AEG
Applied Energy Group

2020 CASCADE NATURAL GAS CONSERVATION POTENTIAL ASSESSMENT

Phase 2 Volume 2, Appendices

June 4, 2021

Report prepared for:
CASCADE NATURAL GAS CORPORATION

Energy Solutions. Delivered.

This work was performed by:

Applied Energy Group, Inc.
2300 Clayton Road, Suite 1370
Concord, CA 94520

Project Director: E. Morris
Project Manager: K. Walter
Lead Analyst: M. McBride
Analysts: R. Strange
N. Perkins
G. Wroblewski

AEG would also like to acknowledge the valuable contributions of

Cascade Natural Gas Corporation
1600 Iowa Street
Bellingham, WA 98229

Project Team: M. Cowlishaw
K. Burin
P. Hensyel

APPENDIX SUMMARY

This appendix volume provides additional data and context to Cascade's Natural Gas CPA. General background information and summary results can be found in Volume 1.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1

INTRODUCTION

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

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

Conservation Potential Assessment Objectives

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

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

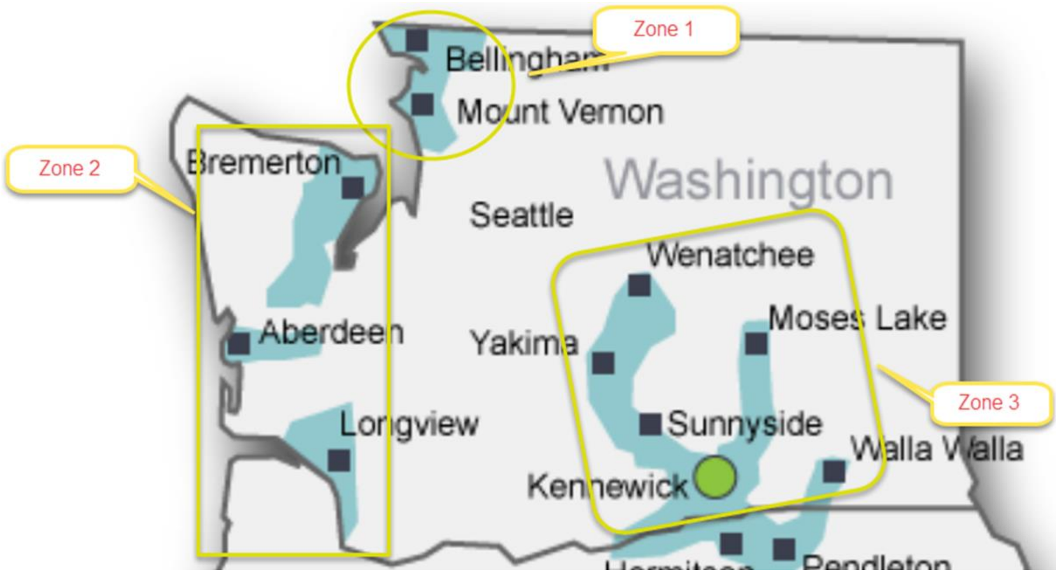
Thirdly, the CPA is intended to support the design of programs to be implemented by Cascade during the upcoming years. One output of the LoadMAP model is a comprehensive summary of measures, documenting input assumptions and sources on a per-unit basis, program applicability and achievability (ramp rates),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

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

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

present a map of Cascade's Washington climate zones in Figure 1-1 to summarize the terms we reference throughout this study.

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



Specific Goals of Phase 2

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

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

Study Considerations

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

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

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

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

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

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

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

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

- Assessing Potential Under a Resource Value Test (RVT): At the time of the 2017 CPA, Washington Utilities and Transportation Commission (WUTC) staff was considering the development of a Resource Value Test to assess the cost-effectiveness of energy efficiency measures. To investigate the impacts on potential of including benefits not captured in the Total Resource Cost test, AEG performed a review of treatment in other jurisdictions, ultimately adopting a 20% benefit adder for the purpose of the sensitivity analysis.

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

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

Summary of Report Contents

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

Volume 1, Final Report:

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

Volume 2, Appendices:

- Alignment with the Council's Methodology. Discussion on how this study aligns with Council electric-centric methodologies, including ramp rates, regional data, and measure assumptions.
- Market Profiles. Detailed market profiles for each market segment. Includes equipment saturation, unit energy consumption or energy usage index, energy intensity, and total consumption.

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

Abbreviations and Acronyms

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

Table 1-1 Explanation of Abbreviations and Acronyms

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

A

ALIGNMENT WITH THE COUNCIL'S 2021 PLAN METHODOLOGY

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

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

We describe these in more detail below.

Estimate technical, achievable technical, and achievable economic potential

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

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

Utilize regional market baseline data

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

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

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

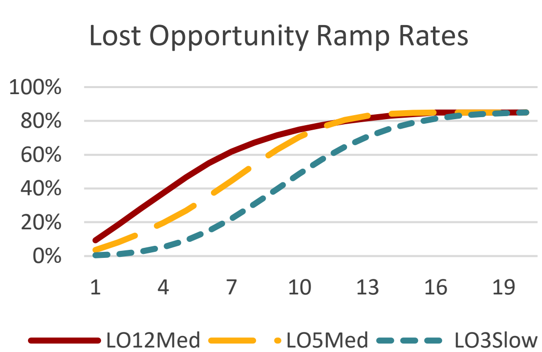
While many of the Council and RTF assumptions were developed with electricity savings in mind, there is data that may be adapted for use in estimating gas potential. For example, weatherization measures may be applied equally to both electric and gas heating systems, so assumptions on lifetime and cost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

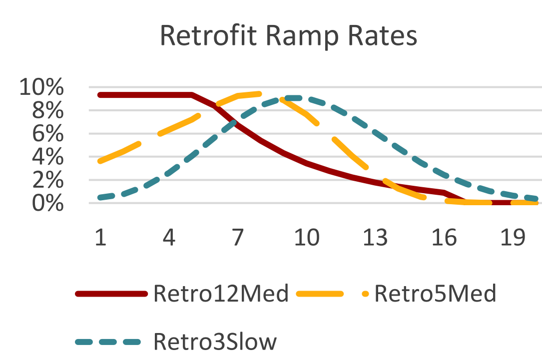
When developing the measure list for this study, AEG began with workbooks from the 2021 Plan and RTF to ensure that all similar measures were captured. We used assumptions from these workbooks when appropriate, and substituted gas-specific details as necessary.

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

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

Figure A-1 Example Power Council Ramp Rates





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

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

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

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

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

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

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

- Account for non-gas impacts, such as cooling savings within a weatherization program or lighting savings from a retrocommissioning program

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

B

DATA DICTIONARY

This appendix provides definitions for a list of terms commonly used in the development of Cascade's 2021 Conservation Potential Assessment (CPA).

Modeling Tool

LoadMAP End-Use Forecasting Tool

AEG's custom end-use energy forecasting and modeling tool. The model is separated into three modules as detailed below.

LoadMAP Baseline

Baseline end-use forecasting tool. The model takes a units-based approach to stock turnover, tracking equipment installations in each year.

LoadMAP Potential

Potential forecasting module which calculates potential relative to the baseline projection developed in the previous module. This model begins with the detailed stock accounting results from the LoadMAP Baseline analysis but converts all measures to single line-item for transparency and ease of review.

LoadMAP Results

Summarizes modeling outputs from the two prior modules at both a high level and in measure-by-measure detail. This module does not perform any potential estimation calculations but is instead intended to serve as a centralized location for reviewing model outputs and summarizing results.

Model Input Spreadsheets

Three separate spreadsheets are used to develop inputs that feed into the LoadMAP model. These allow us to organize data, efficiently update assumptions, and convert data into a format more suitable for computer use.

Market Profile

LoadMAP input tool which deconstructs utility-provided base-year consumption data into detailed sectors, segments, end uses, and technologies as described below.

Equipment Input Generator

Formats modeling inputs for all equipment types of technologies. The LoadMAP modeling framework defines a piece of equipment as a piece of energy-consuming technology whose primary function is to deliver an end-use service, such as heating a home.

Non-Equipment Input Generator

Formats modeling inputs for all non-equipment types of measures. The primary purpose of non-equipment measures is to modify energy consumption of equipment technologies and save energy. Examples include smart thermostats and low-flow showerheads.

Occasionally, an equipment technology may be classified as a non-equipment measure for modeling considerations, such as if the equipment in question does not directly use the energy fuel under study, or if more than one end use would be affected. This occurs in the case of clothes washers, which consume electricity to mechanically clean clothes, but will save natural gas if connected to a gas-fired water heater.

Market Profile

Market profiles characterize energy use for each customer segment, end use, and technology for the base year. The base-year market profiles are the basis for developing the forecast of annual energy use by customer segment and end use.

Segmentation

The purpose of segmenting a market is to group customers into segments with common properties. When developing a profile, we break energy out using the following categories:

Market Sector

Distributes the market by general use type. The most common sectors are residential, commercial, and industrial.

Market Segment

Defines the primary market segments. This approach is useful because energy-use patterns differ strongly across home types in the residential sector, building types in the commercial sector, and industries in the industrial sector. Differences reflect variation in energy-using activities and energy-using equipment and technologies.

Vintage

The model separates floor area into new and existing vintages. Existing homes are present in the base-year of the study and go off-market over the study period. The new vintage includes new construction as well as major retrofits which are subject to current building codes. The new vintage grows over time.

End Use

An energy end use is the ultimate service delivered by energy-using equipment, such as Space Heating, Water Heating, etc.

Technology

The term "Technology" is used in LoadMAP to indicate the specific type of equipment used to deliver the end-use service. Equipment technologies consume energy and represent the most granular energy classification within the market profile. Examples of equipment technologies include forced-air furnaces, tankless water heaters, and ovens.

Profile Parameters

The market profile contains the following data fields:

Control Total

Annual energy consumption in the base year of the study, typically the most recent calendar year with 12 months of billing data.

Market Size

Number of modeling units within a given sector and segment. These are generally defined in households for the residential sector, floor stock for the commercial sector, and employment for the industrial sector.

Saturation

Indicates 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. This applies to cooling and heating end uses.
- The whole-building approach measures shares of space in a building with an end use regardless of the portion of each building that is served by the end use. Examples are commercial refrigeration and 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. This is used for process and miscellaneous consumption.

UEC or EUI

Unit Energy Consumption (the amount of energy a given piece of equipment is expected to use in one year) or Energy Use Index (a UEC indexed to a non-building market unit, such as per square foot or per employee).

These are indices that refers 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.

Energy Intensity

Intensity is computed as the product of the saturation and the UEC or EUI and represents the <u>average</u> use for the technology across <u>all</u> market units. If the saturation is 100%, the intensity will exactly equal the UEC or EUI.

Intensity may be summed up at the end use level to calculate the average end-use consumption for a given market segment or fully summed to calculate consumption for an average home, square foot, or employee. The market profile is calibrated to the intensity calculated as the quotient between the control total and market size.

Base-Year Energy Equation

These are the key concepts used in end-use energy analysis. By developing data for these concepts, a complete profile of sector-level energy use can be produced. With the usage index set to 1.0, the central energy equipment defined the current energy use for each segment as the product of three factors: market size, saturation, and UEC or EUI. For a specific market segment, end use and technology, the central energy equation is:

$$Energy = \sum_{s}\sum_{e}\sum_{i} N_s \times Share_{se} \times UEC_{sei}$$

Where:

- N = market size
- Share = average saturation of space served by an end use and technology
- UEC (or EUI) is the average energy use per market size (floor space, GDP or home) of served space

Indices:

- s = segment
- e = end use
- i = technology

Market size, share and UEC / EUI values for each segment are the base-year input data required by end-use models. These data are combined in the central energy equation to give sales by end use and technology for each segment.

Segmentation Definitions

The following section describes the details that comprise each market segment. For end use and equipment technology definitions, please refer to the measure list Excel file delivered as part of this study.

Residential Segmentation

Residential segmentation is broken down into two or more housing types, as described below.

Single Family

Single family homes consist of standalone homes as well as town homes where less than five units are connected (e.g., duplexes, triplexes, etc.). Due to a larger footprint and fewer shared walls/ceilings/floors, single family homes consume considerably more energy per unit than the multifamily units described below.

Multifamily

The multifamily segment consists of both low-rise and high-rise apartment buildings as well as town homes where more than four units are connected. These units individually consume less energy than a single-family home and may have centralized heating or water heating equipment serving more than one unit at a time.

Income Level

For Phase 2, we conducted an analysis of customers by income group and included three classifications in the segmentation of the CPA – Low Income, Moderate Income, and customers above the Median household income.

Commercial Segmentation

Commercial segmentation is broken down by building type, as described below.

Office

Traditional office-based businesses including finance, insurance, law, government buildings, etc.

Retail

Department stores, services, boutiques, strip malls etc.

Restaurant

Sit-down, fast food, coffee shop, food service, etc.

Grocery

Supermarkets, convenience stores, market, etc.

Education

College, university, trade schools, etc.as well as day care, pre-school, elementary, secondary schools

Health

Health practitioner office, hospital, urgent care centers, etc.

Lodging

Hotel, motel, bed and breakfast, etc.

Warehouse

Large storage facility, refrigerated/unrefrigerated warehouse

Miscellaneous

Catchall for buildings not included in other segments, includes churches, recreational facilities, public assembly, correctional facilities, etc.

Industrial Segmentation

Industrial segmentation is broken down by industry type. These include food products, agriculture, primary metals, stone clay and glass, petroleum, paper and printing, instruments, wood and lumber products, and other industrial.

End-Use Definitions

The following table describes the end uses modeled as part of this study and identifies which market sectors each applies to. In each case, we only call out segments where consumption of the end use is considerable. The remaining applications get captured by the miscellaneous end-use category.

Table B-1 Description of End Uses by Market Sector

End Use	Description	Residential	Commercial	Industrial
Space Heating	Provides heating for conditioned spaces and freeze protection for select unconditioned spaces	X	X	X
Secondary Heating	Provides backup or supplemental heating and is normally installed along with primary space heating equipment. May be used for aesthetic reasons rather than practical.	X		
Water Heating	Heating of potable hot water for domestic applications, typically delivered via faucets and showerheads.	X	X	
Appliances	Energy-consuming piece of equipment especially for use in the home or for performance of domestic chores.	X		
Food Preparation	Equipment designed for the use in commercial or institutional-scale kitchens used to cook and store food.		X	
Process	Industrial processes which use heat to form, process, or dry manufactured goods.			X

Miscellaneous	Catch-all category which includes small or non-typical applications. This includes equipment such as gas barbeques and pool heaters	X	X	X

Baseline Projection

For the base year, the market profiles discussed above provide a detailed depiction of energy-use patterns at the end-use level. The end-use forecasting framework projects these detailed profiles into the future. It is applied separately to each segment. As a result, it is appropriate to think of an end-use model as a matrix of models.

Projection Modeling Components

The following discussion describes each model component briefly within the end-use forecasting framework.

Market Size Projection

This component is used to organize information about the existing market size and to forecast future size. The outlook for market size embodies the utility planning assumptions about growth in population for the residential sector and growth in economic activity for the commercial and industrial sectors.

Saturation Growth/Decay

This component reflects trends in construction practices and consumer purchases for new and replacement appliances and equipment. While some end-use models attempt to model these changes in saturations, others (like LoadMAP) rely on observed historical trends and expected future outcomes to develop these forecasts.

UEC or EUI Changes

These values reflect the choices among energy technologies, primarily the decision to select a specific design option, defined by equipment type and efficiency level. The choices are reflected in a forecast of purchase shares for each specific design option. Combined with building and dwelling characteristics and initial usage patterns, this decision determines the UEC or EUI for each segment and end-use technology.

Projection Parameters

Once a building is constructed and equipment is in place, changes in usage levels reflect daily decisions about the frequency and intensity of equipment use. These decisions are determined by the behavior of building occupants and managers. The factors that influence usage are typically explicitly identified in an end-use model as energy prices, weather data, and other user-defined exogenous variables. These parameters include:

Purchase Shares

Represent equipment purchasing decisions for each year of the projection. Each share represents the percent of equipment purchased for each efficiency level within a technology. For each technology permutation, these must sum up to exactly 100% and obey off-market designations whenever a new federal standard or state building code goes into effect.

Vintage Distribution

Represents the age of equipment present in the base-year of a study. Equipment is classified into annual bins based on age. LoadMAP's stock-accounting model steps vintage forward one year then identifies the number of equipment units which have exceeded their lifetime. The model then repurchases equipment at the efficiency levels defined by that year's purchase shares.

Utilization Index

In the base year, usage levels are set to 1.0, providing an index of usage. Changes relative to the base-year usage pattern will be modeled as changes in the usage index, proportional to the starting value. For example, if a natural gas price increase leads to a change in thermostat settings that causes a 5% decline in space heating use, the usage index for natural gas would drop from 1.0 to .95.

Baseline Projection Equation

Within each market segment, or model cell, the end-use model computes energy sales using the central energy equation. For a given customer segment (s), end use (e), technology (i), this equation sums across all vintages as follows:

$$\sum_{v} Nv_v \times Share_v \times UEC_v \times Util_v$$

This equation defines the annual energy sales as the sum across vintages (v) of the product of four factors:

- Market size of vintage v
- The share of vintage market size using the end-use technology
- The UEC in vintage v
- Utilization rates in vintage v

Potential Estimation

In this study, the savings estimates are developed for three types of potential: technical potential, economic potential, and achievable potential. These are developed at the measure level, and results are provided as savings impacts over the 21-year forecasting horizon. The various levels are described below.

Technical Potential

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

Technical potential also assumes the adoption of every other available measure, where technically feasible. For example, it includes installation of high-efficiency windows in all new construction opportunities and furnace maintenance in all existing buildings with installed furnaces. These retrofit measures are phased in over a number of years to align with the stock turnover of related equipment units, rather than modeled as immediately available all at once.

Achievable Technical Potential

Achievable technical potential refines technical potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and other factors that affect market penetration of conservation measures. The customer adoption rates used in this study were the ramp rates developed for the Northwest Power & Conservation Council's 2021 Plan, modified for use in natural gas conservation programs.

UCT Achievable Economic Potential

UCT achievable economic potential further refines achievable technical potential by applying an economic cost-effectiveness screen. In this analysis, primary cost-effectiveness is measured by the Utility Cost Test (UCT), which assesses cost-effectiveness from the utility's perspective. This test compares lifetime energy benefits to the costs of delivering the measure through a utility program, excluding monetized non-energy impacts. These costs are the incentive, as a percent of incremental cost of the given efficiency measure, relative to the relevant baseline course of action, plus any administrative costs that are incurred by the program to deliver and implement the measure. If the benefits outweigh the costs (that is, if the UCT ratio is greater than 0.9), a given measure is included in the economic potential. Note that we set the measure-level cost-effectiveness threshold at 0.9 for this analysis since Cascade is allowed to include non-cost-effective measures as long as the entire portfolio is cost effective. This is important because a portfolio considers more than just energy savings. Cascade may include popular measures that are on the cusp of cost-effectiveness, accommodate variance between climate zones, maintain a robust portfolio, or include a measure that improves customer outreach and communication.

TRC Achievable Economic Potential

TRC achievable economic potential is similar to UCT achievable economic potential in that it refines achievable technical potential through cost-effectiveness analysis. The Total Resource Cost (TRC) test assesses cost-effectiveness from a combined utility and participant perspective. As such, this test includes full measure costs but also includes non-energy impacts realized by the customer if quantifiable and monetized. As a secondary screen, we include TRC results for comparative purposes and future use if Cascade uses the TRC as their primary cost-effectiveness screen in the future.

RVT Achievable Economic Potential

RVT Achievable Economic Potential is similar to the UCT and TRC achievable economic potential but assesses cost-effectiveness from a regional perspective. The Resource Value Test (RVT) reframes the analysis around accomplishing a jurisdiction's regional policy goals and includes hard-to-quantify impacts through quantitative or qualitative approaches. This test allows jurisdictions to define policy goals which may include additional impacts beyond the traditional utility-customer TRC approach. In May of 2017, the National Efficiency Screening Project (NESP) released a National Standard Practice Manual[2] (2017 NSPM) which details an approach for conducting screening measures under the RVT. AEG assessed preliminary estimates of potential under the RVT as part of this study, but since policy goals are defined at the regional level under this test, we are awaiting recommendations on non-energy impacts and values from the Washington Utilities and Transportation Commission (WUTC). The model has been configured to accommodate these future updates as they become available.

A key step in the process of estimating energy conservation potential is the definition of each measure in terms of key parameters. These define how much energy a measure saves, how much it costs, how long the savings will last, any additional impacts the measure may have, the portion of the population where the measure is already installed, the percentage of the population for which measure installation is technically feasible, and the rate at which a measure may be achievably installed.

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

ECM Parameters

Lifetime

The effective useful lifetime (EUL) of an ECM. Determines the number of years for which a measure may be installed before requiring replacement. In the equipment model, EUL is typically defined as a range that averages out to a deemed value. This is done to the portion of the population which may maintain a unit longer than average and the portion that purchases new equipment earlier in a product's lifetime.

Measure Cost

Incremental cost of equipment plus labor required to install a measure. In the case of equipment measures, this is the difference in cost between installation of an efficient unit and the minimum baseline required by federal standards and building codes. In the case of non-equipment measures, the baseline is no action or installation, thus incremental costs equal full measure cost plus any labor.

Non-Energy Impacts

Additional benefits or costs present when installing a measure which may be present in addition to energy savings. A positive value represents a benefit while a negative value represents a cost. NEIs must be monetized in some way in order to be included within cost-effectiveness testing, typically as an annual $/year benefit, but may be monetized as a percentage scalar on utility costs or as a flat benefit added to the benefit-to-cost ratio calculation. Examples include reductions in water, detergent, and wood fuel usage.

O&M Impacts

Operation and maintenance costs or benefits required to keep a measure in operation. Most types of equipment technologies require periodic maintenance, so this cost or benefit only captures the difference in O&M between technologies. A piece of efficient equipment may be more complex, requiring more upkeep and therefore costing the consumer additional money each year. They may also be more robust and require less maintenance overall. Impacts due to a difference in baseline and efficient-case lifetimes may also be represented as an O&M impact and captured by the model.

Unit Energy Savings

Unit energy savings (UES) represent the annual savings, in therms, for a given measure or technology. This is specified in LoadMAP for each end use and technology for which it applies. In the case of efficient equipment, this is the difference in consumption between baseline technology and an efficient piece of equipment. The UES is given for the base-year of the study and is likely to change over time as baseline equipment becomes more efficient and exogenous utilization factors affect consumption.

Base Saturation

Percentage of market units for which a measure is present in the baseline. For equipment units, multiplying measure saturation by market units results in the total number of technology installations present. A subset of these units may be eligible for ECMs as determined by the stock turnover engine.

For non-equipment measures, this is the fraction of the population where a measure is already installed.

Technical Applicability

Technical applicability is the percentage of the market where a measure may be technically installed. This accounts for instances where a measure design may not be feasibly installed or where a technical barrier to installation is present. In equipment measures, this percentage is multiplied by the base saturation to determine the applicable percentage of the market. Since equipment measures are already limited by annual turnover, this is set to 100% by default and normally adjusted only for emerging technologies. Since this value is multiplied by equipment saturation, applicability fractions may be less than saturations.

For non-equipment measures, this represents the total fraction of the population upon which a measure may be installed. The difference between technical applicability and base saturation represents the technically eligible fraction of a population. Due to this arithmetic, applicability for a non-equipment measure must always be greater than or equal to its base saturation.

Additionally, applicability may be used to model the installation of more than one efficient technology or measure type, such as tanked and tankless water heaters or Class 30 and Class 22 windows. By splitting the applicability between two options, the model may include two mutually inclusive measures within the potential without running the risk of double-counting potential.

Please note that since LoadMAP only applies measures to relevant, specified equipment types, applicability does not represent the applicable percentage of end-use load (e.g. percent of heating which is ducted).

Ramp Rates

Also known as participation rates or potential factors. Ramp rates represent the achievable percentage of measure installations available in a given year. For equipment measures, these ramp rates are known as lost opportunity (LO) and represent the total percent of equipment turnover upon which a measure may be installed. As such, "LO" ramp rates begin at the base-year percentage and gradually increase until they reach maximum achievability.

For non-equipment measures, generally known as retrofits (Retro), ramp rates represent the percentage of entire stock eligible for measure installation. Since retrofit measures are not gated by end-of-life purchasing decisions, the total available number of units is much larger than in the lost opportunity case. These ramp rates are calculated from the lost opportunity ramp rates as the difference between two subsequent years. As such, retrofit ramp rates sum up to the steady-state maximum achievability rather than gradually reach it over time.

The standard assumption in CPAs in the Northwest is that ramp rates reach 85% achievability by the end of the study period. An exception is made for emerging technology ramp rates, which instead reach 55%. This may be modified on a measure-by-measure or program basis if real-world installation conditions differ from the regional average upon which these ramp rates are based.

C

RESOURCE VALUE TEST POTENTIAL

Background

As part of the 2020 CPA analysis, AEG has developed an approach for quantifying additional non-energy impacts (NEIs) used for assessing cost-effectiveness under the Resource Value Test (RVT). This test is similar in nature to a Total Resource Cost (TRC) test but reframes the analysis around accomplishing a jurisdiction's regional policy goals and includes hard-to-quantify impacts through quantitative or qualitative approaches. This test allows jurisdictions to define policy goals which may include additional impacts beyond the traditional utility-customer TRC approach. It is worth noting that certain impacts, such as those on public health, may be lessened for natural gas analysis, compared to electricity, especially in the Northwest. In the case of one notable impact, health benefits of emissions reductions, the impact is primarily from the reduction of fossil fuel electricity generation. Since natural gas is much cleaner than other fuels, translating this impact to end-user combustion will result in a small benefit. Additionally, this impact will be substantially reduced in the Northwest since the majority of generation comes from low-emission hydroelectric generation.

For the 2017 CPA, AEG recommended capturing all quantified and monetized impacts from the TRC described in the main volume of this report as well as a preliminary percent adder of 20% to all avoided costs to represent the impacts that cannot be easily monetized and have yet to be defined at a jurisdictional level.

Update to the RVT Proxy for the 2020 CPA

For the 2020 CPA, AEG updated its recommendation to reflect the sector level adjustment seen in some other jurisdictions and take advantage of the new income group analysis in the residential sector. To that end, the proxy RVT adder was updated to the following:

- Low Income Residential: +25% adder
- Other Residential and all C&I: +15% adder

The Washington Utilities and Transportation Commission (Commission) is currently developing recommendations for implementing the RVT by investor-owned utilities in the state and has provided guidance that this test be included in the current round of Conservation Potential Assessments (CPAs). Accordingly, AEG has built RVT functionality into its LoadMAP potential model. This includes the ability to assign quantified RVT-specific non-energy impacts and benefit-to-cost ratio adders at the detailed measure-level as well as to apply additional dollar and percentage benefits directly to avoided energy costs. Since the Commission has not yet finalized the jurisdiction's recommended policy goals, AEG recommends including the RVT as a secondary test for this CPA and not using RVT results for the setting of conservation goals. Placeholders have been included within LoadMAP to accept these specific benefits as they are defined.

In May of 2017, the National Efficiency Screening Project (NESP) released a National Standard Practice Manual[3] (2017 NSPM) which details an approach for conducting screening measures under the RVT. AEG will follow the approach for conducting resource value cost-effectiveness testing as described in this

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

manual. The following sections of this memo provide a summary of RVT benefits and AEG's initial recommendations for Cascade's territory and documents our proposed approach for quantifying additional NEIs.

Summary of RVT Impacts and AEG's Recommendations

The 2017 NSPM provides details on potential policy goals to include and recommends five different approaches for quantifying the associated impacts. One key component of this analysis is symmetry, ensuring the inclusion of any related benefits associated with the costs are included in testing. An example of this would be the inclusion customer-side NEIs such as the water savings when also including the non-incentivized portion of a high-efficiency clothes dryer measure installation.

Another important aspect to be aware of within these categories is impact overlap. This may manifest itself in two different ways.

- First, care must be taken to exclude impacts already accounted for in utility avoided costs. For example, if the avoided costs already include a social cost of carbon or energy risk adders, then it is not appropriate to include these costs within the "Energy Security" category as well.
- Second, overlapping impacts between categories must also be accounted for. For example, if the economic benefits due to reduced energy bills are quantified as part of the "Economic Development and Jobs" category, then they should not be included as poverty alleviation under the "Impacts on Low-Income Customers" category.

The table below summarizes the eight categories of non-utility impacts presented in Table 6 of the 2017 NSPM. While this list is not intended to be exhaustive, it provides a detailed list of impacts to consider and is a suitable starting point. Once finalized, AEG recommends Cascade update this list based on the final set of impacts provided by the Commission, if applicable to Cascade's service territory and the region. Please note that the 10% bonus for the energy and capacity benefits of conservation[4] from the Pacific Northwest Electric Power Planning and Conservation Act does not fall neatly into one of the categories below but may also be included in some form if determined to be applicable to natural gas.

Table C-1 Non-Utility RVT Impacts Considered for the 2020 Cascade CPA

NSPM Section[5]	Non-Utility Impact	Recommendation	Description
3.3.2	Participant Impacts	Consider in Future	The more tangible benefits are already captured in the sections below. May include intangibles such as comfort and productivity if the Commission provides a recommendation.
3.3.3	Impacts on Low-Income Customers	Include Low-Income Measures in Model	The benefits of low-income energy efficiency programs are well-recognized and have been included in other jurisdictions around the country. We recommend including a tailored set of low-income measures in LoadMAP and applying a benefit-to-cost ratio adder to these measures, which may allow them to pass with an RVT ratio of less than one.

[4] Washington Administrative Code 194-37-070 (5) (c) (xiv) http://apps.leg.wa.gov/WAC/default.aspx?cite=194-37-070

[5] Table 6 indicates that examples begin in section 3.3.1, but actually begin in 3.3.2. The first section instead summarizes the approach for the following eight impacts.

NSPM Section[5]	Non-Utility Impact	Recommendation	Description
3.3.4	Other Fuel Impacts	Include	AEG recommends capturing the benefits from secondary fuels for measures where natural gas measures may have an impact. For weatherization measures, this would include a reduction in wood fuel use and/or the impact on electric cooling in the summertime.
3.3.5	Water Impacts	Include	Water impacts are already monetized for RTF and 2021 Plan measures. AEG recommends including these and expanding to non-RTF measures if appropriate.
3.3.6	Environmental Impacts	Carbon already included in Utility Avoided Costs	A carbon credit is already included in the avoided cost of energy used for this analysis.
3.3.7	Public Health Impacts	Exclude	Due to the potentially large impacts and variance in existing estimates, AEG believes that this category should be quantified at a regional level for use by all investor-owned utilities. AEG will add a placeholder within the LoadMAP model to be updated should the Commission provide a recommended value for this category.
3.3.8	Economic Development and Jobs	Include	These impacts include both the use of conservation as a vehicle for job growth/job retention and an increase in a customer's disposable income and are of interest to both Cascade and the Commission.
3.3.9	Energy Security	Risk is already included in Utility Avoided Costs	Reliance on volatile energy markets is already reflected in the avoided energy costs as a risk premium adder.

Methodology for Quantifying Benefits

Table 12 of the 2017 NSPM recommends five different approaches for accounting for NEIs under the RVT. When followed in order, these approaches transition from more local and quantitative to more national and qualitative in nature. We detail the five approaches below.

Jurisdiction-Specific Studies

Relevant studies in Cascade's territory and the state of Washington should be used when available. These may take the form of low-income housing research, regional electricity prices for other fuel impacts, and local water costs for Cascade's territory. Since the RVT is a relatively new test and hasn't been widely implemented, we anticipate quantifying the more traditional NEIs using this approach.

Studies from Other Jurisdictions

Studies from other areas in the country or national sources may be used to quantify NEIs in the absence of regional sources. If these are used, care must be taken that assumptions are appropriate for Cascade's territory. For example, costs from a state that spends three to five times more on conservation than the average may not yield applicable data for more rural areas in Washington. In these cases, it still may be possible to adapt the methodology to Cascade's territory rather than the actual value.

Apply Similar Proxies

When no relevant sources are available, it may be useful to identify a similar metric or NEI and adapt it for use. One example where this may be appropriate is the ten percent electricity conservation credit defined above. While that credit may not fit neatly into one of the categories listed previously, it may provide insight for some combination of environmental impacts and energy security since the Conservation Act includes it to prioritize conservation over fossil-fuel emitting generation, which could require fuel to be imported from outside the region.

Quantitative and Qualitative Information and Alternative Thresholds

Care must be taken when using the final two approaches described in the 2017 NSPM, as they may not be traceable to well-documented sources. These approaches are important in context of the RVT because of the underlying test principle that *"using best-available information, proxies, alternative thresholds, or qualitative considerations to approximate hard-to-monetize impacts is preferable to assuming those cost and benefits do not exist or have no value"* (2017 NPSM, pg. viii).

Qualitatively monetized impacts will likely take the form of a percent addition to the avoided cost of energy ($/therm) since they likely will not be detailed enough to be applied to specific measures. This approach may be useful for highly subjective participant impacts, such as comfort, if determined to be an appropriate category in the region.

One example where an alternative threshold may be used would be to assess low-income measure cost-effectiveness. Since some low-income benefits such as reduced mobility may be difficult to quantify but we do not want to apply a low-income benefit globally to all measures, we may add a benefit-to-cost adder to all low-income measures, allowing them to pass with a cost-effectiveness ratio of 0.50 instead of 1.0 for example.

Preliminary Results of RVT Analysis

While developing potential estimates for the CPA analysis, AEG estimated preliminary impacts resulting from the additional non-energy impacts present within the RVT. The table below summarizes these impacts for selected years, compared to potential from the UCT test as well as the achievable technical and technical cases. As seen below, the RVT estimate is lower than UCT potential throughout the study period. These values may change as additional impacts are finalized within the region.

Table C-2 Preliminary Potential Estimates using the RVT (thousand therms)

Scenario	2021	2022	2023	2024	2025	2030
Baseline Forecast (thousand therms)	246,225	248,892	251,569	255,494	256,840	268,912
Cumulative Savings (thousand therms)						
UCT Achievable Economic Potential	765	1,630	2,694	3,550	4,954	15,610
RVT Achievable Economic Estimate	551	1,157	1,944	2,695	3,822	12,281
Achievable Technical Potential	1,678	3,486	5,544	7,473	9,955	25,538
Technical Potential	5,496	10,399	15,612	19,781	25,104	53,337
Energy Savings (% of Baseline)						
UCT Achievable Economic Potential	0.3%	0.7%	1.1%	1.4%	1.9%	5.8%
RVT Achievable Economic Estimate	0.2%	0.5%	0.8%	1.1%	1.5%	4.6%
Achievable Technical Potential	0.7%	1.4%	2.2%	2.9%	3.9%	9.5%

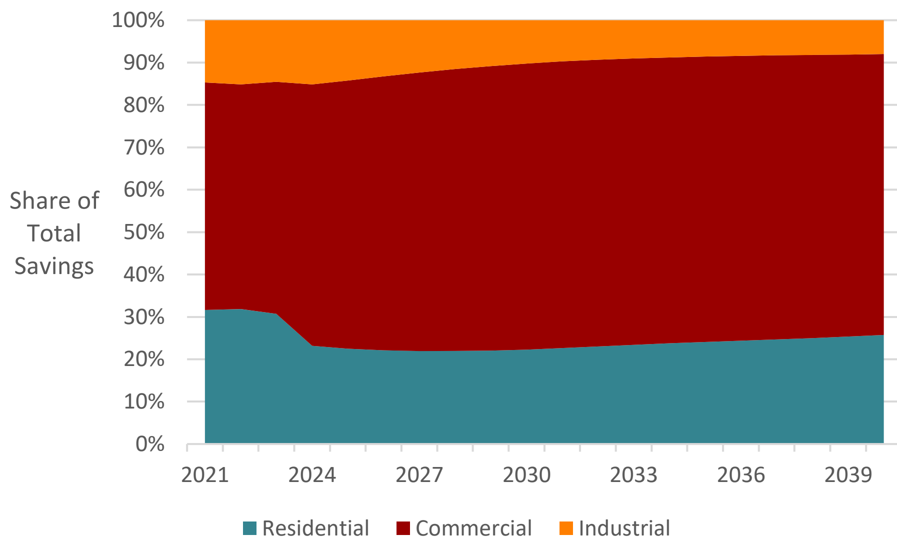
Technical Potential	2.2%	4.2%	6.2%	7.7%	9.8%	19.8%

As part of this analysis, we also summarize RVT estimates by market sector. The table and figure below display RVT estimates for the residential, commercial, and industrial sectors for select years. Compared to the UCT, RVT estimates are higher in the residential sector, and comparable to UCT in the commercial and industrial sectors. A large portion of commercial and industrial potential is already cost-effective, muting these impacts.

Table C-3 Preliminary RVT Potential Estimates by Sector (thousand therms)

Sector	2021	2022	2023	2024	2025	2030
Residential	174	368	597	624	861	2,736
Commercial	296	614	1,064	1,662	2,416	8,294
Industrial	81	175	283	408	545	1,252
Total	**551**	**1,157**	**1,944**	**2,695**	**3,822**	**12,281**

Figure C-1 Annual Share of Preliminary RVT Estimates by Sector



D

POTENTIAL BY SEGMENT

This section presents potential at the segment level for each sector. For details on the development of potential, please see Chapter 6 of volume 1 of this report.

Residential Potential

Table D-1 Residential Cumulative UCT Achievable Economic Potential by Segment (thousand therms)

Climate Zone and Housing Type	Income Group	2021	2022	2023	2024	2025	2030	2040
CZ1 - Single Family	Above Median	76	165	269	304	413	1,251	2,917
	Moderate Income	75	163	266	305	415	1,257	2,900
	Low Income	7	16	26	31	43	136	307
CZ1 - Multi Family	Above Median	10	21	34	36	48	131	321
	Moderate Income	13	27	44	46	62	170	422
	Low Income	1	2	3	3	5	14	31
CZ2 - Single Family	Above Median	36	79	131	148	202	622	1,454
	Moderate Income	36	79	129	149	204	627	1,448
	Low Income	3	7	12	15	21	69	156
CZ2 - Multi Family	Above Median	1	3	5	5	7	19	49
	Moderate Income	2	4	6	7	9	25	64
	Low Income	0	0	0	0	1	2	5
CZ3 - Single Family	Above Median	65	136	220	241	329	1,033	2,425
	Moderate Income	46	96	156	174	239	753	1,741
	Low Income	7	15	24	28	40	140	311
CZ3 - Multi Family	Above Median	5	10	16	16	22	63	151
	Moderate Income	6	13	21	22	29	87	208
	Low Income	1	3	5	5	7	23	52
Total	**Above Median**	**193**	**415**	**675**	**750**	**1,021**	**3,121**	**7,317**
	Moderate Income	**177**	**382**	**622**	**703**	**958**	**2,920**	**6,783**
	Low Income	**20**	**43**	**71**	**82**	**116**	**384**	**863**
Grand Total		**390**	**840**	**1,368**	**1,535**	**2,095**	**6,424**	**14,962**

Commercial Potential

Table D-2 Commercial Cumulative UCT Achievable Economic Potential by Segment (thousand therms)

Segment	2021	2022	2023	2024	2025	2030	2040
Office	61	125	207	310	433	1,309	2,420
Retail	43	104	202	357	572	2,431	4,562
Restaurant	27	60	107	172	259	1,023	2,481
Grocery	14	30	49	73	102	325	814
Education	47	98	157	225	301	805	1,514
Healthcare	31	62	98	138	180	432	831
Lodging	14	29	45	64	83	188	342
Warehouse	10	22	45	81	132	596	1,194
Miscellaneous	53	108	180	273	384	1,196	2,342
Grand Total	**301**	**639**	**1,091**	**1,693**	**2,445**	**8,304**	**16,500**

Industrial Potential

Table D-3 Industrial Cumulative UCT Achievable Economic Potential by Segment (thousand therms)

Segment	2021	2022	2023	2024	2025	2030	2040
Agriculture	11	23	36	51	67	158	323
Food Products	25	51	78	107	136	279	467
Instruments	6	12	19	27	34	80	159
Paper and Printing	2	4	6	8	10	20	35
Petroleum	4	8	13	17	22	42	65
Primary Metals	6	13	20	27	34	66	107
Stone, Clay, and Glass	9	17	26	35	44	77	110
Wood and Lumber Products	2	5	7	10	13	28	50
Other Industrial	8	18	29	41	54	131	275
Grand Total	**73**	**152**	**234**	**323**	**414**	**881**	**1,591**

E

MARKET PROFILES

This appendix contains detailed market profiles supplementing the sector-wide versions present in Section 3. We first present the residential profiles, followed by commercial, and finally industrial.

For ease, these profiles have been embedded in Excel format.

New, CNGC 2020 Conservation Potential Assessment WP, 6.15.2021 (C).xlsx

F

CUSTOMER ADOPTION FACTORS

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

AEG based these off the ramp rates developed for electric EE programs by the Council as part of the Seventh Northwest Conservation and Electric Power Plan. We adapted these ramp rates for use in estimating achievable natural gas EE potential using the following methods.

- Reassign an individual measure's ramp rate
- Accelerate or decelerate an existing ramp rate
- Design a new ramp rate

Ramp rates assignments for each measure permutation may be found in the measure summary documentation within Appendix G. More details on the approach for adapting ramp rates may be found in Appendix A.

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

- Lost Opportunity potential occurs at the time of equipment burnout. When equipment is replaced, a unique opportunity exists to upgrade efficiency at incremental (above standard equipment), rather than full cost. If standard equipment is installed, the high-efficiency equipment would not be installed until the new equipment reaches the end of its normal life cycle, without early replacement (usually requiring a significantly higher incremental cost). The same applies for opportunities at the time of new construction. These "LO" ramp rate factors increase over time up to 100%
- Retrofit potential is not subject to such stringent timing constraints and can, theoretically, be acquired at any point in the planning period assuming customer willingness and necessary delivery infrastructure. Since these ramp rates apply to all units in the market, "Retro" ramp rates instead sum to 100% and are intended to phase in potential throughout the study period. The faster ramp rates (e.g. summing up to 100% sooner) will phase potential in over a shorter timeframe.
- Both Lost Opportunity and Retrofit ramp rates are multiplied by an achievability factor (often 85%) to produce the final achievable level. This achievability has the capacity to vary by measure, however Council's guidance for all measures analogous to natural gas remains at 85%.

Table F-1 Ramp Rates Used in CPA Analysis

Ramp Rate	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
LO12Med	11%	22%	33%	44%	55%	65%	72%	79%	84%	88%	91%	94%	96%	97%	99%	100%	100%	100%	100%	100%
LO5Med	4%	10%	16%	24%	32%	42%	53%	64%	75%	84%	91%	96%	99%	100%	100%	100%	100%	100%	100%	100%
LO1Slow	1%	1%	2%	3%	5%	9%	13%	19%	26%	34%	43%	53%	63%	72%	81%	87%	92%	96%	98%	100%
LO50Fast	45%	66%	80%	89%	95%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
LO20Fast	22%	38%	48%	57%	64%	70%	76%	80%	84%	88%	90%	92%	94%	95%	96%	97%	98%	98%	99%	100%
LOEven20	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
LO3Slow	1%	1%	3%	6%	11%	18%	26%	36%	46%	57%	67%	76%	83%	88%	92%	95%	97%	98%	99%	100%
LO80Fast	76%	83%	88%	92%	95%	97%	98%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Retro12Med	11%	11%	11%	11%	11%	10%	8%	6%	5%	4%	3%	3%	2%	2%	1%	1%	0%	0%	0%	0%
Retro5Med	4%	5%	6%	8%	9%	10%	11%	11%	11%	9%	7%	5%	3%	1%	1%	0%	0%	0%	0%	0%
Retro1Slow	0%	1%	1%	1%	2%	3%	4%	6%	7%	8%	9%	10%	10%	9%	8%	7%	5%	4%	2%	2%
Retro50Fast	45%	21%	14%	9%	6%	3%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Retro20Fast	22%	16%	11%	8%	7%	6%	5%	5%	4%	3%	3%	2%	2%	1%	1%	1%	1%	1%	1%	0%
RetroEven20	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Retro3Slow	1%	1%	2%	3%	5%	7%	8%	10%	11%	11%	10%	9%	7%	6%	4%	3%	2%	1%	1%	1%
RetroMed_Avg	2%	3%	4%	5%	7%	8%	10%	11%	11%	10%	8%	7%	5%	3%	2%	2%	1%	1%	0%	0%
AEG_RetroWx_Linear	3%	4%	4%	4%	4%	4%	4%	5%	5%	5%	5%	5%	5%	6%	6%	6%	6%	6%	6%	7%
AEG_RetroTstat_Linear	2%	2%	3%	3%	3%	4%	4%	4%	5%	5%	5%	5%	6%	6%	6%	7%	7%	7%	8%	8%

Applied Energy Group, Inc.
500 Ygnacio Valley Road, Suite 250
Walnut Creek, CA 94596

P: 510.982.3525