the Council's ramp rate assignments from electric measures to their most similar gas counterparts (e.g. started with identical ramp rates for weatherization). We also applied ramp rates based on similar electric technology categories (e.g. similar food preparation rates). The next step was to adapt these for use in natural gas programs, using observations from programs within the region as well as implementation knowledge provided by the Cascade team. This information was used to both identify high-performing programs (accelerate potential) and additional market barriers (to possibly delay potential). To apply these ramp rates to a natural gas potential assessment, AEG utilized three of the following approaches:

- Reassign an individual measure's ramp rate. For example, Cascade's program performance for Furnaces exceeded the default ramp rate values for HVAC equipment, and are moved up to a faster, more mature ramp rate.

- Accelerate or decelerate an existing ramp rate. This involves stepping forward or backward so that the first year of the CPA is aligned with a different "year" of the ramp rate itself. By either delaying the start of a ramp or starting one or two years ahead, a more subtle effect is achieved than a wholesale movement to a new ramp rate. In this study, similar to the previous CPA, Cascade's robust furnace and water heater programs were accelerated so that projected savings started at a point similar to recent achievements, which were in between the two "fast" lost opportunity ramp rates.
- Design a new ramp rate. It is possible to produce new ramp rates that are still consistent with Council methodology in that they capture the full remaining market (to the limit of achievability) over the twenty year planning horizon, such as a linear ramp that has consistent year over year growth rather than the bell curve effect seen in retrofit ramps above.

Beginning with the 2017 CPA, AEG adjusted the Power Council's ramp rates from the Seventh Power Plan using three of the four approaches illustrated below. Although ramp rates themselves have been updated to 2021 Power Plan guidance, most of the same adjustments made in 2017 continue to be appropriate for Cascade's territory.

Incorporate all quantified and monetized non-energy impacts when developing a fully balanced TRC

In addition to the UCT, LoadMAP has been configured to evaluate potential using the TRC. This test focuses on impacts for both the utility and customer, which is a different frame of reference from the UCT. In the TRC, this involves including the full measure cost (incremental for lost opportunities, full cost for retrofits), which is generally substantially higher than the incentive cost included within the UCT. The TRC does include one additional value stream that the UCT does not, non-energy impacts. This test is fully incorporated into LoadMAP and prepared for Cascade to use in the event a "fully balanced" TRC is identified.

In accordance with Council methodology, these impacts must be quantified and monetized, which means impacts such as personal comfort, which are difficult to assign a value to, are not included. What this does include are additional savings such as water reductions due to low-flow measures or less detergent required to wash clothes in a high-efficiency clothes washer. AEG has incorporated these impacts as they are available in source documentation, such as RTF UES workbooks. We estimated TRC non-energy impacts in the following ways:

- Include quantified and monetized non-energy impacts present in Council and RTF workbooks
- Incorporate NEIs directly into the avoided cost (e.g. 10% conservation credit, carbon adders, and natural gas risk adders)
- Account for the presence of secondary heating when calibrating energy models (e.g. apply a calibration credit to many space heating savings)
- Account for non-gas impacts, such as cooling savings within a weatherization program or lighting savings from a retrocommissioning program

These impacts are quantified within the LoadMAP models and utilized to assess achievable economic potential under the TRC. Results of this analysis may be found in Sections 5 and 6 of this report.

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