AEG
Applied Energy Group

MARKET POTENTIAL STUDY

February 17, 2021

Report prepared for:
PEOPLES GAS AND LIGHT COMPANY,
NORTH SHORE GAS

Energy Solutions. Delivered.

This work was performed by:

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

Project Director: I. Rohmund
Project Manager: K. Chiccarelli
Project Team: F. Nguyen
G. Wroblewski

EXECUTIVE SUMMARY

In 2020, Peoples Gas and Light (PGL) and North Shore Gas (NSG) contracted with Applied Energy Group (AEG) to perform a comprehensive demand-side management (DSM) market potential study (MPS). This study is an integral part of PGL and NSG's program planning process; ultimately the MPS provides guidance for the development of PGL and NSG program plans.

Definitions of Potential

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 annual savings impacts over the nine-year projection horizon. The various levels are described below.

- Technical Potential is the theoretical upper limit of efficiency potential, assuming that customers adopt all feasible measures regardless of their cost or customer preference. At the time of existing equipment failure, customers replace their equipment with the most efficient option available. In new construction, customers and developers also choose the most efficient equipment option.

  Technical potential also assumes the adoption of every other available measure, where applicable. For example, it includes installation of high-efficiency windows in all new construction opportunities and air conditioner maintenance in all existing buildings with central and room air conditioning. These retrofit measures are phased in over a number of years to align with the stock turnover of related equipment units, rather than modeled as immediately available all at once.
- Economic Potential represents the adoption of all cost-effective energy efficiency measures. In this analysis, the cost-effectiveness is measured by the total resource cost (TRC) test, which compares lifetime energy and capacity benefits to the incremental cost of the measure. If the benefits outweigh the costs (that is, if the TRC ratio is greater than 1.0), a given measure is considered in the economic potential. Customers are then assumed to purchase the cost-effective option at any decision juncture.
- Achievable Potential refines economic potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and recent PGL and NSG program history.

Study Approach

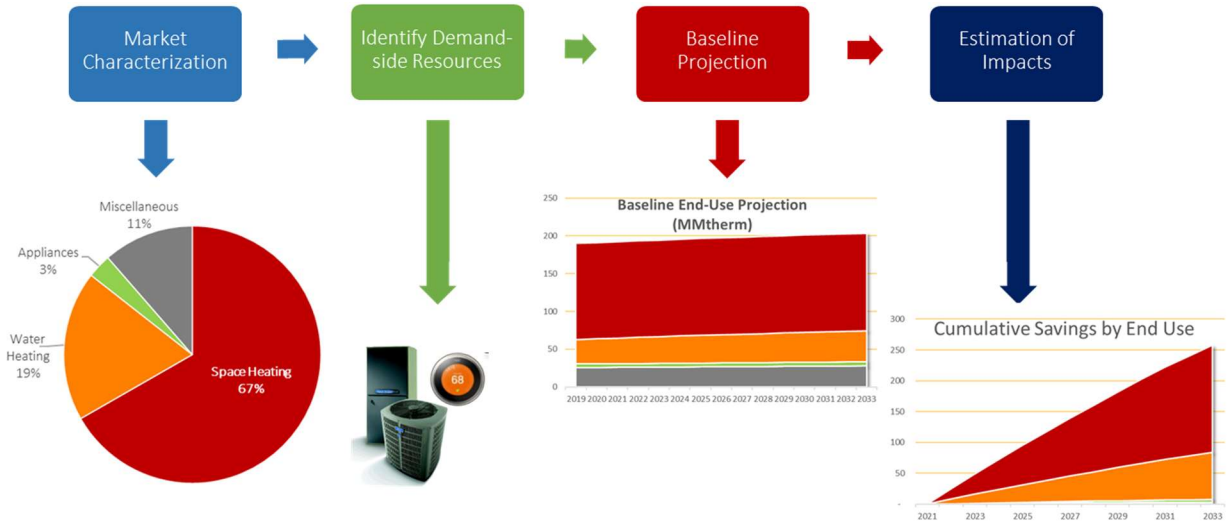
To perform the potential analysis, AEG used a bottom-up approach following the major steps listed below and illustrated in Figure ES-1. The analysis steps are described in more detail in Section 2.

1. Conducted residential customer surveys to identify appliance saturations, dwelling characteristics, measure applicability and saturations, occupant behavior, and customer demographics.
2. Performed a market characterization to describe sector-level natural gas use for the residential and commercial sectors for the base year, 2019. The residential customer surveys from step 1 are the primary data source for the residential characterization. They were supplemented as needed by a variety of secondary data sources.
3. Developed a baseline end-use projection of energy consumption by sector, segment, end use, and technology for 2020 through 2030.

4. Defined and characterized energy efficiency measures to be applied to all sectors, segments, and end uses. AEG developed the measure list using PGL and NSG's current programs, measure lists from other studies, new/emerging technologies, and feedback from the Illinois Energy Efficiency Stakeholder Advisory Group (SAG).
5. Estimated technical, economic and achievable potential at the measure level for 2022 through 2030.

During the project, PGL/NSG and AEG engaged with the SAG to solicit feedback.

Figure ES-1 Analysis Approach

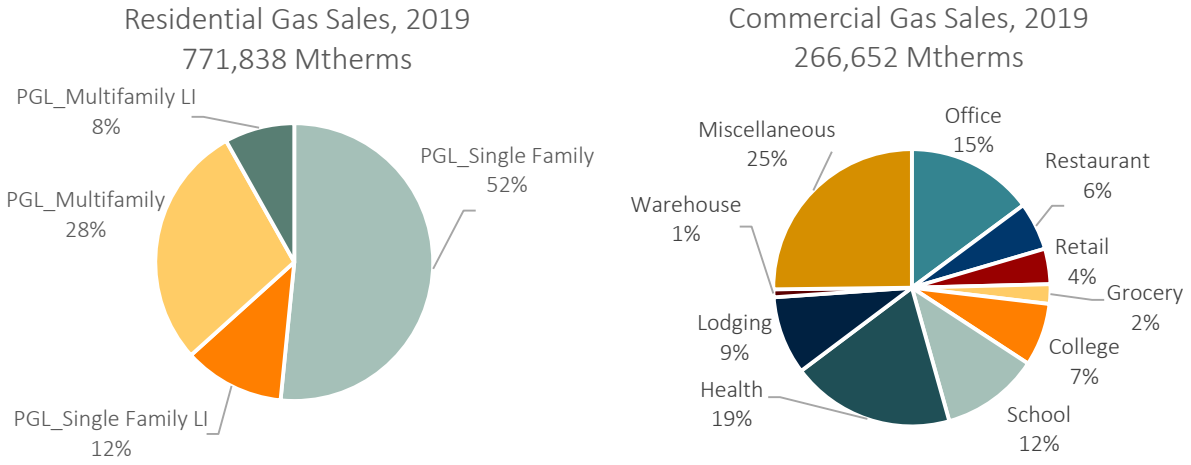


Key Findings for PGL

An important first step of the study is to characterize gas use by segment, end use and technology for the portion of the market that is within scope of the study. PGL's residential accounts for 74% of total gas usage.

The high-level characterization for the PGL gas market is shown in Figure ES-2 below.

Figure ES-2 High-level Characterization of PGL Natural Gas Market



The study identifies savings potential for the upcoming four-year program cycle, as well as for the period of 2022 through 2030.

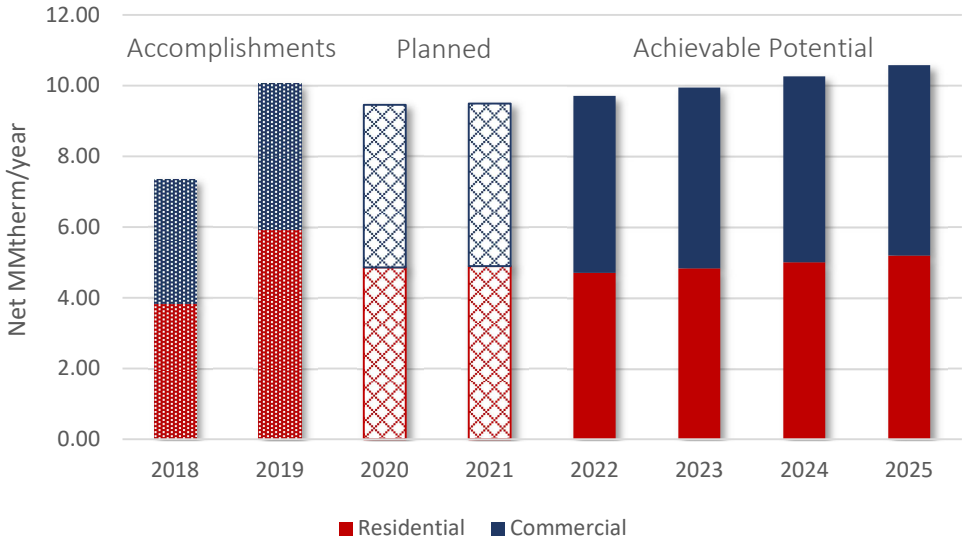
First-year Savings. First-year potential savings for 2022 through 2025 are presented in Table ES-1. The achievable potential is in the range of 9,704 mTherm per year to 10,572 mTherm per year, which corresponds to 1.0% of the baseline projection.

Table ES-1 PGL First-year Electricity Savings for Planning Cycle

All Sectors	2022	2023	2024	2025
Baseline Projection (mTherm)	1,009,752	1,012,767	1,015,832	1,018,586
Incremental Savings (mTherm)				
Achievable Potential	9,704	9,945	10,257	10,572
Economic Potential	29,762	29,519	29,443	29,385
Technical Potential	37,628	36,954	36,463	35,962
Energy Savings (% of Baseline)				
Achievable Potential	1.0%	1.0%	1.0%	1.0%
Economic Potential	2.9%	2.9%	2.9%	2.9%
Technical Potential	3.7%	3.6%	3.6%	3.5%

Figure ES-3 compares recent program accomplishments to planned 2020-2021 performance and to achievable potential savings from 2022 through 2025. Achievable potential estimates are comparable with accomplishments in 2019 and are slightly higher than planned performance for 2020 and 2021. The commercial sector accounts for the larger share of savings, approximately 51% of the market potential savings in each year.

Figure ES-3 PGL Prior-Year Accomplishments and First-Year Achievable Potential (Net MMtherm)[1]



A relatively small number of measures account for the majority of savings in 2022-2025. Key measures driving potential come from the following (cumulative savings from 2022-2025 in parenthesis):

- Industrial steam trap maintenance (4.4 MMtherms)
- Residential ENERGYSTAR connected thermostats (4.0 MMtherms)
- Residential behavioral programs – Home Energy Reports (3.3 MMtherms)
- Commercial steam trap maintenance (3.1 MMtherms)
- Residential gas boiler steam trap maintenance (2.8 MMtherms)
- Commercial gas optimization (2.2 MMtherms)
- Commercial retrocommissioning (2.2 MMtherms)

Cumulative Savings. The study also developed estimates of cumulative savings for the period 2022 through 2030. Cumulative savings reflect new savings from each year plus persisting savings from previous years. Table ES-2 summarizes the efficiency savings in terms of annual energy use for all measures for three levels of potential relative to the baseline projection.

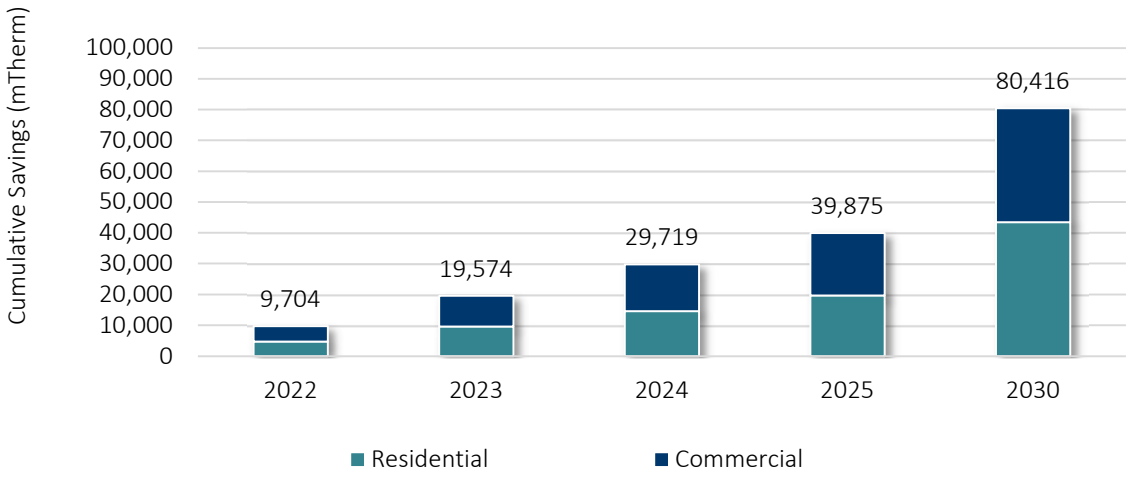
[1] Planned goals refer to the original savings goal approved in the Commission's Final Order approving the EE Plan.

Table ES-2 PGL Summary of Cumulative Potential Savings

	2022	2023	2024	2025	2030
Reference Baseline (mTherms)	1,009,752	1,012,767	1,015,832	1,018,586	1,034,036
Cumulative Savings (mTherms)					
Achievable Potential	9,704	19,574	29,719	39,875	80,416
Economic Potential	29,762	58,851	87,809	115,985	230,956
Technical Potential	37,628	73,666	108,775	142,369	275,170
Savings as % of Baseline					
Achievable Potential	1.0%	1.9%	2.9%	3.9%	7.8%
Economic Potential	2.9%	5.8%	8.6%	11.4%	22.3%
Technical Potential	3.7%	7.3%	10.7%	14.0%	26.6%

Figure ES-4 presents savings by sector. The commercial sector accounts for the larger share of savings.

Figure ES-4 PGL Cumulative Achievable Natural Gas Savings by Sector

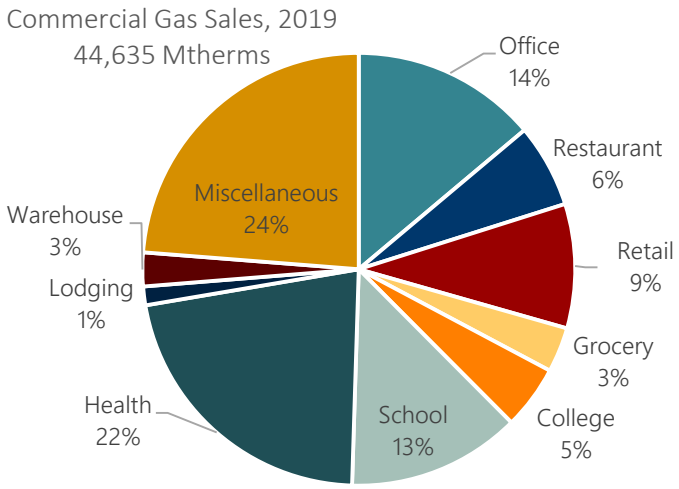


Key Findings for NSG

The high-level characterization for the NSG natural gas market is shown in Figure ES-5. The breakdown of sector-level natural gas use by end use is provided in Section 4. Please note that the residential sector is dominated by single family housing, and therefore not segmented further.

The study identifies savings potential for the upcoming four-year program cycle, as well as for the period of 2022 through 2030.

Figure ES-5 High-level Characterization of NSG Natural Gas Market



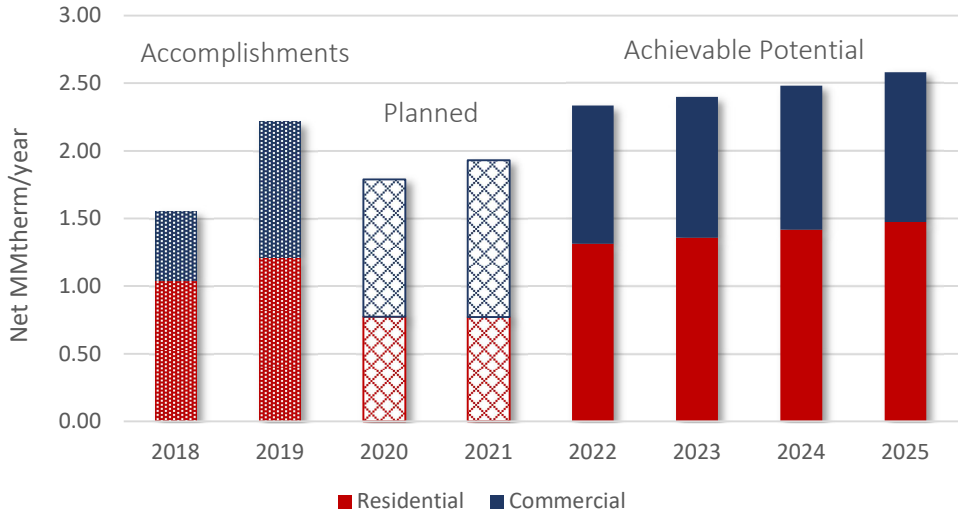
First-year Savings. First-year potential savings for 2022 through 2025 are presented in Table ES-3. The net achievable potential is in the range of 2,335 mTherms to 2,580 mTherms per year, or 1.0% of the baseline projection.

Table ES-3 NSG First-year Natural Gas Savings for Planning Cycle

	2022	2023	2024	2025
Reference Baseline (mTherms)	**231,764**	**232,561**	**233,424**	**234,195**
First-year Savings (mTherms)				
Achievable Potential	2,335	2,400	2,482	2,580
Economic Potential	6,235	6,231	6,265	6,258
Technical Potential	7,379	7,314	7,289	7,250
Savings as % of Baseline				
Achievable Potential	1.0%	1.0%	1.1%	1.1%
Economic Potential	2.7%	2.7%	2.7%	2.7%
Technical Potential	3.2%	3.1%	3.1%	3.1%

Figure ES-6 compares recent prior-year program accomplishments to planned 2020-2021 performance and to achievable potential savings from 2022 through 2025. Achievable potential estimates are comparable with accomplishments in 2019 and slightly higher than expected performance for 2020 and 2021. The residential sector accounts for more achievable savings than commercial throughout the study timeframe. Additionally, achievable potential increases as a result of the increasing adoption rates used in the analysis.

Figure ES-6 NSG Prior-Year Accomplishments and First-Year Achievable Potential (Net MMtherms)



Cumulative Savings. A relatively small number of measures account for the majority of savings during the next program cycle (cumulative savings from 2022-2025 in parenthesis):

- Residential behavioral programs – Home Energy Reports (2.7 MMtherms)
- Industrial steam trap maintenance (1.4 MMtherms)
- Commercial steam trap maintenance (1.4 MMtherms)
- Residential ENERGYSTAR connected thermostats (0.84 MMtherms)

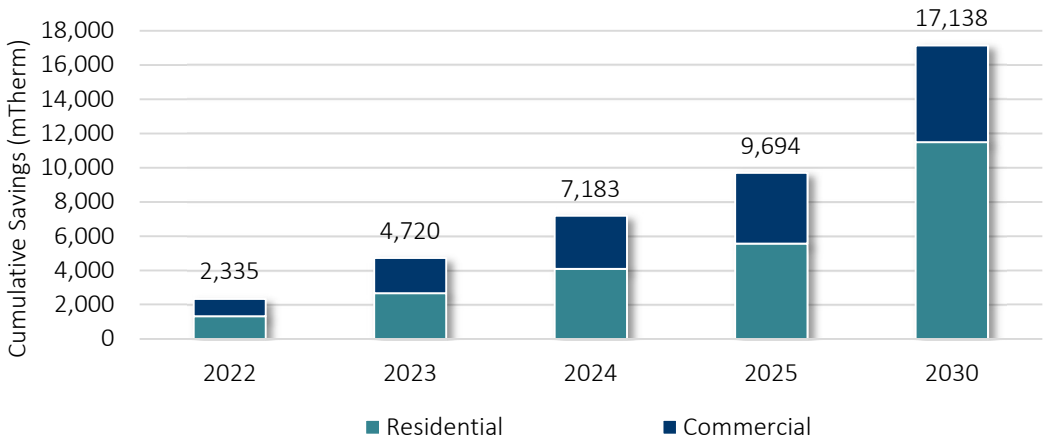
The study also developed estimates of cumulative savings for the period 2022 through 2030. Cumulative savings reflect new savings from each year plus persisting savings from previous years. Table ES-4 summarizes the efficiency savings in terms of annual energy use for all measures for three levels of potential relative to the baseline projection.

Table ES-4 NSG Summary of Cumulative Potential Savings for Natural Gas

	2022	2023	2024	2025	2030
Reference Baseline (mTherms)	231,764	232,561	233,424	234,195	238,226
Cumulative Savings (mTherms)					
Achievable Potential	2,335	4,720	7,183	9,694	17,138
Economic Potential	6,235	12,382	18,556	24,647	48,338
Technical Potential	7,379	14,548	21,634	28,528	54,700
Savings as % of Baseline					
Achievable Potential	1.0%	2.0%	3.1%	4.1%	7.2%
Economic Potential	2.7%	5.3%	7.9%	10.5%	20.3%
Technical Potential	3.2%	6.3%	9.3%	12.2%	23.0%

Figure ES-7 presents savings by sector. In contrast to recent program accomplishments, the residential sector accounts for the larger share of savings during the forecast period.

Figure ES-7 NSG Cumulative Achievable Natural Gas Savings by Sector



Conclusion

The measure level savings potential estimated in this study support diverse future savings for both territories in the residential and commercial sectors. The study identifies continued opportunities for thermostats, steam trap replacements, building shell/weatherization measures, and furnaces in the residential sector. For the commercial sector, substantial opportunities exist for steam trap replacements, gas optimization and retro-commissioning. Many of the measures contributing to savings potential are already offered in current programs.

This study provides important information for PGL and NSG as it plans its programs for the next 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.
- Estimates of the total amount of savings possible from cost-effective measures; these are savings above and beyond those already included in the baseline projection.
- Describes a likely savings outcome, achievable potential, both in the short run for program planning and in the longer term through 2030.

This study provides valuable *guidance* for program design. While the study provides estimates of annual savings for hundreds of measures within dozens of customer segments, the results should be taken with a measure of discretion. The results come from a model and we expect variation in the outcomes in the

real world. This fact gives PGL and NSG staff the opportunity to deviate from specific annual values developed in the study as they design programs and commit to annual program targets.

As a result of this study, PGL and NSG are able to revisit current customer energy-use patterns and existing programs with an eye toward developing the program portfolio for 2022 through 2025. This provides for the opportunity to refine existing programs and develop new programs based on a solid analytical and data-driven foundation.

CONTENTS

List of Figures

LIST OF TABLES

1

INTRODUCTION

Peoples Gas and Light Company (PGL) and North Shore Gas (NSG) selected Applied Energy Group (AEG) to conduct this Demand Side Management (DSM) Market Potential Study (MPS) to assess natural gas energy efficiency potential in the residential and commercial sectors of the PGL and NSG service territories. The key objectives of the study were to:

- Estimate demand-side savings associated with traditional and emerging energy efficiency measures, as well as behavioral program options.
- Update market research to provide insights and enhance the planning representations of customers in the PGL and NSG service territory.
- Engage with PGL and NSG stakeholders –the Illinois Stakeholder Advisory Group (SAG) – during the study to solicit feedback on the study plan, measure list and preliminary analysis results.

The study assesses various tiers of energy-efficiency potential including technical, economic and achievable potential. The study included primary market research to collect data for the PGL and NSG service territories, including natural gas end-use data, end-use saturation data, and customer demographics. This information enables PGL and NSG to understand how their customers use natural gas today. The study also developed updated baseline estimates with the latest information on federal, state, and local codes and standards for improving energy efficiency.

PGL and NSG will use the results of this study as guidance for its Demand Side Management (DSM) planning process to optimally implement energy efficiency related savings programs.

Potential Study Tasks

To produce a reliable and transparent estimate of efficiency potential, AEG performed the following tasks to meet PGL and NSG's key objectives:

- Characterize the PGL and NSG market in the base year (2019) using customer surveys, information and data from PGL and NSG, and secondary data sources, to describe how customers currently use energy by sector, segment, end use and technology.
- Develop a baseline projection of how customers are likely to use natural gas in absence of future EE programs. This defines the metric against which future program savings are measured. This projection used up-to-date technology data, modeling assumptions, and energy baselines that reflect both current and anticipated federal, state, and local energy efficiency legislation and standards that will impact potential.
- Estimate the technical, economic, and achievable potential at the measure level for energy efficiency over the 2022 to 2030 planning horizon to inform PGL and NSG's program design.

This report documents the results of the study as well as the steps followed in its completion. Throughout this study, AEG worked with PGL and NSG to understand the baseline characteristics of their service territory, including a detailed understanding of energy consumption in the territory, the assumptions and methodologies used in PGL and NSG's official load forecast, and recent DSM program accomplishments.

The remainder of this report is divided into three sections. We describe each section below:

- **Analysis Approach and Data Sources** provides a description of the analysis approach to conducting this study.
- **Peoples Gas and Light Analysis** describes energy efficiency potential for natural gas. It includes market characterization, baseline projection, and a detailed breakdown of potential by measure type, sector and end use.
- **North Shore Gas Analysis** describes energy efficiency potential for natural gas. It includes market characterization, baseline projection, and a detailed breakdown of potential by measure type, sector and end use.

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
BEST	AEG's Building Energy Simulation Tool
C&I	Commercial and Industrial
DEEM	AEG's Database of Energy Efficiency Measures
DSM	Demand Side Management
EE	Energy Efficiency
EIA	Energy Information Administration
EISA	Energy Independence and Security Act
EUL	Effective Useful Life
EUI	Energy Utilization Index
HH	Households
HVAC	Heating Ventilation and Air Conditioning
LoadMAP™	AEG's Load Management Analysis and Planning tool
mTherms	Thousand therms
MMtherms	Million therms
O&M	Operations and Maintenance
SAG	Illinois Stakeholder Advisory Group
Sq.Ft.	Square feet of floor space
TRC	Total Resource Cost Test
TRM	Technical Resource Manual
UEC	Unit Energy Consumption

2

ANALYSIS APPROACH AND DATA SOURCES

This section describes the analysis approach taken for the study and summarizes the data sources used to develop the potential estimates.

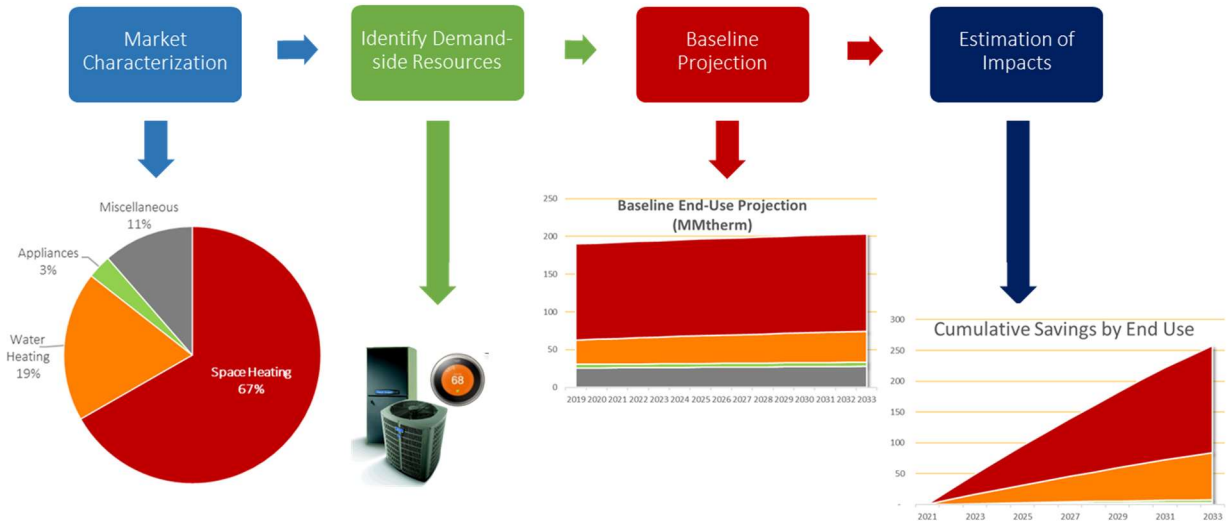
Overview Analysis Approach

To perform the potential analysis, AEG used a bottom-up approach following the major steps listed below and illustrated in Figure 2-1. We describe these analysis steps in more detail in the remainder of this section.

1. Conducted primary market research in the form of residential customer surveys to identify equipment saturations, building characteristics, measure applicability and saturations, occupant behavior, and customer demographics and firmographics.
2. Performed a market characterization to describe sector-level natural gas use for the residential and commercial sectors for the base year, 2019. The residential customer surveys from step 1 are the primary data source for the residential characterization. They were supplemented as needed by a variety of secondary data sources.
3. Developed a baseline end-use projection of energy consumption by sector, segment, end use, and technology for 2020 through 2030.
4. Defined and characterized energy efficiency measures to be applied to all sectors, segments, and end uses. AEG developed the measure list using PGL and NSG's current programs, measure lists from other studies, new/emerging technologies, and feedback from SAG.
5. Estimated technical, economic and achievable potential at the measure level for 2022 through 2030.

Throughout the analysis, PGL and NSG and AEG engaged with the SAG to solicit feedback.

Figure 2-1 Analysis Approach



Definitions of Potential

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 annual savings impacts over the nine-year projection horizon. The various levels are described below.

- **Technical Potential** is the theoretical upper limit of efficiency potential, assuming that customers adopt all feasible measures regardless of their cost or customer preference. At the time of existing equipment failure, customers replace their equipment with the most efficient option available. In new construction, customers and developers also choose the most efficient equipment option.

  Technical potential also assumes the adoption of every other available measure, where applicable. For example, it includes installation of high-efficiency windows in all new construction opportunities and furnace maintenance in all existing buildings with gas 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.

- **Economic Potential** represents the adoption of all cost-effective energy efficiency measures. In this analysis, the cost-effectiveness is measured by the total resource cost (TRC) test, which compares lifetime energy and capacity benefits to the incremental cost of the measure. If the benefits outweigh the costs (that is, if the TRC ratio is greater than 1.0), a given measure is considered in the economic potential. Customers are then assumed to purchase the cost-effective option at any decision juncture.[2]

- **Achievable Potential** refines economic potential by applying customer participation rates that account for market barriers, customer awareness and attitudes, program maturity, and recent PGL and NSG program history.

LoadMAP Model

For this analysis, AEG used its Load Management Analysis and Planning tool (LoadMAP™) version 5.0 to develop both the baseline end use projection and the estimates of potential. AEG developed LoadMAP in 2007 and has enhanced it over time. Built in Excel, the LoadMAP framework (see Figure 2-2) is both accessible and transparent and has the following key features.

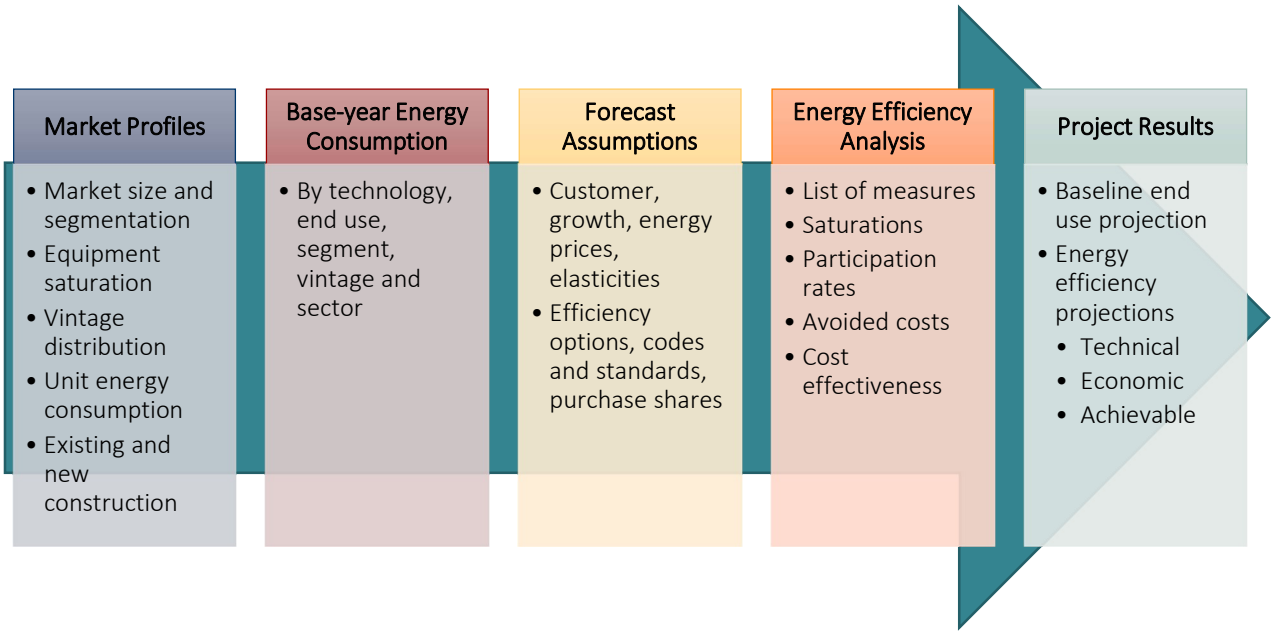
- Embodies the basic principles of rigorous end use models (such as EPRI's REEPS and COMMEND) but in a more simplified, accessible form.
- Includes stock-accounting algorithms that treat older, less efficient appliance/equipment stock separately from newer, more efficient equipment. Equipment is replaced according to the measure life and appliance vintage distributions defined by the user.
- Balances the competing needs of simplicity and robustness by incorporating important modeling details related to equipment saturations, efficiencies, vintage, and the like, where market data are available, and treats end uses separately to account for varying importance and availability of data resources.
- Isolates new construction from existing equipment and buildings and treats purchase decisions for new construction and existing buildings separately.

[2] If faced with a mutually exclusive decision between multiple cost-effective options, the default model assumption is to assume the customer will select the option with the highest amount of energy savings.

- Uses a simple logic for appliance and equipment decisions. Other models available for this purpose embody complex decision choice algorithms or diffusion assumptions, and the model parameters tend to be difficult to estimate or observe and sometimes produce anomalous results that require calibration or even overriding. The LoadMAP approach allows the user to drive the appliance and equipment choices year by year directly in the model. This flexible approach allows users to import the results from diffusion models or to input individual assumptions. The framework also facilitates sensitivity analysis.
- Can accommodate various levels of segmentation. Analysis can be performed at the sector level (e.g., total residential) or for customized segments within sectors (e.g., housing type or income level).
- Natively outputs model results in a detailed line-by-line summary file, allowing for review of input assumptions, cost-effectiveness results, and potential estimates at a granular level.

Consistent with the segmentation scheme and the market profiles we describe below, the LoadMAP model provides projections of baseline energy use by sector, segment, end use, and technology for existing and new buildings. It also provides forecasts of total energy use and energy efficiency savings associated with the various types of potential. [3]

Figure 2-2 LoadMAP Analysis Framework



[3] The model computes energy projection 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 projection (e.g., the technical potential projections).

Customer Surveys

AEG conducted surveys with PGL and NSG residential customers. The objectives of the surveys were to

- Provide the basis for market segmentation in the residential sector . PGL and NSG billing data does not provide adequate indicators of housing type or residential income level, so the study used survey results to develop the segmentation.
- Quantify key inputs for the study , including market size for each segment, energy intensity (e.g., use per household), saturations of residential appliances, and lighting and appliance age which is a proxy for appliance efficiency.

Residential Survey Approach

The residential customer survey used a direct-mail recruiting approach and online data collection. The target number of completions was 800 and the survey had 823 completions. To perform the residential survey, AEG took the following steps:

- Obtained and analyzed PGL and NSG billing data. AEG received a customer list that included detailed information for each record selected, including name, address, annual therm usage, account number, etc. AEG processed the file to yield the universe of program-eligible households directly billed by PGL and NSG by taking the following steps:
  - Remove accounts with less than 6 months of data
  - Remove accounts with very low energy use
- Stratified the sample frame by energy usage. The target sample size of 800 responses, was allocated to the sample strata proportional to the number of customers in each sample cell. Responses were monitored to ensure the completions were representative of the underlying PGL and NSG customer population.
- Postcard invitations with instructions on how to complete the online survey were mailed to households. Customers were offered a $25 incentive for completing the survey.
- In order to qualify to complete the survey, respondents had to meet the following criteria:
  - Have primary or shared responsibility for making energy-related decisions
  - Be at least 18 years old
  - Be billed for natural gas directly by PGL or NSG

The primary focus of the residential questionnaire was on gas-using appliances, dwelling and customer characteristics, awareness of EE programs and demographics.

MPS Analysis Tasks

Market Characterization

To estimate the savings potential from energy-efficient measures, it is necessary to understand how much energy is used today and what equipment is currently in service. This characterization begins with a segmentation of PGL and NSG's energy footprint to quantify energy use by sector, segment, end use

application, and the current set of technologies used. For this we rely primarily on information from PGL and NSG and surveys with samples of its customers, augmenting with secondary sources as necessary.

Segmentation for Modeling Purposes

The segmentation scheme for this study is presented in Table 2-1.

Table 2-1 Overview of PGL and NSG Analysis Segmentation Scheme

Dimension	Segmentation Variable	Description
1	Company	Peoples Gas and Light, North Shore Gas
2	Sector	Residential, Commercial
3	Segment	Residential: by housing type (single family and multi family), income level (low income/ not low income)[4] Commercial: office, retail, restaurant, grocery, college, school, health care, lodging, warehouse, miscellaneous
4	Vintage	Existing and new construction
5	End uses	Space heating, water heating, etc. (as appropriate by sector)
6	Appliances/end uses and technologies	Technologies such as furnaces, boilers, etc. for space heating, etc.
7	Equipment efficiency levels for new purchases	Baseline and higher-efficiency options as appropriate for each technology

With the segmentation scheme defined, we then performed a high-level market characterization of energy sales in the base year, 2019. We used detailed PGL and NSG billing and customer surveys with augmentation from secondary sources to allocate energy use and customers to the various sectors and segments such that the total customer count and energy consumption matched the PGL and NSG system totals from 2019. This information provided control totals at a sector level for calibrating the LoadMAP model to known data for the base-year.

Market Profiles

The next step was to develop market profiles for each sector, customer segment, end use, and technology. A market profile includes the following elements:

- **Market size** is a representation of the number of customers in the segment. For the residential sector, the unit is number of households. In the commercial sector, it is floor space measured in square feet.
- **Saturations** define the fraction of homes and square feet with the various technologies. (e.g., percent of homes with gas water heating).
- **UEC (unit energy consumption) or EUI (energy-utilization index)** describes the amount of energy consumed in the base year by a specific technology in homes or buildings that have the technology. UECs are expressed in therms/household for the residential sector, and EUIs are expressed in therms/square foot for the commercial sector.
- **Annual energy intensity** for the residential sector represents the average energy use for the technology across all homes in 2019. It is computed as the product of the saturation and the UEC and

[4] Please note that the residential sector is dominated by single family housing, and therefore not segmented further.

is defined in therms/household terms. For the commercial sector, intensity, computed as the product of the saturation and the EUI, represents the average use for the technology across all floor space 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 mTherm.

Baseline End Use Projection

The next step was to develop a baseline projection of annual natural gas use for 2020 through 2030 by customer segment and end use to quantify the likely consumption in the future in absence of any energy efficiency programs. The end-use projection includes the relatively certain impacts of codes and standards that will unfold over the study timeframe. All such mandates that were defined as of January 2020 are included in the baseline. The baseline projection also includes projected naturally occurring energy efficiency during the potential forecast period. The baseline projection is the foundation for the analysis of savings from future efficiency cases and scenarios as well as the metric against which potential savings are measured.

Inputs to the baseline projection include:

- Current economic growth forecasts (i.e., customer growth, income growth) provided by PGL and NSG
- Natural gas price forecasts provided by PGL and NSG
- Trends in fuel shares and equipment saturations
- Existing and approved changes to building codes and equipment standards
- Naturally occurring efficiency improvements, which include purchases of high-efficiency equipment options outside of EE programs.

Energy Efficiency Measure Development

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

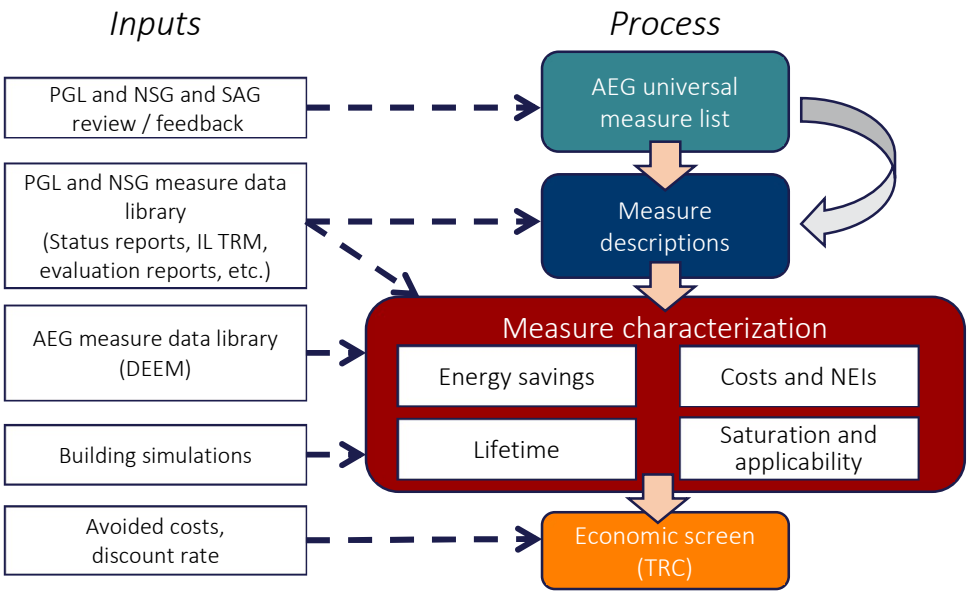
Figure 2-3 outlines the approach for measure analysis. The framework for assessing savings, costs, and other attributes of measures involves identifying the list of measures to include in the analysis, determining their applicability to each market sector and segment, fully characterizing each measure, and performing cost-effectiveness screening. PGL and NSG and stakeholders provided feedback during this process to ensure measure assumptions and results lined up with programmatic experience.

We compiled a robust list of measures for each customer sector, drawing upon PGL and NSG's program experience, the Illinois Technical Resource Manual (TRM), AEG's measure databases and building simulation models, and secondary sources. New and emerging technologies were identified for inclusion in the list through a detailed screening process that assessed the feasibility of measures. AEG engineers, through the AEG DEEM database, constantly monitor for new and emerging measures by following trends

in energy-efficient technologies that are available on the market, as well as those expected to be on market in the coming years.

The measure list was reviewed by PGL and NSG and stakeholders. This universal list of measures covers all major types of end use equipment, as well as devices and actions to reduce energy consumption. If considered today, some of these measures would not pass the economic screens initially but may pass in future years as a result of lower projected equipment costs or higher avoided cost benefits.

Figure 2-3 Approach for Measure Assessment



The selected measures are categorized into two types according to the LoadMAP modeling taxonomy: equipment measures and non-equipment measures.

- **Equipment measures** are efficient energy consuming pieces of equipment that save energy by providing the same service with a lower energy requirement than a standard unit. An example is an ENERGY STAR® residential water heater that replaces a standard-efficiency water heater. For equipment measures, many efficiency levels may be available for a given technology, ranging from the baseline unit (often determined by code or standard) up to the most efficient product commercially available. These measures are applied on a stock-turnover basis, and in general, are referred to as lost opportunity measures since once a purchase decision is made, there will not be another opportunity to improve the efficiency of that equipment item until the lifetime expires again.
- **Non-equipment measures** save energy by reducing the need for delivered energy, but typically do not involve replacement or purchase of major end use equipment (such as a furnace or water heater). Since measure installation is not tied to a piece of equipment reaching end of useful life, these are generally categorized as "retrofit" measures. Non-equipment measures can apply to more than one end use. 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 achievably upgraded without waiting 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 (advanced new construction)
- Displacement measures (destratification fans to reduce use of space heating equipment)
- Retro-commissioning
- Home and business behavioral programs
- Energy management programs
- Behavioral programs (Home Energy Reports)

Once we assembled the list of measures, AEG assessed their energy-saving parameters and characterized incremental cost, effective useful life (EUL), and other performance factors. Following the measure characterization, we performed an economic screening of each measure, which serves as the basis for developing the economic and achievable potential.

Representative Measure Data Inputs

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

Table 2-2 Example Equipment Measures for Furnaces

Efficiency Level	Lifetime (years)	Equipment Cost	Energy Usage (therms/year)	On Market	Off Market
AFUE 80%	18	$3,288	579	2019	2023
AFUE 90%	18	$3,451	520	2019	2023
AFUE 92%	18	$3,510	508	2019	n/a
AFUE 95%	18	$4,776	490	2019	n/a
AFUE 98%	18	$6,220	474	2019	n/a
Convert to Gas Heat Pump	21	$11,507	415	2019	n/a

Table 2-3 lists some of the non-equipment measures applicable to residential furnaces. All measures are evaluated for cost-effectiveness based on the lifetime benefits relative to the cost of the measure. The total savings, costs, and monetized non-energy benefits are calculated for each year of the study and depend on the base year saturation of the measure, the applicability[5] of the measure, and the savings as a percentage of the relevant energy end uses.

[5] Applicability factors take into account whether the measure is applicable to a particular building type and whether it is feasible to install the measure. For instance, duct repair and sealing is not applicable to homes with zonal heating systems since there is no ductwork present to repair.

Table 2-3 Example Non-Equipment Measures

End Use	Measure	Saturation[6]	Applicability	Lifetime (yrs)	Installed Cost	Energy Savings (%)
Heating	Insulation - Ceiling Installation	0%	6%	45	$1,739	29.9%
Heating	Insulation – Ceiling Upgrade	20%	88%	45	$1,739	7.6%
Heating	Ducting Repair and Sealing	15%	50%	20	$794	5.5%
Heating	Windows - High Efficiency/ENERGY STAR	89%	100%	45	$4,689	25.3%

Calculation of Energy Efficiency Potential

The approach we used to calculate the energy efficiency potential adheres to the approaches and conventions outlined in the National Action Plan for Energy-Efficiency (NAPEE) Guide for Conducting Potential Studies.[7] This document represents credible and comprehensive industry best practices for specifying energy efficiency potential. Three types of potential were developed as part of this effort: technical potential, economic potential and achievable potential.

Technical Potential

The calculation of technical potential is a straightforward algorithm which, as described in the Definitions of Potential section, assumes that customers adopt all feasible measures regardless of their cost.

Economic Potential - Screening Measures for Cost-Effectiveness

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

LoadMAP performs an economic screen for each individual measure in each year of the planning horizon. This study uses the TRC test as the cost-effectiveness metric, which compares the lifetime energy benefits and monetized non-energy impacts of each applicable measure with its cost. The lifetime benefits are calculated by multiplying the annual energy savings for each measure by PGL and NSG's avoided cost and discounting the dollar savings to the present value equivalent. Lifetime costs represent incremental measure cost, annual O&M costs, and estimated program costs, also discounted to present value. The analysis uses the measure savings, costs, and lifetimes that were developed as part of the measure characterization process described in the Energy Efficiency Measure Development section.

The LoadMAP model performs the economic screening dynamically, taking into account changing savings and cost data over time. Thus, some measures pass the TRC test for some — but not all — of the years in the forecast.

It is important to note the following about the economic screen:

- The economic evaluation of every measure in the screen is conducted relative to a baseline condition. For instance, in order to determine the therm savings potential of a measure, consumption with the measure applied must be compared to the consumption of a baseline condition.

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

[7] 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.

- Economic screening is 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.

The economic potential includes every program-ready opportunity for energy efficiency savings as well as new measures and additional emerging technologies.

Achievable Potential - Estimating Customer Adoption

Once the economic potential is established, estimates for achievable customer adoption rates for each measure are applied that specify the percentage of customers that will select the highest–efficiency cost-effective option. This phases potential in over a more realistic time frame that considers barriers such as imperfect information, supplier constraints, technology availability, and individual customer preferences.

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:

- PGL and NSG-specific data
- AEG's databases and analysis tools
- Other secondary data and reports

PGL and NSG Data

Our highest priority data sources for this study were those that were specific to PGL and NSG.

- **PGL and NSG customer account database.** The data request included billing data for 2019, the most recent year for which complete billing data was available. PGL and NSG provided 2019 natural gas sales, customers by sector, and customer contact information for the primary market research.
- **Load forecast data.** PGL and NSG provided the following forecast data: customer growth forecasts, natural gas price forecasts, and sales forecast.
- **Economic information.** PGL and NSG provided a discount rate as well as avoided cost forecasts and line loss factors on an annual basis.
- **Energy efficiency program data.** PGL and NSG provided historical EE program accomplishments for 2016-2019.
- **Illinois Statewide Technical Reference Manual (TRM)** : AEG used Illinois TRM (v8) to characterize the majority of energy efficiency measures except for steam traps, which uses assumptions from IL TRM version 9.0.

AEG Data

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

- **AEG Energy Market Profiles.** For more than 15 years, AEG staff has maintained profiles of end use consumption for the residential, commercial, and industrial sectors. These profiles include market size, fuel shares, unit consumption estimates, and annual energy use by fuel, customer segment and end use for 10 regions in the U.S. The Energy Information Administration surveys (RECS, CBECS and MECS) as well as state-level statistics and local customer research provide the foundation for these regional profiles.
- **Building Energy Simulation Tool (BEST)**. AEG's BEST is a derivative of the DOE 2.2 building simulation model, used to estimate base-year UECs and EUIs, as well as measure savings for the HVAC-related measures.
- **AEG's Database of Energy Efficiency Measures (DEEM).** AEG maintains an extensive database of measure data for our studies. Our database draws upon reliable sources including the California Database for Energy Efficient Resources (DEER), the EIA Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, RS Means cost data, and Grainger Catalog cost data.
- **Recent studies**. AEG has conducted more than sixty studies of EE potential in the last five years. We checked our input assumptions and analysis results against the results from these other studies, within the region and numerous studies from across the U.S.

Other Secondary Data and Reports

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

- **Annual Energy Outlook**. The Annual Energy Outlook (AEO), conducted each year by the U.S. Energy Information Administration (EIA), presents yearly projections and analysis of energy topics. For this study, we used data from the 2019 AEO.
- **American Community Survey.** The US Census American Community Survey is an ongoing survey that provides data every year on household characteristics. Data for the State of Illinois was available for this study.
- **Local Weather Data** . Weather data from PGL and NSG's forecasting group was used where applicable.
- **Northwest Power and Conservation Council workbooks** . To develop its Power Plan, the Council and its Regional Technical Forum maintain workbooks with detailed information about measures and customer adoption rates. AEG uses this vetted and publicly available data source to supplement measure information and to develop adoption curves.
- **Other relevant resources:** These include reports from the Consortium for Energy Efficiency, the EPA, and the American Council for an Energy-Efficient Economy.

Application of Data to the Analysis

We now discuss how the data sources described above were used for each step of the study.

Data Application for Market Characterization

To construct the high-level market characterization of energy consumption and market size units (households for residential, floor space for commercial), we used PGL and NSG-provided billing data, PGL and NSG customer surveys, and secondary data from AEG's Energy Market Profiles databases.

Data Application for Market Profiles

The specific data elements for the market profiles, together with the key data sources, are shown in Table 2-4. To develop the market profiles for each segment, we used the following approach:

1. Developed control totals for each segment. These include market size, segment-level annual natural gas use, and annual intensity.
    a. PGL and NSG customer surveys to allocate residential customers by energy service, housing type and income level. This was compared to American Community Survey (ACS) and other studies.
    b. PGL and NSG billing data and customer surveys to estimate sales and square footage by building type for the Commercial sector. The estimates were also compared with the previous PGL and NSG MPS, EIA and our Energy Market Profiles Database.
2. Ensured calibration to control totals for annual natural gas sales in each sector and segment.
3. Compared and cross-checked with other recent AEG studies.
4. Worked with PGL and NSG staff to vet the data against their knowledge and experience.

Table 2-4 Data Applied to the Market Profiles

Model Inputs	Description	Key Sources
Annual energy consumption	Base-year energy consumption by sector as well as detailed market segment	PGL and NSG account database PGL and NSG customer surveys PGL and NSG Load Forecasts
Market size	Base-year residential dwellings, commercial floor space	PGL and NSG customer forecasts PGL and NSG account database PGL and NSG customer surveys Previous PGL and NSG MPS
Annual intensity	Residential: Annual use per household Commercial and Industrial: Annual use per square foot	PGL and NSG customer surveys AEG's Energy Market Profiles Other recent studies
Appliance/equipment saturations	Fraction of dwellings with an appliance/technology Percentage of C&I floor space with equipment/technology	PGL and NSG customer surveys American Community Survey (ACS) Previous PGL and NSG MPS 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 for a technology in floor space that has the technology	Illinois TRM HVAC uses: BEST simulations using prototypes developed for PGL and NSG AEG's DEEM Recent AEG studies
Appliance/equipment age distribution	Age distribution for each technology	PGL and NSG customer surveys Previous PGL and NSG MPS Recent AEG Studies

Data Application for Baseline Projection

Table 2-5 summarizes the LoadMAP model inputs required for the market profiles. These inputs are required for each segment in each sector, as well as for new construction and existing dwellings/buildings.

Table 2-5 Data Applied for the Baseline Projection in LoadMAP

Model Inputs	Description	Key Sources
Customer growth forecasts	Forecasts of new construction in residential and C&I sectors	PGL and NSG customer forecasts
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	Shipment data from AEO and ENERGY STAR AEO regional forecast assumptions[8] Appliance/efficiency standards analysis
Natural gas prices	Forecast of natural gas prices	PGL and NSG forecasts

In addition, assumptions were incorporated for known future equipment standards as of January 2020, as shown in Table 2-6 and Table 2-7. The assumptions tables here extend through 2025, after which all standards are assumed to hold steady.

Table 2-6 Residential Natural Gas Equipment Standards

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

Table 2-7 Commercial and Industrial Natural Gas Equipment Standards

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

[8] We developed baseline purchase decisions using the Energy Information Agency's *Annual Energy Outlook* report (2016), which utilizes the National Energy Modeling System (NEMS) to produce a self-consistent supply and demand economic model. We calibrated equipment purchase options to match distributions/allocations of efficiency levels to manufacturer shipment data for recent years and then held values constant for the study period.

Efficiency Measure Data Application

Table 2-8 details the energy-efficiency data inputs to the LoadMAP model. It describes each input and identifies the key sources used in the PGL and NSG analysis.

Table 2-8 Data Needs for the Measure Characteristics in LoadMAP

Model Inputs	Description	Key Sources
Energy Impacts	The annual reduction in consumption attributable to each specific measure. Savings were developed as a percentage of the energy end use that the measure affects.	IL TRM AEG DEEM BEST AEO 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 and commercial 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.	IL TRM AEG DEEM AEO CA DEER Other secondary sources
Measure Lifetimes	Estimates derived from the technical data and secondary data sources that support the measure demand and energy savings analysis.	IL TRM AEG DEEM AEO 2016 and AEO 2017 Other secondary sources
Applicability	Estimate of the percentage of dwellings in the residential sector, or square feet in the commercial sector, where the measure is applicable and where it is technically feasible to implement.	IL TRM AEG DEEM PGL and NSG Customer Surveys Other secondary sources
On Market and Off Market Availability	Expressed as years for equipment measures to reflect when the equipment technology is available or no longer available in the market.	AEG appliance standards and building codes analysis

Data Application for Cost-effectiveness Screening

To perform the cost-effectiveness screening, a number of economic assumptions were needed. All cost and benefit values were analyzed as real 2020 dollars. We applied an PGL and NSG-provided discount rate in real dollars. All impacts in this report are presented at the customer meter, but energy delivery losses were provided by PGL and NSG to estimate impacts at the generator for economic analysis.

Estimates of Customer Adoption Rates

Adoption rates for equipment and non-equipment measures are described separately below.

Customer adoption rates for equipment measures, 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 portfolio of well-operated efficiency programs under a reasonable policy or regulatory framework. The approach for estimating PGL and NSG adoption rates had two parts:

- First-year (2022) adoption rates. AEG used previous PGL and NSG program accomplishments to inform first-year adoption rates. The underlying assumption is that PGL and NSG will evolve programs from the current plan cycle to the next plan cycle. Therefore, the adoption rates in the first year, 2022, will be similar to 2021. First-year adoption rates were estimated as follows:
  - Group measures in the potential study into categories that align with existing PGL and NSG programs
  - Compute preliminary first-year adoption rates as the average program savings in 2018-2019 divided by the estimate of technical potential in 2022.
  - Set minimum adoption rate to 10%

  These adoption rates are applied to economic potential in 2022 to compute achievable potential.
- Adoption rates for 2023-2030. AEG used the Northwest Power Planning Council's publicly available and well-vetted "ramp rates" to increase customer adoption during the forecast horizon.

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.

The resulting first-year adoption rates used for PGL and NSG are shown in Figure 2-4 and Figure 2-5 below:

Figure 2-4 First-year Customer Adoption Rates for PGL

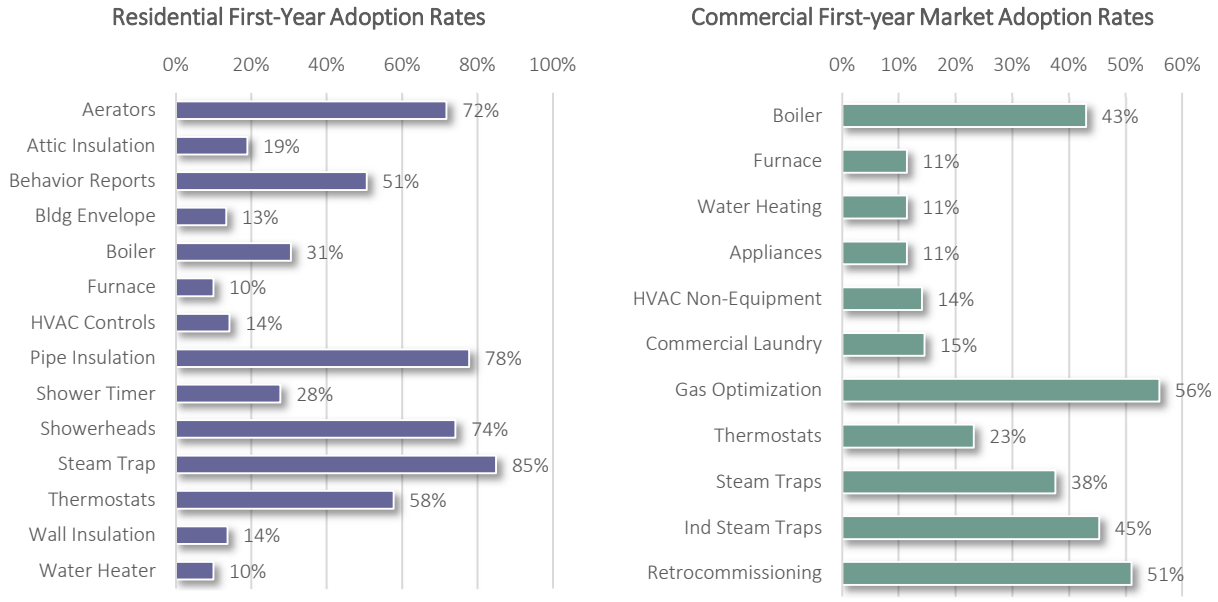
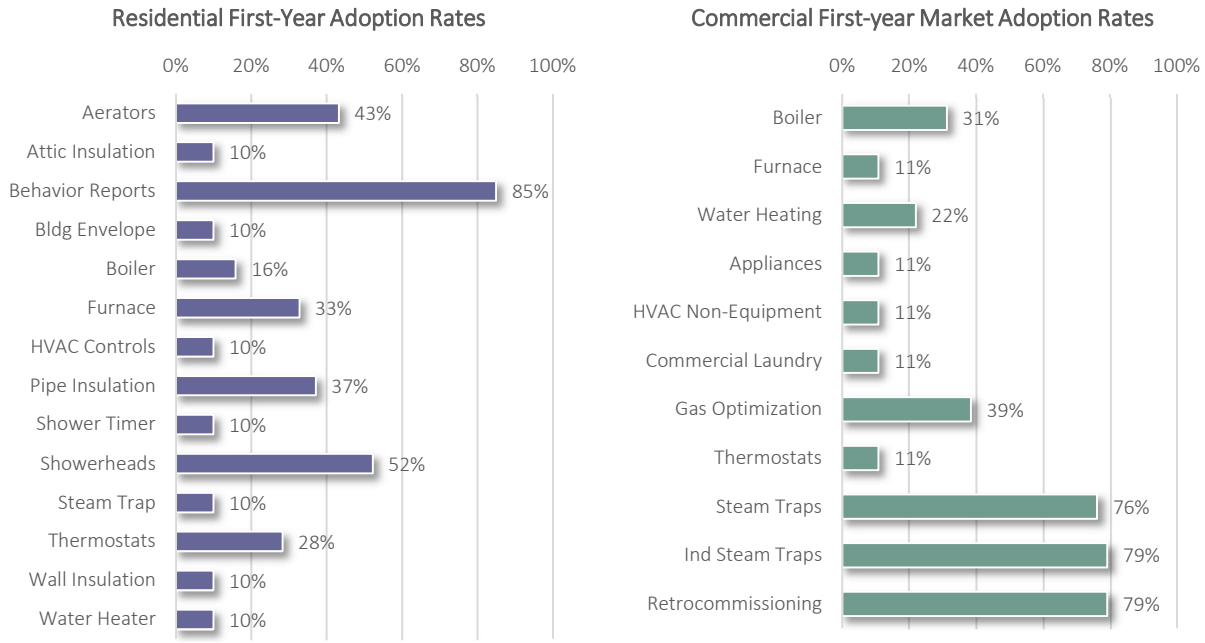


Figure 2-5 First-year Customer Adoption Rates for NSG



3

PEOPLES GAS AND LIGHT ANALYSIS

This section details the study results and potential estimates for Peoples Gas and Light Company (PGL) as a whole and by sector.

Overall Energy Efficiency Potential

This section presents the natural gas energy efficiency potential from two perspectives. First, we show the incremental savings for the next program cycle, 2022 through 2025. Then we show the long run cumulative savings through 2030.

Incremental Potential for Planning Cycle Years

First-year potential savings for 2022 through 2025 are presented in Table 3-1. The net achievable potential is in the range of 9,704 mTherms to 10,572 mTherms per year, or 1.0% of the baseline projection.

The commercial sector accounts for the larger share of savings, approximately 52% of achievable potential savings in each year.

Table 3-1 PGL First-Year Savings Potential for Planning Cycle

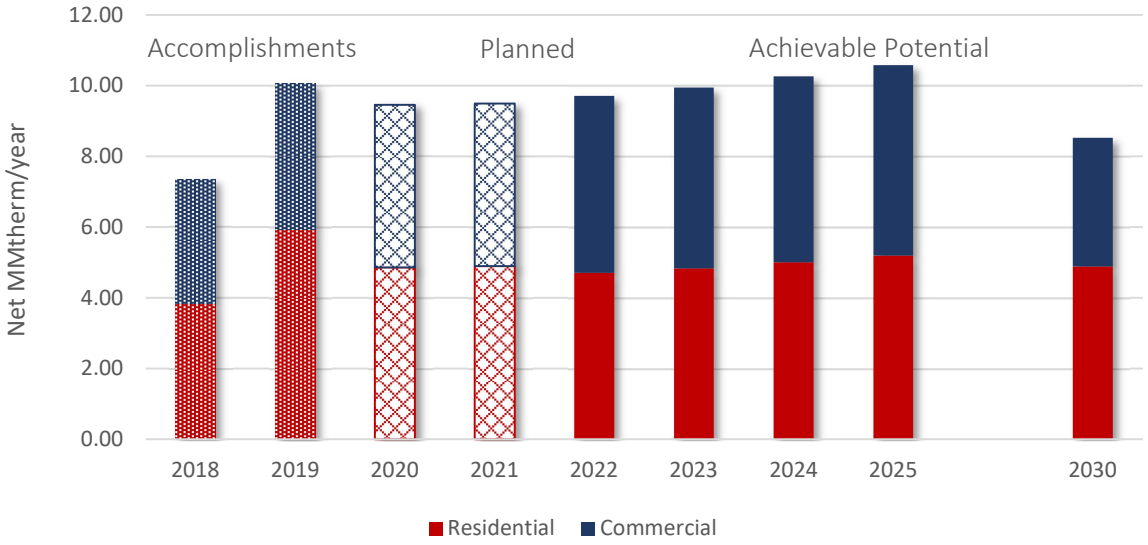
	2022	2023	2024	2025
Reference Baseline (mTherms)	**1,009,752**	**1,012,767**	**1,015,832**	**1,018,586**
First-year Savings (mTherms)				
Achievable Potential	9,704	9,945	10,257	10,572
Economic Potential	29,762	29,519	29,443	29,385
Technical Potential	37,628	36,954	36,463	35,962
Savings as % of Baseline				
Achievable Potential	1.0%	1.0%	1.0%	1.0%
Economic Potential	2.9%	2.9%	2.9%	2.9%
Technical Potential	3.7%	3.6%	3.6%	3.5%

Table 3-2 PGL First-Year Achievable Savings Potential by Sector

Achievable Potential by Sector	2022	2023	2024	2025
Reference Baseline (mTherms)	**1,009,752**	**1,012,767**	**1,015,832**	**1,018,586**
First-year Savings (mTherms)-- All Sectors	**9,704**	**9,945**	**10,257**	**10,572**
Residential	4,701	4,832	5,001	5,191
Commercial	5,003	5,113	5,256	5,381
First-year Savings as % of Baseline-- All	**1.0%**	**1.0%**	**1.0%**	**1.0%**
Residential	0.5%	0.5%	0.5%	0.5%
Commercial	0.5%	0.5%	0.5%	0.5%

Figure 3-1 below compares recent prior-year program accomplishments to planned 2020-2021 performance and to achievable potential savings from 2022 through 2025. Achievable potential estimates are comparable with accomplishments in 2019 and increase each year as a result of the ramp rates.

Figure 3-1 PGL Prior-Year Accomplishments and First-Year Achievable Potential (Net MMtherms)



A relatively small number of measures account for the majority of savings during the next program cycle (cumulative savings from 2022-2025 in parenthesis):

- Industrial steam trap maintenance (4.4 MMtherms)
- Residential ENERGYSTAR connected thermostats (4.0 MMtherms)
- Residential behavioral programs – home energy reports (3.3 MMtherms)
- Commercial steam trap maintenance (3.1 MMtherms)
- Residential gas boiler steam trap maintenance (2.8 MMtherms)
- Commercial gas optimization (2.2 MMtherms)
- Commercial retrocommissioning (2.2 MMtherms)

Cumulative Potential for 2030 Outlook

This section presents the energy conservation potential across PGL. Year-by-year savings for annual energy usage are available in the LoadMAP model, which was provided to PGL at the conclusion of the study.

Table 3-3 summarizes the efficiency savings in terms of annual energy use for all measures for three levels of potential relative to the baseline projection. Savings are represented in cumulative terms, which reflect the effects of persistent savings from prior years in addition to savings from the current year.

Table 3-3 PGL Summary of Cumulative Potential Savings

	2022	2023	2024	2025	2030
Reference Baseline (mTherms)	1,009,752	1,012,767	1,015,832	1,018,586	1,034,036
Cumulative Savings (mTherms)					
Achievable Potential	9,704	19,574	29,719	39,875	80,416
Economic Potential	29,762	58,851	87,809	115,985	230,956
Technical Potential	37,628	73,666	108,775	142,369	275,170
Savings as % of Baseline					
Achievable Potential	1.0%	1.9%	2.9%	3.9%	7.8%
Economic Potential	2.9%	5.8%	8.6%	11.4%	22.3%
Technical Potential	3.7%	7.3%	10.7%	14.0%	26.6%

Residential Sector

In 2019, there were approximately 886,588 households in PGL's Residential sector that used a total of 771,838 mTherms. Average use per household was 871 therms. The sector was allocated into four residential segments, shown in Table 3-4. Single Family customers account for 52% of total usage, and Multifamily customers account for 28%. Low income Single Family and Multifamily customers account for the remainder of usage.

Table 3-4 PGL Residential Control Totals, 2019

Segment	Households	Annual Use mTherms	Use per HH (therms/HH)
Single Family	331,936	398,127	1,199
Single Family Low Income	69,747	90,646	1,300
Multifamily	368,226	220,131	598
Multifamily Low Income	116,679	62,934	539
All Residential	886,588	771,838	871

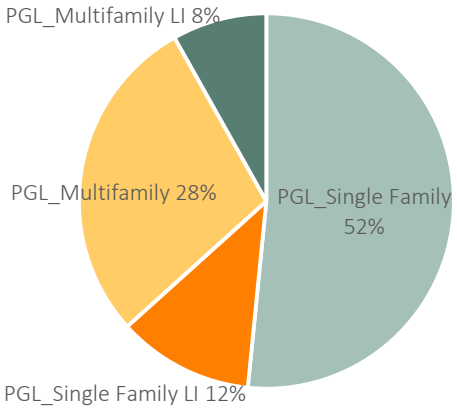


Figure 3-2 shows the average annual natural gas consumption by end use for all residential customers. Space heating accounts for 64% of total usage. Water heating accounts for 19% of total usage, and the miscellaneous category accounts for 14% of total usage. Appliances account for the remaining 3% of total residential gas usage.

Figure 3-3 presents the energy intensity by end use and housing type. Single Family Low Income homes have the highest use per household at 1,300 therms per year.

Figure 3-2 PGL Residential Gas Use by End Use, 2019

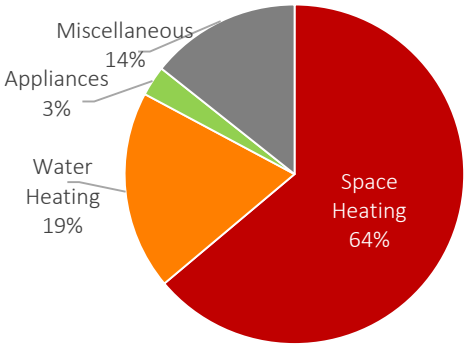
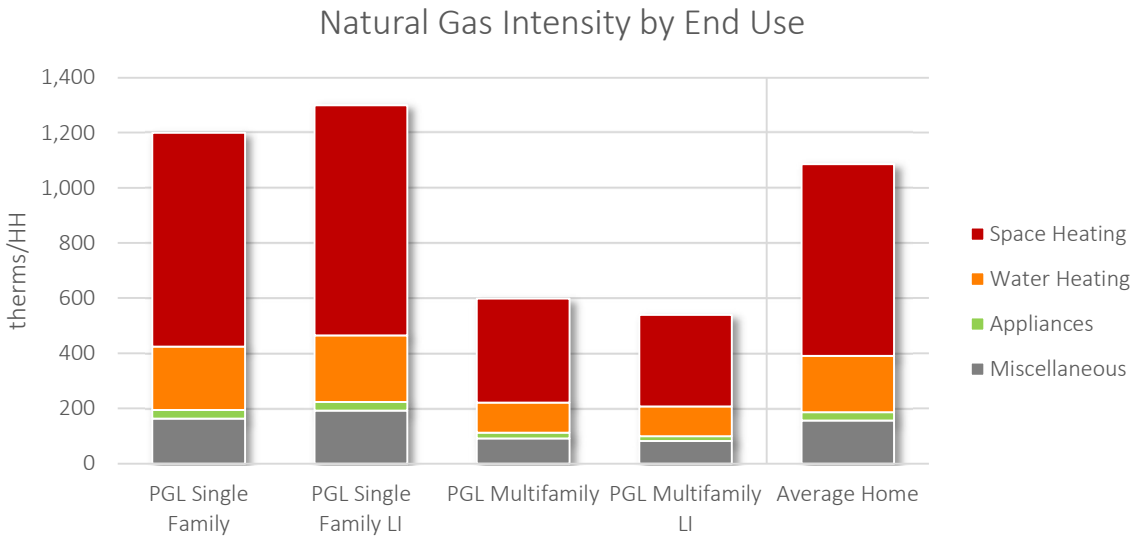


Figure 3-3 PGL Residential Natural Gas Intensity by End Use and Segment, 2019



Residential Baseline Projection

Table 3-5 presents AEG's independent natural gas baseline projection at the end use level for the residential sector. Overall, total residential use increases from 772 MMtherms in 2019 to 776 MMtherms in 2030, an increase of 0.5%. The projection includes effects of standards, codes, and naturally occurring conservation.

Table 3-5 PGL Residential Baseline Projection by End Use (MMtherms)

Natural Gas Use (mTherms)	2019	2025	2030	% Change ('19-'30)	Avg. Growth
Space Heating	493,070	466,415	468,367	-5.0%	-0.47%
Water Heating	146,232	157,355	167,703	14.7%	1.25%
Appliances	22,160	22,848	23,790	7.4%	0.65%
Miscellaneous	110,375	112,699	116,154	5.2%	0.46%
Total	**771,838**	**759,317**	**776,014**	**0.5%**	**0.05%**

Residential Potential

Table 3-6 presents the residential sector energy savings potential estimates. In 2022, achievable potential energy savings are 4,701 mTherms, or 0.6% of the baseline projection. By 2030, cumulative energy savings are 43,427 mTherms, or 5.6% of the baseline.

Table 3-6 PGL Summary of Residential Natural Gas Potential (mTherms)

	First-year Savings Potential				Cumulative Savings Potential				
	2022	2023	2024	2025	2022	2023	2024	2025	2030
Baseline Projection	748,288	752,185	755,966	759,317	748,288	752,185	755,966	759,317	748,288
Potential Savings (mTherms)									
Achievable	4,701	4,832	5,001	5,191	4,701	9,530	14,523	19,689	43,427
Economic	15,534	15,652	15,704	15,806	15,534	31,117	46,684	62,246	135,614
Technical	22,094	22,037	21,909	21,891	22,094	43,809	65,142	86,145	178,322
Potential Savings as % of Baseline									
Achievable	0.6%	0.6%	0.7%	0.7%	0.6%	1.3%	1.9%	2.6%	5.6%
Economic	2.1%	2.1%	2.1%	2.1%	2.1%	4.1%	6.2%	8.2%	17.5%
Technical	3.0%	2.9%	2.9%	2.9%	3.0%	5.8%	8.6%	11.3%	23.0%

Figure 3-4 shows the top 20 measures. Specific observations include:

- Insulation and Building Shell measures double between 2025 and 2030. The aging housing stock increases eligible market
- Connected Thermostat savings reflect PGL program success

Figure 3-4 PGL Residential Top Measures, Cumulative Savings in 2025 and 2030 (mTherms)

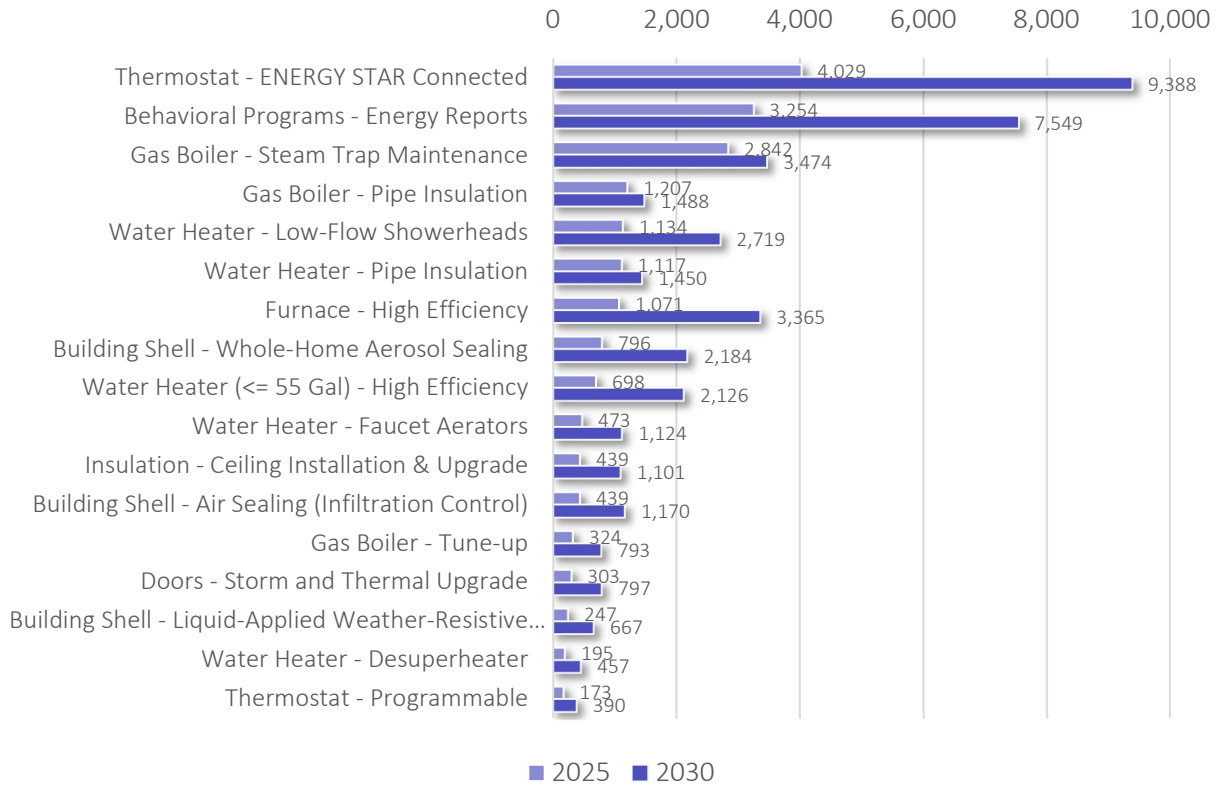
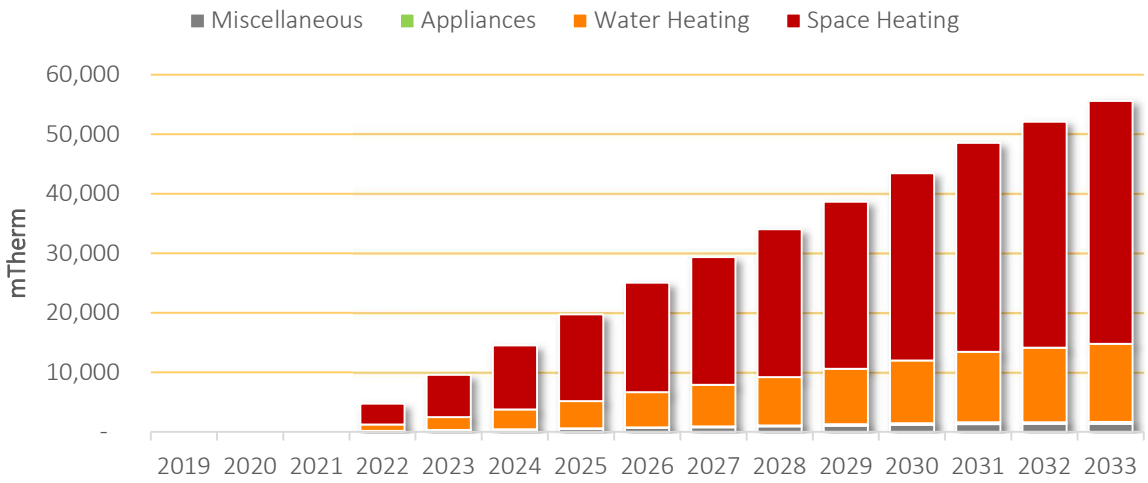


Figure 3-5 shows residential cumulative natural gas savings by end use from 2022 through 2030. Savings by end use are consistent through the forecast, with space heating savings from building envelope measures and high efficiency HVAC equipment. Additionally, stock turnover results in higher appliance and HVAC savings over time.

Figure 3-5 PGL Residential Cumulative Savings by End Use



Commercial Sector

In 2019, PGL commercial customers used a total of 266,652 mTherms, which may also be expressed as an intensity of 0.59 therms per square foot. We allocated this usage to 10 commercial segments, shown in Table 3-7 which excludes Industrial customers with annual usage greater than 4 MMtherms. As shown in Figure 3-6, the miscellaneous segment used approximately 25% of the total electricity consumed in 2019, followed by health (19%), office (15%), school (12%), lodging (9%), college (7%), restaurant (6%), retail (4%), grocery (2%), and warehouse (1%). Please note that the miscellaneous segment includes industrial customers; total usage of the industrial customers and lack of primary data did not support further segmentation.

Table 3-7 PGL Commercial Control Totals, 2019

Segment	Sales (mTherm)	Intensity (therm/sqft)	Floor Space (Million Sq. Ft.)
Office	39,598	0.32	123,370
Restaurant	14,901	1.86	7,993
Retail	11,098	0.47	23,459
Grocery	6,016	0.57	10,604
College	19,555	0.47	41,326
School	30,534	0.41	73,683
Health	51,003	1.23	41,491
Lodging	24,381	0.60	40,781
Warehouse	2,393	0.26	9,200
Miscellaneous	67,173	0.87	77,625
Total	**266,652**	**0.59**	**449,533**

Figure 3-6 Commercial Use by Segment, 2019

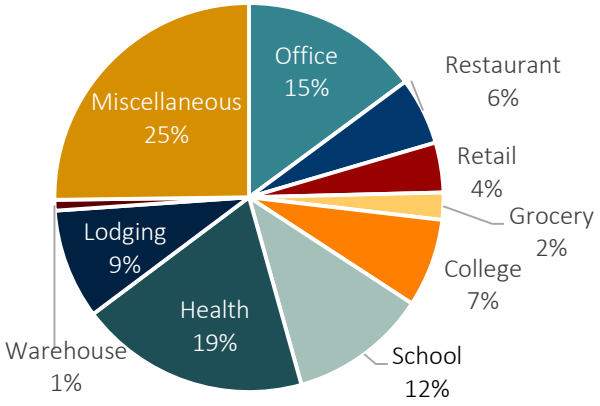


Figure 3-7 shows the distribution of annual natural gas consumption by end use across all commercial buildings. Space heating accounts for 48% of commercial natural gas consumption, while water heating accounts for approximately one third.

As shown in Figure 3-8, natural gas intensity by end use varies significantly across segments. For example, due to cooking equipment consumption, the restaurant segment is the most energy intensive, with significantly higher usage per square foot than any other segment.

Figure 3-7 PGL Commercial Use by End Use, 2019

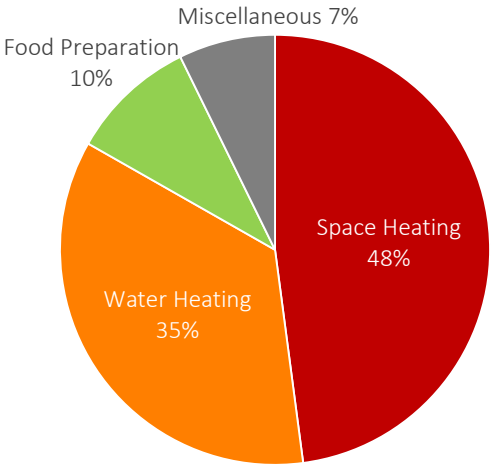
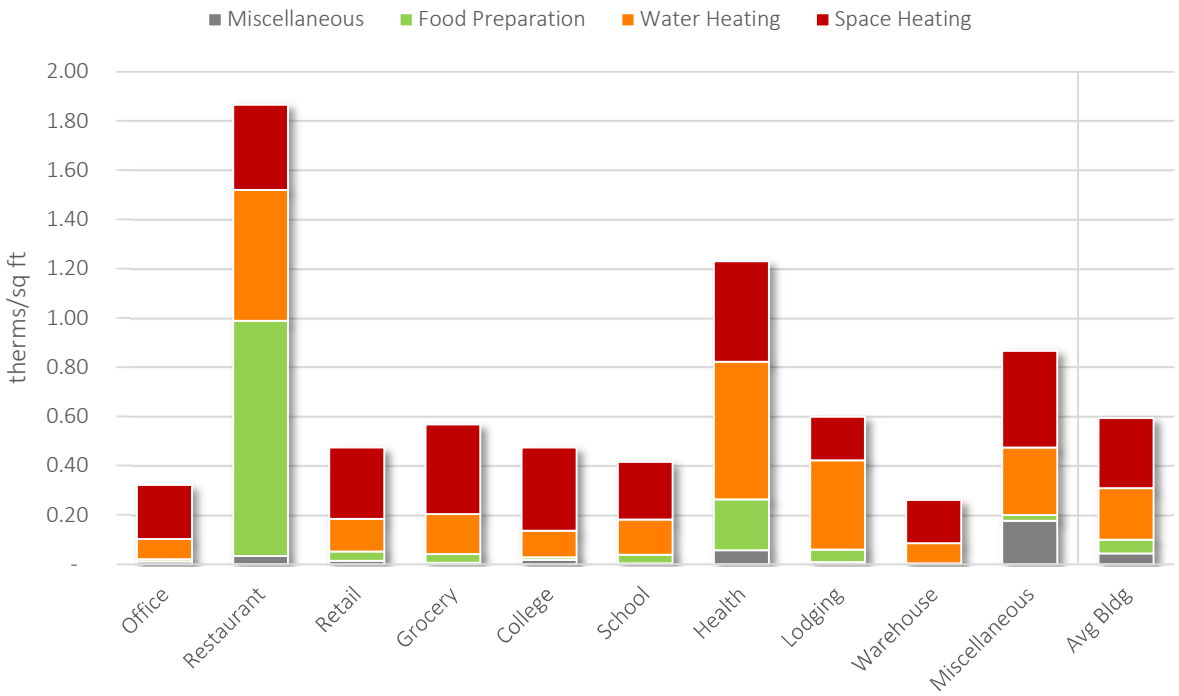


Figure 3-8 PGL Commercial Intensity by End Use and Segment, 2019



Commercial Baseline Projection

Table 3-8 presents AEG's independent natural gas baseline projection at the end use level for the commercial sector. Overall, total commercial usage decreases from 267 MMtherms in 2019 to 258 MMtherms in 2030, or -3.2%.

Table 3-8 PGL Commercial Baseline Projection by End Use (mTherm)

Natural Gas Use (mTherm)	2019	2025	2030	% Change ('19-'30)	Avg. Growth
Space Heating	127,755	118,664	115,244	-9.8%	-0.9%
Water Heating	94,185	91,081	89,020	-5.5%	-0.5%
Food Preparation	25,334	25,793	25,923	2.3%	0.2%
Miscellaneous	19,377	23,731	27,835	43.6%	3.3%
Total	**266,652**	**259,269**	**258,021**	**-3.2%**	**-0.3%**

Commercial Potential

Table 3-9 presents the commercial sector energy savings potential estimates. In 2022, achievable potential energy savings are 5,003 mTherms, or 1.9% of the baseline projection. By 2030, cumulative energy savings are 36,989 mTherms, or 14.3% of the baseline projection.

Table 3-9 PGL Summary of Commercial Natural Gas Potential

	First-year Savings Potential				Cumulative Savings Potential				
	2022	2023	2024	2025	2022	2023	2024	2025	2030
Baseline Projection	261,464	260,582	259,866	259,269	261,464	260,582	259,866	259,269	258,021
First-year Savings (mTherms)									
Achievable Potential	5,003	5,113	5,256	5,381	5,003	10,043	15,196	20,186	36,989
Economic Potential	14,227	13,867	13,739	13,578	14,227	27,734	41,126	53,740	95,342
Technical Potential	15,535	14,917	14,553	14,070	15,535	29,856	43,632	56,225	96,847
Cumulative Savings (% of Baseline)									
Achievable Potential	1.9%	2.0%	2.0%	2.1%	1.9%	3.9%	5.8%	7.8%	14.3%
Economic Potential	5.4%	5.3%	5.3%	5.2%	5.4%	10.6%	15.8%	20.7%	37.0%
Technical Potential	5.9%	5.7%	5.6%	5.4%	5.9%	11.5%	16.8%	21.7%	37.5%

Figure 3-9 presents the top measures in the commercial sector. Specific observations include:

- Steam trap maintenance is the top measure in 2025 and 2030. This finding is consistent with what AEG finds in other studies.
- Gas Optimization and Retro commissioning also provide significant savings.

Figure 3-9 PGL Commercial Top Measures, Cumulative Savings in 2025 and 2030 (mTherms)

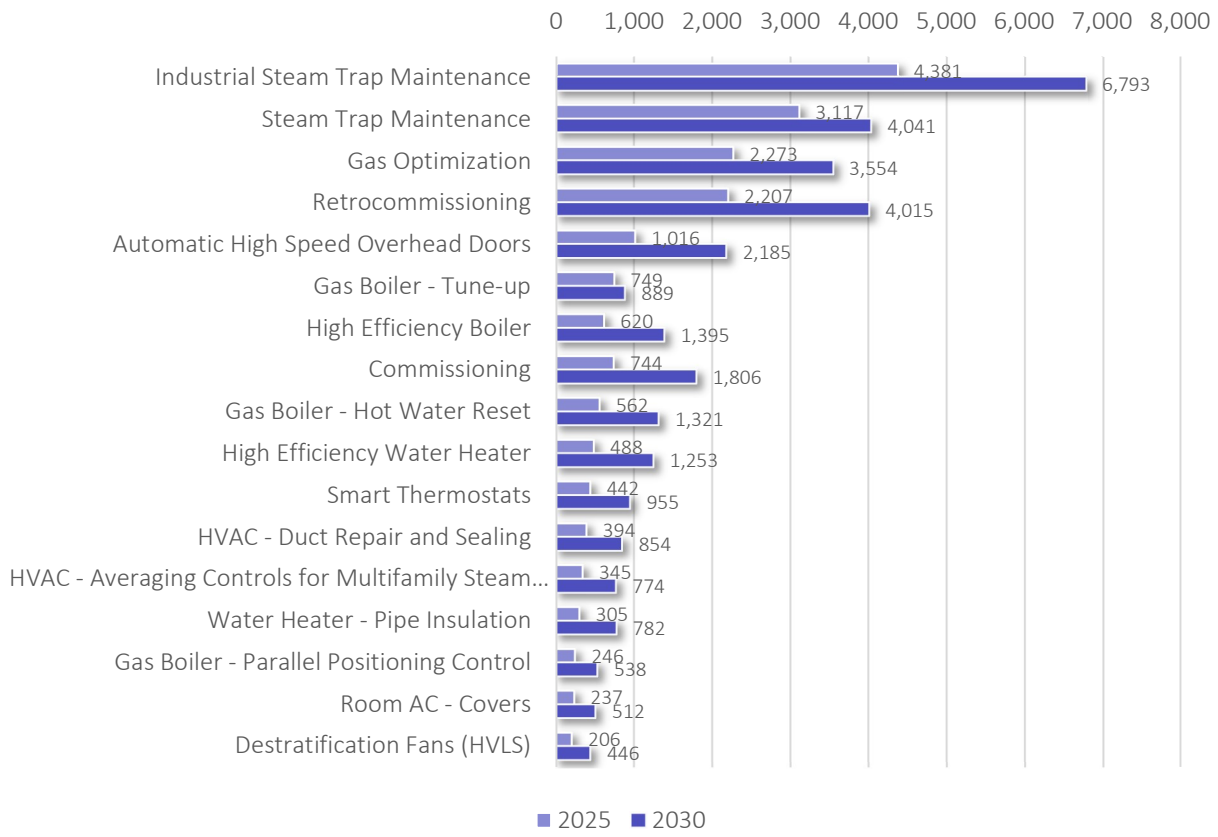
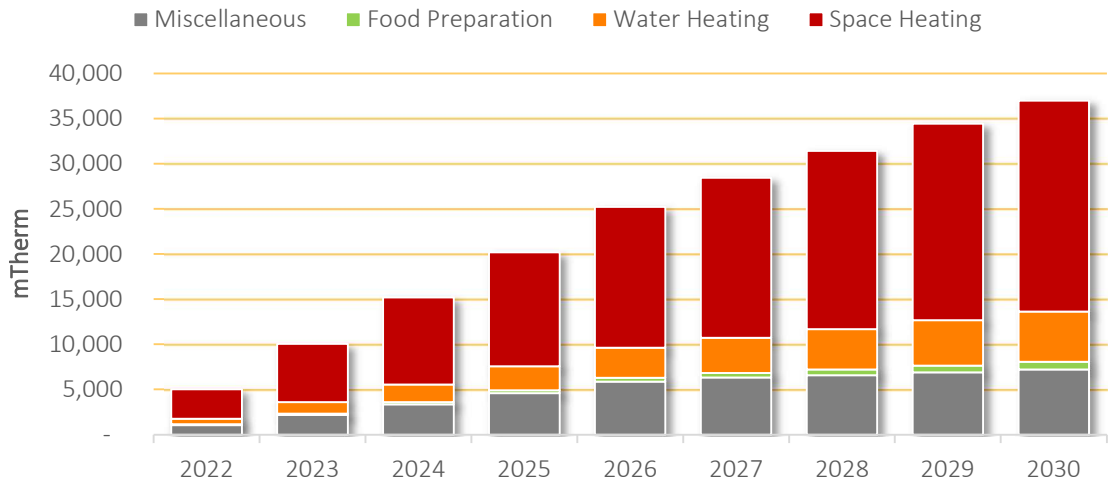


Figure 3-10 below shows commercial cumulative natural gas savings by end use from 2022 through 2030. Space heating savings comprise most of the achievable potential, with the share of savings by end use consistent throughout the forecast.

Figure 3-10 PGLCommercial Cumulative Savings by End Use



4

NORTH SHORE GAS ANALYSIS

This section details the study results and potential estimates for North Shore Gas (NSG) as a whole and by sector.

Overall Energy Efficiency Potential

This section presents the natural gas energy efficiency potential from two perspectives. First, we show the incremental savings for the next program cycle, 2022 through 2025. Then we show the long run cumulative savings through 2030.

Incremental Potential for Planning Cycle Years

First-year potential savings for 2022 through 2025 are presented in Table 4-1. The net achievable potential is in the range of 2,335 mTherms to 2,580 mTherms per year, or 1.0% of the baseline projection.

The residential sector accounts for the majority, approximately 56% of achievable potential savings in each year, as shown in Table 4-2.

Table 4-1 NSG First-Year Savings Potential for Planning Cycle

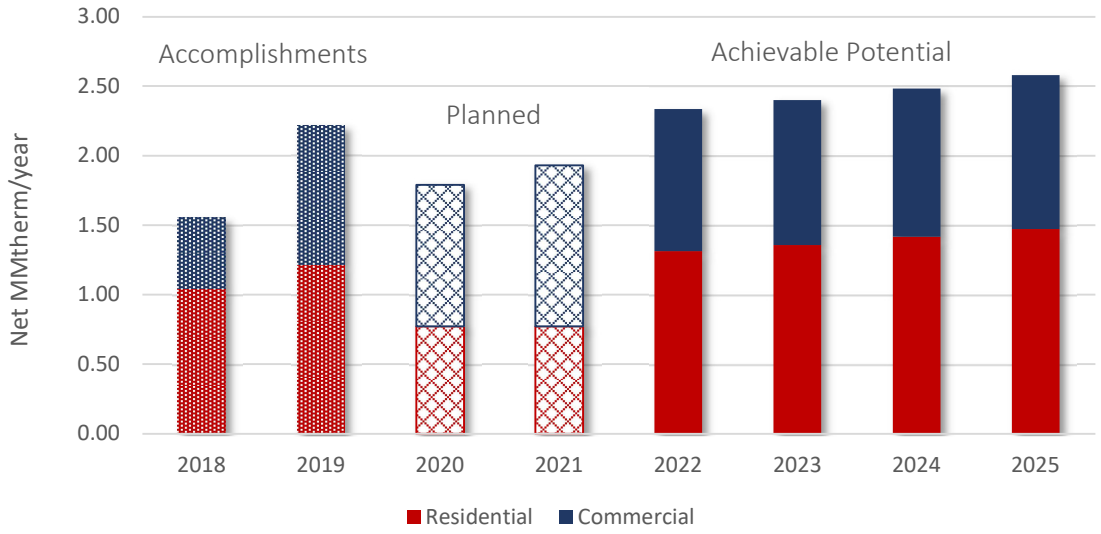
	2022	2023	2024	2025
Reference Baseline (mTherms)	**231,764**	**232,561**	**233,424**	**234,195**
First-year Savings (mTherms)				
Achievable Potential	**2,335**	**2,400**	**2,482**	**2,580**
Economic Potential	6,235	6,231	6,265	6,258
Technical Potential	7,379	7,314	7,289	7,250
Savings as % of Baseline				
Achievable Potential	1.0%	1.0%	1.1%	1.1%
Economic Potential	2.7%	2.7%	2.7%	2.7%
Technical Potential	3.2%	3.1%	3.1%	3.1%

Table 4-2 NSG First-Year Achievable Savings Potential by Sector

Achievable Potential by Sector	2022	2023	2024	2025
Reference Baseline (mTherms)	**231,764**	**232,561**	**233,424**	**234,195**
First-year Savings (mTherms)-- All Sectors	**2,335**	**2,400**	**2,482**	**2,580**
Residential	1,312	1,357	1,416	1,473
Commercial	1,022	1,043	1,066	1,107
First-year Savings as % of Baseline-- All	**1.0%**	**1.0%**	**1.1%**	**1.1%**
Residential	0.6%	0.6%	0.6%	0.6%
Commercial	0.4%	0.4%	0.5%	0.5%

Figure 4-1 below compares recent prior-year program accomplishments to planned 2020-2021 performance and to achievable potential savings from 2022 through 2025. Achievable potential estimates are slightly higher than accomplishments in 2019. Additionally, achievable potential increases as a result of the ramp rates.

Figure 4-1 NSG Prior-Year Accomplishments and First-Year Achievable Potential (Net MMtherms)



A relatively small number of measures account for the majority of savings during the next program cycle (cumulative savings from 2022-2025 in parenthesis):

- Residential behavioral programs – Home Energy Reports (2.7 MMtherms)
- Industrial steam trap maintenance (1.4 MMtherms)
- Commercial steam trap maintenance (1.4 MMtherms)
- Residential ENERGYSTAR connected thermostats (0.84 MMtherms)

Cumulative Potential for 2030 Outlook

This section presents the energy conservation potential across NSG. Year-by-year savings for annual energy usage are available in the LoadMAP model, which was provided to NSG at the conclusion of the study.

Table 4-3 summarizes the efficiency savings in terms of annual energy use for all measures for three levels of potential relative to the baseline projection. Savings are represented in cumulative terms, which reflect the effects of persistent savings in prior years in addition to new savings. This allows for the reporting of annual savings impacts as they impact each year of the forecast.

Table 4-3 NSG Summary of Cumulative Potential Savings

	2022	2023	2024	2025	2030
Reference Baseline (mTherms)	**231,764**	**232,561**	**233,424**	**234,195**	**238,226**
Cumulative Savings (mTherms)					
Achievable Potential	2,335	4,720	7,183	9,694	17,138
Economic Potential	6,235	12,382	18,556	24,647	48,338
Technical Potential	7,379	14,548	21,634	28,528	54,700
Savings as % of Baseline					
Achievable Potential	1.0%	2.0%	3.1%	4.1%	7.2%
Economic Potential	2.7%	5.3%	7.9%	10.5%	20.3%
Technical Potential	3.2%	6.3%	9.3%	12.2%	23.0%

Residential Sector

In 2019, there were approximately 144,973 households in NSG's Residential sector that used a total of 190,262 mTherms, which equates to an average use of 1,312 therms per household. Please note that the residential sector is dominated by single family housing, and therefore not segmented further.

Table 4-4 NSG Residential Control Totals, 2019

Metric	Total
Households	144,973
Annual Use mTherms	190,262
Use per HH (therms/HH)	1,312

Figure 4-2 NSG Residential Gas Use by End Use, 2019

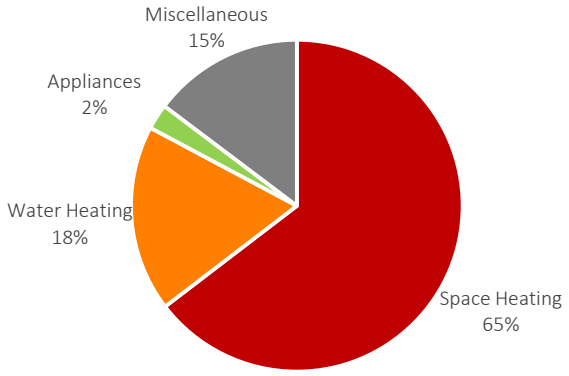


Figure 4-2 shows the average annual natural gas consumption by end use for NSG residential customers. Space heating accounts for 65% of total usage. Water heating accounts for 18% of total usage, and the miscellaneous category accounts for 15% of total usage. Appliances account for the remaining 2% of total residential gas usage.

Residential Baseline Projection

Table 4-5 presents AEG's independent natural gas baseline projection at the end use level for the residential sector. Overall, total residential use increases from 190 MMtherms in 2019 to 195 MMtherms in 2030, an increase of 2.7%. The projection includes effects of standards, codes, and naturally occurring conservation.

Table 4-5 NSG Residential Baseline Projection by End Use (mTherms)

Natural Gas Use (mTherms)	2019	2025	2030	% Change ('19-'30)	Avg. Growth
Space Heating	122,928	118,051	118,072	-4.0%	-0.37%
Water Heating	34,578	38,875	42,023	21.5%	1.77%
Appliances	4,749	4,983	5,180	9.1%	0.79%
Miscellaneous	28,007	29,167	30,066	7.4%	0.65%
Total	**190,262**	**191,077**	**195,341**	**2.7%**	**0.24%**

Residential Potential

Table 4-6 presents the residential sector energy savings potential estimates. In 2022, achievable potential energy savings are 1,312 mTherms, or 0.7% of the baseline projection. By 2030, cumulative energy savings are 11,499 mTherms, or 5.9% of the baseline.

Table 4-6 NSG Summary of PGL Residential Natural Gas Potential (mTherms)

	First-year Savings Potential				Cumulative Savings Potential				
	2022	2023	2024	2025	2022	2023	2024	2025	2030
Baseline Projection	188,268	189,213	190,201	191,077	188,268	189,213	190,201	191,077	195,341
Potential Savings (mTherms)									
Achievable	1,312	1,357	1,416	1,473	1,312	2,668	4,083	5,557	11,499
Economic	4,117	4,160	4,212	4,231	4,117	8,257	12,433	16,639	35,772
Technical	5,085	5,103	5,117	5,131	5,085	10,129	15,138	20,102	41,473
Potential Savings as % of Baseline									
Achievable	0.7%	0.7%	0.7%	0.8%	0.7%	1.4%	2.1%	2.9%	5.9%
Economic	2.2%	2.2%	2.2%	2.2%	2.2%	4.4%	6.5%	8.7%	18.3%
Technical	2.7%	2.7%	2.7%	2.7%	2.7%	5.4%	8.0%	10.5%	21.2%

Figure 4-3 shows the top 15 measures. Specific observations include:

- Along with Behavioral Programs, ENERGY STAR connected thermostats are the top measures, and savings reflect historic NSG program success.
- High Efficiency Furnaces double between 2025 and 2030, as the aging housing stock increases the eligible market for these measures.

Figure 4-3 NSG Residential Top Measures, Cumulative Savings in 2025 and 2030 (mTherms)

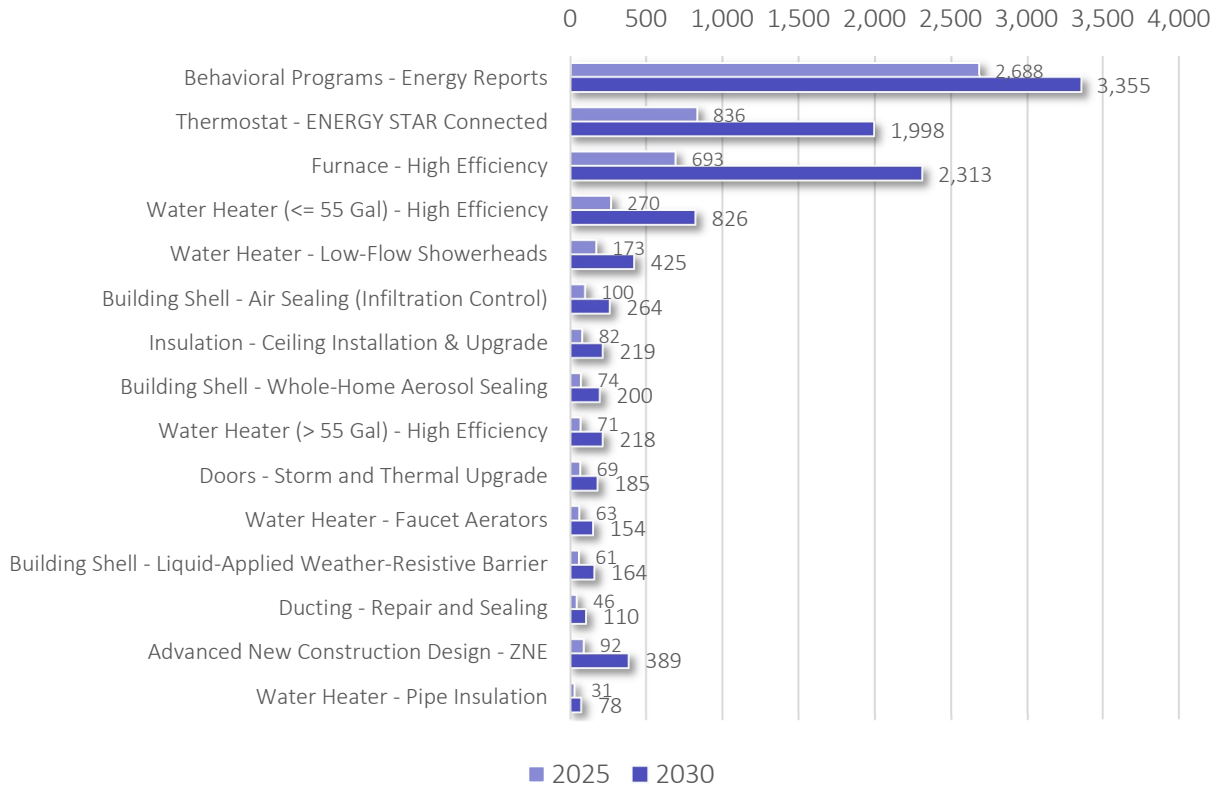
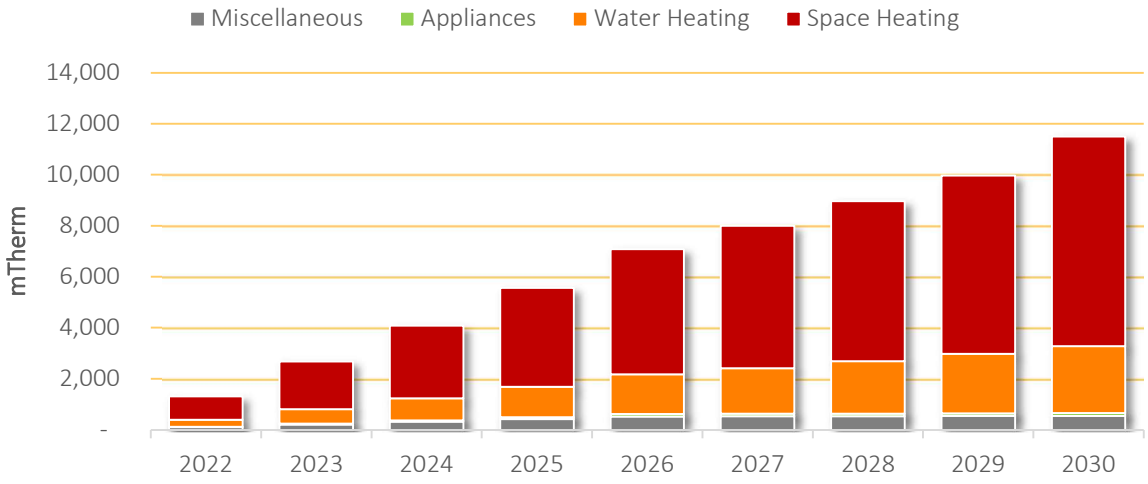


Figure 4-4 shows residential cumulative natural gas savings by end use from 2022 through 2030. Savings by end use are consistent through the forecast, with space heating savings from building envelope measures and high efficiency HVAC equipment. Additionally, stock turnover results in higher appliance and HVAC savings over time.

Figure 4-4 NSG Residential Cumulative Savings by End Use



Commercial Sector

In 2019, NSG commercial customers used a total of 44,635 mTherms, which may also be expressed as an intensity of 0.59 therms per square foot. We allocated these totals into 10 commercial segments, shown in Table 4-7 which excludes Industrial customers with usage greater than 4 MMtherms. As shown in Figure 4-5, the miscellaneous segment used approximately 24% of the total electricity consumed in 2019, followed by health (22%), office (14%), school (13%), retail (9%), restaurant (6%), college (5%), warehouse (3%), grocery (3%), and lodging (1%). Please note that the miscellaneous segment includes industrial customers; total usage of the industrial customers and lack of primary data did not support further segmentation.

Table 4-7 NSG Commercial Control Totals, 2019

Segment	Sales (mTherm)	Intensity (therm/sqft)	Floor Space (Million Sq. Ft.)
Office	6,193	0.33	18,907
Restaurant	2,791	1.86	1,497
Retail	4,141	0.47	8,754
Grocery	1,499	0.57	2,642
College	2,134	0.47	4,509
School	5,778	0.41	13,944
Health	9,745	1.21	8,032
Lodging	624	0.60	1,044
Warehouse	1,125	0.26	4,324
Miscellaneous	10,605	0.87	12,256
Total	**44,635**	**0.59**	**75,909**

Figure 4-5 NSG Commercial Use by Segment, 2019

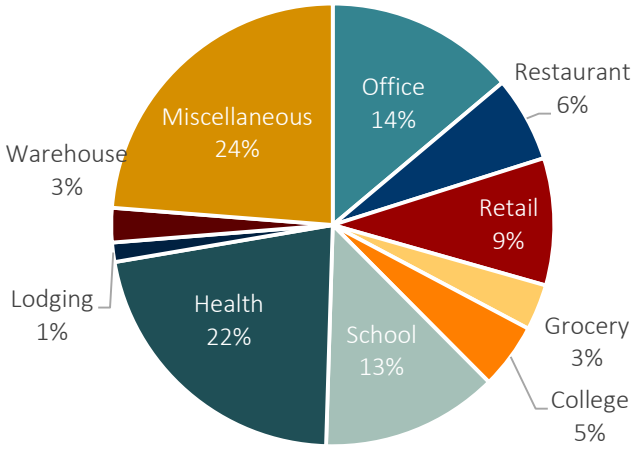


Figure *4-6* shows the distribution of annual natural gas consumption by end use across all commercial buildings. Space heating accounts for 49% of commercial natural gas consumption, while water heating accounts for approximately one third.

As shown in Figure 4-7, natural gas intensity by end use varies significantly across segments. For example, due to cooking equipment consumption, the restaurant segment is the most energy intensive, with significantly higher usage per square foot than any other segment.

Figure 4-6 NSG Commercial Use by End Use, 2019

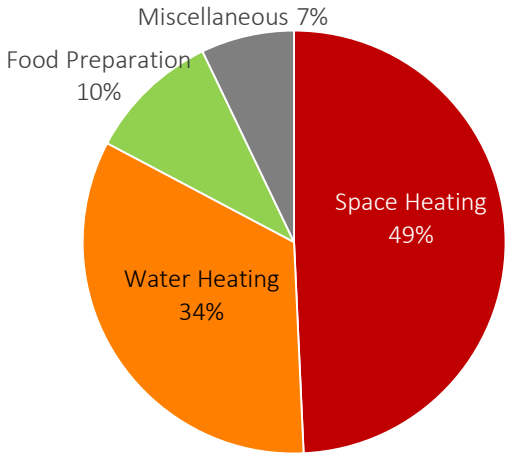
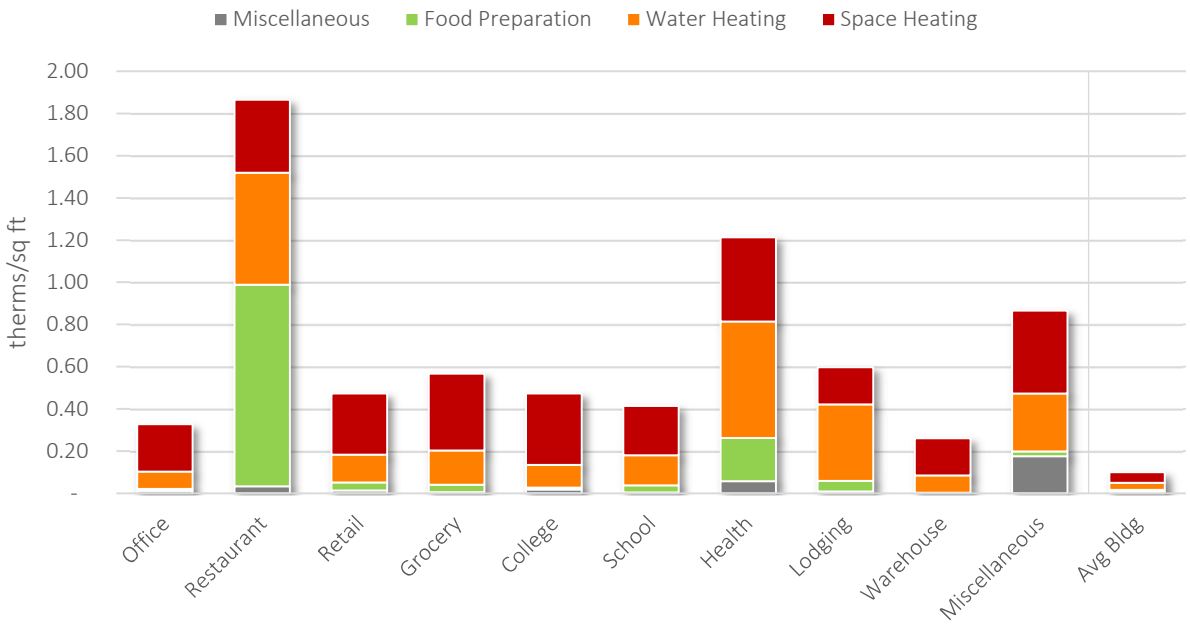


Figure 4-7 NSG Commercial Intensity by End Use and Segment, 2019



Commercial Baseline Projection

Table 4-8 presents AEG's independent natural gas baseline projection at the end use level for the commercial sector. Overall, total commercial usage decreases from 44.6 MMtherms in 2019 to 42.9 MMtherms in 2030, a decrease of 3.9%.

Table 4-8 NSG Commercial Baseline Projection by End Use (mTherm)

Natural Gas Use (mTherm)	2019	2025	2030	% Change ('19-'30)	Avg. Growth
Space Heating	21,996	20,250	19,655	-10.6%	-1.0%
Water Heating	14,942	14,392	14,051	-6.0%	-0.6%
Food Preparation	4,512	4,578	4,598	1.9%	0.2%
Miscellaneous	3,185	3,898	4,580	43.8%	3.3%
Total	**44,635**	**43,118**	**42,884**	**-3.9%**	**-0.4%**

Commercial Potential

Table 4-9 presents the commercial sector energy savings potential estimates. In 2022, achievable potential energy savings are 1,022 mTherms, or 2.4% of the baseline projection. By 2030, cumulative energy savings are 5,639 mTherms, or 13.1% of the baseline projection.

Table 4-9 NSG Summary of Commercial Natural Gas Potential

	First-year Savings Potential				Cumulative Savings Potential				
	2022	2023	2024	2025	2022	2023	2024	2025	2030
Baseline Projection	43,496	43,349	43,223	43,118	43,496	43,349	43,223	43,118	42,884
First-year Savings (mTherms)									
Achievable Potential	1,022	1,043	1,066	1,107	1,022	2,052	3,100	4,137	5,639
Economic Potential	2,118	2,071	2,053	2,027	2,118	4,125	6,123	8,008	12,566
Technical Potential	2,294	2,210	2,171	2,119	2,294	4,419	6,495	8,426	13,227
Cumulative Savings (% of Baseline)									
Achievable Potential	2.4%	2.4%	2.5%	2.6%	2.4%	4.7%	7.2%	9.6%	13.1%
Economic Potential	4.9%	4.8%	4.8%	4.7%	4.9%	9.5%	14.2%	18.6%	29.3%
Technical Potential	5.3%	5.1%	5.0%	4.9%	5.3%	10.2%	15.0%	19.5%	30.8%

Figure 4-8 presents the top measures in the commercial sector. Specific observations include:

- Steam trap maintenance is the top measure in 2025 and 2030. This finding is consistent with what AEG finds in other studies.
- Retrocommissioning in the commercial sector is a restoration of HVAC systems to their original, or better conditions. In the industrial sector these measures are more custom in nature.

Figure 4-8 NSG Commercial Top Measures, Cumulative Savings in 2025 and 2030

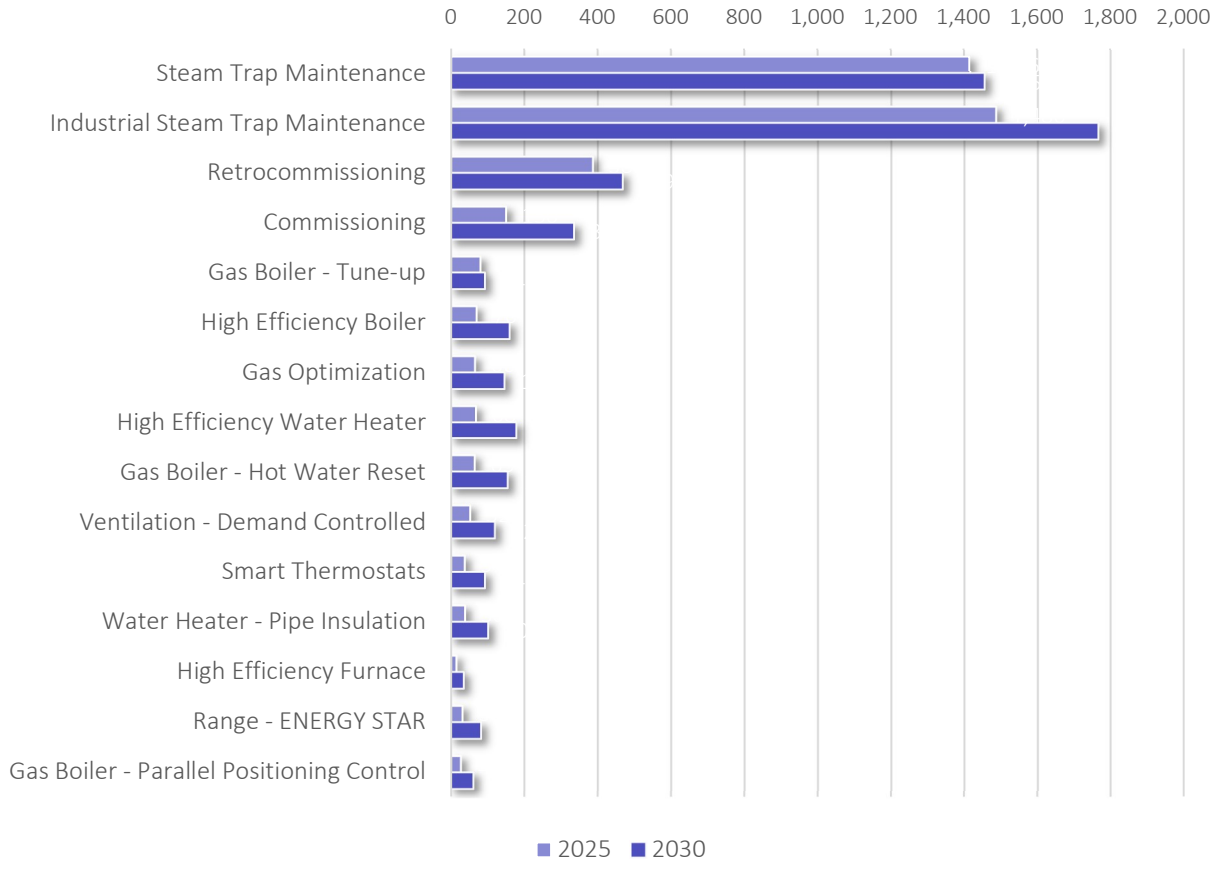


Figure 4-9 shows commercial cumulative natural gas savings by end use from 2022 through 2030. Space heating savings comprise a majority of the achievable potential, with the share of savings by end use consistent throughout the forecast.

Figure 4-9 NSG Commercial Cumulative Savings by End Use