2023 NW Natural Washington Conservation Potential Assessment

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EXECUTIVE SUMMARY

In early 2023, NW Natural selected Applied Energy Group (AEG) to conduct an assessment of available conservation potential in its Washington service territory as an update to the Conservation Potential Assessment (CPA) AEG completed for NW Natural in 2021. The assessment uses standard industry and Northwest regional methodologies to develop reliable estimates of technical, achievable technical, and achievable economic potential from two different cost-effectiveness perspectives for the period from 2024-2050. The assessment was performed in collaboration with NW Natural and Energy Trust of Oregon staff using information specific to NW Natural's customers and existing energy efficiency programs wherever possible.

This study provides important information for planning NW Natural's next energy efficiency program cycles. This study:

- Describes and characterizes the customer base by energy source, sector, customer segment, and end use. At a glance, it is possible to see where the opportunities for program savings are likely to come from.
- Defines a baseline projection of energy use by end use against which savings can be measured. This baseline takes into account existing and planned appliance standards and building codes, as well as naturally occurring efficiency. A key component of this CPA update was explicitly accounting for impacts of the 2021 Washington State Energy Code (WSEC 2021) on the available energy efficiency potential.
- Evaluates a diverse set of energy efficiency measures in all three customer sectors.
- Estimates the total amount of savings possible from cost-effective measures; these are savings above and beyond those already included in the baseline projection, as described in Chapter 4 of this report.

The results presented in this report are estimates based on the best information available at the time of the analysis, and we expect variation in outcomes in the real world. This fact gives energy efficiency administrators the opportunity to deviate from total annual values or measure specific values developed in this study as administrators design programs and commit to annual program targets, as well as gather more territory-specific information about baselines, saturation, and demand for program offerings.

Table ES-1 summarizes the results of this study at a high level. AEG analyzed potential for NW Natural's sales customers[1] across the residential, commercial, and industrial market sectors. As part of this study, AEG estimated achievable economic potential from both the total resource cost (TRC) and utility cost test (UCT) perspectives. The TRC perspective 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)

TABLE ES-1 SUMMARY OF ENERGY EFFICIENCY POTENTIAL (THOUSAND THERMS)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2035	2040	2050
Reference Baseline	86,056	85,329	84,624	82,162	79,092	76,123	70,733
Cumulative Savings (thousand therms)							
Achievable Economic TRC Potential	355	720	1,115	3,099	6,224	9,223	11,129
Achievable Economic UCT Potential	518	1,043	1,597	4,137	7,583	10,736	12,658
Achievable Technical Potential	585	1,180	1,807	4,686	8,526	11,940	13,950
Technical Potential	1,168	2,335	3,532	8,442	13,883	17,305	18,809
Cumulative Savings (% of Baseline)							
Achievable Economic TRC Potential	0.4%	0.8%	1.3%	3.8%	7.9%	12.1%	15.7%
Achievable Economic UCT Potential	0.6%	1.2%	1.9%	5.0%	9.6%	14.1%	17.9%
Achievable Technical Potential	0.7%	1.4%	2.1%	5.7%	10.8%	15.7%	19.7%
Technical Potential	1.4%	2.7%	4.2%	10.3%	17.6%	22.7%	26.6%

Table ES-2 presents the cumulative achievable economic potential by sector from the Total Resource Cost (TRC) test perspective. The residential sector accounts for the majority of the long-term potential, driven largely by that sector's relative share of baseline consumption for sales customers.

TABLE ES-2 CUMULATIVE TRC ACHIEVABLE ECONOMIC POTENTIAL (THOUSAND THERMS) BY SECTOR

Sector	2024	2025	2026	2030	2035	2040	2050
Residential	191	387	607	1,824	3,986	6,179	7,500
Commercial	147	300	459	1,160	2,054	2,814	3,384
Industrial	16	33	49	114	185	231	245
Total	**355**	**720**	**1,115**	**3,099**	**6,224**	**9,223**	**11,129**

[1] AEG also estimated potential for NW Natural's transportation customers as a separate analysis. Those results are not included in the summary, but are presented in Chapter **Error! Reference source not found.** of this report.

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1| INTRODUCTION

This report documents the results and methodology the 2024-2050 Conservation Potential Assessment (CPA), performed by Applied Energy Group (AEG) for NW Natural's service territory in southwest Washington. This new iteration of the CPA refreshes key aspects of the 2021 CPA to assist NW Natural in developing the next iteration of its integrated resource plan (IRP) and program plans. Throughout this study, AEG worked with NW Natural to understand the baseline characteristics of its Washington service territory, including a detailed understanding of energy consumption in the territory, the assumptions and methodologies used in NW Natural's official load forecast, and recent programmatic accomplishments. Figure 1-1 presents a map of NW Natural's service territory.[2]

FIGURE 1-1 NW NATURAL'S SERVICE TERRITORY (COURTESY NW NATURAL)

The primary objective of this study was to develop independent and credible estimates of energy efficiency potential that can be achieved within NW Natural's Washington service territory using accepted regional inputs and methodologies. This included estimating technical, achievable technical, then achievable economic potential using ramp rates from the Northwest Power and Conservation Council's (Council's) 2021 Power Plan as the starting point for all achievability assumptions. The study also utilizes energy efficiency measure assumptions consistent with 2021 Power Plan supply curves, Regional Technical Forum (RTF) measure workbooks, and information from Northwest Energy Efficiency Alliance (NEEA's) market research initiatives where appropriate for use in natural gas planning studies.

To perform this assessment, AEG customized its LoadMAP end-use planning tool with data specific to NW Natural's Washington service territory, supplemented with data from other regional and national

[2] This assessment was specific to NW Natural's Washington service territory and did not attempt to estimate conservation potential for NW Natural's Oregon service territory.

sources. This includes a detailed snapshot of how NW Natural's Washington customers use energy in the base year of the study (2019) and recalibrated to 2022 actuals, assumptions on future customer growth from NW Natural's load forecasting team, and measure assumptions using NW Natural primary data, regional research, and other well-vetted industry sources from around the nation. AEG then developed an independent estimate of achievable, cost-effective energy efficiency potential within NW Natural's Washington service territory between 2024 and 2050.

Study Considerations

Below, AEG notes a number of items that came up during the development of this study based on feedback from NW Natural staff, 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 the previous assessment, 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.
- **Impact of Codes and Legislation:** The past few years have seen several pieces of legislation affecting natural gas use at the state and federal levels. AEG worked with NW Natural to estimate the impacts of state codes and Washington's Climate Commitment Act (CCA) on natural gas additions on consumption and potential savings. In addition, through conversations with NEEA, NW Natural, and via AEG's other work in Washington, we developed a set of assumptions regarding how builders were likely to modify their choices for new construction code credits based on the 2021 Washington State Energy Code (WSEC 2021) which takes effect July 1, 2023.
- **Understanding Residential Potential by Customer Income Level:** Given the increased interest in the low-income customer segment specifically, the CPA includes income level analysis for the residential sector, allowing AEG to present results separately for low, moderate, and above-median income groups. The analysis was created for the previous CPA and was updated with existing customers and customer forecasts from new NW Natural customer information. The 2023 CPA retains the robust segmentation analysis from the 2021 CPA.

Summary of Report Contents

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

Main Report

- **Analysis Approach and Data Development.** Detailed description of AEG's approach to conducting NW Natural's 2024-2050 CPA and documentation of primary and secondary sources used.

- **Market Characterization and Market Profiles.** Characterization of NW Natural's Washington service territory in the base year of the study (2019) including total consumption, number of customers and market units, and energy intensity recalibrated to 2022 actual customers and consumption. This also includes a breakdown of the energy consumption for residential, commercial, 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 2022 sales and NW Natural's official, weather-normalized econometric forecast and then varied to include the impacts of future federal standards, impacts of the 2021 Washington State Energy Code on new construction, and future technology purchasing decisions.
- **Sector-Level Energy Efficiency Potential.** Summary of energy efficiency potential for NW Natural's entire Washington service territory for selected years between 2024 and 2050.[3] Potential is summarized first across all sectors for sales customers then separately for each market sector within NW Natural's service territory, including residential, commercial, industrial customers.
- **Transportation Baseline and Efficiency Potential.** Projection of energy consumption and energy efficiency potential for transportation customer segments. Transportation customers are non-residential natural gas consumers, typically large industrial users, who purchase natural gas from an alternate supplier, but use NW Natural's distribution system to deliver the fuel to their sites. Because these customers are not currently eligible to participate in NW Natural's energy efficiency programs, AEG kept their potential distinct from the potential within sales customer segments presented in Chapter 5| .

Appendix

- **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.

Abbreviations and Acronyms

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

[3] To align with NW Natural's Integrated Resource Plan timeframe, this assessment forecasts savings potential over a 27-year horizon, instead of the typical 20-year period.

TABLE 1-1 EXPLANATION OF ABBREVIATIONS AND ACRONYMS

Acronym	Explanation
AEO	Annual Energy Outlook Forecast Developed by EIA
AFUE	Annual Fuel Utilization Efficiency
BEST	AEG's Building Energy Simulation Tool
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 the analysis approach taken for the study and the data sources used to develop the potential estimates.

Overview of Analysis Approach

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

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 2050.
3. Reviewed high priority residential and commercial measures from 2021 CPA characterization, updating to the best available information.
4. Estimated technical, achievable technical, and achievable economic energy savings at the measure level for 2024-2050. Achievable economic potential was assessed using both the Total Resource Cost (TRC) and Utility Cost Test (UCT) screens.

Comparison with Northwest Power & Conservation Council Methodology

As with the previous CPA, this study uses 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 NW Natural. We discuss this in Appendix A of this report.

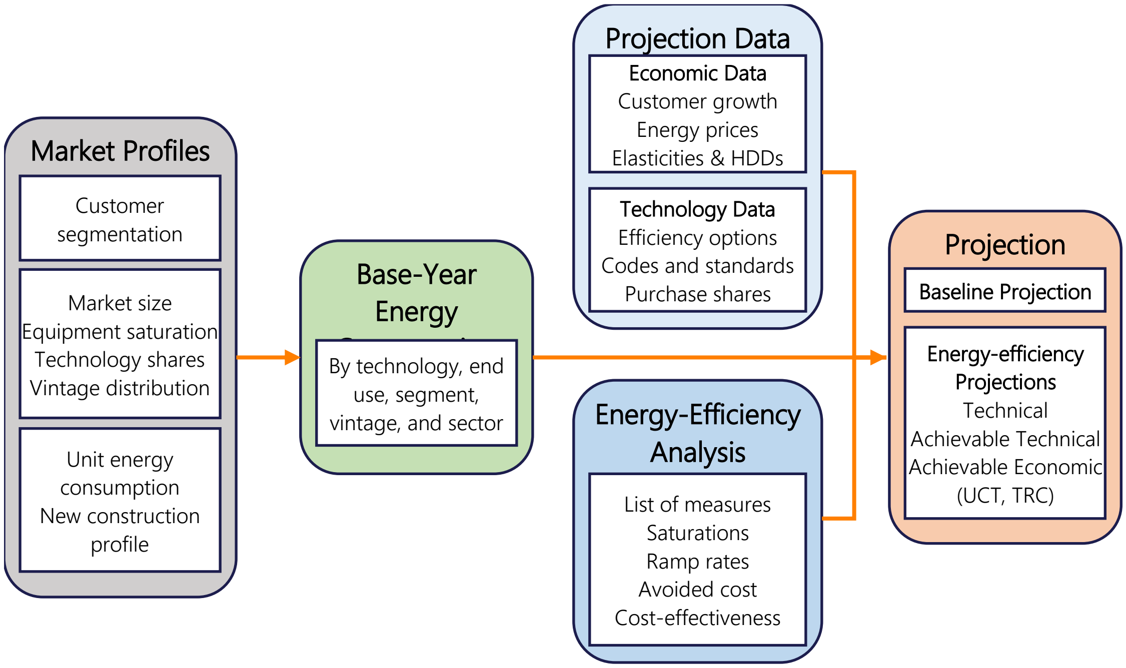
Among other aspects, consistent with the Council's methodology, this approach involves using:

- **Data Sources**: regional surveys, market research, and assumptions
- **Measures and Assumptions**: 2021 Power Plan supply curves and RTF work products
- **Potential Factors**: 2021 Power Plan ramp rates
- **Levels of Potential**: Technical, Achievable Technical, and Achievable Economic
- **Cost-effectiveness Approaches:** assessed potential under the UCT as well as the TRC test, including non-energy impacts that have been quantified and monetized within the TRC. Note, avoided costs for the transportation potential analysis (Chapter 6|) exclude the energy commodity cost because NW Natural does not pay for the natural gas for these customers.
- **Conservation Credits:** applies a 10% conservation credit to avoided energy costs, consistent with the preference for conservation specified in the Northwest Power Act. This credit was embedded in the avoided costs provided by NW Natural.

LoadMAP Model

For this analysis, AEG used its Load Management Analysis and Planning tool (LoadMAP™) to develop both the baseline projection and the estimates of potential. Consistent with the segmentation scheme and the market profiles we describe below, the LoadMAP model provides projections of baseline energy use by sector, segment, end use, and technology for existing and new buildings. It also provides forecasts of total energy use and energy-efficiency savings associated with the various types of potential.[4]

FIGURE 2-1 LOADMAP ANALYSIS FRAMEWORK



Types of Potential Included in the Study

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

TABLE 2-1 LEVELS OF POTENTIAL

Potential Type	Definition
Technical	Everyone chooses the most efficient option regardless of cost at time of equipment replacement or measure adoption.
Achievable Technical	A modified technical potential that accounts for likely measure adoption
Achievable Economic	A subset of achievable technical potential that includes only cost-effective measures

Market Characterization

To estimate the savings potential from energy-efficiency measures, it is necessary to understand how much energy is used today and what equipment is currently in service. This market characterization begins with a segmentation of NW Natural'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 NW Natural, augmenting with secondary sources as necessary.

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

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 (building types, end uses, and other dimensions) that are relevant in NW Natural's service territory. The segmentation scheme for this project is presented in Table 2-2.

TABLE 2-2 OVERVIEW OF NW NATURAL ANALYSIS SEGMENTATION SCHEME

Dimension	Segmentation Variable	Description
1	Sector	Residential, Commercial, Industrial, Transportation
2	Segment	Residential: Single Family, Multi-Family, Manufactured Home, further divided into 3 income groups Commercial: Office, Retail, Restaurant, Grocery, School, Healthcare, Lodging, Warehouse, Miscellaneous Industrial: Firm and Interruptible, with end uses informed by industries Transportation: Same segments as Commercial with additional Industrial segments (Electronics Manufacturing, Lumber & Wood, etc.)
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, AEG then performed a high-level market characterization of natural gas sales in the base year, 2019. NW Natural provided detailed energy consumption data along with market segmentation analysis previously conducted by the Energy Trust of Oregon, which AEG combined to produce the final base year totals used in the CPA. These totals for natural gas use and customers are allocated to the various sectors and segments such that the total customer count and energy consumption matched NW Natural's system totals in 2019.[5] This information provided control totals at a sector level for calibrating the LoadMAP model to known data for the base-year.

Market Profiles

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

Baseline Load Projection

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

[5] 2019 was chosen as the base year as it was deemed to be more reflective of normal conditions than 2020, which was heavily affected by the COVID-19 pandemic.

reference baseline in alignment with NW Natural's long-term demand forecast, with some modifications to account for known future conditions, including impacts from WSEC 2021 on residential and commercial new construction.

AEG refined the baseline projection of annual natural gas use for 2024-2050 from the prior CPA to align with NW Natural's 2022 actual totals. The 2021 CPA reference case forecast was updated with the latest iteration of NW Natural's IRP customer growth projections and weather data, and market based (naturally occurring) efficient purchase shares were reviewed considering changes to the efficiency options provided for equipment replacement.

Inputs to the baseline projection include:

- Current economic and load growth forecasts (i.e., customer growth, climate change assumptions)
- Trends in fuel shares and equipment saturations
- Existing and approved changes to building codes and equipment standards

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

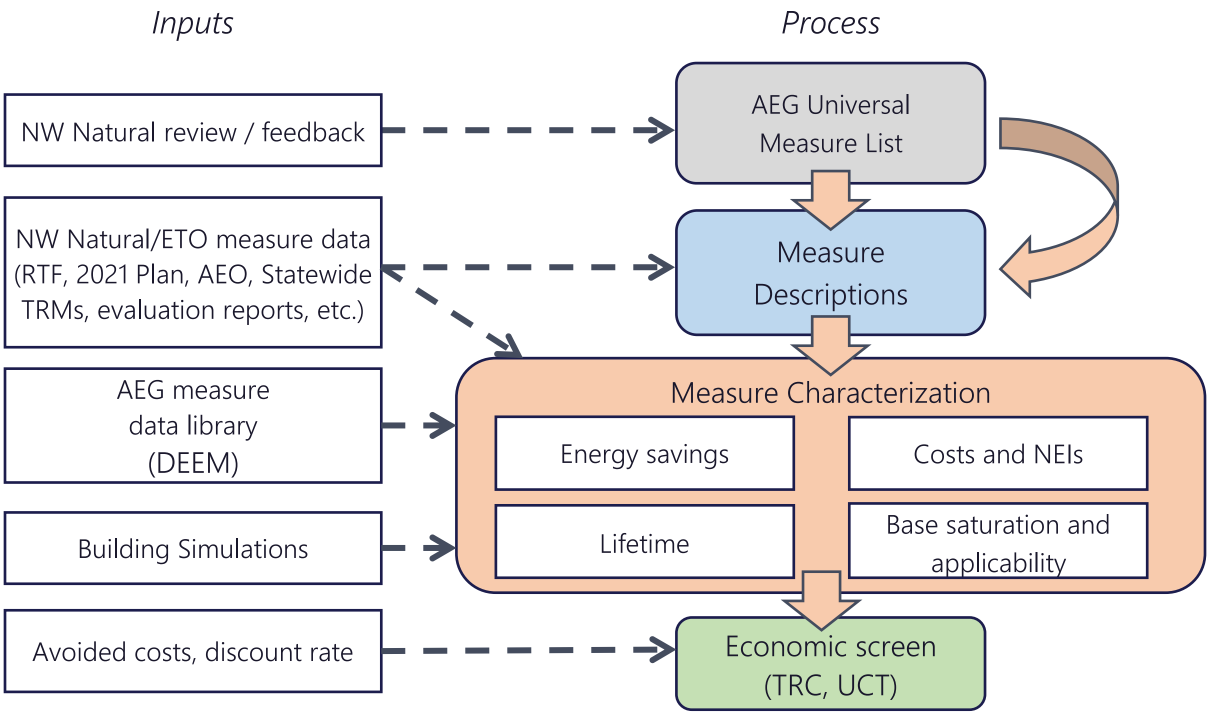
Energy Efficiency Measure Development

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. To develop NW Natural's measure list, AEG used datasets provided by NW Natural and the Energy Trust of Oregon.

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 is characterized with appropriate savings, costs, and other attributes; then cost-effectiveness screening is performed. NW Natural provided feedback during each step of the process to ensure measure assumptions and results lined up with real-world programmatic experience.

We compiled a robust list of conservation measures for each customer sector, drawing upon NW Natural and the Energy Trust of Oregon's program experience, AEG's own measure databases and building simulation models, and secondary sources, primarily the Regional Technical Forum's (RTF) UES measure workbooks and the 2021 Power Plan's electric 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.

FIGURE 2-2 APPROACH FOR ENERGY EFFICIENCY MEASURE CHARACTERIZATION AND 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 0.95) 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
  - Behavioral

AEG developed a preliminary list of efficiency measures, which was reviewed with NW Natural's project team and with the Energy Trust of Oregon to ensure a robust field of options and consistency with program activity where applicable. Once we assembled the list of measures, the AEG team assessed their energy-saving characteristics as well as incremental cost, service life, non-energy impacts, and other performance factors.

For this study, work from the 2021 CPA measure development was retained except for measures identified by AEG and NW Natural requiring an update based on updated technology and non-equipment assumptions made available since the completion of the 2021 CPA.

Calculation of Energy Conservation Potential

The approach we used for this study to calculate the energy conservation potential adheres to the approaches and conventions outlined in the National Action Plan for Energy-Efficiency (NAPEE) *Guide for Conducting Energy Efficiency Potential Studies*.[6] This document represents credible and comprehensive industry best practices for specifying energy conservation potential. Three types of potential were developed as part of this effort: technical potential, achievable technical potential, and achievable economic potential (using the TRC and UCT perspectives). 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. AEG first computes 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 applicability 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. The second upgrades pre-existing insulation if it falls under a certain threshold. We used regional market research data to ensure exclusivity of these two options. NEEA's RBSA 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 insulation measure, but not the other.

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

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, phased in over a more realistic time frame, 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 Power 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 Chapter 5.

Screening Measures for Cost-Effectiveness

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

This study uses the TRC test as the primary cost-effectiveness metric, which compares the lifetime energy and non-energy benefits of each applicable measure with the measure's incremental costs, lifetime operations and maintenance costs, and administrative costs incurred by the utility. The lifetime energy benefits are calculated by multiplying the annual energy savings for each measure by NW Natural'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 and on an annual basis, considering changing savings and cost data over time. Thus, it is possible for measures to 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, to determine the therms 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 respective economic screen.

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:

- NW Natural/Energy Trust of Oregon-provided data
- Pacific Northwest regional data
- AEG's databases and analysis tools
- Other secondary data and reports

NW Natural and Energy Trust of Oregon Data

Our highest priority data sources for this study were those that were specific to NW Natural. This data is specific to NW Natural's Washington service territory and is an important consideration when customizing the model for NW Natural's Washington market. This is best practice when developing CPA baselines when the data are available.

- **NW Natural customer and system totals.** NW Natural provided billing data summaries and sector-level totals for development of customer counts and energy use for each sector. These data were used to develop a detailed estimate of energy consumption within NW Natural's Washington service territory.
- **NW Natural presence of equipment estimates.** NW Natural conducted billing-level analysis of its customer databases to screen for the presence of natural gas space and water heating among its residential customers and space heating for commercial customers. This provided an excellent benchmark to adjust NEEA survey data (see below) to better represent NW Natural customers specifically.
- **Load forecasts.** NW Natural provided forecasts, by sector, of energy consumption, customer counts, weather actuals for 2019, and projected heating degree days (HDDs) for the study period, including assumed climate trends over the period. For the 2023 CPA, NW Natural provided updated customers, consumption, and forecasts for 2021 and 2022 which AEG recalibrated to reflect current NW Natural load.
- **Economic information.** NW Natural provided a discount rate and avoided cost forecasts by sector and end use.
- **Peak Usage Factors.** NW Natural provided the peak day and peak hour usage factors used for calculating peak savings for the day and the hour based on annual savings. These are the same usage factors used for calculating the avoided cost components that vary by end use.
- **NW Natural's Washington program data via Energy Trust of Oregon.** The Energy Trust of Oregon provided information about past and current programs they operate in NW Natural's Washington service territory, including program descriptions, goals, and measure achievements to date. NW Natural also provided a comprehensive list of measure costs, developed from measure installations within actual NW Natural conservation programs as per guidance they received from a previous third-party program evaluation.

Pacific 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 Power Plan and Regional Technical Forum workbooks.** To develop its Power Plan, the Council maintains workbooks with detailed information about measures. This was used as a primary data source when NW Natural-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, 2019 Commercial Building Stock Assessment,** *https://neea.org/resources/cbsa-4-2019-final-report*
- **Northwest Energy Efficiency Alliance, 2014 Commercial Building Stock Assessment,** *https://neea.org/resources/2014-cbsa-final-report*

- **Northwest Energy Efficiency Alliance, 2014 Industrial Facilities Site Assessment,** *https://neea.org/resources/2014-ifsa-final-report*

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

AEG Data

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

- **AEG Energy Market Profiles.** For more than 10 years, AEG 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 Conservation 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 energy efficiency 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 kept data from the 2019 AEO to reflect the study's base year.
- **American Community Survey.** 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.** Weather data from NOAA's National Climatic Data Center for Vancouver, WA.
- **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 NW Natural's Washington territory.

Application of Data to the Analysis

This section provides additional detail on how each of the data sources described above were used for each step of the study.

Data Application for Market Characterization

To construct the high-level market characterization of natural gas consumption and market size units (households for residential, floor space for commercial, and employees for industrial), AEG primarily used NW Natural's customer usage data, secondary data from AEG's Energy Market Profiles database, and Energy Trust measure characterizations.

Data Application for Market Profiles

1. 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:
2. Develop control totals for each segment. These include market size, segment-level annual natural gas use, and annual intensity. Control totals were based on NW Natural's actual sales and customer-level information found in NW Natural's customer billing database.
3. Develop existing appliance saturations and the energy characteristics of appliances, equipment, and buildings using NW Natural's end-use analysis, NEEA's 2016 RBSA, 2019/2014 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.
4. Ensure calibration to NW Natural control totals for annual natural gas sales in each sector and segment.
5. Compare and cross-check with other recent AEG studies.
6. Work with NW Natural 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	NW Natural 2019 weather normalized sales NW Natural customer account database
Annual Intensity	Residential: Annual use per household Commercial: Annual use per square foot Industrial: Annual use per employee	NW Natural customer account database AEG's Energy Market Profiles AEO 2019 – Pacific Region Other recent studies
Appliance/Equipment Saturations	Fraction of dwellings with an appliance/technology Percentage of C&I floor space/employment with equipment/technology	NW Natural 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 NW Natural 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

Model Inputs	Description	Key Sources
Efficiency Options for Each Technology	List of available efficiency options and annual energy use for each technology	Energy Trust of Oregon program data in NW Natural WA service territory AEG DEEM AEO 2019 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 and conversions in residential and C&I sectors	NW Natural load forecast
Equipment Purchase Shares for Baseline Projection	For each equipment/technology, purchase shares for each efficiency level; specified separately for existing equipment replacement and new construction	Shipments data from AEO and ENERGY STAR AEO 2019 regional forecast assumptions[7] Appliance/efficiency standards analysis
Utilization Model Parameters	Price elasticities, elasticities for other variables (income, weather)	EPRI's REEPS and COMMEND models

- **Equipment Standards.** In addition, assumptions were incorporated for known future equipment standards as of June 2023 as shown in Table 2-5 and Table 2-6. These tables extend through 2025, after which all standards are assumed to hold steady.
- **Building Codes for New Construction.** The 2021 CPA assumed new construction would comply with the mandatory portions of the 2018 Washington State Energy Code. The 2023 CPA assumes new construction complies 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 NW Natural, NEEA, and AEG's other clients in the region, we developed a set of assumptions regarding likely credit choices for new construction compliance.

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

TABLE 2-5 RESIDENTIAL NATURAL GAS EQUIPMENT FEDERAL STANDARDS[8]

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
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 NW Natural analysis.

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

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.	– Energy Trust of Oregon program data in NW Natural WA service territory – NWPCC workbooks, RTF – AEG BEST – AEG DEEM – AEO 2017 – 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.	– NW Natural/Energy Trust of Oregon program data – NWPCC workbooks, RTF – AEG DEEM – AEO 2017 – RS Means – Other secondary sources
Measure Lifetimes	Estimates derived from the technical data and secondary data sources that support the measure demand and energy savings analysis.	– NWPCC workbooks, RTF – AEG DEEM – AEO 2017 – 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 – 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 (2021) dollars. The analysis applied NW Natural's long-term real discount rate of 3.39% equal to NW Natural's real after-tax weighted average cost of capital (WACC) for Washington.

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.

3| MARKET CHARACTERIZATION AND MARKET PROFILES

In this section, we describe how customers in NW Natural's Washington service territory use natural gas in the recalibrated year of the study, 2022, beginning with a high-level summary of energy use across all sectors and then delving into each sector in more detail.

A market profile includes the following elements:

- **Market size** is a representation of the number of customers in the segment. For the residential sector, the unit we use is number of households. In the commercial sector, it is floor space measured in square feet. For the industrial sector, it is number of employees. For transportation, it is a combination of floor space for commercial transportation and number of employees for industrial transportation.
- **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 the fraction of each building that is conditioned by the end use (i.e., space heating).
  - The whole-building approach measures shares of space in a building with an end use regardless of the portion of each building that is served by the end use. Examples are commercial refrigeration and food service, 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 2022. 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 (or mTherms).

Overall Energy Use Summary

Total weather normalized natural gas consumption for sales customers across all sectors for NW Natural's Washington service territory in 2022 was 106,518 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 56%, followed by the commercial sales customers at 22%. Industrial sales customers account for 4% of usage while transportation (including commercial and industrial) account for 18% of annual energy use.

Figure 3-1 Sector-Level Natural Gas Use in Normalized Base Year 2022 (annual therms, percent)

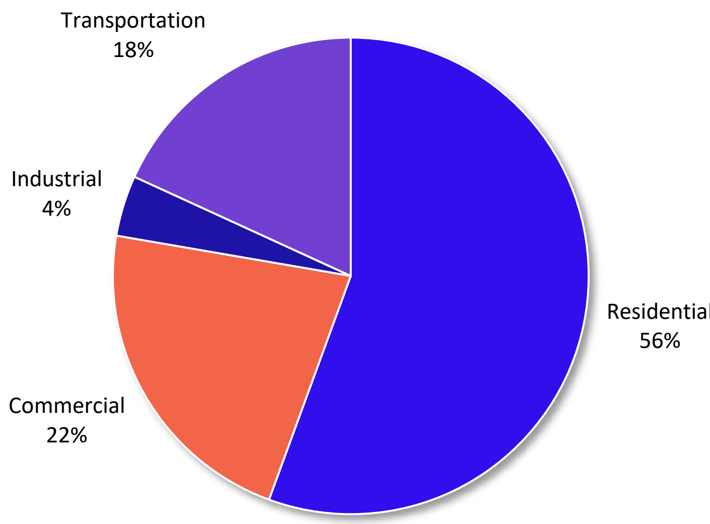


Table 3-1 NW Natural Sector Control Totals, 2022 Weather Normalized

Sector	2022 Normalized Gas Sales (thousand therms)	% of Total Usage
Residential	59,208	56%
Commercial	23,563	22%
Industrial	4,389	4%
Transportation	19,358	18%
Commercial	*2,224*	*2%*
Industrial	*17,134*	*16%*
Total	**106,518**	**100%**

Residential Sector

The total number of households and gas sales for the service territory were obtained from NW Natural's actual sales for 2022. Details, including number of households and 2022 natural gas consumption for the residential sector can be found in Table 3-2 below. In 2022, there were 87,407 households in the NW Natural territory that used a total of over 59 mTherms, resulting in an average use per household of 677 therms per year. This is an important number for the calibration process.

These values have been weather normalized to account for differences in the actual heating degree days for 2022 compared to normal weather. Degree days for the conversion were provided by NW Natural's forecast department.

TABLE 3-2 RESIDENTIAL NATURAL GAS USE BY SEGMENT, 2022 WEATHER NORMALIZED

Segment	Households	Gas Sales (thousand therms)	% of Total Usage	Avg. Use / Household (therms)
Single Family	78,040	55,447	94%	710
Multi-Family	8,928	3,449	6%	384
Manufactured Home	439	312	1%	711
Total	**87,407**	**59,208**	**100%**	**677**

Residential Income Group Analysis

Given increased interest in reaching low-income customer segments in NW Natural's Washington service territory, income-level analysis for the residential sector was included in the scope of this assessment. To protect customer privacy, data on NW Natural's specific customers was limited to their ZIP code and household natural gas use.

Income Group Definitions

AEG worked with NW Natural to develop suitable definitions of each income group to align with program eligibility and other income eligibility criteria in alignment with low-income programs in Washington. The thresholds of household income for low- and moderate-income designations are shown in Table 3-3 below. The low-income threshold corresponds with 200% of the Federal Poverty Level (FPL) which is also the eligibility cutoff for the Washington 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. The definitions below are retained from the 2021 CPA.

TABLE 3-3 DEFINITIONS OF INCOME GROUPS BY HOUSEHOLD SIZE (UP TO)

Household 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 NW Natural customers in each of the income groups, AEG mapped address data or NW Natural 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 NW Natural customers reside. These distributions by housing type and income level serve to split apart the housing types from the original 2019 market profile.

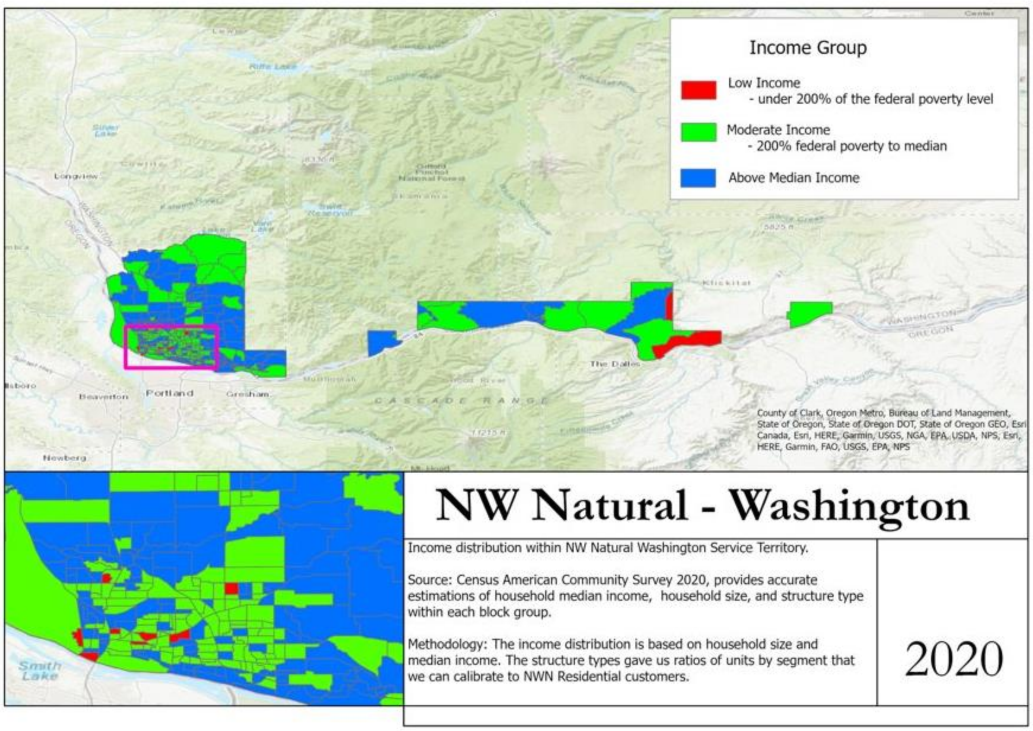
As shown in Table 3-4 below, slightly more than half of NW Natural's Washington residential customers have household incomes at or above the median for Washington. The moderate-income group is the next largest with 46.2% of households, while just 1.9% of households fall into the low-income group.

TABLE 3-4 CUSTOMER DISTRIBUTION BY INCOME GROUPINGS AND HOUSING TYPE (% OF HOUSEHOLDS)

Segment	Above Median	Moderate	Low Income	Total
Single Family	54.0%	44.6%	1.4%	**100%**
Multi-Family	35.1%	59.0%	5.9%	**100%**
Manufactured Homes	38.8%	59.8%	1.4%	**100%**
Total	**52.0%**	**46.2%**	**1.9%**	**100%**

The map in Figure 3-2 shows the distribution of different income groups through NW Natural's service territory.

FIGURE 3-2 INCOME GROUP MAP



Energy Consumption by Income Group

Once the percent of customers in each housing type and income group was known, AEG used RBSA data 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 with gas service from NW Natural have lower presence of gas water heat, but 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 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 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 3-5 shows the residential control totals from above after distributing base-year households and natural gas consumption based on the income group analysis.

TABLE 3-5 RESIDENTIAL NATURAL GAS USE BY INCOME LEVEL, 2022 WEATHER NORMALIZED

Segment	Income Group	Households	% of All Homes	Thousand therms	Therms / Household
Single Family	Above Median	42,104	48.2%	31,644	752
	Moderate Income	34,818	39.8%	23,198	666
	Low Income	1,118	1.3%	604	541
Multi-Family	Above Median	3,136	3.6%	1,322	422
	Moderate Income	5,265	6.0%	1,967	374
	Low Income	528	0.6%	160	303
Manufactured Homes	Above Median	170	0.2%	130	766
	Moderate Income	262	0.3%	178	679
	Low Income	6	0.0%	3	551
Total		**87,407**	**100.0%**	**59,208**	**677**

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 79% 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. Natural gas backyard grills and pool heaters fall into this category.

FIGURE 3-3 RESIDENTIAL NATURAL GAS USE BY END USE, 2022

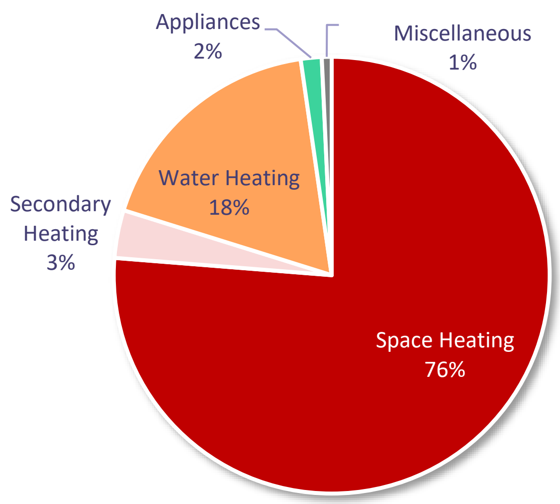
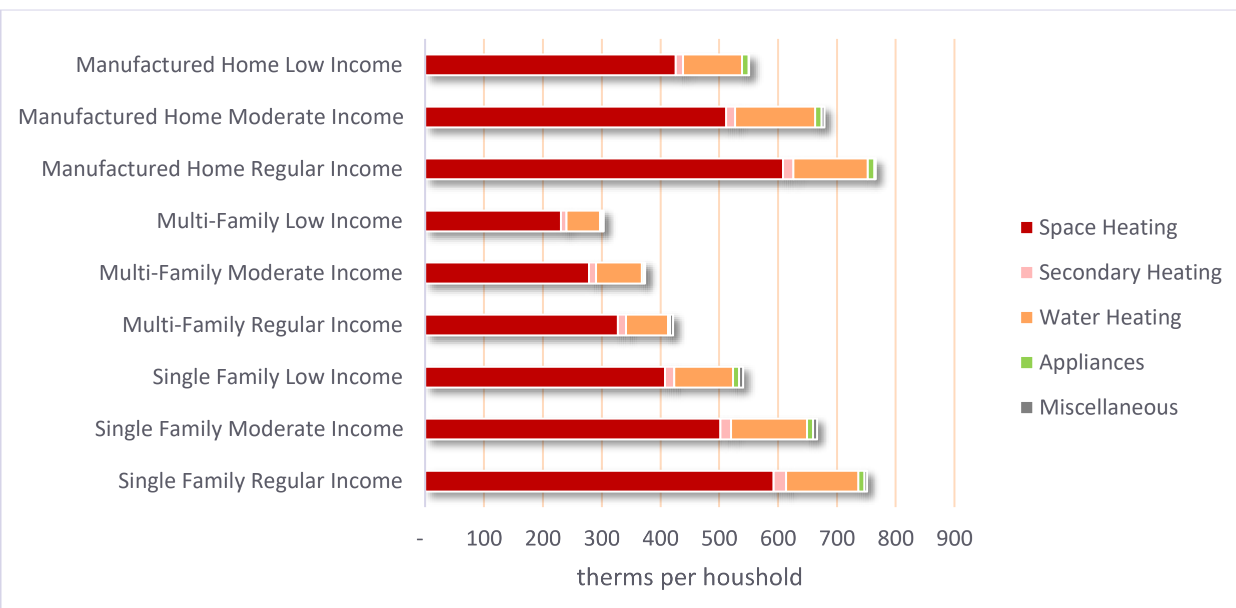


Figure 3-4 presents average residential natural gas intensities by end use and housing type. Manufactured homes consume more energy than other segments, primarily due to an older housing stock with inefficient building envelopes and heating systems. Prior to 1976, no energy code for manufactured homes existed to ensure a minimum level of efficiency, resulting in poorly constructed energy intensive homes. Single family regular income homes also consume substantially more natural gas for 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 loa ds. Higher water heating consumption can often be attributed to having more people in the household, which increases the demand for hot water.

FIGURE 3-4 RESIDENTIAL GAS USAGE INTENSITY BY END USE AND SEGMENT, 2022 (ANNUAL THERMS/HH)



The market profile for an average home in the residential sector is presented in Table 3-6below. 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 3-6 AVERAGE NATURAL GAS MARKET PROFILE FOR THE RESIDENTIAL SECTOR, 2022

End Use	Technology	Saturation	UEC (therms)	Intensity (therms/HH)	Usage (thousand therms)
Space Heating	Furnace	86%	575	497	43,432
	Boiler	5%	497	26	2,285
Secondary Heating	Fireplace	19%	99	19	1,673
Water Heating	Water Heater (<= 55 gal)	80%	147	117	10,198
	Water Heater (> 55 gal)	2%	149	3	296
Appliances	Clothes Dryer	14%	18	3	226
	Stove/Oven	38%	18	7	614
Miscellaneous	Pool Heater	0%	77	0	23
	Miscellaneous	100%	5	5	461
Total				**677**	**59,208**

Commercial Sector

The total number of commercial sales accounts and natural gas sales for the service territory were obtained from NW Natural's customer account data, distributed according to segment tags in the billing system and Energy Trust's prior analysis of non-residential segmentation for previous NW Natural studies.

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 NW Natural's database. The CBSA intensities corresponded to spaces with slightly lower natural gas saturations than NW Natural's database, so AEG increased intensities proportionally based on the additional presence of natural gas-consuming equipment.

TABLE 3-7 COMMERCIAL CONTROL TOTALS, 2022

Segment	Description	Intensity (therms/Sq Ft)	Usage (thousand therms)
Office	Traditional office-based businesses including finance, insurance, law, government buildings, etc.	0.40	4,001
Retail	Department stores, services, boutiques, strip malls etc.	0.28	5,688
Restaurant	Sit-down, fast food, coffee shop, food service, etc.	4.72	4,402
Grocery	Supermarkets, convenience stores, market, etc.	0.47	1,067
College	College, university, trade schools, etc.	0.74	451
School	Day care, pre-school, elementary, secondary schools	0.74	3,204
Hospital	Hospital, urgent care centers, etc.	0.68	1,922
Other Health	Doctor/Dental office, therapy clinics, health practitioner office, etc.	0.66	1,156
Lodging	Hotel, motel, bed and breakfast, etc.	1.46	804

Segment	Description	Intensity (therms/Sq Ft)	Usage (thousand therms)
Warehouse	Large storage facility, refrigerated/unrefrigerated warehouse	0.25	203
Miscellaneous	Catchall for buildings not included in other segments, includes churches, recreational facilities, public assembly, correctional facilities, etc.	0.33	667
Total		0.50	23,563

Figure 3-5 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 2022 are retail, restaurant, offices, and schools, in descending order. As expected, the highest intensity segment is restaurant. This is based on the high presence of food preparation equipment.

FIGURE 3-5 COMMERCIAL NATURAL GAS USE BY SEGMENT, 2022

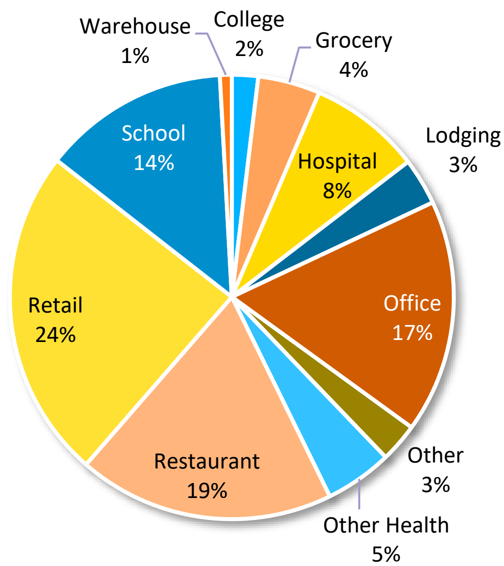


Figure 3-6 shows the distribution of natural gas consumption by end use for the entire commercial sector. Space heating is the largest end use, followed by water heating and food preparation. The miscellaneous end use is quite small, as expected.

FIGURE 3-6 COMMERCIAL NATURAL GAS USE BY END USE, 2022

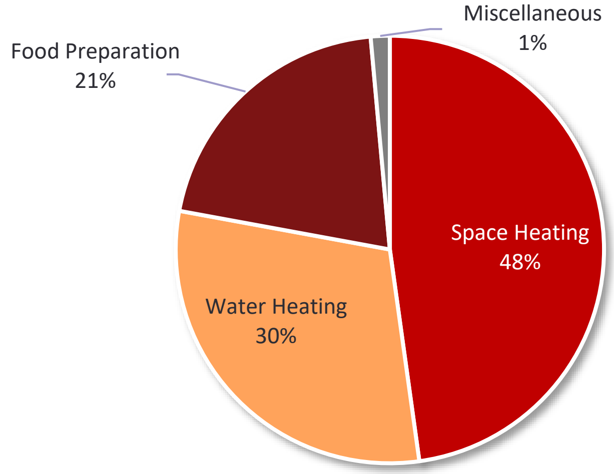
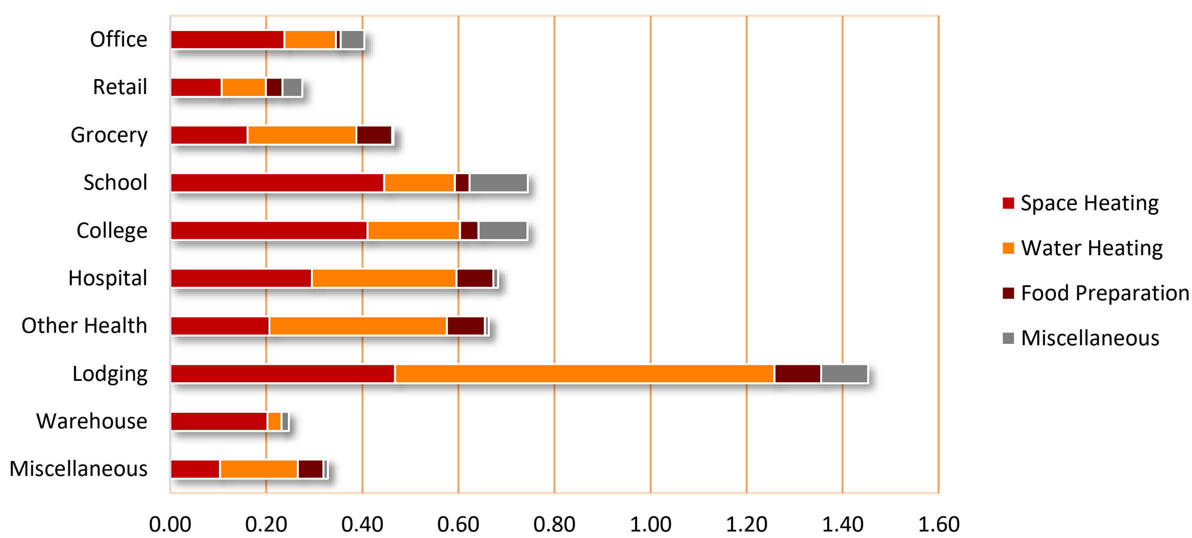
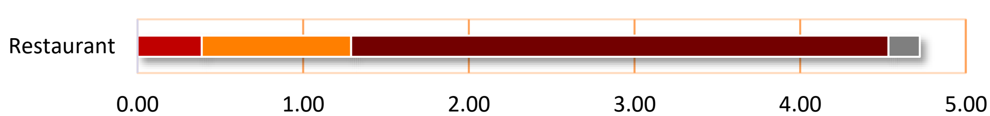


Figure 3-7 presents average commercial natural gas intensities by end use and segment. Due to large food preparation loads, the restaurant segment has a significantly higher intensity than other commercial segments. To allow the distribution of end uses to be visible for all segments, restaurant is displayed on a separate axis.

FIGURE 3-7 COMMERCIAL GAS USAGE INTENSITY BY END USE AND SEGMENT, 2022 (ANNUAL THERMS/SQ. FT)



Restaurant intensity is significantly higher than all other segments due to large impact from Food Preparation which is the main contributor to energy annual energy use. Therefore, we separated Restaurant from the visual above and provided a clearer view below.



The total market profile for an average building in the commercial sector is presented in Table 3-8 below. NW Natural 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 COMMERCIAL NATURAL GAS MARKET PROFILE, 2022

End Use	Technology	Saturation	EUI (therms/sq. ft.)	Intensity (therms/sq. ft.)	Usage (thousand therms)
Space Heating	Furnace	55.5%	0.13	0.07	3,350
	Boiler	26.1%	0.48	0.12	5,789
	Unit Heater	4.7%	0.07	0.00	147
Water Heating	Water Heater	57.8%	0.27	0.16	7,353
Food Preparation	Oven	4.4%	0.10	0.00	212
	Conveyor Oven	2.2%	0.18	0.00	181
	Double Rack Oven	2.2%	0.27	0.01	276
	Fryer	8.5%	0.36	0.03	1,432
	Broiler	5.3%	0.37	0.02	909
	Griddle	8.4%	0.19	0.02	755
	Range	10.3%	0.17	0.02	810
	Steamer	1.6%	0.15	0.00	113
	Commercial Food Prep Other	0.1%	0.02	0.00	1.6
Miscellaneous	Pool Heater	0.2%	0.02	0.00	1.0
	Miscellaneous	100.0%	0.05	0.05	2,233
Total				**0.50**	**23,563**

Industrial Sector

The total sum of natural gas used in 2022 by NW Natural's industrial sales customers in Washington was 4,389 thousand therms. 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. 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 floor area is not as indicative of process loads, which may be constrained to one portion of a larger warehouse/storage facility. AEG 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. This analysis breaks Industrial customers into two groups; firm customers, who receive a guarantee of their gas delivery, and interruptible customers, who's gas service can be interrupted when the system becomes constrained to ensure firm customers are served first. Interruptible industrial customers receive a cheaper gas rate and are a form of demand response on the natural gas system.

TABLE 3-9 INDUSTRIAL CONTROL TOTALS, 2022

Segment	Natural Gas Sales (thousand therms)	% of Total Usage	Intensity (therms/empl.)
Industrial - Firm	3,213	73%	3,393
Industrial - Interruptible	1,177	27%	1,153
Total	**4,389**	**100%**	**2,227**

Figure 3-8 summarizes industrial natural gas consumption by segment.

FIGURE 3-8 INDUSTRIAL NATURAL GAS USE BY SEGMENT, 2022

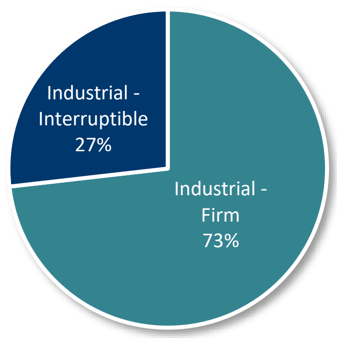


Figure 3-9 shows the distribution of annual natural gas consumption by end use for all industrial customers. Two major sources were used to develop this consumption profile. The first was AEG's analysis of warehouse usage as part of the commercial sector. We begin with this prototype as a starting point 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 82% of energy use. Space heating is the second largest end use, and miscellaneous, non-process industrial uses round out consumption.

FIGURE 3-9 INDUSTRIAL NATURAL GAS USE BY END USE, 2022

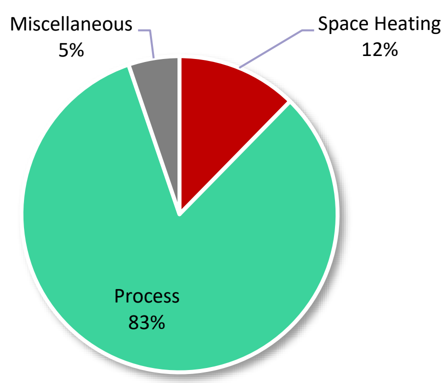


Figure 3-10 summarizes industrial energy intensities by industry type.

FIGURE 3-10 INDUSTRIAL GAS USAGE INTENSITY BY END USE AND SEGMENT, 2022 (ANNUAL THERMS/EMPLOYEE)

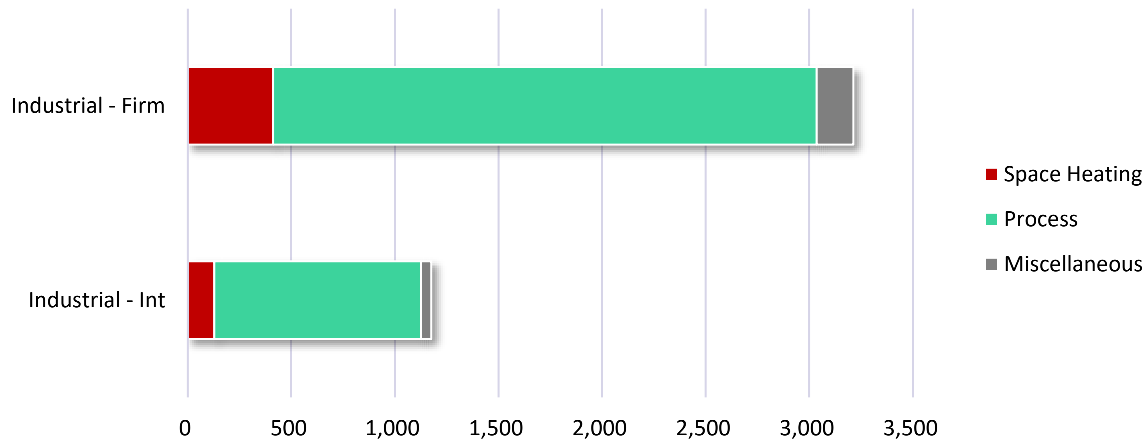


Table 3-10 shows the composite market profile for the industrial sector. Process cooling is very small and represents technologies such as gas-driven absorption chillers.

TABLE 3-10 AVERAGE INDUSTRIAL NATURAL GAS MARKET PROFILE, 2022

End Use	Technology	Saturation	EUI (mTherms/ employee)	Intensity (mTherms/ employee)	Usage (thousand therms)
Space Heating	Furnace	70.6%	0.54	0.37	382
	Boiler	14.0%	0.54	0.07	76
	Unit Heater	15.4%	0.54	0.08	83
Process	Process Boiler	100.0%	1.95	1.91	1,946
	Process Heating	100.0%	1.56	1.53	1,561
	Process Cooling	100.0%	0.01	0.01	11
	Other Process	100.0%	0.08	0.10	100
Miscellaneous	Miscellaneous	100.0%	0.23	0.22	229
Total				**4.30**	**4,389**

Transportation Customers

The total sum of natural gas used in 2022 by NW Natural's commercial and industrial transportation customers in Washington was 19,358 thousand therms. Transportation customers were modeled utilizing the Energy Profile data created for Commercial Sales and Industrial Sales customers. Commercial customers retain segments for Retail, Grocery, Lodging, Other Health, and Miscellaneous. Other Health is the largest gas consumption for the Commercial Transportation customers, but Industrial Transportation customers consumed approximately 89% of all transportation customers for 2022. Food Processing followed by Electronics Manufacturing are the two largest consuming segments for transportation customers.

TABLE 3-11 COMMERCIAL & INDUSTRIAL TRANSPORTATION CONTROL TOTALS, 2022

Sector	Segment	Natural Gas Sales (thousand therms)	% of Total Usage
Commercial	Retail	150	0.8%
Commercial	Grocery	261	1.3%
Commercial	Lodging	156	0.8%
Commercial	Other Health	1,054	5.4%
Commercial	Miscellaneous	603	3.1%
Industrial	Food Processing	7,833	40.5%
Industrial	Electronics Manufacturing	5,167	26.7%
Industrial	Lumber & Wood Products	823	4.3%
Industrial	Stone, Clay, Glass	1,758	9.1%
Industrial	Other Industrial	1,553	8.0%
Total		**19,358**	**100%**

Figure 3-11 summarizes transportation natural gas consumption by segment.

FIGURE 3-11 COMMERCIAL & INDUSTRIAL TRANSPORTATION NATURAL GAS USE BY END USE, 2022

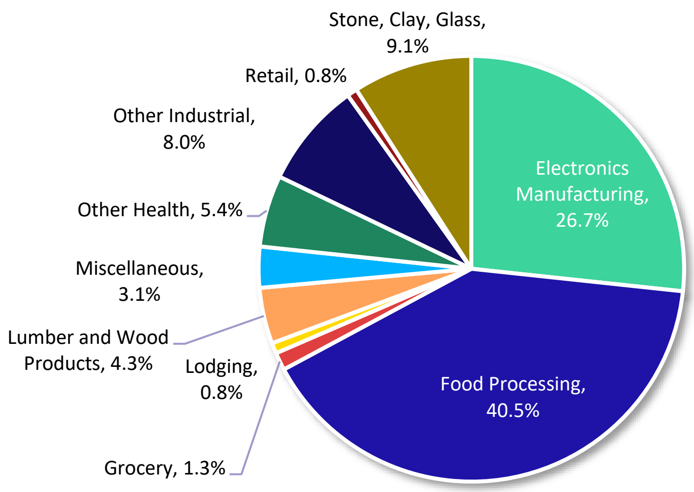
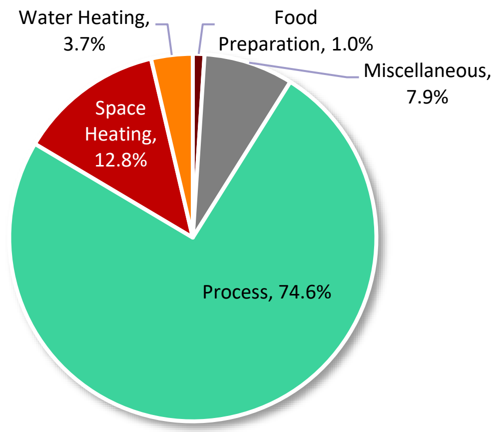


Figure 3-12 shows the distribution of annual natural gas consumption by end use for all transportation customers. Process is the largest overall end use for the transportation customers, accounting for 75% of energy use. Space heating is the second largest end use, and miscellaneous, non-process industrial use rounds out consumption for the top three transportation end uses.

FIGURE 3-12 COMMERCIAL & INDUSTRIAL TRANSPORTATION NATURAL GAS USE BY END USE, 2022



4| BASELINE PROJECTION

This chapter presents AEG's baseline projection of annual natural gas use for NW Natural's sales customers from 2024 through 2050 in the absence of new utility energy-efficiency programs. Baseline load projections for transportation customers are presented in Chapter. 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 to avoid double counting potential opportunities. Thus, the potential analysis captures all possible savings from future programs.

The baseline projection incorporates assumptions about:

- 2022 energy consumption based on the market profiles created for the 2019 base year;
- Customer population growth, considering the effects of the WSEC 2021 on new gas customers;
- Appliance/equipment standards and building codes already mandated;
- Appliance/equipment purchase decisions;
- NW Natural's customer forecast; and
- Trends in fuel shares and appliance saturations and assumptions about miscellaneous natural gas growth.

The baseline projection presented in this chapter is not NW Natural's official load forecast. Rather, it was developed by AEG as an integral component of the modeling construct to serve as the metric against which energy conservation potentials are measured. To align the baseline projection as closely as possible with NW Natural's load forecast, AEG incorporated the same assumptions and data where available. For example, NW Natural's heating degree days (base 58°F) were incorporated into the LoadMAP model to align the baseline projection with NW Natural's forecast. The end-use projection includes impacts of future federal standards that were effective as of June 2023, which drive energy consumption down through the study period.

NW Natural's load forecast informing this assessment uses the base case load forecasting methodology discussed in NW Natural's 2022 IRP. The 2022 IRP projection is based on historical trends of customer additions and gas usage. The reference case shows what load would look like if all trends embedded in historical data continued over the remainder of the planning horizon (2050).

Naturally occurring energy conservation, that is, energy conservation that is realized within the service area independent of utility-sponsored programs, is incorporated into the baseline projection consistent with the US Energy Information Administration's Annual Energy Outlook for the Pacific region. Results of the primary market research were used to calibrate these assumptions to ensure the secondary sources were relevant to NW Natural customers. For example, some customers will purchase and install energy conservation measures that are available in the market without a utility incentive. Please note this is not the "frozen efficiency" case defined by the Council, which is used for comparison with electricity savings from the 2021 Power Plan

Baseline projections by sector are presented below.

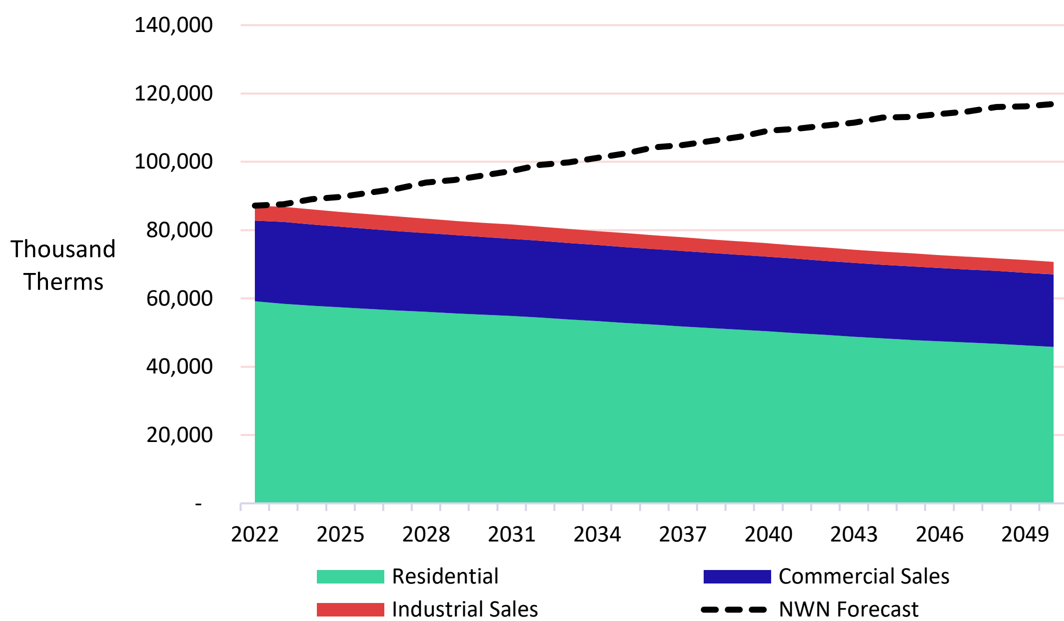
Summary of Overall Baseline Projection

Table 4-1 and Figure 4-1 provide a summary of the baseline projection for annual use by sector for the entire NW Natural Washington service territory. Base year (2019) value are weather normalized using heating degree day (HDD) data provided by NW Natural's load forecast department. Year 2022 consumption and weather data were updated to weather normalized actuals provided by NW Natural. Years 2023 forward include the impact of climate trends through projected heating degree days (HDDs) supplied by NW Natural. Overall, the forecast shows a modest decrease in natural gas consumption, at an average rate of about 0.7% per year, largely driven by restrictions on new construction gas loads detailed in the following section.

TABLE 4-1 BASELINE PROJECTION SUMMARY BY SECTOR, SELECTED YEARS (THOUSAND THERMS)

Sector	2022	2024	2025	2026	2030	2040	2050	% Change ('22-'50)	Avg. Growth
Residential	59,208	57,899	57,413	56,943	55,241	50,355	45,799	-22.6%	-0.9%
Commercial	23,563	23,789	23,594	23,386	22,734	21,827	21,275	-9.7%	-0.4%
Industrial	4,389	4,369	4,322	4,295	4,187	3,940	3,659	-16.6%	-0.7%
Total	**87,160**	**86,056**	**85,329**	**84,624**	**82,162**	**76,123**	**70,733**	**-18.8%**	**-0.7%**

FIGURE 4-1 BASELINE PROJECTION SUMMARY BY SECTOR (THOUSAND THERMS)



Assumptions Regarding WSEC 2021 and New Construction/Renovation

The 2021 Washington State Energy Code (WSEC 2021), which takes effect in July 2023, has significant impacts on new construction and renovated buildings. Through conversations with NW Natural, and through AEG's other work in Washington, 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 NW Natural 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. We retain 20% saturation of furnaces in single family and manufactured homes.
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[9]
Clothes Dryers & Stoves	Assumed 40% of new construction that connects to natural gas will install

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.

Assumptions in the CPA vs NW Natural's IRP

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

Residential Baseline Projection

Table 4-4 and Figure 4-2 present the baseline projection for natural gas at the end-use level for the residential sector, as a whole. Overall, residential use decreases from 59,208 thousand therms in 2022 to 45,799 thousand therms in 2050, a decrease of 22.6%. There are two high-level factors affecting growth. The first is a moderate increase in the number of households and customers, however without

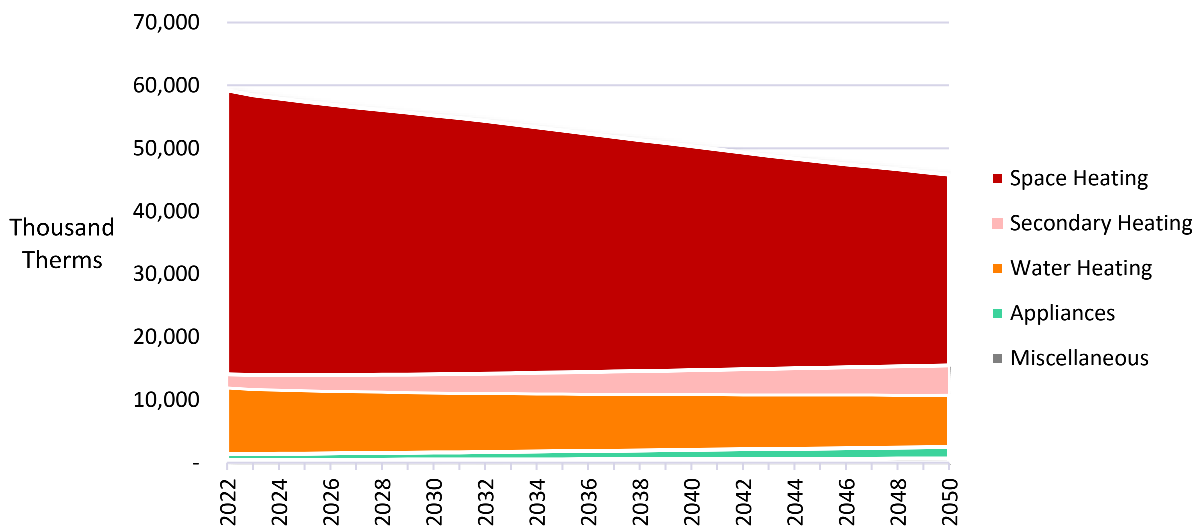
[9] Currently, code credits specify electric heat pump water heaters only. If this changes in the future, it could open the way for gas heat pump water heaters, but as of this study's publication they are unlikely to be selected by builders even if they become widely available soon.

the largest natural gas loads (e.g., furnaces) 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 small end-use in natural gas studies and includes technologies with low penetration, such as natural gas barbeques.

TABLE 4-4 RESIDENTIAL BASELINE PROJECTION BY END USE (THOUSAND THERMS)

End Use	2022	2023	2024	2030	2040	2050	% Change ('22-'50)	Avg. Growth Rate
Space Heating	45,153	44,495	43,983	41,186	35,654	30,330	-32.8%	-1.4%
Secondary Heating	2,100	2,198	2,302	2,900	3,822	4,662	122.1%	2.8%
Water Heating	10,604	10,352	10,209	9,544	8,857	8,321	-21.5%	-0.9%
Appliances	920	937	960	1,119	1,452	1,836	99.7%	2.5%
Miscellaneous	431	436	444	491	571	650	50.6%	1.5%
Total	**59,208**	**58,418**	**57,899**	**55,241**	**50,355**	**45,799**	**-22.6%**	**-0.9%**

FIGURE 4-2 RESIDENTIAL BASELINE PROJECTION BY END USE (THOUSAND THERMS)



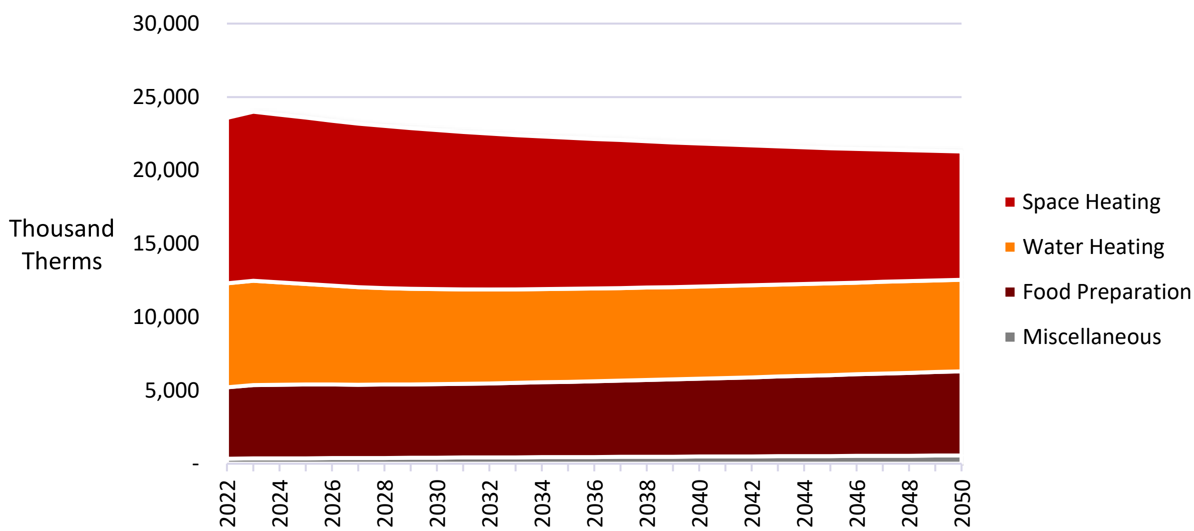
Commercial Baseline Projection

Annual commercial natural gas use is projected to decline at an average rate of 0.4% per year during the overall forecast horizon, starting at 23,563 thousand therms in 2022, and decreasing to 21,275 thousand therms by 2050. Table 4-5 and Figure 4-3 present the baseline projection at the end-use level for the commercial sector, as a whole. Similar to the residential sector, market size is increasing and usage per square foot is decreasing.

TABLE 4-5 COMMERCIAL BASELINE PROJECTION BY END USE (THOUSAND THERMS)

End Use	2022	2023	2024	2030	2040	2050	% Change ('22-'50)	Avg. Growth Rate
Space Heating	11,263	11,518	11,428	10,838	9,749	8,733	-22.5%	-0.9%
Water Heating	7,091	7,115	6,981	6,471	6,283	6,244	-11.9%	-0.5%
Food Preparation	4,870	5,003	5,016	5,013	5,309	5,738	17.8%	0.6%
Miscellaneous	338	355	364	412	486	560	65.4%	1.8%
Total	**23,563**	**23,991**	**23,789**	**22,734**	**21,827**	**21,275**	**-9.7%**	**-0.4%**

FIGURE 4-3 COMMERCIAL BASELINE PROJECTION BY END USE (THOUSAND THERMS)



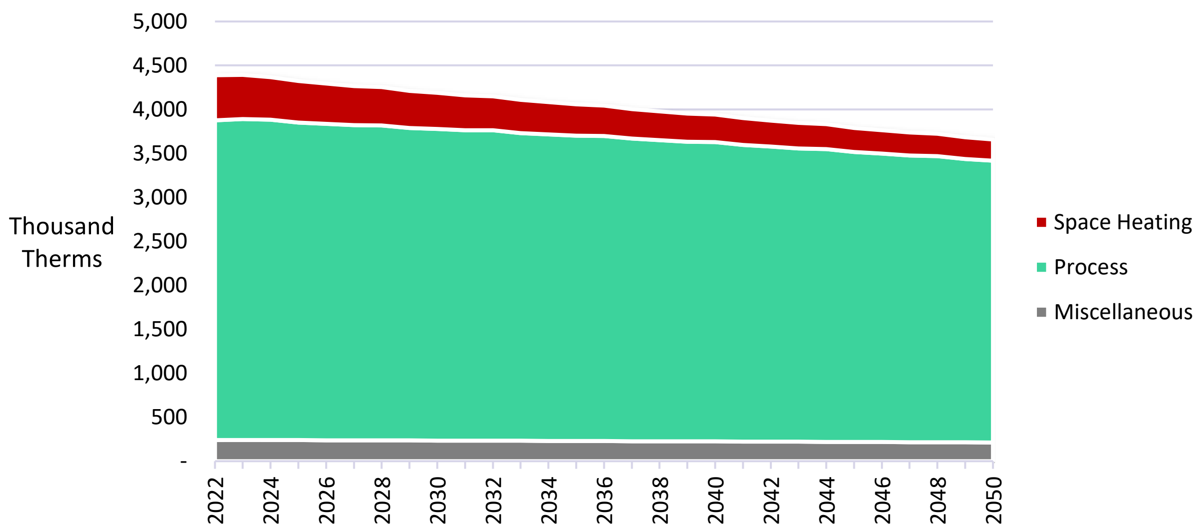
Industrial Baseline Projection

Industrial sector usage is projected to decrease throughout the planning horizon. Table 4-6 and Figure 4-4 present the projection at the end-use level. Overall, industrial annual natural gas use decreases from 4,389 thousand therms in 2022 to 3,659 thousand therms in 2050. The average decline across all end-uses is 0.7% per year, with a larger decline for space heating due to naturally occurring efficiency and new code restrictions on equipment.

TABLE 4-6 INDUSTRIAL BASELINE PROJECTION BY END USE (THOUSAND THERMS)

End Use	2022	2023	2024	2030	2040	2050	% Change ('22-'50)	Avg. Growth Rate
Space Heating	515	502	487	410	311	242	-53.0%	-2.7%
Process	3,633	3,649	3,640	3,542	3,403	3,204	-11.8%	-0.4%
Miscellaneous	241	242	241	235	226	212	-11.8%	-0.4%
Total	**4,389**	**4,393**	**4,369**	**4,187**	**3,940**	**3,659**	**-16.6%**	**-0.7%**

FIGURE 4-4 INDUSTRIAL BASELINE PROJECTION BY END USE (THOUSAND THERMS)



5| ENERGY EFFICIENCY POTENTIAL

This chapter presents the identified energy conservation potential across all sectors for NW Natural sales customers; potential for transportation customers is presented in the following chapter. This includes every measure that is considered in the measure list, regardless of program implementation concerns. 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. 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. 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. In this potential case, efficient equipment makes up all lost opportunity installations and all retrofit measures are installed, regardless of achievability.
    - 2024 first-year savings are 1,168 thousand therms, or 1.4% of the baseline.
    - 2035 cumulative savings are 13,883 thousand therms, or 17.6% of the baseline.
    - 2050 cumulative technical potential reaches 18,809 thousand therms, or 26.6% 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 2024-2050 CPA, ramp rates from the 2021 Power Plan were customized for use in natural gas programs. These ramp rates are provided in Appendix A.
    - 2024 first-year savings are 585 thousand therms, or 0.7% of the baseline.
    - 2035 cumulative savings in 2035 are 8,526 thousand therms, or 10.8% of the baseline.
    - 2050 cumulative achievable technical potential reaches 13,950 thousand therms, or 19.7% 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. AEG 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 were provided by NW Natural, including the 10% conservation credit per the Council's methodology.
    - 2024, first-year savings are 355 thousand therms, or 0.4% of the baseline.
    - 2035 cumulative savings in 2035 are 6,224 thousand therms, or 7.9% of the baseline.

  - 2050 cumulative TRC achievable economic potential reaches 11,129 thousand therms, or 15.7% of the baseline.
    - Potential under the TRC test is lower than under the UCT due to the inclusion of the entire incremental measure costs rather than solely the utility portion.
- **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 were provided by NW Natural with a 10% conservation credit embedded per Council methodologies.
  - 2024 first-year savings are 518 thousand therms, or 0.6% of the baseline.
  - 2035 cumulative savings in 2035 are 7,583 thousand therms, or 9.6% of the baseline.
  - 2050 cumulative UCT achievable economic potential reach 12,658 thousand therms, or 17.9% of the baseline.

TABLE 5-1 SUMMARY OF ENERGY EFFICIENCY POTENTIAL (THOUSAND THERMS)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2035	2040	2050
Reference Baseline	86,056	85,329	84,624	82,162	79,092	76,123	70,733
Cumulative Savings (thousand therms)							
Achievable Econ TRC Potential	355	720	1,115	3,099	6,224	9,223	11,129
Achievable Econ UCT Potential	518	1,043	1,597	4,137	7,583	10,736	12,658
Achievable Technical Potential	585	1,180	1,807	4,686	8,526	11,940	13,950
Technical Potential	1,168	2,335	3,532	8,442	13,883	17,305	18,809
Cumulative Savings (% of Baseline)							
Achievable Econ TRC Potential	0.4%	0.8%	1.3%	3.8%	7.9%	12.1%	15.7%
Achievable Econ UCT Potential	0.6%	1.2%	1.9%	5.0%	9.6%	14.1%	17.9%
Achievable Technical Potential	0.7%	1.4%	2.1%	5.7%	10.8%	15.7%	19.7%
Technical Potential	1.4%	2.7%	4.2%	10.3%	17.6%	22.7%	26.6%

FIGURE 5-1 SUMMARY OF ANNUAL CUMULATIVE ENERGY EFFICIENCY POTENTIAL

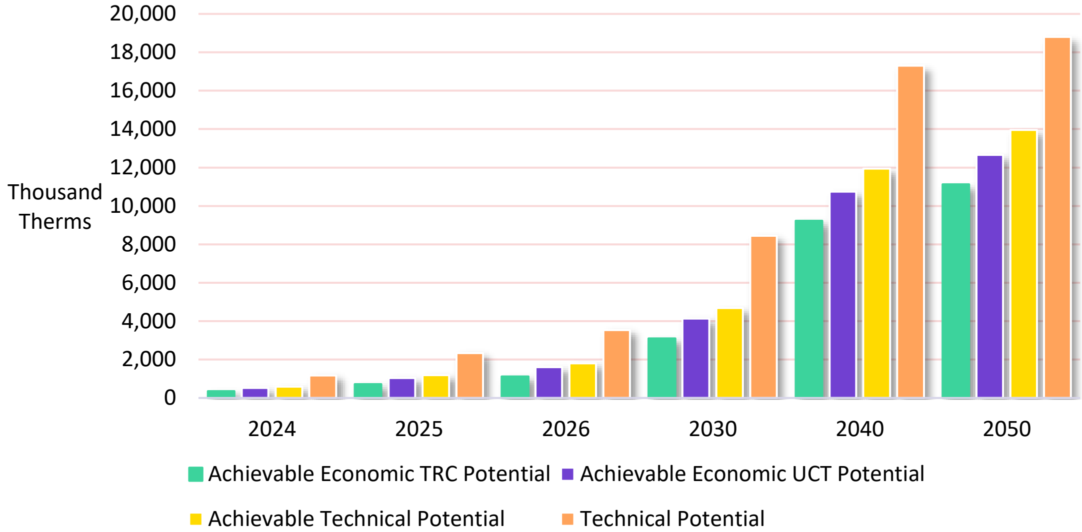


Figure 5-2 displays projected loads after removing each level of potential and as compared to the baseline projection. Because the technical potential represents the largest amount of savings, its resulting load projection is the lowest.

FIGURE 5-2 BASELINE PROJECTION AND ANNUAL ENERGY EFFICIENCY FORECASTS (THOUSAND THERMS)

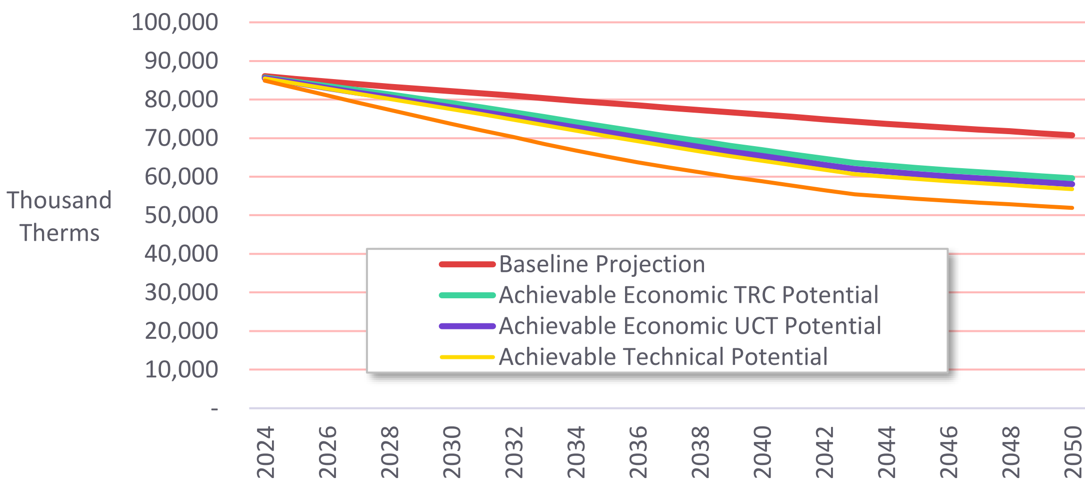


Figure 5-3 shows the cumulative TRC achievable potential by sector for the full timeframe of the analysis as a percent of total savings. Table 5-2 summarizes TRC achievable potential by sector for selected years. The residential sector represents the largest share of potential throughout the study period, followed by commercial and industrial.

FIGURE 5-3 CUMULATIVE TRC ACHIEVABLE ECONOMIC POTENTIAL BY SECTOR (% OF TOTAL)

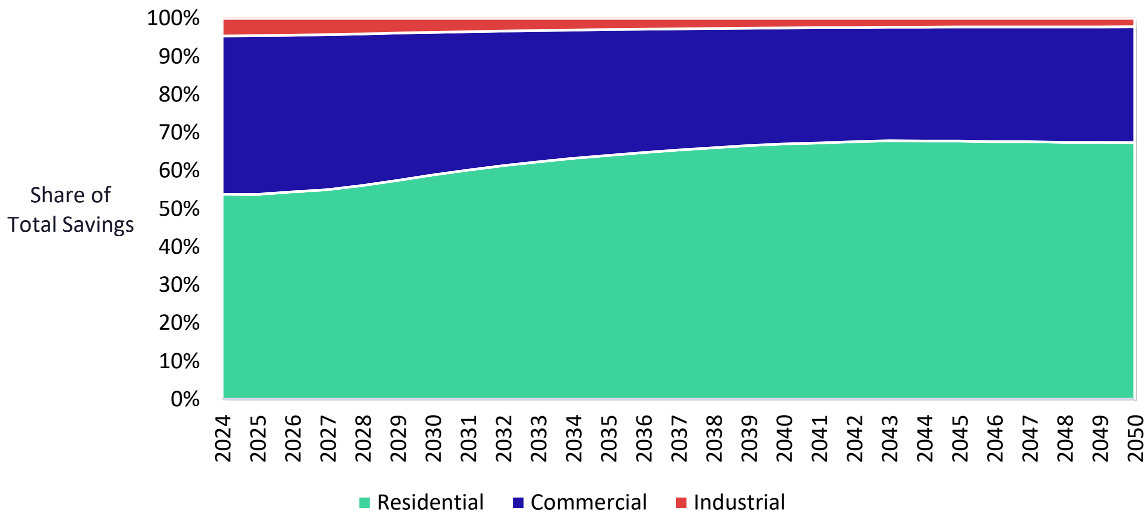


TABLE 5-2 CUMULATIVE TRC ACHIEVABLE ECONOMIC POTENTIAL BY SECTOR, SELECTED YEARS (THOUSAND THERMS)

Sector	2024	2025	2026	2030	2035	2040	2050
Residential	191	387	607	1,824	3,986	6,179	7,500
Commercial	147	300	459	1,160	2,054	2,814	3,384
Industrial	16	33	41	114	185	231	245
Total	**433**	**877**	**1,353**	**3,664**	**7,151**	**10,412**	**12,438**

Residential Sector Potential

Table 5-3 and Figure 5-4 summarize the energy efficiency potential for the residential sector. In 2024, TRC achievable economic potential is 191 thousand therms, or 0.3% of the baseline projection. By 2050, cumulative savings are 7,500 thousand therms, or 16.4% of the baseline.

TABLE 5-3 RESIDENTIAL POTENTIAL SUMMARY (THOUSAND THERMS)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2040	2050
Baseline Forecast	57,899	57,413	56,943	55,241	50,355	45,799
Cumulative Savings (thousand therms)						
Achievable Economic TRC Potential	191	387	607	1,824	6,179	7,500
Achievable Economic UCT Potential	334	671	1,031	2,740	7,536	8,895
Achievable Technical Potential	372	750	1,155	3,102	8,488	9,962
Technical Potential	759	1,514	2,285	5,531	12,032	13,088
Cumulative Savings (% of Baseline)						
Achievable Economic TRC Potential	0.3%	0.7%	1.1%	3.3%	12.3%	16.4%
Achievable Economic UCT Potential	0.6%	1.2%	1.8%	5.0%	15.0%	19.4%
Achievable Technical Potential	0.6%	1.3%	2.0%	5.6%	16.9%	21.8%
Technical Potential	1.3%	2.6%	4.0%	10.0%	23.9%	28.6%

FIGURE 5-4 RESIDENTIAL CUMULATIVE POTENTIAL BY CASE

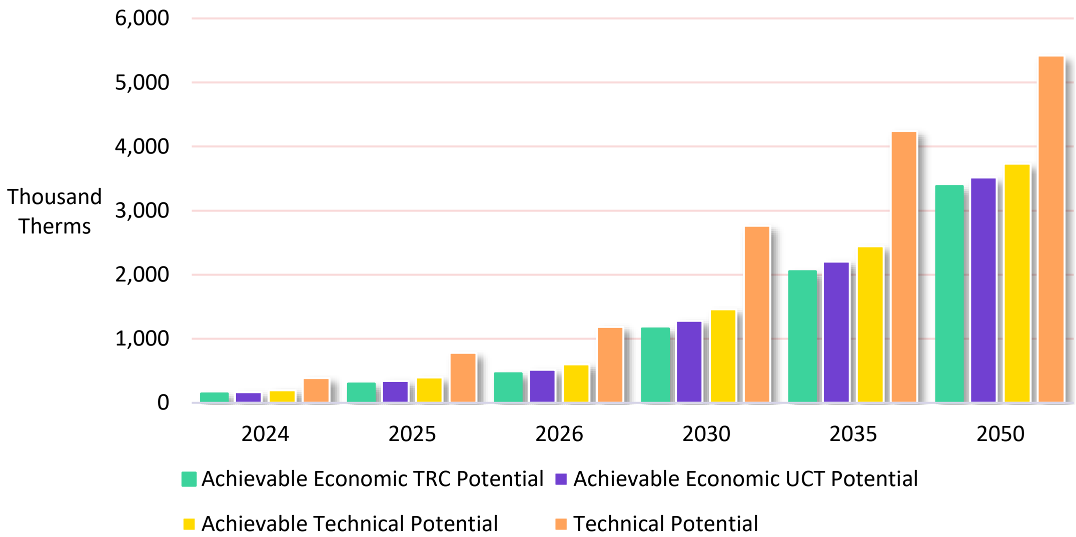


Figure 5-5 presents forecasts of cumulative residential TRC achievable economic potential by end use. Space heating accounts for a majority of potential throughout the study horizon.

FIGURE 5-5 RESIDENTIAL TRC ACHIEVABLE ECONOMIC POTENTIAL – CUMULATIVE POTENTIAL BY END USE

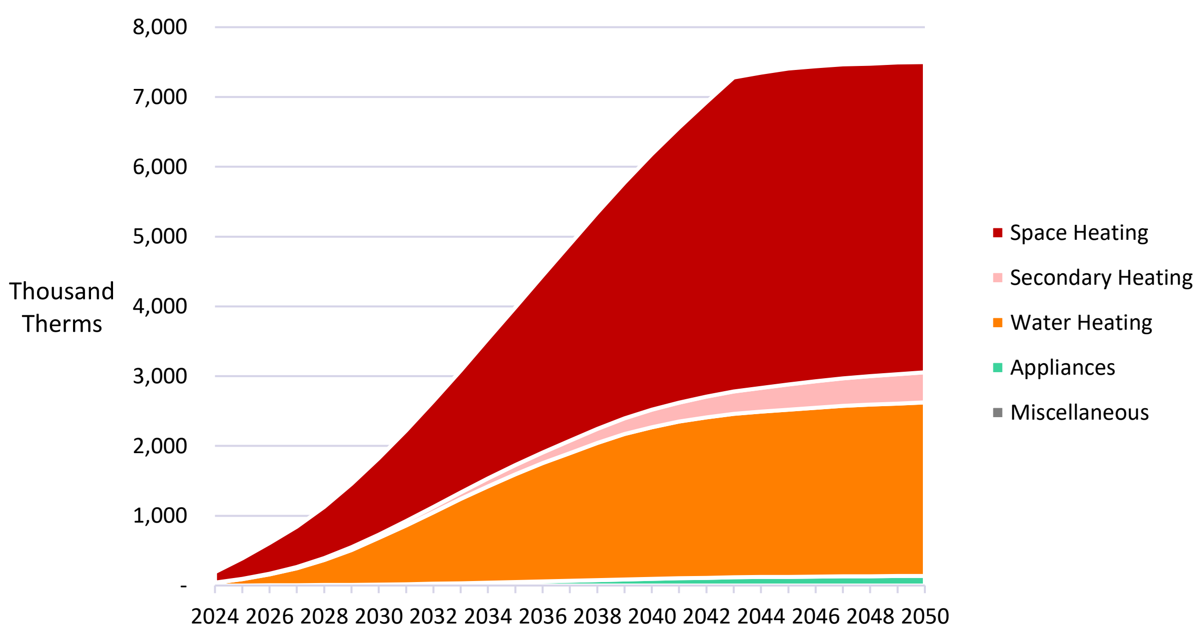


Table 5-4 identifies the top 20 residential measures by cumulative 2050 savings. Connected thermostats, water heaters, furnaces, and efficient fireplaces are the top measures by the end of the study period. Behavioral Programs, represent a large portion of potential in the early years of the study, but that potential does not grow as significantly over the study period as other measures.

Table 5-4 Residential Top Measures in 2024 and 2050, TRC Achievable Economic Potential

Rank	Measure / Technology	2024 Achievable Economic TRC Potential (thousand therms)	2050 Achievable Economic TRC Potential (thousand therms)	% of Total
1	ENERGY STAR - Connected Thermostat - Interactive/learning thermostat	69	2,110	28.1%
2	Water Heater (<= 55 gal) - UEF 0.87 (Instantaneous, ENERGY STAR 4.0)	11	1,690	22.5%
3	Furnace - AFUE 95% (ENERGY STAR 4.1)	23	1,330	17.7%
4	Fireplace - Tier 2 (>75% FE)	0	422	5.6%
5	Insulation - Ceiling, Installation - R-49 (Retro only)	3	306	4.1%
6	Water Heater - Low Flow Showerhead - 1.5 GPM showerhead	2	257	3.4%
7	Ducting - Repair and Sealing - 50% reduction in duct leakage	1	232	3.1%
8	ENERGY STAR Clothes Washers - ENERGY STAR unit	11	150	2.0%
9	Stove/Oven - High Efficiency (730 + 1660 IAEC)	0	138	1.8%
10	Water Heater - Pipe Insulation - Insulated 5' of pipe between unit and conditioned space	1	138	1.8%
11	Water Heater - Temperature Setback - Setback to 120° F	1	110	1.5%
12	Built Green homes - Built Green spec (NC Only)	0	103	1.4%
13	Insulation - Wall Cavity, Installation - R-11	1	102	1.4%
14	Insulation - Ducting - duct thermal losses reduced 50%	1	90	1.2%
15	Behavioral Programs - HER-style customer awareness program	63	88	1.2%
16	Water Heater - Faucet Aerator - 1.5 GPM aerator	1	76	1.0%
17	Intermittent Ignition System - Installed switch/remote on burner system	0	48	0.6%
18	Insulation - Basement Sidewall - R-15	0	42	0.6%
19	Insulation - Floor/Crawlspace - R-30	0	22	0.3%
20	Building Shell - Whole-Home Aerosol Sealing - 20% reduction in ACH50	0	15	0.2%
	Subtotal	**190**	**7,469**	**99.6%**
	Total Savings in Year	**191**	**7,500**	**100%**

Commercial Potential

Table 5-5 and Figure 5-6 summarize the energy conservation potential for the commercial sector. In 2024, TRC achievable economic potential is 147 thousand therms, or 0.6% of the baseline projection. By 2050, cumulative savings are 3,384 thousand therms, or 15.9% of the baseline.

TABLE 5-5 COMMERCIAL POTENTIAL SUMMARY (THOUSAND THERMS)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2040	2050
Baseline Forecast	23,789	23,594	23,386	22,734	21,827	21,275
Cumulative Savings (thousand therms)						
Achievable Economic TRC Potential	147	300	459	1,160	2,814	3,384
Achievable Economic UCT Potential	167	339	517	1,282	2,968	3,518
Achievable Technical Potential	195	394	599	1,462	3,209	3,732
Technical Potential	387	778	1,184	2,765	4,988	5,422
Cumulative Savings (% of Baseline)						
Achievable Economic TRC Potential	0.6%	1.3%	2.0%	5.1%	12.9%	15.9%
Achievable Economic UCT Potential	0.7%	1.4%	2.2%	5.6%	13.6%	16.5%
Achievable Technical Potential	0.8%	1.7%	2.6%	6.4%	14.7%	17.5%
Technical Potential	1.6%	3.3%	5.1%	12.2%	22.9%	25.5%

FIGURE 5-6 COMMERCIAL CUMULATIVE POTENTIAL BY CASE

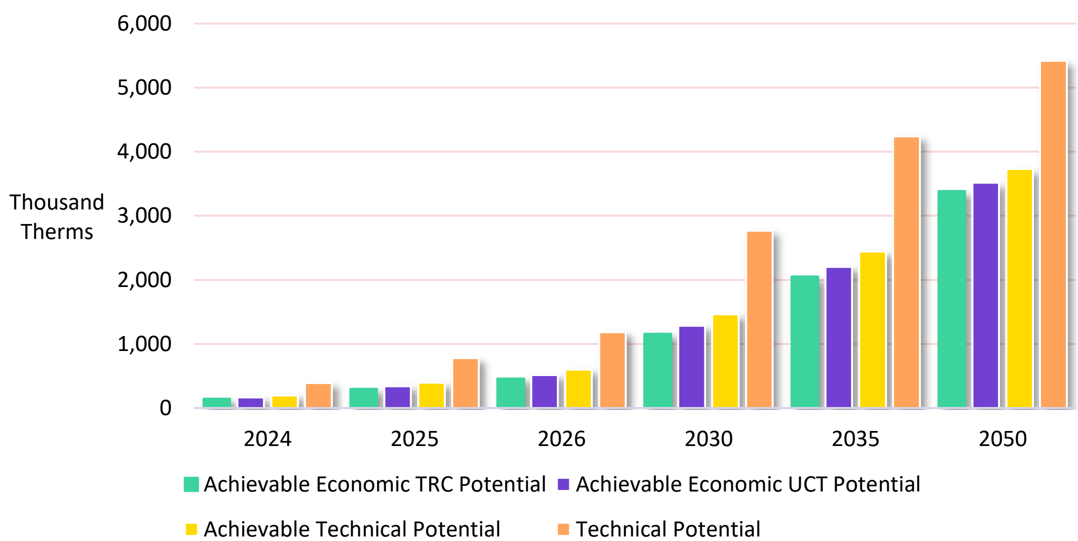


Figure 5-7 presents forecasts of cumulative commercial TRC achievable economic potential by end use. Space heating makes up a majority of the potential early on, but water heating and food preparation equipment upgrades provide substantial savings opportunities in the later years.

FIGURE 5-7 COMMERCIAL TRC ACHIEVABLE ECONOMIC POTENTIAL – CUMULATIVE SAVINGS BY END USE

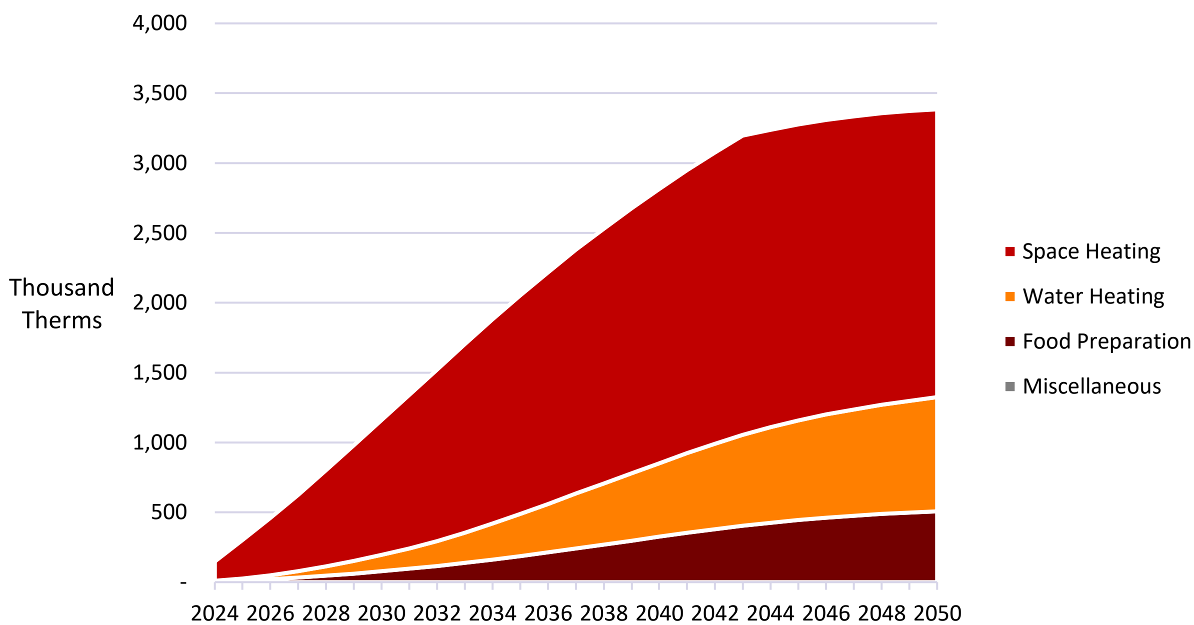


Table 5-6 identifies the top 20 commercial measures by cumulative savings in 2024 and 2050. Over the long term, tankless water heaters are the top measure, followed by ceiling insulation, and efficient broilers.

TABLE 5-6 COMMERCIAL TOP MEASURES IN 2024 AND 2050, TRC ACHIEVABLE ECONOMIC POTENTIAL

Rank	Measure / Technology	2024 Achievable Economic TRC Potential (thousand therms)	2050 Achievable Economic TRC Potential (thousand therms)	% of Total
1	Water Heater - Tankless	4	781	23.1%
2	Insulation - Roof/Ceiling - R-38	49	703	20.8%
3	Broiler - Infrared Burners	3	270	8.0%
4	Insulation - Wall Cavity - R-21	21	255	7.5%
5	Boiler - TE 98%	5	178	5.3%
6	Gas Boiler - Insulate Hot Water Lines - Insulated water lines	9	132	3.9%
7	Range - High Efficiency	1	98	2.9%
8	ENERGY STAR Connected Thermostat - Wi-Fi/interactive thermostat installed	15	90	2.7%
9	Furnace - AFUE 96%	0	82	2.4%
10	Hydronic Heating Radiator Replacement - TBD	4	75	2.2%
11	Double Rack Oven - FTSC Qualified (>50% Cooking Efficiency)	1	71	2.1%
12	HVAC - Demand Controlled Ventilation - DCV enabled	1	65	1.9%

Rank	Measure / Technology	2024 Achievable Economic TRC Potential (thousand therms)	2050 Achievable Economic TRC Potential (thousand therms)	% of Total
13	Thermostat - Programmable - Programmable thermostat installed	4	55	1.6%
14	Kitchen Hood - DCV/MUA - DCV/HUA vent hood	4	53	1.6%
15	Gas Boiler - Insulate Steam Lines/Condensate Tank - Lines and condensate tank insulated	4	52	1.5%
16	Oven - ENERGY STAR (3.0)	1	47	1.4%
17	Building Automation System - Automation system installed and programmed	0	46	1.4%
18	Strategic Energy Management - Energy management system installed and programmed	3	43	1.3%
19	Gas Boiler - Hot Water Reset - Reset control installed	2	43	1.3%
20	Thermostatic Radiator Valves - TBD	2	34	1.0%
	Subtotal	**131**	**3,172**	**93.7%**
	Total Savings in Year	**147**	**3,384**	**100.0%**

Industrial Potential

Table 5-7 and Figure 5-8 summarize the energy conservation potential for the industrial sector. In 2024, TRC achievable economic potential is 16 thousand therms, or 0.4% of the baseline projection. By 2050, cumulative savings reach 245 thousand therms, or 6.7% 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 the potential, these are not possible in all applications, which limits potential at the technical level.

Table 5-7 Industrial Potential Summary (thousand therms)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2040	2050
Baseline Forecast	4,369	4,322	4,295	4,187	3,940	3,659
Cumulative Savings (thousand therms)						
Achievable Economic TRC Potential	16	33	49	114	231	245
Achievable Economic UCT Potential	16	33	49	114	231	246
Achievable Technical Potential	18	35	53	122	243	256
Technical Potential	22	43	64	146	285	299
Cumulative Savings (% of Baseline)						
Achievable Economic TRC Potential	0.4%	0.8%	1.1%	2.7%	5.9%	6.7%
Achievable Economic UCT Potential	0.4%	0.8%	1.1%	2.7%	5.9%	6.7%
Achievable Technical Potential	0.4%	0.8%	1.2%	2.9%	6.2%	7.0%
Technical Potential	0.5%	1.0%	1.5%	3.5%	7.2%	8.2%

FIGURE 5-8 INDUSTRIAL CUMULATIVE POTENTIAL BY CASE

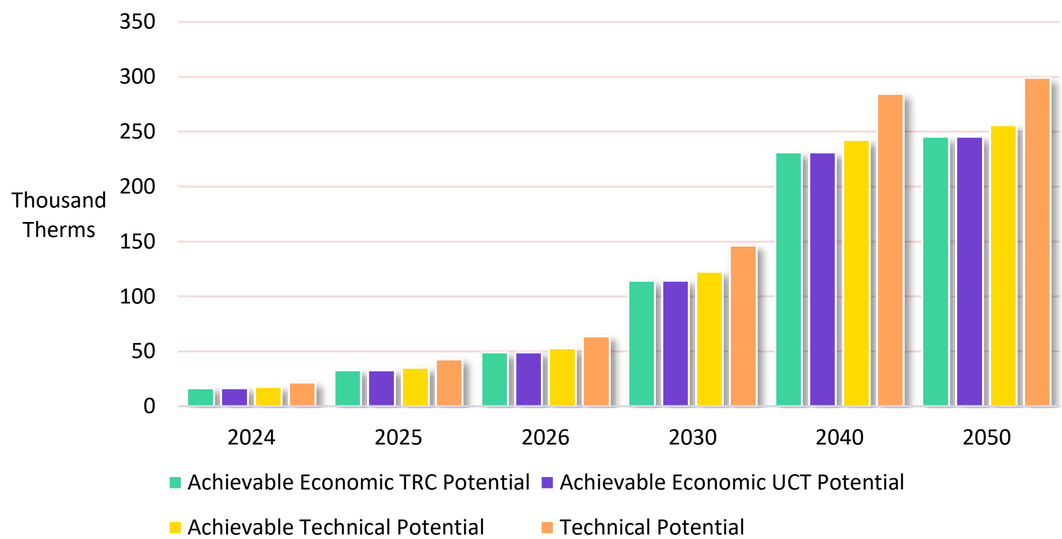


Figure 5-9 presents forecasts of cumulative industrial TRC achievable economic potential by end use.

FIGURE 5-9 INDUSTRIAL TRC ACHIEVABLE ECONOMIC POTENTIAL – CUMULATIVE SAVINGS BY END USE

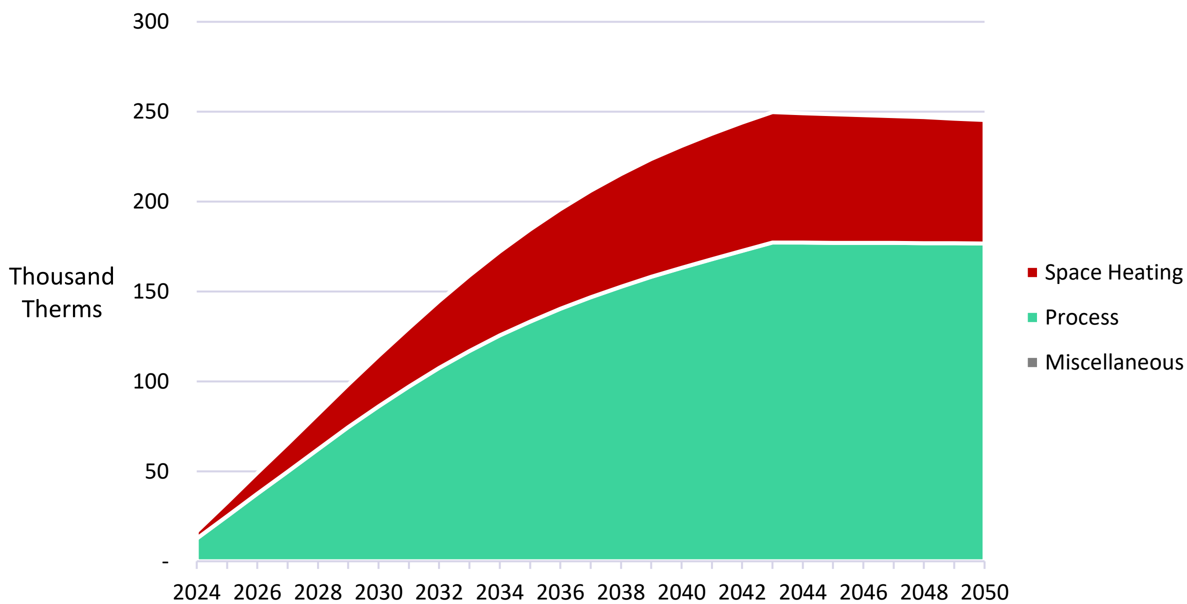


Table 5-8 identifies the top 10 industrial measures by cumulative 2024 and 2050 savings. Strategic energy management of industrial process applications is the highest measure by total potential. For smaller industrial customers, this measure typically involves a cohort of between five to ten customers who form a working group facilitated by an energy management expert. One or more employees at each facility are designated an energy conservation "champion" who work to integrate efficient energy-consuming behavior into the company's culture. Many of these measures are more custom in nature, such as strategic energy management and retro-commissioning. 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 5-8 INDUSTRIAL TOP MEASURES IN 2024 AND 2050, TRC ACHIEVABLE ECONOMIC POTENTIAL (THOUSAND THERMS)

Rank	Measure / Technology	2024 Achievable Economic TRC Potential (thousand therms)	2050 Achievable Economic TRC Potential (thousand therms)	% of Total
1	Strategic Energy Management - Energy management system installed and programmed	4.4	65	26.6%
2	Gas Boiler - Insulate Hot Water Lines - Insulated water lines	2.1	37	14.9%
3	Gas Boiler - Stack Economizer - Economizer installed	2.1	18	7.4%
4	Insulation - Roof/Ceiling - R-38	1.7	18	7.4%
5	Gas Boiler - Insulate Steam Lines/Condensate Tank - Lines and condensate tank insulated	1.0	18	7.2%
6	Gas Boiler - Hot Water Reset - Reset control installed	0.7	16	6.7%
7	Process - Insulate Heated Process Fluids - Insulated process fluid lines	1.9	16	6.4%
8	Building Automation System - Automation system installed and programmed	0.1	15	6.1%
9	Gas Boiler - Burner Control Optimization - Optimized burner controls	0.1	10	4.2%
10	Boiler - TE 98%	0.3	8	3.1%
	Subtotal	**14**	**221**	**90%**
	Total Savings in Year	**16**	**245**	**100%**

Peak Day and Hour Savings

The potential results presented above focus on cumulative annual energy savings. As part of the CPA, NW Natural also asked AEG to estimate potential impacts on the peak day and peak hour. This section presents a summary of potential and top measures on the peak day and peak hour.

Table 5-9 and Table 5-10 present the total reference baseline and potential savings for the peak day and peak hour, respectively. Peak day and hour impacts are estimated using annual energy savings and conversion factors, provided by NW Natural, which relate peak day or hour consumption to annual consumption by end use.

TABLE 5-9 PEAK DAY POTENTIAL SUMMARY (MTHERMS/DAY)

Summary of Peak Savings, Selected Years	2024	2025	2026	2030	2035	2040	2050
Baseline Forecast	1,116	1,107	1,097	1,062	1,012	960	863
Cumulative Savings (mTherms/day)							
TRC Achievable Economic Potential	5	11	16	41	78	115	137
UCT Achievable Economic Potential	8	16	24	59	101	141	163
Achievable Technical Potential	9	19	28	67	115	159	182
Technical Potential	14	28	42	99	161	212	236

Summary of Peak Savings, Selected Years	2024	2025	2026	2030	2035	2040	2050
Cumulative Savings (% of Baseline)							
TRC Achievable Economic Potential	0.5%	1.0%	1.5%	3.8%	7.7%	12.0%	15.9%
UCT Achievable Economic Potential	0.7%	1.5%	2.2%	5.5%	10.0%	14.7%	18.9%
Achievable Technical Potential	0.8%	1.7%	2.5%	6.3%	11.4%	16.6%	21.1%
Technical Potential	1.3%	2.5%	3.9%	9.3%	16.0%	22.1%	27.3%

TABLE 5-10 PEAK HOUR POTENTIAL SUMMARY (MTHERMS/HOUR)

Summary of Peak Savings, Selected Years	2024	2025	2026	2030	2035	2040	2050
Baseline Forecast	85	84	83	80	77	74	67
Cumulative Savings (mTherms/hour)							
TRC Achievable Economic Potential	0	1	1	3	7	10	11
UCT Achievable Economic Potential	1	1	2	4	8	11	13
Achievable Technical Potential	1	1	2	5	9	12	14
Technical Potential	1	2	4	9	15	18	20
Cumulative Savings (% of Baseline)							
TRC Achievable Economic Potential	0.4%	0.9%	1.4%	4.0%	8.5%	13.1%	17.1%
UCT Achievable Economic Potential	0.6%	1.3%	2.0%	5.3%	10.3%	15.2%	19.4%
Achievable Technical Potential	0.7%	1.4%	2.2%	6.0%	11.6%	16.9%	21.4%
Technical Potential	1.4%	2.9%	4.5%	11.1%	19.1%	24.8%	29.3%

Table 5-11 presents the top measures in terms of their impact on the peak day and hour.

TABLE 5-11 TOP PEAK IMPACT MEASURES, DAY AND HOUR POTENTIAL, SELECTED YEARS (THERMS)

Rank	Sector / Technology (Ranked by 2040 Peak Day Impact)	Peak DAY Savings (therms)			Peak HOUR Savings (therms)		
		2024	2031	2040	2024	2031	2040
1	Residential - ENERGY STAR - Connected Thermostat	1,216	12,589	37,136	70	123	169
2	Residential - Behavioral Programs	952	1,776	1,355	67	123	107
3	Residential - Water Heater (<= 55 gal)	37	1,494	5,578	14	115	99
4	Residential - Furnace	405	6,230	23,400	23	64	70
5	Commercial - Water Heater	12	435	2,578	4	33	53
6	Residential - Insulation - Ceiling, Installation	53	528	5,382	3	5	41
7	Commercial - Insulation - Roof/Ceiling	862	6,343	12,373	50	46	40
8	Residential - Fireplace	0.4	1,003	7,435	0.02	14	25

Rank	Sector / Technology (Ranked by 2040 Peak Day Impact)	Peak DAY Savings (therms)			Peak HOUR Savings (therms)		
		2024	2031	2040	2024	2031	2040
9	Commercial - Insulation - Wall Cavity	376	2,599	4,487	22	19	15
10	Residential - Ducting - Repair and Sealing	18	1,132	4,076	1	20	14
11	Residential - Insulation - Wall Cavity, Installation	18	178	1,795	1	2	14
12	Residential - Insulation - Ducting	15	155	1,583	1	2	12
13	Residential - ENERGY STAR Clothes Washers	38	265	493	14	12	10
14	Commercial - Boiler	96	956	3,128	6	8	8
15	Commercial - Gas Boiler - Insulate Hot Water Lines	150	1,127	2,323	9	8	7
16	Residential - Built Green homes	0.6	77	1,819	0.03	2	7
17	Residential - Water Heater - Low Flow Showerhead	7	381	847	2	39	6
18	Residential - Insulation - Basement Sidewall	7	75	743	0.4	1	6
19	Commercial - Furnace	5	200	1,434	0.3	3	4
20	Commercial - Broiler	9	179	962	1	2	4
	Total of Top 20 Measures	**4,279**	**37,723**	**118,928**	**289**	**639**	**711**

6| TRANSPORTATION BASELINE AND EFFICIENCY POTENTIAL

Transportation customers are non-residential natural gas consumers, typically large industrial users, who purchase natural gas from an alternate supplier, but use NW Natural's distribution system to deliver the fuel to their sites. Because these customers are not currently eligible to participate in NW Natural's energy efficiency programs, their potential has not been included in the summaries presented earlier in this report. However, to provide information that may inform future planning, AEG estimated the energy efficiency potential that may exist at transportation customer sites, using the same methodology described previously for sales customers. This chapter presents the transportation baseline projection and the associated identified energy efficiency potential.

Transportation Baseline Projection

Table 6-1 presents the transportation baseline projection by sector. As shown, the industrial sector accounts for roughly 90% of all transportation load in 2022. Industrial transportation load is projected to decline at an average rate of 0.7% over the forecast period, while commercial transportation loads increase by 0.5% per year, leading to an overall projected decline of 0.6% per year.

TABLE 6-1 TRANSPORTATION BASELINE PROJECTION SUMMARY, SELECTED YEARS (THOUSAND THERMS)

Sector	2022	2024	2025	2026	2030	2040	2050	% Change ('22-'50)	Avg. Growth
Commercial	2,224	2,370	2,369	2,367	2,367	2,433	2,527	13.6%	0.5%
Industrial	17,134	17,063	16,871	16,737	16,213	15,064	13,991	-18.3%	-0.7%
Total	**19,358**	**19,434**	**19,241**	**19,104**	**18,580**	**17,497**	**16,518**	**-14.7%**	**-0.6%**

Commercial Transportation Baseline Projection

Commercial transportation usage is projected to increase throughout the planning horizon, as shown in Table 6-2. Overall, commercial annual natural gas use increases from 2,224 thousand therms in 2022 to 2,527 thousand therms in 2050. The average increase across all end-uses is 0.5% per year, with the largest larger increase attributable to miscellaneous loads. Restrictions on space heating and water heating tend to decrease those end uses over time, yet natural gas consumption for commercial transportation customers in NW Natural's territory is continuing to increase.

TABLE 6-2 COMMERCIAL TRANSPORTATION BASELINE PROJECTION BY END USE (THOUSAND THERMS)

End Use	2022	2023	2024	2030	2040	2050	% Change ('22-'50)	Avg. Growth Rate
Space Heating	689	730	721	672	590	514	-25.4%	-1.0%
Water Heating	708	741	726	669	646	637	-10.1%	-0.4%
Food Preparation	198	212	212	209	220	237	19.7%	0.6%
Miscellaneous	628	688	711	817	978	1139	81.2%	2.1%
Total	**2,224**	**2,371**	**2,370**	**2,367**	**2,433**	**2,527**	**13.6%**	**0.5%**

Industrial Transportation Baseline Projection

Industrial transportation usage is projected to decrease throughout the planning horizon, as shown in Table 6-3. Overall, industrial transportation annual natural gas use declines from 17,134 thousand therms in 2022 to 13,991 thousand therms in 2050. The average decline across all end-uses is 0.7% per year, with a larger decline for space heating due to naturally occurring efficiency and new code restrictions on equipment.

TABLE 6-3 INDUSTRIAL TRANSPORTATION BASELINE PROJECTION BY END USE (THOUSAND THERMS)

End Use	2022	2023	2024	2030	2040	2050	% Change ('22-'50)	Avg. Growth Rate
Space Heating	1,792	1,747	1,696	1,427	1,082	841	-53.1%	-2.7%
Process	14,443	14,546	14,467	13,920	13,163	12,379	-14.3%	-0.6%
Miscellaneous	899	905	900	866	819	770	-14.3%	-0.6%
Total	**17,134**	**17,197**	**17,063**	**16,213**	**15,064**	**13,991**	**-18.3%**	**-0.7%**

Summary of Overall Transportation Energy Efficiency Potential

Table 6-4 and Figure 6-1 summarize the energy conservation savings in terms of annual energy use for all measures for four levels of potential relative to the baseline projection. Savings are represented in cumulative terms, reflecting the effects of persistent savings in prior years in addition to new savings.

- **Technical Potential** reflects the adoption of all conservation measures regardless of cost-effectiveness. 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. In this potential case, efficient equipment makes up all lost opportunity installations and all retrofit measures are installed, regardless of achievability.
    - 2024 first-year savings are 137 thousand therms, or 0.4% of the baseline.
    - 2035 cumulative savings are 1,373 thousand therms, or 7.6% of the baseline.
    - 2050 cumulative technical potential reaches 1,705 thousand therms, or 10.3% 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 2024-2050 CPA, ramp rates from the 2021 Power Plan were customized for use in natural gas programs. These ramp rates are provided in Appendix A.
    - 2024 first-year savings are 94 thousand therms, or 0.5% of the baseline.
    - 2035 cumulative savings in 2035 are 1,029 thousand therms, or 5.7% of the baseline.
    - 2050 cumulative achievable technical potential reaches 1,398 thousand therms, or 8.5% 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. AEG 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 were provided by NW Natural, including the 10% conservation credit per the Council's methodology. Note, transportation avoided costs are lower than sales avoided costs, due to the exclusion of the commodity cost, which NW Natural does not pay for.

  - 2024, first-year savings are 78 thousand therms, or 0.4% of the baseline.
  - 2035 cumulative savings in 2035 are 923 thousand therms, or 5.1% of the baseline.
  - 2050 cumulative TRC achievable economic potential reaches 1,293 thousand therms, or 7.8% of the baseline.
    - Potential under the TRC test is slightly lower than under the UCT due to the inclusion of the entire incremental measure costs rather than solely the utility portion.

- **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 were provided by NW Natural with a 10% conservation credit embedded per Council methodologies.
  - 2024 first-year savings are 78 thousand therms, or 0.4% of the baseline.
  - 2035 cumulative savings in 2035 are 923 thousand therms, or 5.1% of the baseline.
  - 2050 cumulative UCT achievable economic potential reach 1,304 thousand therms, or 7.9% of the baseline.

TABLE 6-4 SUMMARY OF TRANSPORTATION ENERGY EFFICIENCY POTENTIAL (THOUSAND THERMS)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2035	2040	2050
Reference Baseline	19,434	19,241	19,104	18,580	17,993	17,497	16,518
Cumulative Savings (thousand therms)							
Achievable Econ TRC Potential	78	156	235	559	918	1,176	1,293
Achievable Econ UCT Potential	78	157	237	563	923	1,184	1,304
Achievable Technical Potential	94	187	282	649	1,029	1,289	1,398
Technical Potential	137	272	407	912	1,373	1,620	1,705
Cumulative Savings (% of Baseline)							
Achievable Econ TRC Potential	0.4%	0.8%	1.2%	3.0%	5.1%	6.7%	7.8%
Achievable Econ UCT Potential	0.4%	0.8%	1.2%	3.0%	5.1%	6.8%	7.9%
Achievable Technical Potential	0.5%	1.0%	1.5%	3.5%	5.7%	7.4%	8.5%
Technical Potential	0.7%	1.4%	2.1%	4.9%	7.6%	9.3%	10.3%

Figure 6-1 Summary of Annual Cumulative Transportation Energy Efficiency Potential

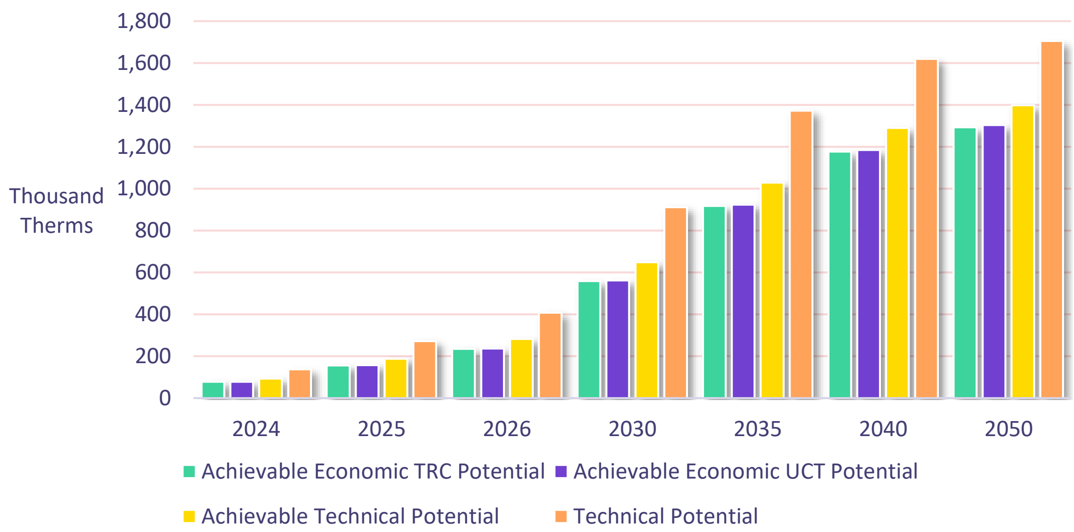


Figure 6-2 displays projected loads after removing each level of potential and as compared to the baseline projection. Because the technical potential represents the largest amount of savings, its resulting load projection is the lowest.

Figure 6-2 Transportation Baseline Projection and Annual Energy Efficiency Forecasts (Thousand Therms)

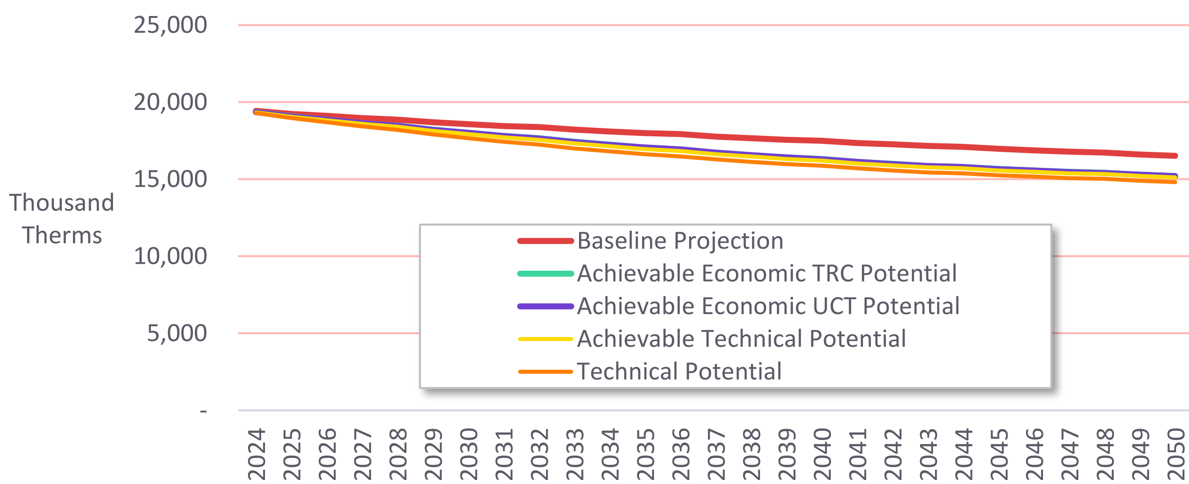


Figure 6-3 shows the cumulative TRC achievable potential for both transportation sectors for the full timeframe of the analysis as a percent of total savings. Table 6-5 summarizes TRC achievable potential by sector for selected years. The industrial sector represents the largest share of transportation customer potential throughout the study period, with commercial share of savings growing over the study timeframe.

FIGURE 6-3 TRANSPORTATION CUMULATIVE TRC ACHIEVABLE ECONOMIC POTENTIAL BY SECTOR (% OF TOTAL)

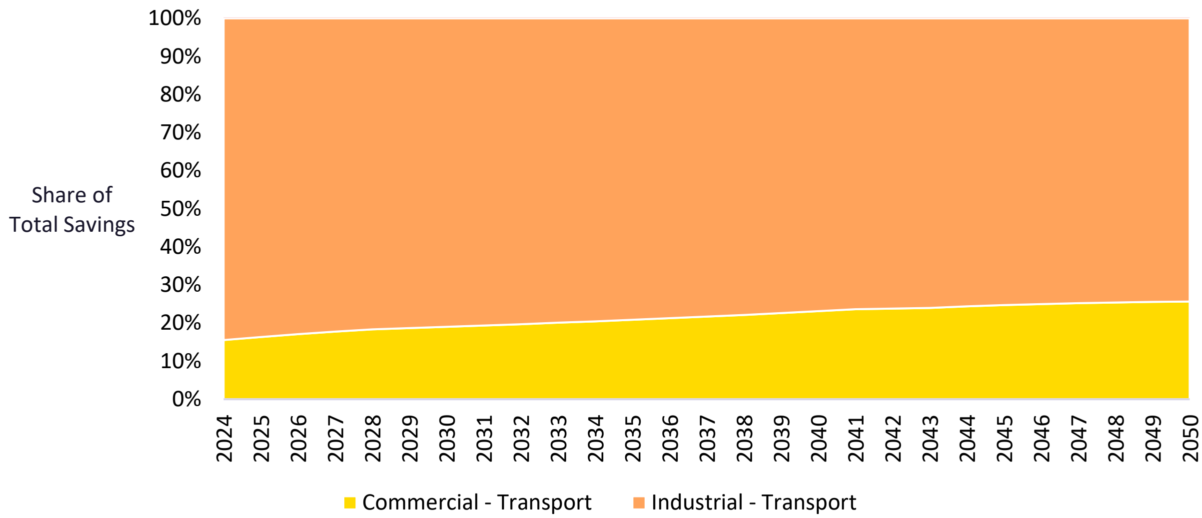


TABLE 6-5 CUMULATIVE TRANSPORTATION TRC ACHIEVABLE ECONOMIC POTENTIAL BY SECTOR, SELECTED YEARS (THOUSAND THERMS)

Sector	2024	2025	2026	2030	2035	2040	2050
Commercial	11	24	38	102	184	262	321
Industrial	66	132	197	457	733	914	972
Total	**78**	**156**	**235**	**569**	**918**	**1,176**	**1,293**

Commercial Transportation Potential

Table 6-6 and Figure 6-4 summarize the energy conservation potential for the commercial transportation customers In 2024, TRC achievable economic potential is 12 thousand therms, or 0.6% of the baseline projection. By 2050, cumulative savings are 336 thousand therms, or 13.3% of the baseline.

TABLE 6-6 COMMERCIAL TRANSPORTATION POTENTIAL SUMMARY (THOUSAND THERMS)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2040	2050
Baseline Forecast	2,370	2,369	2,367	2,367	2,433	2,527
Cumulative Savings (thousand therms)						
Achievable Economic TRC Potential	11	24	38	102	262	321
Achievable Economic UCT Potential	12	25	39	105	269	331
Achievable Technical Potential	23	46	71	161	332	386
Technical Potential	51	102	153	329	497	524
Cumulative Savings (% of Baseline)						
Achievable Economic TRC Potential	0.5%	1.0%	1.6%	4.5%	10.8%	12.7%
Achievable Economic UCT Potential	0.6%	1.0%	1.7%	4.4%	11.1%	13.1%
Achievable Technical Potential	1.0%	1.9%	3.0%	6.8%	13.6%	15.3%
Technical Potential	2.1%	4.3%	6.4%	13.9%	20.4%	20.7%

Figure 6-4 Commercial Transportation Cumulative Potential by Case

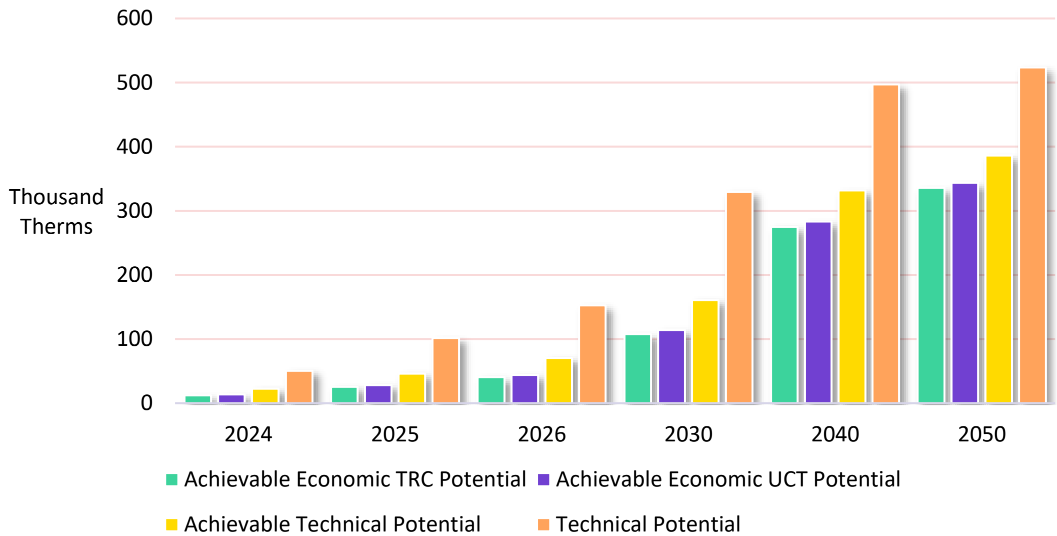


Figure 6-5 presents forecasts of energy savings by end use as a percent of commercial cumulative potential. Water heating represents the majority of the potential over time. The segments represented in Commercial Transportation differ from Commercial Sales causing water heating to show the largest potential growth over the time horizon. To remain consistent with the previous CPA, the segments for Commercial Transportation are excluding large space heating savings associated with Office, Restaurants, and Schools as these segments were not mapped as Commercial Transportation applications during Market Characterization.

Figure 6-5 Commercial Transportation TRC Achievable Economic Potential – Cumulative Savings by End Use

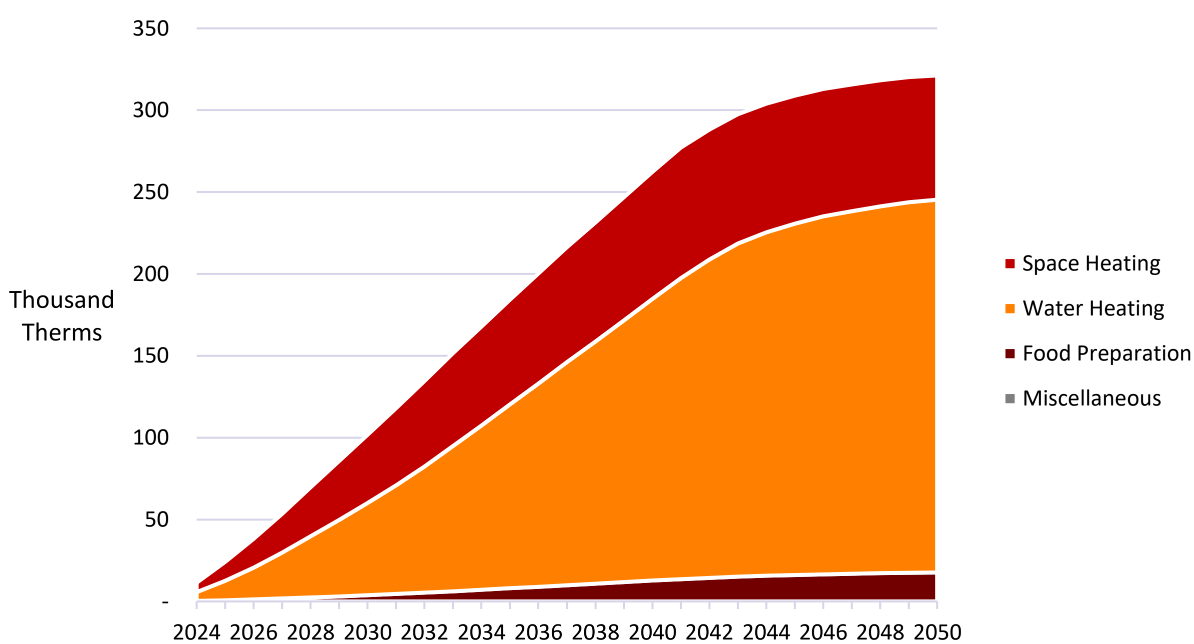


Table 6-7 identifies the top 10 commercial measures by cumulative savings in 2024 and 2050.

TABLE 6-7 COMMERCIAL TRANSPORTATION TOP MEASURES IN 2024 AND 2050, TRC ACHIEVABLE ECONOMIC POTENTIAL

Rank	Measure / Technology	2024 Achievable Economic TRC Potential (thousand therms)	2050 Achievable Economic TRC Potential (thousand therms)	% of Total
1	Water Heater – Gas Fired Absorption HPWH	3.1	217	67.5%
2	Insulation - Roof/Ceiling – R-38	0.9	11	3.5%
3	Water Heater - Pre-Rinse Spray Valve – 2 GPM sprayer nozzle	2.2	9	2.9%
4	Space Heating - Heat Recovery Ventilator – HRV installed	0.6	8	2.5%
5	Gas Boiler - Insulate Hot Water Lines – Insulated water lines	0.5	6	2.0%
6	Boiler – Convert to Gas-Fired ASHP	0.2	6	1.8%
7	Range – High Efficiency	0.1	6	1.8%
8	Hydronic Heating Radiator Replacement	0.5	5	1.7%
9	Kitchen Hood - DCV/MUA – Vent hood	0.3	5	1.5%
10	Broiler – Infrared Burners	0.1	4	1.4%
	Subtotal	**8.5**	**278**	**86.5%**
	Total Savings in Year	**11.4**	**336**	**100.0%**

Industrial Transportation Potential

Table 6-8 and Figure 6-6 summarize the energy conservation potential for the industrial transportation customers. In 2024, TRC achievable economic potential is 66 thousand therms, or 0.4% of the baseline projection. By 2050, cumulative savings reach 972 thousand therms, or 6.9% of the baseline.

TABLE 6-8 INDUSTRIAL TRANSPORTATION POTENTIAL SUMMARY (THOUSAND THERMS)

Summary of Energy Savings, Selected Years	2024	2025	2026	2030	2040	2050
Baseline Forecast	17,063	16,871	16,737	16,213	15,064	13,991
Cumulative Savings (thousand therms)						
Achievable Economic TRC Potential	66	132	197	457	914	972
Achievable Economic UCT Potential	66	132	197	458	915	974
Achievable Technical Potential	71	141	211	488	958	1,012
Technical Potential	86	170	254	582	1,123	1,182
Cumulative Savings (% of Baseline)						
Achievable Economic TRC Potential	0.4%	0.8%	1.2%	2.8%	6.1%	6.9%
Achievable Economic UCT Potential	0.4%	0.8%	1.2%	2.8%	6.1%	7.0%
Achievable Technical Potential	0.4%	0.8%	1.3%	3.0%	6.4%	7.2%
Technical Potential	0.5%	1.0%	1.5%	3.6%	7.5%	8.4%

FIGURE 6-6 INDUSTRIAL TRANSPORTATION CUMULATIVE POTENTIAL BY CASE

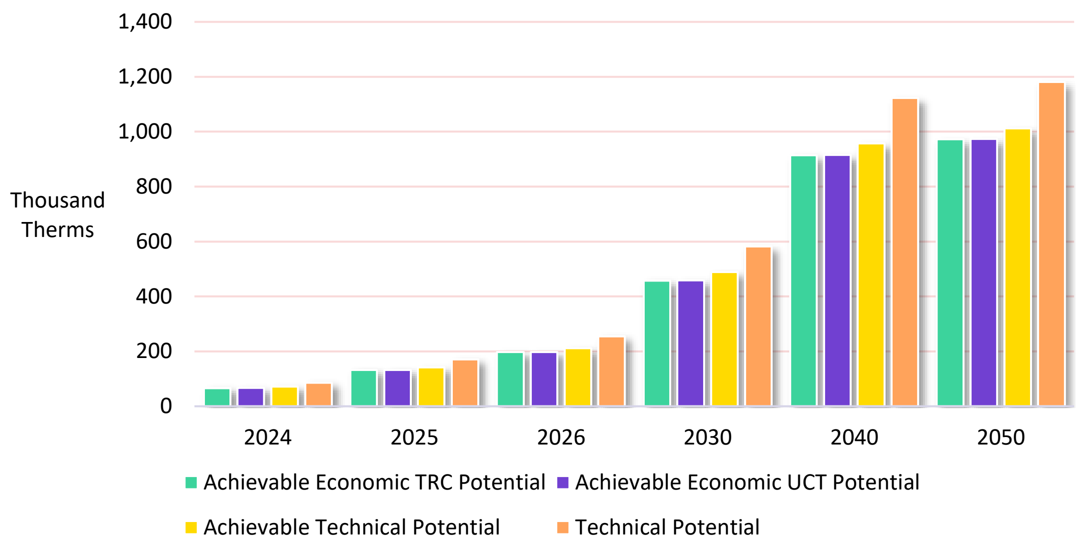


Figure 6-7 presents forecasts of energy savings by end use as a percent of total industrial cumulative potential. As shown, the potential is dominated by opportunities to save energy on process loads.

FIGURE 6-7 INDUSTRIAL TRANSPORTATION TRC ACHIEVABLE ECONOMIC POTENTIAL – CUMULATIVE SAVINGS BY END USE

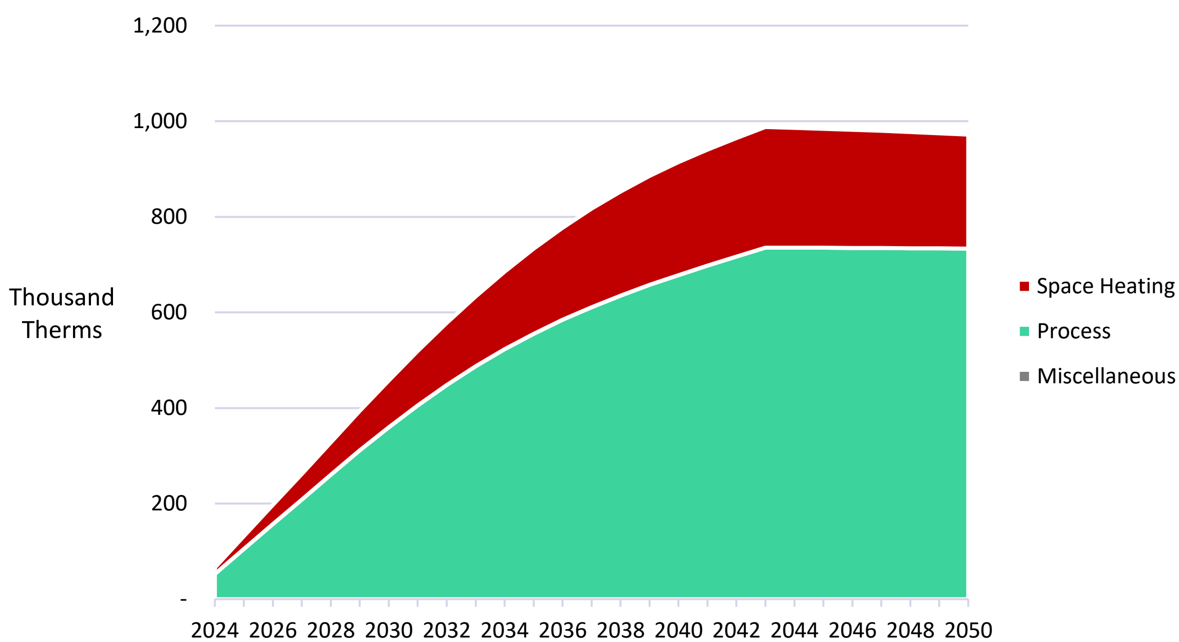


Table 6-9 identifies the top 10 industrial measures by cumulative 2024 and 2050 savings. Strategic energy management of industrial process applications is the highest measure by total potential.

Table 6-9 Industrial Transportation Top Measures in 2024 and 2050, TRC Achievable Economic Potential (thousand therms)

Rank	Measure / Technology	2024 Achievable Economic TRC Potential (thousand therms)	2050 Achievable Economic TRC Potential (thousand therms)	% of Total
1	Strategic Energy Management – Energy management system installed and programmed	17.2	256	26.3%
2	Gas Boiler - Insulate Hot Water Lines – Insulated Water Lines	9.1	155	15.9%
3	Gas Boiler - Stack Economizer – Economizer Installed	8.9	76	7.8%
4	Insulate Steam Lines/Condensate Tank – Lines and condensate tank insulated	4.2	74	7.7%
5	Gas Boiler - Hot Water Reset – Reset control installed	3.1	68	7.0%
6	Insulation - Roof/Ceiling – R-38	5.8	63	6.5%
7	Process - Insulate Heated Process Fluids – Insulated process fluid lines	6.0	53	5.5%
8	Building Automation System – Automation system installed and programmed	0.2	51	5.3%
9	Gas Boiler - Burner Control Optimization – Optimized burner controls	0.3	43	4.4%
10	Gas Boiler - High Turndown – Turndown control installed	3.5	28	2.9%
	Subtotal	**58.2**	**867**	**89%**
	Total Savings in Year	**66.3**	**972**	**100%**

A | ALIGNMENT WITH THE COUNCIL'S 2021 POWER PLAN METHODOLOGY

While developing potential estimates for NW Natural's CPA, AEG strove to adapt the Northwest Power and Conservation Council's 2021 Conservation and Electric Power Plan methodologies wherever appropriate for gas studies to maintain consistency with standard regional approaches. 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 Power Plan and Regional Technical Form (RTF) work products when applicable to natural gas, and utilize or adapt Council and RTF assumptions where possible;
- Adapt the 2021 Power Plan's ramp rates for use in natural gas efficiency programs; and
- Incorporate all quantified and monetized non-energy impacts into the TRC test.

We describe these steps in more detail below.

Estimate Technical, Achievable Technical, and Achievable Economic Potential

Within the 2021 Power Plan, the Council estimates three levels of potential: technical, achievable technical, and achievable economic. This is different from standard-practice methodology in other regions 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 and achievability factors to estimate achievable technical potential, and finally screening for cost effectiveness to estimate achievable economic potential. Within this study, AEG estimated potential from both the Total Resource Cost (TRC) and Utility Cost Test (UCT) perspectives.

Utilize Regional Market Baseline Data

In addition to NW Natural-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 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 things like baseline window types (e.g., single vs. double pane) or number of homes with exterior ductwork.

NEEA's surveys were also used to inform commercial and industrial energy intensities on a per-square-foot and per-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 square feet.

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

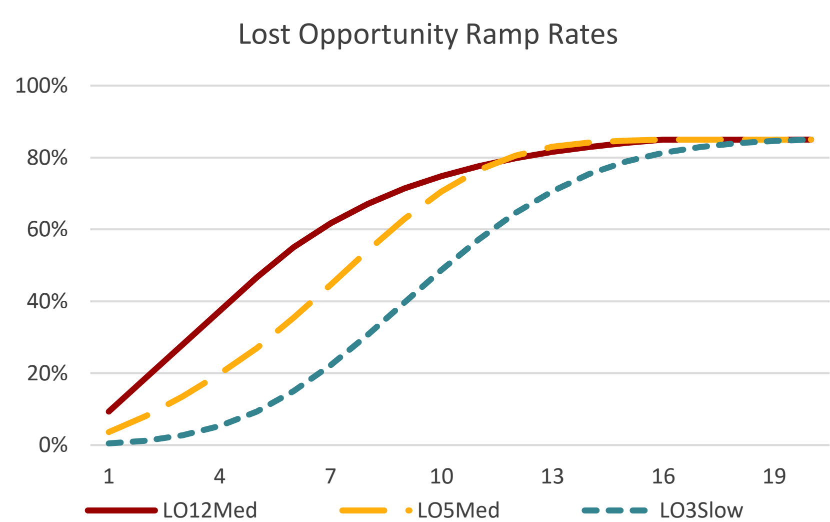
While many of the Council and RTF assumptions were developed with electricity savings in mind, there is data that may be adapted for use in estimating gas potential. For example, weatherization measures may be applied equally to both electric and gas heating systems, so assumptions on lifetime and cost 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.

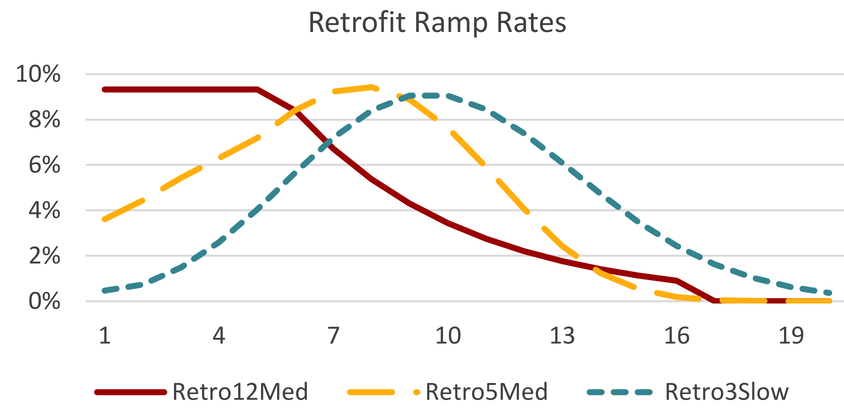
When developing the measure list for this study, AEG began with workbooks from the 2021 Plan and RTF to ensure that all similar measures were captured. We used assumptions from these workbooks when appropriate and substituted gas-specific details as necessary.

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 expected to adopt an efficiency measure as part of a utility energy efficiency 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 NW Natural 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, NW Natural'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, NW Natural'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.

Note that this study identifies cost-effective measures, but it does not adjust ramp rates to account for any potential barriers of new program implementation; for example, the additional lead time to set up and incorporate new measures into existing programs.

Incorporate All Quantified and Monetized Non-Energy Impacts into the TRC Test

The TRC test evaluates impacts for both the utility and customer, while the UCT perspective considers only costs and benefits as they impact the utility. 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 (NEIs).

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. Accordingly, 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.

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