Intermountain Gas Company

2019 Conservation Potential Assessment

Integrated Resource Plan 2021 – 2026

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Intermountain Gas Company

CONSERVATION POTENTIAL ASSESMENT FINAL REPORT

Submitted to: **INTERMOUNTAIN GAS COMPANY**

Prepared by: **DUNSKY ENERGY CONSULTING**

with Gas Technology Institute and Frontier Energy

Contact: Francois Boulanger, Senior Research Lead

July 2019

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SUBMITTED TO:

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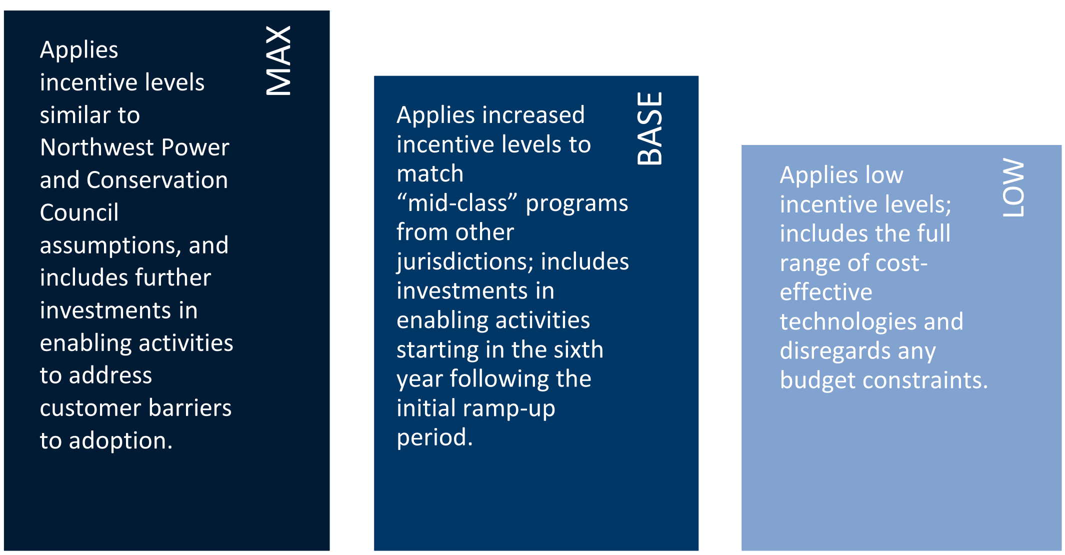
EXECUTIVE SUMMARY

Dunsky Energy Consulting, in collaboration with the Gas Technology Institute (GTI) and Frontier Energy, conducted a conservation potential assessment for the Intermountain Gas Company (IGC) over the 2020-2039 timeframe. Emphasis was placed on the initial 5-year period (2020-2024) The assessment is intended to support both short-term energy efficiency planning and long-term resource planning activities. To this end, the study quantifies energy and demand savings from gas efficiency measures as well as fuel switching from electric heating accounting considering the two climate zones within IGC service territory.

The study relies on interviews with key market actors and subject matter experts, as well as and the most up-to-date market data available for both the residential and commercial sectors. This research provided IGC-specific saturation and baseline efficiencies of energy-using equipment in homes and businesses across the service territory.

Three levels of savings potential were assessed: Technical, Economic, and Achievable. Within the Achievable potential, three scenarios were modeled to examine how Demand-Side Management (DSM) program design factors such as incentive levels and investments in enabling activities can impact potential savings. The achievable potential scenarios are defined at the Low, Base, and Maximum, as described in the figure below.

Figure 1. Alternative Scenario Assumptions for Achievable Potential Applied in this Study



CUMULATIVE SAVINGS POTENTIAL

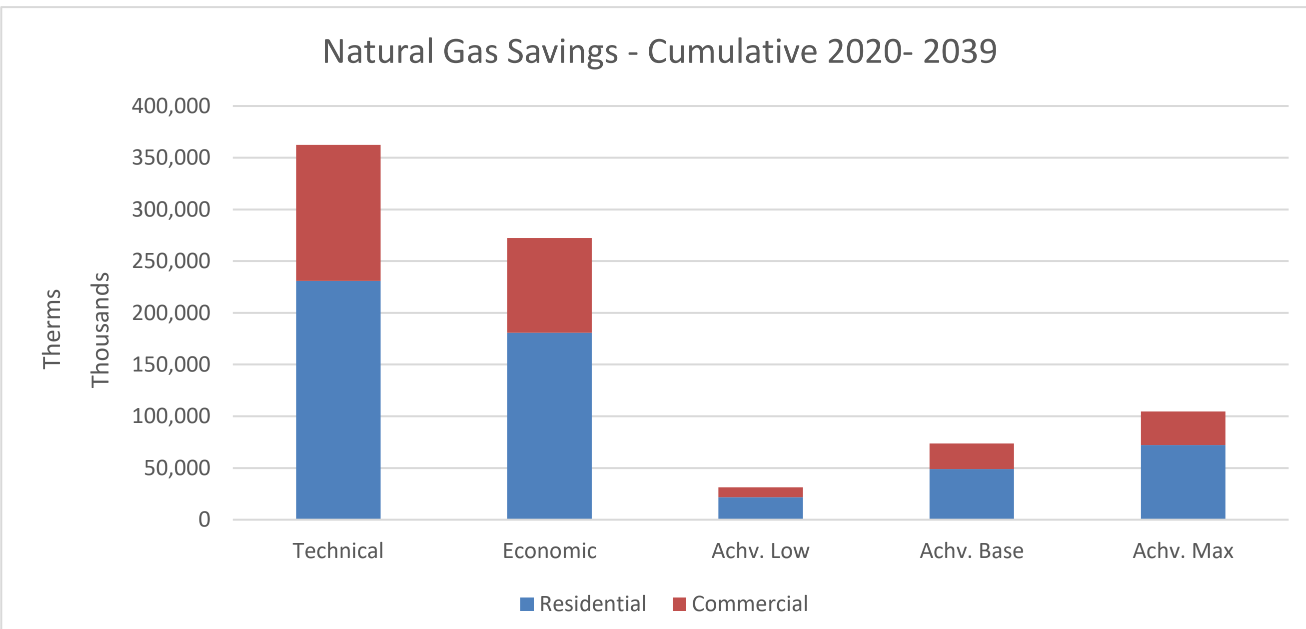
The achievable potential results are presented on both a Cumulative Savings and Program Savings basis, as described below:

- **Cumulative savings** capture a rolling sum of all new savings that will affect energy sales, excluding measure re-participation. Cumulative savings express the long-term energy consumption and demand impacts to inform resource planning for the energy generation and delivery systems.
- **Program savings** capture annual savings from incentivized measures and are not adjusted to remove the impacts of re-participation or mid-life baseline adjustment impacts. Program savings help to understand the expected annual DSM portfolio savings and budgets, to inform DSM program planning.

This section focuses on the cumulative savings results from each technology stream, while the next section provides further details on the program savings.

Below, the technical, economic, and achievable savings are presented side-by-side for natural gas savings (Figure 8).

Figure 2. Cumulative Natural Gas Potential (2020-2039)



From these results, the following observations can be made:

- **Economic Potential is 17% lower than the technical potential** under the least expensive scenario**.** Additional opportunities exist in IGC's service territory that are not considered cost-effective under the current cost-effectiveness framework. This is a consequence of two factors:

- Using the Utility Cost Test (UCT) to screen cost-effective measures with low incentives levels results in higher economic potential than other commonly used cost effectiveness tests, such as the Total Resources Cost (TRC) test or the Societal Cost Test (SCT).
- Measures that are currently not commercially viable, and not expected to become viable within the first 15 years, were excluded from the measure list.[1] This reduces the technical potential but has no impact on other types of potential.
- Under a UCT screen, the economic potential is dependent on the level of incentives provided (see text box, below, for further information).

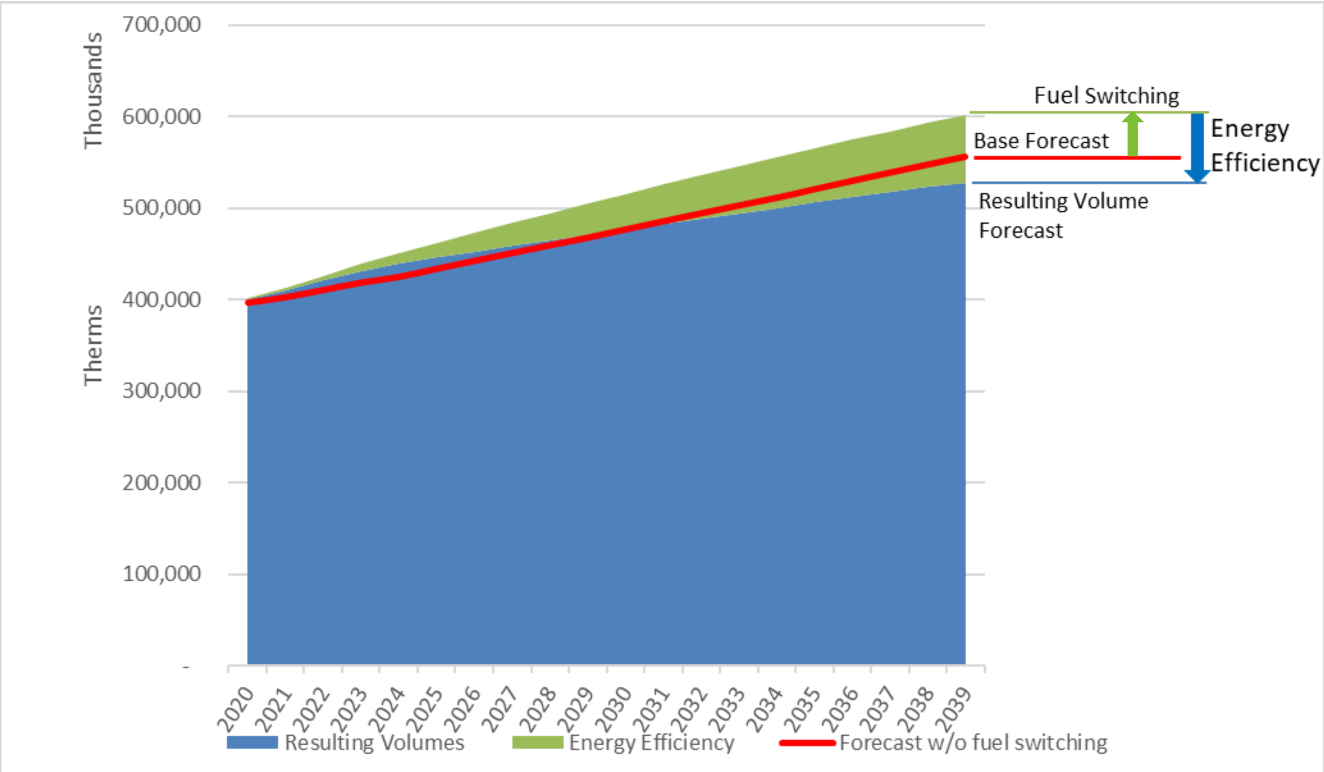
- **Achievable potential is significantly lower than economic potential** for all three scenarios, which is largely attributed to customer bills savings being relatively low compared to efficiency measure costs, and market barriers such as perceived higher cost of energy efficient equipment and uncertainty about the savings from efficiency improvements.
- **Investing in barrier reductions can increase achievable potential over and above raising incentives alone.** The combination of "best-in-class" incentive levels and barrier reduction strategies applied in the Max Scenario more than triple the incremental savings over the Low Scenario.

IMPACT ON GAS VOLUMES AND SALES

The graph below contextualizes potential savings from conservation for the Base Scenario, as well as load growth resulting from fuel-switching, through a comparison to the base volume forecast to demonstrate anticipated network-level effects (Figure 11).

[1] The commercial viability of measures is based on available research, technical and economic analysis, as well as professional judgment of the Dunsky team.

Figure 3. Cumulative Natural Gas Potential: Base Scenario Impact on Natural Gas Volumes



From these results, the following observations can be made:

- **Fuel-switching leads to growth in natural gas volumes and number of customers**, as some customers heated with electricity are expected to switch to natural gas furnaces. If no efficiency programs were implemented, gas consumption could be expected to rise by 50% by 2039 due to customer growth (new construction) and fuel-switching.

- **Efficiency savings has the potential to reduce natural gas consumption by 12% by 2039, after accounting for the impact of fuel-switching.** While fuel-switching could increase consumption by close to 46,000,000 therms in 2039, efficiency savings may generate 70,000,000 therms of savings. Close to 50% of these savings are attributable to HVAC measures.

EFFICIENCY PROGRAM SAVINGS POTENTIAL

The program savings provides further details related to the projected annual savings arising from IGC's portfolio of efficiency programs. These results below present the annual savings and budget for each program stream, and unlike the cumulative savings, they are not adjusted to remove re-participation impacts or mid-life baseline adjustments. Specifically, forecasted annual program savings and their corresponding budgets are presented for the Low and Base Scenarios in Figure 12; savings are also presented as a percent of forecasted natural gas volumes in Figure 13.

Figure 4. Annual Program Savings (Therms): Low and Base Scenarios, Savings and Budget

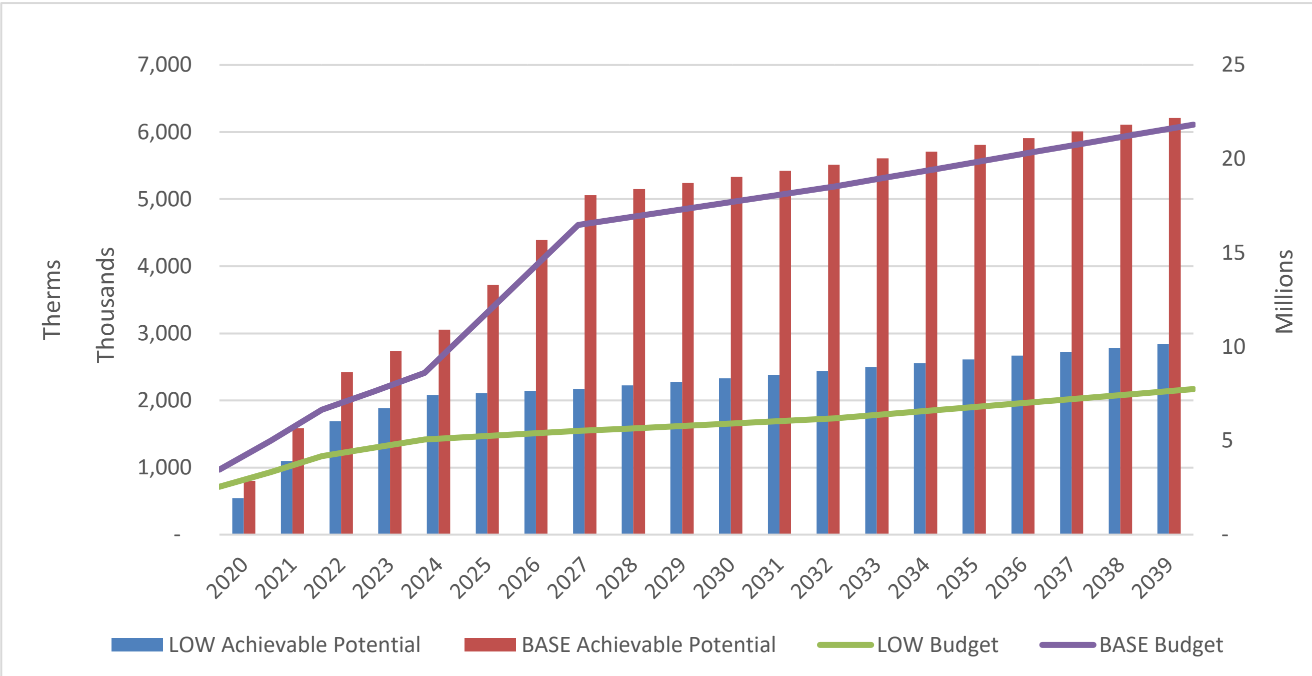
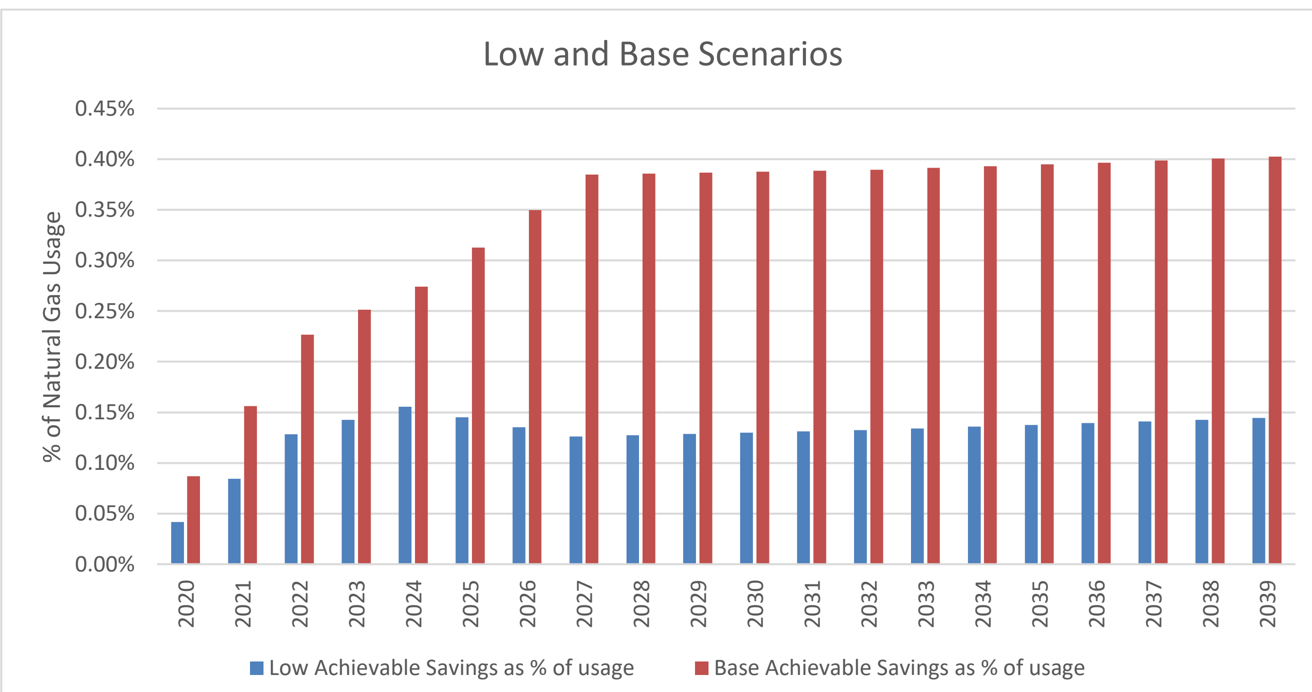


Figure 5. Savings as a Percent of Natural Gas Volumes: Low and Base Scenarios



Based on the above results, the following observations can be made:

- **Savings in both scenarios exhibit strong growth in the first five years, followed by a relatively modest growth for the rest of the study period.** The rapid growth in the first period of the study reflects the expansion of current initiatives in the residential sector and the introduction of new initiatives in the commercial sector. New initiatives and measures have been ramped up over a period of three to six years. The later period growth in savings represents a 2% year-over-year increase, following new construction activity and fuel switching to natural gas heating.

- **Savings under the Base Scenario are 40% higher than under the Low Scenario** in the first five years, with further increases in the remaining portion of the study period, notably due to forecasted investments towards a reduction of market barriers**.** Starting in the sixth year of the study, the Base Scenario's budget is more than double the Low Scenario budget (from an average ratio in the first five years of 1.5:1), as higher incentive levels increases the cost of all savings, not only the incremental portion. This increase in program savings is reflected in the cumulative savings, which shows a similar increase (43%) between the Low and Base Scenarios, due to very similar mixes of measures in each scenario. Despite the higher average cost per therm of savings in the Base Scenario, all of the savings are cost-effective from a UCT perspective.

- **Efficiency measures provide a stable flow of natural gas savings.** Gas savings as a percent of forecasted volumes remain close to 0.5% for the Low Scenario and around 1.0% for the Base Scenario, following the initial ramp-up period assumed in the analysis. Changes in codes and standards or technology do not disrupt natural gas savings potential in a significant manner; however, customer fuel-switching to natural gas heating has a significant impact on the overall gas consumption trend, counter-balancing efficiency savings and leading to an overall net increase in gas consumption.

- **Under the Base Scenario, conservation budgets need to increase significantly**, first as programs are introduced to the market and customers participate in a greater number of such programs, and second as participation further grow due to sustained strategies to address market barriers and further increase program participation.

1. INTRODUCTION

Dunsky Energy Consulting, in collaboration with its subcontractors, Gas Technology Institute (GTI) and Frontier Energy, conducted a conservation potential assessment for the Intermountain Gas Company (IGC) over the 2020-2039 timeframe. The assessment is intended to support both short-term energy efficiency planning and long-term resource planning activities. To this end, the study quantifies energy and demand savings from gas efficiency measures as well as fuel switching from electric heating accounting considering the two climate zones within IGC service territory. In addition to providing an assessment of IGC's combined conservation potential, this report also presents a high-level explanation of our study methods and modelling approach.

CONTEXT

IGC is the sole distributor of natural gas in Southern Idaho, with a service area that extends across the entire breadth of Southern Idaho—covering an area of 50,000 square miles with a population of approximately 1,260,000. During the fiscal year of 2017, IGC served an average of 349,000 customers in 74 communities through a system of over 12,000 miles of transmission, distribution, and service lines.

Beginning October 1, 2017, the Idaho Public Utilities Commission (PUC) granted IGC authority to offer an Energy Efficiency program to residential customers and to collect a per therm charge to fund the program. IGC's initial program offering includes rebates for seven measures in the residential sector—for furnaces, water heaters, fireplaces, as well as a whole home Energy Star verified homes. While this initial program focuses on the most cost-effective demand-side management (DSM) measures, the PUC advised all utilities to investigate all cost-effective DSM.

In response, IGC issued a Request for Proposals for an "Energy Efficiency (Conservation) Potential Assessment and Modeling Software Tool" in May 2018. This study is the final product resulting from that process. It is the first of its kind completed on behalf of IGC. IGC also intends to use this study to explore new commercial DSM programs in addition to its current residential programs.

POTENTIAL STUDY SCOPE

This study assesses the conservation potential of gas measures in both the residential and commercial sectors over the 2020-2039 timeframe. In addition to efficiency measures, it assesses the total energy impacts of replacing electric heating equipment with high-efficiency natural gas equipment where economically beneficial. The study considers the two climate zones within IGC service territory.

REPORT STRUCTURE

This report presents the methods, findings and the conservation potential study results from several perspectives, including cumulative savings by scenario, sector, segment, and end-use. A brief outline of the report structure is provided below.

Section 1 – Introduction

Section 2 – Methodology: this section provides an overview of the potential study model and energy-saving measures.

Section 3 – Cumulative Conservation Potential: This section outlines cumulative savings over the study period, presenting technical, economic, and achievable potential, as well as savings by sector and impacts on gas volumes.

Section 4 – Energy Efficiency Program Savings Potential: This section provides detailed results for program savings, including average annual savings and budgets and energy savings by sector and segment. Top-10 contributing measures are presented for each sector with corresponding savings in therms.

Section 5 – Programs and Scenario Analysis: This section provides a comparison of the three scenarios program savings, budgets, and cost-effectiveness.

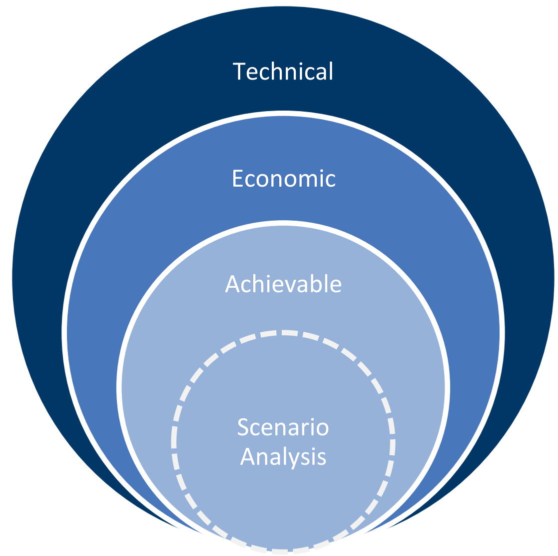
2. METHODOLOGY

The Dunsky Energy Efficiency Potential (DEEP) model employs a multi-step process to develop a bottom-up assessment of the Technical, Economic and Achievable Potentials.

Technical potential: The theoretical maximum conservation potential, ignoring constraints such as cost-effectiveness and market barriers.

Economic potential: The savings opportunities available should customers adopt all cost-effective savings, as established by screening measures against the Utility Cost Test (UCT).

Achievable potential: The savings from cost-effective opportunities once market barriers have been applied, resulting in an estimate of savings that can be achieved through demand-side management programs. Three achievable potential scenarios were modeled to examine how varying factors such as incentive levels and market barrier reductions impact uptake:



- **Low:** Applies low incentive levels (30% of incremental costs), with an unconstrained budget and a broad set of cost-effective measures.
- **Base:** Incentive levels are increased to cover 50% of the measure incremental cost.
- **Maximum (Max):** Incentives are set to 65% of incremental costs, a funding level similar to the assumptions behind the Northwest Power and Conservation Council ramp-rate used for electric conservation potential study in the northwest. This scenario also includes program investments towards reducing market barriers through innovative program delivery.

This remainder of this section provides a high-level overview of the Dunsky potential model. Additional information on the baseline research is provided in Appendix A, with the detailed modeling methodology provided in Appendix B.

POTENTIAL MODEL

The key steps conducted in the energy efficiency potential study were as follows:

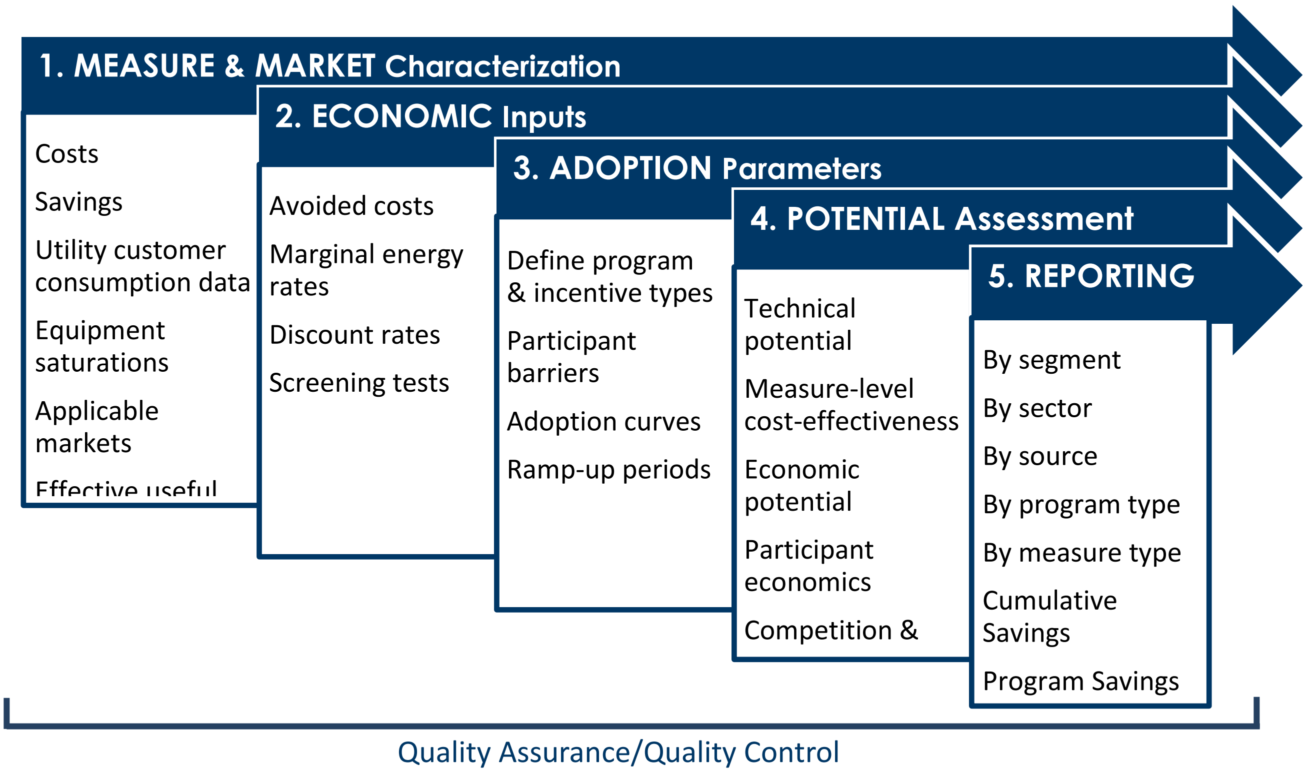
- **Characterize Measures and their Applicable Markets** A comprehensive list of energy saving measures is characterized by applying jurisdiction-specific data and assumptions to each measure and market segment. Primary and secondary data are compiled (as available) to establish an assessment of the market baseline, detailing the current saturation of energy using equipment in each market sector and segment. Markets for energy measures are then assessed by combining utility customer counts with market growth factors, equipment turnover rates, and the market baseline results.

- **Economic Inputs:** The model harnesses key economic inputs to assess the measure cost-effectiveness and benefits. Utility avoided costs, customer discount rates, gas rates, and the utility cost of capital are captured and entered into the model in real dollars based on the study period start year[2]. The cost-effectiveness test that will be applied for economic screening is selected, as well as the other test that will be calculated to benchmark program performance.
- **Adoption Parameters:** For each measure-market combination we assign adoption curves based on customer barrier level assessments. Customer economics inputs such as measure savings, marginal rates and other secondary energy sources) are applied to calculate the participant cost test (PCT), the key driver of adoption levels in each adoption curve. Finally, program characterizations are entered into the model by defining the fixed and variable program costs, incentive levels, and enabling activity impacts on customer barriers.
- **Potential Assessment:** The model assesses the technical potential by combining the measure characterization with the market baseline inputs to determine the theoretical maximum amount of savings possible for each measure-market combination, in each year, over the study period. Measures-market combinations that pass the cost-effectiveness threshold are counted in the economic potential. Achievable potential scenarios are applied by calculating the customer economics, under various incentive program scenarios, and applying the adoption curves. At each level, the model applies chaining factors to account for interactive effects among measures and assigns the appropriate market portion in places where multiple measure may compete for the same market (e.g., Tier 1 and Tier 2 boilers).
- **Reporting:** Reporting is conducted in four steps, from the presentation of the initial Draft Results to the Final Report, each with an increasing level of precision and detail. Each report is vetted by the relevant parties, and all feedback is considered and incorporated into the model and reporting before proceeding to the next step.
- **Quality Assurance / Quality Control (QA/QC):** Throughout the modeling process, a rigorous QA/QC process is applied to ensure the inputs reflect the energy using equipment in the studied jurisdiction, and that the results provide an accurate assessment of the energy savings potential. The model is calibrated to past DSM program performance and benchmarked to the baseline sales projections and individual end-uses, to ensure that the technical, economic and market factors align with the local reality.

These steps are shown graphically in the figure below.

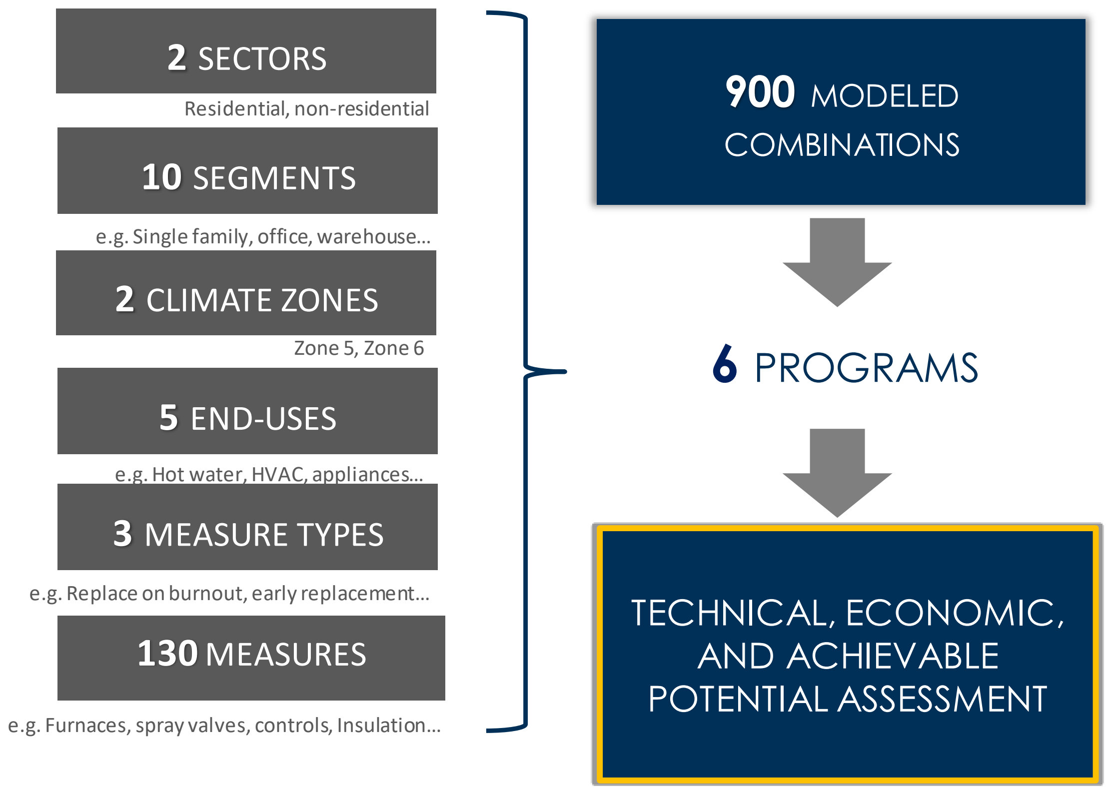
[2] The model conducts several different economic analyses, notably from the utility's perspective, used for cost-effectiveness tests and screening (based on the UCT), but also from the participants' perspective, to forecast adoption to individual measures.

Figure 6. Key Steps and Inputs in Study Methodology



The model conducts a bottom-up analysis of the conservation potential based on the existing building stock and equipment saturation. The assessment is developed at the measure level through individual characterizations which are then combined into measure types, end-uses, climate zones, programs, segments, and sectors, which allowed our Team to assess IGC's potential at a variety of levels, as highlighted in the figure below. In total, more than 900 individual combinations were modeled.

Figure 7. Key Inclusions of the Study



Please see Appendix A for the methodology used to conduct the market baseline research and market characterization, and Appendix B for the detailed modeling methodology.

ENERGY-SAVING MEASURES

MEASURE CHARACTERIZATION

Forty-two residential measures and 66 commercial measures were included in this study, as summarized in Table 1 and Table 2, respectively. All climate-dependent measures (i.e., those related to heating or cooling) were characterized separately for both climate zones. Please refer to Appendix C for details on measure characterization, and Appendix D for a climate zone map.

Table 1. Residential Measures Included in the IGC Potential Study Organized by End-Use

End-Use	Measure	End-Use	Measure
Appliance	Clothes Dryer ENERGY STAR	HVAC	Boiler post 2021 standard
Appliance	Clothes Washer ENERGY STAR	HVAC	Boiler Condensing
Behavioral	Home Energy Report	HVAC	Boiler Reset Control
Envelope	Air Sealing	HVAC	Boiler Tune Up
Envelope	Attic Insulation	HVAC	Combo Boiler (Heating/HE) post 2021 standard
Envelope	Basement Insulation	HVAC	Combo Boiler (Heating/HE)
Envelope	Efficient Windows	HVAC	Duct Insulation
Envelope	ENERGY STAR Doors	HVAC	Duct Sealing
Envelope	New Home Construction Built Green Home	HVAC	Fireplace < 40 kBtu/h
Envelope	New Home Construction ENERGY STAR Certified Home	HVAC	Fireplace >= 40 kBtu/h
Envelope	Wall Insulation	HVAC	Furnace
Hot Water	Faucet Aerator	HVAC	Furnace
Hot Water	Gas Heat Pump Water Heater	HVAC	Furnace Tune Up
Hot Water	Low Flow Shower Head	HVAC	Heat Recovery Ventilator ENERGY STAR
Hot Water	Pipe Wrap (Hot Water)	HVAC	Natural Gas Heat Pump
Hot Water	Storage Water Heater Energy Star	HVAC	Thermostat Programmable
Hot Water	Tankless Water Heater	HVAC	Thermostat Wi-Fi
Hot Water	Tankless Water Heater Energy Star	HVAC	Through-the-Wall Condensing Furnace/AC
Hot Water	Thermostatic Restrictor Shower Valve	Other	Pool Heater

Table 2. Commercial Measures Included in the IGC Potential Study Organized by End-Use

Measure Type	Measure	Measure Type	Measure
Appliance	Modulating Dryer Retrofit	HVAC	Energy Recovery Ventilator (ERV)
Behavioral	Building Operator Certification O&M Only	HVAC	Furnace Shut Off Damper, Space Heating
Behavioral	Building Operator Certification O&M plus Capital Upgrades	HVAC	High Efficiency Unit Heaters
Envelope	Attic/Roof Insulation Flat Roof	HVAC	Infrared Heater
Envelope	Building Shell Air Sealing	HVAC	Kitchen Demand Control Ventilation
Envelope	Green Roof	HVAC	Natural Gas AC and Heat Pump

Measure Type	Measure	Measure Type	Measure
Envelope	Wall Insulation	HVAC	Programmable Thermostat
Hot Water	Condensing Water Heater 2020	HVAC	Steam Boiler Stack Economizer
Hot Water	Hot Water Pipe Insulation	HVAC	Steam Trap HVAC
Hot Water	Indirect Water Heater	HVAC	Ventilation Hoods
Hot Water	Low Flow Faucet Aerator	HVAC	Water Boiler Stack Economizer
Hot Water	Low Flow Shower Head	Kitchen	Dishwasher
Hot Water	Natural Gas Engine Heat Pump Water Heater	Kitchen	Efficient Cookware
Hot Water	Pre-Rinse Spray Valve	Kitchen	Fryer
Hot Water	Recirculation Pump with Demand Controls	Kitchen	Griddle
Hot Water	Tankless Water Heater	Kitchen	Infrared Broiler
HVAC	Advanced Thermostat (Wi-Fi Thermostat)	Kitchen	Oven Combination
HVAC	Air Curtains	Kitchen	Oven Convection - ENERGY STAR
HVAC	Boiler < 300 kBtu/h - Tier I	Kitchen	Oven Convection - High Efficiency
HVAC	Boiler >= 300 kBtu/h	Kitchen	Oven
HVAC	Boiler < 300 kBtu/h- Tier 2	Kitchen	Steamer High Efficiency
HVAC	Boiler >= 300 kBtu/hPost 2024	Laundry	ENERGY STAR Clothes Dryer
HVAC	Boiler Blowdown Heat Recovery	Laundry	ENERGY STAR Clothes Washer
HVAC	Boiler Reset Control	New Construction	LEED Certified
HVAC	Boiler Shut Off Damper, Space Heating	Other	Biodigester
HVAC	Combo Condensing Boiler/Water Heater 90% AFUE	Other	Drain Water Heat Recovery (DWHR) Medium
HVAC	Combo Condensing Boiler/Water Heater 95% AFUE	Other	Duct Insulation and Sealing
HVAC	Condensing Make Up Air Unit with 2 Speed Motor	Other	Pool Cover
HVAC	Condensing RTU	Other	Pool Heater
HVAC	Condensing Unit Heater	Process	Process Boiler - Steam
HVAC	Demand Control Ventilation (DCV)	Process	Process Boiler - Water
HVAC	Destratification Fan - High Efficiency	Process	Process Boiler Tune Up
HVAC	Energy Management System (EMS)	Windows	Efficient Windows

MEASURE TYPES AND REPLACEMENT SCHEDULES

The model considers four types of efficiency measures:

- Replace on Burnout (ROB)
- Early Replacement (ER)
- Addition (ADD)
- New Construction/Installation (NEW)

Each of these measure types requires a different approach for determining the maximum yearly units available for potential calculations. Table 3 provides a guide as to how each measure type is defined and how the replacement or installation schedule is applied within the study to assess the phase-in potentials, year by year.

Table 3. Measure Types and Schedules Applied in the IGC Conservation Potential Assessment Model

Measure Type	Description	Market Base	Yearly Units Calculation
Replace on Burnout (ROB)	Existing units are replaced by efficient units after they fail *Example: Replacing failed boiler with a condensing boiler*	Current building code/equipment standard or industry standard practice	Market[a]/Effective Useful Life (EUL) *The EUL is set at a minimum of 3 years[b] to spread installations over the potential study period. Alternative EULs were used to calculate yearly units if baseline units have a different EUL than efficient units.*
Addition (ADD)	An EE measure is applied to existing equipment or structures *Example: Adding controls to existing lighting systems, adding insulation to existing buildings*	Existing units	The eligible market is distributed over the estimated useful life of the measure using an S-curve function.
New Construction/ Installation **(NEW)**	Measures not related to existing equipment *Example: New building built to LEED standards*	Building code, equipment standard or industry standard practice	Market *Market base is measure-specific and defined as new units per year*

[a] For the purpose of this table, market is defined as the number of units to which a specific measure applies.
[b] The Home Energy Report is a special case with an EUL of one year.

3. CUMULATIVE CONSERVATION POTENTIAL

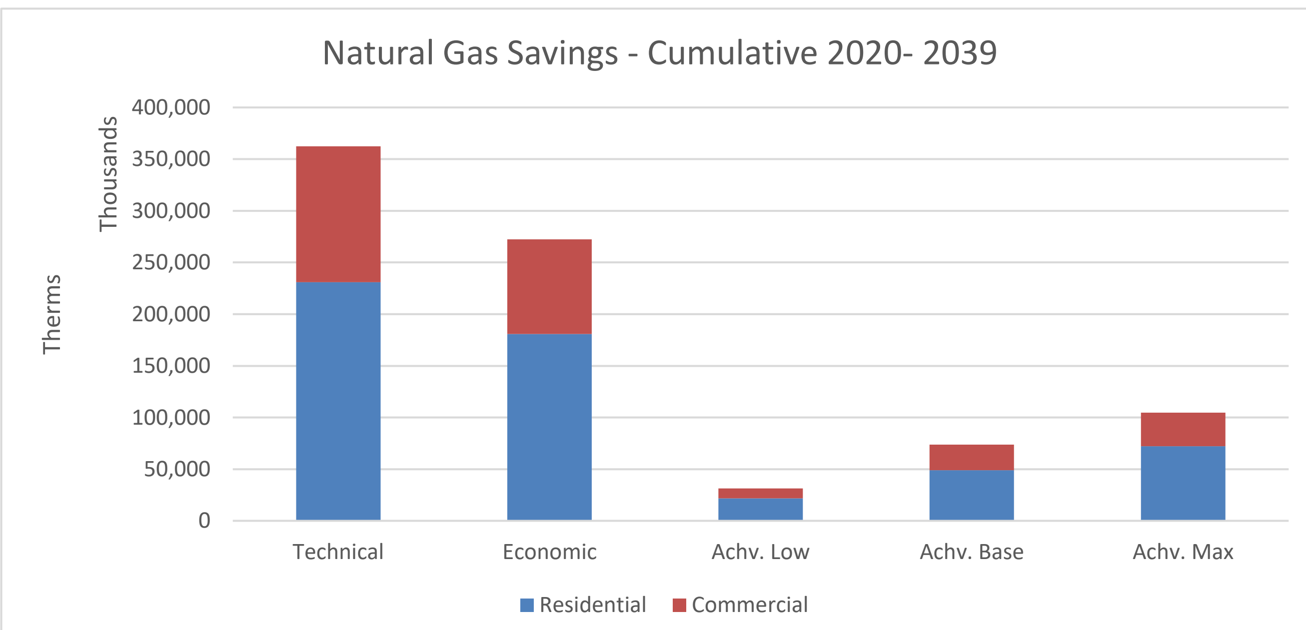
This section presents IGC's cumulative conservation potential. Specifically, it first presents technical, economic, and achievable potential; then savings by sector; and then impact on gas volumes. In reviewing the results and analysis, the reader should be aware of the following:

- **Achievable potential is presented under the Base Scenario** (i.e., incentive levels cover 50% of the measure incremental cost), except where otherwise specified.
- **All savings are expressed in at-the-meter terms**. The savings results have therefore not accounted for line-losses in the transportation and distribution network.
- **All financial metrics are expressed in 2020 dollars.** The applied analysis accounts for inflation and the time value of money, when assessing all benefit and cost assumptions, including program costs, measure costs, avoided energy costs, and marginal rates.

TECHNICAL, ECONOMIC, AND ACHIEVABLE CONSERVATION POTENTIAL

Below, technical, economic, and achievable savings are presented side-by-side for natural gas savings (Figure 8).

Figure 8. Cumulative Natural Gas Potential (2020-2039)



From these results, the following observations can be made:

- **Economic Potential is 17% lower than the technical potential** under the least expensive scenario**.** Additional opportunities exist in IGC's service territory that are not considered cost-effective under the current cost-effectiveness framework. This is a consequence of two factors:
    - Using the Utility Cost Test (UCT) to screen cost-effective measures with low incentives levels results in higher economic potential than other commonly used cost effectiveness tests, such as the Total Resources Cost (TRC) test or the Societal Cost Test (SCT).
    - Measures that are currently not commercially viable, and not expected to become viable within the first 15 years, were excluded from the measure list.[3] This reduces the technical potential but has no impact on other types of potential.
    - Under a UCT screen, the economic potential is dependent on the level of incentives provided (see text box, below, for further information).
- **Achievable potential is significantly lower than economic potential** for all three scenarios, which is largely attributed to customer bills savings being relatively low compared to efficiency measure costs, and market barriers such as perceived higher cost of energy efficient equipment and uncertainty about the savings from efficiency improvements.
- **Investing in barrier reductions can increase achievable potential over and above raising incentives alone.** The combination of "best-in-class" incentive levels and barrier reduction strategies applied in the Max Scenario more than triple the incremental savings over the Low Scenario.

[3] The commercial viability of measures is based on available research, technical and economic analysis, as well as professional judgment of the Dunsky team.

Impact of the Utility Cost Test (UCT) on Economic and Achievable Potential

Throughout this study, the UCT was used as the cost-effectiveness test to assess which measures are included in the economic potential. The UCT examines the costs and the benefits from the Utility's perspective. Benefits are derived from avoided costs attributed to energy savings, while costs are incentive payments made to program participants (program administration costs are included in the program-level UCT calculations). Screening the economic potential by the UTC, as approved by the Idaho PUC, has several implications on results worth noting:

- The maximum achievable potential under a UCT *is not* obtained with 100% incentive levels, but rather with a mix of various incentive levels that depend on each measure's benefits and incremental costs. Maximum achievable potential shown in this study is based on "best-in-class" incentive levels, as it was found to be very close to the theoretical maximum potential.

- Economic potential shown in this study is assessed using lower program incentive levels (Low Scenario), but using Base scenario's incentive levels reduces the economic potential by nearly 10%. Testing a scenario with 100% incentive levels for all programs, which is common practice in potential studies, was found to further reduce economic potential. As a result, increasing incentives beyond a certain level will actually *reduce* the achievable potential, as measures will be screened out (i.e., prevented from contributing to the achievable potential).

As the name suggests, measures screened using the UCT are, by definition, cost-effective to reduce the overall revenue requirements to deliver energy supply.

SAVINGS BY SECTOR

Cumulative gas savings by sector are shown in the figures below by sector.

Figure 9. Cumulative Conservation Potential: Base Scenario Savings by Sector and Time Period

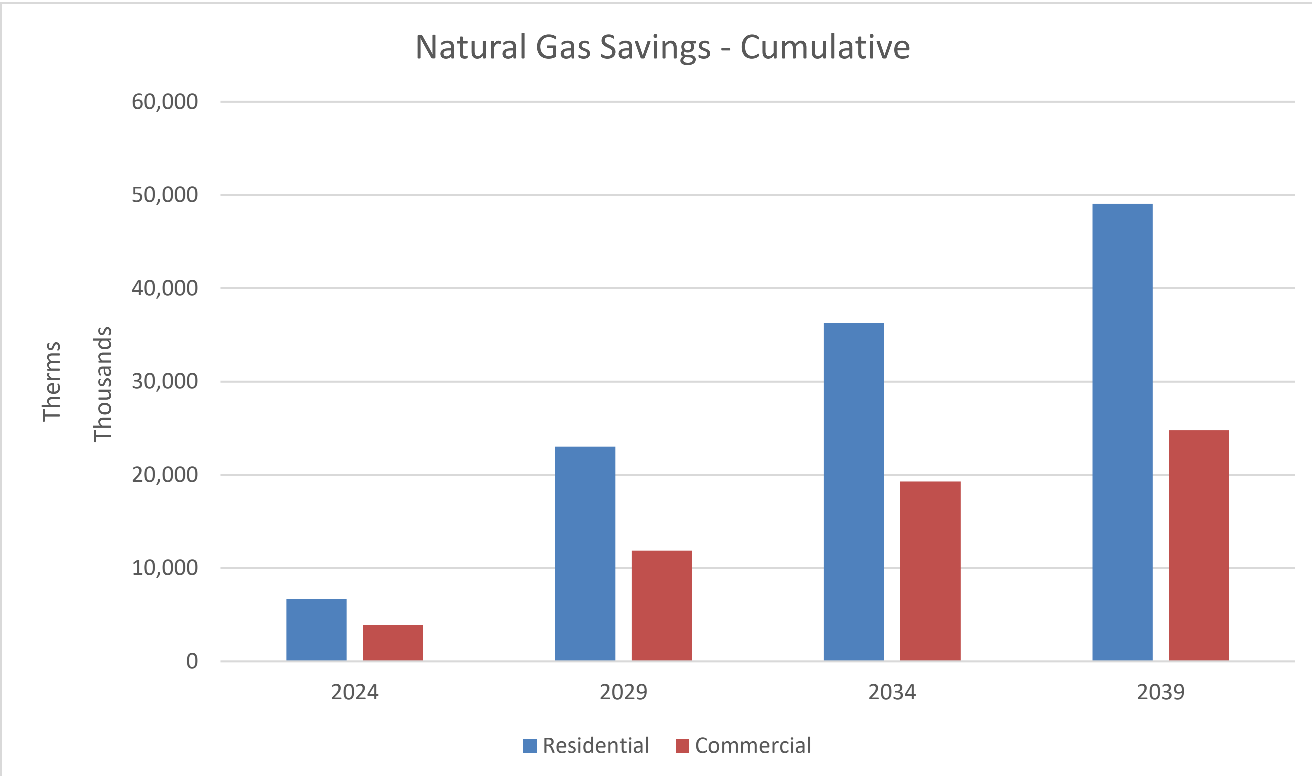
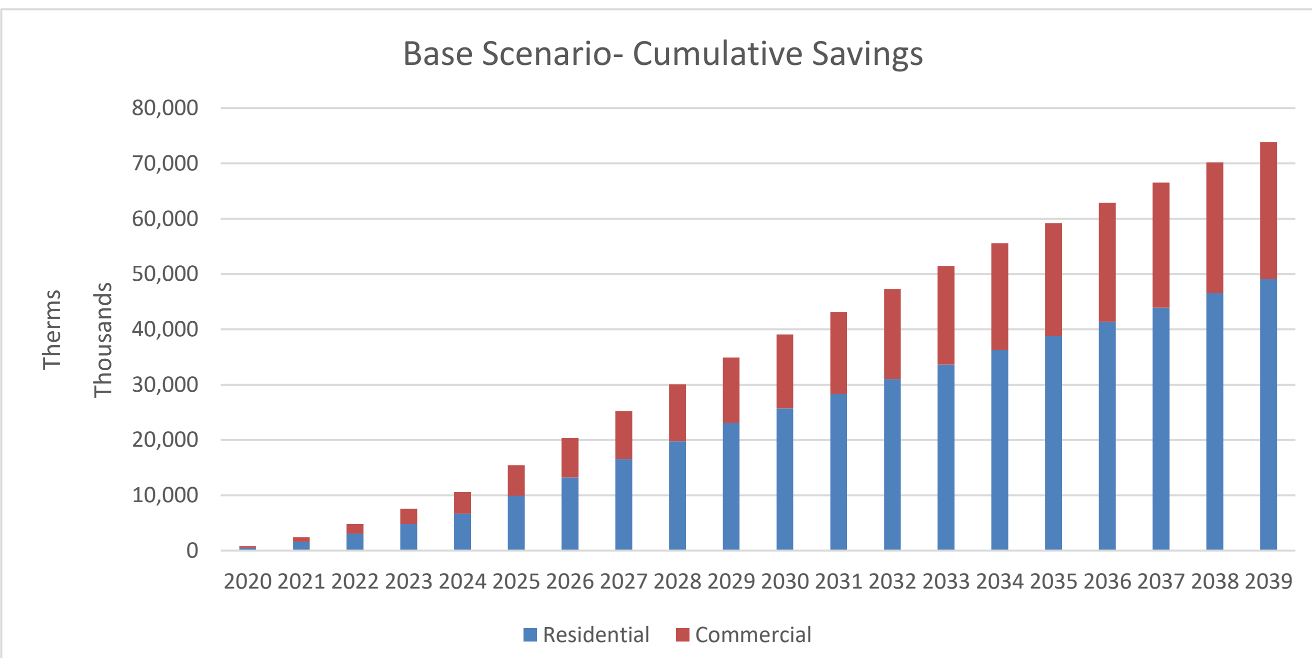


Figure 10. Cumulative Conservation Potential: Base Scenario Savings



Cumulative natural gas savings under the Base Scenario are presented by sector and year/period in Cumulative gas savings by sector are shown in the figures below by sector.

Figure 9 and Figure 10, above. The following remarks can be made on these results:

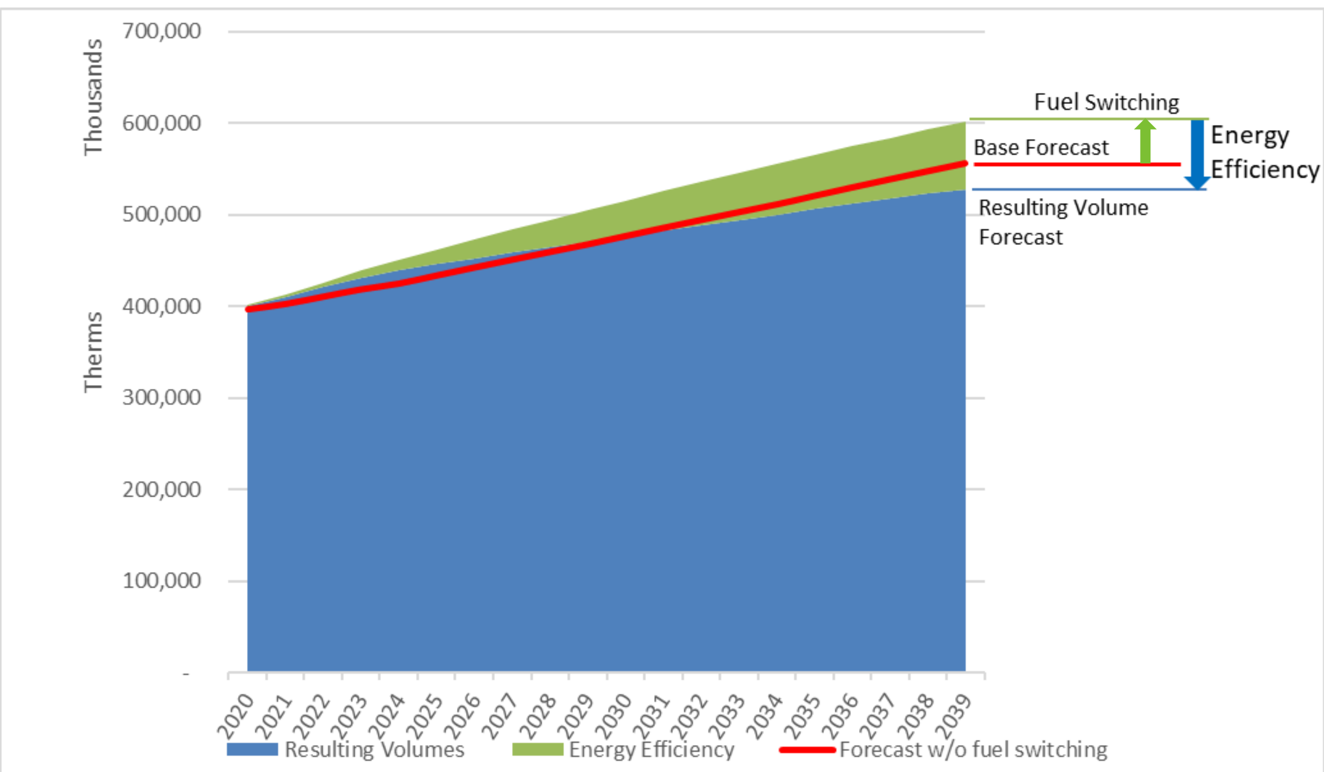
- **Cumulative savings grow at a slower pace during the initial years of the conservation potential study.** Considering that IGC's customer currently only have access to conservation programs for residential new construction and some residential space and water heating appliances, the study includes a ramp-up period for new measures and initiatives to take into consideration the time required to introduce new programs and measures to the market, and for programs to attain maturity and achieve their full market potential. This period varies based on the complexity involved with the design, launch of the program and effort to achieve maturity.

- **Savings are concentrated in the residential sectors.** By the end of the study period, nearly two-thirds (65%) of the natural gas savings are found in the residential sector.

IMPACT ON GAS VOLUMES

The graph below contextualizes potential savings from conservation for the Base Scenario, as well as load growth resulting from fuel-switching, through a comparison to the base volume forecast to demonstrate anticipated network-level effects (Figure 11).

Figure 11. Cumulative Natural Gas Potential: Base Scenario Impact on Natural Gas Volumes



From these results, the following observations can be made:

- **Fuel-switching leads to growth in natural gas volumes and number of customers**, as some customers heated with electricity are expected to switch to natural gas furnaces. If no efficiency programs were implemented, gas consumption could be expected to rise by 50% by 2039 due to customer growth (new construction) and fuel-switching.

- **Efficiency savings has the potential to reduce natural gas consumption by 12% by 2039, after accounting for the impact of fuel-switching.** While fuel-switching could increase consumption by close to 46,000,000 therms in 2039, efficiency savings may generate 70,000,000 therms of savings. Close to 50% of these savings are attributable to HVAC measures.

Fuel Switching Electric Heating Equipment to Natural Gas

The study assessed the impact of residential customers switching their electric heating equipment to high-efficiency natural gas equipment due to the considerable rate advantage of natural gas compared to electricity (given that electricity rates are more than five time higher than natural gas rates, on a per energy unit basis). This analysis did not include any direct incentives for participants and assumed there are no additional costs to homeowners for the natural gas connection.

The cumulative energy impacts from residential homes switching from electric heating to natural gas is presented in the table below.

	2024	2029	2034	2039
Natural Gas (therms)	25,666,955	37,479,176	44,774,316	46,129,317
Electricity (kWh)	-443,344,442	-647,376,552	-773,385,255	-796,790,145
Total Energy Impact (MMBtu)	**1,053,579**	**1,538,447**	**1,837,899**	**1,893,519**

The model assumed that only homeowners with an existing heat distribution system would be interested in fuel switching to natural gas. The baseline condition is an electric heat pump with standard efficiency level. The total energy impacts of fuel switching do not account for power plant generation efficiencies. Additional analysis would be required to include this in the total energy impacts reported.

4. ENERGY EFFICIENCY PROGRAM SAVINGS POTENTIAL

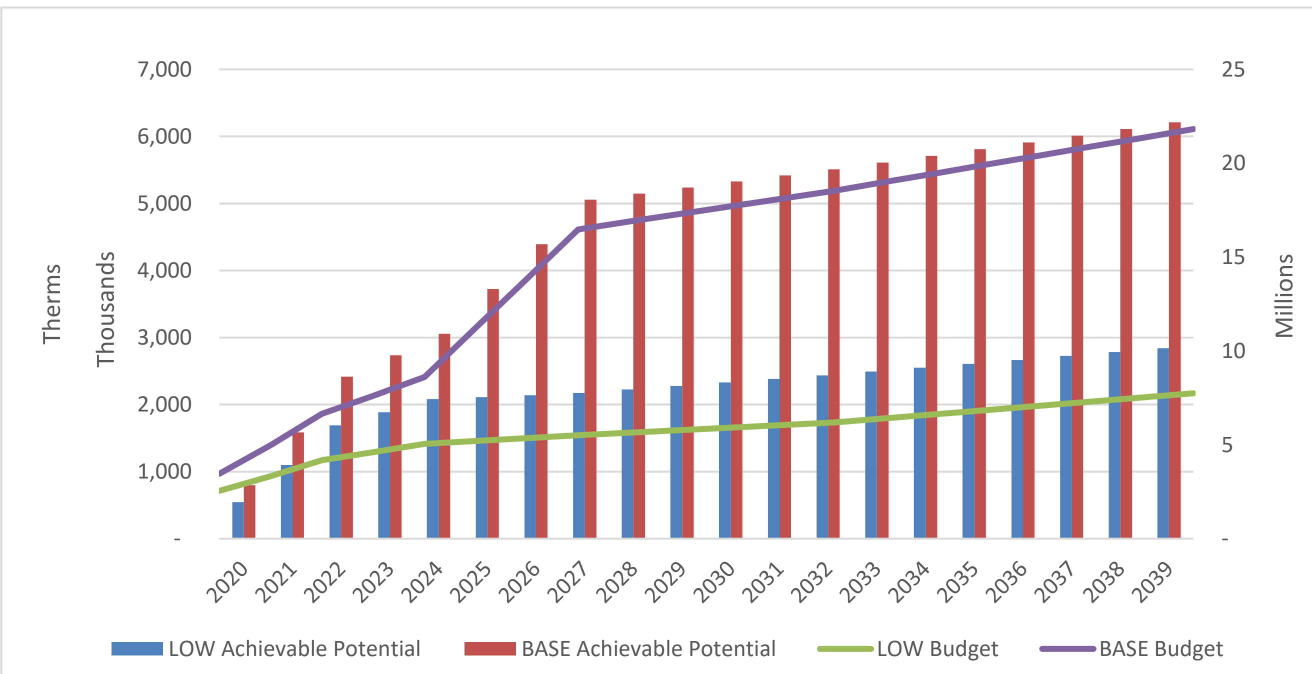
The following graphs and tables present the natural gas conservation potential within IGC's service territory. Program savings refer to the savings from measures that are incentivized through programs in a given year, including savings from measure re-participation.[4] They are most representative of annual program savings and can be used to inform DSM program planning to help meet savings objectives, and to determine which sectors, end-uses, and measures hold the most potential.

All results in this section are achievable potential savings under the Base Scenario, except for average annual savings and budgets results below, which include the Low Scenario to allow for comparison of high-level savings and budgets.

AVERAGE ANNUAL SAVINGS AND BUDGETS

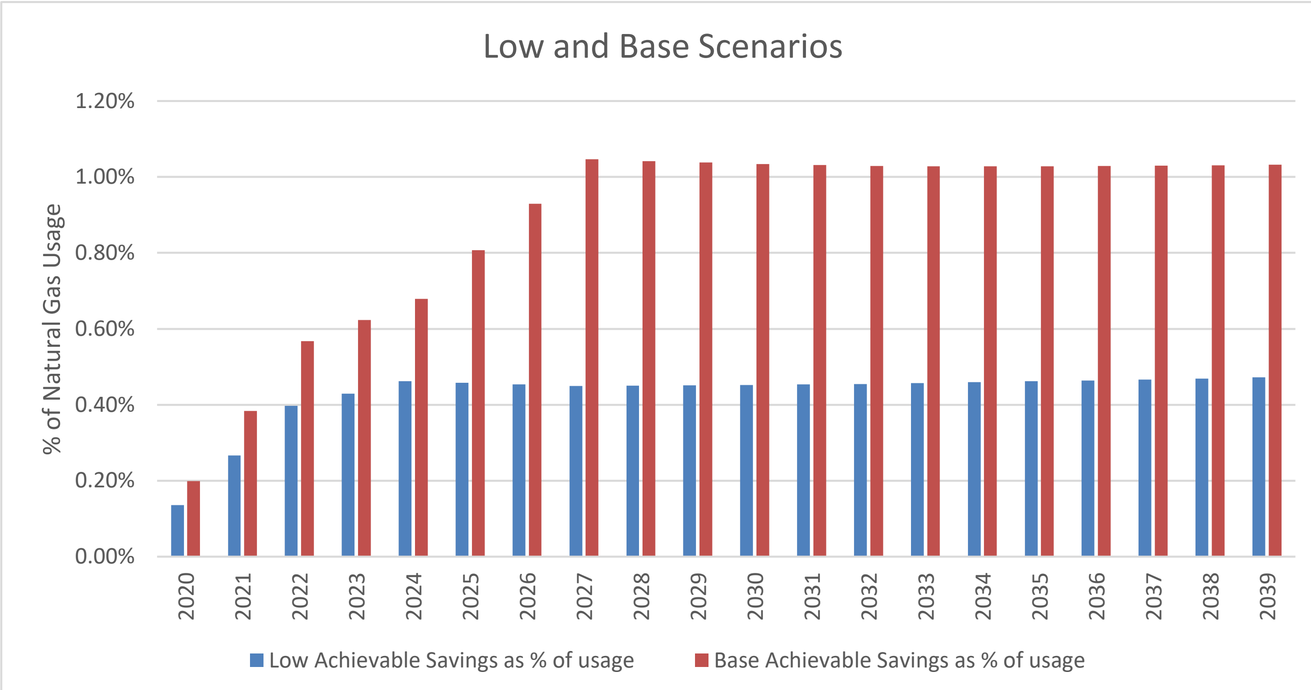
Forecasted annual program savings and their corresponding budgets are presented for the Low and Base Scenarios below (Figure 12). Savings are also presented as a percent of forecasted natural gas volumes (Figure 13).

Figure 12. Annual Program Savings (Therms): Low and Base Scenarios, Savings and Budget



[4] Measure *re-participation* refers to the renewal of past years savings having reached the end of their useful life, but would require new incentives to maintain the savings previously achieved.

Figure 13. Savings as a Percent of Natural Gas Volumes: Low and Base Scenarios



Based on the above results, the following observations can be made:

- **Savings in both scenarios exhibit strong growth in the first five years, followed by a relatively modest growth for the rest of the study period.** The rapid growth in the first period of the study reflects the expansion of current initiatives in the residential sector and the introduction of new initiatives in the commercial sector. New initiatives and measures have been ramped up over a period of three to six years. The later period growth in savings represents a 2% year-over-year increase, following new construction activity and fuel switching to natural gas heating.

- **Savings under the Base Scenario are 40% higher than under the Low Scenario** in the first five years, with further increases in the remaining portion of the study period, notably due to forecasted investments towards a reduction of market barriers**.** Starting in the sixth year of the study, the Base Scenario's budget is more than double the Low Scenario budget (from an average ratio in the first five years of 1.5:1), as higher incentive levels increases the cost of all savings, not only the incremental portion. This increase in program savings is reflected in the cumulative savings, which shows a similar increase (43%) between the Low and Base Scenarios, due to very similar mixes of measures in each scenario. Despite the higher average cost per therm of savings in the Base Scenario, all of the savings are cost-effective from a UCT perspective.

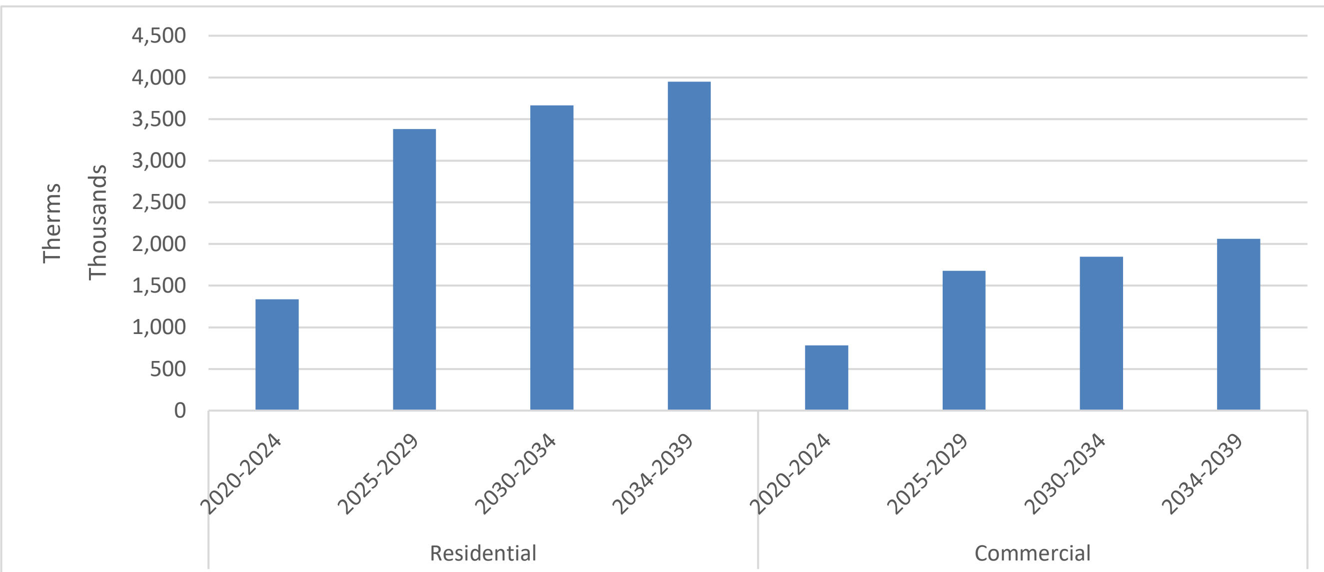
- **Efficiency measures provide a stable flow of natural gas savings.** Gas savings as a percent of forecasted volumes remain close to 0.5% for the Low Scenario and around 1.0% for the Base Scenario, following the initial ramp-up period assumed in the analysis. Changes in codes and standards or technology do not disrupt natural gas savings potential in a significant manner; however, customer fuel-switching to natural gas heating has a significant impact on the overall gas consumption trend, counter-balancing efficiency savings and leading to an overall net increase in gas consumption.

- **Under the Base Scenario, conservation budgets need to increase significantly**, first as programs are introduced to the market and customers participate in a greater number of such programs, and second as participation further grow due to sustained strategies to address market barriers and further increase program participation.

ENERGY SAVINGS BY SECTOR AND SEGMENT

The distribution of combustible savings by fuel type and sector are presented below for years five, 10, and 15 of the study.

Figure 14. Annual Program Conservation Potential (Therms): Base Savings by Sector and Time Period



Based on the above results, the following observations can be made:

- **New initiatives in the residential and commercial sectors are required to achieve the mid- and long-term conservation potential.** There is significant growth in the residential and commercial sectors due to the ramp-up period of new initiatives in the initial years of the study. The residential energy savings could grow by a factor of 150% between the first and second five-year periods, while the commercial energy savings could grow by 115% during the same timeframe.
- **The achievement of the forecasted savings trajectory is contingent on the successful introduction of those new initiatives**. Both internal and external factors may have significant impacts on the trajectory of achieved savings.

The average annual savings by segment are presented below for the first five years (Figure 15) and the next 15 years (Figure 16). Residential segments are shown in yellow, and commercial segments are shown in blue.

Figure 15. Natural Gas Achievable Savings by Segment (Therms): Base Scenario, Annual Average (2020-2024)

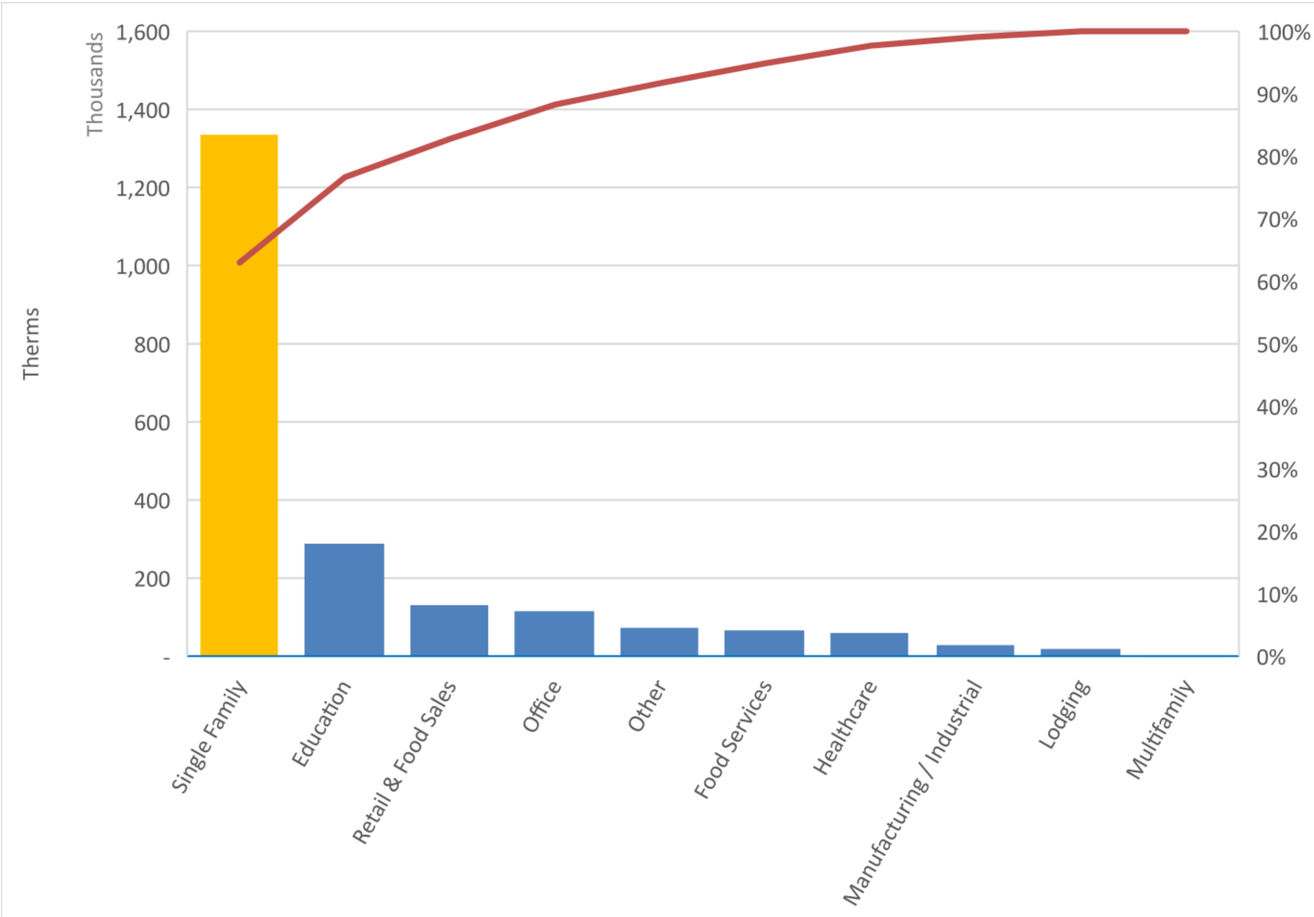
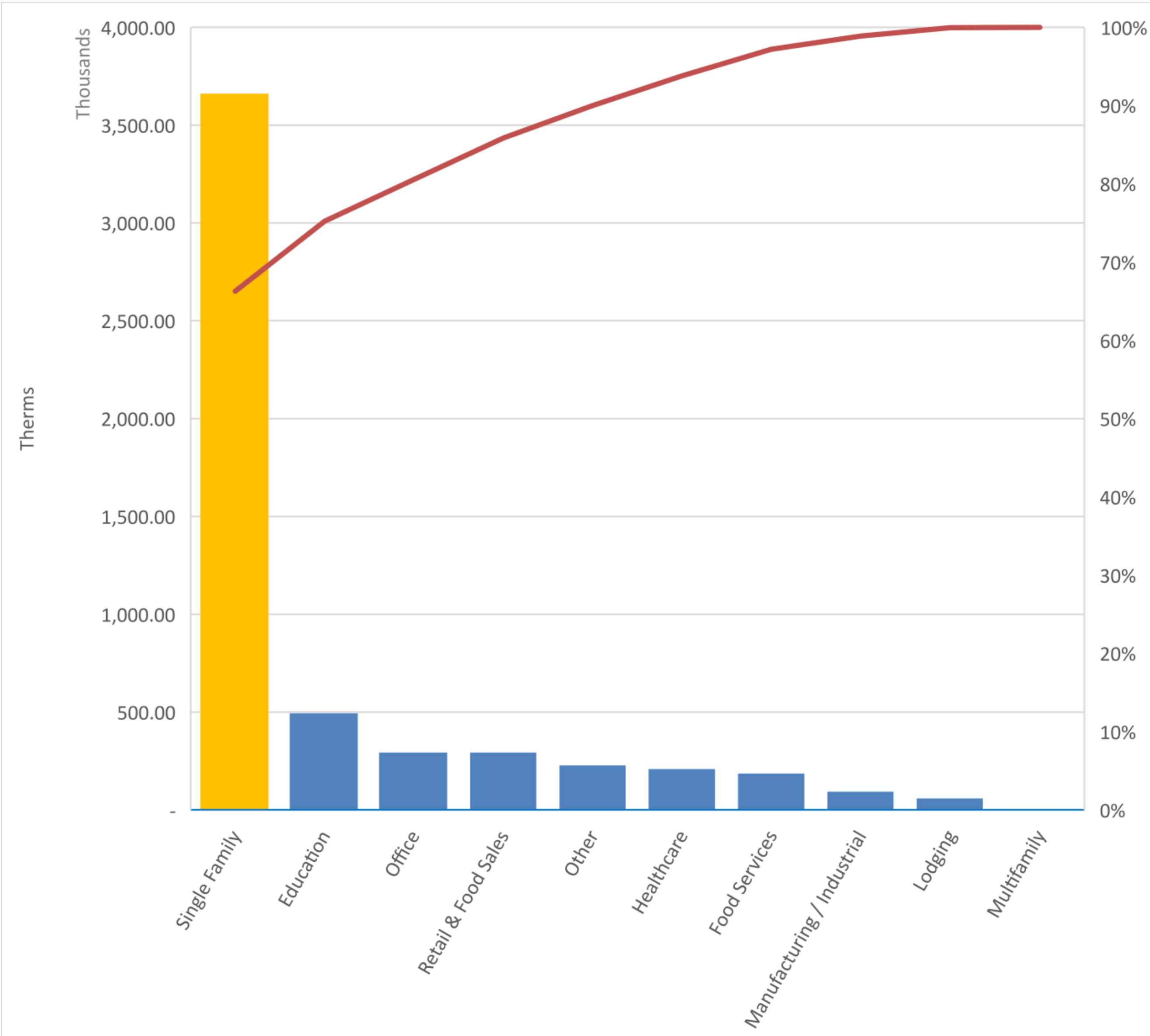


Figure 16. Natural Gas Achievable Savings by Segment (Therms): Base Scenario, Annual Average (2025-2039)



- **Single Family is the segment with the greatest savings potential.** Savings in this segment account for 90% of the total potential. The Single Family segment offers significant savings potential for all end-uses, notably HVAC control (connected thermostats), insulation, and water savings fixtures.
- **In the commercial sector, the Education segment has the greatest savings potential,** closely followed by Office and Retail & Food Sales**.** High-efficiency boilers provide the majority (44%) of savings in these segments.

END-USE BREAKDOWN AND TOP SAVINGS MEASURES

This section presents a breakdown of savings opportunities by end-use and lists the top measures for both the residential and commercial sectors. Both the end-use breakdown and the summary of top measures are quantified using averages of annual program savings for the first 5-year and the last 15-year periods. Lifetime savings are also presented for the top measures and by end-use to provide information about the persistence of savings.

RESIDENTIAL SECTOR

Table 4 below presents the top measure categories ranked by average annual savings. The lifetime savings are also provided to provide an indication on the persistence of savings by measure.

Table 4. Residential Top 10 Measures: Base Scenario, 2020-2024 and 2025-2039

2020-2024			2025-2039		
Measure	Average Annual Savings ('000 Therms)	Lifetime Savings ('000 Therms)	Measure	Average Annual Savings ('000 Therms)	Lifetime Savings ('000 Therms)
Thermostats	458	3,667	Insulation	7,853	179,421
Insulation	332	7,499	Thermostats	3,989	31,913
Low Flow Shower Head	248	2,480	Low Flow Shower Head	1,824	18,237
Faucet Aerators	78	782	Duct Insulation	1,298	32,442
New Construction	76	2,167	New Construction	1,150	31,455
Duct Insulation	68	1,697	Faucet Aerators	663	6,625
Thermostatic Restrictor Shower Valve	32	320	Thermostatic Restrictor Shower Valve	658	6,578
Insulated Door	20	493	Air Sealing	270	4,044
Boilers	15	376	Insulated Door	139	3,479
Fireplace	3	70	Boilers	114	2,853

A breakdown of residential savings by end-use is presented below for the first five years (Figure 17, left) and the next 15 years (Figure 17, right) of the study. Savings shown are averaged annual program savings over the time period. Figure 18 presents lifetime savings by end-use for the same time periods.

Figure 17. Residential Average Annual Savings by End-Use (Therms): Base Scenario, 2020-2024 (left) and 2020-2039 (right)

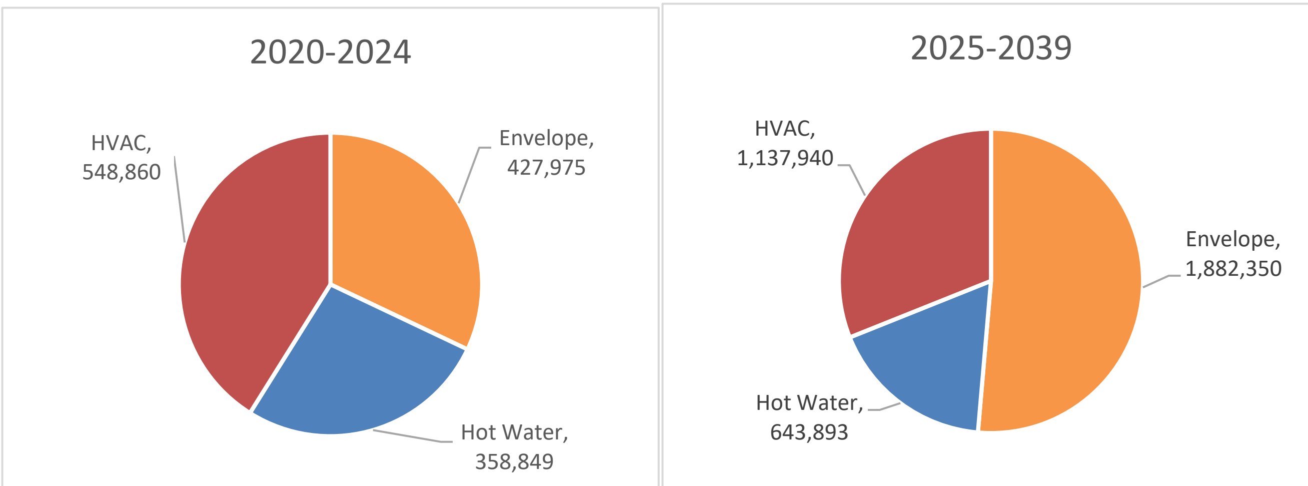
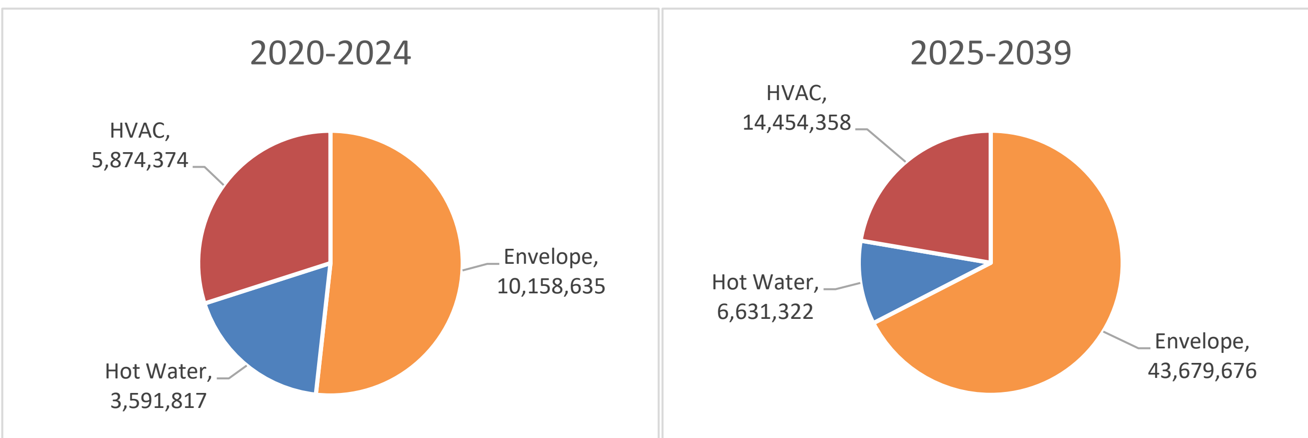


Figure 18. Residential Average Lifetime Savings by End-Use (Therms): Base Scenario, 2020-2024 (left) and 2025-2039 (right)



Based on the above results, the following observations can be made:

- **Envelope measures offer by far the most potential savings.** Envelope improvements can provide 51% of annual savings and 67% of lifetime savings. Insulation, new construction and air sealing are the top three measures in both the short and long-term, and provide the highest annual and lifetime savings, suggesting that they should be the priority for conservation programs.

- **HVAC measures represent the second largest potential savings.** Connected thermostats, duct insulation and efficient boilers generate the majority of savings associated with the HVAC end-use. As noted above, while these measures offer significant savings and are often the easiest retrofit opportunity, they are a second priority when pursuing substantial long-term savings in IGC's service territory.

- **Hot water measures can also generate significant savings**, contributing an estimated 18% of savings in the first five years, mostly through efficient water fixtures, such as shower head and faucet aerators. We note that under the Base Scenario, none of the water heater measures are cost-effective, although they represent an interesting technical opportunity. Lower incentives could be provided for these measures to generate additional savings.

Residential Furnace – Proposed DOE Standard

In 2015, the U.S. Department of Energy (DOE) issued a Notice of Proposed Rulemaking to increase the Residential Furnaces standard from the Annual Fuel Utilization Efficiency (AFUE) of 80% to 92%. This standard was originally expected to come into effect in 2021. The DOE however did not proceed to issue a final rule with regards to a new efficiency standard, and there are proceedings underway which could prevent the DOE from going ahead with the original proposed standard. While the base scenario assumes that new furnaces available on the market will meet the standard proposed in 2015 starting in 2021, additional analysis was conducted to assess the impact on the conservation potential study if the proposed standard is delayed until 2028.

Assuming that the baseline performance of residential furnaces remains at 80% would lead to additional average annual savings of 125,474 Therms during the 2020-2024 period, and would require an average annual budget increase of $930,000.

COMMERCIAL SECTOR

Table 5 below presents the top measures ranked by average annual savings. The lifetime savings are also provided, the ranking of which is largely consistent with the annual savings; a result of the fact that most measures have similarly long EULs.

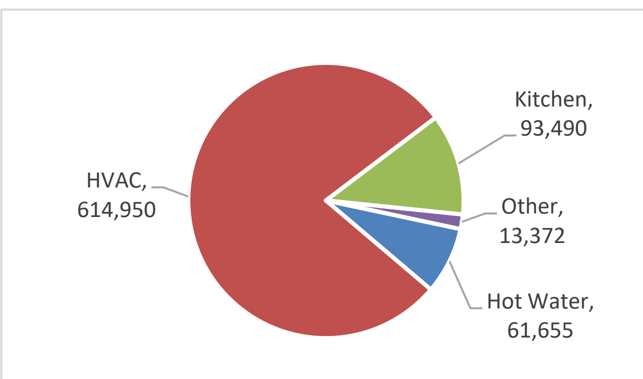
Table 5. Commercial Top 10 Measures: Base Scenario, 2020-2024 and 2025-2039

2020-2024			2025-2039		
Measure	Average Annual Savings ('000 Therms)	Lifetime Savings ('000 Therms)	Measure	Average Annual Savings ('000 Therms)	Lifetime Savings ('000 Therms)
Boilers	246	6,146	Demand Control Ventilation	214	10,715
Demand Control Ventilation	86	858	Attic/Roof Insulation	201	34,152
Boiler Reset Control	57	861	Energy Recovery Ventilator (ERV)	186	13,013
Fryer	50	598	Boilers	148	18,473

2020-2024			2025-2039		
Energy Recovery Ventilator (ERV)	49	680	Efficient Cookware	108	1,621
Attic/Roof Insulation	45	1,533	Boiler Reset Control	106	7,942
Low Flow Faucet Aerator	26	260	High Efficiency Unit Heaters	79	4,769
Kitchen Demand Control Ventilation	20	296	Natural Gas Engine Heat Pump Water Heater	78	3,922
Efficient Cookware	19	56	Fryer	72	4,303
High Efficiency Unit Heaters	17	198	Water Boiler Stack Economizer	65	4,879

Commercial gas savings are broken down by end-use and are presented below for the first five years (left) and last 15 years (right) of the study. Figure 19 presents an average of annual program savings by end-use while Figure 20 presents lifetime savings by end-use.

Figure 19. Commercial Average Annual Savings by End-Use (Therms): Base Scenario, 2020-2024 (left) and 2025-2039 (right)



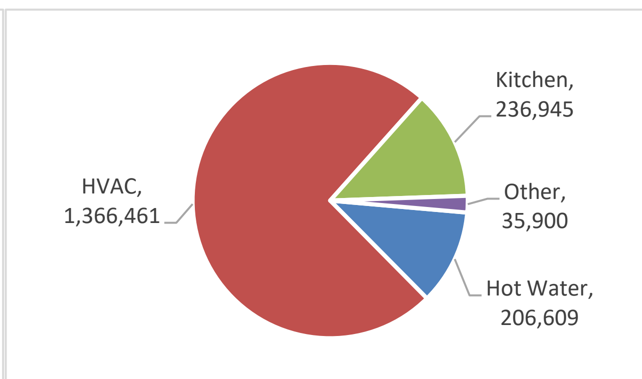
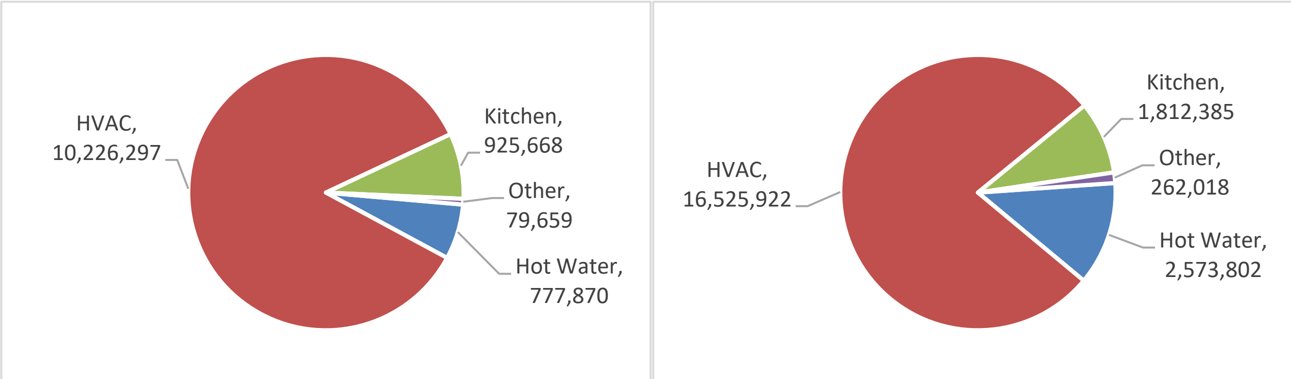


Figure 20. Commercial Average Lifetime Gas Savings by End-Use (Therms): Base Scenario, 2020-2024 (left) and 2025-2039 (right)



Based on the above results, the following observations can be made:

- **HVAC measures provide 75% of potential savings.** Equipment-based measures—notably condensing boilers and energy recovery ventilators—represent a significant share of the potential in the first five years of the study. Incentives for equipment measures can be introduced rapidly in the market and generate most of the savings in the initial period.

- **Share of savings by end-use remains similar for both periods considered.** However, some measures requiring different program strategies represent a higher percentage of achievable savings in the second period. HVAC control and attic insulation notably represent additional opportunities for longer-term savings.

- **Commercial kitchen appliances are a typically untapped savings opportunity.** Representing 14% and 9% of the first and last period savings potential, respectively.

- **Boiler savings decrease in the later years of the study due to new codes and standards.** DOE is considering applying the new ANSI/AHRI standard[5] to gas and oil-fired commercial boilers manufactured on or after January 1, 2023. This new standard will require new boilers to be more efficient and will reduce potential savings that can be counted toward DSM programs.

- **Hot water savings potential can grow through the study period,** notably as natural gas engine heat pump water heaters become cost-effective in the second period of the study. Close to two-thirds of the savings for the hot water end-use come from high-efficiency water heaters.

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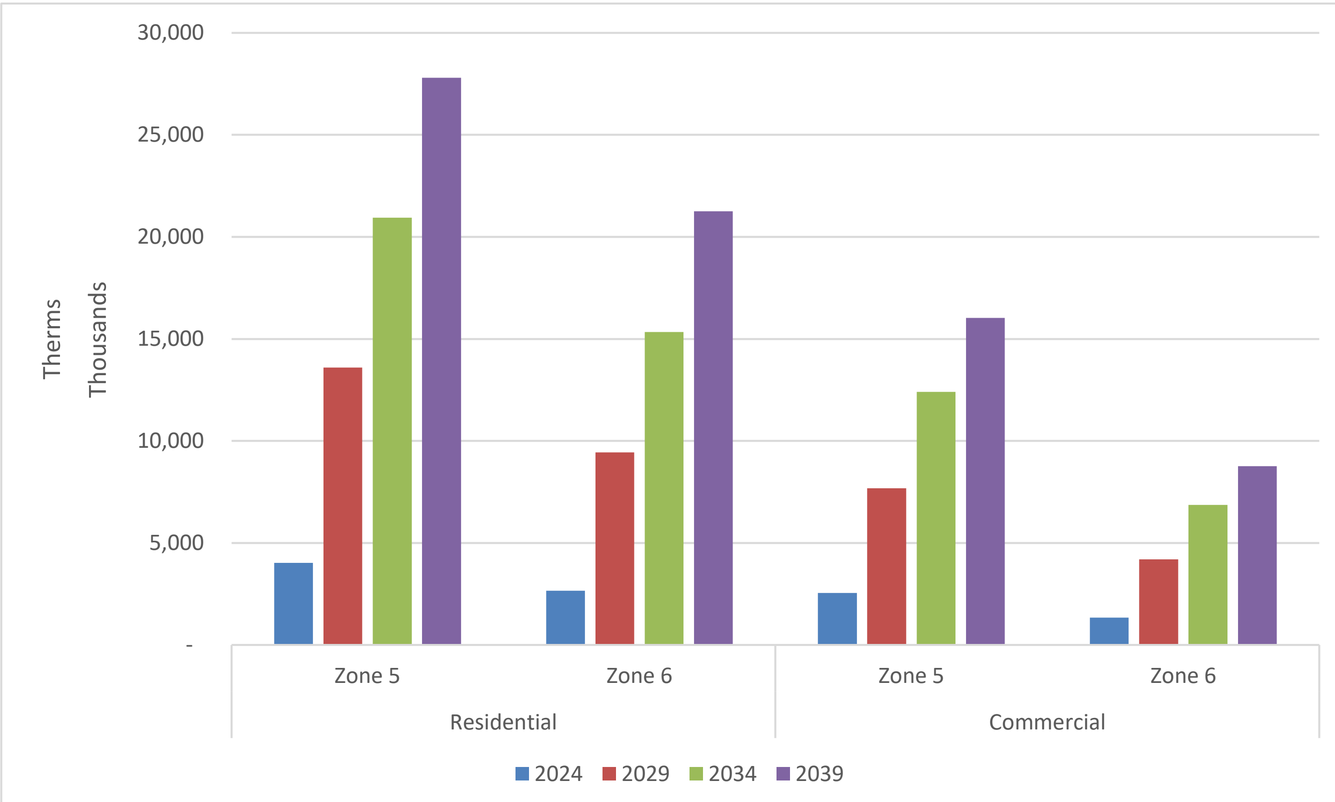
[5] ANSI/AHRI Standard 1500-2015 Standard for Performance Rating of Commercial Space Heating Boilers. Available at http://www.ahrinet.org/App_Content/ahri/files/standards%20pdfs/ANSI%20standards%20pdfs/ANSI.AHRI_Standard_1500-2015.pdf.

SAVINGS BY CLIMATE ZONE

Figure 21 below presents the achievable savings for the Base Scenario for IGC's clients located in the two climate zones in Idaho (Zone 5 and Zone 6).[6] Cumulative savings at the end of each 5-year period are presented.

Figure 21: Cumulative Savings by Sector and Climate Zone, Base Scenario



Of note, for residential customers, the proportion of savings occurring in Zone 6 (approximately 40%) is higher than the proportion of customers located in that zone (approximately 25%). This is notably due to the higher space heating requirement in that zone, leading to improved economic benefit for participants in that zone, which in turn leads to increased adoption of energy efficiency measures.

In the commercial sector, savings are generally well aligned with customer locations in the two climate zones, with 65% of savings in Zone 5 for 67% of customers. This is notably because businesses in Zone 6 have on average a 7% lower annual consumption than those in Zone 5, and because a higher share of the achievable savings are not climate-dependent (notably, water heating and kitchen end-uses).

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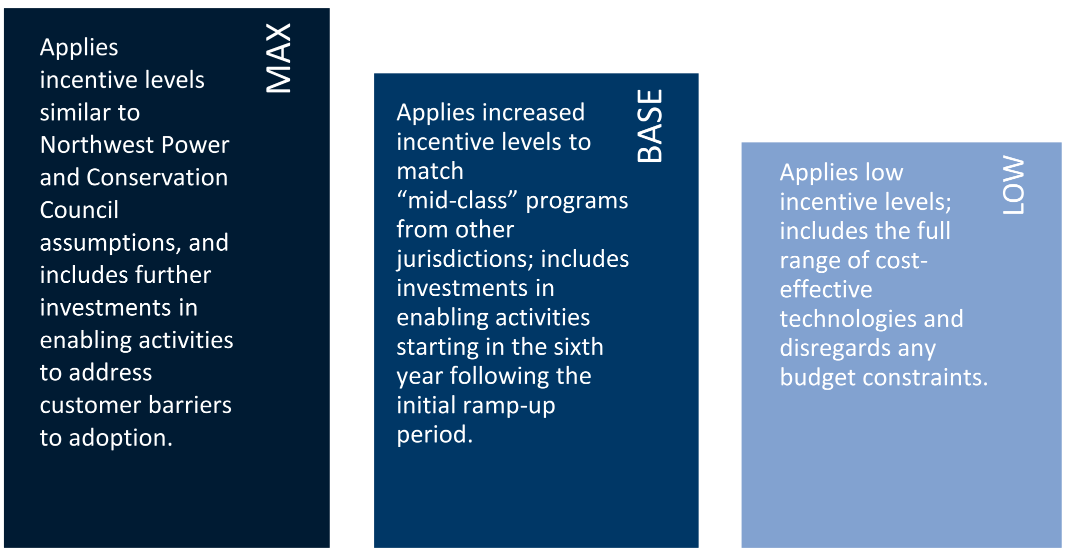
[6] The climate zone map used for the potential study is presented in Appendix D.

5. PROGRAM AND SCENARIO ANALYSIS

The analysis up to this point has focused primarily on the Base Scenario. This section provides a comparison of the three scenarios program savings, budgets, and cost-effectiveness.

As described in Section 2, three achievable potential scenarios were assessed in this study: Low, Base, and Maximum. By varying factors such as incentive levels[7] and barrier reduction strategies (see text box on the following page) between these scenarios, we can develop insights into their respective impacts on program savings, budgets, and cost-effectiveness. A summary of the assumptions associated with each scenario is presented below.

Figure 22. Alternative Scenario Assumptions for Achievable Potential



The Low Scenario is based on what is typically considered as a low incentive level with simple delivery mechanisms. It covers a broad set of measures and does not consider budget constraints. It provides an assessment of the maximum level of savings that could be expected from a simple Conservation Portfolio.

To understand how higher incentives are expected to increase savings, the Base Scenario increases incentive levels to those found in “mid-class” efficiency programs. As with the Base Scenario, typical delivery mechanisms are used in the initial period of the study, a broad set of measures are considered, and no budget constraints are applied. Following the initial ramp-up period, investments to reduce market barriers are included, leading to higher adoption.

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[7] Incentive levels refer to the portion of a measure’s incremental cost covered by a program incentive.

Finally, to quantify the Maximum achievable savings, we applied further enabling strategies with higher incentive levels, similar to those used in DSM planning by the Northwest Power and Conservation Council. Again, a broad set of measures are considered, and no budget constraints are applied.

The results that follow highlight the achievable potential savings under each scenario, budgetary impacts, and an analysis by segment and end-use to identify markets or end-uses for which incentive levels can have a higher influence.

Enabling Strategies: Options for Reducing Customer Barriers

To reach the maximum achievable potential savings, programs must go beyond incentives to address other barriers to customers participating in programs. Barrier reductions can be achieved through activities generally categorized as *enabling strategies*. Examples include consumer education, contractor training and support, market research, program design and enhancements, marketing strategies, program evaluation (which can identify barriers to participation), and others. Enabling strategies can assist IGC in reducing barriers to program uptake by:

- Increasing IGC's understanding of its markets and sectors (and the barriers they face) through evaluation and market research;
- Applying evaluation and market research results to inform program design and enhancements for the purposes of reducing, bypassing, or addressing identified barriers to participation;
- In partnership with other utilities in the region, consider mid-stream and up-stream incentives to bring market actors in the energy efficiency supply chain to promote energy efficient technologies and measures;
- Expanding awareness of conservation opportunities and benefits through:
    - Consumer education through initiatives like website resources, energy manager programs, commercial workplace engagement initiatives, school programs, etc.;
    - Contractor training and support, such as workshops on best practices, certification courses, providing tools and calculators, organizing conferences, technology demonstrations, etc.;
    - Marketing strategies, such as attendance at industry-focused trade shows and other forms of outreach;
- Promoting building and home energy labelling requirements to make energy performance visible to owners and renters;
- Transforming the market by increasing the demand for and availability of energy-efficient options through the deployment of emerging-technology pilots and/or behavior-based initiatives; and
- Offering financing alongside incentives to address access to capital related barriers.

RESIDENTIAL PROGRAMS ANALYSIS

Below, modeled savings from the three achievable potential scenarios are presented (Figure 23). Cost-effectiveness, budgets, and dollar per therm savings are also provided (Table 6). Scenario metrics are averaged over the first years of modeled forecasts.

Figure 23. Comparison of Residential Program Savings: Low, Base and Max Scenarios (2020-2024)

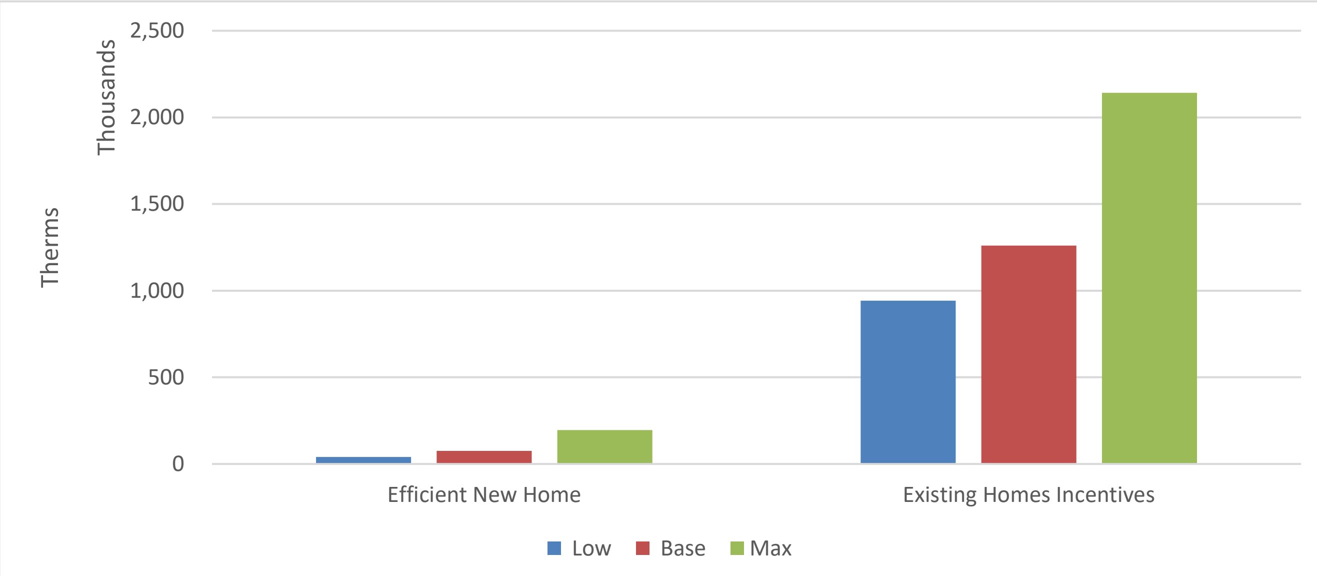


Table 6. Comparison of Residential Program Cost-Effectiveness, Savings, and Budgets by Scenario

Program	UCT			TRC		
	Low	Base	Max	Low	Base	Max
Efficient New Home	1.23	1.34	1.18	1.10	1.33	1.40
Existing Homes Incentives	1.85	1.80	1.52	1.37	1.37	1.29
Total Residential	**1.78**	**1.74**	**1.46**	**1.33**	**1.36**	**1.31**

Program	Budget ('000$)			$/Therm		
	Low	Base	Max	Low	Base	Max
Efficient New Home	292	520	1,515	7.23	6.83	7.73
Existing Homes Incentives	2,457	3,575	7,965	2.61	2.84	3.72
Total Residential	**2,749**	**4,095**	**9,480**	**2.80**	**3.07**	**4.05**

Based on the above results, the following observations can be made:

- **The Existing Homes Incentives program can provide most of the savings in the residential sector**. These savings are also achievable at a much lower unit cost than those required for the Efficient New Home Program.
- **The Base Scenario savings level can be achieved at a marginally higher unit cost than the Low Scenario**. There are significant fixed program administration costs required to deliver whole-house programs targeting the envelope, and higher participation dilutes these costs, thereby lowering the impact on unit cost of savings.
- **Units costs of the Max Scenario are considerably higher than for the other scenarios.** Under this scenario, incentives represent a higher share of the total program costs compared to the other scenarios.
- **Program cost-effectiveness are similar under the Low and Base Scenarios.** Overall, increasing incentive levels to "mid-class" levels under the Base Scenario has a limited impact on program cost-effectiveness. Program are cost-effective under both scenarios.

COMMERCIAL PROGRAMS ANALYSIS

Below, modeled savings from the three scenarios are presented (Figure 24). Cost-effectiveness, budgets, and dollar per therm savings are also provided (Table 7). Scenario metrics are averaged over the first five years of modeled forecasts.

Figure 24. Comparison of Commercial Program Savings: Low, Base and Max Scenarios (2020-2024)

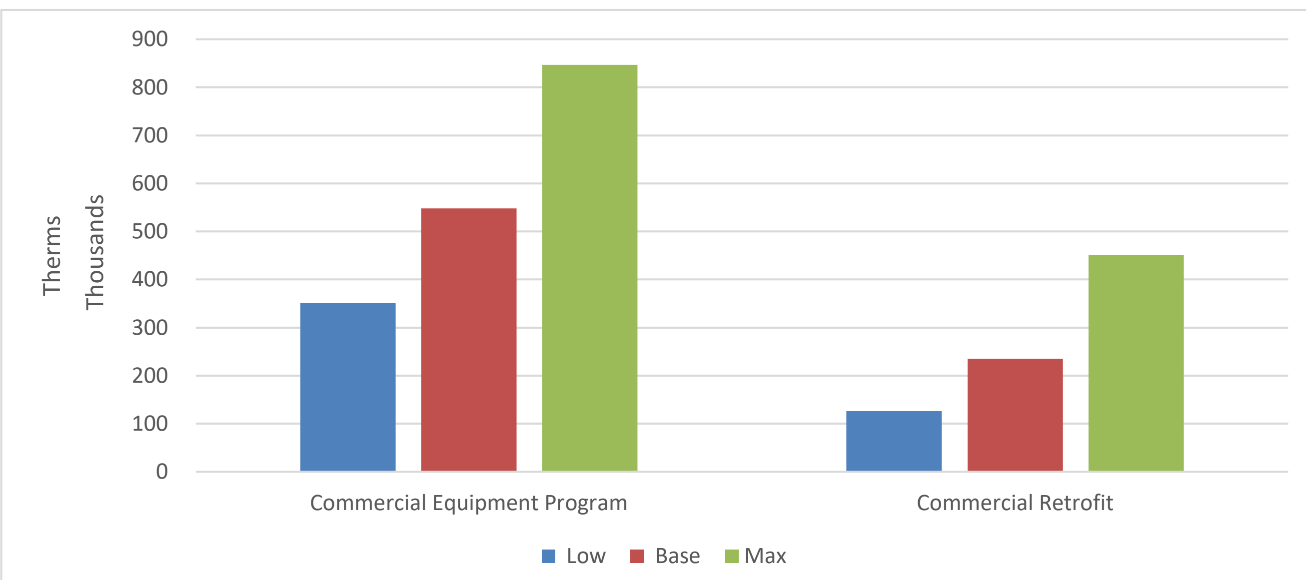


Table 7. Comparison of Commercial Program Cost-Effectiveness, Savings, and Budgets by Scenario

Program	UCT			TRC		
	Low	Base	Max	Low	Base	Max
Commercial Equipment Program	3.56	3.11	2.52	1.99	1.94	1.85
Commercial Retrofit	1.12	1.26	1.17	0.94	0.98	0.95
Total Commercial	**2.40**	**2.21**	**1.81**	**1.53**	**1.49**	**1.38**
Program	**Budget ('000$)**			**$/Therm**		
	Low	Base	Max	Low	Base	Max
Commercial Equipment Program	628	1,120	2,067	1.79	2.04	2.44
Commercial Retrofit	569	1,048	2,298	4.50	4.45	5.09
Total Commercial	**1,198**	**2,168**	**4,365**	**2.51**	**2.77**	**3.36**

Based on the program results above, the following observations can be made:

- **Under the Base Scenario, the Commercial Retrofit Program can provide higher incentives than the Low Scenario at a similar unit cost.** Increased participation will dilute the fixed administration cost required to deliver this type of program.

- **The programs are cost-effective under all scenarios based on the UCT.** However, the commercial retrofit cost-effectiveness results are low under all scenarios. Careful consideration should be given to the design of this initiative to ensure cost-effectiveness of the program, either through incentive-setting strategies or by seeking efficiency in the program delivery strategies.

- **The Commercial Equipment Program can provide robust savings at a low unit cost.** In order to achieve the highest level of savings, IGC could consider maximizing the incentive for this program.

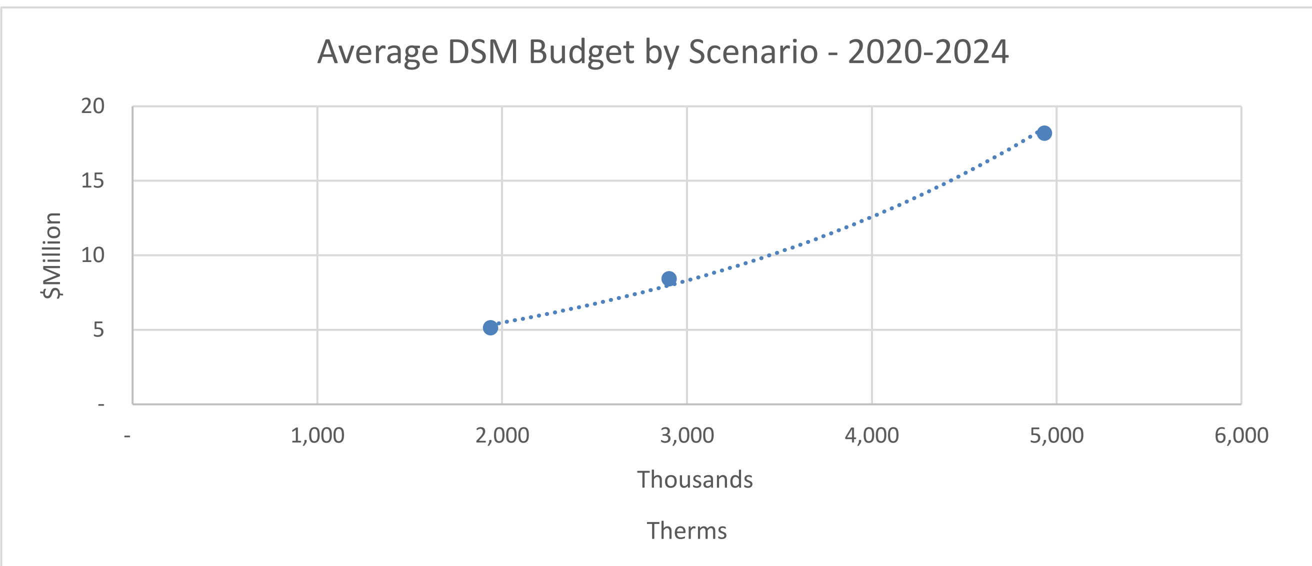
SCENARIO ANALYSIS – AGGREGATE

Portfolio-wide cost-effectiveness, budget, and cost-effectiveness are presented in Table 8 below. The relationship between budget and forecasted savings is further illustrated in Figure 25. Results are presented for the first 5-year period. Please see Appendix F for measure-level cost effectiveness results.

Table 8: Scenario Analysis - Portfolio Cost-Effectiveness, Budget, and Unit Cost

Sector	**UCT**			**TRC**		
	Low	Base	Max	Low	Base	Max
Residential	1.78	1.74	1.46	1.33	1.36	1.31
Commercial	2.40	2.21	1.81	1.53	1.49	1.38
Total	**1.97**	**1.90**	**1.33**	**1.40**	**1.41**	**1.33**
Program	Budget ($M)			$/Therm		
	Low	Base	Max	Low	Base	Max
Residential	2.75	4.10	9.48	2.80	3.07	4.05
Commercial	1.20	2.17	4.36	2.51	2.77	3.36
Total	**3.95**	**6.26**	**13.85**	**2.70**	**2.96**	**3.69**

Figure 25: Scenario Analysis – Gas Savings and Budget



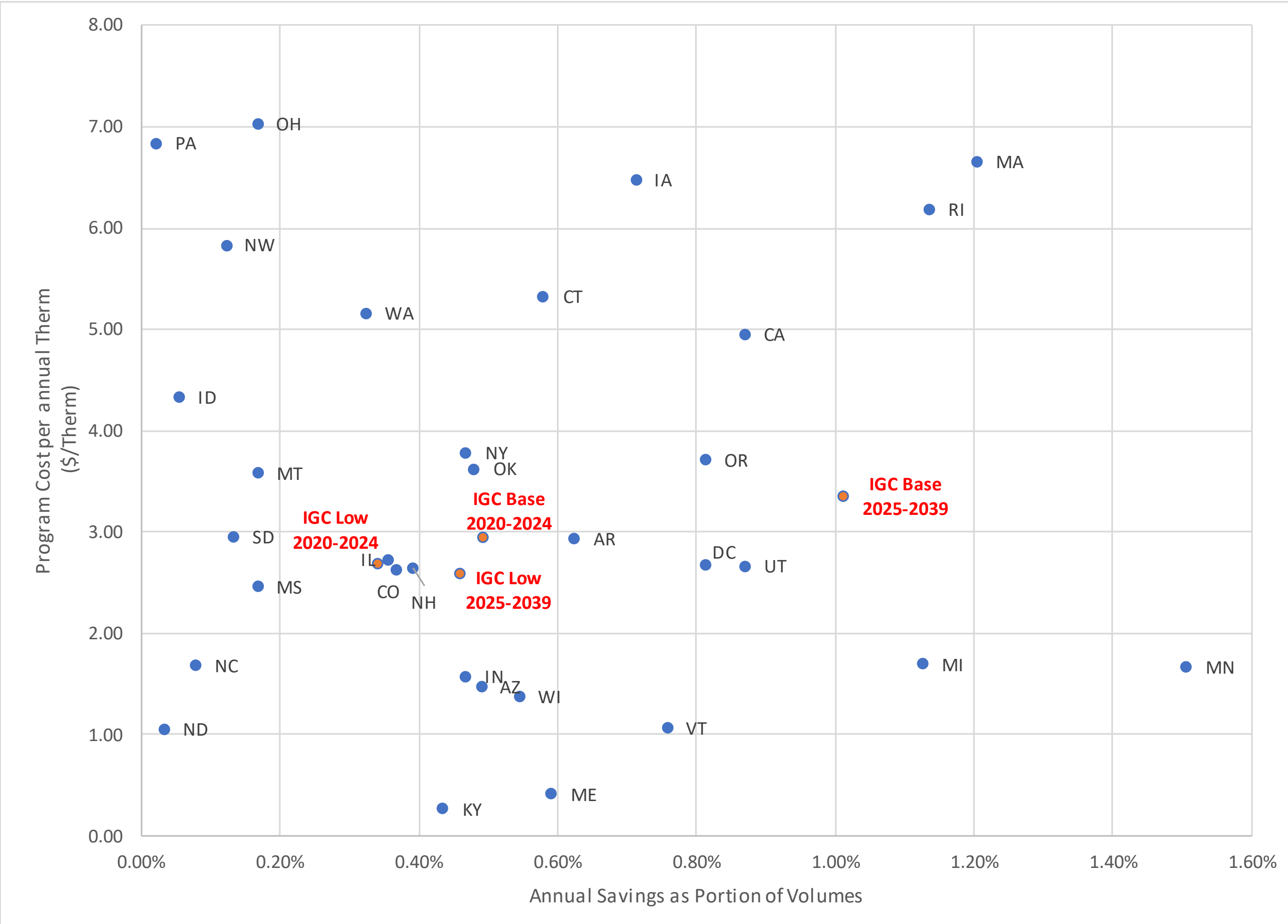
Based on the above scenario results, the following key insights can be gleaned:

- **Savings under the Base Scenario can be achieved at a similar unit cost as the Low Scenario.** While budget increases significantly between the Low and Base Scenarios, this budget increase is commensurate with the higher savings projected under the Base Scenario. Unit costs do not increase materially between the two scenarios.
- **The portfolio as a whole is cost-effective** under the UCT and TRC, for all scenarios.

BENCHMARKING IGC ACHIEVABLE PORTFOLIOS TO OTHER JURISDICTIONS

Figure 26 below compares the IGC conservation potential costs and savings to results from portfolios in other states. The charts show the plot of portfolio costs per unit savings and annual savings as a portion of sales for 2017 program years (converted to 2020 dollars for comparison) for a range of jurisdictions.[8] Results for IGC Low and Base Scenarios are presented separately for the first 5-year period and the last 15 years.

Figure 26: Comparison of Gas Portfolio Savings and Costs



Key insights based on this comparison include:

- In the first five-years of the study, the Low and Base Scenarios savings and unit costs would place IGC among average utilities, with savings ranging between 0.4% and 0.6% of annual volumes, at a unit costs around $3/therm.

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[8]ACEEE, "The 2018 State Energy Efficiency Scorecard", Weston Berg, Seth Nowak, Grace Reif, Shruti Vaidyanathan, Erica Junga, Marianne DiMascio, and Emma Cooper, October 2018.

- Under the Base Scenario, IGC could evolve into one of the leading utilities, while maintaining its unit costs at a reasonable level. In order to accomplish this, investments and sustained growth in the residential home retrofit market will be critical.

Note: most of the jurisdictions depicted in this chart use the TRC to screen measures and programs. In several jurisdictions, natural gas conservation program achievements have been significantly reduced in recent years. Using the UCT to screen measures unlocks additional opportunities to achieve higher saving levels.

APPENDIX A. MARKET BASELINE AND CHARACTERIZATION

This Appendix presents the Dunsky Team's approach for conducting market baseline research and market characterizations in the residential and commercial sectors.

MARKET BASELINE RESEARCH

The Dunsky Team calculated the customer average energy consumption and total customer counts to formulate the residential and commercial baseline. This data was then used to calculate the potential market size for measures and to provide a metric for evaluating total savings. To formulate the baseline, the Dunsky Team used customer data provided by IGC. Additional information on our approach used to define the baseline residential and commercial sectors is provided below.

RESIDENTIAL SECTOR

The residential sector was split into the following categories:

1) Two segments:
    a. Single-Family
    b. Multi-family
2) Two U.S. Department of Energy climate zones:
    a. Zone 5
    b. Zone 6
3) Two gas heating scopes:
    a. Space heating
    b. Hot water and space heating

To calculate the customer average energy consumption and total customer counts by category, IGC provided The Dunsky Team with monthly residential customer data from January 2016 to December 2017. Dunsky then rolled-up consumption data to the premise ID and integrated climate zone data by matching the county data to its climate zone using the U.S. Department of Energy database.[9] Next, customers were tagged as single-family or multi-family using a dataset provided by IGC. Lastly, the Dunsky Team determined gas heating scope based on the customer rate classes (for space heating and hot water vs. space heating only).

The results for the residential market baseline are detailed in Table 9:.

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[9] Volume 7.3: Guide to Determining Climate Regions by County, in *Building America Best Practices Series*. August 2015. Prepared by Pacific Northwest National Laboratory. Available at https://www.energy.gov/sites/prod/files/2015/10/f27/ba_climate_region_guide_7.3.pdf

Table 9: Residential Market Baseline Results

Climate Zone	Housing Type	Heating Scope	Counts	Average Consumption (Therms)
5	Single-Family	Space Heating	45,828	41.3
5	Single-Family	Space & Water Heating	185,995	64.1
5	Multi-Family	Space Heating	9	37.0
5	Multi-Family	Space & Water Heating	183	17.9
6	Single-Family	Space Heating	20,785	45.7
6	Single-Family	Space & Water Heating	59,078	70.8
6	Multi-Family	Space Heating	159	19.0
6	Multi-Family	Space & Water Heating	92	40.9

COMMERCIAL SECTOR

The commercial sector baseline was calculated and split into the following categories:

1) Eight segments:
    a. Education
    b. Food Services
    c. Retail and Food Sales
    d. Healthcare
    e. Lodging
    f. Manufacturing/Industrial
    g. Office
    h. Other
2) Three sizes:
    a. Small
    b. Medium
    c. Large

To calculate the split, IGC first provided The Dunsky Team with monthly commercial customer data from January 2016 to December 2017. The Dunsky Team then rolled-up consumption data to the premise ID and integrated climate zone data by matching the county data to its climate zone using a U.S. Department of Energy database.[10] Next, the Team assigned segments based on the customer SIC code and dropped; customers that appeared in the dataset for less than 24 months or which changed SIC codes. The Dunsky Team determined sizes based on total annual consumption, as shown in Table 10.

[10] Ibid.

Table 10: Size Classification by Therms Consumption in the Commercial Sector

Size	Annual Gas Consumption (Therms)
Small	<250
Medium	250 - 5000
Large	>5000

The results for the commercial market baseline are detailed in Table 11, below.

Table 11: Gas Consumption by Segment and Climate Zone

Segment	Climate Zone	Client Count	Average Consumption Per Client (Therms/year)
Education	5	1295	7,693
Education	6	613	6,960
Food Services	5	1145	6,640
Food Services	6	449	6,387
Healthcare	5	1169	3,488
Healthcare	6	610	2,264
Lodging	5	125	10,255
Lodging	6	117	13,230
Manufacturing / Industrial	5	752	5,902
Manufacturing / Industrial	6	334	7,204
Office	5	5660	3,048
Office	6	2914	2,944
Other	5	3500	3,664
Other	6	1701	3,320
Retail & Food Sales	5	4358	3,497
Retail & Food Sales	6	1992	3,056

MARKET CHARACTERIZATION

To develop estimates of baseline saturation and measure characteristics, the Dunsky Team relied on secondary data from multiple sources and discussions with market actors. Because the team relied on existing data instead of conducting new primary data collection activities, these baseline market characteristics are limited by the source studies' design and results. In order to validate the information used for the Conservation Potential Assessment, the team compared the results from the source material to penetration and saturation data available from other Dunsky potential studies.

RESIDENTIAL SECTOR

METHODOLOGY

The Dunsky Team used the Residential Building Stock Assessment conducted by the Northwest Energy Efficiency Alliance (NEEA) in 2016-17[11] to calculate the measure saturation. This database is a representative sample of single-family, multi-family and manufactured homes gathered across the Northwest region (i.e., Montana, Idaho, Oregon and Washington).

To calculate the saturation of different measures, the Dunsky Team filtered for homes that used gas as their primary heating source. The table below lists the number of homes in the four-state region, in Idaho, and as IGC customers that use gas as their primary heating source.

Table 12: Size classification in the Residential Sector

Scope	Heating Customer Count
Northwest Region	682
Idaho	240
IGC	96

CALCULATED METRICS

For the baseline, we estimated the following metrics to develop saturation calculations per home of measures for the single-family and multi-family subsectors.

- Mean Number of Clothes Dryers
- Mean Number of Clothes Washers
- Mean Number of Kitchen Faucets
- Mean Number of Bathroom Faucets
- Mean Number of Showerheads
- Mean Number of Low-Flow Kitchen Faucets
- Mean Number of Low-Flow Bathroom Faucets
- Mean Number of Low-Flow Showerheads
- Mean Number of Gas Storage Water Heaters
- Mean Number of Gas Instant Water Heaters
- Mean Number of Gas Storage Water Heaters with Pipe Insulation
- Mean Number of Gas Instant Water Heaters with Pipe Insulation
- Mean Number of Furnaces

[11] See https://neea.org/data/residential-building-stock-assessment.

- Mean Number of Furnaces with Smart Thermostats
- Mean Number of Furnaces with Programmable Thermostats
- Mean Number of Furnaces with Manual Thermostats
- Mean Number of Furnaces with Unknown Thermostats
- Mean Number of Boilers
- Mean Number of Doors
- Mean People per Household
- Mean Number of Fireplaces

The Dunsky Team calculated some additional averages to bolster market characterization:

- Average Wall Area (ft^2)
- Average Ceiling Area (ft^2)
- Average High Input Furnace Capacity (Btus)
- Average High Input Furnace Efficiency (%)
- Averages High Input Boiler Capacity (Btus)
- Average High Input Boiler Efficiency (%)
- Average Conditioned Area per Home (ft^2)
- Average Window Area (ft^2)

The saturation values of these measures and metrics by single family and multi-family subsectors are presented in the table below.

Table 13: Residential Market Baseline Data

Metric	Saturation	
	Single Family	Multi-Family
HVAC Heating		
Mean Number of Gas Furnaces	0.98	0.91
Mean Number of Gas Boilers (in Region)	0.05	0.13
Average High Input Gas Furnace Capacity (Btus)	78,566	41000
Average High Input Gas Furnace Efficiency (%)	86%	78%
Average High Input Gas Boiler Capacity (Btus) (in Region)	134,751	68,010
Average High Input Gas Boiler Efficiency (%) (in Region)	84%	79%
HVAC Other		
Mean Number of Gas Furnaces with Smart Thermostats	0.04	0
Mean Number of Gas Furnaces with Programmable Thermostats	0.54	0.18
Mean Number of Gas Furnaces with Manual Thermostats	0.34	0.64
Mean Number of Gas Furnaces with Unknown Thermostats	0.06	0.09
Mean Number of Gas Fireplaces	0.46	0
Domestic Hot Water		
Mean Number of Kitchen Faucets	1.02	1.09

Metric	Saturation	
	Single Family	Multi-Family
Mean Number of Bathroom Faucets	2.52	1.27
Mean Number of Showerheads	1.85	1.36
Mean Number of Low-Flow Kitchen Faucets	0.55	0.55
Mean Number of Low-Flow Bathroom Faucets	0.38	0.36
Mean Number of Low-Flow Showerheads	0.88	0.73
Mean Number of Gas Storage Water Heaters	0.74	0.91
Mean Number of Gas Instant Water Heaters	0.02	0
Mean Number of Gas Storage Water Heaters with Pipe Insulation	0.06	0.09
Mean Number of Gas Instant Water Heaters with Pipe Insulation	0	0
Miscellaneous/Other Appliances		
Mean Number of Clothes Dryers	0.96	0.82
Mean Number of Clothes Washers	0.98	0.82
Building Characteristics		
Mean Number of Doors	2.24	1.09
Average Wall Area (ft2)	1,166	NA
Average Ceiling Area (ft2)	935	795
Average Conditioned Area per Home (ft2)	1,947	795
Average Window Area (ft2)	151.7	79.5
Mean People per Household	2.91	3

CAVEATS

Due to data limitations, we were unable to calculate the saturation in multi-family homes for the following metrics:

1) average wall area
2) average ceiling area
3) average conditioned area
4) annual gas usage

In addition, the saturation data were all based on IGC customers except for in the High Input Boiler metrics (due to a lack of data availability). For these metrics, we used the four-state regional data from NEEA.

COMMERCIAL SECTOR

PRIMARY RESEARCH METHODOLOGY

The Dunsky Team contacted key market actors throughout Idaho, as identified by IGC, in order to develop commercial market saturation and building characteristics baselines for the service territory. Individuals contacted included:

- IGC account managers
- Licensed building and specialty contractors
- Building safety and code experts
- Energy auditors and consultants

Contacts were asked for their knowledge of the saturation and building characteristics data by segment. However, none of the contacts were able to provide quantitative estimates to be included in the baseline data. IGC account managers, one plumbing contractor, and one energy auditor provided anecdotal evidence to confirm the general accuracy of a small number of data points identified via secondary research. Anecdotal evidence about the rates of code compliance from the plumbing contractors served as an input to the calculation of low flow showerheads per business.

For data points in the Food Services segment, the Dunsky Team relied on interviews with subject matter experts in commercial food service who staff Frontier Energy's Food Service Technology Center. Staff provided saturation rates for food service measures that were otherwise not available by IGC territory or the wider region.

SECONDARY RESEARCH METHODOLOGY

Commercial measure saturation data was developed based on several sources to provide the most accurate baseline characterization of commercial buildings within IGC territory. The primary data source was Northwest Energy Efficiency Alliance's (NEEA's) Commercial Building Stock Assessment (CBSA).[12] This 2014 assessment is a comprehensive research study of energy efficiency in Northwest commercial buildings (i.e., Montana, Idaho, Oregon, and Washington). The team used secondary data from several other sources to develop a more comprehensive baseline among commercial segments, namely:

- Pacific Northwest National Laboratory (PNNL) Commercial Building Prototypes
- Oak Ridge National Laboratory (ORNL)– Characterization of the U.S. Industrial/Commercial Boiler Population
- Seventhwave's Small Commercial Characterization for the Minnesota Department of Commerce

[12] Available at https://neea.org/data/commercial-building-stock-assessments.

- 2017 Cascade Natural Gas Conservation Potential Assessment
- NEEA's Building Commissioning Long-Term Monitoring and Tracking

CALCULATED METRICS

For the baseline, the team calculated the saturation per business (building) of various measures for education, food services, healthcare, lodging, manufacturing/industrial, office, retail and other building segments.

- Mean Number of Gas Unit Heaters per Business
- Mean Number of Gas Steam Boilers per Business
- Mean Number of Gas Hot Water Boilers per Business
- Mean Number of low-flow Showerheads Per Business
- Percent of Commercial Kitchen Hoods with a Dedicated Conditioned Makeup Air Unit
- Percent of Commercial Kitchen Hoods with a Dedicated Unconditioned Makeup Air Unit

To calculate saturation figures, the team applied installation data from secondary sources to commercial customer counts by segment. Some data points were extrapolated from related data points within a secondary resource. Low-flow showerhead saturation was calculated using the code compliance rate ascertained by primary research.

In addition to saturation calculations, the team calculated the following data points to support market characterization.

- Average Year Built
- Mean Number of Floors per Business
- Total Roof Area
- Mean number of dock door per business
- Percent of Businesses that were Commissioned when Built
- Average Capacity of Gas Steam Boilers (kBtuh)
- Average Capacity of Gas Hot Water Boilers (kBtuh)

The saturation values of these measures and metrics by segment are provided in the table below.

Table 14: C&I Equipment Market Baseline Data

Metric	Segment							
	Education	Food Services	Healthcare	Lodging	Manufac-turing/ Industrial	Office	Retail	Other
Space Heating								
Percentage of Businesses with a Gas Boiler	49%	3%	34%	22%	6%	17%	5%	18%
Percentage of Businesses with a Gas Steam Boiler	5%	0%	3%	3%	6%	0%	0%	0%
Percentage of Businesses with a Gas Hot Water Boiler	55%	0%	8%	12%	2%	27%	5%	31%
Percentage of Businesses with a District Steam Heat Exchanger	0%	0%	0%	0%	0%	0%	0%	0%
Percentage of Businesses with a Gas Furnace	51%	74%	62%	52%	43%	75%	80%	74%
Percentage of Businesses with a Gas Unit Heater	14%	12%	10%	8%	53%	9%	36%	16%
Percentage of Businesses with a Gas Window/Wall Heater	1%	0%	0%	5%	1%	1%	1%	1%
Mean Number of Gas Furnaces per Business	2.67	0.39	1.64	2.97	1.08	0.99	1.16	1.66
Mean Number of Gas Unit Heaters per Business	0.1	0.31	0.15	0.11	1.2	0.25	0.64	0.3
Mean Number of Gas Steam Boilers per Business	2.57	-	0.22	0.45	0.13	0.13	0.30	-
Mean Number of Gas Hot Water Boilers per Business	2.74	-	0.24	0.48	0.14	0.14	0.32	-
Mean Number of Gas Pool/Spa Heaters per Business	0.01	0.01	0.01	0.43	-	0.01	-	-
Average Input Capacity of Gas Split System Furnaces (kBtuh)	-	-	-	400	400	400	400	400
Average Input Capacity of Gas Package System Furnaces (kBtuh)	400	400	400	400	400	400	400	400
Average Capacity of Gas Steam Boilers (kBtuh)	815	-	4,734	3,035	3,058	2,401	1,925	-
Average Capacity of Gas Hot Water Boilers (kBtuh)	2241	0	1465	772	258	1269	561	910
Water Heating								
Mean Number of Gas Water Heating Units per Business	3.53	1.50	2.00	5.00	-	1.00	1.00	-
Mean Number of Another Kind of Gas Water Heating Units per Business	-	-	-	-	-	-	-	-
Mean Number of Gas Standard Storage Water Heating Units per Business	3.53	1.50	1.91	5.00	-	1.00	1.00	-
Mean Number of Gas Instant Water Heating Units per Business	-	-	-	-	-	-	-	-

Metric	Segment							
	Education	Food Services	Healthcare	Lodging	Manufac-turing/ Industrial	Office	Retail	Other
Mean Number of Gas Central Plant Boiler with Tank Water Heating Units per Business	-	-	0.09	-	-	-	-	-
Mean Input Capacity of Natural Gas Water Heaters (kBtuh)	199.00	199.00	199.00	300.00	-	77.13	36.00	-
Mean Input Capacity of Standard Storage Natural Gas Water Heaters (kBtuh)	199.00	199.00	199.00	300.00	-	77.13	36.00	-
Mean Number of Pre-Rinse Spray Valves Per Business	0.74	0.75	-	0.25	-	-	-	-
Mean Number of Sinks Per Business	20	3.70	20	70	5	2.87	1	5
Mean Number of Low-Flow Faucet Aerators Per Business	5	1	9	45	1.5	1.25	0.25	1.5
Mean Number of Showerheads Per Business	-	-	1	25	-	-	-	-
Mean Number of low-flow Showerheads Per Business	-	-	0.5	12.5	-	-	-	-
Kitchen Equipment								
Percent of Commercial Kitchen Hoods with a Dedicated Conditioned Makeup Air Unit	50%	50%	50%	50%	0%	50%	50%	0%
Percent of Commercial Kitchen Hoods with a Dedicated Unconditioned Makeup Air Unit	26%	26%	26%	26%	0%	26%	26%	0%
Percent of Commercial Kitchen Hoods without a Dedicated Makeup Air Unit	25%	25%	25%	25%	0%	25%	25%	0%
Mean Number of Natural Gas Char Broilers Per Business	0.03	0.23	0.03	0.07	-	-	0.01	0.03
Mean Number of Natural Gas Griddles Per Business	0.03	0.34	0.06	0.10	-	0.01	0.04	0.04
Mean Number of Natural Gas Fryers Per Business	0.07	0.58	0.05	0.11	0.01	0.02	0.07	0.05
Mean Number of Natural Gas Conveyer Ovens Per Business	0.03	0.07	0.04	0.04	-	-	0.02	0.02
Mean Number of Natural Gas Range Ovens Per Business	0.16	0.52	0.36	0.29	0.01	0.05	0.06	0.16
Mean Number of Natural Gas Convection, Combination, or Retherm Ovens Per Business	0.06	0.15	0.08	0.08	-	0.01	0.04	0.03
Mean Number of Dishwashers Per Business	0.77	0.77	0.49	0.25	0.11	0.46	0.03	0.24

Metric	Segment							
	Education	Food Services	Healthcare	Lodging	Manufac-turing/ Industrial	Office	Retail	Other
Miscellaneous Equipment								
Mean Number of Commercial Clothes Washers per Business	0.18	0	0.6	1.27	0	0.023	0.6	0.2
Mean Number of Commercial Clothes Dryers per Business	0.1	0	0.1	0.6	0	0.005	0.1	0.05
Mean Number of Ozone Laundry Systems per Business	-	-	0.10	0.15	-	-	-	-
Building Characteristics								
Percent of Businesses that were Commissioned when Built	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Percent of Businesses Which Undertake Ongoing Retrocommissioning	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Percent of Businesses Which Have Undertaken Retrocommissioning	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mean Number of Floors per Business	1.885	1.21	1.76	2.94	1	1.9	1.48	2.865
Average Year Built	1979	1975	1979	1976	1986	1977	1976	n/a
Average Square footage per Business	24,467	4,473	4,725	18,145	28,267	13,367	11,886	11,886
Percent of Businesses which Undertake Reactive HVAC Maintenance	55%	55%	55%	55%	55%	55%	55%	55%
Percent of Businesses which Undertake Preventative HVAC Maintenance	31%	31%	31%	31%	31%	31%	31%	31%
Average Square footage (new construction per year)	49,100	5,250	-	53,400	20,157	13,000	18,500	16,000
Average wall area per business	6,214	19,562	7,815	5,954	19,301	12,380	11,827	9,491
Total window area	3,620	524	1,524	1,211	113	1,442	492	-
Total Roof Area	12,980	28,348	13,902	8,322	24,467	18,382	16,532	8,540
% of floor area that is heated with natural gas as the primary fuel	79%	77%	90%	22%	50%	49%	79%	73%
Average % of floor that is above basement or crawlspace	10%	17%	9%	28%	0%	38%	5%	18%
Average % of floor that is slab on grade	85%	87%	91%	67%	100%	63%	93%	80%
Mean number of dock door per business	0.60	-	1.20	0.20	-	0.14	0.64	-
Percent of businesses with a dedicated energy manager	72%	13%	0%	47%	5%	51%	38%	44%

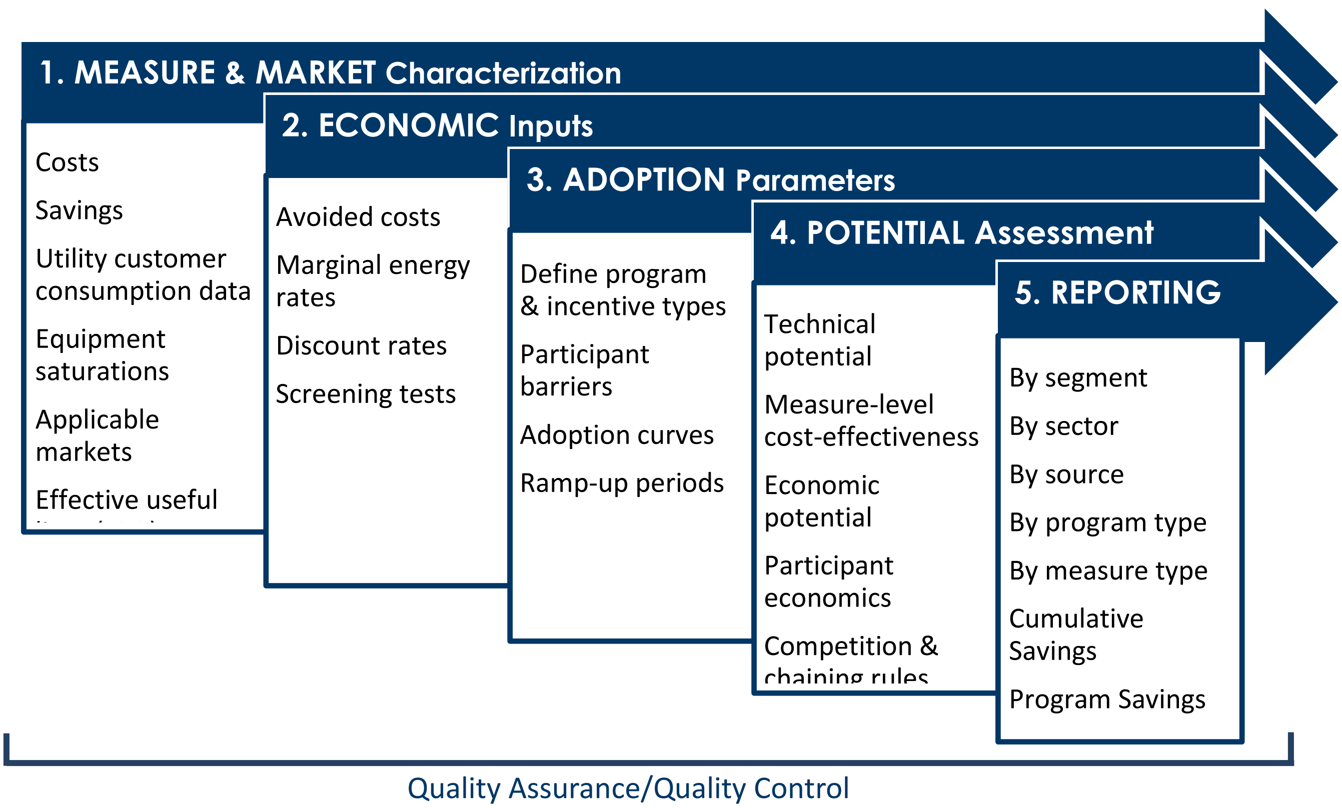
METHODOLOGICAL CAVEATS

Due to the limited commercial data availability from both primary and secondary resources within the IGC service territory, it should be noted that baseline conditions apply generally beyond IGC territory or have been extrapolated from a broader region. Results are limited by the source studies' design and results.

APPENDIX B. DETAILED MODEL METHODOLOGY

The Dunsky Energy Efficiency Potential (DEEP) model employs a multi-step process to develop a bottom-up assessment of the Technical, Economic, and Achievable Potentials. The process begins by establishing a comprehensive set of inputs related to energy savings measures, markets, equipment saturations, and economic factors, which are then applied in the model to assess energy savings potential. This appendix outlines the key features of our modelling technique, including the calculation methodologies employed, and the steps taken to ensure the accuracy and quality of the final results and reporting. The figure below provides a high-level overview of the key assessment steps and inputs, followed by more details throughout this appendix.

Figure 27: Key steps and inputs in study methodology



The key steps in the modelling process are:

- **Characterize Measures and their Applicable Markets** A comprehensive list of energy saving measures is characterized by applying jurisdiction-specific data and assumptions to each measure and market segment. Primary and secondary data are compiled (as available) to establish an assessment of the market baseline, detailing the current saturation of energy using equipment in each market sector and segment. Markets for energy measures are then assessed by combining utility customer counts with market growth factors, equipment turnover rates, and the market baseline results.

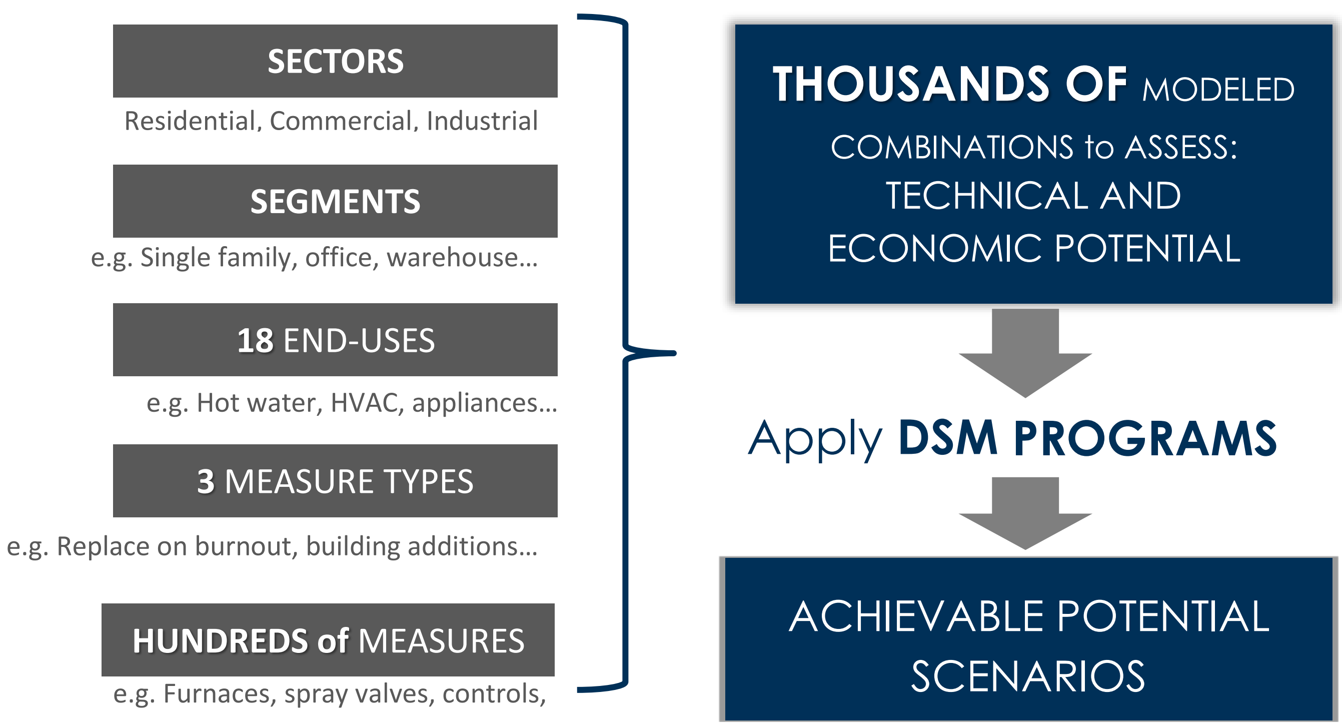
- **Economic Inputs:** The model harnesses key economic inputs to assess the measure cost-effectiveness and benefits. Utility avoided costs, customer discount rates, gas rates, and the utility cost of capital are captured and entered into the model in real dollars based on the study period start year. The cost-effectiveness test that will be applied for economic screening is selected, as well as the other test that will be calculated to benchmark program performance.
- **Adoption Parameters:** For each measure-market combination we assign adoption curves based on customer barrier level assessments. Customer economics inputs such as measure savings, marginal rates and other secondary energy sources) are applied to calculate the participant cost test (PCT), the key driver of adoption levels in each adoption curve. Finally, program characterizations are entered into the model by defining the fixed and variable program costs, incentive levels, and enabling activity impacts on customer barriers.
- **Potential Assessment:** The model assesses the technical potential by combining the measure characterization with the market baseline inputs to determine the theoretical maximum amount of savings possible for each measure-market combination, in each year, over the study period. Measures-market combinations that pass the cost-effectiveness threshold are counted in the economic potential. Achievable potential scenarios are applied by calculating the customer economics, under various incentive program scenarios, and applying the adoption curves. At each level, the model applies chaining factors to account for interactive effects among measures and assigns the appropriate market portion in places where multiple measure may compete for the same market (e.g., Tier 1 and Tier 2 boilers).
- **Reporting:** Reporting is conducted in four steps, from the presentation of the initial Draft Results to the Final Report, each with an increasing level of precision and detail. Each report is vetted by the relevant parties, and all feedback is considered and incorporated into the model and reporting before proceeding to the next step.
- **Quality Assurance / Quality Control (QA/QC):** Throughout the modeling process, a rigorous QA/QC process is applied to ensure the inputs reflect the energy using equipment in the studied jurisdiction, and that the results provide an accurate assessment of the energy savings potential. The model is calibrated to past DSM program performance and benchmarked to the baseline sales projections and individual end-uses, to ensure that the technical, economic and market factors align with the local reality.

BOTTOM-UP ASSESSMENT OF POTENTIAL

DEEP's bottom-up modelling approach assesses each measure-market segment combination, applying incentive programs to arrive at a fulsome assessment of the energy savings potentials. Rather than estimating potentials based on the portion of each end-use that can be reduced by energy saving measures and strategies (often referred to as a top-down analysis), the DEEP model's bottom-up approach applies a highly granular calculation methodology to assess the energy savings opportunity for each measure-market segment opportunity in each year. Key features of this assessment include:

- **Measure-Market Combinations:** Equipment saturations, utility customer counts, and demographic data are applied to create "markets" for each individual measure. The savings per year, and the market size are unique for each measure-market segment combination, thereby increasing the accuracy of the results.
- **Phase-in Potential:** The DEEP model applies the equipment expected useful life (EUL) and market growth factors to determine the number of savings opportunities for each measure-market combination in a given year. This provides an important time series for each gas savings measure, upon which accurate and realistic annual achievable program volumes (measure counts and savings) can be calculated in the model, as well as phase-in technical and economic potentials.
- **Annual and Lifetime Savings:** For each measure-market combination in each year, DEEP calculates the annual savings as well as the lifetime savings, accounting for mid-life baseline adjustments. This provides both an accurate read on the cumulative savings (above and beyond natural uptake), as well as a clear read on the annual savings that will pass through DSM portfolios.

Figure 28. Bottom-up combinations in the DEEP Model



OVERVIEW OF MODELLING CALCULATIONS

The DEEP model assesses three levels of energy savings potential: technical, economic, and achievable. In each case, these levels are defined based on the governing regulations and practice in the modeled jurisdiction, such as applying the appropriate cost-effectiveness tests, and applying the relevant benefit streams to ensure consistency with evaluated past program performance.

- **Technical Potential:** The technical potential accounts for all theoretically possible energy savings stemming from the applied measures. In markets where multiple measures may compete,[13] the measure procuring the most energy savings per unit is selected.
- **Economic Potential:** The economic potential includes all measures that pass the cost-effectiveness test screen. Economic screening is performed at the measure level, and only accounts for direct costs related to the measure (i.e., incentives in the case of the UCT, incremental costs in the case of the TRC), not including general DSM program costs.
- **Achievable Potential:** The achievable potential considers customer barriers and economics to assess the annual adoption of measures within DSM programs. Achievable potential scenarios are applied based on DSM program design variations (incentives and enabling activities).

Figure 29. Bottom-up combinations in the DEEP Model

APPLIED CALCULATION	TECHNICAL POTENTIAL	ECONOMIC POTENTIAL	ACHIEVABLE POTENTIAL
1. ECONOMIC SCREENING	No Screen	Cost-Effectiveness (UCT)	Cost-Effectiveness (UCT and PCT)
2. MARKET BARRIERS	No Barriers (100% Inclusion)	No Barriers (100% Inclusion)	Market Barriers (Adoption Curves)
3. COMPETING MEASURES	Winner takes all	Winner takes all	Competition Groups Applied
4. MEASURES INTERACTIONS	Chaining Adjustment	Chaining Adjustment	Chaining Adjustment

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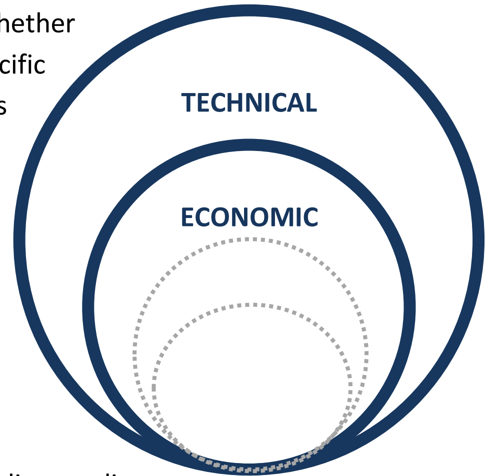
[13] We use the words “market” or “market size” to describe the number of baseline equipment or buildings in a given segment that capture the opportunity for specific energy-efficient measures. For example, the number of shower heads in the single-family residential sector would be an example of a “market” for low-flow shower heads.

CALCULATION OF TECHNICAL AND ECONOMIC POTENTIAL



Various calculation methods are applied at different levels of potential, whether technical, economic, or achievable. These are based on each measure's specific characterization (cost-effectiveness, market applicability), as well as interactive and competition effects among measures.

The calculations applied at the technical and economic levels of potential assessment are outlined below. We note that calculations are conducted independently at each level to account for shifting and dynamic measure mixes and interactive effects at each level.

TECHNICAL POTENTIAL

Technical potential is the theoretical maximum savings opportunity, disregarding constraints such as cost-effectiveness and market barriers. This excludes early replacement and retirement opportunities, which are to be addressed in the subsequent *achievable* potential analysis.

The measure procuring the most energy savings per unit for each sub-sector and end-use is selected, which maximizes overall energy savings. The focus of the technical potential is on energy savings (e.g., the measures selected are based on energy savings, although demand savings are also calculated). The measures applied in the model are outlined in the approved study measure list.

Phase-in Technical Potential: The technical potential, and all other potential levels are calculated on an annual phase-in basis to determine the size of the available market in each year. For each measure for each year, the calculation applies the market size and growth factors, measure type, early and natural replacement rates of existing equipment, and the maximum number of units that could be replaced or installed.

ECONOMIC POTENTIAL

Economic potential is determined by screening technical potential measures – or bundles of measures – against the applicable standard cost-effectiveness tests. It disregards market barriers to adoption.

The model can apply any standard cost-effectiveness test, and adaptations are made to follow local jurisdiction cost-effectiveness testing requirements. The threshold for screening is set at 1.0 (i.e., measures that achieve a higher cost-effectiveness test result are counted in the economic potential) but can be adjusted in the model to test various screening regimes. Tests included in the model are:

- **Utility Cost Test (UCT)**
- **Total Resource Cost (TRC)** Test
- **Societal Cost Test (SCT)**
- **Utility Cost Test (PACT)**
- **Participant Cost Test (PCT)**

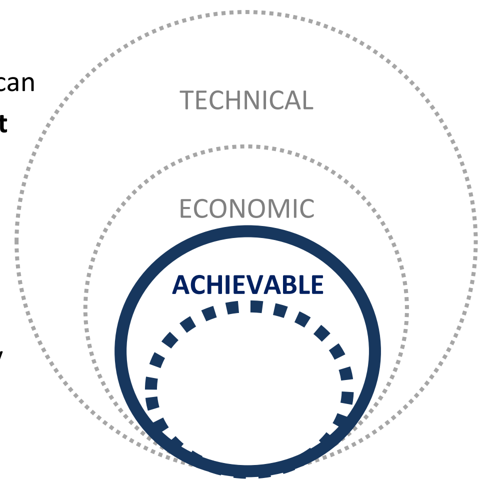
Table 15: Costs and Benefits that May Be Applied for Cost-Effectiveness Screening

Benefits	Costs
• Utility avoided costs (TRC, SCT, UCT) • Customer avoided energy costs (PCT) • Non-energy benefits (SCT, PCT) • GHG Costs (SCT, PACT)	• Incremental measure costs (TRC, SCT, PCT) • Incentive Costs (UCT)

When calculating the inputs above, and indeed throughout the DEEP model, we apply the following:

- **Lifetime Benefits:** All benefits applied in the cost-effectiveness test are multiplied by their corresponding cumulative discounted avoided costs to get a present value ($) of lifetime benefits.
- **Real Dollar Accounting:** All benefits and costs are adjusted to real dollars, expressed in the first year of the study (unless otherwise requested).

ACHIEVABLE POTENTIAL SCENARIO ASSESSMENT



The achievable potential is the amount of energy and demand savings that can be achieved by the portfolio of DSM programs applied to the market. **Market adoption is assessed by applying the PCT along with the market adoption curve** associated with the assigned market barrier level for each measure.

Various scenarios are applied by modifying the DSM program inputs, specifically the incentive levels and barrier reductions from enabling activities. Achievable potential scenarios are defined according to the study requirements.

DSM PROGRAM ARCHETYPES

The achievable potential scenarios are assessed by applying DSM program archetypes that are developed based on an analysis of local DSM program evaluation reports, best practices from other jurisdictions, and through discussion with the DSM program administration team(s). Characterization of each program includes translating enabling strategies into customer barrier reduction impacts, incentive levels, cost structure, and applicable measures; those measures were mapped into the potential model. The model's bottom-up calculation approach is used to obtain costs, savings and average persistence of energy savings at the program level by aggregating measures by program archetypes and using program assumptions such as incentive levels and administration costs.

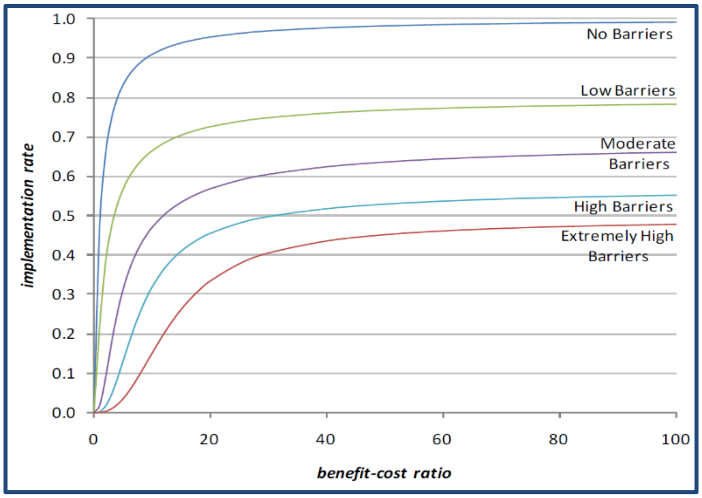
DEEP'S REFINED ADOPTION RATE METHODOLOGY

Rooted in the United States' Department of Energy (U.S. DOE) adoption curves,[14] the model methodology sets adoption rates based on a combination of customer cost-effectiveness – applied differently for each sector – and levels of market barriers. Figure 30 presents a schematic view of resulting adoption curves. Five levels of barriers, to which measure categories are assigned based on market research or professional experience, define the maximum adoption curves. Different end-uses and segments exhibit different barriers.

The DEEP model applies five steps to determine the achievable potential:

1. **Barriers:** Assign each measure category, within each segment to one of five adoption curves based on its assumed market barrier level (these can change over time if market transformation effects are anticipated).
2. **Drivers:** Assign cost-effectiveness metrics to each sector based on market research into economic drivers or professional experience.
3. **Incentives:** Assign assumed incentive levels.
4. **Economics:** Calculate customer cost effectiveness expressed by the PCT.
5. **Adoption:** Calculate resulting adoption rates and adjust as needed based on other external influences such as the ramp-up period (see *Refinement #2* in text box, below).

Figure 30: Adoption Curves Used in the Study



While this methodology is rooted in the U.S. DOE's extensive work on adoption curves, it applies two important refinements, as described in the text box below.

[14] The U.S. DOE uses this model in several regulatory impact analyses. An example can be found in http://www.regulations.gov/contentStreamer?objectId=090000648106c003&disposition=attachment&contentType=pdf, section 17-A.4.

Refinements to U.S. DOE Adoption Curves

Refinement #1: Choice of the cost-benefit criteria. The DOE model assumes that participants make their decisions based on a benefit-cost ratio calculated using discounted values. While this may be true for a select number of large, more sophisticated customers, experience shows that most consumers use simpler estimates, including payback periods. This has implications for the choice and adoption of measures, since payback period ignores the time value of money as well as savings after the break-even point. The model converts DOE's discount rate-driven curves to equivalent curves for payback periods.

Refinement #2: Ramp-up. Two key factors – measure awareness and program delivery structure – can in theory limit program participation, especially during the first few years after a program's launch, and result in lower participation than DOE's achievable rates would suggest. For example, a new home retrofit program that requires the enrollment and training of skilled auditors and contractors by program vendors could take some time to achieve the uptake assumed using DOE's curves. In this study, we have therefore applied an adjustment to select programs on a case-by-case basis.

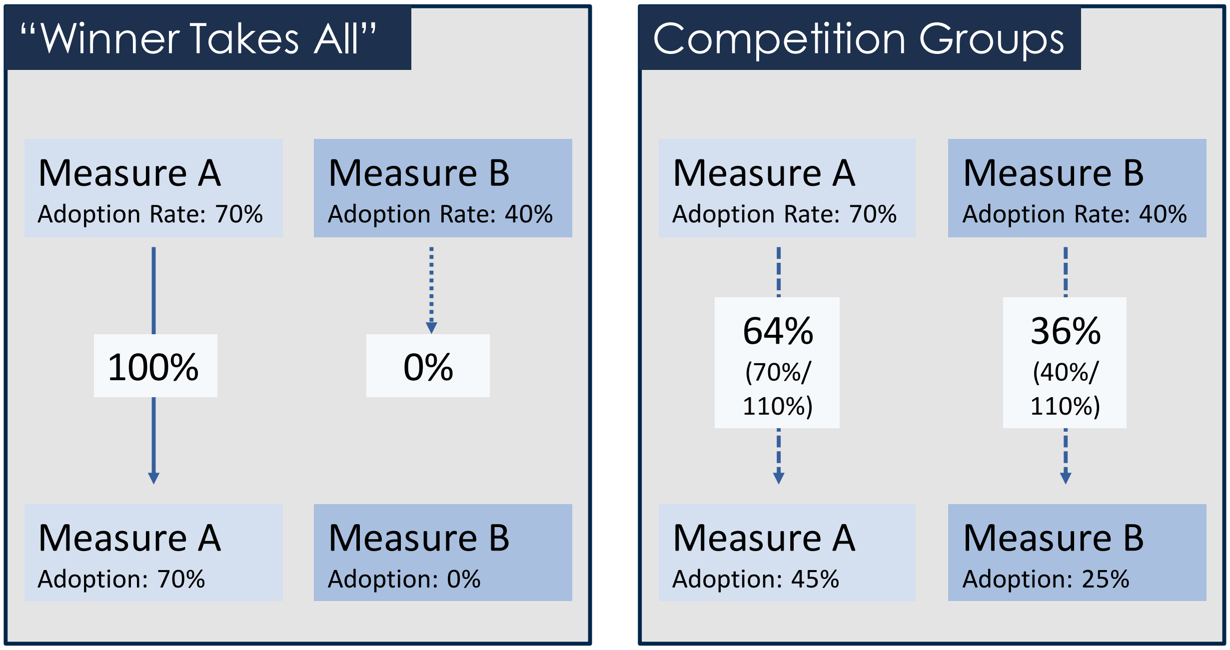
COMPETING MEASURES

Competing measures share the same market opportunity but are mutually exclusive. Examples include ENERGY STAR storage water heaters vs. tankless water heaters. In these cases, the model assesses the market for each depending on the potential level as follows:

- **TECHNICAL POTENTIAL**: 100% of the market is applied to the measure with the highest savings.
- **ECONOMIC POTENTIAL**: 100% of the market is applied to the *cost-effective* measure with the highest savings.
- **ACHIEVABLE POTENTIAL**: All cost-effective measures compete for the same market. Assuming that all measures are cost-effective, each adoption rate will be a pro-rated value based on the maximum adoption rate and each of the measures' respective adoption rates.

Below we present an example where two measures compete. First, the adoption rate is calculated for each measure independent of any competing measures, as outlined in the figure below.

Figure 31. Competing Measures Overview

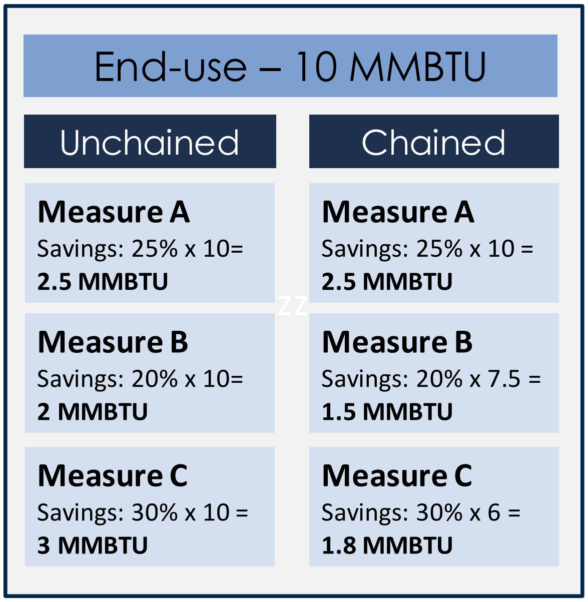


From this example, the maximum adoption rate is 70%, corresponding to the measure with the highest potential adoption. From this, measures adoptions are pro-rated based on their relative independent adoption rates, to arrive at each measure's share of the 70% total adoption rate. As a result, the total adoption rate is still 70%, but it is shared by two different measures.

MEASURE INTERACTIONS - CHAINING

Chained measures are subject to adjustment when other measures are also installed in the same segment. Chaining is applied at all potential levels (technical, economic and achievable), and these interactive effects are automatically calculated according to measure screening and uptake at each potential level. Figure 32 highlights the calculations used when incorporating adoption rates to calculate chaining effects.

Figure 32: Chaining Impact on Savings



An example with Measure A (50% adoption rate) and Measure B (40% adoption rate)

Measure	Market Share	Savings
A alone	30%	2.5 MMBTU
B alone	20%	2 MMBTU
A and B	20%	4 MMBTU
None	30%	0 MMBTU

The DEEP model applies a hierarchy of measures in the chain, reducing the savings from each measure that is lower down the chain. The model adjusts the chained measures' savings for each individual measure, with the final adjustment calculated based on the likelihood that measures will be chained together (determined by their respective adoption rates), and the collective interactive effects of all measures higher in the chain.

CUMULATIVE SAVINGS AND AGGREGATE RESULTS

To calculate the cumulative savings, and report aggregate savings by measure, end-use, segment and sector, the following approaches are applied to roll up and adjust annual measure savings.

- **Cumulative Annual Savings**: Cumulative savings are calculated for each potential type and each year, using incremental savings potentials. Savings from individual measures are removed from the cumulative savings at the end of their effective useful life (EUL). For instance, a measure installed in Year 1 and with a EUL of two years would not be recounted in the cumulative potential starting in Year 3.
- **Mid-Life Baseline Adjustments:** Where a new standard may alter the baseline of a measure before the end of its EUL, the model removes a portion of the savings for previously installed measures from the cumulative savings for that measure. The amount removed is equivalent to the difference between the baselines, which may represent all or just a portion of the previously installed measure's cumulative savings.
- **Aggregate Results and Reporting**: Measure-level consumption and demand savings-related costs, and benefits are aggregated by sector, segment, end-use, measure-type, or program. Costs are reported from both the program administrator's (program spending) and the service territory's perspectives.

The program administrator's costs do not include the participants' share of costs (i.e., costs that are not covered by incentives), nor do they include any adjustments for early retirement measure costs.

ITERATIVE QA/QC AND REFINEMENTS

To ensure that the DEEP model provides valid results for assessing the potential at all levels, we apply a rigorous QA/QC process throughout all steps in the study. This includes industry best-practices including:

- QA/QC checklists for all modelling processes
- Issue identification and trackers to ensure all items are addressed
- Data cleaning and input benchmarking to ensure all inputs
- Automated input compiling to avoid human error when loading model with study data
- Vetting with internal senior research leads, and relevant client/utility experts
- Model calibration to past program performance
- Feedback QA assessments, wherein model outputs are benchmarked to baseline sales data, and inputs are reviewed where anomalous outputs are observed
- Vetting of model with client/utility via sharing of DEEPs transparent input and calculation sheets

The DEEP model draws it inputs from a detailed measure, market, program and economic databases that are developed using jurisdiction specific data, as follows:

- **Measure Inputs:** Each measure is characterized for the specific market being studies (i.e., all parameters are updated to reflect local climate, equipment availability and costs). We then benchmark measure costs, savings, EULs and market applicability against our internal database of over 15 past potential study inputs to ensure that no values fall outside of the expected ranges, and that the inputs.
- **Market Inputs:** Detailed saturation tables are created for each measure-segment combination (refereed to as markets in DEEP's modeling process). These are then benchmarked against recognized building energy thresholds (lighting densities, energy use intensities, cooling and heating capacity per unit condition floor area, average floor area per business, etc.) Finally, the individual equipment saturations are benchmarked against Dunsky's internal database of equipment saturation tables, to identify any inputs that may be out of acceptable ranges or anomalous.
- **Economic Inputs:** All economic inputs are converted to real dollar terms based on the study start year and adapted to fit the model input table formats. These are vetted internally and with the client who provided the sales projections and local economic settings to ensure consistency with internal planning values.
- **Program Inputs:** Program characterizations are developed based on a detailed study of current DSM programs in the jurisdiction, and recent evaluation reports. These are then vetted internally against our internal program characterization database and provided to utility DSM program administration representatives to ensure consistency with current program approaches, costs and incentive levels.

Once the inputs have been prepared and quality checked, a characterization database employs an automated script to assemble the input sheets and avoid any human transfer errors.

MODEL CALIBRATION

Model calibration ensures that the overall estimated energy and demand savings levels are in line with utility forecasts. Because the bottom-up potential methodology is based on baseline equipment saturation data, the focus of the study calibration is on the validation of the market adoption forecast model, and to ensure that the collective inputs provide valid ranges for measure savings, costs, and markets.

The study is refined using the most recently completed year of program activity, as available, using energy savings, demand savings, and costs. This step is more of a "sanity check" on results than an actual model calibration, as there might be good reasons for the potential to be materially different from the last annual DSM results. For instance, some programs may be underperforming what is possible for such programs to achieve, or some other anomaly may impact achieved savings.

To account for these factors, calibration is performed at two levels: the overall program by program comparison, as well as at the measure level for a handful of "bell-weather" technologies that are typically not impacted by differences in program scope or program underperformance.

The calibration exercise identifies the extent to which our assessment of adoption rates – based on a combination of economic drivers and assumed market barrier levels – appears consistent with recent achievements. Large discrepancies are then reviewed and classified with one (or a combination) of four findings:

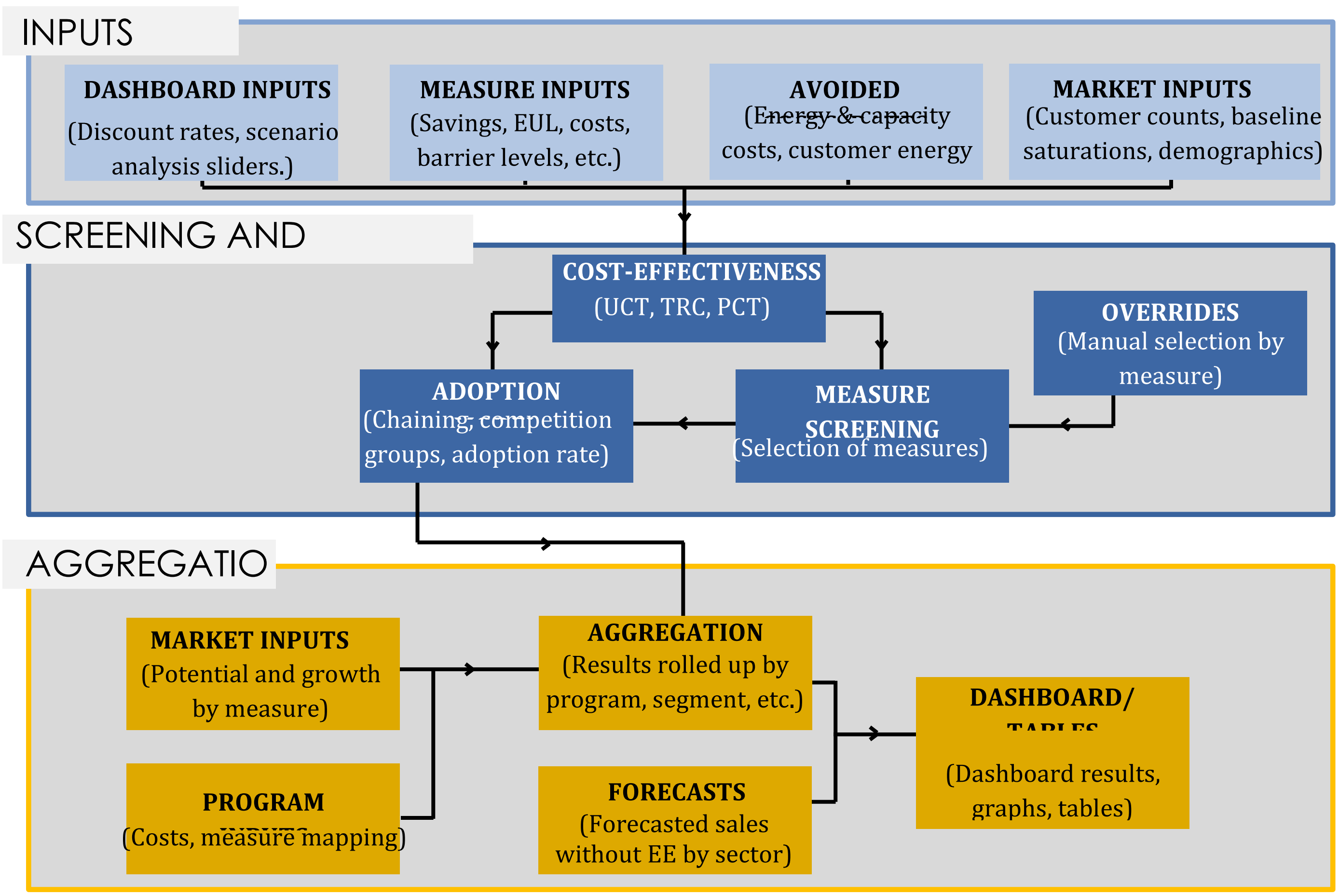
(1) The model is consistent with expected results;
(2) The market adoption algorithm needs to be revisited;
(3) Barrier levels for market adoption need to be revisited; or
(4) An anomaly likely explains an inconsistency, so no change is required.

These findings then inform iterative adjustments to the model inputs and settings before draft and final results are generated and shared with the client and/or stakeholders.

MODEL ARCHITECTURE

The figure below presents an overview of the DEEP model's computational structure, including inputs, calculations, and aggregation. The methodology uses a bottom-up approach, beginning at the measure level with individual measure characterization (the top-most row in the figure below). The measures are then screened and adoption rates are calculated based on cost-effectiveness results (middle row below). Measure results are then rolled-up by program, segment, sector, energy source, and end-use.

Figure 33: DEEP Model Structure



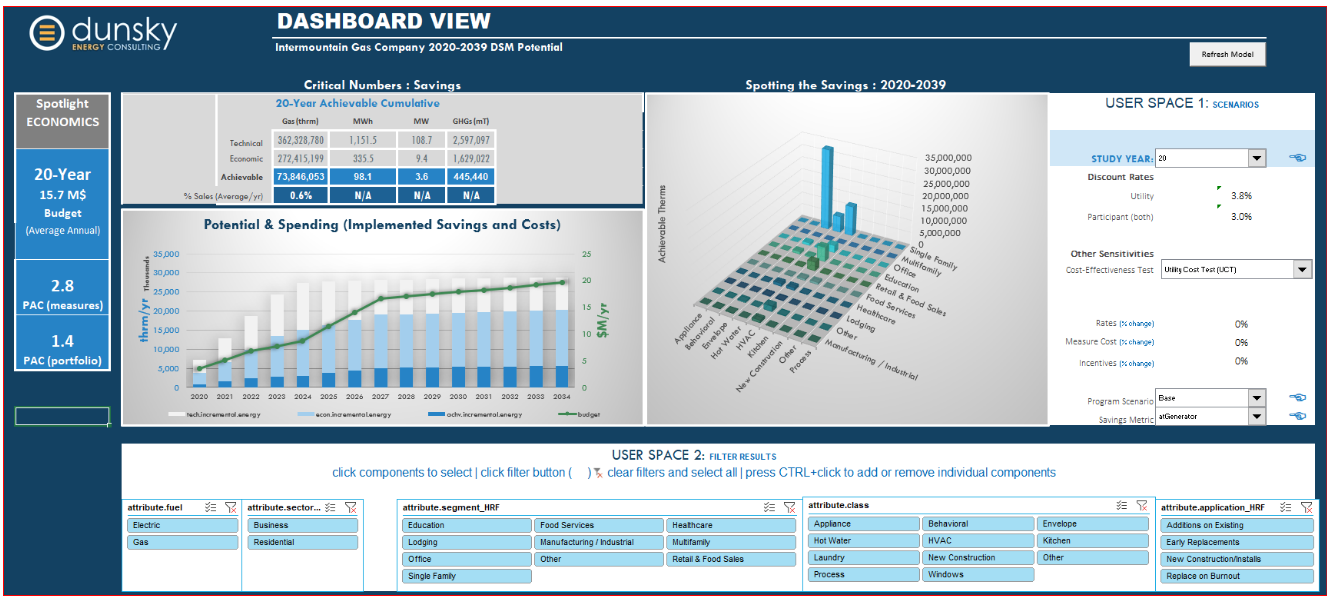
SCENARIO ANALYSIS DASHBOARD

The DEEP model can be delivered for use by the client to run further what-if scenarios. To facilitate this, DEEP is equipped with dashboard that provides a summary of the model outputs (results), and a range of user-input fields to adjust the model settings to test further scenarios. The model comes equipped with all input data and can be run on a PC equipped with MS Excel 2013 or later.

The user also has access to measure and program input and output tables. Core input assumptions in the model are clearly defined and can be easily changed to conduct sensitivity analysis and adjust to changing market conditions (e.g., energy prices, economic growth) as well as recent program and evaluation results.

The figure below shows a snapshot of the DEEP dashboard, which is the main entry point to use the model's features, run sensitivity analyses, and get high-level results.

Figure 34: DEEP Model – Dashboard View



APPENDIX C. MEASURE CHARACTERIZATION DETAILS

This section presents the measure characterization for both the residential and commercial measures. For each sector, characterizations are presented first for available measures and then for emerging technologies. Finally, this appendix summarizes how future codes and standards were considered.

RESIDENTIAL MEASURES

AVAILABLE MEASURES

Table 16 lists the residential measures included in the potential study and the source(s) of the inputs. The table includes the end-use category, measure, applicable TRM or other sources, and any adjustments made.

Table 16: Residential Measure Source

Measure Type	Measure Description	Source
Appliance	Clothes Dryer ENERGY STAR	Mid Atlantic TRM Version 8. Clothes Dryer, p. 239. Vented Gas, Standard size (8.45lbs)
Appliance	Clothes Washer ENERGY STAR	Iowa Statewide Technical Reference Manual Version 2.0; 2.1.1 Clothes Washer p.5.
Behavioral	Home Energy Report	Michigan 2019 Behavior Resource Manual (BRM) --> for therms. Took average over 6 years of percentage reduction for homes with between 900 and 1200 therms annual usage a year.
Envelope	Air Sealing	Iowa Statewide Technical Reference Manual Version 2.0; 2.6.1 Infiltration Control (conservative deemed approach), p. 260.
Envelope	Attic Insulation	2019 Illinois TRM Version 7.0, Volume 3. 5.6.5 Ceiling/Attic insulation p.327.
Envelope	Basement Insulation	2019 Illinois TRM Version 7.0, Volume 3. 5.6.2 Basement Sidewall Insulation p. 306.
Envelope	Efficient Windows	Iowa TRM, Version 2.0, Volume 2. 2.6.8 Efficient Windows, p. 308.
Envelope	ENERGY STAR Doors	Iowa TRM Version 2.0, Volume 2: Residential Measures, 2.6.5 Insulated Doors, p.287.

Measure Type	Measure Description	Source
Envelope	New Home Construction Built Green Home	Cascade natural gas potential study - ratio of 'Built Green Homes' and Energy Star homes to adjust results from Energy Star homes Energy Star Certified Homes, Version 3 (Rev. 08), Cost & Saving Estimates. https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/EstimatedCostandSavings.pdf Assumed that 80% of saving in Energy star homes is heating related (gas) and 20% is not (electricity).
Envelope	New Home Construction ENERGY STAR Certified Home	Energy Star Certified Homes, Version 3 (Rev. 08), Cost & Saving Estimates. https://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/EstimatedCostandSavings.pdf Attribution of savings between electricity and gas is currently done based on professional judgement - assume that 80% of energy saving are heating related and 20% are non-heating related.
Envelope	Wall Insulation	2019 Illinois TRM Version 7.0, Volume 3. 5.6.4 Wall insulation p. 320.
Hot Water	Faucet Aerator	Mid Atlantic TRM V8 - NEEP; Faucet aerators (p. 174 of 529). Used average of kitchen and bathroom values.
Hot Water	Gas Heat Pump Water Heater	2019 Illinois TRM Version 7.0, Residential Measures. 5.3.7 Gas High Efficiency Furnace p.103
Hot Water	Low Flow Shower Head	Mid Atlantic TRM V8 - NEEP; Low flow showerhead (p. 170 of 529).
Hot Water	Pipe Wrap (Hot Water)	NBP TRM, DSM Plan 2019 - 2021 Technical Reference Manual. Hot Water Pipe Insulation p. 23.
Hot Water	Storage Water Heater Energy Star	Mid Atlantic TRM V8 - NEEP; High Efficiency Gas Water Heater (p. 187 of 529). Used values for Gas Condensing.
Hot Water	Tankless Water Heater	Efficiency Maine Retail/Residential TRM Version 2018.3, Effective Jan. 1, 2018. On-Demand Natural Gas Water Heater, p. 97.
Hot Water	Tankless Water Heater Energy Star	Efficiency Maine Retail/Residential TRM Version 2018.3, Effective Jan. 1, 2018. On-Demand Natural Gas Water Heater, p. 97; EF of 0.91 from Union Gas/Enbridge Gas.
Hot Water	Thermostatic Restrictor Shower Valve	Mid Atlantic TRM V8 - NEEP; Thermostatic Restrictor Shower Valve (p .199 of 529).
HVAC	Boiler post 2021 standard	2019 Illinois TRM Version 7.0, Residential Measures. 5.3.6 Gas High Efficiency Boiler p.99.
HVAC	Boiler Condensing	2019 Illinois TRM Version 7.0, Residential Measures. 5.3.6 Gas High Efficiency Boiler p.99.

Measure Type	Measure Description	Source
HVAC	Boiler Reset Control	Mid-Atlantic Technical Reference Manual Version 8.0, May 2018. Boiler Reset Controls, p.152.
HVAC	Boiler Tune Up	Wisconsin Focus on Energy 2018 TRM, Boiler Tune-Up, Single Family p. 757. Algorithm edited to be consistent with other residential measures.
HVAC	Combo Boiler (Heating/HE) post 2021 standard	2019 Illinois TRM Version 7.0, Residential Measures. 5.3.17 Gas High Efficiency Combination Boiler p.167. Hot water inputs from Maine TRM to be consistent with other hot water measures.
HVAC	Combo Boiler (Heating/HE)	2019 Illinois TRM Version 7.0, Residential Measures. 5.3.17 Gas High Efficiency Combination Boiler p.167. Hot water inputs from Maine TRM to be consistent with other hot water measures.
HVAC	Duct Insulation	Efficiency Maine Retail/Residential Technical Reference Manual Version 2018.3; Duct Insulation (Component of LUB), p.79.
HVAC	Duct Sealing	Iowa Statewide Technical Reference Manual Version 2.0; 2.4.16 Duct Sealing. Deemed method.
HVAC	Fireplace < 40 kBtu/h	Union Gas /Enbridge Gas Distribution - Updated DSM Measures and TRM; EB-2016-0246. HE Fireplace with pilotless ignition, zero clearance. 40 kBtu/h input rating or freestanding fireplace, 0.7 Eff; Base: 0.65 Eff. p.7.
HVAC	Fireplace >= 40 kBtu/h	Union Gas /Enbridge Gas Distribution - Updated DSM Measures and TRM; EB-2016-0246. p.7.
HVAC	Furnace	2019 Illinois TRM Version 7.0, Residential Measures. 5.3.7 Gas High Efficiency Furnace p.103.
HVAC	Furnace	2019 Illinois TRM Version 7.0, Residential Measures. 5.3.7 Gas High Efficiency Furnace p.103.
HVAC	Furnace Tune Up	Wisconsin Focus on Energy 2018 TRM, Boiler Tune-Up, p. 77.
HVAC	Heat Recovery Ventilator ENERGY STAR	Iowa Statewide Technical Reference Manual Version 2.0; 2.4.8 Energy Recovery Ventilator, p.156.
HVAC	Thermostat Programmable	Mid-Atlantic Technical Reference Manual Version 8.0, May 2018. Smart Thermostat, p.133. Home Energy Services Impact Evaluation (Res 34), August 2018. Navigant and cadeo for % heating saving, and ratio of cooling saving relative to with a wifi thermostat.

Measure Type	Measure Description	Source
HVAC	Thermostat Wi-Fi	Mid-Atlantic Technical Reference Manual Version 8.0, May 2018. Smart Thermostat, p.133.
Other	Pool Heater	https://www.energy.gov/energysaver/gas-swimming-pool-heaters

EMERGING TECHNOLOGIES

The table below summarizes the key assumptions used for the three (3) emerging technology measures considered in the residential sector: gas heat pump water heaters, through-the-wall condensing furnaces/air-conditioners (ACs), and natural gas heat pumps.

Table 17. Residential Emerging Technologies Included in Potential Study Model

MEASURE	KEY ASSUMPTIONS
Gas Heat Pump Water Heaters	**Measure definition**: Gas-fired heat pump water heater designed for residential applications with a 1.30 Uniform Energy Factor (UEF). **Baseline definition:** 0.62 UEF, minimum efficiency gas storage water heater. **Key assumptions:** For the multifamily market segment, there are a few important considerations. Firstly, it is critical that there be sufficient space around the GHPWH to allow for the needed quantities and movement of air to ensure rated performance of the heat pump. In multifamily circumstances where there were dedicated utility closets used for water heaters, an assurance of adequate amounts of space would be necessary. Secondly, these units are currently designed to be taller than conventional storage tank water heaters. Before a ROB replacement was installed, sufficient vertical clearance will need to be confirmed. If the multifamily site were to use a centralized system, it would likely be more of a hybrid-type arrangement, similar to the integrated GHPWH and A/C technology modeled in the commercial segment. Assumes 84 gallons of hot water use per day. Assumes an effective useful life of 10 years.
Through-the-Wall Condensing Furnaces/ACs	**Measure definition**: Through-the-wall (TTW) condensing system with code minimum 9.0 EER cooling system (minimum code schedule to increase to 11.0 EER on September 23, 2019) and a high-efficiency gas furnace with an AFUE of 90% or greater. **Baseline definition:** TTW unit with a cooling system that meets the current minimum 9.0 EER efficiency rating and a heating unit with an AFUE of 80% or less. **Key assumptions:** Through-the-wall condensing furnace/AC packages have been designed for cold-climate multifamily applications, and most multifamily residences do not have large individual cooling loads, meaning high efficiency cooling has not been a priority. Therefore, high efficiency cooling was not modeled in this measure. As such, the baseline and upgrade AC EER would be the same and the electric savings is assumed to be zero. Assumes 1,516.2 effective full load hours (EFLH) for multifamily applications. Assumes 40,000 Btu/hr capacity. Assumes effective useful life of 16.5 years.

MEASURE	KEY ASSUMPTIONS
Natural Gas Heat Pumps	**Measure definition**: Residential gas-fired, absorption heat pump system with a UEF of 1.30. **Baseline definition:** Standard efficiency, 80% AFUE natural gas-fired furnace and a minimum efficiency, 0.62 EF natural gas storage water heater. **Key assumptions:** Measure performance is based on a prototype system currently in development and expected for commercialization in 3-5 years. GTI's Source Energy and Emissions Analysis Tool (SEEAT) was used to model performance of the measure and baseline systems in a residential detached, 2-story home with 3 occupants located in Boise, Idaho.

COMMERCIAL MEASURES

AVAILABLE MEASURES

Table 18: Commercial Measure Sources

Measure Type	Measure Description	Source
Behavioral	Building Operator Certification O&M Only	MA TRM, October 2015. p.368 of 436.
Behavioral	Building Operator Certification O&M plus Capital Upgrades	MA TRM, October 2015. p.368 of 436.
Envelope	Attic/Roof Insulation Flat Roof	NB Power TRM - September 2017. * Used for kWh heating savings, adapted for GJ Savings
Envelope	Building Shell Air Sealing	Iowa TRM - July 12, 2017. 3.7.1. Infiltration Control

Measure Type	Measure Description	Source
Envelope	Green Roof	Energy intensity from the Commercial Buildings Energy Consumption Survey (CBECS): https://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption, https://www.eia.gov/consumption/commercial/data/2012/c&e/xls/e7.xlsx; Green roof planning study: http://www.mass.gov/eea/docs/doer/green-communities/library/green-roof-boston-st2009.pdf; Assumes incremental costs of $13.50/sq.ft. (mid way between the range of 12$ - 15$ per sq.ft.); Green roof calculator: https://sustainability.asu.edu/urban-climate/green-roof-calculator/ ; Discussion of leaf area index: http://energy-models.com/forum/leaf-area-index-values-roof-vegetation.
Envelope	Wall Insulation	NB Power TRM - September 2017. * Used for kWh heating savings, adapted for GJ Savings
Hot Water	Condensing Water Heater 2020	Measure based on 2020 upcoming regulation for condensing water heaters (https://www.nrcan.gc.ca/energy/regulations-codes-standards/19835) and Union Gas /Enbridge Gas Distribution - Updated DSM Measures and TRM; EB-2016-0246, p.94.
Hot Water	Hot Water Pipe Insulation	MA TRM, G19C2a024.
Hot Water	Indirect Water Heater	MA TRM, October 30, 2015. p. 353 of 435.
Hot Water	Low Flow Faucet Aerator	NY TRM, Version 5, July 17, 2017 Faucet - Low Flow Aerator, p. 198.
Hot Water	Low Flow Shower Head	IA TRM - September 2017. p. 50 of 376.
Hot Water	Pre-Rinse Spray Valve	NY TRM, Version 5, July 17, 2017. Low-Flow Pre-Rinse Spray Valve, p. 206. Standards: https://www.energy.gov/sites/prod/files/2015/12/f27/CPSV%20Final%20Rule.pdf

Measure Type	Measure Description	Source
Hot Water	Recirculation Pump with Demand Controls	Iowa TRM - Volume 3 Non-residential Measures, Jul7 12, 2017, FINAL, 3.2.4 Controls for Domestic Hot Water, p.60.
Hot Water	Tankless Water Heater	Union Gas /Enbridge Gas Distribution - Updated DSM Measures and TRM; EB-2016-0246. p.54.
HVAC	Advanced Thermostat (Wi-Fi Thermostat)	MA TRM - 2016-2018 Program Years; October 2015, HVAC - Programmable Thermostats, p. 250 and Mid-Atlantic TRM v8.0, Final, May 2018, Smart Thermostat, p.452.
HVAC	Air Curtains	Il TRM v5.0, vol.2, Feb. 11, 2016. Section 4.4.33. p.300 of 493.
HVAC	Boiler < 300 kBtu/h _ Tier I	Measure from Union Gas /Enbridge Gas Distribution - Updated DSM Measures and TRM; EB-2016-0246. p.10. Algorithm from Efficiency Maine C/I & Multifamily TRM, Version 2018.3, Effective Jan. 1, 2018, p. 67.
HVAC	Boiler >= 300 kBtu/h	Measure from Union Gas /Enbridge Gas Distribution - Updated DSM Measures and TRM; EB-2016-0246. p.10. Algorithm from Efficiency Maine C/I &Multifamily TRM, Version 2018.3, Effective Jan. 1, 2018, p. 67.
HVAC	Boiler < 300 kBtu/h- Tier 2	Measure and algorithm from Efficiency Maine C/I & Multifamily TRM, Version 2018.3, Effective Jan. 1, 2018, p. 67.
HVAC	Boiler >= 300 kBtu/h_Post 2024	Measure from Union Gas /Enbridge Gas Distribution - Updated DSM Measures and TRM; EB-2016-0246. p.10. Algorithm from Efficiency Maine C/I &Multifamily TRM, Version 2018.3, Effective Jan. 1, 2018, p. 67.
HVAC	Boiler Blowdown Heat Recovery	Derived from IA potential study - calculated from DOE tip sheet #10, 1/2006.
HVAC	Boiler Reset Control	MA TRM
HVAC	Boiler Shut Off Damper, Space Heating	Iowa TRM, vol.3, July 12, 2017. p. 149 of 376.
HVAC	Combo Condensing Boiler/Water Heater 90% AFUE	MA TRM, October 30, 2015. p.113 of 435.
HVAC	Combo Condensing Boiler/Water Heater 95% AFUE	MA TRM, October 30, 2015, p.113 of 435.

Measure Type	Measure Description	Source
HVAC	Condensing Make Up Air Unit with 2 Speed Motor	OEB TRM V3, 2018/12/03 p. 101
HVAC	Condensing Unit Heater	MA TRM, October 2015. p. 337.
HVAC	Demand Control Ventilation (DCV)	IL TRM - v.6.0 Vol. 2 - February 8th 2017, 4.4.19 Demand Controlled Ventilation (p.226) (algorithm, cost, EUL). NB Power DSM Plan 2019-2021. Appendix AC - TRM, September 2017 (EDR).
HVAC	Destratification Fan - High Efficiency	Commercial Destratification Fans, HVLS OEB TRM (not sure if it is published yet); IL TRM v7.
HVAC	Energy Management System (EMS)	Iowa PS measure characterization by Micheals Energy using data from the Michigan Energy Measures Database (MEMD). EUL from MA TRM.
HVAC	Energy Recovery Ventilator (ERV)	OEB TRM v3, 2018/12/03, Commercial - Incremental energy recovery ventilation (ERV) (no ERV baseline) - New construction/retrofit, p. 168 of 320.
HVAC	Furnace Shut Off Damper, Space Heating	Iowa TRM, vol.3, July 12, 2017. p. 149 of 376.
HVAC	Infrared Heater	REVISED - Gazifère Inc, PGEE 2019-2020 IL TRM - v.6.0 Vol. 2 - February 8th 2017, 4.4.12 Infrared Heaters (all sizes), Low Intensity (p.182).
HVAC	Kitchen Demand Control Ventilation	IL TRM v6.0, February 8th 2017, 4.2.16 Kitchen Demand Ventilation Controls, p. 72.
HVAC	Programmable Thermostat	MA TRM - 2016-2018 Program Years; October 2015, HVAC - Programmable Thermostats, p. 250.
HVAC	Steam Boiler Stack Economizer	IL TRM v6.0. Feb.8, 2017. p. 263 of 508.
HVAC	Steam Trap HVAC	Wisconsin Focus on Energy 2018 TRM.
HVAC	Ventilation Hoods	Online LBNL calculator: http://fumehoodcalculator.lbl.gov/ ; EUL: https://www.mountsinai.on.ca/education/staff-professionals/microbiology/microbiology-laboratory-manual/quality-manual/equipment/equipment-life-expectancy-qeqmi02004

Measure Type	Measure Description	Source
HVAC	Water Boiler Stack Economizer	IL TRM v6.0. Feb.8, 2017. p. 263 of 508.
Kitchen	Dishwasher	IOWA TRM - July 12, 2017.
Kitchen	Fryer	MA TRM 2015. p. 327 of 436.
Kitchen	Griddle	MN TRM 2017, p. 430 of 643.
Kitchen	Infrared Broiler	IA TRM, July 12, 2017.p. 274 of 376.
Kitchen	Oven Combination	MI measure database - Rack Oven Single.
Kitchen	Oven Convection - ENERGY STAR	MN TRM 2017, p. 424 of 643.
Kitchen	Oven Convection - High Efficiency	Mi Measure Database - Rack Oven Single.
Kitchen	Steamer High Efficiency	MA TRM, October 2015. p. 328.
Laundry	ENERGY STAR Clothes Dryer	New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs - Residential, Multi-Family and Commercial/Industrial Measures, Version 6. 2019. p. 171.
Laundry	ENERGY STAR Clothes Washer	IA TRM, July 12, 2017. p. 237 of 376.
New Construction	LEED Certified	Various / Professional Judgement (NBP Measure). * Used for kWh heating savings, adapted for GJ Savings.

Measure Type	Measure Description	Source
Other	Biodigester	Marcus Lauer et all. July 2018. Making money from waste: The economic viability of producing biogas and biomethane in the Idaho dairy industry. Kearney TE, Larkin MJ, Levett PN. The effect of slurry storage and anaerobic digestion on survival of pathogenic bacteria. J Appl Bacteriol 1993;74(1):86–93. Klavon KH, Lansing SA, Mulbry W, Moss AR, Felton G. Economic analysis of small-scale agricultural digesters in the United States. Biomass Bioenergy 2013; 54: 36–45. ICF International. Greenhouse gas mitigation options and costs for agricultural land and animal production within the United States; 2013. Option for sustainable heat use of biogas plants. http://www.biogasheat.org/wp-content/uploads/2013/06/4_WIP_Options_Sust_Heat_Use-.pdf. IDENTIFYING BARRIERS AND POTENTIAL SOLUTIONS TO FACILITATE ANAEROBIC DIGESTER PROJECTS IN IDAHO: ROUNDTABLE REPORT. April 2012, https://www.researchgate.net/publication/256064493_Identifying_Barriers_and_Potential_Solutions_to_Facilitate_Anaerobic_Digester_Projects_in_Idaho. https://articles.extension.org/pages/19461/economics-of-anaerobic-digesters-for-processing-animal-manure .
Other	Drain Water Heat Recovery (DWHR) Medium	IA TRM, September 21, 2017. 3.2.6 Drainwater Heat Recovery, p. 65.

Measure Type	Measure Description	Source
Other	Duct Insulation and Sealing	IA TRM, September 21, 2017 3.3.15 Duct Insulation. Temperature Data for ISLIP LONG ISL MACARTHUR AP: http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html MA Measure Characterization.
Other	Pool Cover	Iowa Energy Efficiency Statewide Technical Reference Manual. Volume 3: Non-residential Measures, July 12, 2017. Effective Jan 1, 2018. p.62.
Other	Pool Heater	DTE Energy, NG Efficiency Potential Study, July 29, 2016. https://energy.gov/energysaver/gas-swimming-pool-heaters https://www.michigan.gov/documents/mpsc/DTE_2016_NG_ee_potential_study_w_appendices_vFINAL_554360_7.pdf Capacity range of commercial pool heaters https://www.raypak.com/pool-and-spa/commercial-pool-heaters/ http://www.engineeringtoolbox.com/swimming-pool-heating-d_878.html
Process	Process Boiler - Steam	2017 Michigan energy measures database (excel file).
Process	Process Boiler - Water	2017 Michigan energy measures database (excel file).
Process	Process Boiler Tune Up	2017 Michigan energy measures database (excel file).
Windows	Efficient Windows	IA TRM 2017, 3.7.5 Efficient Windows, p.331 of 376.

EMERGING TECHNOLOGIES

The table below summarizes the key assumptions used for the 10 emerging technology measures considered in the commercial sector.

Table 19. Commercial Measures Included in Potential Study Model

MEASURE	KEY ASSUMPTIONS
High-Efficiency Unit Heaters	**Measure definition**: Condensing, gas-fired unit heater with a thermal efficiency of 0.93. **Baseline definition:** Non-condensing, gas-fired unit heater with a standard thermal efficiency of 0.80. **Key assumptions:** There is a wide range in runtimes for unit heaters – with those conditioning interior zones typically having shorter runtimes (250 annual hours of runtime or less) than those conditioning building perimeter zones (2,500 annual hours of runtime or more). This measure is ideally suited for factories, warehouses, service shops, and some limited "big box" retail stores, etc. These buildings typically have high ceilings and open floor plans. Wider temperature variations are tolerated than in office or school spaces; frequently there is no air conditioning, and sometimes there is only enough heating service to prevent freezing. Assumes effective useful life of 12 years.
Modulating Dryer Retrofits	**Measure definition**: Gas-fired clothes dryer fitted with a post-OEM modulating retrofit. **Baseline definition:** Non-modulating, gas-fired clothes dryer. **Key assumptions:** Targets dryers with capacities of 30-250 pounds. Primary markets that could benefit from this technology are commercial on-premise laundry (OPL) such as laundromats, hospitality, healthcare facilities (nursing homes, hospitals, etc.), prisons, and commercial laundry services. This technology could be used in multifamily buildings as well. Assumes effective useful life of 14 years.
Combination Ovens	**Measure definition**: Combination oven/steamer unit operating at 35% efficiency in oven mode and 20% efficiency in steam mode. **Baseline definition:** Standard 30% efficient, gas-fired, full-size convection oven. **Key assumptions:** Assumes a combination oven/steamer with a 20-pan capacity for this model. Assumes 12 hours of use per day with 50% of the time in steam mode operation. Assumes 250 pounds of food cooked per day. Assumes effective useful life of 12 years.

MEASURE	KEY ASSUMPTIONS
Low-Oil Volume Fryers	**Measure definition**: Standard-sized open deep-fat, gas-fired low oil volume fryer (30 pounds of oil) operating at 56% efficiency. **Baseline definition:** Standard open deep-fat, gas-fired fryer (50 pounds of oil) used in commercial foodservice establishments operating at 40% efficiency. **Key assumptions:** It is important to note that the cost savings of reduced oil usage aren't captured in the energy savings analysis but are expected to be significant. This cost reduction can be even greater if the restaurant is seeking to use (and promote their use of) trans-fat free oils, which are usually more expensive but have become increasingly popular in the past 5 years. The oil savings are based on the average oil savings amounts at six restaurant sites that were monitored as part of a confidential GTI project. Assumes fryer is operating 14 hours/day and 150 pounds of food is cooked daily. Assumes the owning establishment operates 360 days/year. Assumes effective useful life of 12 years.
Condensing RTUs	**Measure definition**: Condensing, warm air furnace with a natural gas thermal efficiency (TE) rating of 90% or higher, or alternatively, the unitary package must have equipment nameplate information for natural gas that identifies a heating output and heating input rating that has an output over input ration of 0.90 or higher. The furnace must be vented and condensate disposed of in accordance with the equipment manufacturer installation instructions and applicable codes. **Baseline definition:** Non-condensing, warm air furnace with a natural gas TE rating of 80% or alternatively, the unitary package will have equipment nameplate information for natural gas that identifies a heating output and heating input rating that has an output over input ratio of 0.80. **Key assumptions:** Condensing RTU system may also require a neutralization system for condensate drainage. The requirement for this is often left up to the local jurisdiction. The annual cost of such a system tends to be small (~$65/yr) and was not included in the costs used in this analysis. Assumes effective useful life of 15 years.

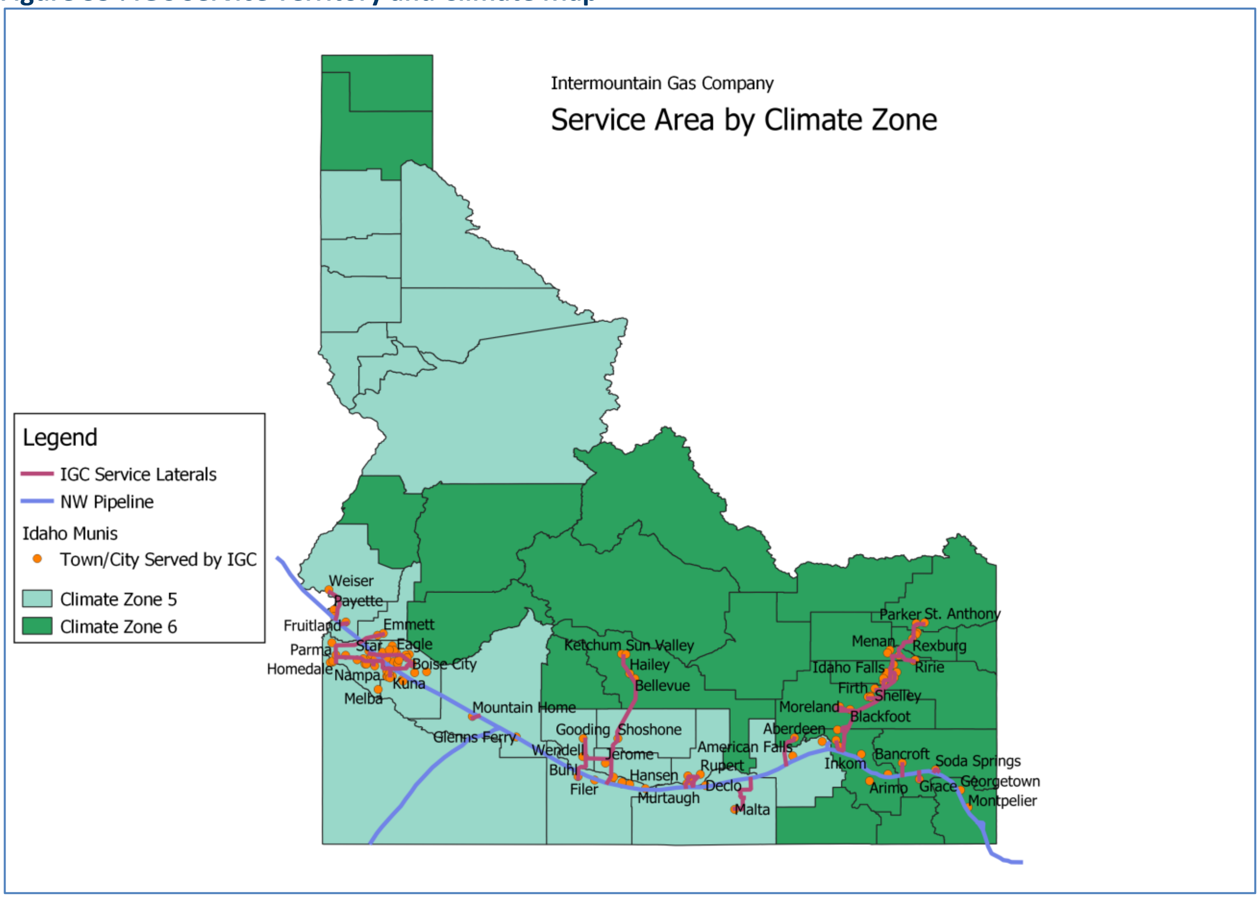
MEASURE	KEY ASSUMPTIONS
Natural Gas AC and Heat Pumps	**Measure definition**: Integrated gas heat pump water heater with space cooling operating with 140% AFUE. **Baseline definition:** A standard 80% AFUE/thermal efficiency commercial gas-fired water heating system as well as 14 SEER space cooling system. **Key assumptions:** The analysis focuses on the application of this technology to the commercial foodservice market, where there are sizable hot water loads as well as the need for some limited, concurrent space cooling. This is an excellent first market for this technology. Measure is based on a prototype unit still under active development and is subject to change based on future refinements in design and features. Assumes 2,500 gallons of hot water used per day. Assumes water heating operates 14.7 hours per day for 360 days per year. Assumes space cooling operates 10 hours per day for 151.5 days per year. Assumptions of measure performance are based on laboratory and field research to date. Assumes effective useful life of 14 years.
Natural Gas Engine Heat Pump Water Heaters	**Measure definition**: Natural gas, engine-driven, air-source heat pump water heater that captures and repurposes waste heat with a 1.2 to 1.8 coefficient of performance (COP), with an overall COP of 1.34. **Baseline definition:** Conventional gas-fired boiler with an efficiency of 0.671 DHW/ .731 HHW. **Key assumptions:** This analysis assumes application in one of the primary target markets with sufficient high hot water usage to ensure economic attractiveness, such as pool facilities, gymnasiums, inpatient healthcare, etc. The assumptions are based on the technology as designed in the Tecogen Ilios gas engine heat pump water heater. It is very important to note that energy savings for this technology are highly customized to the specific application. Hot water usage profiles, storage capacity, ambient temperatures, and a number of other factors affect performance and savings. For this analysis, a simple hybrid installation arrangement is assumed, with a conventional gas boiler providing back-up at times of especially high usage. It assumes limited need for adjustment or customization and that the companion boiler is already on-site and in working condition, i.e., no new equipment or installation costs associated with the conventional boiler. The heat pump is sized with a capacity closer to base load than peak load, which maximizes its use and efficiency. It assumes the technology is used for a multi-story residential-type living facility with approximately 180,000 square feet located in ASHRAE climate zone 4C. Assumes effective useful life of 20,000 hours per engine.

MEASURE	KEY ASSUMPTIONS
Efficient Cookware	**Measure definition**: Fin-bottomed stock pot. **Baseline definition:** Standard 12-inch diameter aluminum stock pot with a 24-quart capacity. **Key assumptions:** Assumes the improved heat transfer to the measure unit provides 50% cooking-energy efficiency as compared to the 27.5% cooking-energy efficiency for the standard pot. Performance based on laboratory testing completed at the Pacific Gas & Electric Foodservice Technology Center in 2008. Assumes effective useful life of 3 years.
Destratification Fans	**Measure definition**: This measure is for the installation of large diameter High Volume Low Speed (HVLS) destratification fans in warehouse-type spaces with high ceilings (retrofit only). **Baseline definition:** The HVLS fans are installed in buildings affected by destratification and where no other mechanisms that combat destratification are present. **Key assumptions:** The HVLS fans are designed to destratify the whole space. It is assumed that the building is heated by natural gas forced air space heating system including unit heaters operating without night setbacks. Assumes a useful life of 15 years. Assumes 4,880 heating hours per year on a 55°F basis, a heat transfer coefficient of 0.05 Btu/°F.h.ft^2 for the roof and 0.062 Btu/°F.h.ft^2 for the walls. Assumes a heating system efficiency of 80%.
Biodigesters	**Measure definition**: This measure consists of installing a biodigester in Idaho dairy farms with more than 3,000 cows. **Baseline definition:** Dairy farm without a biodigester on site. **Key assumptions:** Assumes installation of a biodigester (on-site use) combined with a CHP system to convert the biogas. The measure does not account for operation and maintenance costs and for any additional benefits for the farm such as selling of supplemental heat or electricity. Assumes a useful life of 15 years. Assumes the following efficiencies: 74% for the digester, 48% for heat conversion and 37% for electricity conversion. Assumes the production of 2m^3 of biogas per cow per day and 8,000 operating hours per farm.

APPENDIX D. CLIMATE ZONE MAP

The IGC Potential Model will takes into considerations the two climate zones where IGC's customers are located. Specifically, the customer database was segmented into the respective climate zones, based on the following climate zone map.

Figure 35 : IGC Service Territory and Climate Map



For weather-dependent measures (heating system upgrades, insulations, etc.), each measure is distinctly included in the model to capture different saving levels for participants in each climate zone. Several of our measure characterizations are algorithm based, and explicitly take into considerations the heating degree days (HDD) to calculate savings; these measures will use the relevant HDDs for each zone, as presented in Table 20 below. Cooling Degree Days were also used for measures with secondary cooling impacts.

Table 20: Average HDD and CDD per Climate Zone (2011-2017)

Zone	HDDs	CDDs
Boise (Zone 5)	5,561	1,416
Idaho Falls (Zone 6)	7,737	799

For other climate dependent measures not explicitly using HDDs as part of their algorithm to calculate savings, state-wide averages were corrected based on the ratio of HDD in the target zone to the statewide average.

APPENDIX E. DSM PROGRAM CHARACTERIZATION DETAILS AND MODEL INPUTS

Table E-1: IGC Program Model Inputs Low Scenario

Initiative Name	Fixed Costs	Variable Costs ($/therm)	Percent Incentive	CE Threshold
Efficient New Home	90,000	0.42	35%	1
Existing Homes Incentives	1,000,000	0.73	35%	1
Home Energy Report	235,011	0.01	100%	1
Commercial Equipment Program	247,381	0.26	35%	1
Commercial Retrofit	325,000	0.46	35%	1

Table E-2: IGC Program Model Inputs Base Scenario

Initiative Name	Fixed Costs	Variable Costs ($/therm)	Percent Incentive	CE Threshold
Efficient New Home	90,000	0.42	50%	1
Existing Homes Incentives	1,000,000	0.73	50%	1
Home Energy Report	235,011	0.01	100%	1
Commercial Equipment Program	247,381	0.26	50%	1
Commercial Retrofit	325,000	0.46	50%	1

Table E-3: IGC Program Model Inputs Max Scenario

Initiative Name	Fixed Costs	Variable Costs ($/therm)	Percent Incentive	CE Threshold
Efficient New Home	99,000	0.46	65%	1
Existing Homes Incentives	1,100,000	0.80	65%	1
Home Energy Report	258,512	0.012	100%	1
Commercial Equipment Program	272,119	0.29	65%	1
Commercial Retrofit	370,000	0.51	65%	1

APPENDIX F. UCT RESULTS BY MEASURE

IGC_CPA_App F.xlsx

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