PACIFIC NORTHERN GAS LTD.
and
PACIFIC NORTHERN GAS (N.E.) LTD.

Application to the
British Columbia Utilities Commission
for Approval of Energy Conservation and Innovation (ECI)
Portfolio Funding for 2023 and 2024

August 12, 2022

Table of Contents

1 APPLICATION 1
1.1 Summary 1
1.2 Applicant 2
1.3 Requested Approvals 3
1.4 Regulatory Process 5
2 OVERVIEW 6
2.1 Summary 6
3 REGULATORY AND POLICY FRAMEWORK 8
3.1 Previous Applications 8
3.2 CleanBC Roadmap to 2030 9
3.3 Alignment with Consolidated Resource Plan 10
3.4 Alignment with BC DSM Regulation 11
3.5 Responding to BCUC Directives 13
4 PNG CURRENT STATE 14
4.1 PNG Service Territory and Operating Environment 14
4.2 Current ECI Delivery Partners 15
4.3 Current ECI Stakeholders 16
5 IDENTIFYING AND EVALUATING POTENTIAL ECI PROGRAMS 18
5.1 Introduction 18
5.2 ECI Guiding Principles 18
5.3 PNG ECI Program Market Intelligence 19
6 ECI PORTFOLIO FOR 2023 - 2024 30
6.1 Introduction 30
6.2 Updates to the Assumptions in the Cost Effectiveness Model 30
6.3 Program Design Assumptions 32
6.4 Residential Program Area 32
6.5 Income Qualified Program Area 39

6.6 Commercial Program Area 44
6.7 Energy Transformation Program Area 53
6.8 Enabling Activities 62
7 PORTFOLIO ANALYSIS 64
7.1 A Portfolio Approach to Program Cost Effectiveness 64
7.2 Portfolio Alignment with Guiding Principles 65
8 BUDGET SUMMARY AND CUSTOMER IMPACTS 69
8.1 Customer Bill and Rate Impacts 73
9 OTHER MATTERS 75
9.1 Funding Transfer Rules 75
9.2 Deferral Treatment and Amortization 75
9.3 Metrics 77
APPENDICES 79
APPENDIX A: DRAFT ORDER
APPENDIX B: 2021 CONSERVATION POTENTIAL REVIEW
APPENDIX C: CUSTOMER BILL IMPACTS
APPENDIX D: AVERAGE MEASURE LIFE OF THE 2023-2024 ECI PORTFOLIO
APPENDIX E: FALL 2021 MEDIA CAMPAIGN REPORT

1 APPLICATION

1.1 Summary

In this application (Application), Pacific Northern Gas Ltd. and Pacific Northern Gas (N.E.) Ltd. (collectively, PNG) are seeking British Columbia Utilities Commission (BCUC) acceptance pursuant to Section 44.2(3) of the *Utilities Commission Act* (UCA) of the expenditure schedule for PNG's Energy Conservation and Innovation (ECI) portfolio as set out in Table 1 (2023-2024 ECI schedule of expenditures). Expenditures over the two-year period from 2023 to 2024 fund the continuation of PNG's ECI portfolio of current programs and initiatives, as well as an expansion of the ECI portfolio beginning in 2023. The analysis supporting PNG's proposed 2023-2024 ECI schedule of expenditures is found in this Application.

The CleanBC "Roadmap to 2030" released by the Province of British Columbia (the Province) on October 25, 2021 lays out the role the natural gas delivery system will play to help meet the Province's target of a 40% reduction in greenhouse gas (GHG) emissions from all sectors of the BC economy by 2030, as compared to emissions in 2007. More specifically, the Province has proposed a cap on GHG emissions associated with natural gas consumed in buildings and industrial processes of 6.11 $MtCO_{2e}$ in 2030. This cap is equivalent to a reduction in emissions associated with natural gas consumption in those sectors of approximately 45%, as compared to 2018.

PNG is currently developing and executing its Low Carbon Strategy that is based on a portfolio of initiatives that are intended to meet the Province's GHG reduction target in the most cost-effective manner possible. The ECI portfolio is a key element of this strategy, and the expansion of the ECI portfolio presented in this Application is an important step towards increasing the impact that the portfolio has on reducing GHG emissions associated with natural gas consumption by PNG's customers.

Table 1: ECI Proposed Schedule of Expenditures

	2023 (Budget)	2024 (Budget)	Total Budget (2023 - 2024)
Total Expenditures	**$ 1,679,288**	**$ 2,131,164**	**$ 3,810,452**

1.2 Applicant

PNG owns and operates the PNG-West natural gas transmission and distribution system in west central British Columbia. The pipeline system commences at Summit Lake, just north of Prince George, and extends west to the deep water ports of Prince Rupert and Kitimat. PNG-West serves approximately 20,400 natural gas customers in these communities as well as in Port Edward, Terrace, Smithers, Telkwa, Houston, Burns Lake, Fraser Lake, Fort St. James and Vanderhoof. PNG-West also serves approximately 130 propane customers in the community of Granisle, B.C.

PNG is the parent company of Pacific Northern Gas (N.E.) Ltd. (PNG(NE)) which owns and operates natural gas distribution systems and a gas processing plant in northeastern British Columbia. PNG(NE) provides service to approximately 21,500 natural gas customers in the communities of Fort St. John, Dawson Creek and Tumbler Ridge.

PNG is a company formed under the laws of British Columbia and is a wholly-owned subsidiary of TriSummit Utilities Inc. (TSU), the owner of a number of Canadian utilities and renewable power infrastructure assets. PNG's head office is located at Suite 750, 888 Dunsmuir Street, Vancouver, British Columbia.

The PNG-West and PNG(NE) transmission and distribution systems are presented in Figure 1.

Figure 1: Overview of the PNG and PNG(NE) Natural Gas Pipeline Systems

1.2.1 Principal Contact

All notices and other communications in connection with this Application should be directed to:

Verlon Otto, Director Regulatory Affairs
Pacific Northern Gas Ltd.
Suite 750, 888 Dunsmuir Street
Vancouver, British Columbia V6C 3K4
Tel: 604-697-6218
Fax: 604-697-6210
E-mail: votto@png.ca

And copied to PNG's alternate contact:

Gordon Doyle, Vice President Regulatory Affairs, Legal & Gas Supply
Pacific Northern Gas Ltd.
Suite 750, 888 Dunsmuir Street
Vancouver, British Columbia V6C 3K4
Tel: 604-691-5680
Fax: 604-697-6210
E-mail: gdoyle@png.ca

1.3 Requested Approvals

Schedule of Expenditures

PNG is seeking BCUC acceptance pursuant to Section 44.2(3) of the UCA, of the 2023-2024 ECI schedule of expenditures as set out in Table 1.

In order for the BCUC to accept a schedule of expenditures, the BCUC must find that the schedule is consistent with the public utility's intentions to pursue adequate, cost-effective demand-side measures (DSM), where adequacy and cost-effectiveness are defined through the Demand-Side Measures Regulation (DSM Regulation).

PNG's ECI portfolio currently consists of initiatives that, collectively, meet the adequacy requirements as set out in section 3 of the DSM Regulation. PNG has received approval for the expenditures for these initiatives for the period 2020 to 2022 by way of Order G-265-20. In the current request, PNG proposes to continue initiatives that meet the adequacy requirements.

Pursuant to UCA section 44.2(5)(d), the BCUC must consider whether the demand-side measures are cost-effective within the meaning prescribed by regulation. Section 4 of the DSM

Regulation sets out the cost- effectiveness criteria, referencing the Total Resource Cost (TRC) test, and the modified TRC (mTRC) test which includes an adder for non-energy benefits. The BCUC may determine cost-effectiveness at a program or portfolio level, subject to section 4(1) of the DSM Regulation, and up to 40% of the qualifying portfolio expenditure may be determined to be cost-effective using the mTRC. PNG submits that its ECI programs are cost-effective on a portfolio basis under the mTRC test prescribed in the DSM Regulation.

PNG submits that its schedule of expenditures enabling the continuation and expansion of PNG's ECI portfolio is aligned with achieving BC's Energy Objectives that include conserving energy and reducing GHG emissions.

Finally, PNG submits that the proposed schedule of expenditures is in the interests of customers and potential customers as they encourage energy efficiency and conservation, reduce GHG emissions, and are cost effective. Individual consumers that avail themselves of ECI initiatives will reduce their natural gas consumption and their natural gas bills.

For the reasons set out above, PNG submits that the proposed schedule of expenditures for PNG's ECI portfolio for 2023 and 2024 are in the public interest and in the interest of persons who receive or may receive service from PNG. PNG respectfully submits that the proposed schedule of expenditures meets the requirements of the UCA and should be accepted as filed pursuant to Section 44.2(3) of the UCA.

Funding Transfer Rules

In addition, PNG requests that the BCUC grant approval allowing PNG flexibility in the reallocation of expenditures amongst ECI programs and between program years, subject to the total amount spent by PNG on ECI activities between the date of approval and December 31, 2024 not exceeding the total amount of $3,810,452 sought in this Application, unless otherwise approved by the BCUC. PNG proposes to continue the program funding transfer rules that were approved under Order G-265-20.

Deferral Treatment

PNG is also seeking an order that all expenditures as set out in Table 1 are to be recorded in a rate base regulatory asset deferral account. Lastly, PNG is seeking an order setting the amortization period to ten years for all expenditures charged to this regulatory asset deferral account, an increase from the five year amortization period that was approved for ECI expenditures over the period 2020-2022 under Order G-265-20. For the reasons presented in

Section 9.2**Error! Reference source not found.**, PNG submits that an amortization period of ten years more closely reflects the actual lives of measures funded by the 2023 to 2024 ECI schedule of expenditures, and that a period of ten years is consistent with the amortization period approved by the BCUC for FortisBC Energy Inc.'s (FEI's) DSM expenditures.

A draft order of approvals sought in this Application is attached as Appendix A.

1.4 Regulatory Process

PNG proposes a written review process for this Application, with one round of information requests, under the timetable proposed in Table 2.

Table 2: Requested Regulatory Timetable

Regulatory Timetable Action	Date
Registration of Interveners and Interested Parties	September 9, 2022
BCUC and Intervener Information Request No. 1	September 30, 2022
PNG Response to Information Request No. 1	October 14, 2022
PNG Final Submission	October 21, 2022
Intervener Final Submission	November 4, 2022
PNG Reply Submission	November 18, 2022
Anticipated BCUC Approval	December 31, 2022

2 OVERVIEW

2.1 Summary

PNG has prepared a schedule of expenditures related to PNG's ECI portfolio that will fund the continuation of PNG's current programs and initiatives, and significantly expands the range of programs offered to residential, commercial and industrial customers in 2023 and 2024.

This Application presents the case for an increase in investment in PNG's ECI portfolio to increase participation in, and overall awareness of, PNG's ECI programs, and to reduce GHG emissions associated with the combustion of natural gas.

Consistent with the presentation in its 2020-2022 ECI Portfolio Funding Application, PNG continues to organize its ECI portfolio into the residential, commercial, and conservation education and outreach (CEO) program areas, with the CEO program area now renamed as the "energy transformation" program area.[1] In this Application, PNG has included additional programs in both the residential and commercial program areas, and created a new, "income qualified" program area that encompasses existing as well as new programs.

Table 3 provides an overview of the 2023-2024 ECI Portfolio budget by program area. Enabling Activities support delivery and development of PNG's ECI programs in general and cannot be directly assigned to any one program or program area.

PNG's 2023-2024 ECI Portfolio supports a balanced approach that delivers rebates and incentives to all customer classes, and raises awareness and supports energy decarbonization activities through education, marketing and pilot projects.

The constituent programs in each of the four program areas are presented in Section 6.

[1] The 2020-2022 ECI Portfolio Funding Application was filed along with PNG's 2019 Consolidated Resource Plan (2019 CRP) and subsequently approved under Order G-265-20.

Table 3: ECI Program Portfolio Cost Summary

Program Area	2023 (Budget)	2024 (Budget)	Total Budget (2023 - 2024)	Portion
Residential	$ 275,957	$ 450,600	$ 726,557	19%
Income Qualified	$ 193,662	$ 193,662	$ 387,323	10%
Commercial	$ 487,169	$ 491,903	$ 979,072	26%
Energy Transformation	$ 610,000	$ 820,000	$ 1,430,000	38%
Enabling Activities	$ 112,500	$ 175,000	$ 287,500	8%
Total Expenditures	**$ 1,679,288**	**$ 2,131,164**	**$ 3,810,452**	**100%**

3 REGULATORY AND POLICY FRAMEWORK

3.1 Previous Applications

On September 16, 2014, by Order G-140-14, the BCUC accepted PNG's first consolidated DSM plan for PNG-West and PNG(NE) whereby PNG proposed a limited initial DSM portfolio of programs meeting the adequacy requirements of the DSM Regulation. On December 16, 2015, by way of Order G-203-15A, the BCUC accepted PNG's first expenditure schedules related to the ECI Program in the amount of $1.24 million for calendar years 2015 through 2018.

In providing this acceptance, the BCUC noted this was a first step only and provided several recommendations and directives to PNG for expanding the scope and breadth of its DSM programs and improving the effectiveness of the portfolio.[2]

On December 21, 2018, PNG filed an application with the BCUC pursuant to section 44.2(1)(a) of the UCA for approval of expenditures in the amount of $827,000 that would allow the existing ECI Program to be extended for a further two years to 2020. In its application, PNG submitted revised forecast expenditures, based on actual expenditures for existing programs and supporting activities, and revised forecasts of demand for these programs. In response to changes to the adequacy requirements of the DSM Regulation, PNG proposed additional programs that support the development of standards related to energy conservation and energy efficiency, promote the adoption by local governments and Indigenous Communities of the Energy Step Code, and support the development and adoption of new technologies. PNG also proposed a new Residential Furnace and Boiler Replacement program designed to meet the needs of the underserved residential market in response to some of the recommendations and directives that the BCUC provided in Order G-203- 15A.

On June 6, 2019, in Order G-121-19, the BCUC rejected the Residential Furnace and Boiler Replacement program proposed by PNG along with the costs associated with that program. The BCUC directed PNG to file a revised ECI expenditure schedule for 2019 through 2020 adjusted for the exclusion of the costs associated with the Residential Furnace and Boiler Replacement program. The BCUC also directed "PNG to include in its next DSM plan and related expenditure schedule applications, a review and discussion of new programs for new

[2] Decision and Order G-203-15A, p. i.

construction, under-served markets, and cost-effective programs identified in the [Conservation Potential Review] CPR."[3]

On October 31, 2019, PNG filed an application with the BCUC pursuant to section 44.2(1)(a) of the UCA for approval of expenditures totalling $2,278,000 related to the ECI portfolio for 2020 that were in addition to those previously accepted by way of Order G-121-19 and expenditures for two additional years (2021 and 2022) to fund an expanded ECI portfolio.

On October 23, 2020, in Order G-265-20, the BCUC accepted PNG's Application for ECI Portfolio Funding for 2020 to 2022. In this Order, the BCUC directed PNG, "to include an analysis of bill and rate impacts relating to all customer groups in future DSM/ECI Plans."[4]

3.2 CleanBC Roadmap to 2030

The CleanBC "Roadmap to 2030" released by the Province on October 25, 2021 lays out the role the natural gas delivery system will play to help meet the Province's target of a 40% reduction in GHG emissions from all sectors of the BC economy by 2030, as compared to emissions in 2007.

PNG understands that the Province is contemplating legislation to impose a mandatory requirement on natural gas utilities to reduce the GHG emissions associated with natural gas consumed in buildings and industrial processes of their customers to, or below, a defined emissions cap by 2030. The cap proposed by the Province is set at 6.11 MtCO2e, consistent with the Province's legislated sectoral targets for the built environment and industrial sectors (excluding upstream natural gas) (the GHG Reduction Standard). This cap is equivalent to a reduction in emissions associated with natural gas consumption in those sectors of approximately 45%, as compared to 2018.

PNG is currently developing and executing its Low Carbon Strategy in response to the evolving regulation and guidance on the GHG Reduction Standard and pathways to achieving it.

PNG's Low Carbon Strategy consists of a portfolio of initiatives that are intended to achieve the GHG Reduction Standard by 2030 in the most cost-effective manner possible. The ECI portfolio is a key element of this strategy, and the expansion of the ECI portfolio presented in

[3] Decision and Order G-121-19, p. 25.

[4] Decision and Order G-265-20, p. 24.

this Application is an important step towards increasing the impact that the portfolio has on reducing GHG emissions associated with natural gas consumption by PNG's customers.

The other two elements of PNG's Low Carbon Strategy include: (i) the delivery of Low Carbon Energy (LCE) such as biomethane and hydrogen that replaces natural gas produced from fossil resources (Conventional Natural Gas); and (ii) projects that result in the avoidance of GHG emissions into the atmosphere, or the outright removal of GHG's from the atmosphere with permanent sequestration in biological or geological reservoirs.

PNG is building a portfolio of LCE supplies that replaces a small portion of PNG's existing natural gas supply portfolio and reduces the GHG emissions associated with the consumption of natural gas delivered to PNG's own facilities, as well as to its customers. The LCE supply portfolio and associated rate design is the subject of a continuing BCUC proceeding.[5]

While not currently explicitly enabled by the DSM Regulation or by the Greenhouse Gas Reduction Regulation (GGRR), PNG nevertheless is advocating for the acceptance of GHG emissions reduction or removal projects as another pathway to meeting emissions reduction compliance obligations under an eventual mandatory GHG Reduction Standard.

3.3 Alignment with Consolidated Resource Plan (CRP)

When considering whether to accept a utility's expenditure schedule under section 44.2 of the UCA, the BCUC must consider the utility's most recent long-term resource plan filed under section 44.1 of the UCA.

As part of its 2019 CRP, and in compliance with the provisions of subsection 44.1(2) (b) of the UCA which requires a public utility to file a long-term resource plan that includes a plan of how the public utility intends to reduce demand by taking cost-effective demand-side measures, PNG prepared a DSM plan for the period 2020 to 2022 related to ongoing and proposed programs and initiatives under its ECI Program. Concurrent with the filing of its 2019 CRP and 2019 DSM Plan, PNG requested BCUC approval of a schedule of expenditures for the period 2020 to 2022 for its ECI portfolio of programs and initiatives identified in its 2019 DSM Plan.

[5] On November 17, 2021, PNG submitted its Application for Approval of a Low Carbon Energy Cost Recovery Mechanism and Biomethane Purchase Agreements to the BCUC. The biomethane purchase agreements have been approved under Order E-7-22 and the LCE cost recovery mechanism remains under review in a second phase of the proceeding.

Both the 2019 CRP and the 2019 DSM Plan and schedule of expenditures were approved under Order G-265-20.

The 2023-2024 ECI schedule of expenditures as set out in Table 1 continues funding for the programs and initiatives identified in the 2019 DSM Plan and expands the scope of programs available to PNG's customers. For this reason, the 2023-2024 ECI schedule of expenditures is consistent with the 2019 CRP.

In compliance with Order G-265-20, PNG intends to submit its next CRP (2023 CRP), including its next DSM plan (2023 DSM Plan), on or before December 31, 2023.[6] Upon receiving approval, PNG then anticipates filing its next ECI schedule of expenditures for the period 2025 onwards that implements some or all of the initiatives identified in the 2023 DSM Plan.

3.4 Alignment with BC DSM Regulation

PNG's ECI portfolio must be adequate for the purposes of section 44.1(8) of the UCA. Table 4 lists the adequacy requirement of the DSM Regulation in the left column and provides reference to how PNG's ECI portfolio meets the requirement in the right column.

Table 4: Review of Adequacy Requirements

DSM Regulation Adequacy Requirement	ECI Portfolio (Reference Sections)
a) a demand-side measure intended specifically i. to assist residents of low-income households to reduce their energy consumption, or ii. to reduce energy consumption in housing owned or operated by (A) a housing provider that is a local government, a society as defined in section 1 of the Societies Act, other than a member-funded society as defined in section 190 of that Act, or an association as defined in section 1 (1) of the Cooperative Association Act, or (B) the governing body of a first nation, if the benefits of the reduction primarily accrue to (C) the low-income households occupying the housing,	Income Qualified Program Area (Section 6.5) Income Qualified Efficient Heating (Section 6.5.1) Energy Conservation Awareness Program (Section 6.5.2) Energy Saving Kits (Section 6.5.3)

[6] Decision and Order G-265-20, p. 40.

DSM Regulation Adequacy Requirement	ECI Portfolio (Reference Sections)
(D) a housing provider referred to in clause (A), or (E) a governing body referred to in clause (B) if the households in the governing body's housing are primarily low- income households	
b) if the plan portfolio is submitted on or after June 1, 2009, a demand-side measure intended specifically to improve the energy efficiency of rental accommodations	PNG interprets section 3(1)b of the DSM Regulation as referring to a demand-side measure aimed at rental accommodations, rather than directly at rental residents. In PNG's view the existing Commercial programs (Section 6.6), which are available to owners and operators of rental buildings, meet the adequacy requirements of the DSM Regulation. In Order G-121-19, the BCUC agreed with PNG's position and found "that the ECI expenditure schedule is adequate within the meaning prescribed by the DSM Regulation."[7]
c) an education program for students enrolled in schools in the public utility's service area	K-12 Conservation and Outreach: Energy is Awesome (Section 6.7.2)
d) if the plan portfolio is submitted on or after June 1, 2009, an education program for students enrolled in post-secondary institutions in the public utility's service area.	Post-Secondary Conservation Education and Outreach (Section 6.7.3)
e) one or more demand-side measures to provide resources as set out in paragraph (e) of the definition of "specified demand-side measure", representing no less than i. an average of 1% of the public utility's plan portfolio's expenditures per year over the portfolio's period of expenditures, or ii. an average of $2 million per year over the portfolio's period of expenditures	Innovation (Section 6.7.6.3)

[7] Reasons for Decision and Order G-121-19, p.15.

DSM Regulation Adequacy Requirement	ECI Portfolio (Reference Sections)
f) one or more demand-side measures intended to result in the adoption by local governments and first nations of a step code or more stringent requirements within a step code.	Codes and Standards (Section 6.7.5)

3.5 Responding to BCUC Directives

On October 23, 2020, the BCUC issued Decision and Order G-265-20 following consideration of PNG's Application for Acceptance of its 2019 Consolidated Resource Plan and for Acceptance of Energy Conservation and Innovation (ECI) Portfolio Funding for 2020 to 2022. The BCUC directives and PNG's response to these directives are listed in Table 5**Error! Reference source not found.** below.

Table 5: PNG Response to BCUC Directives

BCUC Directive	PNG Response
"The Panel considers the missing information from Order G-155-15 is still relevant, and therefore directs PNG to include an analysis of bill and rate impacts relating to all customer groups in future DSM/ECI Plans."[8]	The results of this analysis are found in Section 8.
"In the interest of ensuring greater transparency, the Panel directs PNG to report on the following in its Annual Report filed with the BCUC: (i) all transfers of DSM funds from one program area to another program area; and (ii) all transfers of unspent DSM funds from one program to the same program in the following year"[9]	PNG filed its Annual Report for 2021 with the BCUC on May 16, 2022.

[8] Decision and Order G-265-20, p. 24.

[9] Decision and Order G-265-20, p. 52.

4 PNG CURRENT STATE

4.1 PNG Service Territory and Operating Environment

PNG's ECI portfolio is available to all customers in service territories, including the PNG-West division and the PNG(NE) Fort St. John/Dawson Creek and Tumbler Ridge divisions.

PNG's service territories present unique challenges and opportunities for implementing energy efficiency programs. Owing to PNG's low customer density, its ECI programs do not benefit from the economies of scale found in larger jurisdictions. PNG serves over 40,000 customers in approximately 20 cities and towns along over 1,100 km of highway from Dawson Creek to Prince Rupert. Only five cities in PNG's service territory have populations over 10,000. The low density of customers across PNG's service areas challenges the development of cost-effective programs involving trained contractors and energy advisors:

- Because customers tend to be further apart, travel costs are high.
- Travel between and within cities and towns can be difficult during inclement winter weather from October to April.

Additionally, resources needed to deliver ECI programs in the region are less available and can be at higher cost than in larger urban centres:

- Fewer contractors servicing the area.
- Equipment may not be accessible and must also be shipped further for distribution.
- The number of contractors skilled in energy efficient construction and appliance installations, along with associated training opportunities to build this workforce are limited.

The low rate of development across PNG's service areas challenges the feasibility of programs aimed at the new construction sector with new home starts that average less than 200 per year.

Traditional assumptions from DSM industry research may not always apply. Specifically, while buildings and homes are right sized for the communities in PNG's service territory, they may be different in their construction and size from the archetypes used in industry research.

4.2 Current ECI Delivery Partners

As a small utility with approximately 130 staff, PNG does not have a manager who is fully dedicated to the management of the ECI program. The Manager, Energy Solutions is responsible for the development and execution of the ECI programs, and they rely, in turn, on a team of partners and consultants that provide strategic and implementation support as identified in the discussion below.

4.2.1 Strategic Support

Harbourgreene Consulting Inc.

Harbourgeene is an energy management consulting practice. Christine Gustafson, P.Eng., MBA, CEM, is the principal consultant at Harbourgreene Consulting Inc. and has 20 years of experience as a strategic energy management consultant and utility professional. Ms. Gustafson provides support as needed to PNG's Manager, Energy Solutions.

Ecolighten Energy Solutions

Ryan Coleman is the founder and CEO of Ecolighten Energy Solutions and has over 14 years of experience working in the private and public sector. His work is solely focused on the residential energy services space. Mr. Coleman provides support to the residential heating, ventilation and air conditioning (HVAC) aspects of the ECI portfolio.

Posterity Group Consulting Inc.

Posterity Group provides energy, climate policy, and DSM consulting services to utility and government clients across North America. The company focuses on energy modelling, market studies, and DSM program design and evaluation. Posterity Group supported PNG's preparation of the 2021 Conservation Potential Review (CPR) study and the 2023-2024 ECI schedule of expenditures. Posterity Group's staff involved in these projects have more than 50 years combined experience in energy and DSM planning.

4.2.2 Implementation Support

BC Hydro

BC Hydro, BC's primary electrical utility, has been engaged in energy conservation and efficiency for over 30 years. BC Hydro delivers its Energy Savings Kits (ESK's) and Energy

Conservation Assistance Program (ECAP) to income qualified customers to PNG's customers under a cost sharing arrangement with PNG.

Northern Environmental Action Team (NEAT)

NEAT is a non-profit group dedicated to helping residents, schools, and businesses of Northern British Columbia live greener lives. PNG contracts NEAT to deliver the "Energy is Awesome" program to school age children in PNG's service territories.

Ecofitt Corporation

Ecofitt is a conservation focused manufacturer, wholesaler and supplier of products and programs, primarily targeting utilities, retailers and distributors across North America. Ecofitt delivers BC Hydro's and PNG's joint ESK and ECAP programs, as well as PNG's Commercial Efficient Kitchens program.

Summerhill Group

Summerhill is a national energy efficiency services company that has developed and implemented energy efficiency and demand response programs for gas and electric utilities for over 25 years. The Summerhill team provides support to PNG's residential and commercial program delivery and works to increase awareness of, and participation, in PNG's programs.

Other

In addition to the above partners, PNG engages the support of professionals in branding strategy, graphic design, advertising, and communications.

4.3 Current ECI Stakeholders

PNG continues to engage community service organizations, chambers of commerce, local and provincial governments, and relevant non-governmental organizations on DSM programs.

As part of the development of this DSM Plan, PNG invited stakeholders to discuss aspects of the draft DSM Plan via webinar. Participants included HVAC contractors, the Canadian Home Builders Association, BC Sustainable Energy Association, the Community Energy Association, and the BC Non-Profit Housing Association. PNG also held sessions with the Ministry of Energy Mines and Low Carbon Innovation. There was general support for PNG's proposed ECI Portfolio and most stakeholders indicated a desire to work more closely in the future. In response to comments from stakeholders, PNG has added programs and increased incentives

for low income, Indigenous Communities and not-for-profit housing customers, and support for low carbon hybrid heating systems.

5 IDENTIFYING AND EVALUATING POTENTIAL ECI PROGRAMS

5.1 Introduction

This section describes the approach PNG used to identify and analyse the cost effectiveness of potential programs that could be included in its ECI Portfolio that is consistent with the requirements of Section 3 of the DSM Regulation. Programs considered for the ECI Portfolio were identified and evaluated by reviewing information from the following sources:

- PNG's ECI Guiding Principles, as described in Section 5.2; and
- PNG's ECI Program Market Intelligence, described in Section 5.3, that includes:
    - The 2021 Conservation Potential Review: Market Potential Report;
    - 2019 Customer Attitudes Survey;
    - 2013 Residential End Use Survey (2013 REUS); and
    - DSM programs offered in BC by FEI and BC Hydro.

5.2 ECI Guiding Principles

PNG has defined the following principles to guide the development of the ECI Program:

1. Alignment with BC's Energy Objectives as defined by the *Clean Energy Act*;
2. Meet the adequacy requirement of Section 3 of the Demand-Side Measures Regulation;
3. A portfolio of programs that is cost effective at the portfolio level over the funding period as determined by the appropriate application of the Total Resource Cost/Benefit (TRC) and Modified Total Resource Cost/Benefit (mTRC) as prescribed by Section 4 of the DSM Regulation;
4. A portfolio of programs that is cost effective at the portfolio level over the funding period as determined by the cost per tonne of avoided GHG emissions in anticipation of gas utility targets set to achieve goals outlined in the CleanBC Roadmap to 2030.
5. Be responsive to the needs and wants of PNG customers as determined by PNG sources, including but not limited to the 2013 REUS and 2019 Customer Attitudes Survey;

6. Provide a balanced and consistent approach to assisting residential, commercial, and industrial customers in their energy management and reduction of consumption;
7. Goal of limiting the non-incentive costs of each program at 50 percent of the program expenditure in a given year; and
8. Leverage available programs and incentives from other organizations, agencies, and utilities.

5.2.1 GHG Reduction Metric

In Section 3.2, PNG outlined its Low Carbon Strategy to address the emission reduction targets identified in the CleanBC Roadmap to 2030. PNG considers its ECI portfolio to be an important component of its strategy that has the potential to deliver emissions reductions at a lower cost than LCE supply. In order to facilitate a direct comparison of all pathways in its Low Carbon Strategy, PNG also evaluates the cost of its ECI programs based on a cost per tCO_{2e} of emission reduction achieved.

5.3 PNG ECI Program Market Intelligence

PNG completed a CPR study and reviewed earlier surveys and studies in order to inform the development of its ECI portfolio for 2023 and 2024. A brief description of these as well as a summary of the insights gained is presented below.

5.3.1 The 2021 Conservation Potential Review

PNG commissioned Posterity Group to prepare a CPR study to help inform the development of PNG's ECI portfolio. The CPR reviews energy efficiency opportunities available among PNG's residential, commercial, and industrial natural gas customers across a 20-year planning horizon.

The 2021 CPR determined that 85 percent of potential residential sector savings and 98 percent of the potential commercial sector savings arise from space and water heating measures.[10]

[10] Appendix B: PNG 2021 Conservation Potential Review, pp. 79 and 118.

PNG uses the 2021 CPR's medium market potential scenario in 2024 to provide directional level guidance for its ECI portfolio. Measures in the CPR are considered for inclusion in the ECI portfolio based on their TRC/mTRC values, measure life, availability of market supports, acceptance by customers, experience with similar measures, practicality of near-term implementation, and in consideration of current and potential future regulations and PNG's Guiding Principles. The 2021 CPR is attached in Appendix B.

Table 6 below presents the top measures for the residential sector as identified in the 2024 medium market potential scenario of the 2021 CPR and whether these have been included in the ECI portfolio proposed in this Application.

Table 6: Top Residential Measures by TRC (Medium Market Potential Scenario)[11]

Measure	Relevance to ECI Portfolio Funding for 2023-2024
Home Energy Report	Not included. A home energy report provides customers with insights on their current and historical consumption and on their consumption compared to similar homes as well as savings advice and tips. Costs reflected in the CPR results are limited to the marginal cost of delivering such a report and do not reflect the cost to set up the IT system to produce these reports. PNG therefore believes that the TRC/mTRC values are overstated.
Wall Insulation Cavity (R-3 baseline)	Included as part of the Residential Building Envelope program. (Section 6.4.3)
Low Flow Showerhead	Included as part of the Residential Efficient Water Heating program. (Section 6.4.2)
High Efficiency (EnerChoice) Gas Fireplace	Not included. PNG has chosen to focus on the home's primary heating system.
Communicating Thermostat	Included as part of the Residential Efficient Heating program. (Section 6.4.1)
Attic or Crawlspace Duct Insulation	Included as part of the Residential Efficient Heating program. (Section 6.4.1)
Faucet Aerator	Included as part of the Residential Efficient Water Heating program. (Section 6.4.2)

[11] Appendix B: PNG 2021 Conservation Potential Review, p. 78.

Measure	Relevance to ECI Portfolio Funding for 2023-2024
Fireplace Timer	Not included. PNG has chosen to focus on the home's primary heating system.
Attic Insulation (R-12.6 Baseline)	Included as part of the Residential Building Envelope program. (Section 6.4.3)
High Efficiency Energy Star Clothes Washers	Included as part of the Residential Water Heating program. (Section 6.4.2)
New Construction – Step 2 Homes	Included as part of the Codes and Standards Support and Adoption. (Section 6.7.5)
Furnace Early Retirement	Included as part of the Residential Efficient Heating program when installing a hybrid heating system consisting of an air source heat pump matched to a natural gas furnace. (Section 6.4.1)
Pipe Wrap	Included as part of the Residential Efficient Water Heating program. (Section 6.4.2)
Energy Star Dishwasher	Included as part of the Residential Efficient Water Heating program. (Section 6.4.2)

Table 7 below presents the top measures for the commercial sector as identified in the 2024 medium market potential scenario of the CPR and whether these have been included in the ECI portfolio proposed in this Application.

Table 7: Top Commercial Medium Market Potential Measures by TRC[12]

Measure	Relevance to ECI Portfolio Funding for 2023-2024
Heat Transfer Technology	The "heat transfer technology" is an additive to hydronic heating systems (e.g. radiators, heat exchangers) that improves the heat transfer by reducing the surface tension of the heating water, increasing its surface contact with the heat exchanger and transferring heat more efficiently. Not included. Additional market research is needed before considering this measure for inclusion.

[12] Appendix B: PNG 2021 Conservation Potential Review, p. 119.

Measure	Relevance to ECI Portfolio Funding for 2023-2024
Advanced Thermostat	Included as part of the Commercial HVAC Controls program. (Section 6.6.1)
Energy Recovery Ventilator (ERV)	ERVs are systems connected to HVAC system ducts. Using two fans, the ERV draws clean outside air into a building, removes stale air, and uses a heat exchanger to facilitate the transference of heat and moisture between the air streams. Included as part of the Commercial HVAC Controls program. (Section 6.6.1)
Occupant Behaviour	Not Included. Additional market research is needed before considering this measure for inclusion.
Reverse Flow ERV	Included as part of the Commercial HVAC Controls program. (Section 6.6.1)
Comprehensive Building Recommissioning (RCx)	Recommissioning of a building is a process that ensures existing equipment and systems operate optimally, saving energy and improving operations without significant capital investment. Aspects of building commissioning are supported by the Commercial HVAC Controls program (Section 6.6.1), Commercial Efficient Heating program (Section 6.6.2), and Commercial Efficient Water Heating program (Section 6.6.3). In addition, the Innovation program (Section 6.7.6) supports deep energy retrofits of commercial buildings.
Faucet Aerators	Included as part of the Commercial Efficient Water Heating program. (Section 6.6.3)
Boiler/Furnace Tune Up	Included as part of the Commercial HVAC Controls program. (Section 6.6.1)
Efficient Cooking Equipment	ENERGY STAR® gas cooking equipment includes combi ovens, convection ovens, griddles, standard fryers, large vat fryers, and steam cookers. Not included. PNG is focusing on the potential for commercial sector savings that are in space and water heating equipment measures.
Refrigeration Heat Recovery	Heat recovery from refrigeration or compressors is used to pre-heat domestic hot water and displace gas use. May be consider in the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)
Condensing Boiler (Early)	Included as part of the Commercial Efficient Heating program. (Section 6.6.2)

Measure	Relevance to ECI Portfolio Funding for 2023-2024
New Construction Step 2 - Commercial	Not included. PNG chose to focus on the potential for commercial sector savings that are in space and water heating measures.
New Construction Step 3 – Commercial NC Step 3 - Com	PNG's Codes and Standards program (Section 6.7.5) supports the adoption of the BC Energy Step Code.
Dock Door Seal	Not included. PNG chose to focus on the potential for commercial sector savings that are in space and water heating equipment measures.
Condensing MUA (ROB)	The measure is a single-stage, two-stage, or high intensity infrared heater used to heat open spaces with high ceilings by transferring heat directly to people and objects without heating the surrounding air. Two-stage heaters have controls to optimize performance at two levels of output, while high intensity heaters can withstand higher operating temperatures. May be consider in the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)
Window Film	Not included. PNG chose to focus on the potential for commercial sector savings that are in space and water heating equipment measures, rather than on building envelope measures.
Recirculation Demand Control	Recirculation demand controls applies to central gas-fired domestic hot water systems and controls the operation of the recirculation pump only in response to domestic hot water demand rather than running continuously. May be considered in the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)
Air Sealing	Not included. PNG chose to focus on the potential for commercial sector savings that are in space and water heating equipment measures.
Gas Heat Pumps for Space Heating	Included as part of the Commercial Efficient Heating program. (Section 6.6.2)
Boiler Controls	Included as part of the Commercial HVAC Controls program. (Section 6.6.1)

Table 8 that follows presents the top measures for the industrial sector as identified in the 2024 medium market potential scenario of the CPR. Owing to the small size of the industrial sector and the diverse nature of their operations, these measures are included within the Commercial Program Area.

Table 8: Top Industrial Medium Market Potential Measures by TRC[13]

Measure	Relevance to ECI Portfolio Funding for 2023-2024
Process Control	Process control enhancement for ovens, dryers, and kilns. This includes the use of advanced metering, data collection and processing to optimize operation. Considered as part of the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)
Energy Management	Not Included. Additional market research is needed before considering this measure for inclusion.
Greenhouse Envelope and Greenhouse Curtains	This measure entails improving envelope air-tightness, application of insulation, and using more energy efficient glazing material. Not Included. Additional market research is needed before considering this measure for.
Advanced Thermostats	May be considered as part of the Commercial HVAC Controls program – Custom Process. (Section 6.6.1)
Replace Steam Traps	Not Included. Additional market research is needed before considering this measure for inclusion.
Advanced Veneer Dryer	May be considered as part of the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)

[13] Appendix B: PNG 2021 Conservation Potential Review, p. 156.

Measure	Relevance to ECI Portfolio Funding for 2023-2024
Combustion Testing	Complete combustion testing and adjustment of the fuel/air ratio, for ovens, kilns, direct-fired heating, dryers, petrochemical refining and heat treating. This measure includes: • Measure combustion efficiency using an electronic flue gas analyzer • Adjust airflow and reduce excessive stack temperatures • Adjust burner and gas input, manual or motorized draft control May be considered as part of the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)
Heat Recovery Systems	The measure is the installation of heat exchangers to recover heat from steam systems, to offset process boiler heating. May be considered as part of the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)
Process Boiler Load Control	This measure is improving controls for a gas-fired industrial process boiler, to manage the load. In a multi-boiler plant, demand-load management optimizes the distribution of steam and water demand among the units and adjusts the overall output to meet working requirements. This ensures that boilers are fired only when required. Alternatively, demand-load management can allow each boiler to operate for the same amount of time. May be considered as part of the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)
Boiler Tune Up	Considered as part of the Commercial HVAC Controls program - Custom Process. (Section 6.6.1)

5.3.2 2019 Customer Attitudes Survey

PNG completed a survey of customer attitudes towards energy conservation in 2019 and used the results to better understand demographic and socio-demographic characteristics, dwelling characteristics, environmental beliefs, actions, and activities, as well as experience with customer service and programs in order to help shape the development of ECI programs. Key findings are noted below, by theme:

Efforts to reduce energy use:

- Three quarters (75 percent) of residential customers feel knowledgeable about what affects their home's energy use. Five percent do not, and 19 percent are unsure.
- Similar proportions of commercial customers feel knowledgeable about what affects energy use for their business or organization (74 percent knowledgeable, six percent not knowledgeable, and 20 percent are unsure).
- 82 percent of residential survey respondents undertook at least one energy-related renovation during the last five years. The top three energy-related renovations included weather stripping or caulking (undertaken by 40 percent of respondents), installing a hot water tank (32 percent), and installing a programmable or "smart" learning style thermostat (30 percent).
- Eight percent of residential survey respondents and 10 percent of commercial survey respondents reported that they had participated in a utility or government energy-efficiency program in the last two years. The majority of residential and commercial respondents participating in a program indicated it was sponsored by BC Hydro (78 percent and 69 percent respectively). A small percentage (three and four percent, respectively) indicated the program was sponsored by PNG. Residential and commercial survey respondents in PNG-West and Tumbler Ridge were more likely than those in Fort St. John and Dawson Creek to have participated in a program.
- Significant proportions of residential and commercial customers reported that they feel they have reduced their energy use as much as reasonably possible (55 percent residential, 69 percent commercial).

Feedback on PNG's energy efficiency programs:

- Awareness of PNG energy efficiency programs is low. Only 17 percent of residential customers were aware of PNG's Income Qualified programs prior to taking the survey. The lack of awareness was common to respondents in all regions, customer sizes, and household incomes. For commercial survey respondents, only six percent were aware of PNG's Commercial Efficient Water Heater Program, three percent were aware of the Commercial Efficient Boiler Program, and one percent were aware of the Commercial Efficient Kitchens Program. There were no statistically significant differences in awareness by region or customer size.

- Residential customer satisfaction with PNG's efforts to help them use energy efficiently is very low, with only 11 percent of respondents satisfied, 49 percent neutral, and 30 percent dissatisfied. The remaining 11 percent were unsure how satisfied they were with PNG's efforts – a response consistent with the low awareness of PNG residential energy efficiency programs. Customers in Fort St. John and Dawson Creek were somewhat more satisfied than their counterparts in PNG-West and Tumbler Ridge (mean satisfaction scores of 5.7 and 5.2, respectively).
- Commercial customer satisfaction with PNG's efforts to help their business or organization use energy efficiently is moderate, with 44 percent satisfied, 39 percent neither satisfied nor dissatisfied, 7 percent dissatisfied, and 9 percent unsure. Like that of residential customers, commercial customers in PNG-West and Tumbler Ridge were less satisfied with PNG's efforts than their counterparts in Fort St. John and Dawson Creek.

Interest in energy efficiency programs:

- Survey respondents were asked to express interest in a variety of programs and services to help them reduce their energy use. Residential customers expressed the most interest in a furnace tune up program (53 percent very or extremely interested), a draft proofing program (44 percent) and programs to upgrade exterior doors and windows (42 percent for each).
- Program ideas attracting the most interest from commercial survey respondents include an energy audit to identify opportunities to save energy (28 percent very or extremely interested), a program to install or upgrade building automation controls (19 percent), and a program to upgrade HVAC controls (17 percent).

5.3.3 2013 Residential End Use Survey (2013 REUS)

PNG is in the process of completing an updated REUS and plans to incorporate the results into program design as they become available this fall. In the meantime, PNG finds that the insights from the 2013 REUS continue to support existing programs and the additions proposed – both focused on improving the heating systems in older homes and providing supports to our low income customers.

Of the customers that responded to the 2013 REUS:

- 85 percent indicated they live in a single-family detached home.
- 77 percent of those homes were built before 1996.
- 90 percent use natural gas as the main heating fuel.
- 50 percent of respondents indicated that their furnace was of low- or mid-efficiency.
- Approximately 16 percent of PNG's residential customers can be considered low income households.

The following summarizes key findings from questions asked about customer attitudes towards energy conservation:

- There is a lack of knowledge about certain energy efficiency measures, such as not knowing the type of insulation present in dwellings, or the energy rating of appliances.
- While 32 percent of households claimed to have an ENERGY STAR® qualified model, nearly the same proportion (30 percent) were not sure if their model was ENERGY STAR® qualified or not.
- Lower income households were more likely than other groups to choose "not at all interested" in any of the energy efficiency programs suggested on the survey. Similarly, the highest income households were most likely to be "very interested" in any of the programs. Programs where this pattern did not hold included installing programmable thermostats and furnace or heat pump tune ups, which exhibited broad interest across all income groups.

5.3.4 DSM Programs Offered in BC

A review of the CleanBC Better Homes and Better Buildings websites found that energy efficiency programs noted below are available to PNG's customers. This information helps PNG identify where its efforts may have most value. PNG identified the continued need for support from our existing programs, and the pressing need for new supports for hybrid heating systems and building envelope improvements.

Residential Renovation

CleanBC Better Homes and Home Renovation Rebate Program

- Heat Pumps for Space and Water Heating
- Window and Door Replacement
- Insulation Rebates
- Rebates for Ventilation
- Home Energy Improvement Bonus
- Two Upgrade Bonus

BC Hydro

- Appliance Rebates
- Energy Saving Kits
- Energy Conservation Assistance Program

Canada Greener Homes Grant

CMHC Green Home Canada Mortgage and Housing Corporation Green Home

Sagen Energy-Efficient Home

Residential New Construction

Canada Mortgage and Housing Corporation Green Home

Federal & Provincial GST/HST New Housing Rebate

Commercial Renovation

CleanBC

- Custom Program
- Custom-Lite Program
- Commercial Express
- Social Housing Incentive Program

Canada Greener Homes Grant for small Multi-Unit Residential Buildings

BC Hydro Energy Saving Incentives for Business

Canada Mortgage and Housing Corporation Green Home Program - Condo Units

Genworth Energy-Efficient Housing Program - Condo Units

6 ECI PORTFOLIO FOR 2023 - 2024

6.1 Introduction

This section presents PNG's proposed ECI portfolio of programs along with a description of each program, annual budgets, key assumptions (such as number of participants), estimated natural gas savings and the results of the cost effectiveness tests. The ECI portfolio is organized into four program areas, each having several programs, with one or more measures in each program:

1. Residential Program Area;
2. Income Qualified Program Area;
3. Commercial Program Area; and
4. Energy Transformation Program Area.

Many of the programs have previously been approved by the BCUC. PNG proposes to expand several existing programs and to introduce new programs where opportunities have been identified to serve the residential and commercial markets.

6.2 Updates to the Assumptions in the Cost Effectiveness Model

PNG's cost effectiveness model incorporates the equations and methodology described in the California Standard Practice Manual which in turn sets out the calculations for the Total Resource Cost (TRC) test, as well as other cost effectiveness tests widely used by utilities to evaluate DSM programs: the Utility Cost Test (UCT), also referred to as the Program Administrator Cost Test (PACT), the Participant Cost Test (PCT) and the Rate Impact Measures Test (RIM).[14]

PNG's cost effectiveness model also now includes the cost per tonne of GHG emissions saved ($/t$CO_{2e}$) as a model output. PNG anticipates using this metric in planning its portfolio of GHG reduction measures. The cost per tonne of GHG emissions saved metric is based on the utility

[14] California Public Utilities Commission, California Standard Practice Manual – Economic Analysis of Demand-Side Programs and Projects.

cost test that is the sum of administration and incentive costs divided by the present value of GHG emissions.[15]

For this DSM Plan, PNG made the updates listed in Table 9 to the cost effectiveness model.

Table 9: Updates to the PNG Cost Effectiveness Assumptions

Parameter	2019	2022
Cost of Gas	Based on Q2-2019 costs and the most current forward strip	Based on Q1-2022 costs and the most current forward strip
Delivery Rates	2019 approved rates held constant over the forecast period	Forecast from 2022 Revenue Requirements Application
Carbon Tax	$40 per tonne increasing by $5 per tonne on April 1 of 2020, and 2021	$50 per tonne from April 1, 2022, increasing by $15 per tonne annually until reaching $170 per tonne in 2030
ZEEA ($/MWh)*	$106.00	$106.00
ZEEA ($/GJ)*	$29.44	$29.44
Utility Discount Rate	6.92%	7.07%

* ZEEA is an acronym for "Zero Emission Energy Alternative"

Only the costs and benefits over the forecast period (beginning in 2023 and ending at the end of the measure life of the longest-living measure installed in 2024) are included in the determination of the cost effectiveness ratios. None of the sunk costs associated with the development and execution of existing programs over the historical period from 2019 to 2022 are included. PNG submits that this is the appropriate treatment of costs and benefits because it provides the most accurate assessment of the expected future performance of existing programs and of the expected performance of the portfolio as a whole.

[15] The present value expressions of the non-monetary units for GHG emissions and natural gas annual energy demand (tonnes of CO_2 equivalent and GJ, respectively) use a societal discount rate of 0%.

6.3 Program Design Assumptions

Assumptions made by PNG while developing the proposed ECI programs are:

Participation Rates

Participation rates and budgets are based on market research and PNG's experience with its existing ECI programs.

Budgets

The budgets presented in this Application include incentive costs, program administration costs, and all costs to support the development, delivery, and management of the programs.

Energy Savings

The energy savings assumptions are determined from energy modelling or engineering calculations, many of which were completed in the 2021 CPR.

6.4 Residential Program Area

PNG proposes to expand the Residential Program Area introduced as part of the 2019 DSM Plan by adding two new measures to the Efficient Heating program and by adding Efficient Water Heating and Building Envelope programs:

a) Residential Efficient Heating (Expanded);

b) Residential Efficient Water Heating (new); and

c) Residential Building Envelope (new).

6.4.1 Residential Efficient Heating

PNG proposes to expand the Efficient Heating program introduced as part of the 2019 DSM Plan. In addition to the existing Home Heating System Tune Up and Smart Thermostat Installation measure, PNG proposes incentives for Hybrid Heating, and Heat Recovery Ventilators.

PNG delivers the program through a network of registered HVAC contractors that have been reviewed and approved by PNG (PNG Preferred Contractors).

Home Heating System Tune Up and Smart Thermostat Installation

PNG will continue to offer incentives to customers who request a furnace or boiler tune up and an installed smart thermostat.

Participation has been strong. Since its launch in early 2021 and to the end of 2021, PNG's Preferred Contractors have completed 322 furnace tune ups and installed 26 smart thermostats. To date, PNG has registered eight contractors who collectively serve 10 communities in PNG's service areas.

During the first year of the program, PNG noted that more participant rebates were issued for the tune up with far fewer being issued for the smart thermostat. Going forward, PNG will allow residential customers to purchase and install qualifying smart thermostats themselves and submit an application for a rebate directly to PNG through its delivery partner, Summerhill Group. In addition, the incentive for the tune up will be reduced and will be available only in the shoulder season. Income qualified customers will have access to a higher incentive throughout the year. These changes are made to encourage uptake on the higher potential energy saving Smart Thermostats and help manage the workflow of contractors.

Hybrid Heating Systems

A hybrid or dual heating system is one that combines a natural gas furnace or boiler with an electric air source heat pump (ASHP). During mild temperatures, the heat pump operates as the primary home heating device. When the outside temperature drops below a certain temperature, known as the switch-over point, the heat pump shuts off and heating is provided by a gas furnace or boiler. These systems can overcome some of the shortfalls of heat pumps, namely their reduced efficiency and operability in very cold conditions, by taking advantage of the affordability and higher reliability of natural gas. They help to balance the electrical grid by offloading demand during peak periods and reduce GHG emissions associated with space heating by limiting the use of natural gas to the periods of peak heating demand.

PNG's service areas, where daily temperatures fall below -10°C regularly, there is a significant concern amongst customers and HVAC contractors on relying on a heat pump as the sole source of heating through the entire winter season. Using a hybrid system ensures reliable heating even in the coldest of temperatures while remaining the most cost-effective solution compared to all-electric heating systems.

Hybrid heating systems offer significant natural gas savings and GHG reductions for PNG customers. The 2021 CPR estimates that hybrid heat systems can provide an estimated

technical potential savings of 300 TJ in 2024 for the residential sector.[16]

To help customers reduce their carbon footprint, PNG proposes incentives for hybrid heating systems when a new ASHP is integrated with the customer's existing natural gas furnace or boiler. The incentive is intended to reduce the cost of integrating the ASHP with the existing natural gas furnace or boiler and is applicable to the installation of a heat exchanger in the existing ductwork of a natural gas forced air furnace, controls that ensure the heat pump operates on all but the coldest days, or changes to the existing natural gas heating system that are required to integrate with an ASHP.

In its discussions with HVAC contractors, PNG understands that integrating an ASHP with an existing furnace is not always mechanically possible or desirable. PNG's analysis shows providing an additional incentive for replacing an inefficient furnace or boiler having an annualized fuel utilization efficiency (AFUE) of 80 percent or lower is a cost-effective measure to further reduce natural gas consumption and its associated emissions.

In evaluating the cost effectiveness of this incentive, PNG considered the incentives already available from BC Hydro to customers who install electric ASHP's.

Heat Recovery Ventilators

A heat recovery ventilator (HRV) is a ventilation device that pre-warms the fresh outdoor air intake to the furnace from heat recovered from the stale air vented back outdoors. HRVs are identified as the highest saving measure under the 2024 medium market potential (mTRC scenario) in the CPR and have been recommended by the contractors consulted during the development of the ECI portfolio.[17] Heating systems account for the majority of a home's energy use and installing HRVs will help customers reduce their heating costs and reduce their carbon footprint.

[16] Appendix B: PNG 2021 Conservation Potential Review, p. 61. Only the technical and economic potential savings estimates for hybrid heating measures are presented in the CPR as there is insufficient information available to estimate the market potential at this time.

[17] Appendix B: PNG 2021 Conservation Potential Review, p. 78.

Summary

The forecast cost effectiveness parameters and underlying cost assumptions for the Residential Efficient Heating program are shown in Table 10.

Table 10: Residential Efficient Heating Program Summary

Summary					
Residential Efficient Heating					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	Summerhill		5,998		755
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 260,000	$ 430,000	0.38	2.23	1.47
Administration	$ 20,000	$ 20,000	PCT	RIM	$/tCO$_2$e
Total	**$ 280,000**	**$ 450,000**	1.58	0.43	$ 93

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
Home heating tune-up	100	$ 150	$ 50	1.7	2	10.0%	5.0%
Home heating tune-up for Income Qualified Customers	200	$ 150	$ 125	1.7	2	0.0%	0.0%
Smart thermostat	350	$ 300	$ 300	5.1	10	10.0%	5.0%
Res. Hybrid heating with existing furnace	30	$ 6,937	$ 2,500	45.0	15	0.0%	0.0%
Res. Hybrid heating with new furnace	30	$ 8,145	$ 3,000	65.0	15	0.0%	0.0%
Heat Recovery Ventilator (HRV) - Retrofit	30	$ 2,400	$ 1,000	12.5	14	0.0%	0.0%
Heat Recovery Ventilator (HRV) - New Construction	15	$ 2,400	$ 1,000	8.4	14	0.0%	0.0%
Weighted Average per Participant		**$ 941**	**$ 457**	**8.1**	**7**	**6.0%**	**3.0%**

6.4.2 Residential Efficient Water Heating

PNG proposes a new Efficient Water Heating program that provides incentives to residential customers to reduce natural gas consumption associated with their existing water heating systems. Measures proposed under this program include pipe wrap and insulated blankets for hot water tanks, low flow showerheads, faucet aerators and ENERGY STAR® certified clothes washers and dishwashers. These measures proposed for the Efficient Water Heating program are the top five measures identified for the residential domestic hot water segment in 2024 under the medium market potential (TRC) scenario, generating a forecast 12 TJ of annual savings in 2024.[18]

These new measures can be readily integrated into PNG's current delivery model. PNG customers will purchase discounted pipe wrap, insulated blankets and low flow devices directly from PNG's existing ecommerce portal and will complete the installation themselves. Eligible customers who submit receipts showing the purchase of qualifying ENERGY STAR® clothes and dishwasher models will be provided with a rebate through PNG's online rebate application portal developed to manage the Smart Thermostat rebate.

The forecast cost effectiveness parameters and underlying cost assumptions for the Efficient Water Heating program are shown in Table 11.

[18] Appendix B: PNG 2021 Conservation Potential Review, p. 78.

Table 11: Residential Efficient Water Heating Program Summary

Summary					
Residential Efficient Water Heating					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	n/a		109		310
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 5,617	$ 10,260	4.71	16.52	1.23
Administration	$ -	$ -	PCT	RIM	$/tCO$_2$e
Total	**$ 5,617**	**$ 10,260**	13.98	0.41	$ 112

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
Pipe Wrap	125	$ 1	$ 1	0.2	15	0.0%	0.0%
Low Flow Showerhead	20	$ 16	$ 16	0.9	10	0.0%	0.0%
Faucet Aerator	10	$ 4	$ 4	0.3	10	0.0%	0.0%
ENERGY STAR Clothes Washer	68	$ 14	$ 50	0.7	14	0.0%	0.0%
ENERGY STAR Dish Washer	68	$ -	$ 50	0.1	11	0.0%	0.0%
Water Heater Wrap	20	$ 36	$ 36	0.5	5	0.0%	0.0%
Weighted Average per Participant		**$ 7**	**$ 26**	**0.4**	**13**	**0.0%**	**0.0%**

6.4.3 Residential Building Envelope

PNG proposes a Building Envelope program that offers incentives to residential customers to add exterior wall cavity and/or attic insulation, and to replace existing windows and doors. PNG understands that although CleanBC currently offers incentives for windows and doors, they will be phased out of the Better Homes and Home Renovation Rebate Program.

The Building Envelope program will ensure that PNG customers continue to have access to similar rebates for measures previously supported by the CleanBC Better Homes and Home

Renovation Rebate Program. The wall cavity and attic insulation are the top two building envelope measures in 2024 under the CPR medium market potential (mTRC) scenario, generating a forecast 13 TJ of annual savings.[19]

The forecast cost effectiveness parameters and underlying cost assumptions for the program are shown in Table 12.

Table 12: Residential Building Envelope Program Summary

Summary					
Residential Building Envelope					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	n/a		221		107
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 15,340	$ 15,340	0.56	1.83	2.36
Administration	$ -	$ -	PCT	RIM	$/tCO$_2$e
Total	**$ 15,340**	**$ 15,340**	1.87	0.50	$ 47

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
Exterior wall cavity insulation	2	$ 5,616	$ 1,200	72.0	30	0.0%	0.0%
Attic – flat and cathedral ceiling insulation	5	$ 1,028	$ 588	8.0	30	0.0%	0.0%
HP windows and doors	100	$ 479	$ 100	0.4	18	0.0%	0.0%
Weighted Average per Participant		**$ 601**	**$ 143**	**2.1**	**19**	**0.0%**	**0.0%**

[19] Appendix B: PNG 2021 Conservation Potential Review, p. 78.

6.4.4 Residential Program Area Budget

Table 13 summarizes the residential programs including expenditures, the average number of participants, and the forecast cumulative annual net energy savings.

Table 13: Residential Program Area Budget and Cost Test Results

Residential Program Summary					
Program	Avg. Annual Participation	Forecast Expenditures		Cumulative Annual Gas Savings (GJ)	
		2023	2024	2023	2024
Residential Efficient Heating	755	$ 280,000	$ 450,000	4,489	11,997
Residential Efficient Water Heating	310	$ 5,617	$ 10,260	77	217
Residential Building Envelope	107	$ 15,340	$ 15,340	221	442
Total	**1,172**	**$ 300,957**	**$ 475,600**	**4,787**	**12,656**

6.5 Income Qualified Program Area

PNG proposes an Income Qualified program area that includes the following programs:

a) Income Qualified Efficient Heating (new);

b) Energy Conservation and Assistance Program (ECAP) (existing); and

c) Energy Savings Kit (ESK) (existing).

These programs are available to low income households, as defined in the DSM Regulation and subject to PNG's determination of participant eligibility by referencing a table of total household income that includes the combined income of all members in the household over the age of 18. Program participation also extends to non-profit housing and public housing providers and Indigenous Communities.

6.5.1 Income Qualified Efficient Heating

PNG proposes to tailor the Residential Efficient Heating program introduced as part of the 2019 DSM Plan, to income qualified participants. In addition to the Home Heating System Tune Up and Smart Thermostat Installation measures, PNG intends to provide an incentive for the early replacement of low efficiency furnaces.

Home Heating System Tune Up

In Section 6.4.1, PNG presented modifications to the Home Heating System Tune Up and Smart Thermostat measure that reduces the incentive for the home heating system tune up and limits its availability to certain times in the year. However, in order to provide increased

support to its low income customers, PNG proposes to increase the current incentive available to low income customers for the Home Heating System Tune Up, and to maintain its availability year round for these customers.

Low Efficiency Furnace Early Replacement

In Order G-121-19, the BCUC rejected PNG's proposal to implement a Residential Furnace and Boiler Replacement program based on the determination that it was not in the public interest. Upon further analysis and refinement of the opportunity, PNG has identified sound potential for the early replacement of low efficiency gas furnaces in income qualified homes. Early replacements of low efficiency (AFUE 60 percent) are estimated to generate potential savings of 2.7 TJ in 2024 under the medium market potential (mTRC scenario).[20]

PNG heard from discussions with our ESK and ECAP partners, BC Hydro and FortisBC, that low income customers are unlikely, for cost reasons, to replace their low efficiency furnace before it fails. These customers are also unlikely to replace their equipment with a cold-climate heat pump or hybrid heating system given the high upfront capital costs.

The forecast cost effectiveness parameters and underlying cost assumptions for the Income Qualified Efficient Heating program are shown in Table 14. The assumptions reflect only the Low Efficiency Furnace Early Replacement measure; the costs, participation and energy savings associated with the Home Heating System Tune Up are captured in the Residential Efficient Heating program described in Section 6.4.1.

[20] Appendix B: PNG 2021 Conservation Potential Review, p. 78.

Table 14: Income Qualified Efficient Heating Program Summary

Summary					
Income Qualified Efficient Heating					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	n/a		1,010		25
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 125,000	$ 125,000	1.42	7.42	0.34
Administration	$ -	$ -	PCT	RIM	$/tCO$_2$e
Total	**$ 125,000**	**$ 125,000**	7.01	0.21	$ 392

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
Home heating equipment early replacement for Income Qualified Customers	25	$ 1,199	$ 5,000	40.4	6	0.0%	0.0%
Weighted Average per Participant		**$ 1,199**	**$ 5,000**	**40.4**	**6**	**0.0%**	**0.0%**

6.5.2 Energy Conservation and Assistance Program (ECAP)

The ECAP program is targeted at helping low income households achieve energy savings. The program offers a personalized home energy evaluation, personalized energy efficiency advice, and the installation of energy saving products by a qualified contractor. The bundle of measures to be installed may include low flow fixtures, water heater pipe wrap, professional draft proofing, outlet gaskets, window film, insulation, improved ventilation, and carbon-monoxide (CO) detectors.

In 2018, BC Hydro and PNG entered into an agreement whereby PNG funds a portion of the cost of offering the ECAP measure to low income households in its service area. Under this agreement, BC Hydro continues to receive and process applications through its existing call centre and online channels. When an application is identified as belonging to a BC Hydro customer residing in a community in which PNG provides natural gas delivery service, PNG is

responsible for paying a portion of the cost associated with delivering the ECAP to that customer. PNG proposes to continue to fund the ECAP measure pursuant to the terms of its existing and ongoing agreement with BC Hydro.

The forecast cost effectiveness parameters and underlying cost assumptions for the program are shown in Table 15.

Table 15: ECAP Program Summary

Summary					
Income Qualified ECAP					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	BC Hydro		732		100
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 29,000	$ 29,000	2.05	8.97	2.05
Administration	$ 2,500	$ 2,500	PCT	RIM	$/tCO$_2$e
Total	**$ 31,500**	**$ 31,500**	5.79	0.47	$ 68

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
ECAP	100	$ 290	$ 290	7.3	12	0.0%	0.0%

6.5.3 Energy Savings Kits (ESK)

The ESK program intends to reach a wide range of low income households in single family dwellings, duplexes, townhomes, mobile homes and apartments. ESKs are delivered directly to customers and include a bundle of easy-to-install items that save energy. The bundle may include low flow fixtures, water heater pipe wrap, caulking, draft proofing tape, outlet gaskets, and window film.

In 2016, PNG and BC Hydro entered into an agreement whereby PNG reimburses BC Hydro a portion of the cost of ESKs delivered to customers in PNG's service areas. Under this

agreement, BC Hydro continues to receive and process applications through its existing call centre and online channels. When an application is identified as belonging to a BC Hydro customer residing in a community in which PNG provides natural gas delivery service, PNG is responsible for paying a portion of the cost associated with delivering an ESK to that customer. PNG proposes to continue to fund the ESK measure pursuant to the terms of its existing and ongoing agreement with BC Hydro.

The forecast cost effectiveness parameters and the underlying cost assumptions for the program are shown in Table 16.

Table 16: ESK Program Summary

Summary					
Income Qualified ESK					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	BC Hydro, FEI and Ecofitt		757		381
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 10,638	$ 10,638	4.59	20.87	4.59
Administration	$ 1,524	$ 1,524	PCT	RIM	$/tCO$_2$e
Total	**$ 12,162**	**$ 12,162**	15.97	0.53	$ 31

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
ESK	381	$ 28	$ 28	2.7	10	44.0%	17.0%

6.5.4 Income Qualified Program Area Budget

Table 17 summarizes the Income Qualified programs including expenditures, the average number of participants, and the forecast cumulative annual net energy savings.

Table 17: Income-Qualified Program Area Budget and Cost Test Results

Income Qualified Program Summary					
Program	Average Annual Participation	Forecast Expenditures		Cumulative Annual Gas Savings (GJ)	
		2023	2024	2023	2024
Income Qualified Efficient Heating	25	$ 125,000	$ 125,000	1,010	2,020
Income Qualified ECAP	100	$ 31,500	$ 31,500	732	1,464
Income Qualified ESK	381	$ 12,162	$ 12,162	757	1,513
Total	**506**	**$ 168,662**	**$ 168,662**	**2,499**	**4,997**

6.6 Commercial Program Area

PNG proposes a Commercial program area that includes retaining one program, and revising three programs:

a) Commercial HVAC Controls (Expanded);

b) Commercial Efficient Heating (Expanded);

c) Commercial Efficient Water Heaters (Expanded); and

d) Commercial Efficient Kitchens (existing).

All these programs are available to all non-residential customers, including PNG's industrial customers which are estimated to have the largest cost-effective savings potential on the TRC economic screen relative to other sectors.

6.6.1 Commercial HVAC Controls

PNG launched the Commercial Efficient HVAC Controls program in the third quarter of 2021. The program provides rebates for a number of pieces of equipment and services that improve the performance of building HVAC systems. Included in the program are rebates for:

i. Advanced Rooftop Unit Controls allowing remote monitoring, and control of fan speed, economizer function, and the thermostat, making it easier, and cheaper, to maintain occupant comfort and system efficiency. This measure results in both heating and cooling savings.

ii. Boiler Outdoor Reset Controls that optimize boiler operation by responding to changes in weather. It is achieved through the addition of controls that lower the outlet water temperature of space heating hot water boilers when the outdoor air temperature increases.

iii. Space Heating Boiler Tune Up that inspects and cleans the boiler, as well as optimizes the air/fuel ratio to reduce excess air and stack temperature, and recommissions boiler controls.

iv. Automatic Blowdown Valve for a steam boiler where feed water is chemically treated, and a surface blowdown valve operates continuously to remove Total Suspended Solids (TDS) and undissolved solids that are left behind as feed water evaporates. The automatic blowdown feature has a sensor which measures the TDS level and triggers the valve to open whenever required to maintain TDS concentrations below maximum allowable limits.

The rebates are provided to customers by contractors registered with PNG's Preferred Contractor network and the program is administered by Summerhill Group.

PNG proposes to expand the Commercial HVAC Controls program to include two new measures: advanced thermostats and energy recovery ventilators (ERVs). The 2021 CPR ranked advanced thermostats as having the second highest potential savings in the commercial sector in 2024.[21] ERVs are a promising measure for PNG's northern climate and are well understood and recommended by the contractors consulted as part of the DSM Plan development.

Custom Process Stream

In designing its rebate-based HVAC controls program offering, PNG realized that a broader set of opportunities for reducing GHG emissions associated with natural gas consumption exists amongst PNG's commercial and industrial customers. Opportunities identified in the 2021 CPR are diverse with improvements to industrial process control identified as the top measure under the medium market potential (TRC and mTRC) scenarios, resulting in an estimated 5.5 TJ of savings in 2024.[22]

The 2021 CPR stated that the "industrial sector is estimated to have the largest cost-effective savings potential on the TRC economic screen relative to other sectors. However, industrial customers require shorter payback periods relative to commercial and residential customers.

[21] Appendix B: PNG 2021 Conservation Potential Review, p. 119.

[22] Appendix B: PNG 2021 Conservation Potential Review, p. 156.

Achieving savings from industrial measures that are cost-effective but have longer customer payback periods may be challenging and/or more expensive due to higher incentives and program costs."[23]

PNG recognized the opportunity to broaden the impact of its Commercial HVAC Controls program and PNG implemented a customized incentive program in 2021 that decreases the pay-back period for projects that improve the energy efficiency of existing heating systems or thermal processes and thereby improve the customers' return on investment for these types of projects. The incentive is based on a number of criteria including the total cost of the project, payback periods with and without the incentive, and the cost of avoided emissions (characterized as a cost per gigajoule of natural gas).

Summary

The forecast cost effectiveness parameters and the underlying cost assumptions for the Commercial HVAC Controls program that includes the Custom Process Stream are shown in Table 18.

Table 18: HVAC Controls Program Summary

Summary					
Commercial HVAC Controls					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	n/a		7,788		63
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 278,095	$ 329,193	0.77	2.73	2.46
Administration	$ -	$ -	PCT	RIM	$/tCO$_2$e
Total	**$ 278,095**	**$ 329,193**	1.72	0.59	$ 55

*Direct program administration expenses.

[23] Appendix B: PNG 2021 Conservation Potential Review, p. 9.

Measure Details							
Measure	Avg. Participants per Year	Incremental Cost	Participant Incentive	Gas Savings per Participant (GJ/y)	Measure Life (years)	Free Ridership	Spillover Rate
Advanced Rooftop Unit Controls	6	$ 7,199	$ 1,625	19.2	15	10.0%	0.0%
Outdoor Boiler Reset Controls	6	$ 1,500	$ 750	25.0	20	10.0%	0.0%
Space Heating Boiler Tune Up	6	$ 744	$ 400	82.0	3	10.0%	0.0%
Automatic Blowdown Valve	6	$ 7,800	$ 3,250	87.0	5	10.0%	0.0%
Commercial - Advanced Thermostats	13	$ 300	$ 150	8.4	15	10.0%	0.0%
Energy Recovery Ventilator (ERV)	13	$ 4,899	$ 2,450	105.0	14	10.0%	0.0%
Reverse Flow Energy Recovery Ventilator (RF-ERV)	13	$ 5,655	$ 2,800	121.0	14	10.0%	0.0%
Custom with Payback Period	1	$ 800,000	$ 200,000	4,444.0	15	10.0%	0.0%
Weighted Average per Participant		**$ 16,626**	**$ 4,858**	**138.5**	**13**	**10.0%**	**0.0%**

6.6.2 Commercial Efficient Heating

PNG proposes to expand the existing Commercial Efficient Boilers program into a broader Commercial Efficient Heating program. The program will include existing incentives for the early replacement of operational boilers with qualifying natural gas fired boilers, hybrid heating systems, and natural gas heat pumps.

Natural Gas Fired Boilers Early Replacement

PNG will continue to offer incentives to commercial customers who purchase and install ENERGY STAR® or Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certified™ natural gas-fired boilers to replace their existing boilers. Incentives from PNG will be discontinued when the new energy efficiency standard for commercial gas boilers comes into effect on January 1, 2023.[24] The 2021 CPR estimates there is 389 GJ of remaining energy

[24] The BC Energy Efficiency Standards Regulation requires all commercial gas boilers sold on or after January 2, 2023 to have a minimum efficiency of 90%. BC Regulatory Bulletin: BC EMLI, Mach 17, 2021: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/energy-efficiency/reg_bulletin_-_commercial_boilers_-_march_17_2021.pdf

savings for natural gas fired boilers in the commercial medium market potential savings scenario in 2024.[25]

Hybrid Heating Systems

A hybrid or dual heating system is one that combines a natural gas furnace or boiler with an electric air source heat pump (ASHP). During mild temperatures, the heat pump operates as the primary space heating device. When the outside temperature drops below a certain temperature, known as the switch-over point, the heat pump shuts off and heating is provided by a gas furnace or boiler. These systems can overcome some of the shortfalls of heat pumps, namely their reduced efficiency and operability in very cold conditions, by taking advantage of the affordability and higher reliability of natural gas. They help to balance the electrical grid by offloading demand during peak periods and reduce GHG emissions associated with space heating by limiting the use of natural gas to the periods of peak heating demand.

In PNG's service areas, where daily temperatures fall below -10°C regularly, there is a significant concern amongst customers and HVAC contractors on relying on a heat pump as the sole source of heating through the entire winter season. Using a hybrid system ensures reliable heating even in the coldest of temperatures while remaining the most cost-effective solution compared to all-electric heating systems.

Hybrid heating systems offer significant natural gas savings and GHG reductions for PNG's commercial customers. The 2021 CPR estimates that hybrid heat systems can provide an estimated technical potential savings of 17 TJ in 2024 for the commercial sector.[26]

To help customers reduce their carbon footprint, PNG proposes incentives for hybrid heating systems when a new ASHP is integrated with the customer's existing natural gas furnace or boiler. The incentive is intended to reduce the cost of integrating the ASHP with the existing natural gas furnace or boiler and is applicable to the installation of a heat exchange in the existing ductwork of a natural gas forced air furnace, controls that ensure the heat pump

[25] Appendix B: PNG 2021 Conservation Potential Review, p. 119.

[26] Pacific Northern Gas, 2021 Conservation Potential Review, p. 98. Only the technical and economic potential savings estimates for hybrid heating measures are presented in the CPR, as there is insufficient information available to estimate the market potential at this time.

operates on all but the coldest days, or changes to the existing natural gas heating system that are required to integrate with an ASHP.

In its discussions with HVAC contractors, PNG understands that integrating an ASHP with an existing furnace or boiler is not always mechanically possible or desirable. PNG's analysis shows providing an additional incentive for replacing an inefficient furnace or boiler having an AFUE of 80 percent or lower is a cost effective measure to reduce natural gas consumption and its associated emissions.

In evaluating the cost effectiveness of its incentive, PNG considered the incentives already available from CleanBC, to customers who install electric ASHP's.[27]

Natural Gas Heat Pumps

Gas heat pumps work similarly to any other air-source heat pump, except instead of using electricity to fuel their operation they rely on natural gas to drive their refrigeration cycle. They come in two types: gas-engine heat pumps (GEHPs) and gas-absorption heat pumps (GAHPs). The former uses a natural gas-fired engine to power a compressor, which then drives the same refrigeration cycle that ASHPs commonly use, while the latter uses the heat produced from burning natural gas to power an ammonia-water absorption cycle.

Awareness of gas heat pump technology and products is low amongst HVAC contractors in PNG's service area, as is the availability of products. PNG therefore expects that it will require some time to raise awareness of gas heat pump products amongst HVAC contractors and potential customers, and to help to build the capacity amongst HVAC contractors to install and service these products. Therefore, while PNG would make incentives for gas heat pumps available to its commercial customers, PNG does not expect to issue any incentives until 2024.

Summary

The forecast cost effectiveness parameters and underlying cost assumptions for the Commercial Efficient Heating program are shown in Table 19.

[27] The CleanBC Custom program provides incentives at a rate of $60/tonne CO_{2e} for rooftop air source heat pumps.

Table 19: Efficient Heating Program Summary

Summary					
Commercial Efficient Heating					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	n/a		5,620		23
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 175,680	$ 135,500	1.02	5.14	2.87
Administration	$ -	$ -	PCT	RIM	$/tCO$_2$e
Total	**$ 175,680**	**$ 135,500**	2.31	0.56	$ 47

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
Early Efficient Boiler Replacement	9	$ 4,849	$ 4,849	293.0	7	0.0%	0.0%
Early Efficient Boiler Replacement for Non-Profits	2	$ 2,595	$ 5,000	93.0	7	0.0%	0.0%
Com. Hybrid heating with existing furnace	5	$ 22,407	$ 9,000	225.0	15	0.0%	0.0%
Com. Hybrid heating with new furnace	5	$ 20,180	$ 8,100	312.0	15	0.0%	0.0%
Gas Heat Pump	3	$ 17,452	$ 10,000	152.0	18	0.0%	0.0%
Weighted Average per Participant		**$ 12,627**	**$ 6,915**	**249.8**	**11**	**0.0%**	**0.0%**

6.6.3 Commercial Efficient Water Heaters

PNG proposes to expand the existing Commercial Efficient Water Heater program to include pipe wrap, and low flow devices including showerheads and faucet aerators. These measures were chosen for their cost-effective energy savings potential savings according the 2021 CPR as well as their relatively low cost integration with the current program. PNG customers will be able to purchase pipe wrap, insulated blankets and low flow devices at discounted cost directly from PNG's existing ecommerce portal and will install the products themselves. PNG will

continue to offer eligible commercial customers incentives for the purchase and installation of qualifying high efficiency natural gas fired water heaters to replace existing, low efficiency water heaters.

The forecast cost effectiveness parameters and underlying cost assumptions for the program are shown in Table 20.

Table 20: Efficient Water Heaters Program Summary

Summary					
Commercial Efficient Water Heating					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	n/a		572		326
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 24,264	$ 21,581	1.92	6.73	2.06
Administration	$ 7,000	$ 3,500	PCT	RIM	$/tCO$_2$e
Total	**$ 31,264**	**$ 25,081**	6.19	0.53	$ 66

*Direct program administration expenses.

Measure Details							
Measure	**Avg. Participants per Year**	**Incremental Cost**	**Participant Incentive**	**Gas Savings per Participant (GJ/y)**	**Measure Life (years)**	**Free Ridership**	**Spillover Rate**
Efficient Water Heaters	8	$ 2,258	$ 2,000	63.0	15	38.0%	9.0%
Commercial - Pipe Wrap	148	$ 34	$ 34	0.9	15	9.0%	9.0%
Commercial - Low Flow Showerhead	60	$ 16	$ 16	1.2	10	0.0%	0.0%
Commercial - Faucet Aerator	90	$ 4	$ 4	0.1	10	0.0%	0.0%
Commercial - Water Heater Wrap	20	$ 36	$ 36	0.5	5	0.0%	0.0%
Weighted Average per Participant		**$ 77**	**$ 70**	**2.2**	**12**	**5.0%**	**4.3%**

6.6.4 Commercial Efficient Kitchens

The Efficient Kitchen program offers customers operating commercial kitchen facilities a free efficient pre-rinse spray valve to effectively remove excess food residue from dishes. The models offered by PNG use less hot water than standard spray valves, saving water and energy.

PNG plans to continue with the direct purchase strategy introduced in the 2019 DSM Plan. Kitchen faucet aerators will also be offered to improve the value to customers. The Efficient Kitchens program is delivered by Ecofitt and is promoted through channels including bill inserts, print ads and online.

The forecast cost effectiveness parameters and underlying cost assumptions for the program are shown in Table 21.

Table 21: Efficient Kitchens Program Summary

Summary					
Commercial Efficient Kitchens					
New/Retrofit	**Partner**		**Avg. Annual Gas Savings (GJ)**		**Avg. Annual Participants**
Retrofit	Ecofitt		161		20
Forecast Expenditures*			**Benefit/Cost Ratios**		
Expenditure Type	**2023**	**2024**	**TRC**	**MTRC**	**UCT**
Incentives	$ 1,430	$ 1,430	2.60	11.71	2.60
Administration	$ 700	$ 700	PCT	RIM	$/tCO$_2$e
Total	**$ 2,130**	**$ 2,130**	7.14	0.50	$ 50

*Direct program administration expenses.

Measure Details							
Measure	Avg. Participants per Year	Incremental Cost	Participant Incentive	Gas Savings per Participant (GJ/y)	Measure Life (years)	Free Ridership	Spillover Rate
Pre-rinse spray valve	10	$ 140	$ 140	16.0	5	0.0%	0.0%
Commercial - Kitchen Aerator	10	$ 3	$ 3	0.1	10	0.0%	0.0%
Weighted Average per Participant		**$ 72**	**$ 72**	**8.0**	**8**	**0.0%**	**0.0%**

6.6.5 Commercial Program Area Budget

Table 22 summarizes the Commercial programs including expenditures, the average number of participants, and the forecast cumulative annual net energy savings.

Table 22: Commercial Program Area Budget and Cost Test Results

Commercial Program Summary					
Program	Average Annual Participation	Forecast Expenditures		Cumulative Annual Gas Savings (GJ)	
		2023	2024	2023	2024
Commercial Efficient Heating	23	$ 175,680	$ 135,500	7,794	11,239
Commercial Efficient Water Heating	326	$ 31,264	$ 25,081	622	1,145
Commercial Efficient Kitchens	20	$ 2,130	$ 2,130	161	322
Commercial HVAC Controls	63	$ 278,095	$ 329,193	6,877	15,576
Total	**431**	**$ 487,169**	**$ 491,903**	**15,454**	**28,282**

6.7 Energy Transformation Program Area

6.7.1 Overview

The conservation education and outreach or CEO program area is renamed as the Energy Transformation program area to avoid confusion with the CEO programs that are included under this program area, and also to more clearly align with the purpose of the activities funded in this program area.

PNG's CEO programs, as well as its support for codes and standards, and funding of innovative energy saving and emission reducing technologies are all designed to raise awareness amongst customers of the challenges of, and opportunities for, transforming PNG's natural gas distribution services to lower GHG emissions.

Five programs are included under the Energy Transformation program area:

a) Elementary School Program;

b) Post-Secondary Program;

c) General Conservation Education and Outreach Program;

d) Codes and Standards; and

e) Innovation.

6.7.2 Elementary School Program

PNG's Energy is Awesome program provides safety and conservation instruction for grades 4 and 5 students. This program is intended to foster a culture of conservation by helping students learn about energy efficiency and reductions in GHG emissions.

PNG delivers K-12 conservation education and outreach to all elementary schools in all of PNG's service areas in partnership with the Northern Environmental Action Team (NEAT), a not-for-profit society active in PNG's Fort St. John and Dawson Creek service areas.

Due to social distancing measures in place in response to the COVID-19 pandemic, PNG and NEAT were unable to deliver PNG's "Energy is Awesome" program in 2021. PNG and NEAT took this opportunity to redevelop all of the course content to better align it with the grade four and five curriculum, and to adopt it to an online course format. The revised course and new delivery options broaden the impact of the Energy is Awesome program, in terms of both a larger and more engaged audience of school children and their teachers, and the geographic reach of the program. PNG anticipates being able to reach more students through in class presentations, remote presentations, and downloaded course materials during the 2022/23 school year.

6.7.3 Post-Secondary Program

PNG delivers post-secondary conservation education and outreach through an expert lecture series that entails inviting experts in energy efficiency and conservation to campuses throughout PNG service territories. PNG is in discussions with the Northern Lights College about providing subject matter experts to lecture on topics related to existing and emerging energy technologies, and that comprise a certificate program in clean energy technologies.

6.7.4 General Conservation Education and Outreach

The goal of PNG's general Conservation Education and Outreach program is to increase awareness amongst PNG's customers of the ECI programs and associated incentives in order to increase participation.

In 2021, PNG increased its marketing activities and launched three advertising campaigns that, collectively, spanned 27 weeks in the winter, summer and fall. PNG developed electronic and print ads under the brand "Smart Energy Solutions" that were posted on PNG's own social media accounts and on paid services during the campaigns. Ads were placed on social media news feeds, on the electronic as well as printed versions of local newspapers, and through search engine marketing services. The performance of each campaign, measured by the level of engagement with PNG's Smart Energy Solutions web pages, was reviewed after each campaign and used to inform the advertising tactics for the next campaign

6.7.5 Codes and Standards Support and Adoption

In collaboration with the Community Energy Association (CEA), BC Institute of Technology (BCIT), and local governments, PNG is supporting the delivery of workshops in its service areas, aimed at training local builders, tradespeople and building officials on how to build to the BC Energy Step Code. A BCIT instructor will use the institution's zero emissions building (ZEB) lab-in-a-box to deliver hands-on high-performance building training in the communities served by PNG.

The training program introduces the fundamental principles of building science while helping students advance their construction knowledge and skills with respect to building envelope design, construction and performance verification for airtightness and advanced thermal performance of residential buildings (Part 9 Buildings). The course will present building enclosure assemblies, construction methods, and solutions for managing control barriers with a focus on improved thermal performance of residential buildings. Students will develop their knowledge of building science, airtightness strategies, and assembly details to meet the BC Energy Step Code.

6.7.6 Innovation

PNG allocates a portion of its Innovation budget to support the development and adoption of new energy and GHG emission reduction technologies. PNG typically provides funding for

research or pilot installations of pre-commercial technology through the Natural Gas Innovation Fund (NGIF) or the Canadian Gas Association (CGA). Doing so leverages PNG's relatively small contribution with the contributions of other CGA member utilities. Programs funded by PNG may include funding laboratory and field testing of commercial and pre-commercial high efficiency natural gas equipment to demonstrate its viability to builders, HVAC professionals and policy makers; or funding research into the impact of injecting quantities of hydrogen into natural gas distribution systems and for safe use in appliances.

PNG proposes to expand its Innovation budget for 2023 and 2024 to support two new initiatives: PNG's role in the BC Hydrogen – Natural Gas Blending Study, and Deep Energy Retrofits (DERs).

6.7.6.1 BC Hydrogen – Natural Gas Blending Study

Background

As stated in Section 3.2, PNG's Low Carbon Strategy consists of a portfolio of initiatives that are intended to achieve the GHG Reduction Standard by 2030 in the most cost-effective manner possible. In tandem with its efforts to reduce natural gas consumption through the cost effective demand side measures of its ECI programs, PNG is building a portfolio of LCE supplies that replaces a portion of PNG's existing natural gas supply portfolio and reduces the GHG emissions associated with the consumption of natural gas delivered to PNG's own facilities, as well as to its customers. Central to the LCE portfolio is PNG's strategy of acquiring or producing hydrogen and blending it with natural gas delivered through its natural gas distribution systems.

In order to meet this goal, PNG is collaborating with Enbridge and FEI to complete a study to investigate the extent to which hydrogen produced from renewable and low-carbon resources could be blended with natural gas to reduce the carbon intensity of delivered gas in BC (BC Hydrogen Natural Gas Blending Study).

The overall goals of the BC Hydrogen Natural Gas Blending Study are to: (i) build a knowledge base to inform the safety, technical, economic, regulatory, innovation, research and development, capital investment and other requirements needed to introduce and increase the hydrogen blend concentration levels over time throughout the transmission and distribution systems in BC; (ii) address all of the unknowns to support key internal and external stakeholder decision making, including the Province, and define the role for PNG, Enbridge, and FEI in

deploying low-carbon hydrogen; and (iii) identify the requirements and the work that will need to be completed in the near term and longer term to ensure the energy delivery networks and customers' "behind-the-meter" end-use equipment, processes, systems, and applications will continue to operate safely and reliably.

The study will address the multi-disciplinary technical assessment as follows:

1. Pre-feasibility scoping studies to confirm detailed scope, budget, schedule, and resourcing requirements. Three separate pre-feasibility scoping studies have been generated by each of PNG, Enbridge and FEI;
2. Technical assessments to evaluate the effects of hydrogen-natural gas blends on the overall gas supply chain (including potential impacts to safety, reliability, and operations) and, if feasible, establish maximum hydrogen blend limits with: (a) minimal modifications and outline requirements to achieve these blend limits; and (b) economic modifications and outline requirements to achieve these blend limits;
3. Hydrogen deployment strategies to identify changes needed in each of PNG, Enbridge and FEI's business operations and customers to adapt to using hydrogen-natural gas as a fuel;
4. Hydrogen roadmaps that chart near-term and long-term work required to prepare the gaseous energy supply chain to achieve the feasible blend levels; and
5. A hydrogen standard for the three companies to govern all aspects of hydrogen in the natural gas network (similar to the standards for renewable natural gas today).

The five components of the study will inform federal and provincial policy planning in terms of defining an action plan and time required to complete work for hydrogen blending and to increase the share of hydrogen in the natural gas supply delivered in BC.

This study represents an important opportunity to initiate the transformation of BC's and Canada's natural gas sector to net zero emissions, including transitioning the sector's existing talent pool and creating new clean energy jobs. Given the study's critical role in facilitating the growth of BC's hydrogen economy, the Province has committed funding to the study.

PNG's Study

The scope of work that PNG has committed to as its part of the BC Hydrogen Natural Gas Blending Study includes an assessment of the ability of PNG's natural gas distribution system

to deliver a hydrogen-natural gas fuel blend safely and reliably to its residential, commercial, and industrial customers. The BC Hydrogen Natural Gas Blending Study is expected to deliver information and data that allows PNG to define a project to upgrade a portion of its distribution system, along with customer appliances to accept quantities of hydrogen blended with natural gas deliveries. The study will be focused on portions of the distribution systems serving PNG's communities. Key deliverables of the study are:

- Database of system pipe and appurtenances, and appliances with H2 readiness assessment for each;
- A structured methodology for assessing the hydrogen readiness of pipeline system that can be applied to other portions of PNG's distribution systems; and
- Developing PNG's capacity for assessing, constructing and operating hydrogen ready distribution systems.

PNG, along with Enbridge and FEI are finalizing a formal request for proposal package that will be issued to pre-qualified proponents in the third quarter of 2022. PNG expects to award a contract to the selected proponent before the end of 2022 and commence its part of the study in early 2023. PNG anticipates completing the study in 2024.

PNG has allotted approximately $1 million to its portion of the BC Hydrogen Natural Gas Blending Study, some of which will be offset by PNG's allocated share of the committed contribution from the Province. PNG proposes to fund its portion, estimated at $600,000, through the Innovation program included as part of its ECI portfolio.

6.7.6.2 Deep Energy Retrofits

A DER is a comprehensive, whole-building strategy to renewing the building's envelope, mechanical, and electrical systems to drastically reduce all energy loads including from space heating and air conditioning, hot water, lighting, and appliances. Upgrades can include:

- Replacement of the heating and ventilation systems with high efficiency equipment;
- Increased insulation of basements and crawlspaces;
- Increased insulation and air-sealing of roofs and walls;
- Replace windows with low-emissivity models;
- Utilization of high efficiency Energy Star appliances; and

- Implementation of renewable energy sources such as solar panels, solar-thermal systems and biomethane.

A DER can substantially reduce energy consumption of a building by at least 50% and enhance the building's value through improved occupant comfort, durability, indoor air quality, and noise reduction. DER's can typically be undertaken as a single comprehensive project or be staged over three to five years.

However, there can be significant barriers to deep energy retrofits. Barriers of awareness, availability, acceptance, and affordability are discussed below.

Awareness – Building science and energy efficiency are not often top of mind for many. While there may be a fair level of awareness for the individual technical solutions that comprise DER projects, there are widespread low levels of awareness of the integration or sequencing of new technologies within their existing systems and the increased benefits, and costs. Nor is it well known that retrofits carried out in isolation can have unintended consequences or create barriers for future projects of related measures. This low level of awareness extends to owners, professionals, and tradespeople alike.

Availability – Should an owner be aware and interested in DER's, the availability of information and the workforce needed to respond effectively is limited. In absence of information and professional services, owner decisions are based primarily on their needs and wants, aesthetics, and upfront costs without consideration to DER benefits or lifecycle analysis.

The availability of a technology can also be a barrier in smaller or remote communities where the demand is not yet great enough for it to be readily available.

Acceptance – A DER approach is relatively new and project successes are not well documented. DER's are complex, involving multiple contractors over extended project timelines, and can be disruptive. Ensuring the tenant's safety and livability are important considerations. DER projects can also have unintended or hazardous consequences if not managed using a building science approach. For example, air sealing and insulating without proper mechanical ventilation can cause mold growth or too much ventilation can cause combustion spillage.

The configuration and construction of the building may also present limitations that are sometimes insurmountable. For example, the duct size or configuration may be

insufficient to meet the requirements of a new system or incorporating suite-level energy recovery ventilators into a centrally ventilated and pressurized building may cause significant pressure differences.

Affordability – High upfront costs given the large scope of a DER can also be a barrier and financing options may be limited. This is particularly true for buildings with high redevelopment potential or strong competing priorities when a high aesthetic is desired and the benefits of comfort, health, safety, and resiliency are not well understood.

Additional professional services and high-quality contractors can drive costs even higher. In addition, there may be a need for expensive remediation such as the safe removal of asbestos, vermiculate, and lead.

PNG has identified DER's as a key strategy for reducing natural gas consumption in buildings. Natural gas consumption in PNG's residential sector is highest in single family dwellings or duplex type homes (91% of total residential demand), and 36% of residential consumption is in older homes built between 1950 and 1975. On the whole, the residential sector is estimated to have a potential savings of 2% of consumption available under the medium market potential scenario.[28] However, targeting high potential, older single family dwellings and taking a DER approach to energy conservation can lead to greater energy and GHG emissions savings and deeper engagement with partners and customers. The opportunity is similar in multi-unit residential buildings.

PNG intends to build support throughout the DER process for owners and contractors who need them. This will start with building awareness and communications, may include funding for deep energy retrofit roadmaps and training subsidies for trades and professional service providers, and could extend to providing centralized expertise and/or pilot projects.

Building awareness through communications will help boost interest and demand for DER's. PNG plans to leverage existing communications channels to share both the monetary benefits: energy bill savings, reduced maintenance costs, increased rental income, increased property value, and the non-monetary benefits: reduced greenhouse gas emissions, increased building resilience, better health and wellbeing, and social equity.

[28] Appendix B: PNG 2021 Conservation Potential Review, pp. 43-44.

A roadmap based on building science for the DER is critical as it presents a series of cost-effective projects that can be completed over a longer period. Not many owners will be ready or willing to replace something that is working or complete DER as one project. Through longer term planning, the team can then also make use of lease turnovers or building sales and capital budget cycles as milestones for action. PNG could provide supports for the energy assessments and/or roadmap development.

Quality workmanship helps to optimize energy performance; however, many trades, engineers, and other professional service providers do not have the specific skills and expertise needed for DER projects. PNG could support training and wage subsidies, case studies and other open-source reference materials.

Pilot projects are a great way to test ideas and approaches, document lessons learned, identify risks and provide confidence for future projects. PNG proposes to spend a portion of its innovation budget on DER's of either residential or commercial buildings located in its service area. Such retrofits may include one or more measures identified above applied to several buildings in a community, or a portfolio of measures applied to only a few buildings, depending on the costs and the budget available.

6.7.6.3 Development of Codes and Standards

PNG has budgeted $100,000 in support of the development of codes and standards, equivalent to approximately 2.5% of its annual forecast ECI expenditures in 2023 and 2024. PNG has identified opportunities for advancing the standards required to blend hydrogen in natural gas systems and end use appliances and this work will be further defined and completed as part of PNG's participation in the BC Hydrogen Natural Gas Blending Study.

6.7.7 Energy Transformation Budget

Table 23 provides a program summary for the Energy Transformation program area. Unlike other program areas, no customer incentives are included, nor are any directly attributable energy savings. The programs included in this program area therefore cannot be evaluated by the cost-effectiveness tests. However, their costs can be included and evaluated at the portfolio level.

Table 23: Budget – Energy Transformation

Energy Transformation Program Summary	Forecast Expenditures	
Program	**2023**	**2024**
CEO (Elementary School)	$ 60,000	$ 60,000
CEO (Post Secondary)	$ 30,000	$ 30,000
CEO (General)	$ 90,000	$ 90,000
Codes and Standards Support and Adoption	$ 30,000	$ 40,000
Innovation (H2 Study, Deep Retrofits)	$ 400,000	$ 600,000
Hydrogen Study	*$ 300,000*	*$ 300,000*
Deep Energy Retrofits	*$ 50,000*	*$ 250,000*
Development of Codes and Standards	*$ 50,000*	*$ 50,000*
Total	**$ 610,000**	**$ 820,000**

6.8 Enabling Activities

Enabling Activities are programs that support delivery and development of PNG's ECI programs. Enabling Activities do not have any direct energy savings associated with them and therefore cannot be evaluated by the cost-effectiveness tests. However, their costs can be included and evaluated at the portfolio level.

Where costs are not clearly assigned to a program they are categorized as Enabling Activities and include the costs for some of PNG's partners to complete the detailed program design, as well as to develop, negotiate, and manage partnerships. Enabling Activities also include evaluation, measurement and verification of the performance of programs.

PNG has modified the allocation of these costs to individual programs from that described in PNG's 2019-2020 ECI Program Funding Application and that was subsequently approved by way of Order G-121-19. Under that allocation, 90 percent of the cost of Enabling Activities was allocated equally to all measures directly administered by PNG. The ESK and ECAP programs administered by BC Hydro, and the elementary school conservation education program administered by NEAT were not assigned any costs.

In this Application, PNG has modified the allocation to be based on the proportion of individual measure budgets to the annual budget as a whole. The ESK and ECAP programs administered by BC Hydro, and the elementary school conservation education program administered by NEAT remain excluded from the allocation. In addition, the Codes and Standards, and Innovation programs are no longer assigned any costs related to Enabling Activities because

of the low administrative burden associated with these programs, and that all costs are directly assignable.

The allocation to individual programs reflects the ratios presented in Table 24. Changing the allocation of Enabling Activities costs in the manner proposed in this Application reduces the cost burden on the smaller programs and better reflects the actual administrative burden of each program.

Table 24: Enabling Activities Allocation Factors

	2023		2024	
Program	**%**	**$**	**%**	**$**
Residential Efficient Heating	27.1%	$ 30,490	37.1%	$ 64,948
Residential Efficient Water Heating	0.5%	$ 612	0.8%	$ 1,481
Residential Building Envelope	1.5%	$ 1,670	1.3%	$ 2,214
Commercial HVAC Controls	26.9%	$ 30,283	27.1%	$ 47,512
Commercial Efficient Heating	17.0%	$ 19,130	11.2%	$ 19,557
Commercial Efficient Water Heating	3.2%	$ 3,636	2.2%	$ 3,927
Commercial Efficient Kitchens	0.0%	$ -	0.0%	$ -
Income Qualified Efficient Heating	12.1%	$ 13,612	10.3%	$ 18,041
Income Qualified ECAP	0.0%	$ -	0.0%	$ -
Income Qualified ESK	0.0%	$ -	0.0%	$ -
CEO - K-12	0.0%	$ -	0.0%	$ -
CEO - Post Secondary	2.9%	$ 3,267	2.5%	$ 4,330
CEO - General	8.7%	$ 9,800	7.4%	$ 12,990
Codes and Standards Support and Adopti	0.0%	$ -	0.0%	$ -
Innovation Funding	0.0%	$ -	0.0%	$ -
Enabling	0.0%	$ -	0.0%	$ -
Total	**100.0%**	**$ 112,500**	**100.0%**	**$ 175,000**

PNG has budgeted $112,000 in 2023, and $175,000 in 2024 for Enabling Activities. This budget will be used primarily to fund a new ECI program manager whose role will be to assist the Manager Energy Solutions in implementing and administering the ECI portfolio. PNG will continue to rely on its team of service providers presented in Section 0 to deliver various aspects of the ECI portfolio. However, the addition of numerous new measures proposed in this Application will require more effort to implement and manage. The addition of an ECI program manager who will oversee the implementation, administration, marketing and promotion of the ECI programs will ensure the timely and effective roll-out of PNG's proposed new measures.

7 PORTFOLIO ANALYSIS

7.1 A Portfolio Approach to Program Cost Effectiveness

Evaluation of the cost effectiveness of PNG's ECI programs at the portfolio level is consistent with Section 4(1) of the DSM Regulation, which stipulates that the BCUC, in determining the cost effectiveness of demand side measures that are part of a portfolio of demand side measures, may compare the costs and benefits:

a) of the demand side measure individually;

b) together with other demand side measures in the portfolio; or

c) the portfolio as a whole.

Further, the portfolio approach is appropriate for evaluating PNG's ECI programs for several reasons:

- The portfolio approach provides the most flexibility for PNG to implement programs that meet customer needs while addressing the requirements of the DSM Regulation and maintaining a cost-effective portfolio.
- According to Sections 4(4) and 4(5) of the DSM Regulation, the BCUC must use the portfolio approach in assessing the cost effectiveness of "specified demand-side measures" and "public awareness programs."
    - Specified demand side measures incorporated into PNG's ECI portfolio include: education programs for students, funding for energy efficiency training, funding for codes and standards development, a community engagement program, and a technology innovation program.
- A portfolio approach to cost effectiveness allows PNG to offer programs to low income and rental sectors, in compliance with Section 3 of the DSM Regulation and BCUC directives, while maintaining a cost-effective portfolio of programs.
- A portfolio approach is also consistent with the BCUC's Order G-36-09 in FEI's 2008 Energy Efficiency and Conservation Application, and subsequent decisions where the BCUC determined that the cost effectiveness of DSM activities should be measured at the portfolio level.

7.2 Portfolio Alignment with Guiding Principles

PNG continues to develop and expand its ECI portfolio and programs in a manner that aligns with the ECI Guiding Principles described in Section 5.2.

ECI Portfolio is Aligned with BC's Energy Objectives

PNG's proposed ECI portfolio is consistent with BC's Energy Objectives that include conserving energy as well as reducing GHG emissions. As shown in Table 25, PNG estimates the net cumulative natural gas savings and GHG reductions over the life of measures installed over the period from 2023 to 2024 to be 562 TJ and almost 30 kilotonnes, respectively.

Table 25: ECI Portfolio Energy Savings and GHG Reductions over the Life of the Measures

	Gas Savings (over life)	GHG Reduction (over life)
Sector	**GJ**	**tCO2e**
Residential	164,026	8,634
Commercial	353,396	18,603
Low Income	44,818	2,359
Subtotal	**562,240**	**29,596**
Energy Transformation	0	0
Enabling	0	0
Portfolio Total	**562,240**	**29,596**

ECI Portfolio is adequate within the meaning as prescribed by the DSM Regulation

PNG has maintained and expanded existing programs that, collectively, meet the adequacy requirements established in Section 3 of the Demand-Side Measures Regulation as described in Section 3.4.

ECI Portfolio is in the interest of persons in BC who may receive service from PNG

The programs included in the ECI portfolio are in the interests of customers and potential customers as they encourage energy efficiency and conservation, reduce GHG emissions, and are cost effective. Individual consumers who participate in ECI programs will reduce their natural gas consumption and their natural gas utility bills. PNG is proposing an ECI portfolio that is cost effective, both in terms of the cost of energy saved and the cost of GHG emissions reductions (Table 26).

Table 26: Cost of Energy and GHG Emissions Reductions

	2023-2024	
ECI Spending per customer per year	$ 45.22	$/cust/year
Cost of energy saved*	$ 6.78	$/GJ
Cost of GHG reduction*	$ 128.75	$/tonne CO_2e

*Forecast expenditures divided by the cumulative net energy savings and net GHG reductions over the life of the measures installed from 2023-2024

PNG proposes a portfolio of programs designed to find broad acceptance amongst customers, with expenditures allocated roughly equally to the residential/income qualified, commercial and CEO programs (Table 3). In addition, PNG aims to limit the non-incentive costs of each program to 50% of the expenditure in a given year. Based on current projections, the non-incentive portion of costs for PNG's incentive programs at 13% falls within the guideline (Table 27).

Table 27: Incentive and Non-incentive Portions of the ECI Portfolio

		Costs (2023-2024)			Non-Incentive Portion of Program Cost
Sector	**Program**	**Total**	**Incentive**	**Non-Incentive***	
Residential	Residential Efficient Heating	$ 825,438	$ 690,000	$ 135,438	16%
Residential	Residential Efficient Water Heating	$ 17,969	$ 15,877	$ 2,092	12%
Residential	Residential Building Envelope	$ 34,564	$ 30,680	$ 3,884	11%
Commercial	Commercial Efficient Heating	$ 388,975	$ 311,180	$ 77,795	20%
Commercial	Commercial Efficient Water Heating	$ 95,031	$ 45,844	$ 49,187	52%
Commercial	Commercial Efficient Kitchens	$ 11,824	$ 2,860	$ 8,964	76%
Commercial	Commercial HVAC Controls	$ 607,288	$ 607,288	$ -	0%
Low Income	Income Qualified Efficient Heating	$ 281,653	$ 250,000	$ 31,653	11%
Low Income	Income Qualified ECAP	$ 63,000	$ 58,000	$ 5,000	8%
Low Income	Income Qualified ESK	$ 24,323	$ 21,275	$ 3,048	13%
Subtotal	**Incentive Programs**	**$ 2,350,065**	**$ 2,033,004**	**$ 317,061**	**13%**
CEO	CEO - K-12	$ 120,000	$ -	$ 120,000	100%
CEO	CEO - Post Secondary	$ 67,597	$ -	$ 67,597	100%
CEO	CEO - General	$ 202,790	$ -	$ 202,790	100%
Codes & Standards	Support and Adoption	$ 70,000	$ -	$ 70,000	100%
Innovation	Innovation Funding	$ 1,000,000	$ -	$ 1,000,000	100%
Enabling	Enabling	$ -	$ -	$ -	0%
Portfolio Total		**$ 3,810,452**	**$ 2,033,004**	**$ 1,777,448**	**47%**

* Includes an allocation of Enabling costs as per Table 24.

ECI Portfolio is Cost Effective

Table 28 presents portfolio-level cost effectiveness results for the TRC, UCT, PCT and RIM tests, as well as the mTRC for programs requiring its application. All programs proposed by PNG are cost effective as measured by either the TRC or mTRC.

PNG has applied the TRC based on the equations listed in the California Standard Practice Manual. The mTRC results reflect the prescribed use of the Zero Emissions Energy Alternative (ZEEA) that is represented by BC Hydro's long-run marginal cost of acquiring electricity generated from clean or renewable sources in British Columbia, and societal benefits determined as listed in Sections 4(1.1)(c) and 4(2) of the of the DSM Regulation. Accordingly, the mTRC of the ESK, ECAP, and Income Qualified Efficient Heating programs reflect the ZEEA as the avoided cost and the inclusion of non-energy benefits that increase benefits under the TRC by forty percent.

PNG's proposed Residential Efficient Heating, Residential Building Envelope and Commercial HVAC Controls programs all require the application of the mTRC to be deemed cost effective. Accordingly, PNG has applied the ZEEA and non-energy benefits adder of fifteen percent to these programs. The expenditures for programs requiring application of the mTRC comprise 39% of the total expenditures of the ECI portfolio.

The education and outreach programs do not have any energy savings directly associated with them. As a result, these individual education and outreach programs are not run through the standard DSM cost-effectiveness tests at a program level.

The overall cost effectiveness ratio for the portfolio is 1.79, meeting the cost-effectiveness requirement of Section 4 of the DSM Regulation.

Table 28: Portfolio-Level Cost-Effectiveness

		Benefit/Cost Ratios			
Sector	**Program**	**TRC**	**mTRC**	**UCT**	**RIM**
Residential	Residential Efficient Heating	0.38	2.23	1.47	0.43
Residential	Residential Efficient Water Heating	4.71	16.52	1.23	0.41
Residential	Residential Building Envelope	0.56	1.83	2.36	0.50
Commercial	Commercial Efficient Heating	1.02	5.14	2.87	0.56
Commercial	Commercial Efficient Water Heating	1.92	6.73	2.06	0.53
Commercial	Commercial Efficient Kitchens	2.60	11.71	2.60	0.50
Commercial	Commercial HVAC Controls	0.77	2.73	2.46	0.59
Low Income	Income Qualified Efficient Heating*	1.42	7.42	0.34	0.21
Low Income	Income Qualified ECAP*	2.05	8.97	2.05	0.47
Low Income	Income Qualified ESK*	4.59	20.87	4.59	0.53
Subtotal	**Incentive Programs**				
Energy Transformation	CEO - K-12				
Energy Transformation	CEO - Post Secondary				
Energy Transformation	CEO - General				
Energy Transformation	Codes and Standards Support and Adoption				
Energy Transformation	Innovation Funding				
Enabling	Enabling				
Portfolio Total		0.53	2.27	1.05	0.42
Portfolio Total		**1.79****		**1.05**	**0.42**

* Section 4 of the BC DSM Regulation, as amended in March 2017, requires the use of the Zero Emission Energy Alternative and a forty percent benefit adder in calculating the mTRC for income qualified programs

** Includes the mTRC adder of fifteen percent for programs that require it.

8 BUDGET SUMMARY AND CUSTOMER IMPACTS

The tables that follow present a summary of forecast expenditures, participation, energy savings, and GHG emission reductions under each program over the period 2023 to 2024. While the forecast expenditures are in many cases significantly higher than historical expenditures over the period 2020 and 2021, the increased level of marketing that PNG is completing in 2022 is raising awareness amongst PNG's customers of PNG's ECI programs. This is especially true in the case of the Commercial Efficient Heating and Commercial Efficient HVAC Controls programs. PNG's change to the Residential Home Heating System Tune Up and Smart Thermostat measure is expected to increase the number of rebates issued for smart thermostats in 2022 and beyond.

PNG is including greater support for residential and commercial customers wishing to upgrade their space heating equipment. The addition of the Hybrid Heating measure to the Residential and Income Qualified Efficient Heating programs beginning in 2023 is expected to increase participation by residential customers. Similarly, the addition of the Hybrid Heating and Gas Heat Pump measures to the Commercial Efficient Heating programs beginning in 2023 is expected to increase participation by commercial customers.

Table 29 presents actual, approved, and forecast expenditures for PNG's residential program area.

Table 29: Residential Program Area Expenditures

Residential: Efficient Heating	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 13,671	$ 41,598	$ 146,466	$ 280,000	$ 450,000
Approved Expenditures	$ 193,700	$ 188,700	$ 188,700	$ -	$ -
Variance (Actual - Approved)	$ (180,029)	$ (147,102)	$ (42,234)	$ 280,000	$ 450,000
Actual/Forecast Applicants	0	322	550	670	840
Cumulative Annual Savings (GJ)	0	547	2,077	6,566	14,074
Annual GHG Reduction (Tonnes CO2e)	0	29	109	346	741

Residential: Building Envelope	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures				$ 15,340	$ 15,340
Approved Expenditures				$ -	$ -
Variance (Actual - Approved)				$ 15,340	$ 15,340
Actual/Forecast Applicants				107	107
Cumulative Annual Savings (GJ)				221	442
Annual GHG Reduction (Tonnes CO2e)				12	23

Residential: Efficient Water Heating	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures				$ 5,617	$ 10,260
Approved Expenditures				$ -	$ -
Variance (Actual - Approved)				$ 5,617	$ 10,260
Actual/Forecast Applicants				190	430
Cumulative Annual Savings (GJ)				77	217
Annual GHG Reduction (Tonnes CO2e)				4	11

Table 30 presents actual, approved, and forecast expenditures for PNG's income qualified program area.

Table 30: Income Qualified Program Area Expenditures

Income Qualified: Efficient Heating	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures				$ 125,000	$ 125,000
Approved Expenditures				$ -	$ -
Variance (Actual - Approved)				$ 125,000	$ 125,000
Actual/Forecast Applicants				25	25
Cumulative Annual Savings (GJ)				1,010	2,020
Annual GHG Reduction (Tonnes CO2e)				53	106

Income Qualified: ECAP	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 16,556	$ 5,097	$ 5,000	$ 31,500	$ 31,500
Approved Expenditures	$ 48,500	$ 48,500	$ 48,500	$ -	$ -
Variance (Actual - Approved)	$ (31,944)	$ (43,403)	$ (43,500)	$ 31,500	$ 31,500
Actual/Forecast Applicants	76	21	21	100	100
Cumulative Annual Savings (GJ)	557	711	865	1,597	2,329
Annual GHG Reduction (Tonnes CO2e)	29	37	46	84	123

Income Qualified: ESK	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 16,493	$ 6,819	$ 24,603	$ 12,162	$ 12,162
Approved Expenditures	$ 12,900	$ 12,900	$ 12,900	$ -	$ -
Variance (Actual - Approved)	$ 3,593	$ (6,081)	$ 11,703	$ 12,162	$ 12,162
Actual/Forecast Applicants	491	258	381	381	381
Cumulative Annual Savings (GJ)	968	1,476	7,587	8,344	9,100
Annual GHG Reduction (Tonnes CO2e)	51	78	342	439	479

Table 31 presents actual, approved, and forecast expenditures for PNG's commercial program area.

Table 31: Commercial Program Area Expenditures

Commercial: Efficient Heating	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 6,913	$ 66,071	$ 140,128	$ 175,680	$ 135,500
Approved Expenditures	$ 51,000	$ 51,000	$ 51,000	$ -	$ -
Variance (Actual - Approved)	$ (44,087)	$ 15,071	$ 89,128	$ 175,680	$ 135,500
Actual/Forecast Applicants	0	12	24	30	15
Cumulative Annual Savings (GJ)	0	8,078	24,233	32,027	35,472
Annual GHG Reduction (Tonnes CO2e)	0	425	644	1,686	1,867

Commercial: Efficient Kitchens	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 5,596	$ 11,546	$ 40,231	$ 2,130	$ 2,130
Approved Expenditures	$ 48,700	$ 48,700	$ 48,700	$ -	$ -
Variance (Actual - Approved)	$ (43,104)	$ (37,154)	$ (8,469)	$ 2,130	$ 2,130
Actual/Forecast Applicants	0	72	100	20	20
Cumulative Annual Savings (GJ)	0	119	283	444	605
Annual GHG Reduction (Tonnes CO2e)	0	0	142	23	32

Commercial: Efficient Water Heating	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 9,596	$ 12,177	$ 38,722	$ 31,264	$ 25,081
Approved Expenditures	$ 49,200	$ 49,200	$ 49,200	$ -	$ -
Variance (Actual - Approved)	$ (39,604)	$ (37,023)	$ (10,478)	$ 31,264	$ 25,081
Actual/Forecast Applicants	4	4	16	403	248
Cumulative Annual Savings (GJ)	91	182	1,526	2,148	2,671
Annual GHG Reduction (Tonnes CO2e)	5	10	75	113	141

Commercial: HVAC Controls	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 6,063	$ 57,242	$ 112,722	$ 278,095	$ 329,193
Approved Expenditures	$ 208,500	$ 203,500	$ 203,500	$ -	$ -
Variance (Actual - Approved)	$ (202,437)	$ (146,258)	$ (90,778)	$ 278,095	$ 329,193
Actual/Forecast Applicants	0	0	4	47	78
Cumulative Annual Savings (GJ)	0	0	28,555	35,432	44,131
Annual GHG Reduction (Tonnes CO2e)	0	0	1,599	1,865	2,323

Table 32 presents actual, approved, and forecast expenditures for PNG's Energy Transformation program area.

Table 32: Energy Transformation Program Area Expenditures

CEO: Elementary School	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 32,066	$ 37,226	$ 21,108	$ 60,000	$ 60,000
Approved Expenditures	$ 60,000	$ 60,000	$ 60,000	$ -	$ -
Variance (Actual-Approved)	$ (27,934)	$ (22,774)	$ (38,892)	$ 60,000	$ 60,000

CEO: Post Secondary	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 6,446	$ 8,177	$ 42,722	$ 30,000	$ 30,000
Approved Expenditures	$ 24,000	$ 31,700	$ 31,700	$ -	$ -
Variance (Actual-Approved)	$ (17,554)	$ (23,523)	$ 42,722	$ 30,000	$ 30,000

CEO: General	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 7,041	$ 119,442	$ 128,522	$ 90,000	$ 90,000
Approved Expenditures	$ 33,500	$ 115,900	$ 92,900	$ -	$ -
Variance (Actual-Approved)	$ (26,459)	$ 3,542	$ 35,622	$ 90,000	$ 90,000

Codes and Standards Support	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 5,000	$ 2,000	$ 10,000	$ 30,000	$ 40,000
Approved Expenditures	$ 10,000	$ 10,000	$ 10,000	$ -	$ -
Variance (Actual-Approved)	$ (5,000)	$ (8,000)	$ -	$ 30,000	$ 40,000

Funds for Innovation	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 44,629	$ -	$ 205,243	$ 400,000	$ 600,000
Approved Expenditures	$ 35,000	$ 50,000	$ 50,000	$ -	$ -
Variance (Actual-Approved)	$ 9,629	$ (50,000)	$ 155,243	$ 400,000	$ 600,000

Table 33 presents a summary of PNG's actual and proposed expenditures allocated to Enabling Activities. Expenditures related to program design and administration, marketing, and evaluation, measurement and verification (EM&V) activities are assigned to Enabling Activities.

Table 33: Enabling Activities Expenditures

Enabling Activities	2020	2021	2022	2023	2024
Item	(Actual)	(Actual)	(Projected)	(Forecast)	(Forecast)
Actual/Forecast Expenditures	$ 4,352	$ 6,360	$ 25,451	$ 112,500	$ 175,000
Approved Expenditures	$ 6,000	$ 10,000	$ 60,000	$ -	$ -
Variance (Actual-Approved)	$ (1,648)	$ (3,640)	$ (34,549)	$ 112,500	$ 175,000

Table 34 summarizes actual (2020 – 2021), approved (2022) and forecasted (2023 – 2024) ECI expenditures for new and existing programs.

Table 34: Summary of New and Existing Programs

Summary: New and Existing Programs and Initiatives					
Item	**2020**	**2021**	**2022**	**2023**	**2024**
Actual/Forecast Expenditures	**(Actual)**	**(Actual)**	**(Projected)**	**(Forecast)**	**(Forecast)**
Existing Programs and Initiatives	$ 174,422	$ 373,755	$ 940,918	$ 1,533,330	$ 1,980,565
New Programs and Initiatives	$ -	$ -	$ -	$ 145,957	$ 150,600
Actual/Forecast Expenditures	$ 174,422	$ 373,755	$ 940,918	$ 1,679,288	$ 2,131,164
Approved Expenditures	$ 781,000	$ 880,100	$ 907,100	$ -	$ -
Variance (Actual-Approved)	$ (606,578)	$ (506,345)	$ 33,818	$ 1,679,288	$ 2,131,164

8.1 Customer Bill and Rate Impacts

In Decision attached to Order G-265-20 approving PNG's 2020 – 2022 ECI Schedule of Expenditures the BCUC directed PNG to "include an analysis of bill and rate impacts relating to all customer groups in future DSM/ECI Plans".[29]

PNG has completed such an analysis and the results are presented in Appendix C: Customer Bill Impacts. The cost impacts have been determined based on the current accounting treatment of ECI expenditures that were approved in Order G-265-20, namely that ECI expenditures continue to be recorded in a rate base deferral account that is amortized over a five year period.

The impact on delivery rates in 2025 when the full impact of the amortization of $3.8 million in cumulative expenditures from the ECI portfolio is reflected, is approximately 1.4% in PNG-West, 1.2% in Tumbler Ridge, and, owing to the lower delivery rates, 2.5% in Fort St. John and Dawson Creek. For residential customers in PNG-West and Tumbler Ridge, the impact is equivalent to approximately $1.07 and $0.88 per month, respectively. Owing to the higher average use per account, the impact on a residential customer in Fort St. John and Dawson Creek is approximately $1.27 per month.

In Section 9.2, PNG presents a case for increasing the amortization of ECI expenditures over a period of ten years rather than five years as currently approved.[30] Ten years is comparable

[29] Decision and Order G-265-20, p. 24.

[30] Decision and Order G-265-20, p. 52.

to the cost-weighted average measure life of the 2023 – 2024 ECI portfolio and is also consistent with the amortization period currently approved by the BCUC for FEI's DSM expenditures.

Increasing the amortization period to ten years reduces the impact on customer's bills by about 35%. The impact on delivery rates in 2025 is approximately 0.9% in PNG-West, 0.8% in Tumbler Ridge, and 1.6% in Fort St. John and Dawson Creek. For residential customers in PNG-West and Tumbler Ridge, the impact is reduced to approximately $0.70 and $0.59 per month, respectively. Owing to the higher average use per account, the impact on a residential customer in Fort St. John and Dawson Creek is reduced to approximately $0.82 per month.

9 OTHER MATTERS

9.1 Funding Transfer Rules

PNG requests that the BCUC grant approval allowing PNG flexibility in the reallocation of expenditures amongst different ECI programs and between program years. PNG proposes to continue the program funding transfer rules that have been established since the inception of PNG's ECI portfolio in 2015 and that have been most recently approved under Order G-265-20:

(i) Prior BCUC approval is not required for a funding transfer from one program area to another program area in the accepted expenditure schedule within the same year, if the funding transfer is less than or equal to 25 percent of the budget for each of the program areas;

(ii) Prior BCUC approval is required for each funding transfer from one program area to another program area in the accepted expenditure schedule, if the funding transfer is greater than 25 percent of the budget of either program area; and

(iii) Unspent funds from a program in the accepted expenditure schedule may be transferred to the next year for spending on the same program without prior approval of the BCUC.[31]

9.2 Deferral Treatment and Amortization

PNG seeks approval to continue to record all ECI expenditures as set out in Table 1 in a rate base regulatory asset deferral account. This accounting treatment was approved for ECI expenditures over the period 2020 to 2022 under Order G-265-20.

PNG also seeks approval to set the amortization period for all expenditures charged to this regulatory asset deferral account to ten years, an increase from the amortization period of five years approved for ECI expenditures over the period 2020 to 2022 under Order G-265-20. An amortization period of ten years more closely reflects the actual lives of measures funded by the 2023 to 2024 ECI schedule of expenditures. An analysis of the expected expenditures,

[31] Reasons for Decision and Order G-265-20, p. 52.

GHG savings, and measure lives is presented in Appendix D. Measure lives and GHG savings are taken from the analyses supporting the 2021 CPR. In its analysis, PNG has included all incentive programs as well as its CEO programs and Enabling Activities, assigning those a measure life of zero. Similarly, PNG has not assigned any GHG savings to its CEO programs and Enabling Activities.

Funding for measures having lives 10 years or greater comprise 51 percent of the total 2023-2024 ECI expenditures. On the basis of expected annual GHG savings, measures having lives 10 years or greater comprise 77 percent of the expected annual GHG savings. PNG's analysis using both a budget weighted portfolio, and a GHG savings weighted portfolio approach results in a weighted average life of 8.7 years and 12.3 years, respectively.

PNG acknowledges the BCUC's reluctance, in earlier applications made by FEI, to increase the amortization period of FEI's DSM portfolio beyond ten years.[32] In Reasons for Decision attached to Order G-10-19, the BCUC determined that it did "not consider the evidence for the 16 year period to be sufficiently compelling at this time to warrant approval of an increase in the amortization period" and stated that the "measure life is influenced by factors that are outside of FEI's control, such as user participation and behaviour, and is based on achieving the estimated volumes, mix and lives of the various measures proposed in the Application".[33]

PNG concedes that its own analysis is also subject to achieving the forecast participation and GHG savings, and durability of its measures. However, PNG's analysis does differ in one important respect, namely that it has included its entire program budget in the analysis and assigned no weight to non-incentive program expenditures.

Regardless of whether the BCUC decides to assign any weight to PNG's analyses, PNG submits that the over arching consideration is the mitigation of rate impacts to customers. The BCUC has accepted FEI's 10-year amortization on the basis of mitigating rate impacts:

> *The Panel is prepared to accept the requested amortization period of 10 years at this time, primarily on the basis of rate impact concerns.*[34]

[32] Reasons for Decision Order G-10-19, p. 21.

[33] Reasons for Decision Order G-10-19, p. 22.

[34] Reasons for Decision Order G-138-14 (FortisBC Energy Inc., 2014-2018 PBR Decision), p. 279.

In Section 8.1, PNG presented the impact on customer rates of the amortization of ECI expenditures over a period of five years as well as ten years. Increasing the amortization to 10 years decreases the impacts on customers by approximately 35%.

While extending the amortization period to 10 years results in a modest decrease in customer rates under the proposed ECI schedule of expenditures, a longer amortization will have an increasingly beneficial impact as PNG increases its spending on its ECI programs. As stated in Section 3.2, PNG is currently developing and executing its Low Carbon Strategy in response to the evolving regulation and guidance on the GHG Reduction Standard and pathways to achieving it. The ECI portfolio is a key element of this strategy, and the expansion of the ECI portfolio presented in this Application, as well as further expansions in subsequent years, are important steps towards increasing the impact that the portfolio has on reducing GHG emissions associated with natural gas consumption by PNG's customers. As ECI expenditures increase, mitigation of the impact to customers is expected to become increasingly important. PNG views an increase to the amortization period to 10 years as an important aspect of controlling the rate impacts to its customers. For this reason, and to ensure that PNG's customers are treated consistently with FEI's customers, PNG submits that increasing the amortization period to ten years is appropriate at this time.

9.3 Metrics

In Reasons for Decision on Order G-265-20, the BCUC agreed with "BCOAPO's observation that without specific metrics to measure customer awareness and satisfaction, it is difficult for PNG to maximize the effectiveness of its ECI portfolio spending." The BCUC therefore encouraged PNG to "include such metrics in its next ECI Application".[35]

Over the past two years, PNG has increased its advertising activities to more aggressively promote its residential and commercial programs. PNG has branded its ECI programs under the name "Smart Energy Solutions" and developed a portfolio of electronic and printed media that is used in a sustained electronic media campaign. The effectiveness of the campaign in raising awareness amongst customers is measured directly based on the traffic generated on PNG's website in general, and on the Smart Energy Solutions web pages specifically.

[35] Reasons for Decision and Order G-265-20, p. 49.

PNG regularly assesses the effectiveness of its media campaigns and uses the results to inform subsequent campaigns. Overall, a recent campaign completed in the Fall of 2021 resulted in an increase of 116% in traffic on PNG's website, compared to the same period in 2020.[36]

[36] A report on a recent media campaign is attached as Appendix E.

APPENDICES

Appendix A Draft Order

Appendix B 2021 Conservation Potential Review

Appendix C Customer Bill Impacts

Appendix D Average Measure Life of ECI Portfolio

Appendix E Fall 2021 Media Campaign Report

APPENDIX A: DRAFT ORDER

DRAFT

bcuc
British Columbia
Utilities Commission

Suite 410, 900 Howe Street
Vancouver, BC Canada V6Z 2N3
bcuc.com

P: 604.660.4700
TF: 1.800.663.1385
F: 604.660.1102

ORDER NUMBER
G-xx-22

IN THE MATTER OF
the *Utilities Commission Act*, R.S.B.C. 1996, Chapter 473

and

Pacific Northern Gas Ltd. and Pacific Northern Gas (N.E.) Ltd.
An Application for Approval of
Energy Conservation and Innovation Portfolio Funding for 2023 and 2024

BEFORE:
????????, Commissioner
????????, Commissioner

on December ??, 2022

ORDER

WHEREAS:

A. On August 12, 2022, Pacific Northern Gas Ltd. and Pacific Northern Gas (N.E.) Ltd. (collectively, PNG) (PNG) filed for acceptance by the British Columbia Utilities Commission (BCUC) the expenditure schedule for the Energy Conservation and Innovation (ECI) Portfolio for 2023 and 2024 (2023-2024 ECI Expenditure Schedule), pursuant to section 44.2 of the *Utilities Commission Act* (UCA) (the Application);

B. In the Application, PNG also seeks the following approvals:

    1. Flexibility in the reallocation of expenditures amongst Demand Side Management (DSM) programs and between program years, subject to the total amount not exceeding the total amount of $3,810,000 as per the 2023-2024 ECI Expenditure Schedule; and

    2. Approval to record all DSM expenditures in a rate base regulatory asset deferral account, and to change the amortization period to ten years from five years for DSM expenditures approved by BCUC Order G-265-20;

C. By Order G-XX-22, the BCUC established a public hearing process and a regulatory timetable for review of the Application, which consisted of intervener registration, BCUC and intervener information requests (IRs), PNG responses to IRs, final arguments from PNG and interveners, and reply argument from PNG;

D. By September XX, 2022, ?? and ?? registered as interveners;

E. The BCUC has completed its review of the evidence and submissions by all parties and finds that the following determinations are warranted.

NOW THEREFORE pursuant to section 44.2 of the UCA, and for the reasons set out in Decision accompanying this Order, the BCUC orders as follows:

1. PNG's 2023-2024 Energy Conservation and Innovation Expenditure Schedule in the amount of $3.810 million as set out in Table ? of the Decision is accepted.

2. PNG is directed to comply with the funding transfer rules for reallocation expenditures amongst DSM program areas and between program years as approved in section ? of the Decision accompanying this Order.

3. PNG's proposed continuation of the inclusion of ECI expenditures in a rate base deferral account is approved, and PNG's proposed amortization of deferred expenditures over a ten-year period is approved.

4. PNG is directed to comply with all other determinations and directives as set out in the Decision accompanying this Order.

DATED at the City of Vancouver, in the Province of British Columbia, this xx day of December 2022.

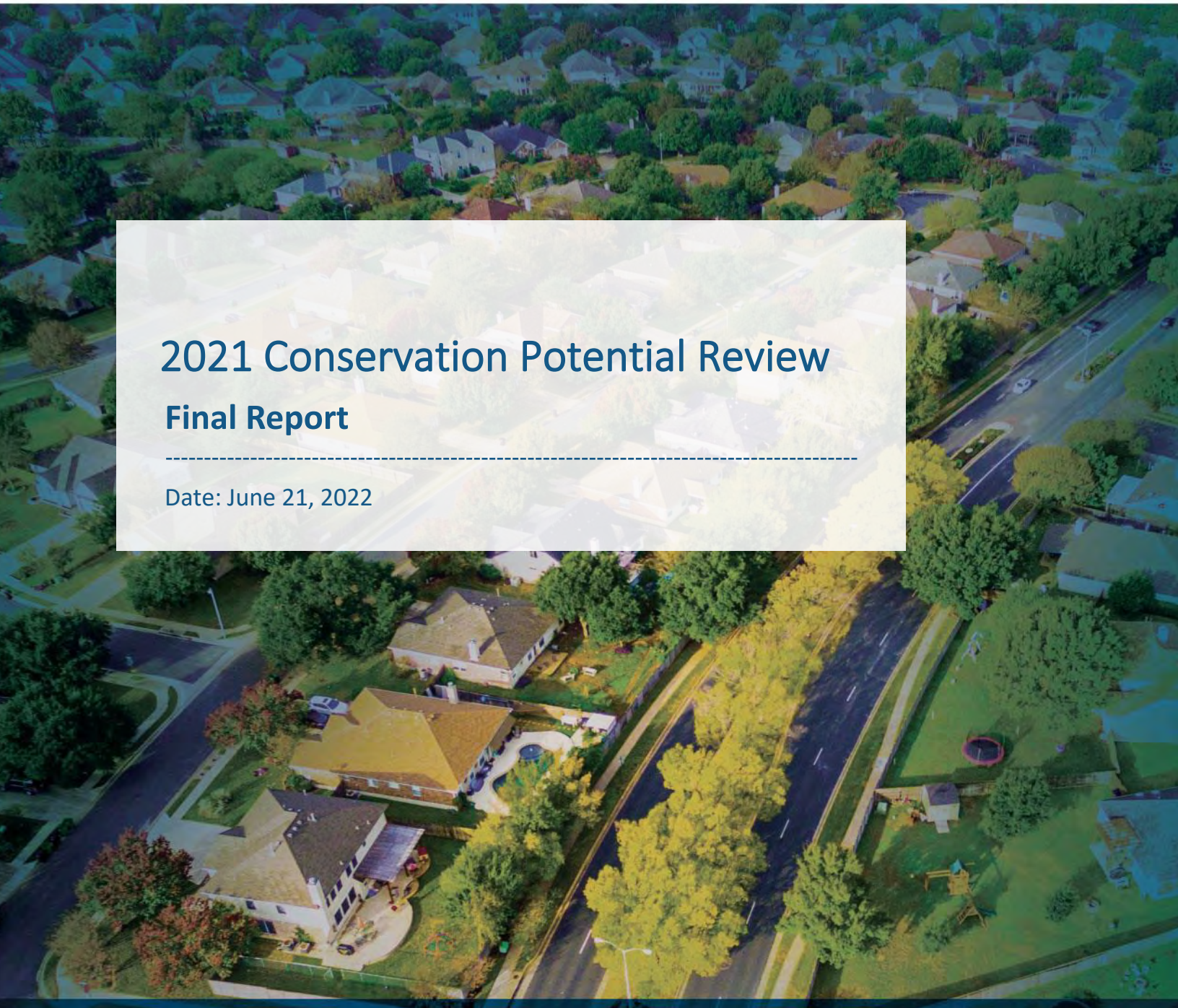
BY ORDER

????????
Commissioner

Attachment

APPENDIX B: 2021 CONSERVATION POTENTIAL REVIEW

POSTERITY GROUP



2021 Conservation Potential Review

Final Report

Date: June 21, 2022

Al Kleinschmidt, P.Eng., Manager, Energy Solutions
Pacific Northern Gas Ltd.
750-888 Dunsmuir Street
Vancouver, BC V6C 3K4

Posterity Group
43 Eccles St, 2nd Floor – Unit 2
Ottawa, ON K1R 6S3

Contents

Executive Summary 8
Background and Objectives 8
Findings Summary 8
Scope 9
Approach 10
Results and Findings 13

1 Introduction 22
1.1 Background and Study Goals 22
1.2 Report Organization and Results Presentation 22
1.3 Caveats and Limitations 22

2 Study Scope 23
2.1 Definition of Terms 23
2.2 CPR Coverage 26

3 Study Approach 29
3.1 Major CPR Analysis Steps 29
3.2 Base Year Energy Use Model Development 33
3.3 Reference Case Forecast Development 35
3.4 Measure Characterization 36
3.5 Technical Potential Forecast Development 38
3.6 Economic Potential Forecast Development 40

4 Residential Sector Results 41
4.1 Residential Segments, End Uses, Vintages 41
4.2 Base Year Natural Gas Use 42
4.3 Reference Case Natural Gas Use 50
4.4 Measure Assessment 53
4.5 Technical Potential 59

4.6 Economic Potential 64
4.7 Market Potential 72

5 Commercial Sector Results 84
5.1 Commercial Segments and End Uses 84
5.2 Base Year Natural Gas Use 86
5.3 Reference Case Natural Gas Use 90
5.4 Measure Assessment 93
5.5 Technical Potential 98
5.6 Economic Potential 104
5.7 Market Potential 110

6 Industrial Sector Results 124
6.1 Industrial Segments and End Uses 124
6.2 Base Year Natural Gas Use 127
6.3 Reference Case Natural Gas Use 132
6.4 Measure Assessment 134
6.5 Technical Potential 138
6.6 Economic Potential 143
6.7 Market Potential 149

List of Exhibits

Exhibit 1 – Map of PNG's Service Area 26
Exhibit 2 – CPR Segments, End Uses, & Vintages by Sector 27
Exhibit 3 – Difference Between Technical, Economic, and Market Potential 32
Exhibit 4 – 2021 CPR Model Parameters 33
Exhibit 5 – Base Year Calibration Steps for All Sectors 34
Exhibit 6 – Reference Case Development Steps for All Sectors 35
Exhibit 7 – CPR Measure Characterization Workbook Example: Residential Communicating Thermostat 37
Exhibit 8 – Residential Sector Segments, End Uses, and Vintages 41
Exhibit 9 - Residential Natural Gas Consumption (GJ) in 2020 by Segment 42
Exhibit 10 - Residential Natural Gas Consumption (GJ) in 2020 by End Use 42
Exhibit 11 - Residential Natural Gas Consumption (GJ) in 2020 by Region 43
Exhibit 12 - Residential Natural Gas Consumption (GJ) in 2020 by Vintage 43
Exhibit 13 - Number of Residential Dwellings in 2020 44
Exhibit 14 - 2020 Modelled UEC Values by End Use, Gas, and Non-Gas-Heated SFD/Duplex Dwellings in the Northeast 46
Exhibit 15 – 2020 Modelled UEC Values for DHW Sub-End Uses, SFD/Duplex Dwellings in the Northeast 47
Exhibit 16 – 2020 Modelled Average Annual Gas Use Per Dwelling by End Use, Gas and Non-Gas SFD/Duplex Heated Dwellings in the Northeast 48
Exhibit 17 – 2020 Modelled Average Annual Gas Use Per SFD/Duplex Dwellings in the Northeast by DHW Sub-End Uses and Predominant Heating Fuel 49
Exhibit 18 - Number of Residential Accounts, 2020 vs 2041, by Region, Segment, and Vintage 50
Exhibit 19 - 2020 vs 2041 Residential Gas Consumption (GJ) by Segment 51
Exhibit 20 - 2020 vs 2041 Residential Gas Consumption (GJ) by End Use 51
Exhibit 21 - 2020 vs 2041 Residential Gas Consumption (GJ) by Region 51
Exhibit 22 - 2021-2041 Gas Consumption (GJ) by New and Existing and Segment 52
Exhibit 23 – 2021 vs 2041 Residential Gas Accounts Forecast by Existing and New Vintage 53
Exhibit 24 – Residential Sector Conservation and Energy Management Measures 54
Exhibit 25 – Residential Sector Results: Sector Averages (Sorted by High to Low MTRC) 56
Exhibit 26 – Residential Technical Potential Savings (GJ) 59
Exhibit 27 – Technical Savings Potential as a Percent of Residential Reference Case Consumption (%) 60
Exhibit 28 – Technical Potential – Annual Gas Savings from Top 25 Residential Measures in 2024 (GJ) 61
Exhibit 29 – Residential Sector: Technical Potential Supply Curve – TRC 62
Exhibit 30 – Residential Sector: Technical Potential Supply Curve – MTRC 63
Exhibit 31 – Economic Potential Savings (GJ) – Residential, TRC and MTRC 64
Exhibit 32 – Economic Potential Consumption (GJ) Forecasts – Residential, TRC and MTRC 65
Exhibit 33 – Economic Potential Savings by Region in 2024 – Residential, TRC 66
Exhibit 34 – Economic Potential Savings by Region in 2024 – Residential, MTRC 66
Exhibit 35 – Economic Potential Savings by Segment and Vintage in 2024 – Residential, TRC 67
Exhibit 36 – Economic Potential Savings by Segment and Vintage in 2024 – Residential, MTRC 67
Exhibit 37 – Economic Potential Savings by End Use in 2024 – Residential, TRC 68
Exhibit 38 – Economic Potential Savings by End Use in 2024 – Residential, MTRC 68
Exhibit 39 – Economic Potential Savings by End Use in 2041 – Residential, TRC and MTRC 69
Exhibit 40 – Residential Economic Potential (TRC) – Annual Gas Savings from All TRC-Passing Measures in 2024 (GJ) 69
Exhibit 41 – Economic Potential in 2024 (GJ) By End Use – Residential, TRC 70
Exhibit 42 – Residential Economic Potential (MTRC) - Annual Gas Savings from Top 25 MTRC-Passing Measures in 2024 (GJ) 70
Exhibit 43 – Economic Potential (GJ) in 2024 By End Use – Residential, MTRC 71
Exhibit 44 – Market Potential Savings (GJ) – Residential, TRC 72
Exhibit 45 – Market Potential Savings (GJ) – Residential, MTRC 73
Exhibit 46 – Market Potential Consumption (GJ) Forecasts – Residential, TRC 73

Exhibit 47 – Market Potential Consumption (GJ) Forecasts – Residential, MTRC 74
Exhibit 48 – Medium Market Potential Savings by Region in 2024 – Residential, TRC 74
Exhibit 49 – Medium Market Potential Savings by Region in 2024 – Residential, MTRC 75
Exhibit 50 – Medium Market Potential Savings by Segment and Vintage in 2024 – Residential, TRC 75
Exhibit 51 – Medium Market Potential Savings by Segment and Vintage in 2024 – Residential, MTRC 76
Exhibit 52 – Medium Market Potential Savings by End Use in 2024 – Residential, TRC 76
Exhibit 53 – Medium Market Potential Savings by End Use in 2024 – Residential, MTRC 77
Exhibit 54 – Medium Market Potential Savings by End Use in 2041 – Residential, TRC and MTRC 77
Exhibit 55 – Medium Market Potential (TRC on Left, MTRC on Right) - Top 14 Residential Measures in 2024 (GJ) 78
Exhibit 56 – Medium Market Potential (TRC on Left, MTRC on Right) – Savings by End Use in 2024 (%) 79
Exhibit 57 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, TRC 80
Exhibit 58 - Medium and High Market Total Costs per Natural Gas Savings – Residential, TRC 81
Exhibit 59 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, MTRC 82
Exhibit 60 - Medium and High Market Total Costs per Natural Gas Savings – Residential, MTRC 83
Exhibit 61 – Definition of Commercial Sector Segments, End Uses, and Vintages 84
Exhibit 62 - PNG Rate Classes Reviewed vs Not Reviewed 85
Exhibit 63 - Accounts and Consumption of Reviewed and Not Reviewed Rate Classes 85
Exhibit 64 - Small Commercial Segment Breakdown 86
Exhibit 65 – 2020 Commercial Natural Gas Consumption (GJ) by Segment 87
Exhibit 66 – 2020 Commercial Natural Gas Consumption (GJ) by End Use 87
Exhibit 67 – 2020 Commercial Natural Gas Consumption (GJ) by Region 87
Exhibit 68 – 2020 Commercial Natural Gas Accounts by Segment 88
Exhibit 69 – 2020 Commercial Natural Gas Accounts by Region 88
Exhibit 70 – 2020 Space Heating UEC values by End Use, Large Offices in the Northeast 89
Exhibit 71 – 2020 Average Annual Space Heating Gas Use Per m^2, Large Offices, Northeast 89
Exhibit 72 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by Segment 90
Exhibit 73 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by End Use 91
Exhibit 74 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by Region 91
Exhibit 75 – 2020 vs 2041 Commercial Gas Accounts Forecast by Segment 92
Exhibit 76 – 2021 vs 2041 Commercial Gas Accounts Forecast by Existing and New Vintage 92
Exhibit 77 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by Existing and New Vintage 93
Exhibit 78 – Commercial Sector Conservation and Energy Management Measures 94
Exhibit 79 – Commercial Sector Measures with Average TRC and MTRC Results 95
Exhibit 80 – Commercial Technical Potential Savings (GJ) 98
Exhibit 81 – Technical Savings Potential as a Percent of Commercial Reference Case Consumption (%) 99
Exhibit 82 – Technical Potential - Top 25 Commercial Measures in 2024 (GJ) 100
Exhibit 83 - Technical Potential - Top 25 Commercial Measures in 2024 (GJ) excluding Panel Retrofit 101
Exhibit 84 – Commercial Sector: Technical Potential Gas Supply Curve in 2041 – TRC 102
Exhibit 85 – Commercial Sector: Technical Potential Supply Curve – MTRC 103
Exhibit 86 – Economic Potential Savings (GJ) – Commercial, TRC and MTRC 104
Exhibit 87 – Economic Potential Consumption (GJ) Forecasts – Commercial, TRC and MTRC 105
Exhibit 88 – Economic Potential Savings by Region in 2024 – Commercial, TRC 105
Exhibit 89 – Economic Potential Savings by Region in 2024 – Commercial, MTRC 106
Exhibit 90 – Economic Potential Savings by Segment in 2024 – Commercial, TRC 106
Exhibit 91 – Economic Potential Savings by Segment in 2024 – Commercial, MTRC 107
Exhibit 92 – Economic Potential Savings by End Use in 2024 – Commercial, TRC 107
Exhibit 93 – Economic Potential Savings by End Use in 2024 – Commercial, MTRC 108
Exhibit 94 – Economic Potential Savings by End Use in 2041 – Commercial, TRC and MTRC 108
Exhibit 95 – Economic Potential (TRC on Left, MTRC on Right) - Top 25 Commercial Measures in 2024 (GJ) 109
Exhibit 96 – Market Potential Savings (GJ) – Commercial, TRC 110
Exhibit 97 – Market Potential Savings (GJ) – Commercial, MTRC 111

Exhibit 98 – Top 10 Commercial Measures Contributing to Difference in Medium and High Market Potential Scenarios (Using MTRC Screen) by 2040 112
Exhibit 99 – Top 10 Commercial Measures Contributing to Difference in Medium and High Market Potential Scenarios (Using TRC Screen) by 2040 113
Exhibit 100 – Commercial Market Potential Consumption (GJ) Forecasts – Commercial, TRC 114
Exhibit 101 – Commercial Market Potential Consumption (GJ) Forecasts – Commercial, MTRC 115
Exhibit 102 – Medium Market Potential Savings by Region in 2024 – Commercial, TRC 115
Exhibit 103 – Medium Market Potential Savings by Region in 2024 – Commercial, MTRC 116
Exhibit 104 – Medium Market Potential Savings by Segment in 2024 – Commercial, TRC 116
Exhibit 105 – Medium Market Potential Savings by Segment in 2024 – Commercial, MTRC 117
Exhibit 106 – Medium Market Potential Savings by End Use in 2024 – Commercial, TRC 117
Exhibit 107 – Medium Market Potential Savings by End Use in 2024 – Commercial, MTRC 117
Exhibit 108 – Medium Market Potential Savings by End Use in 2040 – Commercial, TRC and MTRC 118
Exhibit 109 – Medium Market Potential (TRC on Left, MTRC on Right) - Gas Savings from Top 25 Commercial Measures in 2024 (GJ) 119
Exhibit 110 – Medium and High Market Incentive Costs and Natural Gas Savings – Commercial, TRC 120
Exhibit 111 - Medium and High Market Total Costs per Natural Gas Savings – Commercial, TRC 121
Exhibit 112 – Medium and High Market Incentive Costs and Natural Gas Savings – Commercial, MTRC Ratio 122
Exhibit 113 - Medium and High Market Total Costs per Natural Gas Savings – Commercial, MTRC 123
Exhibit 114 - PNG Rate Classes Reviewed vs Not Reviewed 125
Exhibit 115 - Accounts and Consumption of Reviewed and Not Reviewed Rate Classes 125
Exhibit 116 - Small Industrial Segment Breakdown 126
Exhibit 117 – 2020 Industrial Natural Gas Consumption (GJ) by Segment 127
Exhibit 118 – 2020 Industrial Natural Gas Consumption (GJ) by End Use 128
Exhibit 119 – 2020 Industrial Natural Gas Consumption (GJ) by Region 128
Exhibit 120 – 2020 Industrial Accounts by Segment 129
Exhibit 121 – 2020 Industrial Accounts by Region 129
Exhibit 122 – 2020 UEC Values by End Use, Wood Products Segment in the West (West) Region 131
Exhibit 123 – 2020 Average Annual Gas Use per Account by End Use, Wood Products Account in West (West) Region 131
Exhibit 124 – 2020 vs 2041 Industrial Gas Consumption (GJ) by Region 132
Exhibit 125 – 2020 vs 2041 Industrial Gas Consumption (GJ) by Segment 133
Exhibit 126 – 2020 vs 2041 Industrial Gas Consumption (GJ) by End Use 133
Exhibit 127 – Industrial Sector Conservation and Energy Management Measures 134
Exhibit 128 – Industrial Sector Measures with Average TRC and MTRC Results 135
Exhibit 129 – Industrial Technical Potential Savings (GJ) 139
Exhibit 130 – Technical Potential Savings as a Percent of Industrial Reference Case Consumption (%) 139
Exhibit 131 – Technical Potential – Top 25 Industrial Measures in 2024 (GJ) 140
Exhibit 132 – Industrial Sector: Technical Potential Supply Curve, 2041 – TRC 141
Exhibit 133 – Industrial Sector: Technical Potential Supply Curve, 2041 – MTRC 142
Exhibit 134 – Economic Potential Savings (GJ) - Industrial, TRC and MTRC 143
Exhibit 135 – Economic Potential Consumption (GJ) Forecasts – Industrial, TRC, and MTRC 144
Exhibit 136 – Economic Potential Savings by Region in 2024 – Industrial, TRC 144
Exhibit 137 – Economic Potential Savings by Region in 2024 – Industrial, MTRC 145
Exhibit 138 – Economic Potential Savings by Segment in 2024 – Industrial, TRC 145
Exhibit 139 – Economic Potential Savings by Segment in 2024 – Industrial, MTRC 146
Exhibit 140 – Economic Potential Savings by End Use in 2024 – Industrial, TRC 146
Exhibit 141 – Economic Potential Savings by End Use in 2024 – Industrial, MTRC 147
Exhibit 142 – Economic Potential Savings by End Use in 2041 – Industrial, TRC and MTRC 147
Exhibit 143 – Economic Potential (TRC on Left, MTRC on Right) - Top 25 Industrial Measures in 2024 (GJ) 148
Exhibit 144 – Market Potential Savings (GJ) – Industrial, TRC 149
Exhibit 145 – Market Potential Savings (GJ) – Industrial, MTRC 150
Exhibit 146 – Market Potential Consumption (GJ) Forecasts – Industrial, TRC 151

Exhibit 147 – Market Potential Consumption (GJ) Forecasts – Industrial, MTRC 152
Exhibit 148 – Medium Market Potential Savings by Region in 2024 – Industrial, TRC 152
Exhibit 149 – Medium Market Potential Savings by Region in 2024 – Industrial, MTRC 153
Exhibit 150 – Medium Market Potential Savings by Segment in 2024 – Industrial, TRC 153
Exhibit 151 – Medium Market Potential Savings by Segment in 2024 – Industrial, MTRC 154
Exhibit 152 – Medium Market Potential Savings by End Use in 2024 – Industrial, TRC 154
Exhibit 153 – Medium Market Potential Savings by End Use in 2024 – Industrial, MTRC 155
Exhibit 154 – Medium Market Potential Savings by End Use in 2040 – Industrial, TRC and MTRC 155
Exhibit 155 – Medium Market Potential (TRC on Left, MTRC on Right) - Gas Savings from Top 25 Industrial Measures in 2024 (GJ) 156
Exhibit 156 – Medium and High Market Incentive Costs and Natural Gas Savings – Industrial, TRC 157
Exhibit 157 – Medium and High Market Total Costs per Natural Gas Savings – Industrial, TRC 158
Exhibit 158 – Medium and High Market Incentive Costs and Natural Gas Savings – Industrial, MTRC 159
Exhibit 159 – Medium and High Market Total Costs per Natural Gas Savings – Industrial, MTRC 160

Acronyms

BAS	Building Automation System
C&EM	Conservation and Energy Management
CCE	Cost of Conserved Energy
CEUS	Commercial End Use Survey
CPR	Conservation Potential Review
DHW	Domestic Hot Water
DIY	Do-It-Yourself
DSM	Demand Side Management
ECM	Energy Conservation Measure
EECAG	Energy Efficiency and Conservation Advisory Group
EUI	Energy Use Intensity
PG	Posterity Group
PNG	Pacific Northern Gas Ltd.
GJ	Gigajoule
HE	High Efficiency
HVAC	Heating, Ventilation, and Air Conditioning
LTGRP	Long Term Gas Resource Plan
MUA	Make Up Air
NAICS	North American Industry Classification System
NEW	New Construction
O&M	Operation and Maintenance
PJ	Petajoule, i.e. 1 million gigajoules
RET	Retrofit
REUS	Residential End Use Survey
ROB	Replace-on-burnout
RTU	Remote Terminal Unit
TJ	Terajoule, i.e. 1 thousand gigajoules
TMP	Thermomechanical Pulping – an industrial Pulp & Paper segment term
TRM	Technical Resource Manual
UEC	Unit Energy Consumption
ZEEA	Zero Emission Energy Alternative

Executive Summary

Background and Objectives

The 2021 Conservation Potential Review (CPR) is the review of energy efficiency opportunities available among Pacific Norther Gas's (PNG) residential, commercial, and industrial natural gas customers.

The CPR will support PNG's Demand Side Management (DSM) plan for regulatory filing in 2022. For this CPR, Posterity Group reviewed estimated technical, economic, and market potential natural gas savings in PNG's service territory over a 20-year period. The CPR is an important guiding document for ongoing conservation and energy management program development and support at PNG. PNG has also retained Posterity Group to develop their 2022 Demand Side Management (DSM) plan for regulatory filing.

Findings Summary

- This study has found significant cost-effective and market achievable natural gas savings throughout the study period 2020-2041, and in all sectors and segments.

  Across all sectors, and using the MTRC screen, medium market potential savings are estimated at approximately 202 TJ, or 2% of reference consumption in 2024, rising to 845 TJ, or 12% of reference consumption, in 2041.

  This estimated 845 TJ savings by 2041 includes potential savings from Residential, Industrial, and Commercial sectors of 529 TJ, 202 TJ, and 114 TJ respectively.

- In the ***residential sector***, only a small number of measures are cost-effective based on the TRC test, most being low-cost retrofit measures. Measures that pass the MTRC screen only become more important in the residential sector as the study period progresses.
  - In terms of percentage of reference case consumption forecast, more residential opportunities are available in the space heating end use followed by domestic hot water throughout the study period. In absolute terms, the savings potential for space heating measures (391 TJ by 2041 in the medium market potential scenario, MTRC screen) is significantly higher than that of domestic hot water measures (119 TJ by 2041 in the medium market potential scenario, MTRC screen).

- ***Commercial sector*** savings show the most variance between the high and medium market potential scenarios. Using the MTRC screen, by 2041 the difference in potential between the medium and high market scenarios is 179 TJ.

  Efficient new construction (NC Step Codes 2 and 3), energy recovery ventilators, and condensing MUAs are major contributing factors to this difference. These measures have high technical and economic potential, but future uptake is uncertain. For example, in the medium scenario, NC Step Codes are modelled as new buildings with minimal forecasted growth. In the high scenario, they are modelled with higher forecasted growth, especially in the second half of the study period (2030-2040).

- The ***industrial sector*** is estimated to have the largest cost-effective savings potential on the TRC economic screen relative to other sectors. However, industrial customers require shorter payback periods relative to commercial and residential customers. Achieving savings from industrial measures that are cost-effective but have longer customer payback periods may be challenging and/or more expensive due to higher incentives and program costs.

Scope

Timing: The base year for this study is the 2020 calendar year, where the reference case forecast is from 2021 to 2041 with results calculated for each intervening year.

Regions: This study divides the PNG gas regions in British Columbia into three regions: Northeast, West (West), and West (East).

The CPR divides the PNG gas regions in British Columbia (BC) into three regions: Northeast, West (West), and West (East). A map of the PNG service area is shown in EX 1.

EX 1 – Map of PNG's Service Area

Sectors: The study addresses three sectors: residential, commercial, and industrial. The breakdown of each sector is shown in EX 2, organized by segment.

EX 2 – CPR Segments

Residential	Commercial	Industrial
• Single Family Detached/Duplexes • Single Family Attached/Row • Mobile/Other Residential	• Apartments – Medium • Apartments – Large Food Retail • Hospital • Hotel – Medium • Hotel – Large • Non-Food Retail – Medium • Non-Food Retail – Large • Nursing Home • Office – Medium • Office – Large • Other Commercial • Restaurant • School – Medium • School – Large • University/College • Warehouse	• Agriculture (includes greenhouses) • Chemical • District energy providers • Fabricated Metal • Food & Beverage • Other Manufacturing (includes transportation and other industrial) • Mining • Non-metallic Mineral (includes cement) • Primary Metals • Pulp & Paper – Kraft • Upstream Oil and Gas • Utilities • Wood Products

End uses vary and are described in Section 2 of this report. The residential sector is also broken down into vintages that define the time periods when the dwellings were constructed.

Approach

The CPR model was developed using Posterity Group's Navigator™ Energy and Emissions Simulation Suite. Data was collected from various sources for the analysis and inputted to the model.

The CPR followed these key steps to perform the analysis:

1. Determine the current (Base Year) customer base and their energy consumption.
    a. Collect and review data on the building stock in PNG's service territory, including end use surveys and previous CPRs.
    b. Develop energy use models of each building or facility type (segments) and model energy consumption by end use.
    c. Collect and review actual base year (2020) energy use and billing data of PNG's customers.
    d. Use the billing data to calibrate the base year energy consumption in each sector's energy model.

2. Develop reference case energy consumption forecast.

    a. Collect and review data on all factors that will affect energy use trends over the study period (2021 to 2041 in this study's case).
        i. This includes analyzing and modelling natural improvements in building energy use intensities (e.g. from natural replacement of furnaces with new, higher efficiency ones at replacement time).
        ii. Other factors are existing building demolition / renovation trends, rate of new building stock construction, baseline energy efficiency of new buildings and equipment, and known changes to policies and codes and standards that will impact the energy use of buildings.
    b. Use this data to develop an energy consumption forecast model for each sector.
    c. Calibrate the reference case based on PNG's own account forecasts at the region and rate class level.

3. Characterize energy conservation measures.

    a. Select a set of energy conservation measures for each sector. Measures range from mature, widely known measures (e.g. commercial condensing boilers) to innovative or enabling technologies (e.g. smart residential water heater controllers). Behavioural measures are also considered (e.g. thermostat setback).
    b. For each measure, review and collect data on energy savings, costs, useful life, and the baseline equipment or technology that it should be compared with (if applicable).
    c. Use the data to characterize the technology's energy savings potential, cost-effectiveness, and financial attractiveness.
    d. Use the data as inputs to the energy model for each sector.

4. Estimate technical savings potential.

    a. For each measure, determine its technical applicability (i.e. how many buildings or facilities can this measure be applied to, considering only technical barriers).
    b. Determine the measures' current market penetration (i.e. how many buildings or facilities have already installed a measure).
    c. Estimate the measures' reference adoption – their natural rate of uptake in the absence of incentives or utility program intervention.
    d. Input all data into the energy model for each sector and develop a estimate of the technically feasible energy savings potential within PNG's service territory.[1]

[1] See Exhibit 3 for an overview of the constraints considered in the technical potential scenario, and the differences between the potential scenarios.

5. Estimate economic savings potential.

    a. Screen each measure for cost-effectiveness from PNG's perspective by determining whether the benefit to cost ratio of each measure is 1.0 or above (pass) or if it is below 1.0 (fail) for two cost effectiveness tests: TRC and MTRC.
    b. Update the technical potential model with only the TRC-passing measures, removing measures that are not cost-effective.
    c. Estimate the economic savings potential of all cost-effective measures applied to all technically feasible buildings in the customer base.[2]
    d. Repeat steps 5b and 5c using the MTRC screen. This study presents findings from two economic (and subsequent market potential) models: One with TRC as the economic screen and one with MTRC.

6. Estimate market savings potential.

    a. Based on existing research, develop sets of "generic" adoption curves based on customer payback acceptance and typical market diffusion patterns.[3]
    b. Apply these generic curves to each measure in the economic potential model to develop "simplified market potential" estimates at the measure level.
    c. Apply this data to the TRC economic potential model to develop a simplified market potential.
    d. Develop a more realistic market potential for each measure by soliciting feedback from PNG on the simplified market potential.[4]
    e. Perform sensitivity analysis by varying measure capital and installation costs.
    f. Repeat steps 6c to 6e using the MTRC economic potential model to estimate low, medium, and high market potential scenarios using the MTRC economic screen.

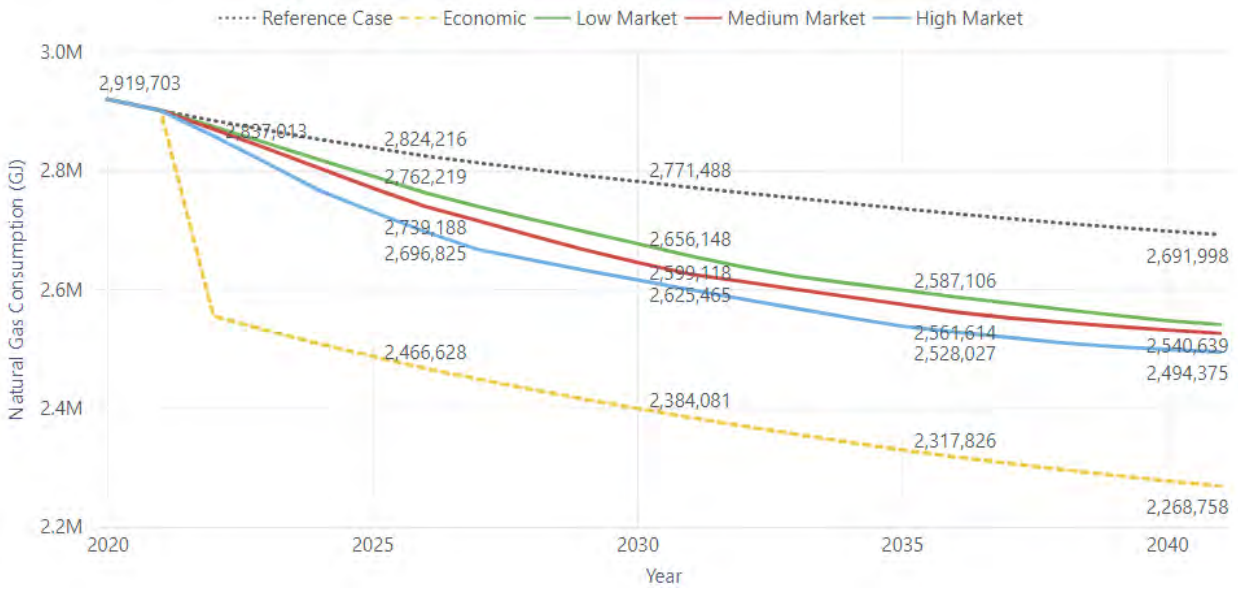
[2] See Exhibit 3 for an overview of the constraints considered in an economic potential scenario.
[3] Generic adoption curves primarily consider two things: the current market penetration of the measure, and its simple payback. Based on these factors, the curves are applied to each measure to estimate generic participation rates as a percentage of economic potential.
[4] This process includes selecting representative, high-impact measures and adjusting their generic participation rates using historical program data, local market knowledge, and industry insights/feedback, then extrapolating these calibrated participation rates to other similar measures within each sector.

Results and Findings

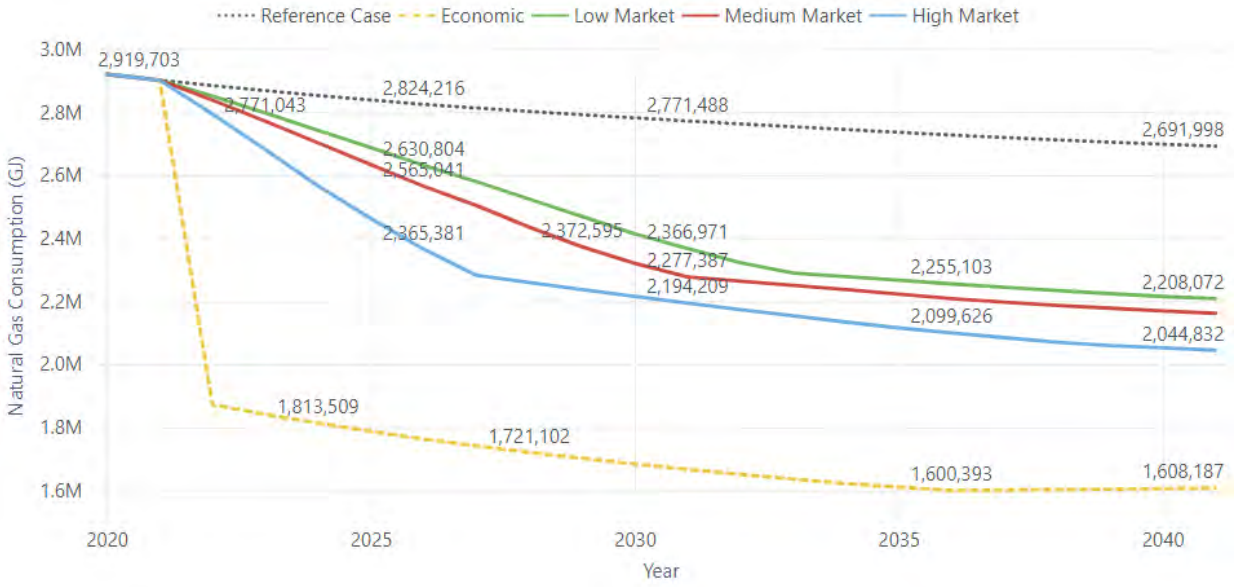
Residential

Forecasted gas consumption under the three market potential scenarios for the commercial sector are shown in EX 3 (TRC) and EX 4 (MTRC). The reference consumption is forecasted to drop to 2,692 TJ in 2041 from 2,920 PJ today. The residential low, medium, and high market TRC potential consumption levels are estimated to be 2,541 TJ, 2,526 TJ, and 2,494 TJ by 2041. For MTRC, the potential consumption levels are estimated to be 2,208 TJ, 2,162 TJ, and 2,045 TJ, respectively.

EX 3 – Market Potential Consumption (GJ) Forecasts – Residential, TRC



EX 4 – Market Potential Consumption (GJ) Forecasts – Residential, MTRC



The incentive and non-incentive spending amounts required to achieve the medium and high market potential are shown in EX 5 (TRC) and EX 6 (MTRC). Medium and high market incentives are 50% and 100% of measures' incremental costs, respectively. The tables show the total and incremental savings from the new measures installed every year.

EX 5 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, TRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$294K	$44K	$338K	14,498	14,498	$23.32	$1,155K	$87K	$1,241K	25,917	25,917	$47.89
2023	$340K	$51K	$391K	30,825	16,327	$12.69	$1,310K	$98K	$1,409K	54,882	28,965	$25.67
2024	$375K	$56K	$431K	48,566	17,740	$8.87	$1,436K	$108K	$1,544K	86,015	31,133	$17.95
2025	$405K	$61K	$466K	67,832	19,267	$6.87	$1,230K	$92K	$1,322K	107,635	21,620	$12.28
2026	$389K	$58K	$448K	85,028	17,196	$5.27	$1,193K	$89K	$1,282K	127,391	19,756	$10.07
2027	$349K	$52K	$402K	97,873	12,845	$4.10	$1,198K	$90K	$1,288K	146,091	18,700	$8.82
2028	$367K	$55K	$422K	111,134	13,261	$3.80	$317K	$24K	$340K	152,610	6,519	$2.23
2029	$385K	$58K	$442K	124,738	13,604	$3.55	$328K	$25K	$353K	159,247	6,637	$2.21
2030	$353K	$53K	$406K	136,321	11,584	$2.98	$288K	$22K	$310K	165,703	6,456	$1.87
2031	$282K	$42K	$324K	146,024	9,702	$2.22	$298K	$22K	$320K	172,370	6,667	$1.86
2032	$85K	$13K	$98K	149,739	3,716	$0.65	$299K	$22K	$321K	179,045	6,675	$1.79
2033	$87K	$13K	$100K	153,571	3,831	$0.65	$303K	$23K	$325K	185,747	6,701	$1.75
2034	$89K	$13K	$103K	157,412	3,841	$0.65	$306K	$23K	$329K	192,481	6,734	$1.71
2035	$92K	$14K	$106K	161,385	3,973	$0.65	$289K	$22K	$311K	197,710	5,229	$1.57
2036	$95K	$14K	$109K	165,430	4,045	$0.66	$256K	$19K	$275K	199,018	1,308	$1.38
2037	$80K	$12K	$92K	167,397	1,967	$0.55	$248K	$19K	$267K	200,236	1,219	$1.33
2038	$71K	$11K	$81K	167,146	-251	$0.49	$251K	$19K	$270K	201,517	1,281	$1.34
2039	$69K	$10K	$80K	166,874	-272	$0.48	$175K	$13K	$189K	200,928	-589	$0.94
2040	$68K	$10K	$78K	166,579	-295	$0.47	$163K	$12K	$175K	199,187	-1,741	$0.88
2041	$68K	$10K	$78K	166,326	-253	$0.47	$168K	$13K	$181K	197,622	-1,565	$0.91
Total	**$4,342K**	**$651K**	**$4,993K**	**2,484,697**	**166,326**	**$2.01**	**$11,210K**	**$841K**	**$12,051K**	**3,151,354**	**197,622**	**$3.82**

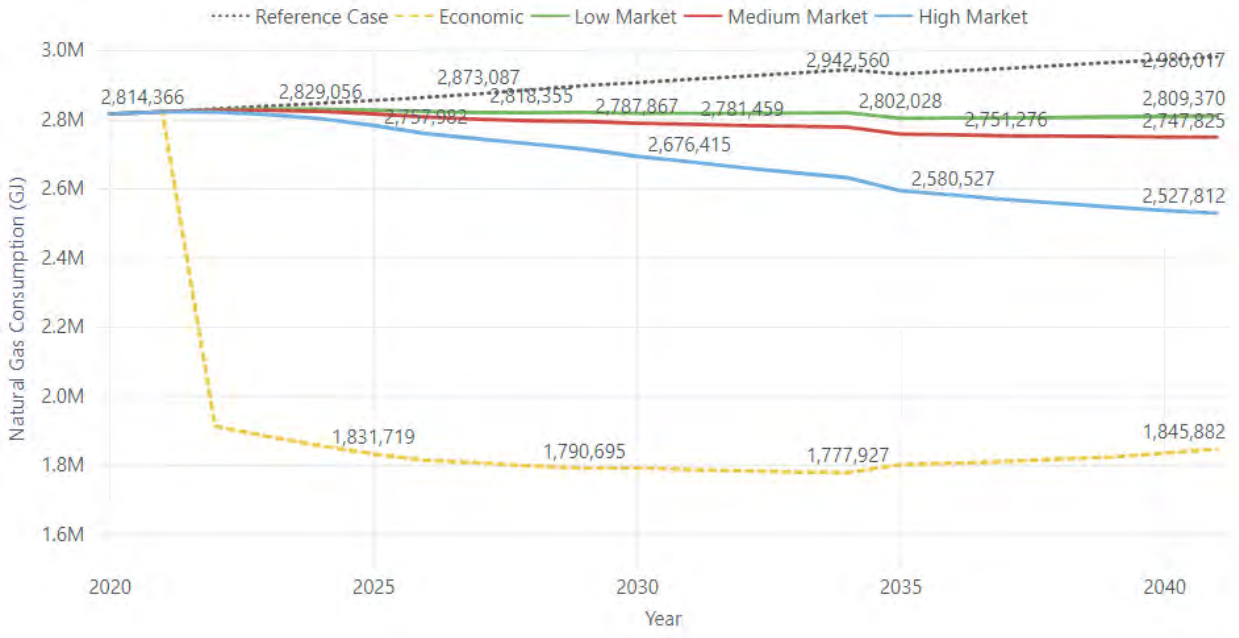
EX 6 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, MTRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$3,837K	$576K	$4,413K	46,197	46,197	$95.52	$15,477K	$1,161K	$16,638K	90,029	90,029	$184.81
2023	$4,232K	$635K	$4,867K	96,795	50,598	$50.28	$16,820K	$1,262K	$18,082K	186,467	96,437	$96.97
2024	$4,498K	$675K	$5,173K	150,048	53,254	$34.47	$17,731K	$1,330K	$19,061K	286,300	99,833	$66.58
2025	$4,680K	$702K	$5,381K	205,440	55,392	$26.19	$17,963K	$1,347K	$19,310K	376,380	90,080	$51.31
2026	$4,806K	$721K	$5,527K	259,176	53,735	$21.33	$17,260K	$1,294K	$18,554K	458,835	82,455	$40.44
2027	$4,929K	$739K	$5,668K	309,189	50,013	$18.33	$15,987K	$1,199K	$17,186K	530,581	71,746	$32.39
2028	$5,802K	$870K	$6,673K	366,981	57,792	$18.18	$3,345K	$251K	$3,596K	542,354	11,773	$6.63
2029	$5,306K	$796K	$6,102K	418,681	51,700	$14.57	$3,408K	$256K	$3,664K	554,287	11,932	$6.61
2030	$4,788K	$718K	$5,506K	461,062	42,381	$11.94	$3,288K	$247K	$3,534K	565,728	11,441	$6.25
2031	$3,741K	$561K	$4,302K	494,101	33,039	$8.71	$3,263K	$245K	$3,508K	577,279	11,551	$6.08
2032	$970K	$145K	$1,115K	498,255	4,154	$2.24	$3,198K	$240K	$3,438K	588,532	11,253	$5.84
2033	$1,004K	$151K	$1,155K	502,799	4,544	$2.30	$3,151K	$236K	$3,388K	599,538	11,006	$5.65
2034	$1,045K	$157K	$1,202K	507,612	4,813	$2.37	$3,122K	$234K	$3,356K	610,367	10,828	$5.50
2035	$1,088K	$163K	$1,251K	512,888	5,276	$2.44	$3,092K	$232K	$3,324K	620,119	9,752	$5.36
2036	$1,130K	$169K	$1,299K	518,434	5,546	$2.51	$3,076K	$231K	$3,307K	627,419	7,300	$5.27
2037	$1,080K	$162K	$1,242K	522,201	3,767	$2.38	$3,018K	$226K	$3,244K	634,462	7,043	$5.11
2038	$1,061K	$159K	$1,221K	524,330	2,129	$2.33	$3,055K	$229K	$3,284K	641,801	7,339	$5.12
2039	$1,038K	$156K	$1,194K	526,444	2,114	$2.27	$2,593K	$194K	$2,787K	645,013	3,212	$4.32
2040	$1,008K	$151K	$1,160K	528,359	1,916	$2.19	$2,503K	$188K	$2,691K	645,736	722	$4.17
2041	$1,001K	$150K	$1,151K	530,443	2,083	$2.17	$2,574K	$193K	$2,767K	647,166	1,430	$4.28
Total	**$57,044K**	**$8,557K**	**$65,601K**	**7,979,434**	**530,443**	**$8.22**	**$143,924K**	**$10,794K**	**$154,718K**	**10,428,393**	**647,166**	**$14.84**

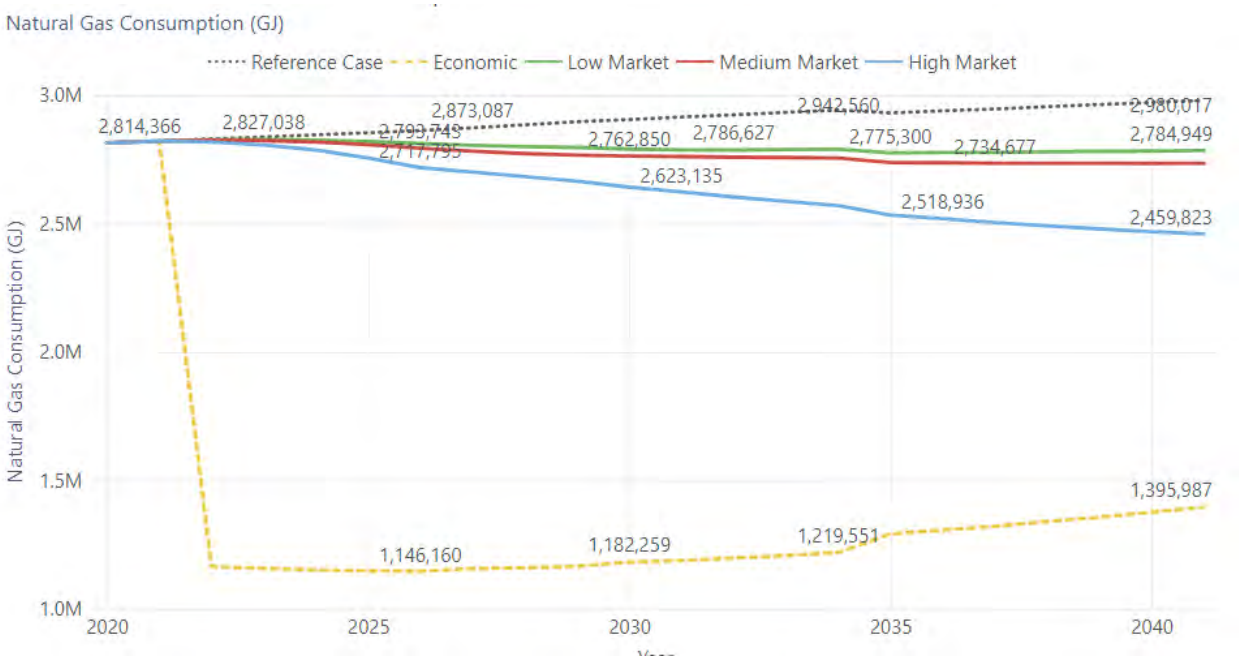
Commercial

The forecasted gas consumption under the three market potential scenarios for the commercial sector are shown in EX 7 (TRC) and EX 8 (MTRC). The commercial low, medium, and high market TRC potential consumption levels are estimated to be 2,809 TJ, 2,748 TJ, and 2,527 TJ by 2041, while reference consumption is forecasted to reach 2,980 TJ. The commercial low, medium, and high market MTRC potential consumption levels are estimated to be 2,785 TJ, 2,735 TJ, and 2,460 TJ by 2041, while reference consumption is forecasted to reach 2,980 TJ.

EX 7 – Commercial Market Potential Consumption (GJ) Forecasts – Commercial, TRC



EX 8 – Commercial Market Potential Consumption (GJ) Forecasts – Commercial, MTRC



The incentive and non-incentive spending in the MTRC scenario required to achieve the medium and high market potential are shown in EX 9 and EX 10. Medium and high market incentives are assumed to be 50% and 100% of measures' incremental costs, respectively. The tables show the total and incremental savings from the new measures installed every year.

EX 9 – Medium and High Market Incentive Costs and Natural Gas Savings – Commercial, TRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$80K	$12K	$92K	4,827	4,827	$19.09	$441K	$33K	$474K	9,656	9,656	$49.11
2023	$128K	$19K	$147K	12,476	7,649	$11.76	$697K	$52K	$749K	24,028	14,372	$31.17
2024	$184K	$28K	$212K	23,739	11,263	$8.94	$1,031K	$77K	$1,108K	44,725	20,697	$24.78
2025	$253K	$38K	$291K	38,711	14,973	$7.51	$1,489K	$112K	$1,601K	72,122	27,397	$22.20
2026	$318K	$48K	$365K	56,535	17,823	$6.46	$1,927K	$145K	$2,072K	104,855	32,733	$19.76
2027	$383K	$57K	$441K	73,693	17,158	$5.98	$2,305K	$173K	$2,478K	130,419	25,564	$19.00
2028	$374K	$56K	$430K	89,505	15,812	$4.81	$2,278K	$171K	$2,449K	156,704	26,285	$15.63
2029	$376K	$56K	$432K	103,636	14,132	$4.17	$2,418K	$181K	$2,599K	183,590	26,886	$14.16
2030	$515K	$77K	$592K	117,358	13,722	$5.05	$3,172K	$238K	$3,410K	212,912	29,322	$16.02
2031	$356K	$53K	$410K	129,814	12,455	$3.15	$2,327K	$175K	$2,502K	238,491	25,579	$10.49
2032	$366K	$55K	$421K	142,075	12,262	$2.96	$2,395K	$180K	$2,575K	263,877	25,385	$9.76
2033	$362K	$54K	$416K	154,039	11,963	$2.70	$2,368K	$178K	$2,546K	288,433	24,556	$8.83
2034	$360K	$54K	$414K	165,793	11,754	$2.50	$2,332K	$175K	$2,507K	312,148	23,715	$8.03
2035	$922K	$138K	$1,060K	174,170	8,377	$6.09	$5,657K	$424K	$6,081K	337,406	25,258	$18.02
2036	$337K	$51K	$387K	184,792	10,622	$2.10	$2,185K	$164K	$2,349K	358,813	21,407	$6.55
2037	$317K	$48K	$364K	194,921	10,130	$1.87	$2,011K	$151K	$2,162K	378,905	20,092	$5.70
2038	$331K	$50K	$380K	204,448	9,526	$1.86	$2,154K	$162K	$2,316K	398,718	19,813	$5.81
2039	$321K	$48K	$370K	214,098	9,650	$1.73	$1,968K	$148K	$2,116K	418,132	19,414	$5.06
2040	$310K	$46K	$356K	223,342	9,244	$1.59	$1,793K	$134K	$1,927K	435,694	17,563	$4.42
2041	$301K	$45K	$346K	232,192	8,850	$1.49	$1,745K	$131K	$1,876K	452,205	16,511	$4.15
Total	**$6,892K**	**$1,034K**	**$7,926K**	**2,540,163**	**232,192**	**$3.12**	**$42,694K**	**$3,202K**	**$45,896K**	**4,821,830**	**452,205**	**$9.52**

EX 10 – Medium and High Market Incentive Costs and Natural Gas Savings – Commercial, MTRC

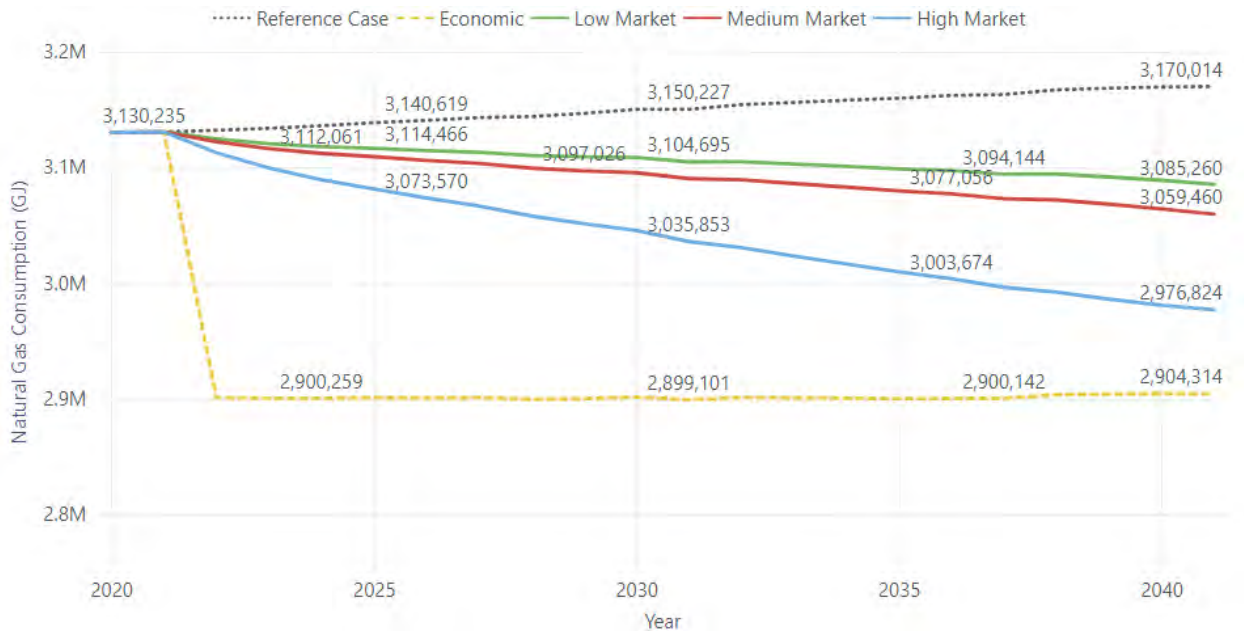
Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$92K	$14K	$106K	5,366	5,366	$19.72	$706K	$53K	$759K	12,016	12,016	$63.16
2023	$151K	$23K	$174K	14,198	8,832	$12.24	$1,147K	$86K	$1,234K	30,888	18,872	$39.94
2024	$227K	$34K	$261K	27,839	13,642	$9.37	$1,709K	$128K	$1,837K	59,358	28,470	$30.94
2025	$316K	$47K	$363K	46,502	18,663	$7.81	$2,407K	$181K	$2,588K	98,096	38,738	$26.38
2026	$398K	$60K	$458K	69,094	22,592	$6.62	$3,066K	$230K	$3,296K	145,042	46,945	$22.73
2027	$472K	$71K	$543K	91,308	22,214	$5.94	$3,266K	$245K	$3,511K	172,697	27,656	$20.33
2028	$463K	$69K	$532K	112,353	21,045	$4.74	$3,264K	$245K	$3,508K	201,679	28,981	$17.40
2029	$446K	$67K	$512K	129,669	17,316	$3.95	$3,554K	$267K	$3,821K	231,460	29,781	$16.51
2030	$549K	$82K	$631K	142,375	12,706	$4.43	$4,533K	$340K	$4,873K	263,588	32,128	$18.49
2031	$371K	$56K	$427K	153,918	11,544	$2.77	$3,405K	$255K	$3,660K	291,771	28,183	$12.54
2032	$384K	$58K	$441K	165,161	11,242	$2.67	$3,518K	$264K	$3,782K	319,703	27,932	$11.83
2033	$375K	$56K	$431K	176,069	10,908	$2.45	$3,449K	$259K	$3,708K	346,591	26,888	$10.70
2034	$373K	$56K	$429K	186,792	10,722	$2.30	$3,378K	$253K	$3,632K	372,508	25,917	$9.75
2035	$982K	$147K	$1,130K	192,632	5,841	$5.87	$7,391K	$554K	$7,946K	397,398	24,890	$19.99
2036	$349K	$52K	$401K	202,281	9,649	$1.98	$3,112K	$233K	$3,345K	420,404	23,006	$7.96
2037	$324K	$49K	$373K	211,521	9,240	$1.76	$2,838K	$213K	$3,050K	442,044	21,641	$6.90
2038	$350K	$52K	$402K	220,076	8,555	$1.83	$3,153K	$237K	$3,390K	463,611	21,567	$7.31
2039	$329K	$49K	$378K	228,834	8,758	$1.65	$2,742K	$206K	$2,947K	484,406	20,794	$6.08
2040	$324K	$49K	$372K	237,114	8,281	$1.57	$2,614K	$196K	$2,810K	503,323	18,918	$5.58
2041	$313K	$47K	$360K	245,108	7,993	$1.47	$2,390K	$179K	$2,570K	520,194	16,871	$4.94
Total	**$7,586K**	**$1,138K**	**$8,723K**	**2,858,209**	**245,108**	**$3.05**	**$61,641K**	**$4,623K**	**$66,265K**	**5,776,777**	**520,194**	**$11.47**

Industrial

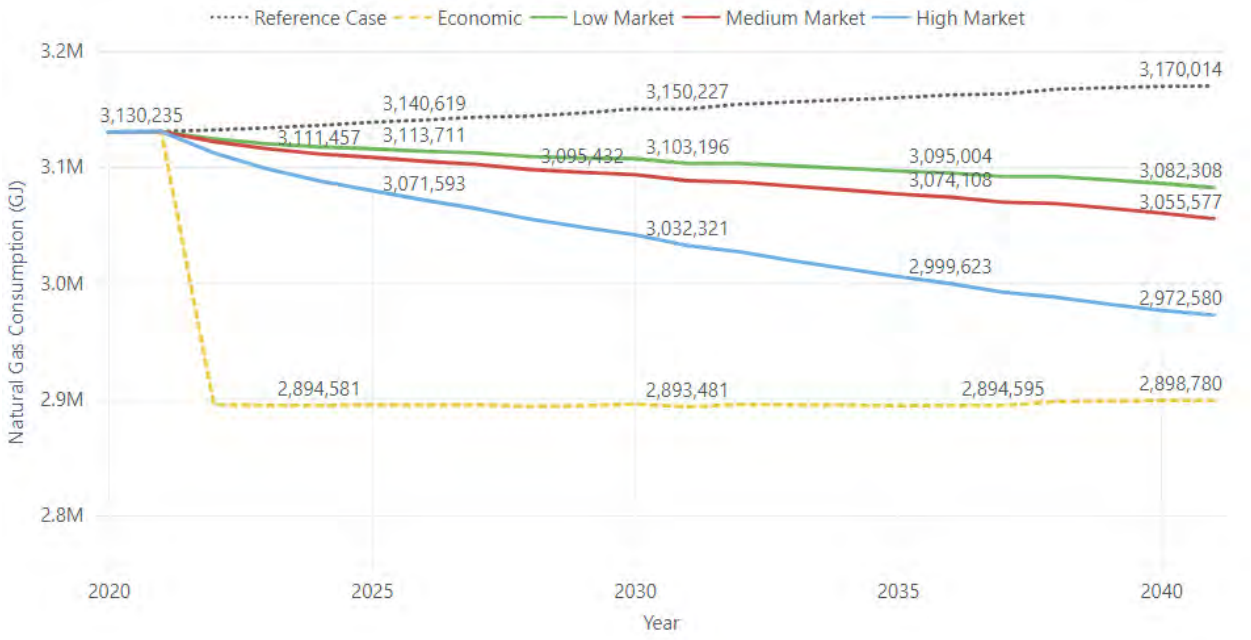
The market potential consumption results are shown in EX 11 and EX 12. The results for the TRC and MTRC screens appear quite similar because of the 38 measures included in the assessment, 36 pass the TRC and 38 pass the MTRC.

The industrial low, medium, and high market TRC potential consumption levels are estimated to be 3,085 TJ, 3,059 TJ, and 2,977 TJ by 2041, while reference consumption is forecasted to reach 3,170 TJ. The industrial low, medium, and high market MTRC potential consumption levels are estimated to be 3,082 TJ, 3,056 TJ, and 2,973 TJ by 2041.

EX 11 – Market Potential Consumption (GJ) Forecasts – Industrial, TRC



EX 12 – Market Potential Consumption (GJ) Forecasts – Industrial, MTRC



The incentive and non-incentive spending required to achieve the medium and high market potential are shown in EX 13 (TRC) and EX 14 (MTRC). Medium and high market incentives are assumed to be 50% and 100% of measures' incremental costs, respectively. The tables show the total and incremental savings from the new measures installed every year.

EX 13 – Medium and High Market Incentive Costs and Natural Gas Savings – Industrial, TRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$49K	$7K	$57K	9,869	9,869	$5.73	$196K	$15K	$210K	19,385	19,385	$10.85
2023	$48K	$7K	$55K	17,599	7,730	$3.12	$189K	$14K	$203K	34,445	15,060	$5.88
2024	$46K	$7K	$53K	23,918	6,318	$2.20	$180K	$14K	$194K	46,666	12,221	$4.15
2025	$44K	$7K	$50K	29,454	5,536	$1.71	$173K	$13K	$186K	57,298	10,632	$3.24
2026	$43K	$6K	$50K	34,565	5,111	$1.43	$169K	$13K	$182K	67,049	9,750	$2.71
2027	$43K	$6K	$50K	39,590	5,025	$1.26	$169K	$13K	$181K	76,559	9,510	$2.37
2028	$44K	$7K	$51K	44,623	5,033	$1.14	$172K	$13K	$184K	86,014	9,455	$2.14
2029	$46K	$7K	$52K	49,692	5,069	$1.05	$177K	$13K	$190K	95,470	9,455	$1.99
2030	$48K	$7K	$55K	54,820	5,128	$1.00	$184K	$14K	$198K	104,963	9,494	$1.89
2031	$50K	$7K	$57K	59,938	5,118	$0.95	$192K	$14K	$206K	114,374	9,411	$1.81
2032	$51K	$8K	$59K	65,036	5,097	$0.90	$196K	$15K	$211K	123,684	9,309	$1.71
2033	$51K	$8K	$58K	70,127	5,092	$0.83	$195K	$15K	$210K	132,923	9,239	$1.58
2034	$49K	$7K	$57K	75,187	5,060	$0.75	$181K	$14K	$194K	141,621	8,698	$1.37
2035	$48K	$7K	$55K	80,207	5,020	$0.68	$173K	$13K	$186K	150,190	8,569	$1.24
2036	$47K	$7K	$54K	85,201	4,994	$0.63	$167K	$13K	$180K	158,582	8,392	$1.13
2037	$47K	$7K	$54K	90,218	5,017	$0.60	$163K	$12K	$176K	166,857	8,275	$1.05
2038	$48K	$7K	$55K	95,265	5,047	$0.57	$161K	$12K	$173K	175,020	8,163	$0.99
2039	$48K	$7K	$55K	100,338	5,073	$0.55	$142K	$11K	$153K	182,499	7,479	$0.84
2040	$49K	$7K	$57K	105,450	5,112	$0.54	$108K	$8K	$116K	188,886	6,387	$0.61
2041	$50K	$8K	$58K	110,555	5,105	$0.52	$87K	$7K	$94K	193,190	4,305	$0.49
Total	**$948K**	**$142K**	**$1,090K**	**1,241,652**	**110,555**	**$0.88**	**$3,374K**	**$253K**	**$3,627K**	**2,315,675**	**193,190**	**$1.57**

EX 14 – Medium and High Market Incentive Costs and Natural Gas Savings – Industrial, MTRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$68K	$10K	$79K	10,072	10,072	$7.81	$273K	$20K	$293K	19,789	19,789	$14.82
2023	$67K	$10K	$77K	18,003	7,931	$4.28	$266K	$20K	$285K	35,248	15,459	$8.10
2024	$65K	$10K	$75K	24,522	6,519	$3.05	$257K	$19K	$276K	47,864	12,616	$5.77
2025	$63K	$9K	$73K	30,257	5,735	$2.40	$250K	$19K	$268K	58,888	11,023	$4.56
2026	$62K	$9K	$72K	35,567	5,310	$2.02	$246K	$18K	$264K	69,025	10,138	$3.83
2027	$62K	$9K	$72K	40,791	5,223	$1.76	$245K	$18K	$264K	78,919	9,894	$3.34
2028	$63K	$9K	$73K	46,021	5,230	$1.58	$248K	$19K	$267K	88,755	9,836	$3.01
2029	$65K	$10K	$75K	51,286	5,265	$1.45	$254K	$19K	$273K	98,587	9,832	$2.77
2030	$67K	$10K	$77K	56,610	5,324	$1.36	$261K	$20K	$281K	108,454	9,867	$2.59
2031	$69K	$10K	$79K	61,923	5,313	$1.28	$194K	$15K	$209K	117,906	9,452	$1.77
2032	$70K	$11K	$81K	67,214	5,291	$1.20	$198K	$15K	$213K	127,256	9,350	$1.67
2033	$70K	$11K	$81K	72,499	5,285	$1.11	$272K	$20K	$292K	136,860	9,605	$2.14
2034	$69K	$10K	$79K	77,752	5,252	$1.01	$182K	$14K	$196K	145,596	8,736	$1.35
2035	$67K	$10K	$77K	82,964	5,213	$0.93	$175K	$13K	$188K	154,204	8,607	$1.22
2036	$66K	$10K	$76K	88,149	5,184	$0.86	$169K	$13K	$182K	162,634	8,430	$1.12
2037	$66K	$10K	$76K	93,355	5,206	$0.82	$165K	$12K	$178K	170,946	8,312	$1.04
2038	$67K	$10K	$77K	98,591	5,236	$0.78	$163K	$12K	$175K	179,146	8,200	$0.98
2039	$67K	$10K	$78K	103,851	5,260	$0.75	$144K	$11K	$155K	186,659	7,513	$0.83
2040	$68K	$10K	$79K	109,149	5,298	$0.72	$110K	$8K	$118K	193,087	6,429	$0.61
2041	$69K	$10K	$80K	114,438	5,289	$0.70	$89K	$7K	$96K	197,435	4,347	$0.49
Total	**$1,332K**	**$200K**	**$1,532K**	**1,283,016**	**114,438**	**$1.19**	**$4,162K**	**$312K**	**$4,474K**	**2,377,257**	**197,435**	**$1.88**

1 Introduction

1.1 Background and Study Goals

The 2021 Conservation Potential Review (CPR) is the review of energy efficiency opportunities available among Pacific Northern Gas' (PNG) residential, commercial, and industrial natural gas customers.

For this CPR, Posterity Group (PG) reviewed estimated technical, economic, and market potential natural gas savings in PNG's service territory over a 20-year period from 2020 to 2041. The CPR is an important guiding document for ongoing conservation and energy management program development and support at PNG.

1.2 Report Organization and Results Presentation

1.2.1 This Report

The 2021 CPR has been prepared as **a single report that contains results for three sectors: residential, commercial, and industrial.** The report has been structured as follows:

- **Section 2** provides an overview of the CPR scope and definitions of key terms and acronyms.
- **Section 3** presents the overall steps taken and approach followed to complete this CPR. This section is applicable to all three sectors.
- **Section 4** presents the **residential** sector results. These include findings on base year and reference case energy forecasts, measure analysis, technical potential, economic potential, and market potential.
- **Section 5** presents the **commercial** sector results, following the same format as Section 4.
- **Section 6** presents the **industrial** sector results, following the same format as Section 4.

1.2.2 Presentation of CPR Potential Results

There are two deliverables included in the CPR report:

- **This report**, which presents the conservation potential results for the residential, commercial, and industrial sectors.
- **Measure Analysis Workbooks** that provide final versions of the workbooks containing measure assumptions for each sector, which have been shared for reference.

1.3 Caveats and Limitations

Forecasting and modelling are a key part of this CPR study. Both activities require extensive research and more importantly, require assumptions, engineering estimates, and the professional judgement of the study team. The study team strove to ensure these assumptions are in line with the PNG team's knowledge of their customer base and are made with the best information available. However, given the nature of forecasting, the results in this report should be considered as estimates.

All potential scenarios in this report are estimated in relation to a "business as usual" reference case scenario, which is described in Section 3.1. The CPR reference case incorporates PNG's account forecast

and observed customer consumption trends. By incorporating these sources, the reference case implicitly includes the effects of current policy but does not adjust for potential future policy changes. Scenarios with specific regulation/policy drivers, including high electrification, are not assessed within the scope of the CPR.

2 Study Scope

This section defines some common terms used in this study and an overview of what is covered in this CPR.

2.1 Definition of Terms

Accounts – Number of PNG customer accounts. This report refers to 'accounts' rather than customers, as one customer could have multiple accounts.

Benefit/Cost Ratio – Expresses the attractiveness of a measure relative to its costs. A measure with a ratio of 1 or higher has benefits that outweigh its costs. For this study, two measure cost tests were used, both expressed as a Benefit/Cost ratio. These tests, the Total Resource Cost (TRC) test and the Modified Total Resource Cost Test (MTRC), are defined below.

"Business as Usual" Reference Case – The scenario continues as normal without any changes to current operations. In the reference case scenario, no energy conservation measures have been applied.

Early Replacement – The act of replacing equipment prior to failure, while it has some remaining useful life. Contrast with "Replace on Burnout (ROB)", below.

End Use, Sub-End Use – The final purpose for which energy is being used. For example, space heating, domestic hot water (DHW), or industrial process heat. In the CPR model, end uses are occasionally further divided into smaller subcategories referred to as Sub-End Uses. For example, Residential DHW is further divided by into shower DHW, washer DHW, dishwasher DHW, and other DHW to facilitate analysis of measures that apply to a specific portion of the end-use energy.

Energy Conservation Measure (ECM, or Measure) – An equipment, technology, or a behavior that results in reduction of energy use in a dwelling, building, or facility.

Fuel Share – Ratio of a specific end use load that is met by a particular fuel. For example, if 90% of single-family dwelling space heating load is met by natural gas equipment, the natural gas fuel share for space heating in single-family dwellings is 90%.

Full Cost Measure – A measure whose benefit/cost ratio is evaluated based on its full cost, as opposed to the incremental cost between the measure and a less-efficient "baseline" alternative. See "Retrofit (RET)" below for further explanation.

Gas-Heated Dwelling, Non-Gas-Heated Dwelling – In the residential sector, a dwelling that primarily uses gas for space heating heat (>50% of the fuel share for space heating) is considered a gas-heated dwelling. A dwelling that has a natural gas space heating fuel share <50% is considered a non-gas-heated dwelling. Gas-heated dwellings may have other fuels serving the space heating end use, but gas comprises at least 50% of the fuel share.

GJ – Gigajoule, or one billion joules. The unit of energy used by PNG for billing purposes.

Incremental Cost Measure – A measure whose benefit/cost ratio is evaluated on the basis of its incremental cost relative to a less-efficient alternative. See definition of "Replace on Burnout (ROB)" for further explanation.

Modified Total Resource Cost (MTRC) – A modified version of the TRC test that includes an alternate avoided cost and an adder for non-energy benefits. Per section 4 (1.1) (a) of the BC's DSM Regulation, the MTRC test incorporates the avoided cost of electricity – BC Hydro's marginal cost of acquiring electricity generated from clean or renewable resources, called the Zero Emission Energy Alternative (ZEEA) - rather than the marginal cost of new gas supply.

Participation or Participation Rate – The rate or percentage of buildings or end users that take part in a utility's program. This is a measurement of customer uptake of a measure and is an input to determine market potential.

Region – For the purposes of this CPR, PNG's gas service territory is divided into three regions: Northeast; West (West), which includes the communities of Prince Rupert, Kitimat, and Terrace in the western portion of the PNG-West system; and West (East), which includes the communities between Vanderhoof and Smithers in the eastern portion of the PNG-West system.

Replace on Burnout (ROB) – One of two primary measure replacement types. Replace-on-burnout measures are typically time, labour, and cost intensive and are applied at the end of the useful life of the underlying equipment. For example, boiler replacements are typically evaluated as replace on burnout. ROB measures are typically evaluated on the basis of their incremental cost relative to a less-efficient, code-compliant alternative. Contrast with "Early Replacement", above and Retrofit (RET) below.

Retrofit (RET) – One of two primary measure replacement types. Retrofit measures are typically less costly measures that can be installed at any time. For example, a communicating thermostat or low-flow showerhead. RET measures are typically evaluated on their full costs. Contrast with "Early Replacement" and "Replace on Burnout (ROB)" above.

R-Value – A measure of a material's resistance to heat flow. In the context of building science, R-value is used to measure the effectiveness of insulation for building envelope components (e.g. attic insulation). The higher the R value, the better the measure's ability to insulate.

Saturation – For most end uses, Saturation is the extent to which an end use is present in a region, and segment. For some specific end uses that are associated with appliances, Saturation is defined as the average number of appliances per Unit.

Sector – Grouping or category of customers or buildings by customer type: residential, commercial, and industrial.

Segment – Grouping or category of buildings (e.g., single-family detached in residential, large offices in commercial). Segments reflect the main purpose of the building and helps to differentiate between energy use intensity or patterns across building types within a sector.

Simple Payback – The duration of time to recover the cost of a project based on cumulative savings, without taking into account the time value of money. In the context of energy conservation measures, savings are accrued based on the value of energy savings. Simple payback is calculated from the perspective of the end user and is presented as a number of years. For example, a measure that costs $600 and results in energy savings valued at $200 annually has a simple payback $600 / $200 = 3 years.

Size Factor – The change in average number of units per account. This is primarily used to reflect the forecast change in production volumes in industry.

Step Code – Compliance path in British Columbia Building Code (BCBC) for achieving energy efficiency in new construction beyond the minimum code requirements.

Stock Average Efficiency – Average efficiency of equipment serving the tertiary load for that end use.

Tertiary Load – The useful energy delivered to an end use. In the context of the CPR, tertiary load is the amount of energy required to be delivered as an end use service, for example, heat delivered by a furnace to a residential dwelling.

Total Resource Cost (TRC) – A metric for evaluating the cost-effectiveness of an energy conservation measure based on both the participants and utility's costs and benefits.

Unit Energy Consumption (UEC) – The amount of energy used by each end use per unit.

Units – The sector-specific unit of analysis: dwellings in the residential sector, square metres in the commercial sector, and production capacity in the industrial sector.

Vintage – A grouping of facilities based on their age.

2.2 CPR Coverage

2.2.1 Timing

The base year for the CPR Study is the 2020 calendar year. The reference case forecast is for 2021 to 2041. Results are calculated for each intervening year.

2.2.2 Regions

The CPR divides the PNG gas regions in British Columbia (BC) into three regions: Northeast, West (West), and West (East). A map of the PNG service area is shown in Exhibit 1.

Exhibit 1 – Map of PNG's Service Area

2.2.3 Sectors, Segments, and End Uses

The 2021 CPR covers three sectors: residential, commercial, and industrial. Each sector is unique and has important differences which are reflected in how inputs and outputs are organized. Exhibit 2 presents the way each sector is organized into segments, energy end uses, and building vintages in the CPR model.

A segment is a grouping or category of buildings, such as a single-family Detached dwelling in Residential, or large offices in Commercial, for example. Segments reflect the main purpose of the building and help to differentiate between energy use intensity or patterns across building types within a sector.

Exhibit 2 – CPR Segments, End Uses, & Vintages by Sector

	Residential	Commercial	Industrial
Segments	Single Family Detached/Duplexes Single Family Attached/Row Mobile/Other Residential	Apartments – Medium Apartments – Large Food Retail Hospital Hotel – Medium Hotel – Large Non-Food Retail – Medium Non-Food Retail – Large Nursing Home Office – Medium Office – Large Other Commercial Restaurant School – Medium School – Large University/College Warehouse	Agriculture (includes greenhouses) Chemical District energy providers Fabricated Metal Food & Beverage Other Manufacturing (includes transportation[5] and other industrial) Mining Non-metallic Mineral (includes cement) Primary Metals Pulp & Paper – Kraft Upstream Oil and Gas Utilities Wood Products
End Uses[6]	Clothes dryer Cooking Domestic hot water[7] Dishwasher DHW Washer DHW Shower DHW Other DHW Fireplace Other gas uses (outdoor fireplaces, patio heaters) Pool & spa heaters Space heating	Cooking Domestic Hot Water Other[8] Pools, Spas & Hot tubs Space Heating	Direct-fired heating Direct Consumption of Gas in Process[9] Heat Treating Kilns On-Site Power Generation[9] Other[8] Ovens Process Boilers Product Drying Space Heating [includes HVAC air heating and HVAC boilers] Water heaters

5 In the 2015 CPR, 'transportation' pertained to facilities that supported the transportation sector.
6 All-electric end uses, such as clothes washer, lighting or plug loads, are not included in the reported results, and therefore are excluded from the End Uses row of this table.
7 In some cases, end uses are broken out into sub-end uses to facilitate CPR measure analysis. DHW can be reported at the end use or sub-end use level in the CPR.
8 The 'other' end use is a catch all for equipment that account for a small portion of consumption in the sector. In the commercial sector, examples of 'other' equipment are patio heaters and laundry dryers.
9 No CPR measures are applied to this end use; included for tracking purposes only.

Vintages[10]	Pre-1950 1950-1975 1976-1985 1986-1995 1996-2005 2006-2015 Post-2015 (Existing) New	Existing New	Existing New

10 The residential sector segments are divided into vintages that define time periods when residential dwellings were built. 'New' residential dwellings do not appear until the first year of the reference case.

3 Study Approach

This section presents the major steps that were taken to complete this CPR. Subsequent sections present the process for completing each CPR step in further detail.

3.1 Major CPR Analysis Steps

7. **Determine the current (Base Year) customer base and their energy consumption**
    a. Collect and review data on the building stock in PNG's service territory, including end use surveys and previous CPRs.
    b. Develop energy use models of each building or facility type (segments) and model energy consumption by end use.
    c. Collect and review actual base year (2020) energy use and billing data of PNG's customers.
    d. Use the billing data to calibrate the base year energy consumption in each sector's energy model.
8. **Develop "business as usual" reference case energy consumption forecast**
    a. Collect and review data on all factors that will affect energy use trends over the study period (2021 to 2041 in this study's case).
    b. This includes analyzing and modelling natural improvements in building energy use intensities (e.g. from natural replacement of furnaces with new, higher efficiency ones at replacement time).
        i. Other factors are existing building demolition / renovation trends, rate of new building stock construction, baseline energy efficiency of new buildings and equipment, and known changes to policies and codes and standards that will impact the energy use of buildings.
        ii. Use this data to develop an energy consumption forecast model for each sector.
    c. Calibrate the reference case based on PNG's own account forecasts at the region and rate class level.

9. Characterize energy conservation measures

    a. Select a set of energy conservation measures for each sector. Measures range from mature, widely known measures (e.g. commercial condensing boilers) to innovative or enabling technologies (e.g. smart residential water heater controllers). Behavioural measures are also considered (e.g. thermostat setback).[11]

    b. For each measure, review and collect data on energy savings, costs, useful life, and the baseline equipment or technology that it should be compared with (if applicable).

    c. Use the data to characterize the technology's energy savings potential, cost-effectiveness, and financial attractiveness.

    d. Use the data as inputs to the energy model for each sector.

10. Estimate technical savings potential

    a. For each measure, determine its technical applicability (i.e. how many buildings or facilities can this measure be applied to, considering only technical barriers).

    b. Determine the measures' current market penetration (i.e. how many buildings or facilities have already installed a measure).

    c. Estimate the measures' reference adoption – their natural rate of uptake in the absence of incentives or utility program intervention.

    d. Input all data into the energy model for each sector and develop a estimate of the technically feasible energy savings potential within PNG's service territory.[12]

11. Estimate economic savings potential

    a. Screen each measure for cost-effectiveness from PNG's perspective by determining whether the benefit to cost ratio of each measure is 1.0 or above (pass) or if it is below 1.0 (fail) for two cost effectiveness tests: TRC and MTRC.

    b. Update the technical potential model with only the TRC-passing measures, removing measures that are not cost-effective.

    c. Estimate the economic savings potential of all cost-effective measures applied to all technically feasible buildings in the customer base.[13]

    d. Repeat steps 5b and 5c using the MTRC screen. This study presents findings from two economic (and subsequent market potential) models: One with TRC as the economic screen and one with MTRC.

---

11 Hybrid heat pumps were considered and analyzed separately. The results were not incorporated into the technical, economic, and market potential scenarios because they represent an alternative option, rather than a complimentary option to the measures presented.

12 See Exhibit 3 for an overview of the constraints considered in the technical potential scenario, and the difference between different potential scenarios.

13 See Exhibit 3 for an overview of the constraints considered in an economic potential scenario.

12. Estimate market savings potential

a. Based on existing research, develop sets of "generic" adoption curves based on customer payback acceptance and typical market diffusion patterns.[14]

b. Apply these generic curves to each measure in the economic potential model to develop "simplified market potential" estimates at the measure level.

c. Apply this data to the TRC economic potential model to develop a simplified market potential.

d. Develop a more realistic market potential for each measure by soliciting feedback from PNG on the simplified market potential.[15]

e. Perform sensitivity analysis by varying measure capital and installation costs.

f. Repeat steps 6c to 6e using the MTRC economic potential model to estimate low, medium, and high market potential scenarios using the MTRC economic screen.

14 Generic adoption curves primarily consider two things: the current market penetration of the measure, and its simple payback. Based on these factors, the curves are applied to each measure to estimate generic participation rates as a percentage of economic potential.

15 This process includes selecting representative, high-impact measures and adjusting their generic participation rates using historical program data, local market knowledge, and industry insights/feedback, then extrapolating these calibrated participation rates to other similar measures within each sector.

Exhibit 3 – Difference Between Technical, Economic, and Market Potential

Constraints	Description
Technical applicability	Is the measure compatible with the current systems in place in the building or facility? Are there any technical constraints that will prevent installation in specific buildings or facilities? If not, then the measure's hypothetical energy savings can be included in the technical potential. Example: If this is a furnace-related measure, do I have a forced air heating system in my building?
Cost-Effectiveness	In addition to the technical constraints above: From the utility's perspective, are the energy savings that result from installing the measure financially attractive? Do they provide a return on investment (i.e., the capital and installation costs) based on the economic screen the utility is required to use? If yes, then the measure's hypothetical energy savings can be included in the economic potential.
Market-related	In addition to the technical and economic constraints above: Are there any constraints related to the market, logistics, or the target customers? Is the measure readily available in the market? Are customers aware of the measure? Realistically, how many customers will have the willingness or interest to install the measure given its costs and benefits? How would the customers' willingness change if the incentives to install these measures increased?
Utility-related *(out of scope for this study, as this is typically a program design activity)*	In addition to all the constraints above: What are the utility's constraints around encouraging the uptake of this measure? How much budget does the utility have to spend on a program and incentives for a measure? How many resources can a utility allocate to delivering a program realistically?

3.2 Base Year Energy Use Model Development

The CPR model is developed in the following sequence for each sector:

- Base Year (2020): the first year of a forecast period, based on historical data provided by PNG.
- Reference Case (2021-2041): forecast of natural gas consumption over a twenty-year (2021-2041) period based on exogenous conditions that follow a "business-as-usual" scenario.

The base year and reference case were modelled for each sector using Posterity Group's Navigator™ Energy and Emissions Simulation Suite. This section provides an overview of the model structure and the process to develop the base year and reference case.

Exhibit 4 defines the six parameters that provide the structure for the model used for the CPR.[16]

Exhibit 4 – 2021 CPR Model Parameters

Parameter	Definition
Accounts[17]	Number of PNG customer accounts.
Units	The basis for how energy consumption is expressed. The unit of analysis is unique to each sector: dwellings in the residential sector, square metres in the commercial sector and production capacity in the industrial sector.
Size Factor	The change in average number of units per account. This is primarily used to reflect the forecast change in production volumes in industry.
Saturation	For most end uses, saturation is the extent to which an end use is present in a region, and segment.[18] For some specific end uses that are associated with appliances, Saturation is defined as the average number of appliances per Unit.
Fuel Share	The percentage of the energy end use that is supplied by each fuel.
Unit Energy Consumption (UEC)	The amount of energy used by each end use per unit.

16 Some of the model parameters are adjusted when necessary to reflect a distinct characteristic of a sector. Any adjustments are explained in this document.
17 PG uses 'accounts' instead of customers in this document as one customer could have multiple accounts.
18 A segment is a grouping or category of buildings (e.g., single-family detached in residential, large offices in commercial). Segments reflect the main purpose of the building and helps to differentiate between energy use intensity or patterns across building types within a sector.

Once each parameter of the model is populated with the applicable data, energy consumption is calculated for a specific end use for each region, segment, and vintage each year using the following equation:

$$Consumption = Units * Saturation * Fuel\ Share * Unit\ Energy\ Consumption$$

Exhibit 5 presents the detailed steps that the team took to calibrate the base year energy consumption in the CPR model with PNG's actual customer energy use.

Exhibit 5 – Base Year Calibration Steps for All Sectors

Step	Description
1	Compile and analyze available data on PNG's existing building stock by segment, including consultation of Residential End Use Survey (REUS) and relevant third-party data.
2	Develop detailed technical descriptions of the existing building stock at the subsector, end use, and end use equipment level. For each sector, detailed regional and subsector assumptions regarding fuel shares, end use penetrations, equipment saturations and equipment efficiency levels are aggregated in Excel workbooks as inputs into the Navigator™ model under step 4.
3	Compile utility billing data by subsector and region.
4	Create sector model inputs and generate preliminary results.
5	Adjust input assumptions for end uses with greater uncertainty until the results closely match the actual utility billing data.

3.3 Reference Case Forecast Development

As explained in Section 3.2 Base Year Energy Use Model Development, the reference case begins with the base year values and forecasts natural gas use based on exogenous conditions that follow a "business-as-usual" scenario. The reference case for the CPR is intended to represent the baseline from which calculation of new potential can be calculated. It considers current energy consumption patterns and known future changes, including expected customer growth, current and known future changes to codes and standards, and natural replacement of equipment at end of life. The reference case does not account for potential changes in fuel share or end use saturations, except those that would occur incidentally because of different rates of new construction for different types of buildings or in the different regions.

The reference case starts with actual 2020 consumption, which includes all DSM activity up to that point. The subsequent years of the reference case incorporate natural conservation, such as the natural turnover of furnaces and other appliances. It does not include conservation from DSM activities carried out after 2020.

Exhibit 6 – Reference Case Development Steps for All Sectors

Step	Description
1	Compile and analyze available data on PNG's new building stock by segment and gather forward-looking estimates of demolition rates.
2	Develop detailed technical descriptions of the new building stock at the subsector, end use, and equipment level.
3	Compile data on forecast levels of construction, demolition and natural (non-utility-influenced) efficiency within the existing and new (post 2020) buildings stock.
4	Create sector model inputs and generate gas use forecasts by adding accounts to match forecast construction levels in cooperation with PNG Load Forecasting staff.

3.4 Measure Characterization

In this CPR activity, energy conservation measures were selected and analyzed. The team started with a list of measures used in the 2020 FortisBC CPR, then finalized this list in collaboration with PNG. For each measure, the team reviewed and updated, where necessary, information on energy savings, costs, useful life, and the baseline equipment or technology that it should be compared to (if applicable). This data was used to characterize the technology's energy savings potential, cost-effectiveness, and financial attractiveness to the utility and the end user.

3.4.1 Development of Measures List

Under this task, the study team reviewed existing energy efficiency measure analysis and program assumptions, assessed gaps, and developed a measure list for input by PNG staff.

Measures range from mature and widely known to innovative or enabling technologies. Several behavioural measures (e.g. thermostat setback) are included as well. The team also developed "mature market" versions of some technologies. These mature market measures assumed that within two to five years, various measures that are currently at an early stage of market entry would have lower costs, improved energy performance, or both. This approach allowed the study team to include these measures in subsequent analysis at a point after the first forecast year, consistent with best estimates of market entry.

The study team solicited feedback on the measures list from PNG and made any necessary adjustments.

3.4.2 Energy Performance and Costs of Selected Measures

Under this task, the study team developed one Excel-based measure analysis workbook per sector in which all measure data was recorded. The intent of these workbooks was to have each measure's metrics and assumptions easily reviewable, referenceable, and reusable by the PNG team. Exhibit 7 shows an example of a measure from the workbook.

Measures were characterized using the following metrics:

- Type of replacement (Retrofit or Replace on Burnout)
- Cost basis on which the measure should be evaluated – full or incremental
- Energy performance metrics and savings (% against end use and absolute)
- Technical applicability to various segments and / or vintages
- Cost of Conserved Energy (CCE) and simple payback metrics
- Cost-effectiveness on TRC and MTRC scales

3.4.3 Measure Cost Sensitivity Analysis

Measure costs were originally developed for southern BC, which may have lower measure costs than in the PNG territory. As such, a sensitivity analysis of the measure costs was conducted, using a 30% price adder to reflect the potentially higher costs in the PNG service territory. Both baseline and upgrade capital, installation, and operating and maintenance costs were increased by 30% for all measures.

Exhibit 7 – CPR Measure Characterization Workbook Example: Residential Communicating Thermostat

MEASURE SUMMARY						NOTES	DATA SOURCES
Measure Description	Installation of a communicating (also often referred to as "smart," advanced, wi-fi or connected) thermostat to replace a manually operated or conventional programmable thermostat. Thermostat must be on the ENERGY STAR® list of Smart Thermostats and be able to: - Work as a basic thermostat in absence of connectivity to the service provider. - Give residents some form of feedback about the energy consequences of their settings. - Provide information about HVAC energy use, such as monthly run time. - Provide the ability to set a schedule. - Provide the ability to work with utility programs to prevent brownouts and blackouts, while preserving consumers' ability to override those grid requests.						
Measure Type	Controls						
Baseline Condition Description	The baseline condition is an assumed mix of manual and programmable thermostats.						
Calculation Method Description	Space heating and cooling savings estimated based on review of MN and Mid-Atlantic TRMs assumptions for ENERGY STAR® qualifying communicating thermostats. See general notes and sources section below for additional details.						
Measure Applicability	Applies to existsing homes where a manual or programmable thermostat previously existed.						
APPLICABILITY							
Affected Natural Gas End-Uses	Space Heating					You can select up to 2 end-uses affected by this measure. Leave second one blank if not needed.	
Affected Electricity End-Uses	Space Cooling					You can select up to 2 end-uses affected by this measure. Leave second one blank if not needed.	
Applicable Codes / Standards	n/a						
Meets DSM Definition	Yes						
Meets Tech Innovation Definition	Yes						
Applicable Years	**First:**	2020	**Last:**	2040			
MODEL INPUT ASSUMPTIONS							
Measure Specifications	**Base Case**		**Upgrade Case**		**Notes**		**Data Sources**
Effective Useful Life (years)	10		10				1

RESULTS (SPECIFIC TO A GIVEN REGION, SEGMENT AND VINTAGE)							
Region	Northeast				Segment Sheet Row#	Change the selections in light blue to see the results specific to a region, segment and vintage.	
Segment	SFD/Duplex				17		
Main Heating Fuel	Gas Heat				Segment sheet name		
Vintage	Pre-1950				Comm T-Stat - Segment		
Costs	**Base Case**	**Upgrade**	**Increment**	**Units**		**Notes**	**Data Sources**
Capital	$ -	$ 248	$ 248	per thermostat			1, 7
Installation	$ -	$ -	$ -	per thermostat			
O&M	$ -	$ -	$ -	per thermostat			
Energy Savings (%)	**Space Heating**					**Notes**	**Data Sources**
Natural Gas (%)	6%					Estimating 5% savings based on MN and Mid-Atlantic TRMs.	1,7
	Space Cooling						
Electricity (%)	8%					Estimating 8% savings based on MN and Mid-Atlantic TRMs.	1,7
Energy Use (Absolute)	**Base Case**	**Upgrade Case**	**Savings**	**Units**			
Natural Gas	122.5	115.1	7.3	GJ /year			
Electricity	101.7	93.6	8.1	kWh /year			
Water	-	-	-	m3 /year			
Financial Metrics					**Units**		
Simple Payback				4.59	years		
NPV of Avoided Utility Costs (TRC)				405.18	$ / yr		
NPV of Avoided Utility Costs (mTRC)				1,773.24	$ / yr		
Cost of Conserved Energy (CCE)				3.37	$ / GJ		
Cost Effectiveness					**Units**		
Measure TRC				1.6	total		
Measure mTRC				8.2	total		

3.5 Technical Potential Forecast Development

The technical potential forecast includes the installation of all conservation measures that are technically feasible. This exercise is hypothetical in nature and is used to provide a starting point on which to develop the economic and market potential. Refer to Exhibit 3 for an overview of the differences between the potential scenarios.

Technical potential estimates ignore all non-engineering and financial constraints, such as cost-effectiveness and the willingness of end users to adopt measures. This analysis is done to estimate the theoretical maximum amount of energy use that could be captured by energy efficiency measures. In this study, the following assumptions were made:

- Retrofit (RET) measures that are technically feasible are applied immediately (that is, in the first year of the CPR study period, 2022).
- Replace on burnout (ROB) measures that are technically feasible are implemented at the rate of failure of the underlying baseline equipment, to better match in-market replacement rates. However, there are ROB measures that have "Early Replacement" versions (e.g. early replacement of a commercial boiler) that are treated the same way as RET measures.
- New construction measures that are technically feasible are implemented immediately as new buildings are added to the stock each year.

Development of the technical potential involved the following steps:

- Select the measures to be included from the Measure Analysis Workbook.
- Determine each measure's technical applicability (i.e. what portion of buildings can a measure be applied to considering only technical constraints) and current market penetration (i.e. what portion of buildings have already installed a measure).

  This information is gathered from various data sources and literature review, including PNG's Residential End-Use Survey (REUS). The percentage of technically applicable customers that have already adopted a measure are excluded from the technical potential.
- Estimate reference adoption – the natural rate of adoption of a measure. For example, if 2% of the technically eligible customers are expected to implement a measure each year without any utility intervention, reference adoption is 2%. These customers are excluded from the technical potential.
- Apply measure information to the model. For each measure, the following inputs are required: measure's description, the baseline equipment it affects, incremental or full costs, energy savings information, the total proportion of accounts or dwellings under different segments and vintages that the measure is applicable to, and the pre-retrofit and post-retrofit energy consumption.
- Determine the order that measures should be applied against the baseline energy end-use, and whether these measures are applied in series (in which case measure impacts

"cascade") or in parallel (in which case measure impacts are directly additive). This is an important feature of Posterity Group's modelling software that serves two purposes:

- It avoids overestimation and double counting of savings in instances where measures are not additive. For example, assume there is a reference-case house that uses 100 GJ of natural gas for the space heating end use. An air sealing measure is applied to this house, and it is expected to save 20% of space heating energy. A communicating thermostat can also be installed – it is expected to save 5% of total remaining space heating natural gas use.
- If both measures are applied to the same house, the air sealing measure would reduce the overall heating load, reducing the absolute potential savings for the thermostat. In other words, the thermostat saves 5% of 80 GJ (post-air-sealing consumption), not 5% of 100 GJ. Total natural gas savings in this example are 20 GJ + 4 GJ = 24 GJ.
- It avoids applying two mutually exclusive technologies to the same building. For example, a typical single-family house can be upgraded to a new high-efficiency furnace, or a new high-efficiency boiler, but almost never both. Additionally, there are many upgrade measures that apply to the same end use and baseline equipment. The model's cascade feature ensures that only one appropriate upgrade measure is applied to an eligible account or building.

- Run the model to calculate technical potential – this includes savings from all retrofit measures that can be immediately applied, savings from replace-on-burnout measure at their natural rate of replacement, and savings from new construction measures.

3.6 Economic Potential Forecast Development

Economic potential is the subset of technical potential that is financially cost-effective. Cost-effectiveness is determined by screening each measure with the benefit/cost ratio test required by the utility's regulatory authorities. Economic potential considers the cost of the efficiency measures themselves, ignoring market constraints and programmatic barriers. Using economic screening, measures that have a benefit/cost ratio of greater than 1.0 under either the Total Resource Cost Test (TRC) or modified TRC (MTRC) "pass" the screening test and are included in the economic potential. Measures that score below 1.0 are not considered cost-effective and are excluded from future analysis.[19]

Retrofit (RET) measures are evaluated on the basis of their full costs including capital, labour, and maintenance costs. This is because the baseline for a retrofit measure is typically "do-nothing": the customer has the option to not install the measure, in which case they would not incur any costs.

Replace on burnout (ROB) measures are evaluated on the basis of their incremental costs – the cost difference between the high-efficiency measure versus the baseline, less-efficient option. This difference is because the baseline for a replace on burnout measure is typically "do something" because the underlying base equipment has reached the end of its useful life.

New construction measures were also evaluated based on their incremental costs.

Two economic models were developed for each sector – one with TRC as the economic screen and one with MTRC.

Development of the economic potential scenarios involved:

- Determining how measures should be assessed based on their replacement type: retrofit (immediate replacement at full cost), replace on burnout (end of life replacement at incremental cost), or new construction (immediate installation at incremental cost).
- Running the technical potential model using the TRC economic screen – this produces the subset of measures that are cost-effective in terms of TRC (i.e. they have a TRC benefit/cost ratio 1.0 or higher).
- Rerunning the technical potential model using the MTRC economic screen – this produces the subset of measures that are cost-effective in terms of MTRC (i.e. they have an MTRC benefit/cost ratio of 1.0 or higher).

19 If the DSM regulations are modified in the future to require economic tests other than the TRC and MTRC it is possible that measures that currently do not pass the economic screen would be included, affecting the overall economic potential estimate.

4 Residential Sector Results

This section presents the residential sector results and key findings, including:

- Base year (2020) natural gas use
- Reference case consumption forecast (2021-2041)
- Measure assessment
- Technical potential
- Economic potential

4.1 Residential Segments, End Uses, Vintages

The residential sector is divided into three segments, seven major energy end uses, and eight housing vintages. The residential domestic hot water (DHW) end use is further subdivided into four end uses, as shown in Exhibit 8.

Exhibit 8 – Residential Sector Segments, End Uses, and Vintages

Segments (3)	End Uses[20] (7)	Vintages[21] (8)
Single Family Detached/Duplexes	Clothes dryer	Pre-1950
Single Family Attached/Row	Cooking	1950-1975
Mobile/Other Residential	Domestic hot water[22]	1976-1985
	Dishwasher DHW	1986-1995
	Washer DHW	1996-2005
	Shower DHW	2006-2015
	Other DHW	Post-2015 (Existing)
	Fireplace	New
	Other gas uses (outdoor fireplaces, patio heaters)	
	Pool & spa heaters	
	Space heating	

20 All-electric end uses, such as clothes washer, lighting or plug loads, are not included in the reported results, and therefore are excluded from the end uses row listed in this table.
21 The residential sector has vintages to define time periods when residential dwellings are built. Existence categories also apply to the residential vintages, as there is conversion of existing dwellings into new homes (i.e., renovations). 'New' residential dwellings do not appear until the first year of the reference case.
22 The DHW end use has been broken out into sub-end uses to facilitate CPR measure analysis. DHW can be reported at the end use or sub-end use level in the CPR.

4.2 Base Year Natural Gas Use

This section profiles the base year (2020) natural gas consumption for the residential sector. The following exhibits summarize how natural gas is used in the residential sector by segment, end use, region, and vintage.

Natural gas consumption in the residential sector base year is highest:

- In single-family detached (SFD)/duplex segment (91% of consumption), as shown in Exhibit 9
- For the space heating end use (74%), as shown in Exhibit 10
- In the Northeast region (60%), as shown in Exhibit 11
- In homes built between 1950 and 1975 (36%), as shown in Exhibit 12

Exhibit 9 - Residential Natural Gas Consumption (GJ) in 2020 by Segment

Segment	Natural Gas Consumption (GJ)	% of Total
Attached/Row	57,892	2%
Mobile/other	202,153	7%
SFD/Duplex	2,659,659	91%
Grand Total	**2,919,703**	**100%**

Exhibit 10 - Residential Natural Gas Consumption (GJ) in 2020 by End Use

Parent End Use	Natural Gas Consumption (GJ)	% of Total
Clothes Dryer	6,308	0%
Cooking	29,180	1%
Domestic Hot Water (DHW)	458,095	16%
Fireplace	204,721	7%
Other Gas Uses	64,166	2%
Pool & Spa Heaters	5,473	0%
Space Heating	2,151,760	74%
Grand Total	**2,919,703**	**100%**

Exhibit 11 - Residential Natural Gas Consumption (GJ) in 2020 by Region

Region	Natural Gas Consumption (GJ)	% of Total
Northeast	1,763,955	60%
West (East)	484,413	17%
West (West)	671,335	23%
Grand Total	**2,919,703**	**100%**

Exhibit 12 - Residential Natural Gas Consumption (GJ) in 2020 by Vintage[23]

Segment Vintage	Natural Gas Consumption (GJ)	% of Total
Pre-1950	189,052	7%
1950-1975	979,838	36%
1976-1985	687,839	25%
1986-1995	321,706	12%
1996-2005	260,813	10%
2006-2015	112,938	4%
Post-2015	165,366	6%
Grand Total	**2,717,551**	**100%**

23 Totals in Exhibit 11 and Exhibit 12 are different because “Mobile” has been excluded from the vintage results in this report; “mobile/other” appears in the segment results. The sample sizes for mobile dwellings in the REUS were too small to reliably divide the segment into vintages.

4.2.1 Accounts

Base year residential natural gas accounts are presented in Exhibit 13 by segment, region, and vintage. The largest number of residential accounts in 2020 were:

- SFD / duplex type homes (87%)
- In the Northeast region (51%)
- Homes built between 1950 and 1975 (30%)

Exhibit 13 - Number of Residential Dwellings in 2020

Segment	Northeast	West (East)	West (West)	Grand Total
Attached/Row	608	241	236	1,085
Pre-1950	15	6	6	27
1950-1975	271	107	105	483
1976-1985	85	33	33	151
1986-1995	69	28	27	124
1996-2005	62	25	24	111
2006-2015	7	3	3	13
Post-2015	99	39	38	176
Mobile/other	2,016	567	924	3,507
All	2,016	567	924	3,507
SFD/Duplex	15,921	6,799	9,085	31,805
Pre-1950	949	405	541	1,895
1950-1975	5,297	2,262	3,024	10,583
1976-1985	4,078	1,742	2,327	8,147
1986-1995	1,983	848	1,131	3,962
1996-2005	1,688	720	963	3,371
2006-2015	782	334	446	1,562
Post-2015	1,144	488	653	2,285
Grand Total	18,545	7,607	10,245	36,397

4.2.2 Unit Energy Consumption

This section presents UEC by end use for dwellings that have gas as the predominant heating fuel and dwellings that have fuels other than gas as the predominant heating fuel[24] (referred to as "gas-heated" and "non-gas-heated" dwellings for simplicity). Unit energy consumption (UEC) is the amount of energy used by each end use per unit (a "unit" in the residential sector is a dwelling). Fuel share is the percentage of the energy end use that is supplied by each fuel.

Tertiary load is the useful energy delivered to an end use, or end use energy requirement: heat delivered by a furnace to a house, for example. This differs from natural gas consumption which is impacted by equipment efficiency: in the furnace example, consumption is equal to the tertiary load divided by seasonal efficiency of the furnace.

Tertiary loads for gas-heated and non-gas-heated dwellings are modelled identically for all end uses, except for space heating. Based on PNG's database of end-use information, non-gas-heated dwellings in BC tend to have slightly lower space heating loads than gas-heated dwellings, meaning that they are somewhat smaller, better insulated, heated to a lower temperature, or some combination of these three variables.

Also presented in this section is *stock average efficiency*, which is the average efficiency of equipment serving the tertiary load for that end use. The UEC by end use is calculated by dividing unit tertiary load with stock average efficiency.

Exhibit 14 presents the 2020 modelled values for unit tertiary load, stock average efficiency and UEC values for all end uses (DHW sub-end uses are shown separately in Exhibit 15) for gas-heated and non-gas-heated SFD dwellings in the Northeast region, for illustrative purposes.

24 "Predominant heating fuel" represents if a building primarily uses gas for heat (>50% of the fuel share for space heating is from gas) or other fuels (>50% of fuel share for space heating is from fuels other than gas). In this report, we refer to this as 'gas-heated' and 'non-gas-heated' dwellings to simplify the text. Note that gas-heated dwellings can have other fuels supplying space heating, but gas is at least 50% of the fuel share.

Exhibit 14 - 2020 Modelled UEC Values by End Use, Gas, and Non-Gas-Heated SFD/Duplex Dwellings in the Northeast

	Unit Tertiary Load (GJ/Dwelling/yr.)	Stock Average Efficiency (%)[25]	UEC
Predominantly Gas-Heated Dwellings			
Clothes Dryer	3.5	85%	4.1
Cooking	2.6	51%	5.1
Fireplace	9.4	51%	18.5
Other Gas Uses	1.8	100%	1.8
Pool & Spa Heaters	23.5	85%	27.7
Space Heating	80.8	87%	93.1
Domestic Hot Water	11.3	63%	18.0
Predominantly Non-Gas-Heated Dwellings			
Clothes Dryer	3.5	85%	4.1
Cooking	2.6	51%	5.1
Fireplace	9.4	51%	18.5
Other Gas Uses	1.8	100%	1.8
Pool & Spa Heaters	23.5	85%	27.7
Space Heating	79.8	87%	91.9[26]
Domestic Hot Water	11.3	63%	18.0

The 2020 modelled values for unit tertiary load, stock average efficiency and UEC values for the DHW sub-end uses are shown in Exhibit 15. As DHW gas consumption does not vary by the predominant heating fuel in the dwelling, the table does not differentiate by gas versus non-gas-heated dwellings. The values are specific to the SFD/Duplex segment in the Northeast region.

25 Average stock efficiencies are only used to calculate tertiary load and are not used in the measure savings calculations or elsewhere in the modelling.

26 This UEC number represents the usage a non-gas heated home would have if it did use gas to supply all its heat. "Non-gas" means "mostly non-gas", so there is still some gas heat in these homes – the dividing line is at 50% of heat supplied by gas, so these homes are anything below that level. Exhibit 16 shows that applying the assumption of 25% fuel share for the average home in this category results in average annual gas use 23 GJ for space heating.

Exhibit 15 – 2020 Modelled UEC Values for DHW Sub-End Uses, SFD/Duplex Dwellings in the Northeast

	Unit Tertiary Load (GJ/Dwelling/yr.)	Stock Average Efficiency (%)	UEC
Other DHW	2.2	63%	3.5
Dishwasher DHW	1.4	63%	2.2
Shower DHW	6.1	63%	9.7
Washer DHW	1.7	63%	2.7

4.2.3 Average Natural Gas Use per Dwelling

The following exhibits present average annual natural gas consumption per account by end use. Included in the exhibits are:

- UEC: the amount of energy used by each end use per unit (the "unit" in the residential sector is typically a dwelling, with some minor exceptions described below).
- Fuel Share: the percentage of the energy end use that is supplied by natural gas
- Saturation: For most end uses, saturation reflects the extent to which an end use is present in a region, and segment. In the residential sector, cooking, space heating, DHW, and 'other gas uses' have a saturation of 100% as these end uses are assumed to be present in all residential dwellings.

  Three end uses – clothes dryers, fireplaces, and pool & spa heaters – are not present in every residential dwelling. In these cases, saturation is used to show the average number of appliances per dwelling supplying those end uses, and the "unit" referred to in the UEC is one equipment unit: a fireplace for example. In the exhibits below, saturation for these three end uses is not 100%: greater than 100% means that the average residential dwelling has more than one appliance related to that end use (e.g., fireplaces) and less than 100% means that the average residential dwelling has less than one (therefore no) appliances related to that end use (e.g., pool & spa heaters).

Average annual gas consumption per unit is calculated by multiplying these three variables together; therefore, they are included in the exhibits below. This number is equivalent to the Energy Use Intensity (EUI).

Exhibit 16 presents the modelled average annual gas use per residential dwelling by end use (DHW sub-end uses are presented separately in Exhibit 17) for gas and non-gas-heated dwellings, respectively. Note that these values are specific to the SFD/Duplex segment and the Northeast region.

Exhibit 16 – 2020 Modelled Average Annual Gas Use Per Dwelling by End Use, Gas and Non-Gas SFD/Duplex Heated Dwellings in the Northeast

	UEC	Fuel Share	Saturation	Average Annual Gas Use (GJ/yr.)
Predominantly Gas-Heated Dwellings				
Clothes Dryer	4.1	4%	99%	0.2
Cooking	5.1	16%	100%	0.8
Fireplace	18.5	47%	70%	6.1
Other Gas Uses	1.8	100%	100%	1.8
Pool & Spa Heaters	27.7	5%	11%	0.2
Space Heating	93.1	84%	100%	78.4
DHW	18.0	75%	100%	13.5
Total Annual Consumption for an Average Residential Customer in Northeast				**100.9**
Predominantly Non-Gas-Heated Dwellings				
Clothes Dryer	4.1	5%	99%	0.2
Cooking	5.1	15%	100%	0.8
Fireplace	18.5	41%	70%	5.3
Other Gas Uses	1.8	100%	100%	1.8
Pool & Spa Heaters	27.7	5%	11%	0.2
Space Heating	91.9	25%	100%	23.0
DHW	18.0	72%	100%	12.9
Total Annual Consumption for an Average Residential Customer in Northeast				**44.2**

Exhibit 17 presents the modelled average annual gas use per residential dwelling by DHW sub-end use for gas and non-gas-heated dwelling, respectively. Note that these values are specific to the SFD/Duplex segment and the Northeast region.

Exhibit 17 – 2020 Modelled Average Annual Gas Use Per SFD/Duplex Dwellings in the Northeast by DHW Sub-End Uses and Predominant Heating Fuel

	UEC	Gas Fuel Share	Saturation	Average Annual Gas Use (GJ/dwelling/yr.)
Predominantly Gas-Heated Dwellings				
Other DHW	3.5	75%	100%	2.6
Dishwasher DHW	2.2	75%	100%	1.6
Shower DHW	9.7	75%	100%	7.3
Washer DHW	2.7	75%	100%	2.0
Predominantly Non-Gas-Heated Dwellings				
Other DHW	3.5	72%	100%	2.5
Dishwasher DHW	2.2	72%	100%	1.6
Shower DHW	9.7	72%	100%	7.0
Washer DHW	2.7	72%	100%	1.9

4.3 Reference Case Natural Gas Use

This section profiles the reference case base year (2020) and forecast (2021-2041) natural gas consumption for the residential sector.

Overall gas consumption is forecasted to decline by approximately 8% by 2041 compared to 2020 consumption, with an average annual decrease of about 0.40%. While the forecast shows an increase in the number of residential accounts (as shown in Exhibit 18), the growth in accounts is less than the decrease in usage per account, so the net result is that consumption declines.

Exhibit 18 - Number of Residential Accounts, 2020 vs 2041, by Region, Segment, and Vintage

Region	Northeast		West (East)		West (West)		Total	
Segment	2020	2041	2020	2041	2020	2041	2020	2041
Attached/Row	608	1,418	241	467	236	475	1,085	2,360
Pre-1950	15	10	6	4	6	4	27	18
1950-1975	271	177	107	70	105	69	483	316
1976-1985	85	55	33	22	33	22	151	99
1986-1995	69	46	28	19	27	18	124	83
1996-2005	62	42	25	17	24	16	111	75
2006-2015	7	5	3	2	3	2	13	9
Post-2015	99	1,083	39	333	38	344	176	1,760
Mobile/other	2,016	2,505	567	629	924	1,004	3,507	4,138
All	2,016	2,505	567	629	924	1,004	3,507	4,138
SFD/Duplex	15,921	18,723	6,799	7,416	9,085	9,650	31,805	35,789
Pre-1950	949	621	405	265	541	354	1,895	1,240
1950-1975	5,297	3,467	2,262	1,480	3,024	1,979	10,583	6,926
1976-1985	4,078	2,667	1,742	1,140	2,327	1,523	8,147	5,330
1986-1995	1,983	1,297	848	554	1,131	740	3,962	2,591
1996-2005	1,688	1,104	720	471	963	629	3,371	2,204
2006-2015	782	512	334	218	446	292	1,562	1,022
Post-2015	1,144	9,055	488	3,288	653	4,133	2,285	16,476
Grand Total	18,545	22,646	7,607	8,512	10,245	11,129	36,397	42,287

Exhibit 19, Exhibit 20, and Exhibit 21 present how natural gas is forecasted to be used from 2020 to 2041 by segment, end use, and region, respectively. Section 4.3.1 focuses on consumption from existing and new dwellings over the reference case. These exhibits illustrate forecasted trends in consumption over the reference case, including:

- Many consumption patterns evident in the base year are expected to persist throughout the reference case: natural gas is predominately used in the SFD/Duplex segment, in the Northeast region, and for space heating throughout the study period.
- In 2020, post-2015 residential dwellings account for approximately 6% of consumption. By 2041, this vintage is projected to use about 37% of consumption.

Exhibit 19 - 2020 vs 2041 Residential Gas Consumption (GJ) by Segment

Segment	2020	2041	% Change
SFD/Duplex	2,659,659	2,377,343	-10%
Attached/Row	57,892	90,130	56%
Mobile/other	202,153	209,579	4%
Total	**2,919,703**	**2,677,052**	**-8%**

Exhibit 20 - 2020 vs 2041 Residential Gas Consumption (GJ) by End Use

Parent End Use	2020	2041	% Change
Clothes Dryer	6,308	7,844	9%
Cooking	29,180	34,742	19%
Domestic Hot Water (DHW)	458,095	432,104	-6%
Fireplace	204,721	217,346	6%
Other Gas Uses	64,166	104,865	63%
Pool & Spa Heaters	5,473	6,159	13%
Space Heating	2,152,760	1,874,992	-13%
Total	**2,919,703**	**2,677,052**	**-8%**

Exhibit 21 - 2020 vs 2041 Residential Gas Consumption (GJ) by Region

Region	2020	2041	% Change
Northeast	1,763,955	1,590,353	-10%
West (East)	484,413	463,776	-4%
West (West)	671,335	622,922	-7%
Total	**2,919,703**	**2,677,052**	**-8%**

4.3.1 Reference Case Natural Gas Use: Existing versus New Residential Dwellings

Exhibit 22 illustrates the expected increase in consumption from new residential dwellings over the reference case, from 2% in 2021 to approximately 31% in 2041, compared to existing dwellings.

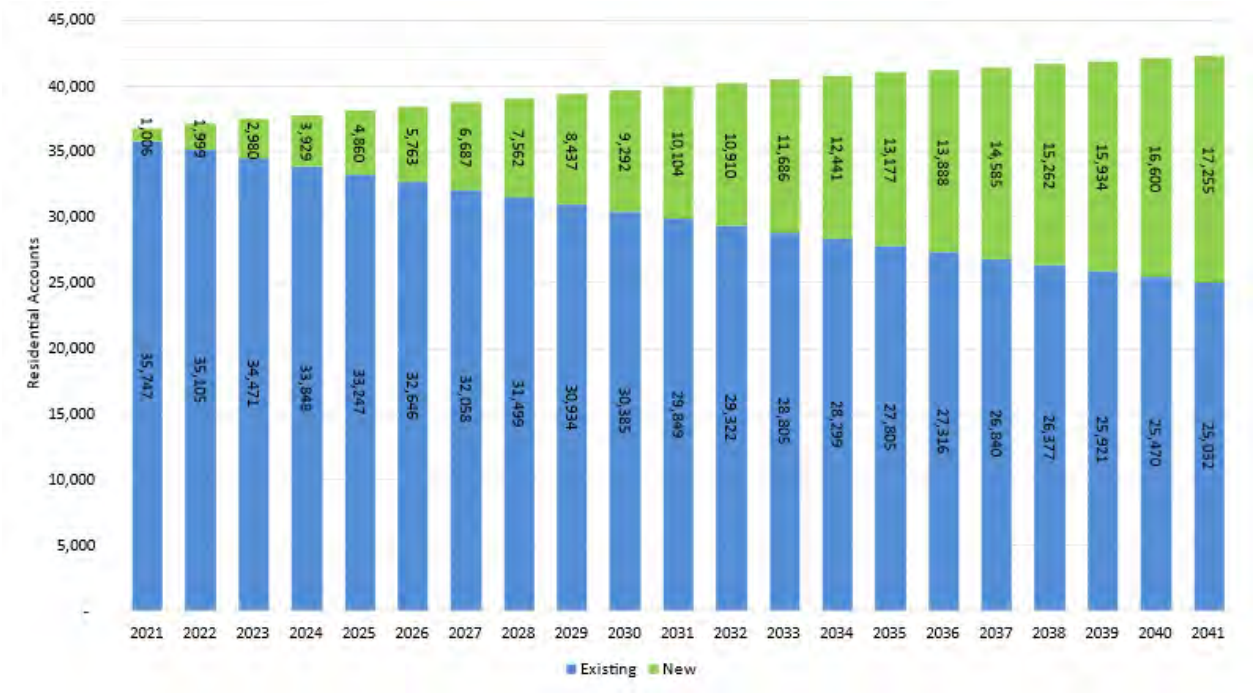
Exhibit 22 - 2021-2041 Gas Consumption (GJ) by New and Existing and Segment

Existing/New	2021[27]	2041	% Change
Existing	**2,848,994**	**1,844,045**	**-35%**
Attached/Row	56,381	35,014	-38%
Mobile/Other	200,716	185,440	-8%
SFD/Duplex	2,591,897	1,623,592	-37%
New	**51,335**	**833,006**	**1523%**
Attached/Row	3,552	55,116	1452%
Mobile/Other	1,572	24,139	1436%
SFD/Duplex	46,211	753,751	1531%
Total	**2,900,328**	**2,677,052**	**-8%**

Despite the reference case showing an 8% decrease in residential sector gas use from 2021 to 2041, residential accounts are expected to grow by approximately 15% from 2021 to 2041, from 36,800 to 42,300. The portion of PNG accounts from new residential dwellings is forecasted to increase over the reference case from 3% in 2021 to 41% in 2041, with new construction contributing over 17,000 new accounts, and approximately 11,000 existing dwellings being demolished over the reference case period. This represents 30% of the existing dwellings being demolished between 2021 and 2041, a demolition rate of approximately 2% per year. These results are shown in Exhibit 23.

27 The year 2021 is used in this exhibit instead of the base year, 2020, because new building forecasting begins in 2021.

Exhibit 23 – 2021 vs 2041 Residential Gas Accounts Forecast by Existing and New Vintage



4.4 Measure Assessment

4.4.1 List of Measures

The list of residential measures that were included in this CPR are presented in Exhibit 24. The measures are divided into categories by end use and measure type.

Please see the MS Excel file titled “Res Measure Analysis Workbook” for a description of each measure and a full analysis.

Measures were classified in five measure type categories:

- Building Envelope (also referred to as “envelope measures”)
- Equipment
- Controls
- Energy Management (including behavioural measures)
- New Construction – all new construction measures were placed in a separate category

New construction measures are analyzed using a whole-building approach, represented by the Step 2 - Step 5 BC Energy Step Code measures listed below.

One additional measure was considered and analyzed separately, hybrid heat pumps.[28] Only technical and economic potential savings estimates are presented, as there is insufficient information available to

28 Hybrid heat pumps - electric heat pumps with gas back up for low temperature conditions.

estimate the market potential at this time. Please see the MS Excel file titled "Res Measure Analysis Workbook" for a description and full analysis of this measure.

Exhibit 24 – Residential Sector Conservation and Energy Management Measures

Space Heating – Building Envelope

Attic Duct Insulation
Attic Insulation (R-20 and R-12.6 Baselines)
Basement or Crawlspace Insulation
Comprehensive Air Sealing
Comprehensive Draft Proofing
Exposed Floor Insulation
High Performance Windows and Doors
Manufactured Homes Duct Sealing
Manufactured Homes Floor Insulation
Wall Insulation – Cavity (R-10 and R-3 Baselines)
Wall Insulation – Sheathing (R-7 Baseline)

Space Heating – Equipment

Boiler Reset Controls
Boiler Tune-Up
Communicating Thermostat
Fireplace Timer
Furnace Early Retirement
Furnace Early Retirement (60 AFUE)
Furnace Tune-Up
Gas Heat Pump – Space Heating
High Efficiency Boiler
High Efficiency Fireplace
High Efficiency Furnace
High Efficiency Furnace Dual Fuel-Gas Primary
High-Efficiency Heat Recovery Ventilator

Water Heating – Equipment

Connected Water Heater Controller
Drain Water Heat Recovery
Faucet Aerator
Gas Heat Pump – Domestic Hot Water
High-Efficiency Condensing Gas Tankless Water Heater
High-Efficiency Condensing Gas Tankless Water Heater – Mature Market Costs
High-Efficiency Condensing Gas Water Heater
High-Efficiency Storage Gas Water Heater
Low Flow Showerhead
Pipe Wrap
Thermostatic Restrictor Shower Valve
Water Heater Tune-Up

Appliances

Convection Oven
ENERGY STAR Dishwasher
High Efficiency (ENERGY STAR®) Clothes Washer
High Efficiency (ENERGY STAR®) Gas Clothes Dryer
High Efficiency Gas Range

New Construction

New Construction - Step 2 Homes
New Construction - Step 3 Homes
New Construction - Step 4 Homes
New Construction - Step 5 Homes
New Construction – Step 5 Homes – Mature Market Costs

Other

Deep Energy Retrofits[29] (Envelope, Mechanical, Electrical)
ENERGY STAR Manufactured Home
Home Energy Report

29 Note that the analysis that forms the technical, economic and market potential is based on individual measures rather than on "packages of measures" or program delivery approaches. Measures packaged in comprehensive programs such as deep energy retrofits were assessed within this analysis individually but also collectively as a program package.

4.4.2 Results

The measure-level results for the residential sector are shown in Exhibit 25 in order of decreasing cost effectiveness.

Measures were assessed based on their replacement type: **retrofit** (immediate replacement at full cost), **replace on burnout** (end of life replacement at incremental cost), or **new construction** (immediate installation at incremental cost). Installation costs were not included for any measure that could reasonably be expected to be installed by the homeowner, such as pipe wrap.

The TRC and MTRC results are presented at the measure-level and exclude program costs and free-ridership.

Key findings of the measure assessment for the residential sector include:

- Of the 54 measures originally analysed, 49 were included in the final residential model. The three deep energy retrofit measures were excluded as they can alternatively be shown as a combination of other measures. The High Efficiency Condensing Gas Tankless Water Heater was also excluded (the Mature Market version alone is sufficient). The New Construction – Step 4 Homes was excluded because it has lower savings than the Step 3 Homes measure.
- Of the 49 remaining measures, 13 pass the TRC screen. Substantially more, 34 measures, pass the MTRC screen.
- The most attractive space heating measures, and the only ones that pass the TRC (i.e., TRC is 1.0 or higher) are wall insulation (R-3 baseline), attic duct insulation, attic insulation (R-12.6 baseline), communicating thermostats, high-efficiency fireplaces, and fireplace timers.
- The most attractive water heating measures (i.e. measures with the highest TRC) include pipe wrap, faucet aerators, and low flow showerheads.
- Appliance measures do well. ENERGY STAR dishwashers and high efficiency ENERGY STAR clothes washers have the first and third highest TRC, respectively.
- Other building envelope measures, such as attic insulation (R-20 baseline), floor insulation, and air sealing measures do not pass the TRC (i.e. TRC is less than 1.0).
- Gas heat pumps, hybrid heat pumps, and DHW gas heat pumps pass the MTRC. None pass the TRC.
- Of the Step Code new construction measures, only Step 2 passes the TRC. Steps 2 and 3 pass the MTRC.
- The hybrid heat pump was found to have a TRC of 0.3 and an MTRC of 1.3.

Exhibit 25 – Residential Sector Results: Sector Averages (Sorted by High to Low MTRC)

#	Measure	Measure Type	Replacement Type	TRC	MTRC
1	ENERGY STAR Dishwasher[30]	Equipment	ROB	100.0	100.0
2	Pipe Wrap	Equipment	RET	18.2	73.4
3	High Efficiency (ENERGY STAR®) Clothes Washer	Equipment	ROB	10.5	43.0
4	Faucet Aerator	Equipment	RET	6.9	32.0
5	Low Flow Showerhead	Equipment	RET	4.0	18.4
6	Fireplace Timer	Equipment	RET	3.1	11.6
7	High Efficiency (EnerChoice®) Gas Fireplace or Vertically Direct Vented Fireplace	Equipment	RET	2.5	10.0
8	Attic or Crawlspace Duct Insulation	Equipment	RET	1.9	7.2
9	Wall Insulation – Cavity (R-3 baseline)	Building Shell	RET	2.0	7.2
10	Communicating Thermostat	Controls	RET	1.2	5.3
11	Furnace Early Retirement (60 AFUE)	Equipment	RET	0.8	4.6
12	New Construction - Step 2 Homes	New Construction	NEW	1.1	4.0
13	Attic Insulation (R-12.6 Baseline)	Building Shell	RET	1.0	3.7
14	Home Energy Report	Energy Management	RET	1.4	3.5
15	Basement or Crawlspace Insulation	Building Shell	RET	0.7	2.5
16	Comprehensive Air Sealing	Building Shell	RET	0.6	2.4
17	Drain Water Heat Recovery	Equipment	RET	0.6	2.4
18	Attic Insulation (R-20 Baseline)	Building Shell	RET	0.7	2.3
19	Furnace Early Retirement	Equipment	RET	0.4	2.2
20	New Construction - Step 3 Homes	New Construction	NEW	0.6	2.1
21	Exposed Floor Insulation	Building Shell	RET	0.6	2.0
22	Boiler Reset Controls	Equipment	RET	0.5	2.0
23	Wall Insulation – Cavity (R-10 baseline)	Building Shell	RET	0.6	2.0
24	High-Efficiency Heat Recovery Ventilator	Equipment	RET	0.5	1.9
25	High Efficiency Boiler	Equipment	ROB	0.5	1.9
26	Gas Heat Pump - Space Heating	Equipment	ROB	0.5	1.9

30 The incremental cost of ENERGY STAR dishwashers is reportedly zero compared to other, less efficient dishwashers, so this measure is automatically cost-effective.

27	Gas Heat Pump - DHW	Equipment	ROB	0.4	1.7
28	Manufactured Homes Floor Insulation	Equipment	RET	0.4	1.4
29	Wall Insulation – Sheathing (R-7 baseline)	Building Shell	RET	0.4	1.3
30	Manufactured Homes Duct Sealing	Equipment	RET	0.3	1.3
31	High-Efficiency (ENERGY STAR®) Condensing Gas Tankless Water Heater - Mature Market Costs	Equipment	ROB	0.3	1.3
32	Electric Heat Pump with Gas Back Up (Hybrid Heat Pump)[31]	Equipment	RET	0.3	1.3
33	Comprehensive Draft Proofing	Building Shell	RET	0.2	1.1
34	High-Efficiency Storage Gas Water Heater	Equipment	ROB	0.3	1.0
35	High Efficiency (ENERGY STAR®) Gas Clothes Dryer	Equipment	ROB	0.2	0.8
36	High-Efficiency (ENERGY STAR®) Condensing Gas Water Heater	Equipment	ROB	0.2	0.7
37	High Efficiency Gas Range	Equipment	ROB	0.2	0.7
38	High Efficiency Furnace	Equipment	ROB	0.2	0.6
39	Convection Oven	Equipment	ROB	0.1	0.6
40	Connected Water Heater Controller	Controls	RET	0.2	0.4
41	Boiler Tune-Up	Equipment	RET	0.1	0.4
42	High Efficiency Furnace Dual Fuel-Gas Primary	Equipment	ROB	0.1	0.4
43	Furnace Tune-Up	Equipment	RET	0.1	0.4
44	New Construction - Step 5 Homes - Mature Market Costs	New Construction	NEW	0.1	0.4
45	New Construction - Step 5 Homes	New Construction	NEW	0.1	0.4
46	High Performance Windows and Doors	Building Shell	ROB	0.1	0.3
47	ENERGY STAR® Manufactured Home	Equipment	RET	0.1	0.3
48	Thermostatic Restrictor Shower Valve	Equipment	RET	0.03	0.1
49	Water Heater Tune-Up	Energy Management	RET	0.02	0.1

31 Hybrid heat pumps were considered and analyzed separately so the results were not incorporated into the technical, economic, and market potential scenarios.

4.4.3 Measure Cost Sensitivity Analysis

Measure costs were originally developed for southern BC, which may have lower measure costs than in the PNG territory. As such, a sensitivity analysis of the measure costs was conducted, using a 30% price adder to reflect the potentially higher costs in the PNG service territory and determine to what extent achieving cost effective DSM may be more challenging in remote and smaller markets. The results of this sensitivity analysis are not reflected in the potential scenarios presented in this report.

The following measures previously passed the TRC test but do not pass it in any region or segment with a 30% cost adder:

- Attic Insulation (R-12.6 Baseline)
- New Construction – Step 2 Homes

The following measures previously passed the TRC test but do not pass it in at least one ore more regions or segments with a 30% cost adder:

- Attic or Crawlspace Duct Insulation
- Communicating Thermostat
- Home Energy Report
- Wall Insulation Cavity (R-3 baseline)

The following measures previously passed the MTRC test but do not pass it in any region or segment with a 30% cost adder:

- High-Efficiency (ENERGY STAR) Condensing Gas Tankless Water Heater - Mature Market Costs
- High-Efficiency Storage Gas Water Heater

The following measures previously passed the MTRC test but do not pass it in at least one or more regions or segments with a 30% cost adder:

- Attic Insulation (R-20 Baseline)
- Basement or Crawlspace Insulation
- Boiler Reset Controls
- Comprehensive Air Sealing
- Comprehensive Draft Proofing
- Exposed Floor Insulation
- Furnace Early Retirement
- Gas Heat Pump – DHW
- Gas Heat Pump – SH
- High-Efficiency Boiler
- High-Efficiency Heat Recovery Ventilator
- Manufactured Homes Duct Sealing
- Wall Insulation Cavity (R-10 baseline)
- Wall Insulation Sheathing (R-7 baseline)

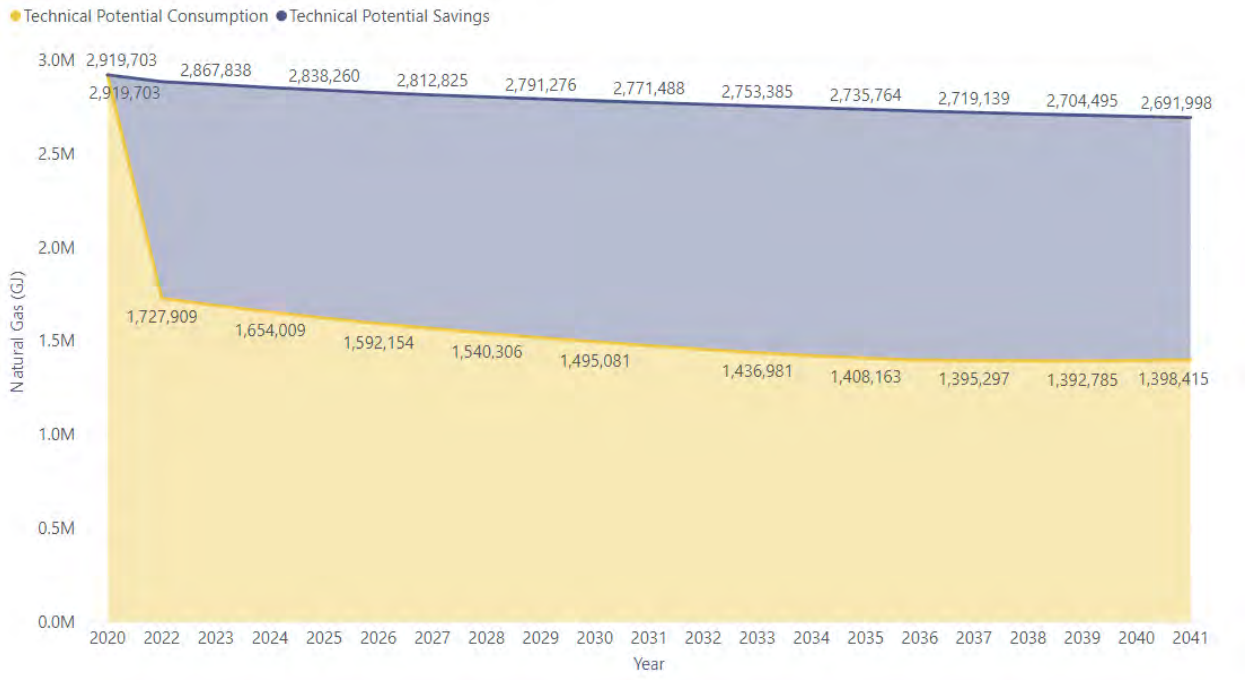
4.5 Technical Potential

This section provides an overview of the technical potential savings results for the residential sector. This section provides an overview of the technical potential savings results for the industrial sector. The technical potential forecast includes the installation of all conservation measures that are technically feasible. Technical potential estimates ignore all non-engineering and financial constraints, such as cost-effectiveness and the willingness of end users to adopt measures. This scenario is included to estimate the theoretical maximum amount of energy use that could be captured by all energy efficiency measures.

Overall results, excluding hybrid heat pumps, are presented in Exhibit 26 and Exhibit 27, followed by measure level results in Exhibit 28, and supply curves for the TRC and MTRC results in Exhibit 29 and Exhibit 30. Results are shown from 2022 to 2041 as measures are not applicable until 2022; before that, there are no potential savings.

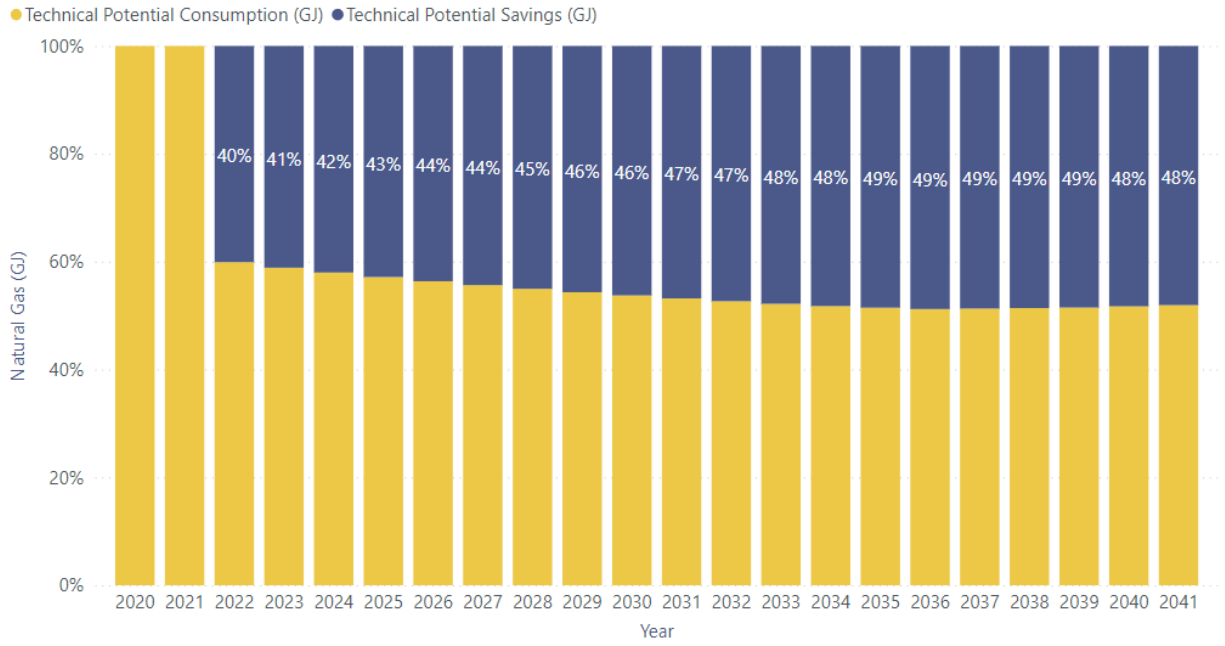
As shown in Exhibit 26, most of the residential technical potential (1,160 TJ) would be available in 2022 and would increase to 1290 TJ in 2041. This indicates that a small amount of the potential, approximately 130 TJ, would come from replace on burnout measures over the next two decades. The forecasted natural gas consumption for the residential sector is included for reference.

Exhibit 26 – Residential Technical Potential Savings (GJ)



As shown in Exhibit 27, the technical potential savings is about 40% of residential reference case consumption in 2022 and increases to 48% by 2041. This result further indicates that replace on burnout measures have a noticeable but limited impact on technical potential.

Exhibit 27 – Technical Savings Potential as a Percent of Residential Reference Case Consumption (%)



The technical potential savings by 2024 broken down by the top 25 measures are presented in Exhibit 28. Three of the top four measures are space heating measures. The technical potential savings of hybrid heat pumps are estimated to be 300 TJ in 2024.

Exhibit 28 – Technical Potential – Annual Gas Savings from Top 25 Residential Measures in 2024 (GJ)

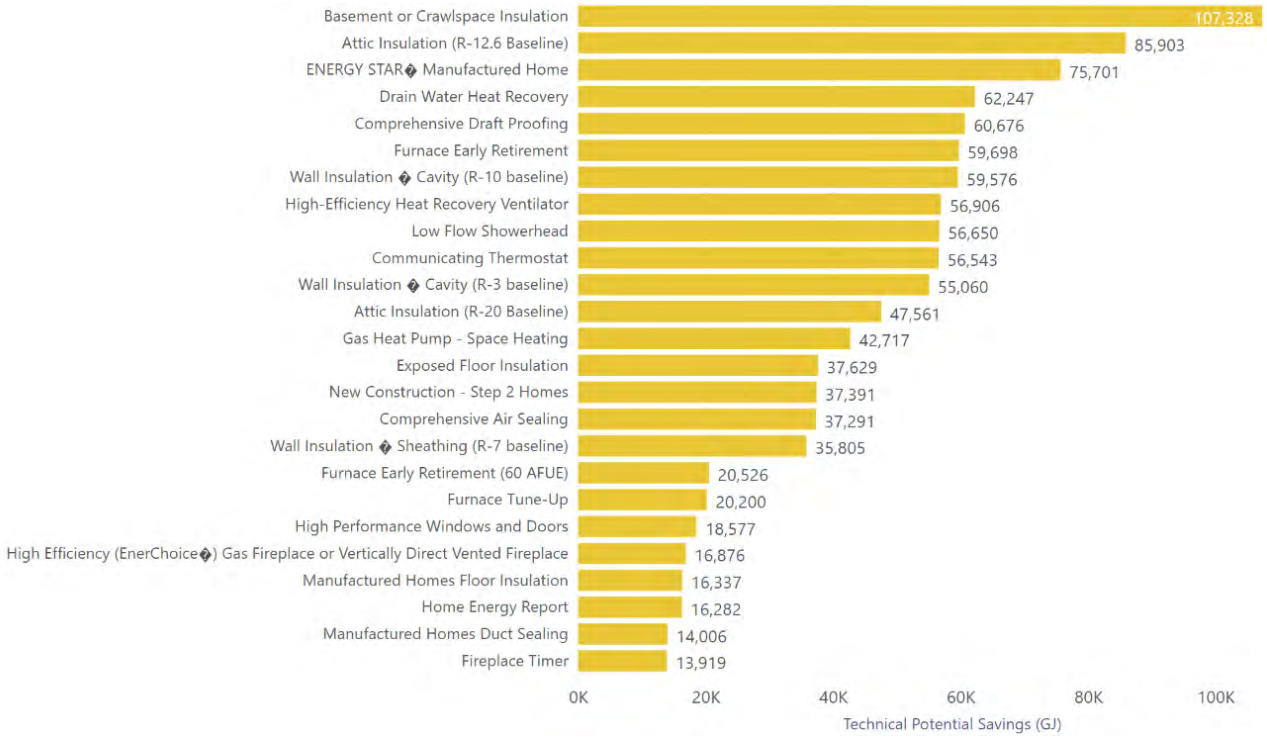


Exhibit 29 shows the cumulative residential sector technical potential savings in 2041, arranged as a supply curve, with measures ordered by decreasing TRC ratio from left to right. The graph shows that approximately 33% (approximately 430 out of 1290 TJ) of the residential sector's technical potential by 2041, comes from measures with a TRC of 1.0 or higher. Approximately 130 TJ of savings come from measures with a TRC ratio of greater than 2. These results are shown in aggregate.

Exhibit 29 – Residential Sector: Technical Potential Supply Curve – TRC

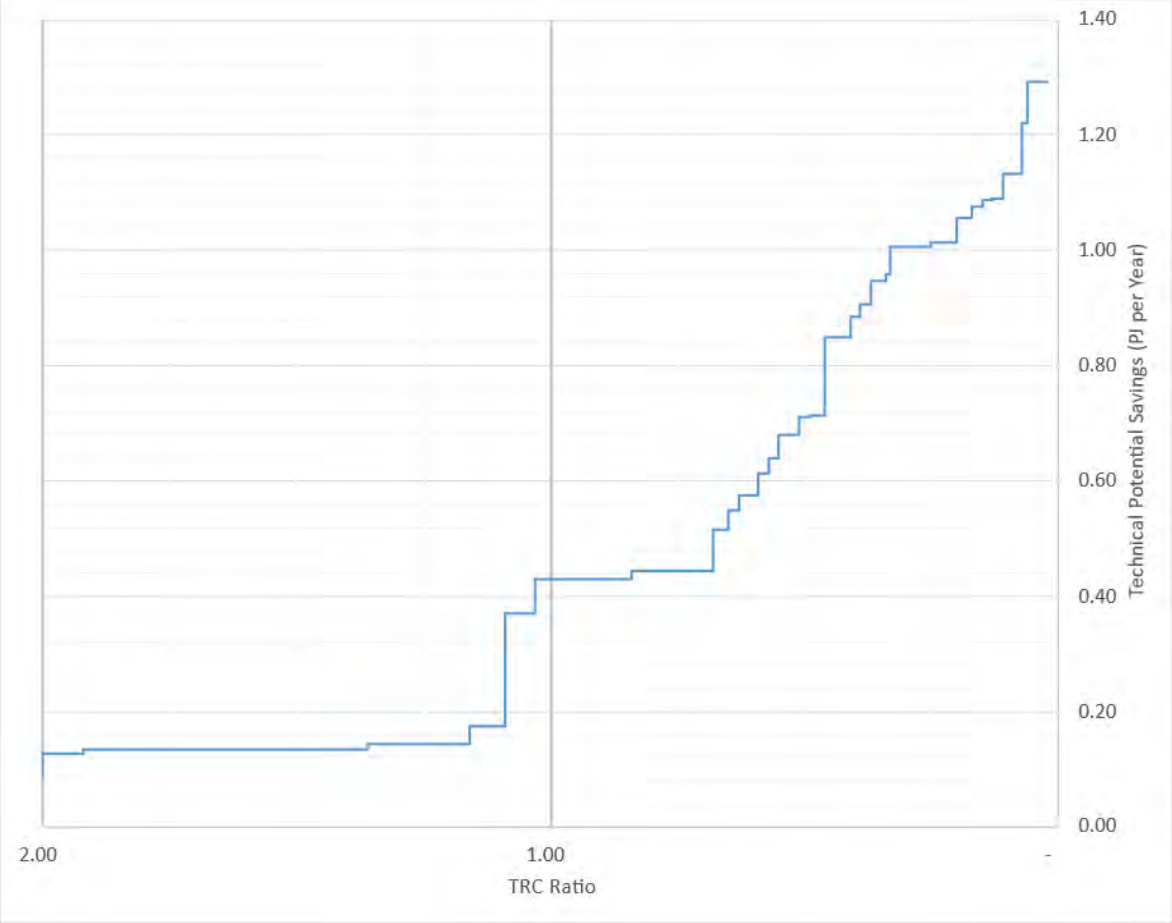
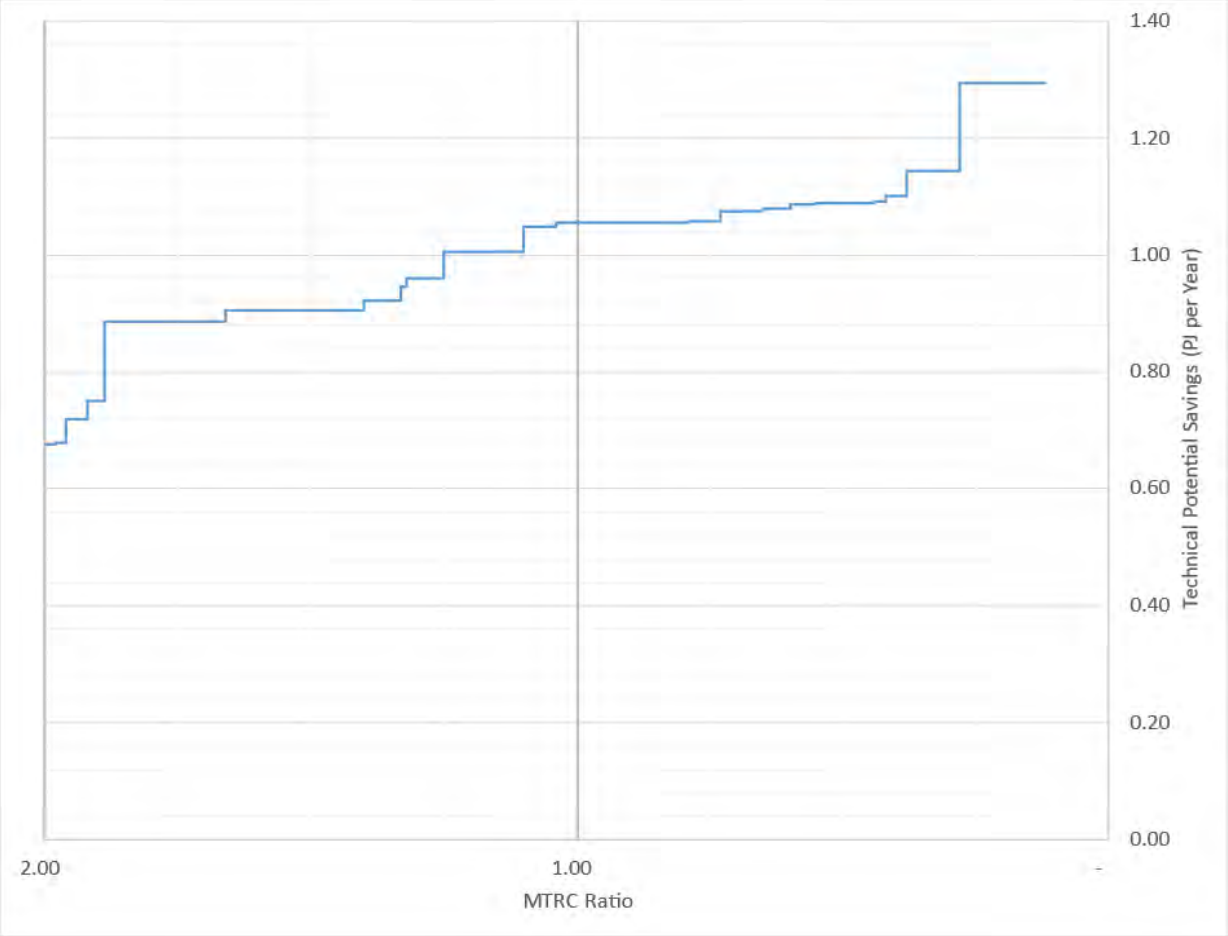


Exhibit 30 shows a similar supply curve, but with measures ordered by decreasing MTRC ratio from left to right. The graph shows that 82% (approximately 1060 out of 1290 TJ) of the residential sector's technical potential by 2041 comes from cost-effective measures with an MTRC of 1.0 or higher. Approximately 680 TJ of savings come from measures with an MTRC ratio of greater than 2. These results are shown in aggregate.

Exhibit 30 – Residential Sector: Technical Potential Supply Curve – MTRC

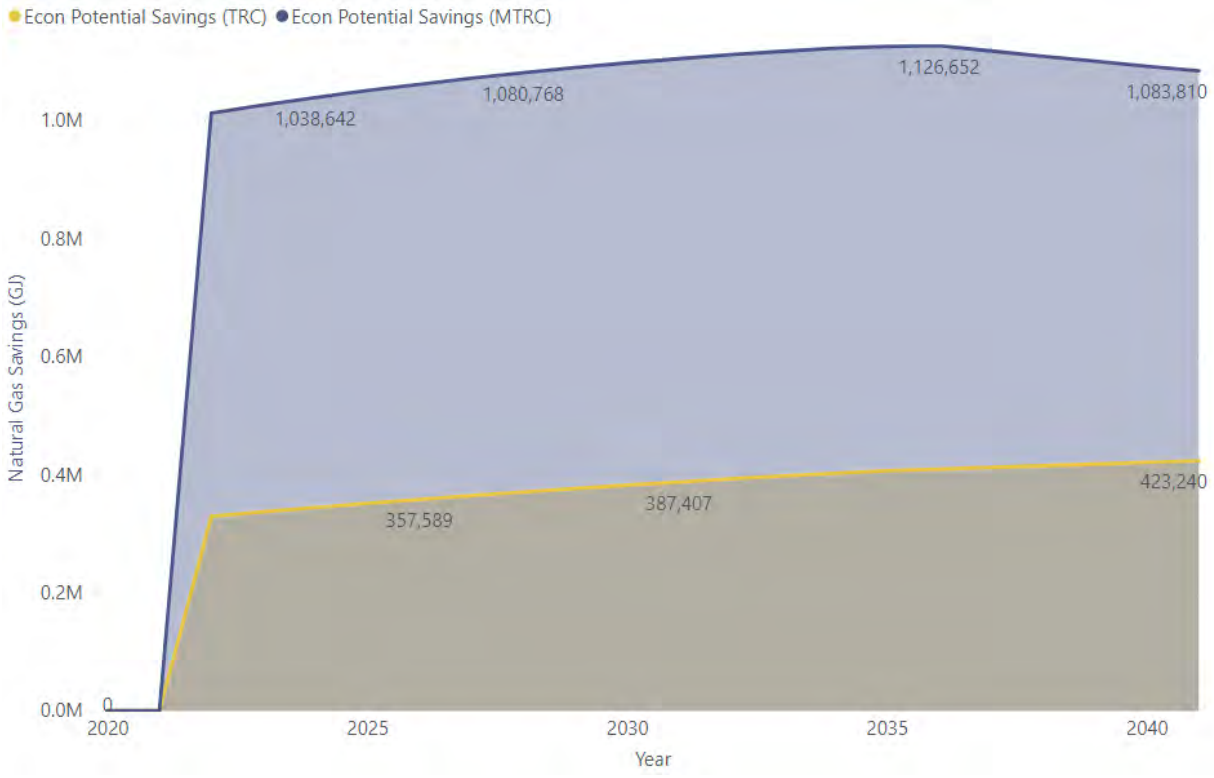


4.6 Economic Potential

This section provides the economic potential savings results for the residential sector from 2021 to 2041. We conducted two economic potential assessments: one using a TRC screen that includes measures with a TRC ratio of 1.0 and above, and one using an MTRC screen that includes measures with an MTRC of 1.0 and above. Outputs of both economic models are presented in this section.

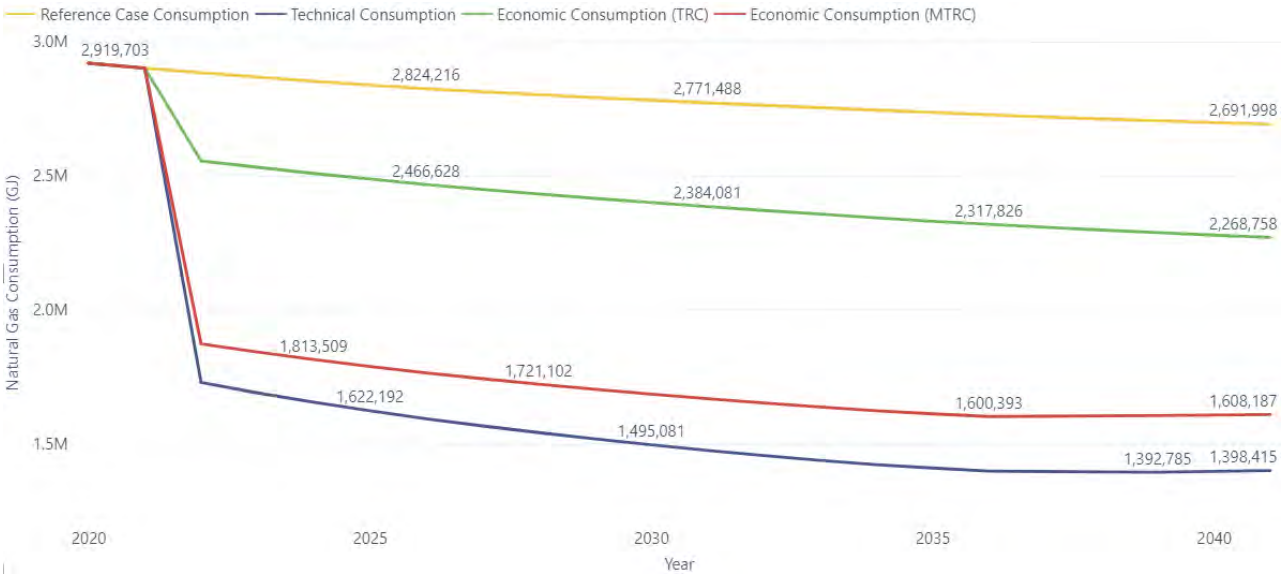
The residential sector economic potential savings with a TRC screen and with an MTRC screen are shown in Exhibit 31. Of the 48 measures included in the assessment, only 13 pass the TRC screen whereas 33 measures pass the MTRC screen. Those 20 measures that pass the MTRC but fail the TRC make up the difference between the two economic potential scenarios. This difference in economic potential in 2024 is approximately 694 TJ. In 2024, 33% of the MTRC economic potential comes from measures that pass the TRC as well; by 2041, that share is 40%.

Exhibit 31 – Economic Potential Savings (GJ) – Residential, TRC and MTRC



The forecasted gas consumption under the technical potential, economic potential with a TRC screen, economic potential with an MTRC screen, and reference case scenarios for residential sector are shown in Exhibit 32.

Exhibit 32 – Economic Potential Consumption (GJ) Forecasts – Residential, TRC and MTRC



Results by Region

The TRC and MTRC economic potential savings in 2024 are presented by region in Exhibit 33 and Exhibit 34, respectively. The largest economic potential savings (236 TJ to 656 TJ depending on the economic screen) are estimated to occur in the Northeast region. The percentage of consumption captured by economic potential is highest in the Northeast region for both economic screens (14% for TRC and 38% for MTRC). Savings are similar between the two West regions – approximately 9-10% under TRC screen and 33-34% under MTRC.

Exhibit 33 – Economic Potential Savings by Region in 2024 – Residential, TRC

Region	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Northeast	1,715,990	236,214	14%
West (West)	659,712	61,771	9%
West (East)	476,449	46,086	10%
Total	**2,852,151**	**344,072**	**12%**

Exhibit 34 – Economic Potential Savings by Region in 2024 – Residential, MTRC

Region	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Northeast	1,715,990	655,835	38%
West (West)	659,712	220,796	33%
West (East)	476,449	162,011	34%
Total	**2,852,151**	**1,038,642**	**36%**

Results by Segment and Vintage

The TRC and MTRC economic potential savings in 2024 are presented by segment and vintage in Exhibit 35 and Exhibit 36 respectively. As expected, older single-family dwellings present the most opportunities for economic potential absolute savings under both economic screens. However, in the TRC economic potential, the largest percentage of consumption is captured by the post-2015 vintage in both single-family and attached segments. This implies a sizeable potential contribution by Step Code new construction measures (specifically Step 2 which is the only step code measure to pass the TRC screen).

Exhibit 35 – Economic Potential Savings by Segment and Vintage in 2024 – Residential, TRC

Segment	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
⊟ **SFD/Duplex**	**2,582,880**	**321,727**	**12%**
1950-1975	860,162	106,246	12%
1976-1985	613,971	72,579	12%
Post-2015	322,849	49,404	15%
1986-1995	284,794	33,878	12%
1996-2005	230,526	27,643	12%
Pre-1950	169,212	21,569	13%
2006-2015	101,365	10,408	10%
⊟ **Mobile/other**	**203,123**	**16,494**	**8%**
All	203,123	16,494	8%
⊟ **Attached/Row**	**66,149**	**5,851**	**9%**
Post-2015	21,209	3,062	14%
1950-1975	24,687	1,577	6%
1976-1985	7,355	453	6%
1986-1995	5,783	364	6%
1996-2005	4,932	316	6%
Pre-1950	1,570	55	3%
2006-2015	613	24	4%
Total	**2,852,151**	**344,072**	**12%**

Exhibit 36 – Economic Potential Savings by Segment and Vintage in 2024 – Residential, MTRC

Segment	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
⊟ **SFD/Duplex**	**2,582,880**	**945,142**	**37%**
1950-1975	860,162	328,878	38%
1976-1985	613,971	232,272	38%
1986-1995	284,794	107,207	38%
Post-2015	322,849	87,805	27%
1996-2005	230,526	86,382	37%
Pre-1950	169,212	65,299	39%
2006-2015	101,365	37,298	37%
⊟ **Mobile/other**	**203,123**	**74,518**	**37%**
All	203,123	74,518	37%
⊟ **Attached/Row**	**66,149**	**18,982**	**29%**
1950-1975	24,687	8,218	33%
Post-2015	21,209	4,902	23%
1976-1985	7,355	2,273	31%
1986-1995	5,783	1,658	29%
1996-2005	4,932	1,409	29%
Pre-1950	1,570	406	26%
2006-2015	613	116	19%
Total	**2,852,151**	**1,038,642**	**36%**

Results by End Use

The TRC and MTRC economic potential savings in 2024 are presented by end use in Exhibit 37 and Exhibit 38, respectively. The largest savings are expected to be captured under the space heating end use (221 TJ or 826 TJ, for the TRC and MTRC results, respectively). In terms of the percent of reference case consumption captured by economic potential, domestic hot water captures the largest share in both economic screens (20% TRC, 40% MTRC). Although smaller in absolute savings, the fireplace end use has an economic potential of 16% of consumption under both screens.

Exhibit 37 – Economic Potential Savings by End Use in 2024 – Residential, TRC

Parent End Use	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Space Heating	2,079,880	220,811	11%
Domestic Hot Water (DHW)	447,883	90,349	20%
Fireplace	208,061	32,538	16%
Cooking	30,530	268	1%
Clothes Dryer	6,446	57	1%
Pool & Spa Heaters	5,641	48	1%
Other Gas Uses	73,710	0	0%
Total	**2,852,151**	**344,072**	**12%**

Exhibit 38 – Economic Potential Savings by End Use in 2024 – Residential, MTRC

Parent End Use	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Space Heating	2,079,880	826,154	40%
Domestic Hot Water (DHW)	447,883	179,565	40%
Fireplace	208,061	32,547	16%
Cooking	30,530	270	1%
Clothes Dryer	6,446	57	1%
Pool & Spa Heaters	5,641	48	1%
Other Gas Uses	73,710	0	0%
Total	**2,852,151**	**1,038,642**	**36%**

The TRC and MTRC economic potential savings in 2041 are presented by end use in Exhibit 39. The large difference, of approximately 660 TJ, is due to the number of measures that pass the MTRC but fail the TRC. The biggest difference between the economic screens stems from measures that affect space heating. The only other end use that has noticeably different savings between the two screens is domestic hot water.

Exhibit 39 – Economic Potential Savings by End Use in 2041 – Residential, TRC and MTRC

Parent End Use	Economic Savings (GJ) - TRC	Economic Savings (GJ) - MTRC	Difference (GJ)
Space Heating	282,918	829,489	546,571
Domestic Hot Water (DHW)	116,609	230,600	113,992
Fireplace	23,440	23,446	6
Cooking	197	199	2
Clothes Dryer	41	41	0
Other Gas Uses	0	0	0
Pool & Spa Heaters	34	34	0
Total	**423,240**	**1,083,810**	**660,571**

Results by Measure

The TRC economic potential savings in 2024 broken down by measure are shown in Exhibit 40, sorted by decreasing potential. The savings breakdown by end use is shown in Exhibit 41. Space heating savings make up 64% of the economic potential, domestic hot water 26% and fireplace measures 9% of the savings.

Exhibit 40 – Residential Economic Potential (TRC) – Annual Gas Savings from All TRC-Passing Measures in 2024 (GJ)

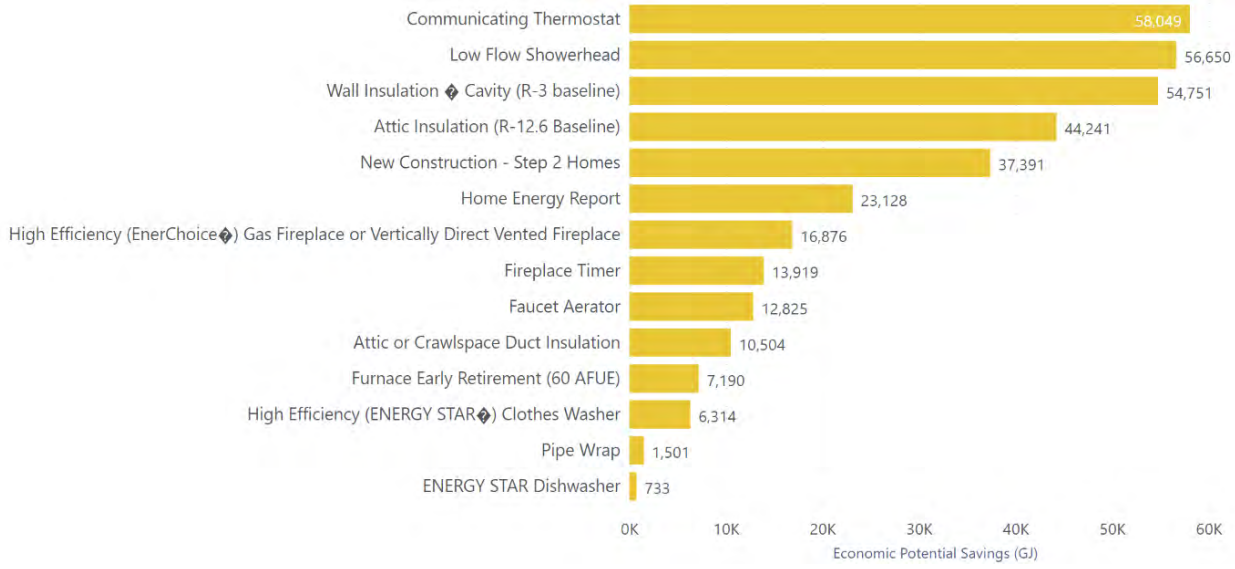
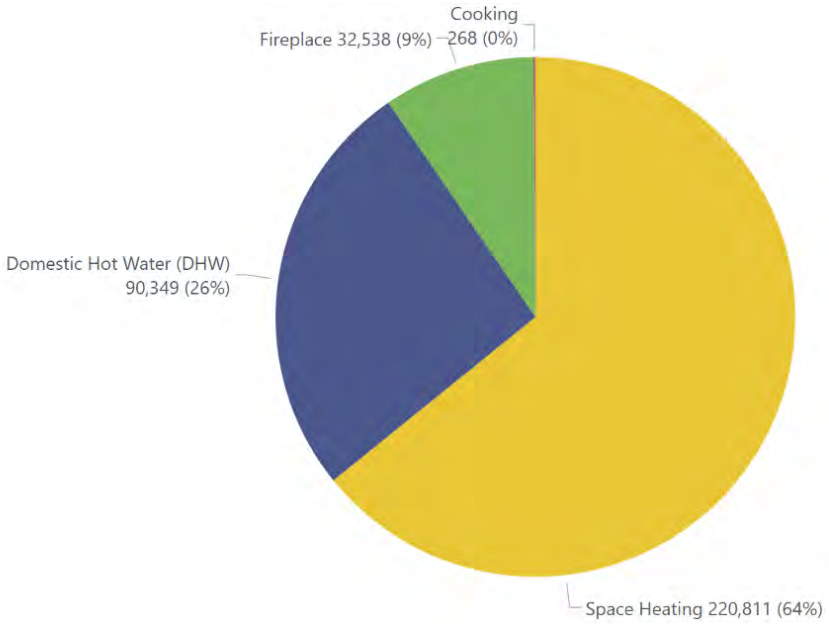


Exhibit 41 – Economic Potential in 2024 (GJ) By End Use – Residential, TRC



The MTRC economic potential savings by 2024 broken down by measure (showing only the top 25 measures) are presented in Exhibit 42. The savings breakdown by end use are presented in Exhibit 43. Space heating measures and their savings makes up the vast majority (78%) of the MTRC economic potential.

Exhibit 42 – Residential Economic Potential (MTRC) - Annual Gas Savings from Top 25 MTRC-Passing Measures in 2024 (GJ)

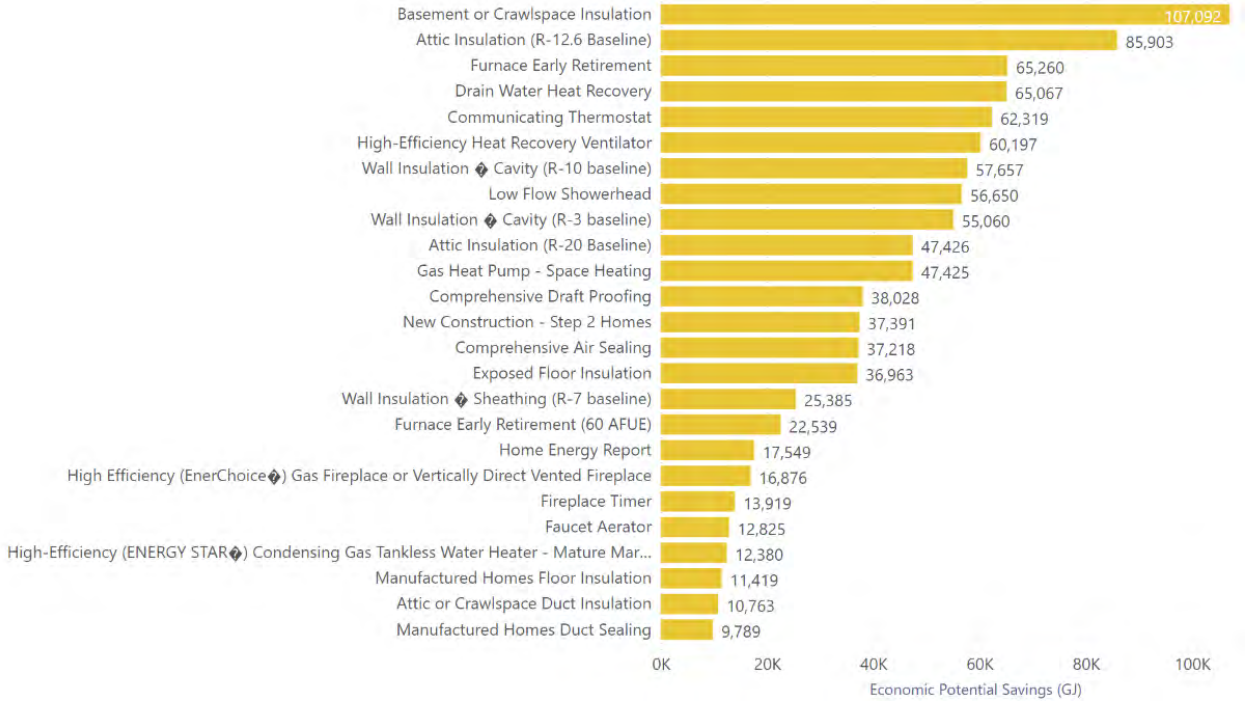
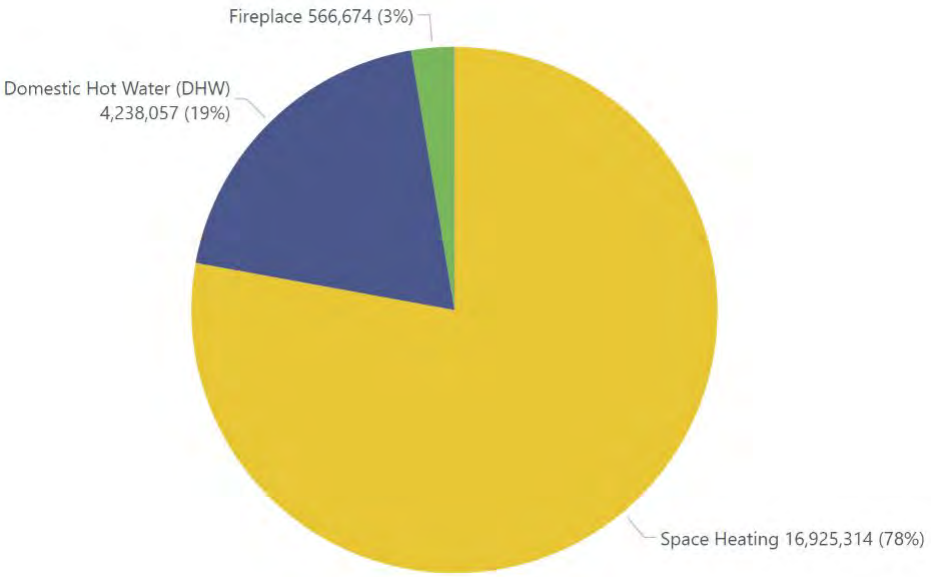


Exhibit 43 – Economic Potential (GJ) in 2024 By End Use – Residential, MTRC



4.7 Market Potential

This section provides an overview of the low, medium, and high market potential results for the residential sector.

Low, medium, and high scenarios assume that measure incentive levels will be 25%, 50% and 100% of incremental costs, respectively. For example, assume that a high-efficiency furnace may cost $200 more than a standard furnace, meaning the furnace would have an incremental cost of $200. In the medium scenario, this measure's hypothetical incentive from PNG would be $100. The other $100 would be paid by the end user. In all scenarios, the non-incentive program costs are assumed to be 15% of the medium market potential incentive cost. In the example above, PNG's non-incentive spending would be $15. PNG's total cost for providing the measure to an end user would be $115.

The market potential savings results, with a TRC screen and with an MTRC screen, are shown in Exhibit 44 and Exhibit 45, respectively. The medium market potential using the MTRC screen is over three times the market potential using TRC screen.

By 2041, the residential low, medium, and high market TRC potential savings are estimated to be 150 TJ, 166 TJ, and 198 TJ, respectively. By 2041, the low, medium, and high market MTRC potential savings are estimated to be 484 TJ, 530 TJ, and 647 TJ, respectively.

Exhibit 44 – Market Potential Savings (GJ) – Residential, TRC

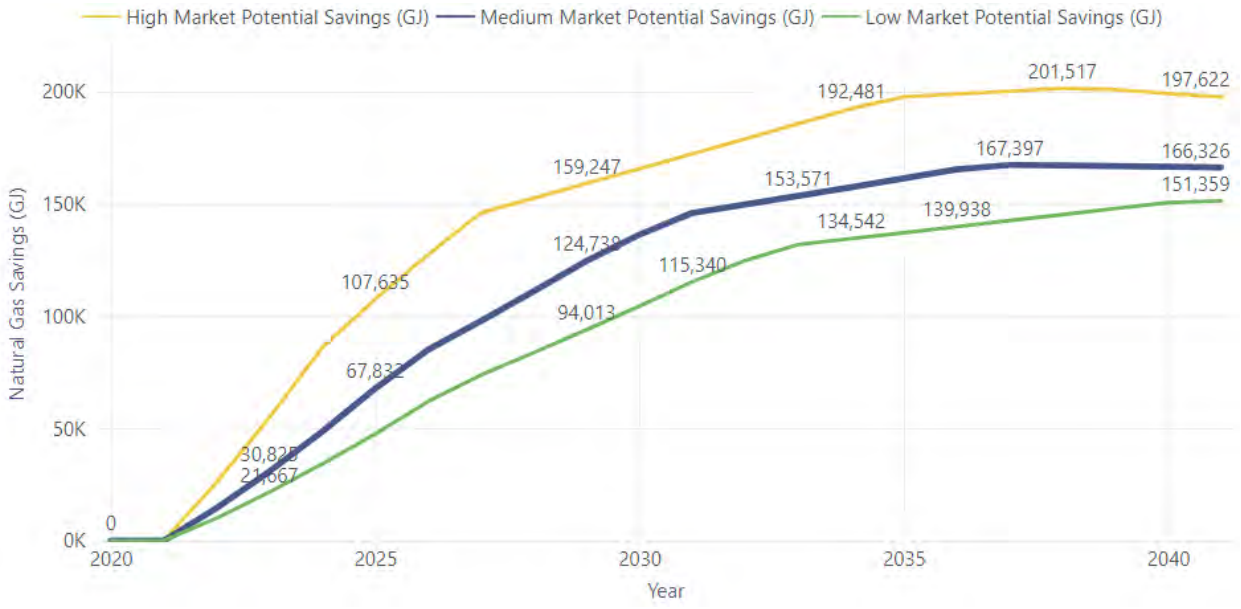
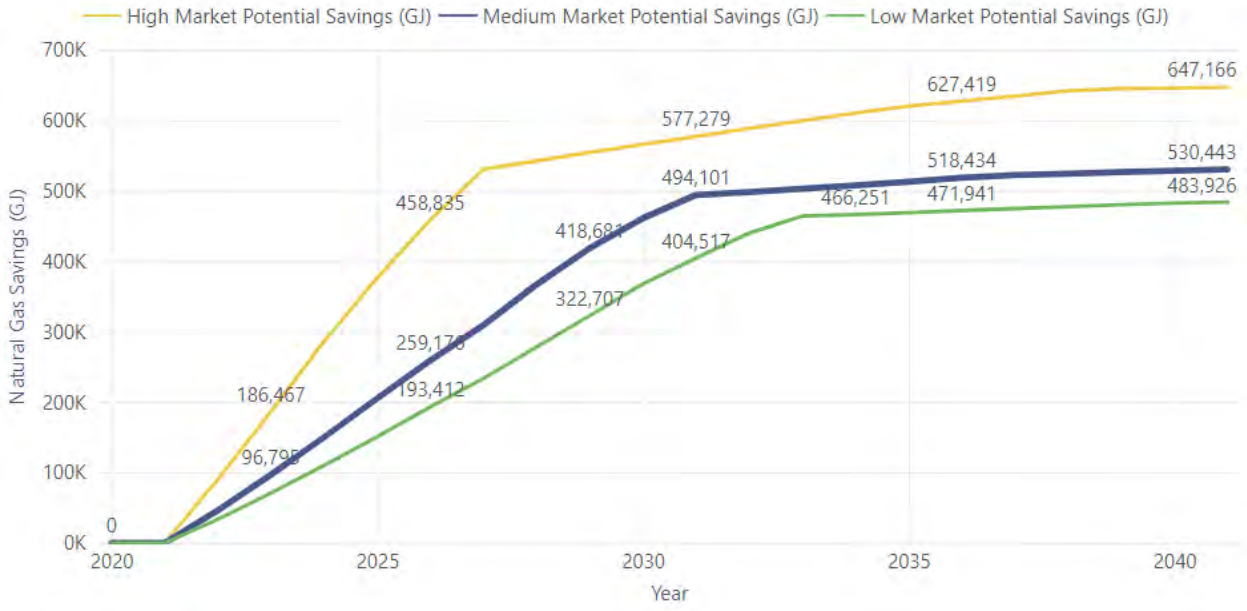


Exhibit 45 – Market Potential Savings (GJ) – Residential, MTRC



The forecasted residential gas consumption under the three market potential scenarios relative to reference case scenario is shown in Exhibit 46 (TRC) and Exhibit 47 (MTRC). The reference consumption is forecasted to drop to 2,690 TJ, from 2,880 TJ today. By 2041, the residential low, medium, and high market TRC potential consumption levels are estimated to be 2,540 TJ, 2,530 TJ, and 2,490 TJ, respectively. By 2041, the low, medium, and high market MTRC potential consumption levels are estimated to be 2,210 TJ, 2,160 TJ, and 2,040 TJ, respectively.

Exhibit 46 – Market Potential Consumption (GJ) Forecasts – Residential, TRC

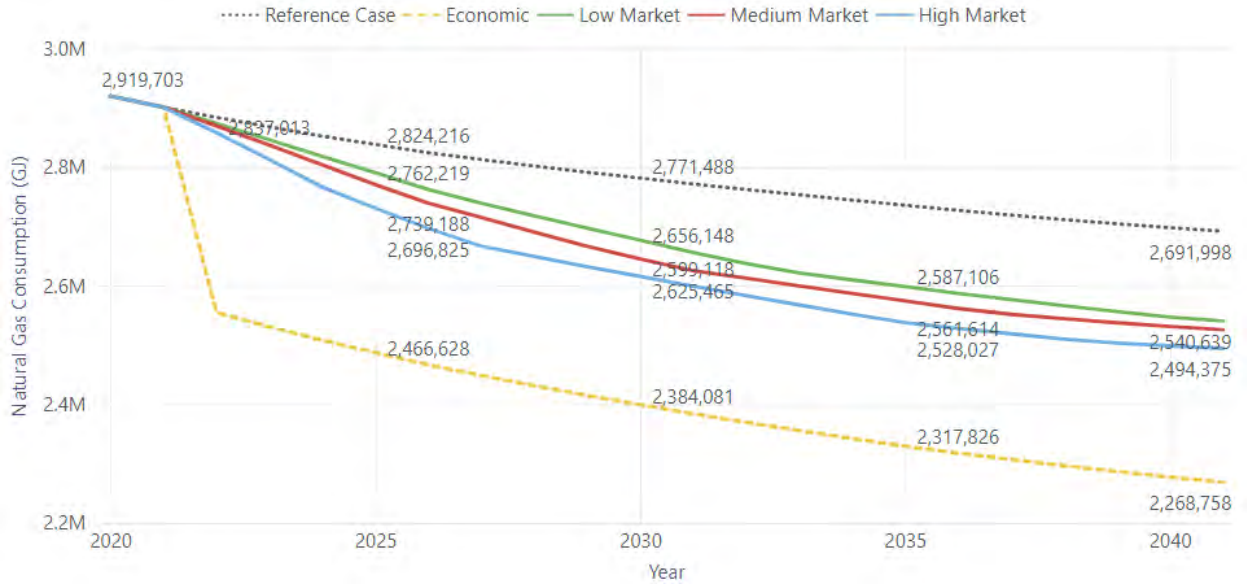
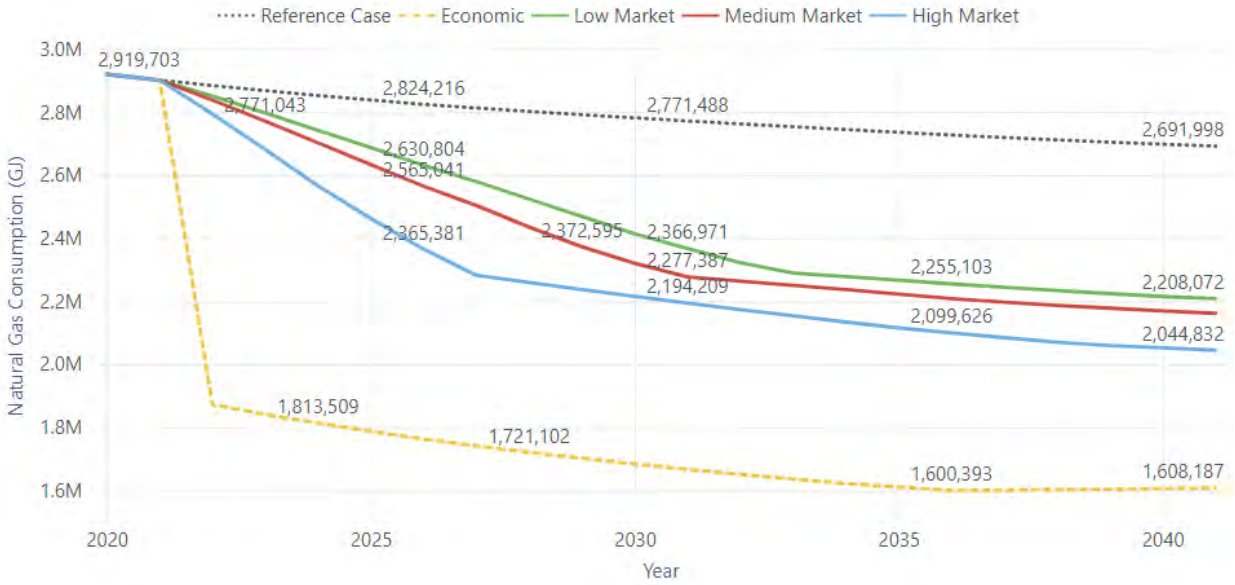


Exhibit 47 – Market Potential Consumption (GJ) Forecasts – Residential, MTRC



The remainder of this section presents detailed results of the medium market potential scenario only. Similarly detailed results of the low and high market potential scenarios can be found on the Power BI dashboard and the Excel workbooks.

Results by Region

The medium market potential savings for 2024 are presented by region in Exhibit 48 and Exhibit 49 using TRC and MTRC screen, respectively. Medium market potential savings in 2024 are estimated to be 2% of reference case consumption in all regions with TRC screen, and 5%-6% with MTRC. The largest portion of savings is expected to be in the Northeast region.

Exhibit 48 – Medium Market Potential Savings by Region in 2024 – Residential, TRC

Region	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Northeast	1,715,990	30,220	2%
West (West)	659,712	10,625	2%
West (East)	476,449	7,720	2%
Total	**2,852,151**	**48,566**	**2%**

Exhibit 49 – Medium Market Potential Savings by Region in 2024 – Residential, MTRC

Region	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Northeast	1,715,990	95,065	6%
West (West)	659,712	31,960	5%
West (East)	476,449	23,022	5%
Total	**2,852,151**	**150,048**	**5%**

Results by Segment and Vintage

The TRC and MTRC economic potential savings in 2024 are presented by segment and vintage in Exhibit 50 and Exhibit 51 respectively. Single-family dwellings present the most market potential under both economic screens.

Exhibit 50 – Medium Market Potential Savings by Segment and Vintage in 2024 – Residential, TRC

Segment	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
⊟ **SFD/Duplex**	**2,582,880**	**46,087**	**2%**
1950-1975	860,162	16,599	2%
1976-1985	613,971	11,906	2%
1986-1995	284,794	5,540	2%
1996-2005	230,526	4,449	2%
Pre-1950	169,212	3,092	2%
Post-2015	322,849	2,579	1%
2006-2015	101,365	1,922	2%
⊟ **Mobile/other**	**203,123**	**2,105**	**1%**
All	203,123	2,105	1%
⊟ **Attached/Row**	**66,149**	**374**	**1%**
1950-1975	24,687	227	1%
Post-2015	21,209	57	0%
1976-1985	7,355	36	0%
1986-1995	5,783	26	0%
1996-2005	4,932	23	0%
Pre-1950	1,570	4	0%
2006-2015	613	0	0%
Total	**2,852,151**	**48,566**	**2%**

Exhibit 51 – Medium Market Potential Savings by Segment and Vintage in 2024 – Residential, MTRC

Segment	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
SFD/Duplex	**2,582,880**	**140,180**	**5%**
1950-1975	860,162	50,985	6%
1976-1985	613,971	36,148	6%
1986-1995	284,794	16,535	6%
1996-2005	230,526	13,316	6%
Pre-1950	169,212	10,008	6%
Post-2015	322,849	7,602	2%
2006-2015	101,365	5,588	6%
Mobile/other	**203,123**	**7,895**	**4%**
All	203,123	7,895	4%
Attached/Row	**66,149**	**1,973**	**3%**
1950-1975	24,687	1,155	5%
Post-2015	21,209	251	1%
1976-1985	7,355	234	3%
1986-1995	5,783	178	3%
1996-2005	4,932	145	3%
Pre-1950	1,570	7	0%
2006-2015	613	3	0%
Total	**2,852,151**	**150,048**	**5%**

Results by End Use

The TRC and MTRC medium market potential savings in 2024 are presented by segment in Exhibit 52 and Exhibit 53 respectively. In the TRC potential, the largest amount of absolute savings in 2024 is expected to be from space heating end use. These savings are approximately 1% of the space heating end use reference case consumption in that year. When evaluating percentages, domestic hot water (DHW) and fireplace end uses have a larger potential (3% and 4% of end use consumption, respectively, in that year). In the MTRC potential, the largest amount of absolute and proportional savings in 2024 comes from space heating end use, where these savings amount to 6% of the end use reference case consumption. As in the TRC potential, fireplace and DHW end uses have a significant amount of absolute medium market savings potential in the MTRC potential.

Exhibit 52 – Medium Market Potential Savings by End Use in 2024 – Residential, TRC

Parent End Use	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Space Heating	2,079,880	27,163	1%
Domestic Hot Water (DHW)	447,883	13,849	3%
Fireplace	208,061	7,371	4%
Cooking	30,530	131	0%
Clothes Dryer	6,446	28	0%
Pool & Spa Heaters	5,641	24	0%
Other Gas Uses	73,710	0	0%
Total	**2,852,151**	**48,566**	**2%**

Exhibit 53 – Medium Market Potential Savings by End Use in 2024 – Residential, MTRC

Parent End Use	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Space Heating	2,079,880	118,618	6%
Domestic Hot Water (DHW)	447,883	23,834	5%
Fireplace	208,061	7,404	4%
Cooking	30,530	140	0%
Clothes Dryer	6,446	29	0%
Pool & Spa Heaters	5,641	24	0%
Other Gas Uses	73,710	0	0%
Total	**2,852,151**	**150,048**	**5%**

The TRC and MTRC medium market potential savings in 2041 are presented by end use in Exhibit 54. MTRC market potential is over three times the TRC market potential. The biggest difference between the two economic screen scenarios comes from measures that affect space heating.

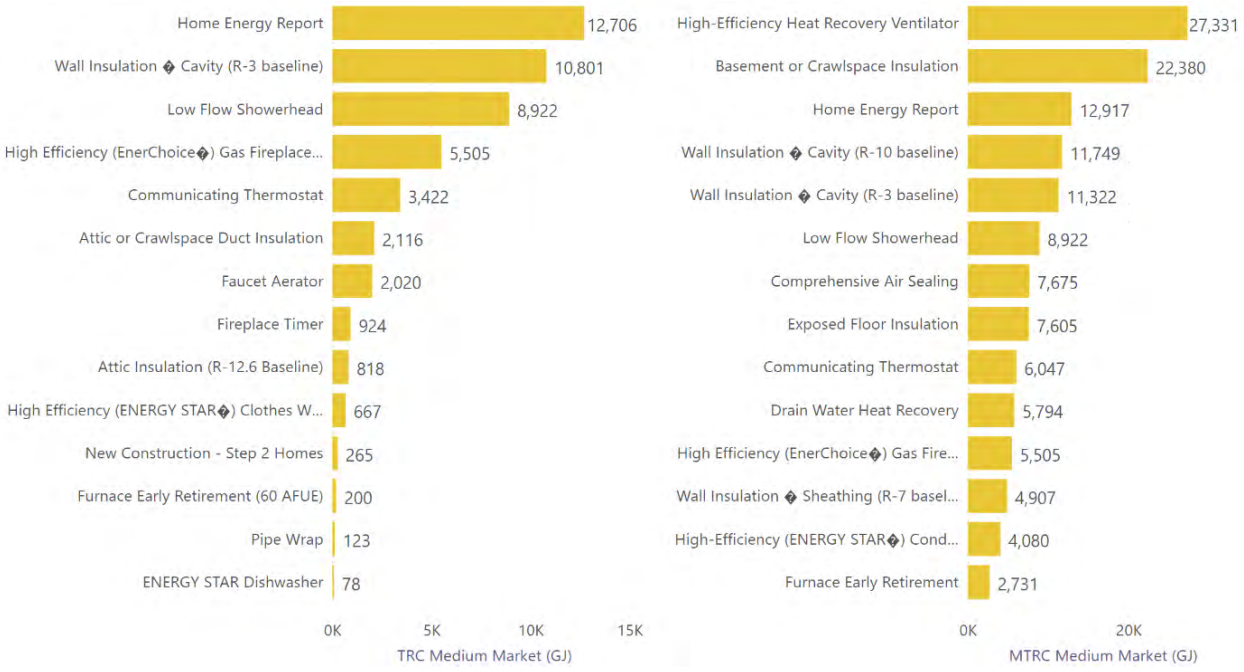
Exhibit 54 – Medium Market Potential Savings by End Use in 2041 – Residential, TRC and MTRC

Parent End Use	Medium Potential Savings (GJ) - TRC	Medium Potential Savings (GJ) - MTRC	Difference (GJ)
Space Heating	89,424	391,223	301,799
Domestic Hot Water (DHW)	56,723	118,972	62,249
Fireplace	19,922	19,974	52
Cooking	184	199	15
Clothes Dryer	39	41	2
Other Gas Uses	0	0	0
Pool & Spa Heaters	34	34	0
Total	**166,326**	**530,443**	**364,117**

Results by Measure

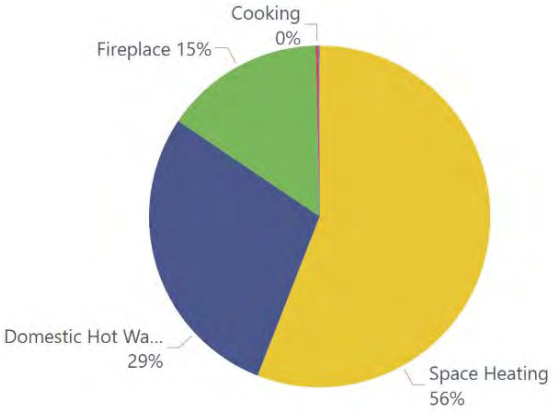
The medium market potential savings in 2024 of the top 14 residential measures are shown in Exhibit 55. The top measures in the TRC medium market potential are shown on the left and top measures in the MTRC scenario are shown on the right. Home energy reports and wall cavity insulation rank high in both scenarios. More space heating measures contribute to savings in the MTRC screen, as evident from the measures list and the end use breakdown difference in Exhibit 56. However, both screens save most of their energy in space heating.

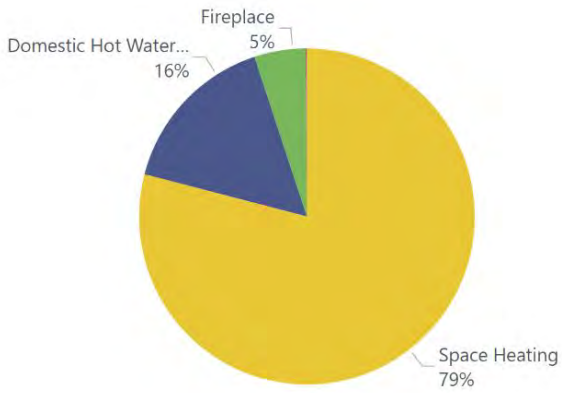
Exhibit 55 – Medium Market Potential (TRC on Left, MTRC on Right) - Top 14 Residential Measures in 2024 (GJ)[32]



32 The label of the thirteenth measure on the MTRC list on the right side of Exhibit 55 is cut-off in this picture and should read "High-Efficiency (ENERGY STAR) Condensing Gas Tankless Water Heater – Mature Market."

Exhibit 56 – Medium Market Potential (TRC on Left, MTRC on Right) – Savings by End Use in 2024 (%)





4.7.1 Incentive and Non-Incentive Spending

The incentive and non-incentive spending required to achieve the medium and high market potential are shown in Exhibit 57 (TRC) and Exhibit 59 (MTRC). Medium and high market incentives are assumed to be 50% and 100% of measures' incremental costs, respectively. In both medium and high scenarios, non-incentive costs are estimated to be 15% of medium market potential incentive costs. The tables also show the total as well as incremental (that is, savings from new measures installed in a year) savings every year.

Exhibit 57 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, TRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$294K	$44K	$338K	14,498	14,498	$23.32	$1,155K	$87K	$1,241K	25,917	25,917	$47.89
2023	$340K	$51K	$391K	30,825	16,327	$12.69	$1,310K	$98K	$1,409K	54,882	28,965	$25.67
2024	$375K	$56K	$431K	48,566	17,740	$8.87	$1,436K	$108K	$1,544K	86,015	31,133	$17.95
2025	$405K	$61K	$466K	67,832	19,267	$6.87	$1,230K	$92K	$1,322K	107,635	21,620	$12.28
2026	$389K	$58K	$448K	85,028	17,196	$5.27	$1,193K	$89K	$1,282K	127,391	19,756	$10.07
2027	$349K	$52K	$402K	97,873	12,845	$4.10	$1,198K	$90K	$1,288K	146,091	18,700	$8.82
2028	$367K	$55K	$422K	111,134	13,261	$3.80	$317K	$24K	$340K	152,610	6,519	$2.23
2029	$385K	$58K	$442K	124,738	13,604	$3.55	$328K	$25K	$353K	159,247	6,637	$2.21
2030	$353K	$53K	$406K	136,321	11,584	$2.98	$288K	$22K	$310K	165,703	6,456	$1.87
2031	$282K	$42K	$324K	146,024	9,702	$2.22	$298K	$22K	$320K	172,370	6,667	$1.86
2032	$85K	$13K	$98K	149,739	3,716	$0.65	$299K	$22K	$321K	179,045	6,675	$1.79
2033	$87K	$13K	$100K	153,571	3,831	$0.65	$303K	$23K	$325K	185,747	6,701	$1.75
2034	$89K	$13K	$103K	157,412	3,841	$0.65	$306K	$23K	$329K	192,481	6,734	$1.71
2035	$92K	$14K	$106K	161,385	3,973	$0.65	$289K	$22K	$311K	197,710	5,229	$1.57
2036	$95K	$14K	$109K	165,430	4,045	$0.66	$256K	$19K	$275K	199,018	1,308	$1.38
2037	$80K	$12K	$92K	167,397	1,967	$0.55	$248K	$19K	$267K	200,236	1,219	$1.33
2038	$71K	$11K	$81K	167,146	-251	$0.49	$251K	$19K	$270K	201,517	1,281	$1.34
2039	$69K	$10K	$80K	166,874	-272	$0.48	$175K	$13K	$189K	200,928	-589	$0.94
2040	$68K	$10K	$78K	166,579	-295	$0.47	$163K	$12K	$175K	199,187	-1,741	$0.88
2041	$68K	$10K	$78K	166,326	-253	$0.47	$168K	$13K	$181K	197,622	-1,565	$0.91
Total	**$4,342K**	**$651K**	**$4,993K**	**2,484,697**	**166,326**	**$2.01**	**$11,210K**	**$841K**	**$12,051K**	**3,151,354**	**197,622**	**$3.82**

Exhibit 58 - Medium and High Market Total Costs per Natural Gas Savings – Residential, TRC

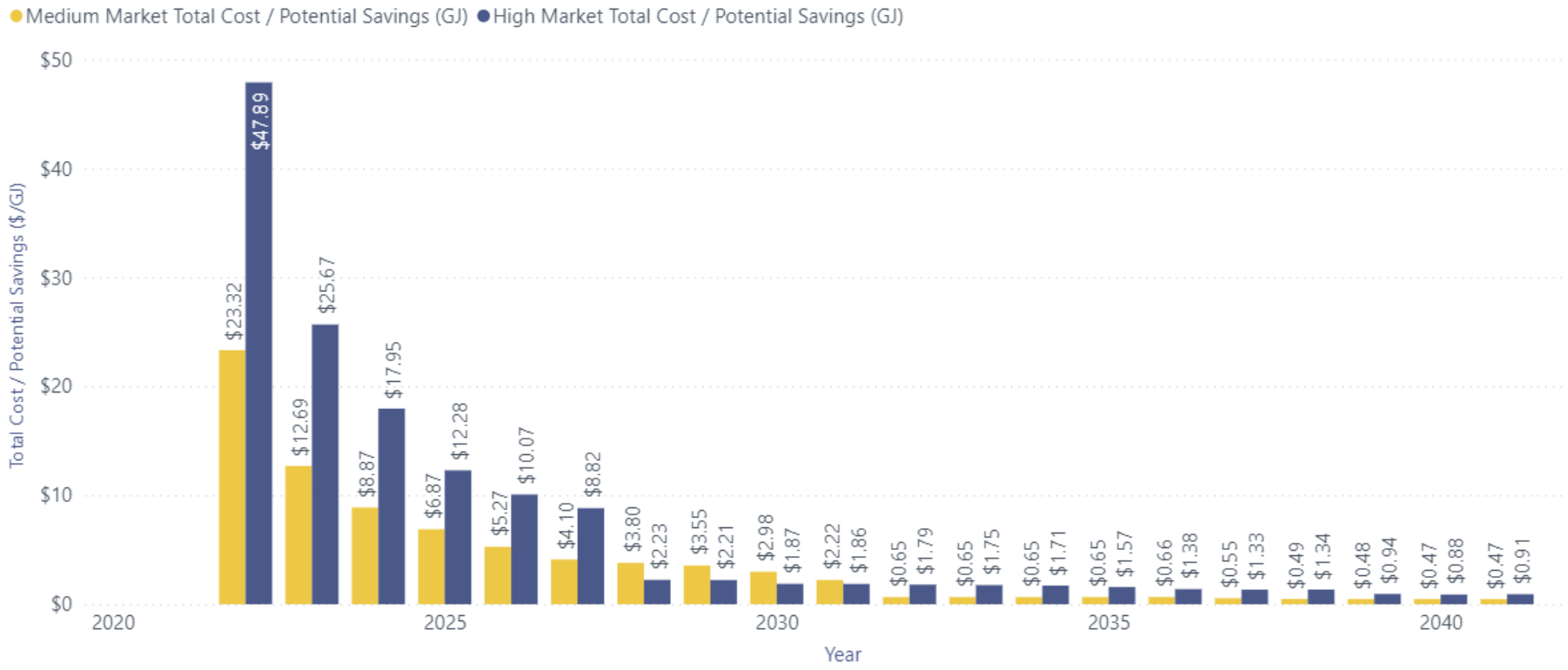
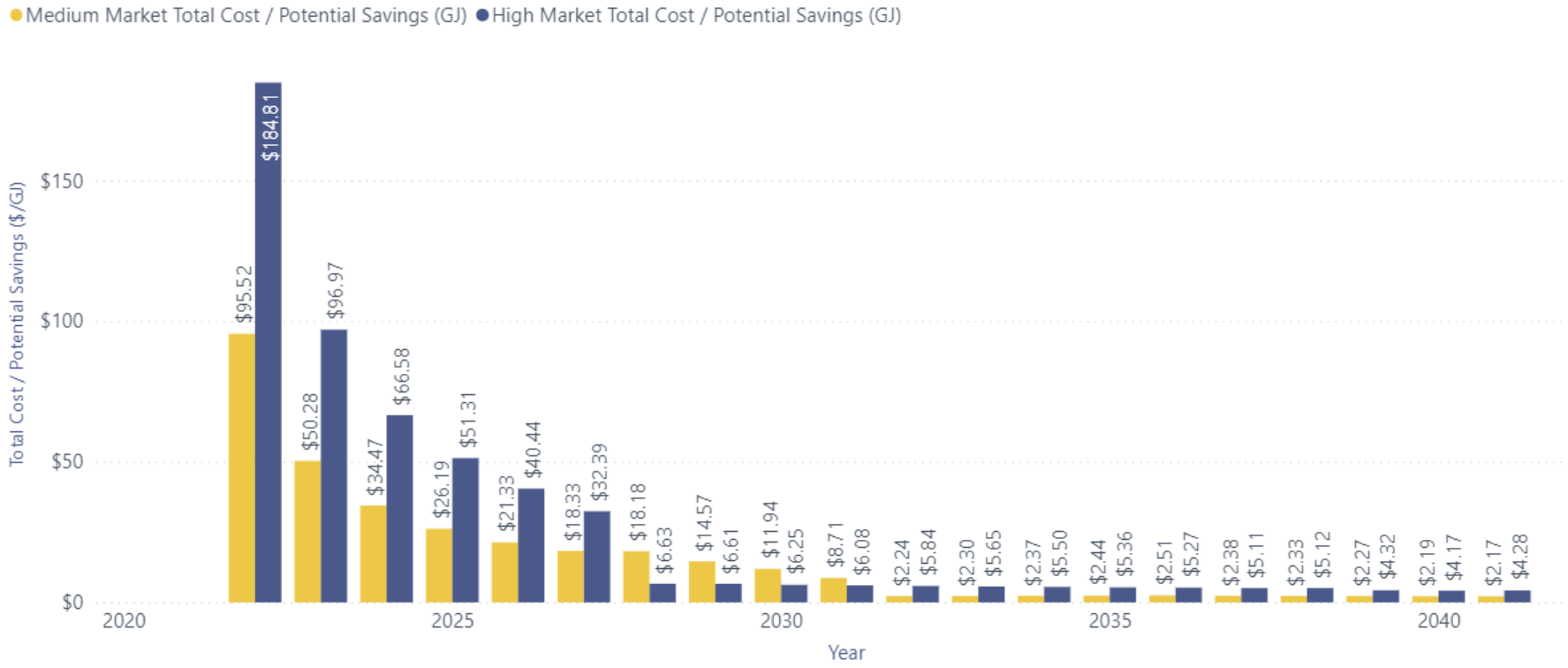


Exhibit 59 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, MTRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$3,837K	$576K	$4,413K	46,197	46,197	$95.52	$15,477K	$1,161K	$16,638K	90,029	90,029	$184.81
2023	$4,232K	$635K	$4,867K	96,795	50,598	$50.28	$16,820K	$1,262K	$18,082K	186,467	96,437	$96.97
2024	$4,498K	$675K	$5,173K	150,048	53,254	$34.47	$17,731K	$1,330K	$19,061K	286,300	99,833	$66.58
2025	$4,680K	$702K	$5,381K	205,440	55,392	$26.19	$17,963K	$1,347K	$19,310K	376,380	90,080	$51.31
2026	$4,806K	$721K	$5,527K	259,176	53,735	$21.33	$17,260K	$1,294K	$18,554K	458,835	82,455	$40.44
2027	$4,929K	$739K	$5,668K	309,189	50,013	$18.33	$15,987K	$1,199K	$17,186K	530,581	71,746	$32.39
2028	$5,802K	$870K	$6,673K	366,981	57,792	$18.18	$3,345K	$251K	$3,596K	542,354	11,773	$6.63
2029	$5,306K	$796K	$6,102K	418,681	51,700	$14.57	$3,408K	$256K	$3,664K	554,287	11,932	$6.61
2030	$4,788K	$718K	$5,506K	461,062	42,381	$11.94	$3,288K	$247K	$3,534K	565,728	11,441	$6.25
2031	$3,741K	$561K	$4,302K	494,101	33,039	$8.71	$3,263K	$245K	$3,508K	577,279	11,551	$6.08
2032	$970K	$145K	$1,115K	498,255	4,154	$2.24	$3,198K	$240K	$3,438K	588,532	11,253	$5.84
2033	$1,004K	$151K	$1,155K	502,799	4,544	$2.30	$3,151K	$236K	$3,388K	599,538	11,006	$5.65
2034	$1,045K	$157K	$1,202K	507,612	4,813	$2.37	$3,122K	$234K	$3,356K	610,367	10,828	$5.50
2035	$1,088K	$163K	$1,251K	512,888	5,276	$2.44	$3,092K	$232K	$3,324K	620,119	9,752	$5.36
2036	$1,130K	$169K	$1,299K	518,434	5,546	$2.51	$3,076K	$231K	$3,307K	627,419	7,300	$5.27
2037	$1,080K	$162K	$1,242K	522,201	3,767	$2.38	$3,018K	$226K	$3,244K	634,462	7,043	$5.11
2038	$1,061K	$159K	$1,221K	524,330	2,129	$2.33	$3,055K	$229K	$3,284K	641,801	7,339	$5.12
2039	$1,038K	$156K	$1,194K	526,444	2,114	$2.27	$2,593K	$194K	$2,787K	645,013	3,212	$4.32
2040	$1,008K	$151K	$1,160K	528,359	1,916	$2.19	$2,503K	$188K	$2,691K	645,736	722	$4.17
2041	$1,001K	$150K	$1,151K	530,443	2,083	$2.17	$2,574K	$193K	$2,767K	647,166	1,430	$4.28
Total	**$57,044K**	**$8,557K**	**$65,601K**	**7,979,434**	**530,443**	**$8.22**	**$143,924K**	**$10,794K**	**$154,718K**	**10,428,393**	**647,166**	**$14.84**

Exhibit 60 - Medium and High Market Total Costs per Natural Gas Savings – Residential, MTRC



5 Commercial Sector Results

This section presents the commercial sector results and key findings, including:

- Base year (2020) natural gas use
- Reference case consumption forecast (2021 – 2041)
- Measure assessment
- Technical potential
- Economic potential

5.1 Commercial Segments and End Uses

In this CPR, the commercial sector is divided into 17 segments, 5 energy end uses, and 2 vintages.

Exhibit 61 – Definition of Commercial Sector Segments, End Uses, and Vintages

Segments (17)	End Uses[33] (5)	Vintages (2)
Apartments – Medium	Food Service	Existing
Apartments – Large	Water Heating	New
Food Retail	Other[35]	
Hospital	Pools, Spas & Hot tubs	
Hotel – Medium	Space Heating	
Hotel – Large		
Non-Food Retail – Medium		
Non-Food Retail – Large		
Nursing Home		
Office – Medium		
Office – Large		
Other Commercial[34]		
Restaurant		
School – Medium		
School – Large		
University/College		
Warehouse		

33 All-electric end uses, such as clothes washer, lighting or plug loads, are not included in the reported results and are therefore excluded from the End Uses row of this table.
34 The "other" segment includes facilities that do not fit into any of the other segments.
35 The "other" end use is a catch all for equipment that account for a small portion of consumption in the sector. In the commercial sector, examples of "other" equipment are patio heaters and laundry dryers.

PNG's commercial and industrial rate classes were evaluated by number of accounts and total consumption to identify high consumption categories to be manually sorted into the appropriate commercial and industrial segments. Exhibit 62 summarizes which rate classes were reviewed and sorted. Only two rate classes were not reviewed and sorted: Small Commercial <5,500 GJ and Small Commercial – First Nations. As shown in Exhibit 63, 316 accounts, representing 64% of total consumption, were reviewed and sorted.

Exhibit 62 - PNG Rate Classes Reviewed vs Not Reviewed

	Reviewed	Not Reviewed
PNG Rate Class Description	Large Commercial Firm Sales Small Industrial Firm Sales Large Commercial IT Sales Seasonal Sales Small Commercial <5,500 GJ Transport Large Commercial Transport Commercial Transport	Small Commercial <5,500 GJ Small Commercial – First Nations

Exhibit 63 - Accounts and Consumption of Reviewed and Not Reviewed Rate Classes

	Accounts	Consumption (GJ)	% Of Total Consumption
Reviewed	316	3,811,352	64%
Not reviewed	5,286	2,133,245	36%
Total	**5,602**	**5,944,597**	**100%**

The name of each account within the reviewed rate classes was evaluated and an internet search was used, where required, to sort the accounts into the appropriate segments.

For the remaining small commercial rate classes, which were not reviewed, the following steps were used to define the number of accounts and consumption by sector and segment:

1. The percent splits between the commercial and industrial sectors by number of accounts and amount of consumption for Northern BC in the 2020 FortisBC CPR were used to define the percent split between the commercial and industrial sectors.
2. The commercial sector breakdown for Northern BC in the 2020 FortisBC CPR was used to define the account and consumption share by commercial segment.
3. All values were rounded to whole numbers and adjusted where necessary to ensure the numbers still added up to the correct total.

It was estimated the commercial sector represented 91% of the accounts and 47% of the total consumption. The assumed account and consumption breakdowns of the rate classes that were not reviewed for the commercial sector are shown in Exhibit 64.

Exhibit 64 - Small Commercial Segment Breakdown

Segment	Account Breakdown	Consumption Breakdown
Apartment	7.3%	7.2%
Food Retail	2.2%	1.4%
Hospital	1.6%	1.4%
Hotel	3.0%	4.8%
Non-food Retail	12.4%	10.7%
Nursing Home	0.3%	0.6%
Office	19.9%	19.0%
Other	38.6%	33.6%
Restaurant	5.7%	8.2%
School	2.6%	5.9%
University/College	0.2%	0.1%
Warehouse	6.1%	7.1%

5.2 Base Year Natural Gas Use

This section profiles the base year (2020) natural gas consumption for the commercial sector.

The following exhibits summarize how natural gas is used in the commercial sector by segment[36], end use, and region, respectively.

Natural gas consumption in the commercial sector base year is highest:

- In the other (28%), office (18%) and school (9%) segments, as shown in Exhibit 65
- In the space heating (74%) and water heating (15%) end uses, as shown in Exhibit 66
- In the Northeast (59%) region, as shown in Exhibit 67

36 Several commercial segments are further segmented by size (large or medium/small) including apartment, hotel, non-food retail, office, and school. The "other" segment includes facilities that do not fit into any of the other segments.

Exhibit 65 – 2020 Commercial Natural Gas Consumption (GJ) by Segment

Segment	Consumption (GJ)	%
Apartment	145,281	5%
Food Retail	115,928	4%
Hospital	177,383	6%
Hotel	156,414	6%
Non-food Retail	236,529	8%
Nursing Home	83,653	3%
Office	493,540	18%
Other	801,209	28%
Restaurant	162,189	6%
School	246,419	9%
University/College	38,459	1%
Warehouse	157,412	6%
Grand Total	**2,814,415**	**100%**

Exhibit 66 – 2020 Commercial Natural Gas Consumption (GJ) by End Use

Parent End Use	Consumption (GJ)	%
Food Service	185,013	7%
Other	107,969	4%
Pools, Spas & Hot Tubs	17,854	1%
Space Heating	2,090,002	74%
Water Heating	413,578	15%
Grand Total	**2,814,415**	**100%**

Exhibit 67 – 2020 Commercial Natural Gas Consumption (GJ) by Region

Region	Consumption (GJ)	%
Northeast	1,653,089	59%
West (East)	457,573	16%
West (West)	703,753	25%
Grand Total	**2,814,415**	**100%**

5.2.1 Accounts

Base year commercial natural gas accounts are presented by segment in Exhibit 68 and by region in Exhibit 69. As shown in these exhibits, in 2020 the greatest number of commercial natural gas accounts were in:

- The other (37%), office (20%), and non-food retail (12%) segments
- The Northeast region (51% of accounts)

Exhibit 68 – 2020 Commercial Natural Gas Accounts by Segment

Segment	Accounts	%
Apartment	359	7%
Food Retail	122	2%
Hospital	91	2%
Hotel	163	3%
Non-food Retail	614	12%
Nursing Home	25	0%
Office	1,017	20%
Other	1,908	37%
Restaurant	278	5%
School	203	4%
University/College	12	0%
Warehouse	306	6%
Grand Total	**5,098**	**100%**

Exhibit 69 – 2020 Commercial Natural Gas Accounts by Region

Regions	Accounts	%
Northeast	2,607	51%
West (East)	1,225	24%
West (West)	1,266	25%
Grand Total	**5,098**	**100%**

5.2.2 Unit Energy Consumption

This section presents a sample calculation of UEC for one segment (large offices), region (Northeast), and end use (space heating) as an example.

Unit energy consumption (UEC) is the amount of energy used by each end use per unit (a "unit" in the commercial sector is square meter of floor area). Fuel share is the percentage of the energy end use that is supplied by each fuel.

Also presented in this section are *unit tertiary load*, which is the average tertiary load, by end use, per square meter, and *stock average efficiency*, which is the average efficiency of equipment serving the tertiary load for that end use. The UEC by end use is calculated by dividing unit tertiary load by stock average efficiency.

Tertiary load is the useful energy delivered to an end use. In the context of the CPR, tertiary load is the amount of energy required to be delivered as an end use *service*: heat delivered by a boiler to a square meter of office space, for example. This differs from consumption of natural gas which is impacted by the efficiency of the equipment: in the boiler example, consumption is equal to the tertiary load divided by the seasonal efficiency of the boiler.

Exhibit 70 presents unit tertiary load, stock average efficiency and UEC values for space heating in large offices in the Northeast region.

Exhibit 70 – 2020 Space Heating UEC values by End Use, Large Offices in the Northeast

End Use	Unit Tertiary Load (GJ/m^2/yr.)	Stock Average Efficiency (%)	UEC (GJ/m^2/yr.)
Space Heating	0.5	78%	0.7

5.2.3 Average Natural Gas Use per Building

The following exhibit presents average annual natural gas consumption per m^2 for space heating. Included in the exhibit is:

- UEC: the amount of energy used by each end use per unit. The "unit" in commercial sector is square meter of floor area.
- Fuel Share: the percentage of the energy end use that is supplied by each fuel Saturation: reflects the extent to which an end use is present in a region, and segment.

Average annual gas consumption per unit is calculated by multiplying these three variables together; therefore, they are included in the table below. Values are presented for one segment, region and end use as an example. Exhibit 71 presents average annual gas use for space heating per office in the Northeast region.

Exhibit 71 – 2020 Average Annual Space Heating Gas Use Per m^2, Large Offices, Northeast

End Use	UEC	Fuel Share	Saturation	Average Annual Gas Use (GJ/m^2/yr.)
Space Heating	0.7	70%	100%	0.48

5.3 Reference Case Natural Gas Use

This section profiles the reference case base year (2020) and forecast (2021-2041) natural gas consumption for the commercial sector.

Overall gas consumption in the commercial sector is forecasted to increase over time: consumption in 2041 is expected to be approximately 6% higher than consumption in 2020, with an average annual increase of about 0.3% from 2020 to 2041. Consumption patterns from the 2020 base year are expected to persist throughout the reference case. Natural gas is expected to continue to be used largely in other and office segments (Exhibit 72), for space heating (Exhibit 73) and in the Northeast region (Exhibit 74).

Exhibit 72 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by Segment

Segment	2020	2041	Change %
Apartment	145,281	153,047	5%
Food Retail	115,928	113,760	-2%
Hospital	177,383	175,241	-1%
Hotel	156,414	166,183	6%
Non-food Retail	236,529	263,045	11%
Nursing Home	83,653	81,015	-3%
Office	493,540	533,787	8%
Other	801,209	831,514	4%
Restaurant	162,189	186,707	15%
School	246,419	261,561	6%
University/College	38,459	37,566	-2%
Warehouse	157,412	174,182	11%
Grand Total	**2,814,415**	**2,977,610**	**6%**

Space heating and water heating end uses are expected to grow more slowly than other end uses, as shown in Exhibit 73. This also implies a slight decline in their ratio to overall building consumption by 2041. This decline is largely driven by:

- Improved new construction practices and more stringent equipment performance standards.
- Natural replacement of space heating and water heating equipment at the end of life. It is assumed that 50% of those replacing such equipment would adopt space heating equipment that was 85% efficient and water heating equipment that was 80% efficient. As a result, the average consumption per square meter for these two end uses was assumed to be declining slightly with time.

Exhibit 73 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by End Use

Parent End Use	2020	2041	Change %
Food Service	185,013	213,990	16%
Other	107,969	121,974	13%
Pools, Spas & Hot Tubs	17,854	20,574	15%
Space Heating	2,090,002	2,174,188	4%
Water Heating	413,578	446,883	8%
Grand Total	**2,814,415**	**2,977,610**	**6%**

Exhibit 74 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by Region

Region	2020	2041	Change %
Northeast	1,653,089	1,829,948	11%
West (East)	457,573	453,128	-1%
West (West)	703,753	694,533	-1%
Grand Total	**2,814,415**	**2,977,610**	**6%**

There is a forecasted increase in the number of commercial accounts, as shown in Exhibit 75. The growth in accounts is somewhat counterbalanced by a decrease in usage per square meter. However, the decrease in usage per square meter is less per year on average than the increase in floor area due to account growth. The net result is consumption is forecasted to increase by about 0.3% per year.

Exhibit 75 – 2020 vs 2041 Commercial Gas Accounts Forecast by Segment

Segment	2020	2041	Change %
Apartment	359	432	20%
Food Retail	122	142	16%
Hospital	91	108	19%
Hotel	163	193	18%
Non-food Retail	614	737	20%
Nursing Home	25	27	8%
Office	1,017	1,216	20%
Other	1,908	2,292	20%
Restaurant	278	332	19%
School	203	237	17%
University/College	12	14	17%
Warehouse	306	368	20%
Grand Total	**5,098**	**6,098**	**20%**

5.3.1 Commercial Reference Case Natural Gas Use: Existing versus New Buildings

This section compares the consumption in existing versus new commercial facilities in the reference case forecast. Estimated new construction rates are drawn from rate-class level estimates developed by PNG and are applied by segment. Demolition rates are estimated at approximately 2% of floor area per year and held constant across segments. It is assumed that existing commercial buildings that are demolition are replaced by newly constructed buildings. This results in a forecasted commercial gas account increase of 18% by 2041, as shown in Exhibit 76.

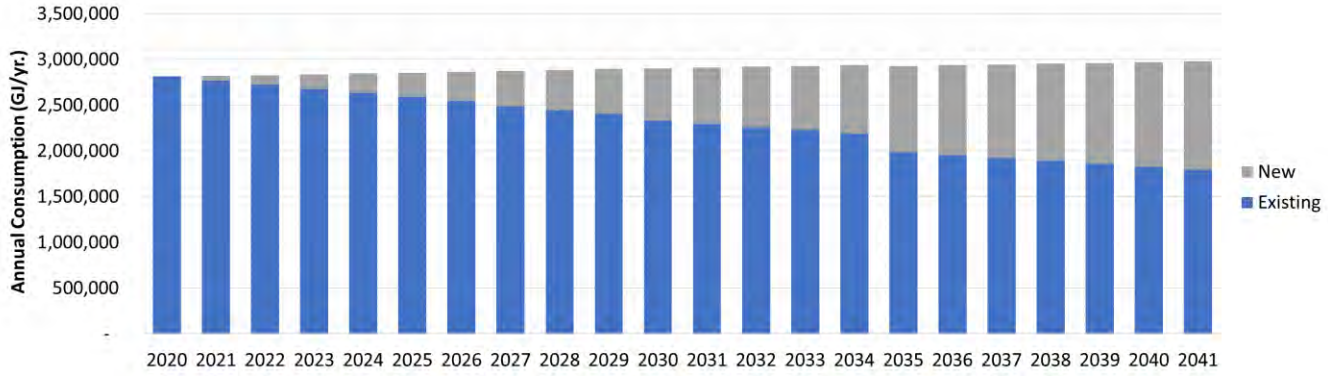
In 2021, natural gas consumption from new buildings was approximately 53 thousand GJ, or 2% of the total commercial sector consumption. By 2041, new buildings are forecasted to use 1.1 million GJ (39% of total sector), as shown in Exhibit 77.

Exhibit 76 – 2021 vs 2041 Commercial Gas Accounts Forecast by Existing and New Vintage

Existing/New	2021[37]	2041	Change %
Existing	5,002	3,348	-33%
New	144	2,750	1810%
Grand Total	**5,146**	**6,098**	**18%**

37 The year 2021 is used in this exhibit instead of the base year, 2020, because new building forecasting begins in 2021.

Exhibit 77 – 2020 vs 2041 Commercial Gas Consumption Forecast (GJ) by Existing and New Vintage



5.4 Measure Assessment

5.4.1 List of Measures

The list of commercial measures that were included in this CPR are presented in Exhibit 78. The measures are divided into categories by end use and measure type.

Please see the MS Excel file titled “Com Measure Analysis Workbook” for a description of each measure and a full analysis.

Measures were classified in five measure type categories:

- Equipment
- Controls
- Building Envelope
- Energy Management (including behavioural measures)
- New Construction – all new construction measures were placed in a separate category

New construction measures are analyzed using a whole-building approach, represented by the Step 2 - Step 4 BC Energy Step Code measures. One additional measure was considered and analyzed separately, hybrid heat pumps.[38] Only technical and economic potential savings estimates are presented, as there is insufficient information available to estimate the market potential at this time. Please see the MS Excel file titled “Com Measure Analysis Workbook” for a description and full analysis of this measure.

38 Hybrid heat pumps - electric heat pumps with gas back up for low temperature conditions.

Exhibit 78 – Commercial Sector Conservation and Energy Management Measures

Appliances – Equipment

Demand Control Kitchen Ventilation
Efficient Pre-Rinse Spray Valve
Efficient Commercial Cooking Equipment
ENERGY STAR Dishwasher
ENERGY STAR Clothes washer

New Construction

Step 2 Level-of-Performance
Step 3 Level-of-Performance
Step 4 Level-of-Performance

Water Heating - Equipment

Condensing DHW – On-Demand
Condensing DHW – Storage
Condensing DHW Supply Boilers
DHW Tank Insulation
Drain Water Heat Recovery
Faucet Aerators
Low-Flow Showerhead
Pipe Insulation
Solar DHW Preheat
Thermostatic Shower Restriction Valve

Space Heating – Envelope

High-Performance Air Sealing
High-Performance Window Upgrade
Low-e Window Film
Panelized Retrofit
Roof Insulation
Wall Insulation

Space Heating – Equipment

Advanced BAS
Advanced Thermostats
Air Curtains
Condensing Boiler – Early/ROB
Condensing MUAs – Early/ROB
Condensing Unit Heaters
Destratification Fans
Dock Door Seals
Electric Air-to-Water Heat Pump with Existing Gas Furnace or Boiler Backup (Dual-Fuel Measure)
Electric Air-to-Water Heat Pump with New Gas Furnace or Boiler Backup (Dual-Fuel Measure)
Energy Recovery Ventilators
Gas Boiler/Furnace Tune-Up
Hydronic Additives
Heat Recovery – Waste Heat Chiller
Heat Recovery Ventilator
Infrared Heaters
Residential-Style Condensing Furnace – Early/ROB
Reverse Flow Heat Recovery Ventilator
Strip Curtains

Controls

Advanced Remote Terminal Unit (RTU) Controls
Boiler Combustion Controls
DHW Recirculation Controls
Hotel Occupancy Controls
Return Water Temperature Optimization

Energy Management and Other

Comprehensive Recommissioning
Heat Recovery – Health Care Sterilizers
Multi-Unit Gas Submetering
Occupant Behaviour
Refrigeration Waste Heat Recovery
Rink De-Aerator
Steam to Hot Water Conversion

5.4.2 Results

The measure-level results for the commercial sector are shown in Exhibit 79 in order of decreasing cost effectiveness.

Measures were assessed based on their replacement type: **retrofit** (immediate replacement at full cost), **replace on burnout** (end of life replacement at incremental cost), or **new construction** (immediate installation at incremental cost). The TRC and MTRC results are presented at the measure-level and exclude program costs and free-ridership.

Key findings of the measure assessment for the commercial sector include:

- Of the 62 measures included in the assessment, 46 pass the TRC screen and 56 pass the MTRC screen.
- All New Construction Steps pass the TRC screen.
- Gas heat pumps for space heating and domestic hot water pass the TRC.
- Aerosol-applied air sealing passes TRC screen, with significant potential for energy savings in existing buildings (especially MURBs).
- The hybrid heat pump was found to have a TRC of 0.3 and an MTRC of 1.1.

Exhibit 79 – Commercial Sector Measures with Average TRC and MTRC Results

#	Measure	Measure Type	Replacement Type	TRC	MTRC
1	ESTAR Dishwasher	Equipment	ROB	100.0	100.0
2	Faucet Aerators	Equipment	RET	42.2	51.2
3	DHW Tank Insulation	Equipment	RET	5.7	24.1
4	DC Kitchen Vent	Energy Management	RET	5.5	21.0
5	Efficient Cook Equip	Equipment	ROB	5.3	21.7
6	Steam Trap	Equipment	RET	4.9	24.5
7	Occupant Behaviour	Energy Management	RET	4.5	24.4
8	Advanced Thermostat	Energy Management	RET	4.4	10.7
9	Rev Flow ERV	Equipment	ROB	3.9	15.2
10	Window Film	Building Shell	RET	3.5	4.9
11	Refrigeration heat recovery	Equipment	RET	3.4	13.0
12	Boiler/Furnace Tune-Up	Equipment	RET	3.1	17.2
13	Eff Pre-Rinse Spray	Equipment	RET	3.1	16.5
14	Dock Door Seal	Equipment	RET	2.9	11.9
15	Air Sealing	Building Shell	ROB	2.9	9.6
16	Low Flow Showerhead	Equipment	RET	2.9	12.6
17	NC Step 2 - Non-Step	New Construction	NEW	2.8	5.1
18	NC Step 2 - Res	New Construction	NEW	2.7	5.5

#	Measure	Measure Type	Replacement Type	TRC	MTRC
19	Lower Boiler Ret Temp	Equipment	RET	2.4	8.7
20	NC Step 2 - Com	New Construction	NEW	2.4	4.4
21	Cond Storage DHW	Equipment	ROB	2.4	9.1
22	Air Curtain	Building Shell	RET	2.2	8.6
23	Pipe Insulation	Equipment	RET	2.1	8.0
24	HRV	Equipment	ROB	2.0	7.9
25	ERV	Equipment	ROB	2.0	7.7
26	NC Step 3 - Non-Step	New Construction	NEW	1.9	4.0
27	NC Step 3 - Res	New Construction	NEW	1.9	4.2
28	Cond On-Demand DHW	Equipment	ROB	1.9	6.7
29	Cond Boiler (Early)	Equipment	RET	1.9	9.2
30	NC Step 3 - Com	New Construction	NEW	1.7	3.4
31	Cond Unit Heater	Equipment	RET	1.6	5.9
32	Heat Transfer Tech	Equipment	RET	1.6	8.6
33	IR Heaters	Equipment	RET	1.6	5.5
34	Recirc Demand Control	Controls	RET	1.6	5.7
35	Condensing MUA (ROB)	Equipment	ROB	1.6	6.0
36	Strip Curtains	Equipment	RET	1.5	8.2
37	GHP - SH	Equipment	ROB	1.4	5.2
38	Passive DWHR	Equipment	RET	1.4	4.6
39	Comprehensive RCx	Energy Management	RET	1.3	4.1
40	RTU Controls	Equipment	RET	1.3	2.2
41	Boiler Controls	Equipment	RET	1.3	5.1
42	Cond Supply Boiler	Equipment	ROB	1.2	4.3
43	GHP - DHW	Equipment	ROB	1.1	3.9
44	NC Step 4 - Non-Step	New Construction	NEW	1.0	2.1
45	Steam to HW	Energy Management	RET	1.0	3.4
46	NC Step 4 - Res	New Construction	NEW	1.0	2.2
47	HR Chiller	Equipment	ROB	0.9	3.3
48	Panel Retrofit	Building Shell	RET	0.9	3.1
49	Window Upgrade	Building Shell	ROB	0.9	2.9
50	Roof Insulation	Building Shell	ROB	0.8	2.7
51	Advanced BAS	Equipment	RET	0.8	2.9
52	ESTAR Clothes Washer	Equipment	ROB	0.7	2.8

#	Measure	Measure Type	Replacement Type	TRC	MTRC
53	Destratification	Equipment	RET	0.6	2.4
54	Condens MUA (Early)	Equipment	RET	0.4	1.9
55	Submetering	Equipment	RET	0.4	1.7
56	Sterilizer HR	Equipment	RET	0.3	1.3
57	Res Furnace (Early)	Equipment	RET	0.3	1.7
58	Res. Electric Heat Pump with Gas Backup (Hybrid Heat Pump)[39]	Equipment	RET	0.3	1.1
59	Wall Insul	Building Shell	ROB	0.3	1.0
60	Tstat Shower Valve	Equipment	RET	0.2	1.0
61	Solar DHW Preheat	Energy Management	RET	0.2	0.7
62	Hotel Controls	Equipment	RET	0.0	0.0

5.4.3 Measure Cost Sensitivity Analysis

Measure costs were originally developed for southern BC, which may have lower measure costs than in the PNG territory. As such, a sensitivity analysis of the measure costs was conducted, using a 30% price adder to reflect the potentially higher costs in the PNG service territory and determine to what extent achieving cost effective DSM may be more challenging in remote and smaller markets. The results of this sensitivity analysis are not reflected in the potential scenarios presented in this report.

The following measures previously passed the TRC test in at least one region or segment but do not pass it in any region or segment with a 30% cost adder:

- Comprehensive Recommissioning
- Gas heat pump – space heating
- Low flow showerhead
- Steam to HW
- Thermostatic shower valve

The following measures previously passed the TRC test but do not pass it in at least one ore more regions or segments with a 30% cost adder:

- Condensing MUA (ROB)
- Heat transfer technology
- NC Step 4 - Non-Step
- Panel retrofit
- RTU Controls
- Window film

The following measures previously passed the MTRC test but do not pass it in at least one ore more regions or segments with a 30% cost adder:

- Condensing MUA (Early)
- Window film
- Panel Retrofit

39 Hybrid heat pumps were considered and analyzed separately so the results were not incorporated into the technical, economic, and market potential scenarios.

5.5 Technical Potential

This section provides an overview of the technical potential savings results for the commercial sector This section provides an overview of the technical potential savings results for the industrial sector. The technical potential forecast includes the installation of all conservation measures that are technically feasible. Technical potential estimates ignore all non-engineering and financial constraints, such as cost-effectiveness and the willingness of end users to adopt measures. This scenario is included to estimate the theoretical maximum amount of energy use that could be captured by all energy efficiency measures.

Overall results are presented below, followed by measure level results and supply curves for the TRC and MTRC results.

As shown in Exhibit 80, the majority of the commercial technical potential (1740 TJ) would be available in 2022 and would increase to 1770 TJ in 2034. This indicates that approximately 30 TJ of the savings would come from replace on burnout measures over the next two decades. The technical potential savings of hybrid heat pumps are estimated to be 17 TJ in 2024.

The forecasted natural gas consumption is included for reference.

Exhibit 80 – Commercial Technical Potential Savings (GJ)

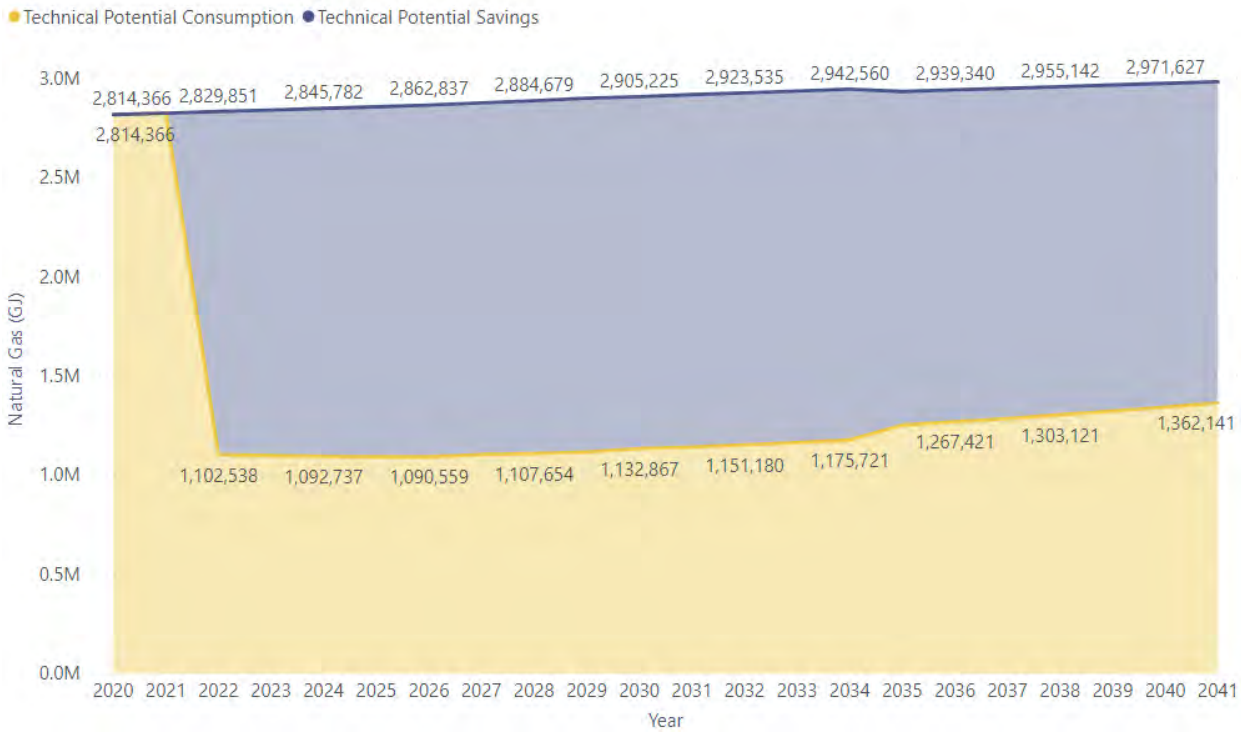
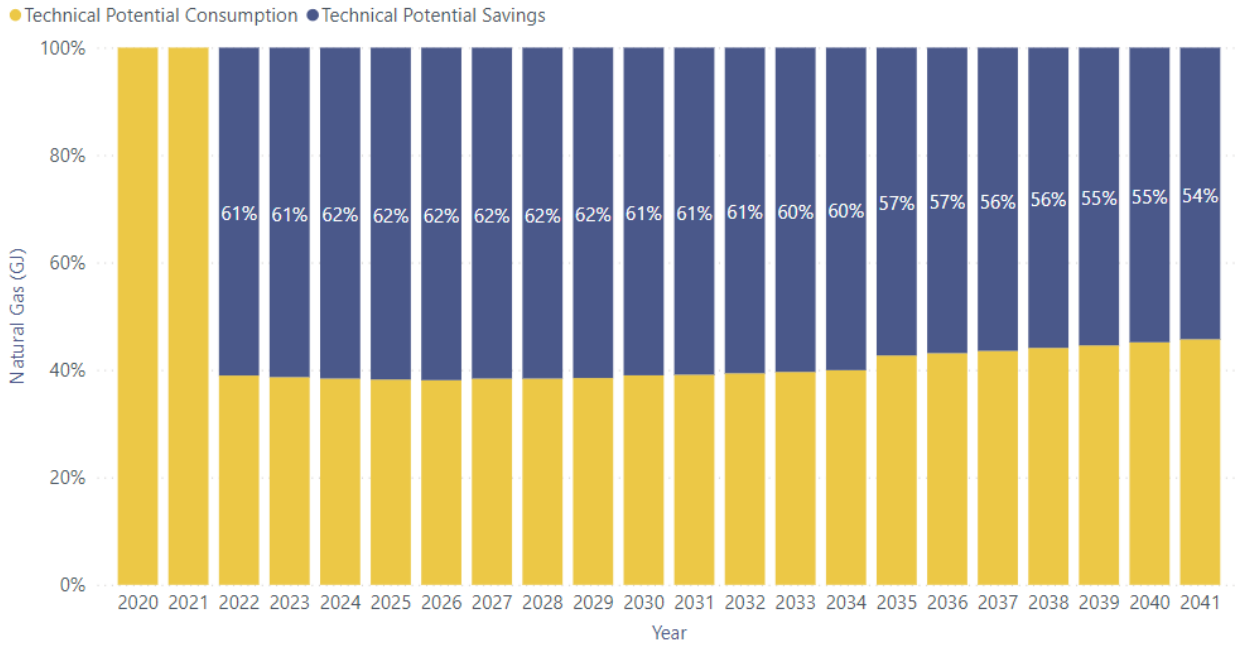


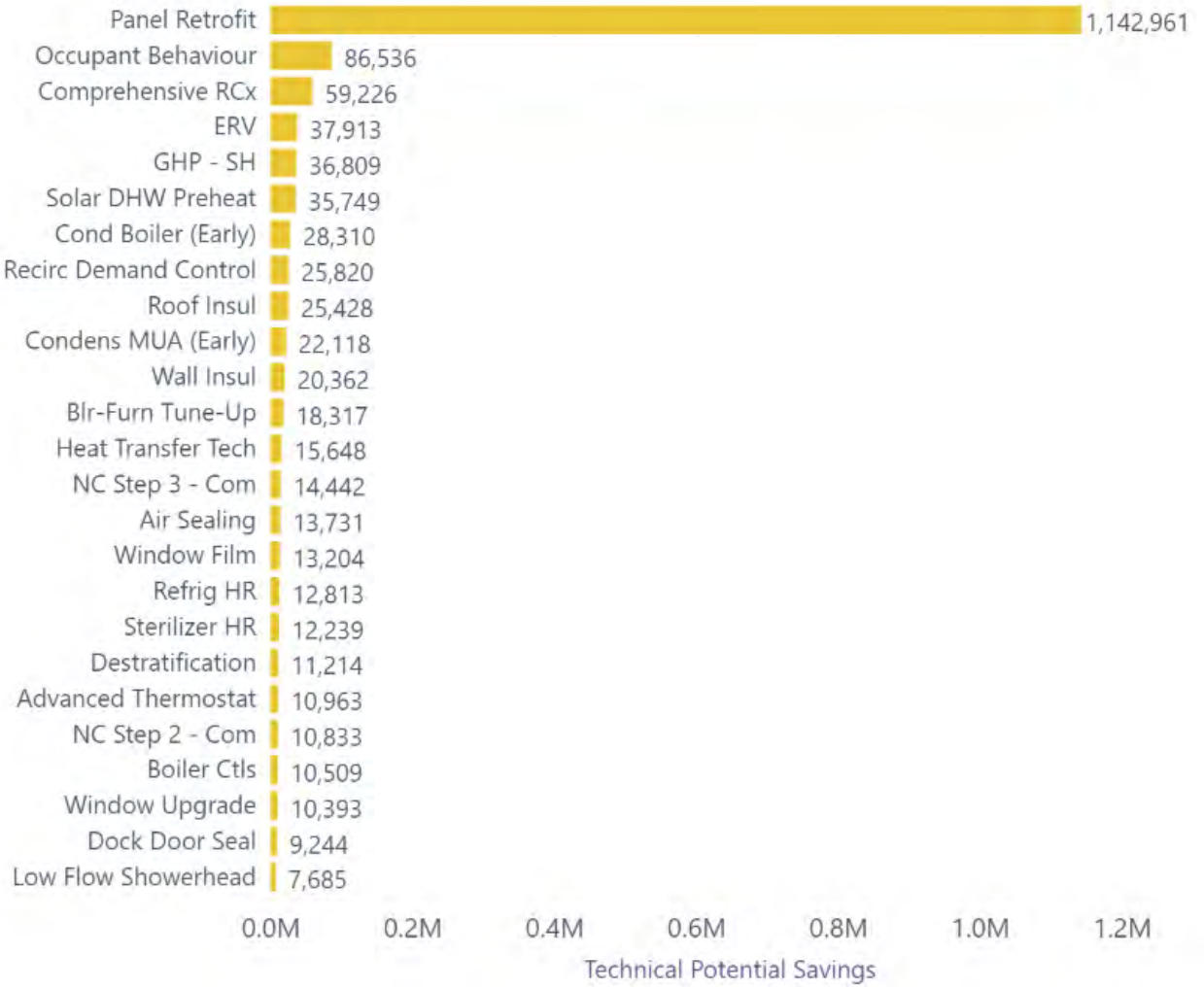
Exhibit 81 – Technical Savings Potential as a Percent of Commercial Reference Case Consumption (%)



As shown in Exhibit 81, the technical potential savings is about 61% of commercial reference case consumption in 2022, increases to 62% in 2024 and remains relatively constant until 2034, when it begins to decrease.

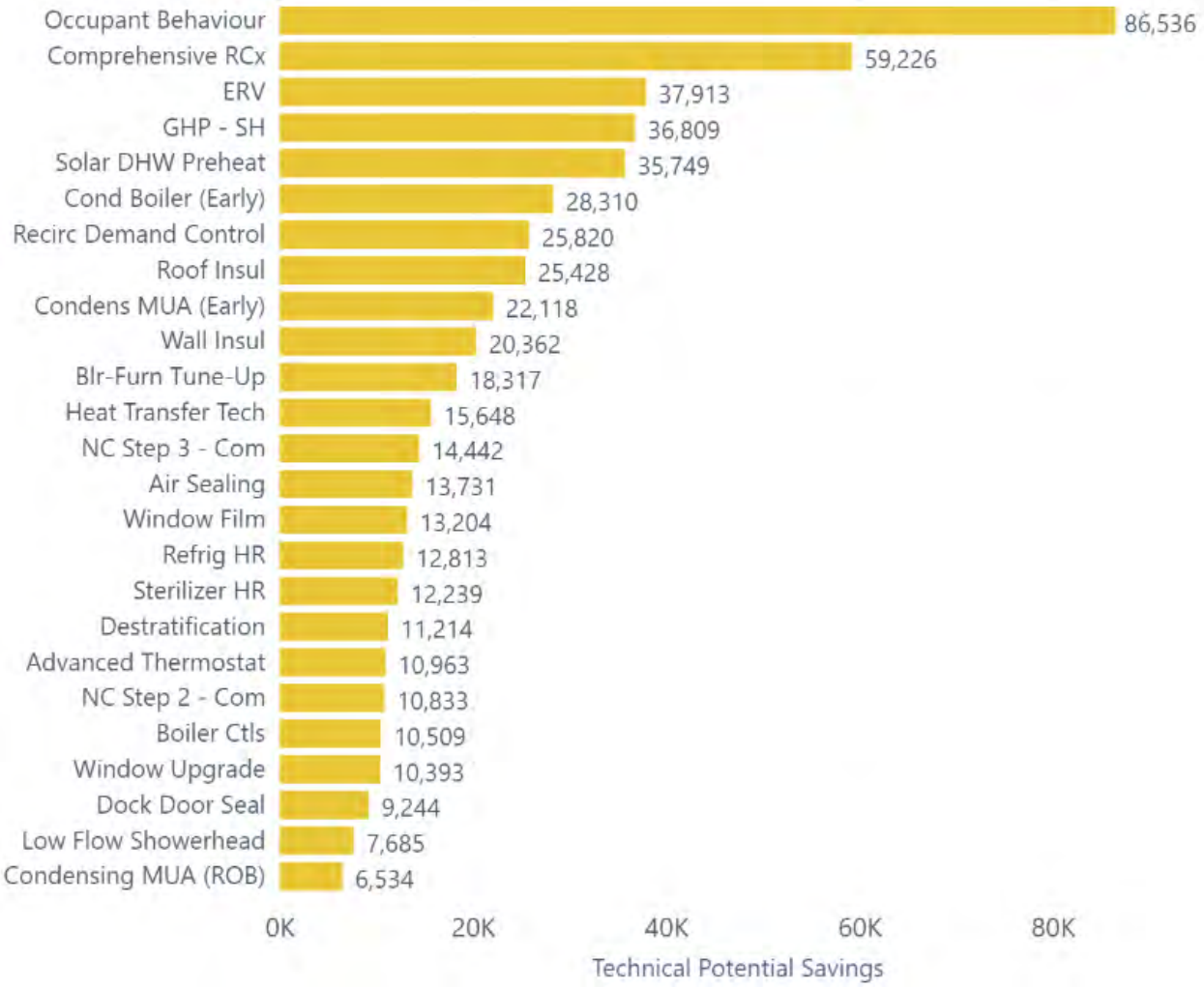
The technical potential savings in 2024 broken down by the top 25 measures are presented in Exhibit 82. Of the top 5 measures that are expected to contribute most of the technical potential savings, only Panel Retrofit does not pass the TRC test in all regions and segments (average TRC of 0.90)[40] but passes the MTRC test (3.07). The remaining four measures pass both the TRC and MTRC tests. This means that, depending on the test used, Panel Retrofit[41] may not impact the economic potential savings in all regions. Exhibit 83 shows the technical potential savings in 2024 broken down by measure, excluding Panel Retrofit.

Exhibit 82 – Technical Potential - Top 25 Commercial Measures in 2024 (GJ)



40 Although the average TRC is 0.9, some combinations of segment and region have a TRC of over 1.0.
41 A panel retrofit involves retrofitting existing buildings with panelized envelope systems (e.g., Energiesprong approach), improving roof, walls, windows, and air tightness. Upgrade specifications are: roof and walls - R-30; windows - USI-1.42; air leakage - 0.05 L/s/sq-m GFA. This technology is not yet widely available and may become more economically feasible as it becomes more widely available.

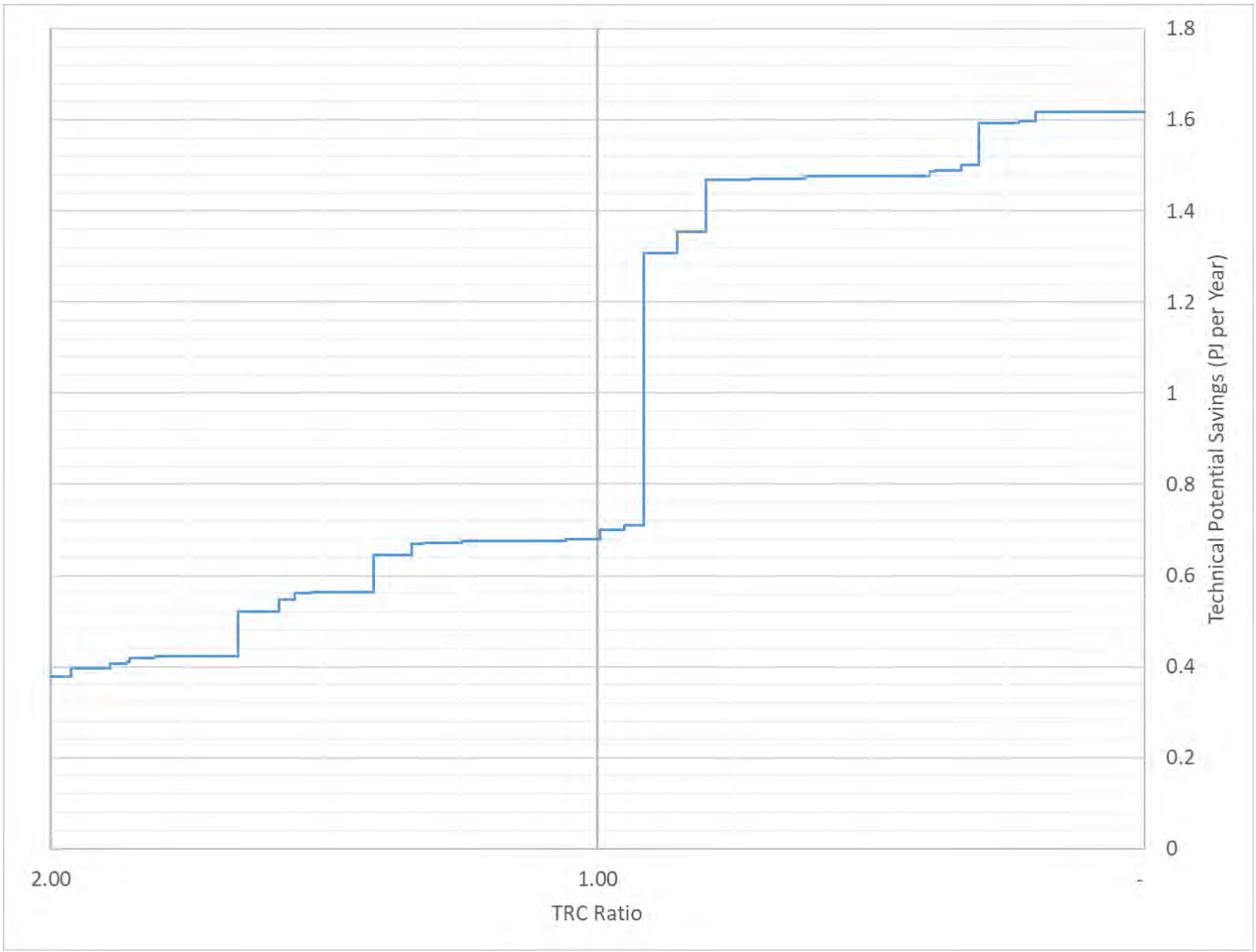
Exhibit 83 - Technical Potential - Top 25 Commercial Measures in 2024 (GJ) excluding Panel Retrofit



The cumulative commercial sector technical potential savings in 2041 are presented in Exhibit 84 as a supply curve, with measures ordered by decreasing TRC ratio from left to right.

As shown, approximately 43% of the commercial sector technical potential savings (approximately 0.68 of 1600 TJ) comes from measures with a TRC of 1.0 or higher. Approximately 400 TJ of savings come from measures with a TRC ratio of greater than 2. These are shown in aggregate.

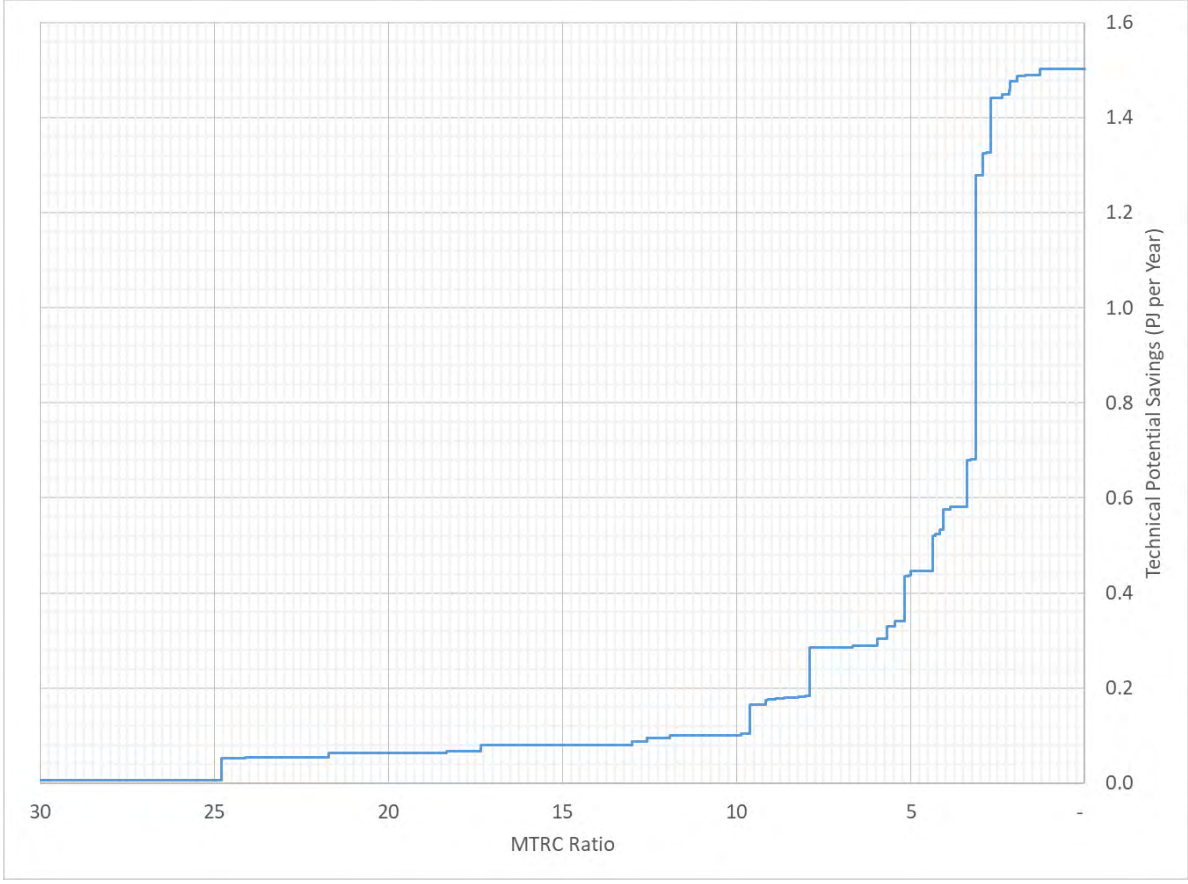
Exhibit 84 – Commercial Sector: Technical Potential Gas Supply Curve in 2041 – TRC



The cumulative commercial sector technical potential savings in 2041 are presented in Exhibit 85 as a supply curve, with measures ordered by decreasing MTRC ratio from left to right.

As shown, approximately 98% of the commercial sector technical potential savings (approximately 1470 of 1500 TJ) by 2041, comes from measures with an MTRC of 1.0 or higher. Approximately 290 TJ of savings come from measures with an MTRC ratio of greater than 7. These are shown in aggregate.

Exhibit 85 – Commercial Sector: Technical Potential Supply Curve – MTRC

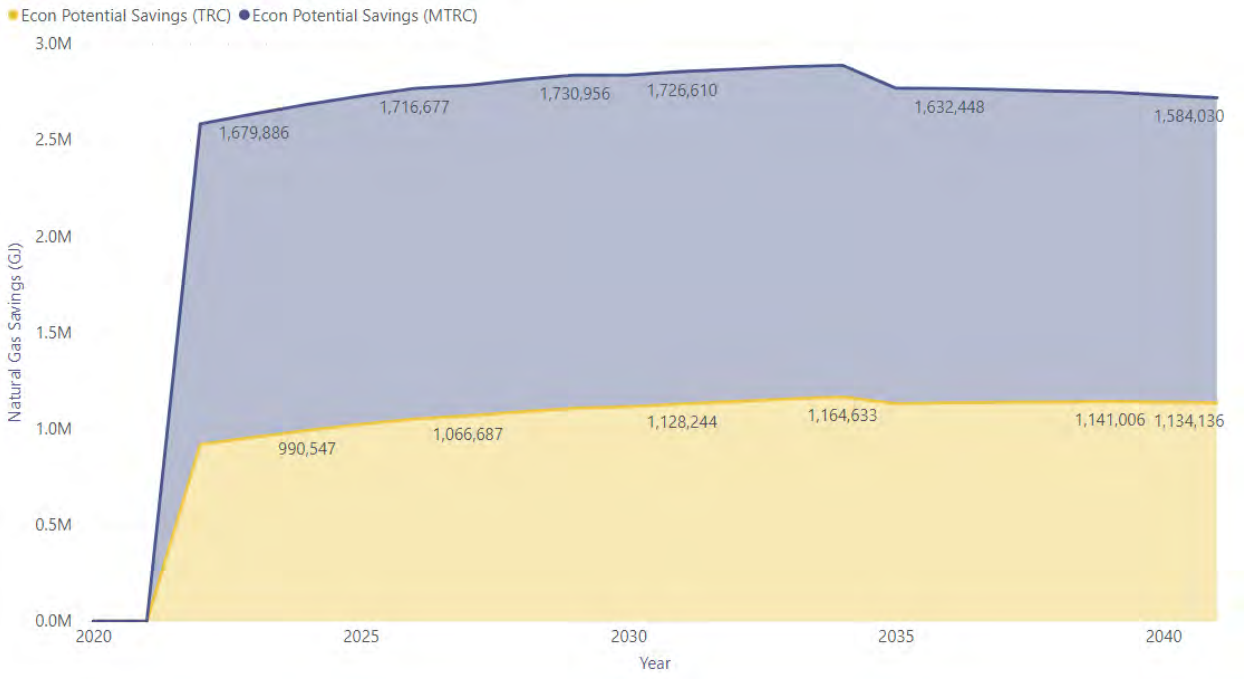


5.6 Economic Potential

This section provides the economic potential savings results for the commercial sector from 2022 to 2041. We conducted two economic potential assessments: one using a TRC Screen that includes measures with a TRC ratio of 1 and above, and one using an MTRC screen that includes measures with an MTRC of 1 and above. Outputs of both economic models are presented in this section.

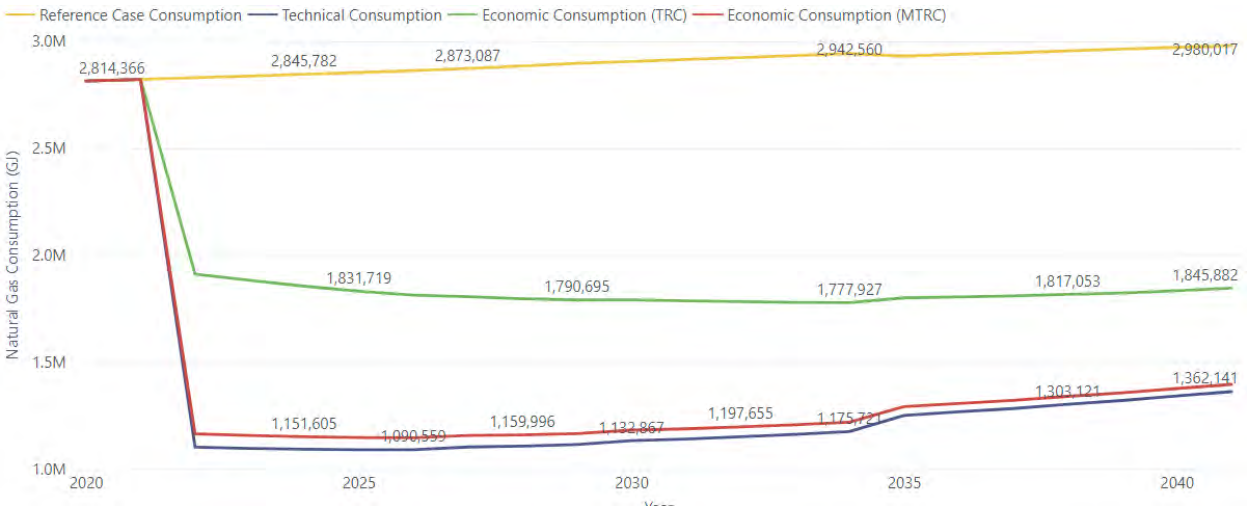
The commercial sector economic potential savings with a TRC screen and with an MTRC screen are shown in Exhibit 86. Of the 61 measures included in the assessment, 46 pass the TRC screen and 59 pass the MTRC screen. The 13 measures that that pass the MTRC but fail the TRC make up the difference between the two economic potential scenarios. The difference in economic potential in 2024 is about 704 TJ. Another way to look at it is that the 60% of the MTRC economic potential comes from measures that pass the TRC as well.

Exhibit 86 – Economic Potential Savings (GJ) – Commercial, TRC and MTRC



The forecasted gas consumption under the technical potential, economic potential with a TRC screen, economic potential with an MTRC screen, and reference case scenarios for the commercial sector are shown in Exhibit 87. The immediate drop in consumption in the first year in each of the savings scenarios is due to the implementation of the retrofit measures. The rest of the curves follow the shape of the reference case curve, as the replace on burnout measures are implemented at equipment end of life.

Exhibit 87 – Economic Potential Consumption (GJ) Forecasts – Commercial, TRC and MTRC



Results by Region

The TRC and MTRC economic potential savings in 2024 are presented by region in Exhibit 88 and Exhibit 89, respectively. The largest economic potential savings (620 TJ to 1,014 TJ depending on economic screen) are estimated to occur in the Northeast region. Although smaller in absolute savings, the largest percentage of savings using the MTRC test is expected to be captured in the West (East) region (more than 62% of reference case consumption).

Exhibit 88 – Economic Potential Savings by Region in 2024 – Commercial, TRC

Region	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Northeast	1,689,425	620,257	37%
West (West)	700,842	208,762	30%
West (East)	455,515	161,529	35%
Total	**2,845,782**	**990,547**	**35%**

Exhibit 89 – Economic Potential Savings by Region in 2024 – Commercial, MTRC

Region	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Northeast	1,689,425	1,013,857	60%
West (West)	700,842	396,948	57%
West (East)	455,515	283,372	62%
Total	**2,845,782**	**1,694,177**	**60%**

Results by Segment

The TRC and MTRC economic potential savings in 2024 are presented by segment in Exhibit 90 and Exhibit 91, respectively. The largest amounts of savings are expected to occur in other, office, and school segments. In the TRC scenario, the highest percentage of savings are expected to be captured in universities, offices, and hospitals. While in the MTRC scenario, the highest percentage of savings are expected to be captured in schools, offices, and warehouses.

Exhibit 90 – Economic Potential Savings by Segment in 2024 – Commercial, TRC

Segment	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Other	807,561	178,560	22%
Office	500,700	349,037	70%
School	249,863	91,841	37%
Nonfood Retail	240,996	49,008	20%
Hospital	177,444	75,113	42%
Restaurant	167,111	25,912	16%
Warehouse	160,026	34,903	22%
Hotel	158,973	59,687	38%
Apartment	146,198	50,151	34%
Food Retail	115,601	29,738	26%
Nursing Home	83,079	20,439	25%
University/College	38,231	26,158	68%
Total	**2,845,782**	**990,547**	**35%**

Exhibit 91 – Economic Potential Savings by Segment in 2024 – Commercial, MTRC

Segment	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Other	807,561	469,900	58%
Office	500,700	371,621	74%
School	249,863	191,716	77%
Nonfood Retail	240,996	151,092	63%
Hospital	177,444	85,284	48%
Restaurant	167,111	44,052	26%
Warehouse	160,026	128,846	81%
Hotel	158,973	65,299	41%
Apartment	146,198	52,550	36%
Food Retail	115,601	66,273	57%
Nursing Home	83,079	42,505	51%
University/College	38,231	25,038	65%
Total	**2,845,782**	**1,694,177**	**60%**

Results by End Use

The TRC and MTRC economic potential savings in 2024 are presented by segment in Exhibit 92 and Exhibit 93, respectively. The largest amounts, in absolute savings and percentage of savings relative to the reference case consumption are expected to be captured under the space heating end use. Absolute savings range from 891 TJ to 1,583 TJ and percent savings range from 42% to 75%.

Exhibit 92 – Economic Potential Savings by End Use in 2024 – Commercial, TRC

Parent End Use	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Space Heating	2,106,411	891,486	42%
Water heating	419,443	96,018	23%
Food Service	190,826	3,043	2%
Other	110,668	0	0%
Pools; Spas & Hot Tubs	18,434	0	0%
Total	**2,845,782**	**990,547**	**35%**

Exhibit 93 – Economic Potential Savings by End Use in 2024 – Commercial, MTRC

Parent End Use	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Space Heating	2,106,411	1,583,162	75%
Water heating	419,443	107,972	26%
Food Service	190,826	3,043	2%
Other	110,668	0	0%
Pools; Spas & Hot Tubs	18,434	0	0%
Total	**2,845,782**	**1,694,177**	**60%**

The TRC and MTRC economic potential savings in 2041 are presented by end use in Exhibit 94. The difference of almost 450 TJ is mostly a result of more space heating measures being included in the MTRC scenario.

Exhibit 94 – Economic Potential Savings by End Use in 2041 – Commercial, TRC and MTRC

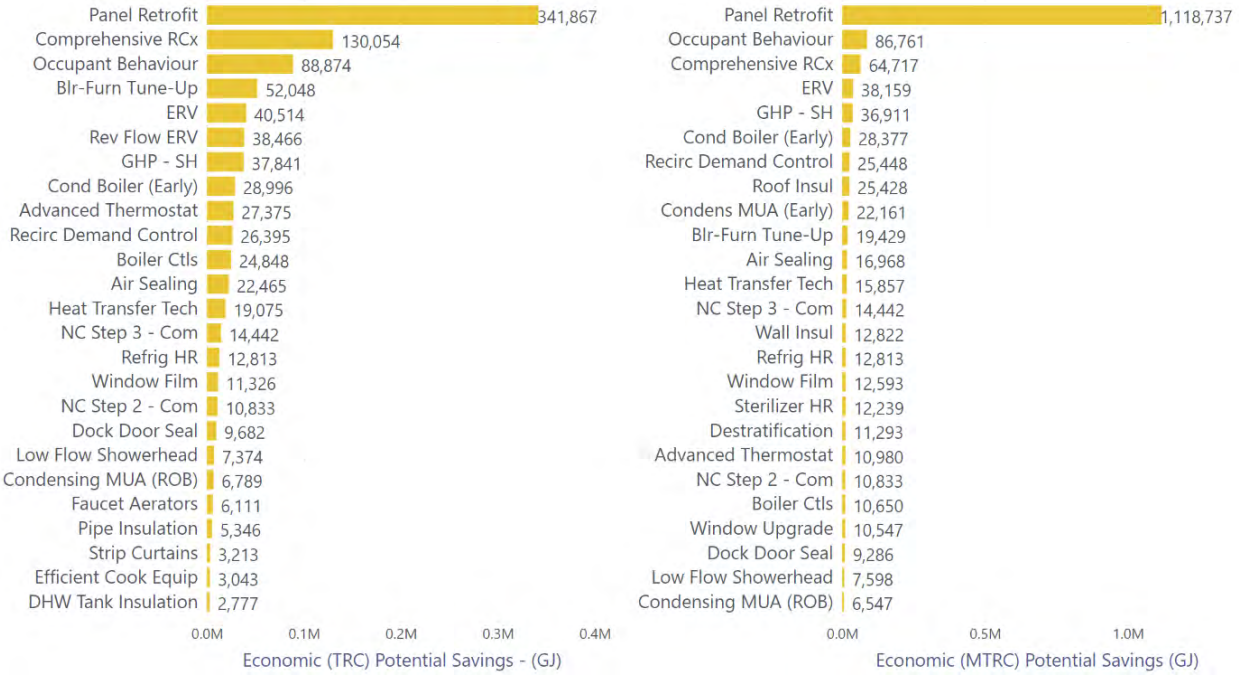
Parent End Use	Economic Savings (GJ) - TRC	Economic Savings (GJ) - MTRC	Difference (GJ)
Space Heating	1,013,151	1,449,535	436,384
Water heating	112,302	125,813	13,511
Food Service	8,683	8,683	0
Other	0	0	0
Pools; Spas & Hot Tubs	0	0	0
Total	**1,134,136**	**1,584,030**	**449,895**

Results by Measure

The economic potential savings in 2024 broken down by measure (only the top 25 measures are shown) are presented in Exhibit 95. The top measures in the TRC economic potential are shown on the left and on the MTRC scenario is shown on the right. Panel Retrofit and ERV top the list in both scenarios. The MTRC scenario list on the right is similar to the top technical potential measures presented in Exhibit 82.

The main differences between the TRC and MTRC list are that the roof insulation becomes one of the top measures under MTRC.

Exhibit 95 – Economic Potential (TRC on Left, MTRC on Right) - Top 25 Commercial Measures in 2024 (GJ)



5.7 Market Potential

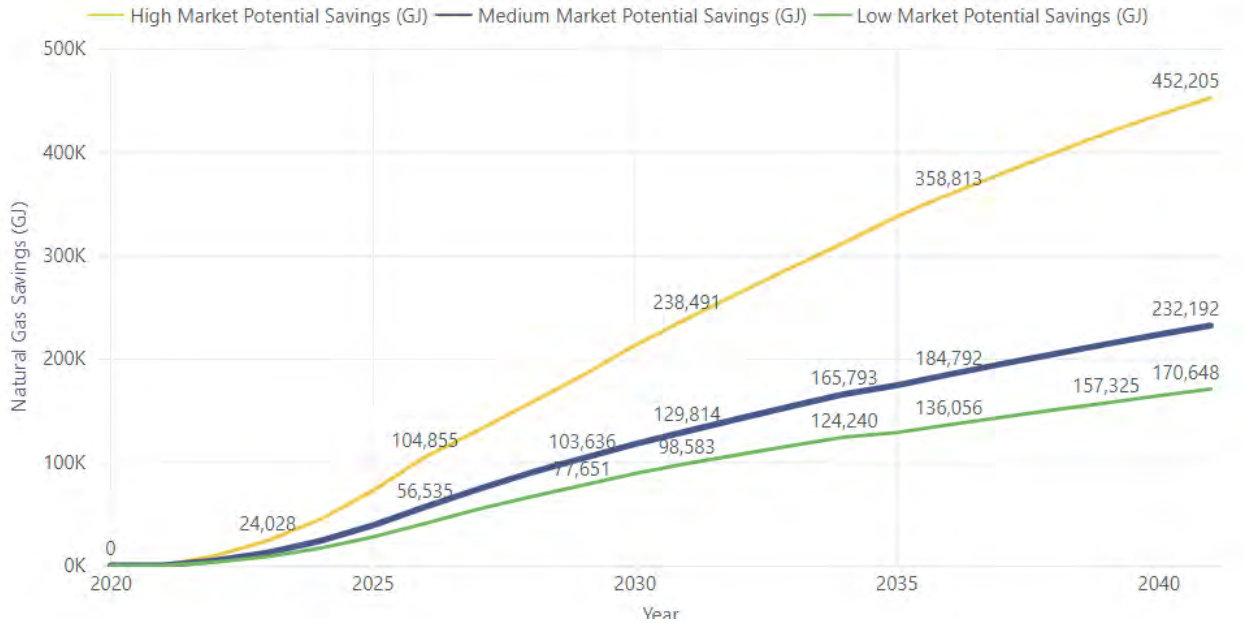
This section provides an overview of the low, medium, and high market potential results for the commercial sector.

Low, medium, and high scenarios assume that measure incentive levels will be 25%, 50% and 100% of incremental costs, respectively. For example, assume that a high-efficiency furnace may cost $200 more than a standard furnace, meaning the furnace would have an incremental cost of $200. In the medium scenario, this measure's hypothetical incentive from PNG would be $100. The other $100 would be paid by the end user. In all scenarios, the non-incentive program costs are assumed to be 15% of the incentive cost. In the example above, PNG's non-incentive spending would be $15. PNG's total cost for providing the measure to an end user would be $115.

The market potential savings results, with a TRC screen and with an MTRC screen, are shown in Exhibit 96 and Exhibit 97, respectively. The medium, or realistic, market potential scenarios under both economic screens are close, as the majority of the measures pass both screens.

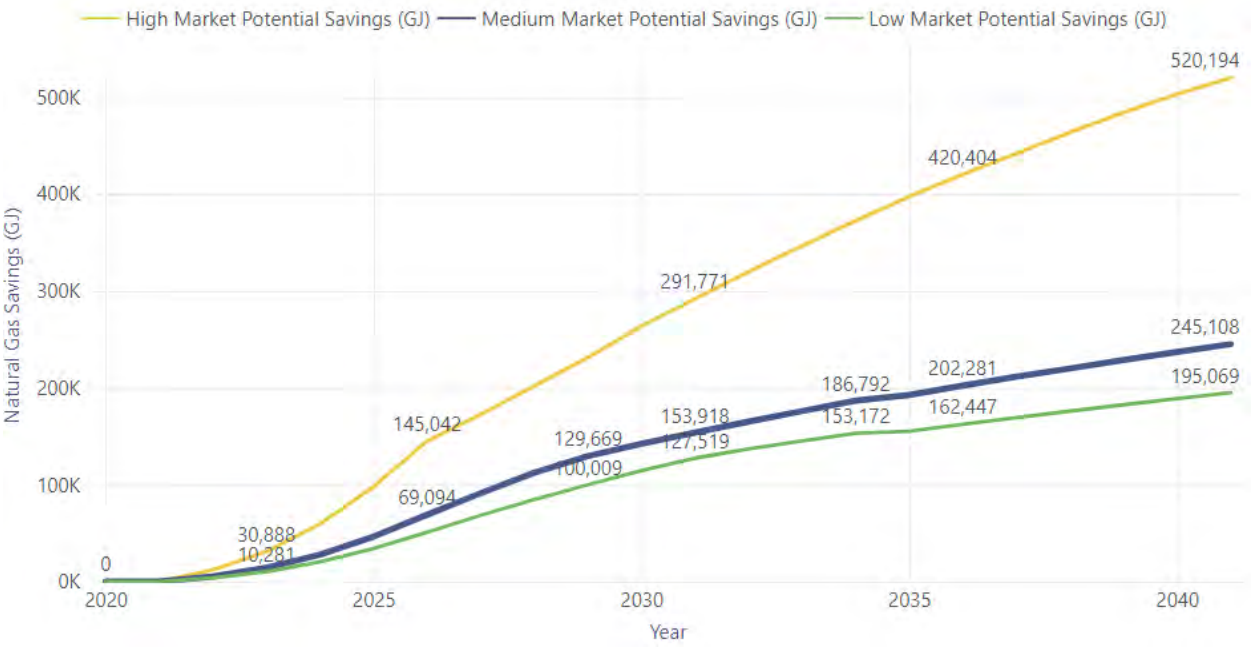
By 2040, the commercial low, medium, and high market TRC potential savings are estimated to be 171 TJ, 232 TJ, and 452 TJ, respectively.

Exhibit 96 – Market Potential Savings (GJ) – Commercial, TRC



By 2040, the commercial low, medium, and high market MTRC potential savings are estimated to be 195 TJ, 245 TJ, and 520 TJ, respectively.

Exhibit 97 – Market Potential Savings (GJ) – Commercial, MTRC



The high market potential scenario is much higher than the medium market potential in the MTRC scenario. By 2040, the difference in potential between the medium and high market MTRC scenarios is 275 TJ. In this case, NC Step Codes 2 & 3 are a major factor contributing to the difference.

The difference in MTRC medium and high potential scenarios by 2040, broken down by measure, as shown in Exhibit 98. Only the top 10 measures that contribute to the difference are presented. NC Step Codes 3 and 2 top the list, but ERVs, Window Upgrades and Condensing MUAs are also influence the difference. In the TRC medium and high potential scenarios, as shown in Exhibit 99, the difference in market potentials is even more impacted by NC Step Code measures.

Exhibit 98 – Top 10 Commercial Measures Contributing to Difference in Medium and High Market Potential Scenarios (Using MTRC Screen) by 2040

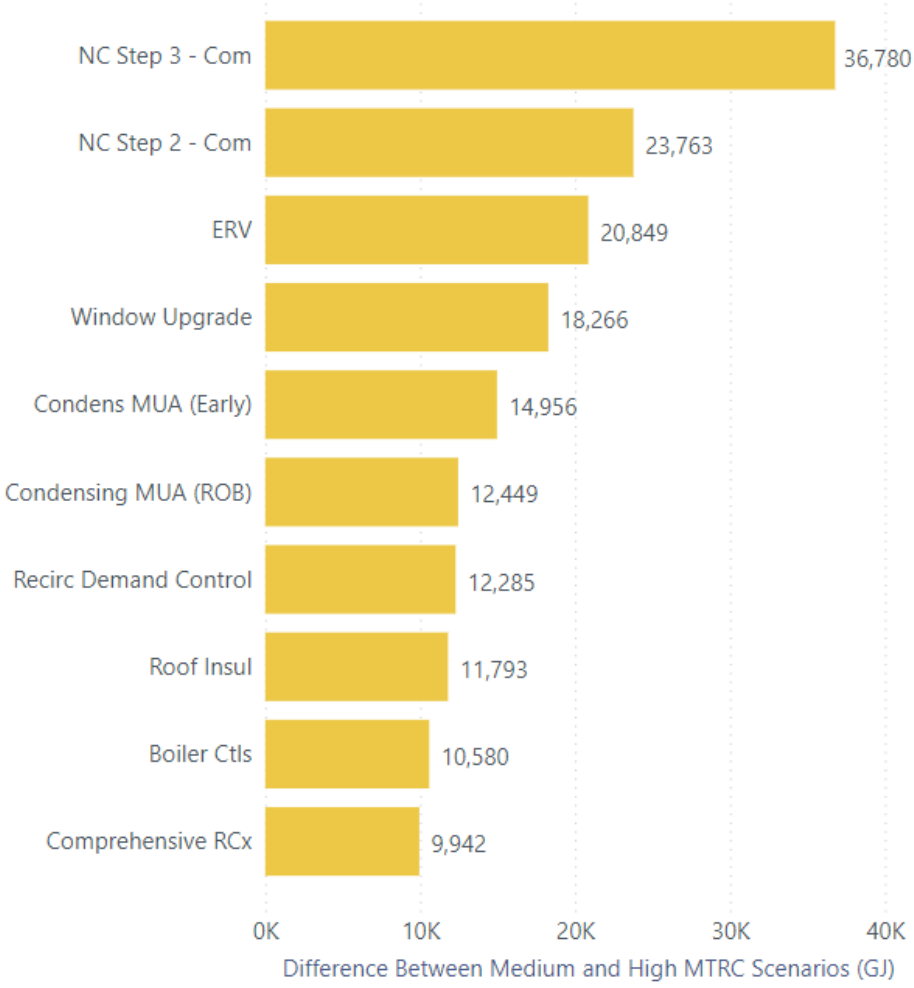
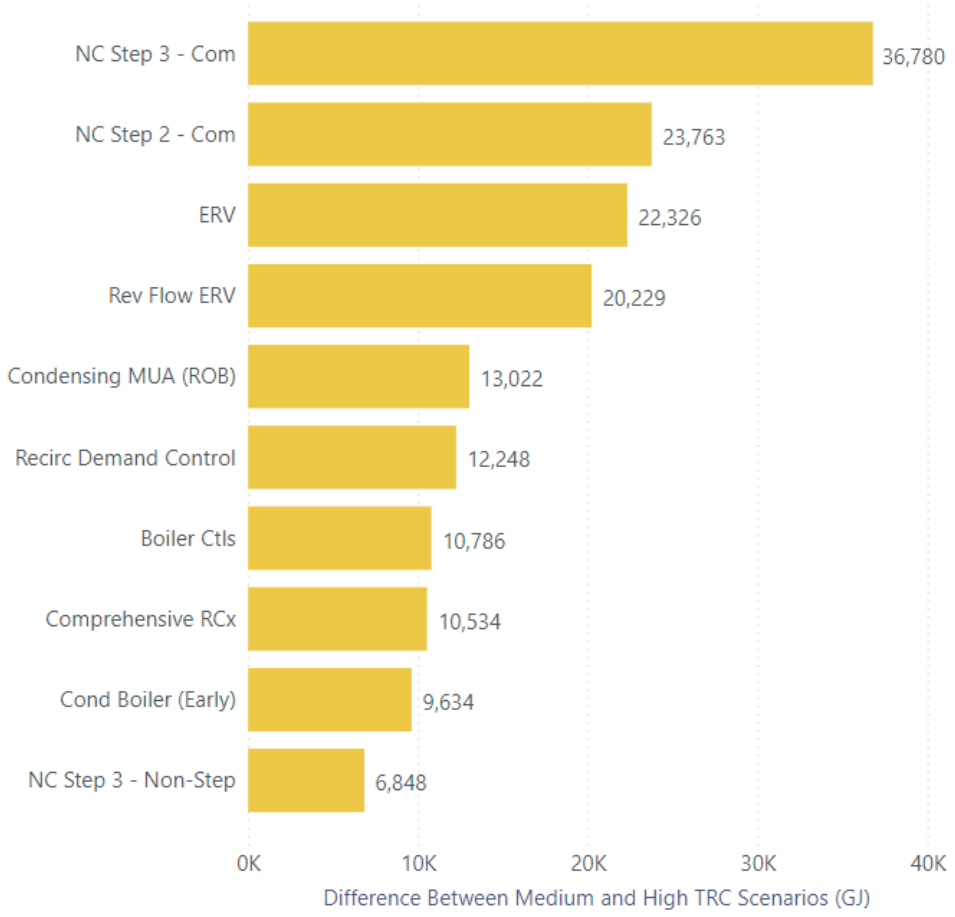


Exhibit 99 – Top 10 Commercial Measures Contributing to Difference in Medium and High Market Potential Scenarios (Using TRC Screen) by 2040



The forecasted gas consumption under the three market potential scenarios relative to reference case scenario for the commercial sector are shown in Exhibit 100 (TRC) and Exhibit 101 (MTRC). By 2040, the commercial low, medium, and high market TRC potential consumption levels are estimated to be 2810 TJ, 2750 TJ, and 2530 TJ, respectively, while reference consumption is forecasted to reach 298 TJ. By 2040, the commercial low, medium, and high market MTRC potential consumption levels are estimated to be 2780 TJ, 2730 TJ, and 2460 TJ, respectively, while reference consumption is forecasted to reach 2980 TJ.

Exhibit 100 – Commercial Market Potential Consumption (GJ) Forecasts – Commercial, TRC

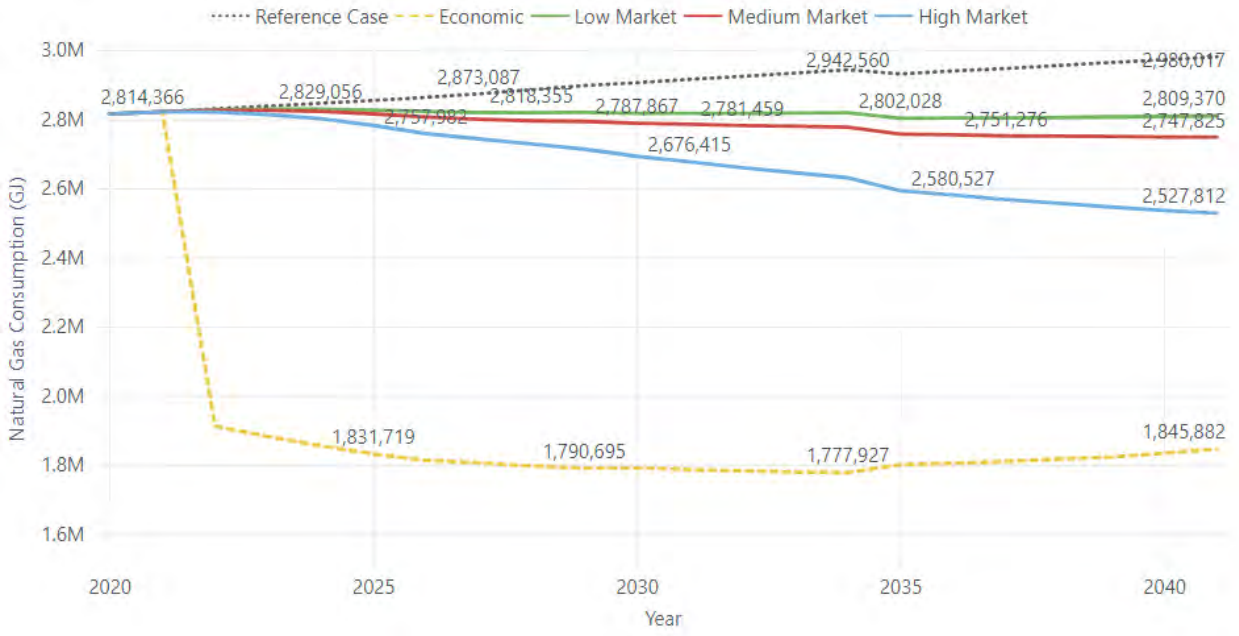
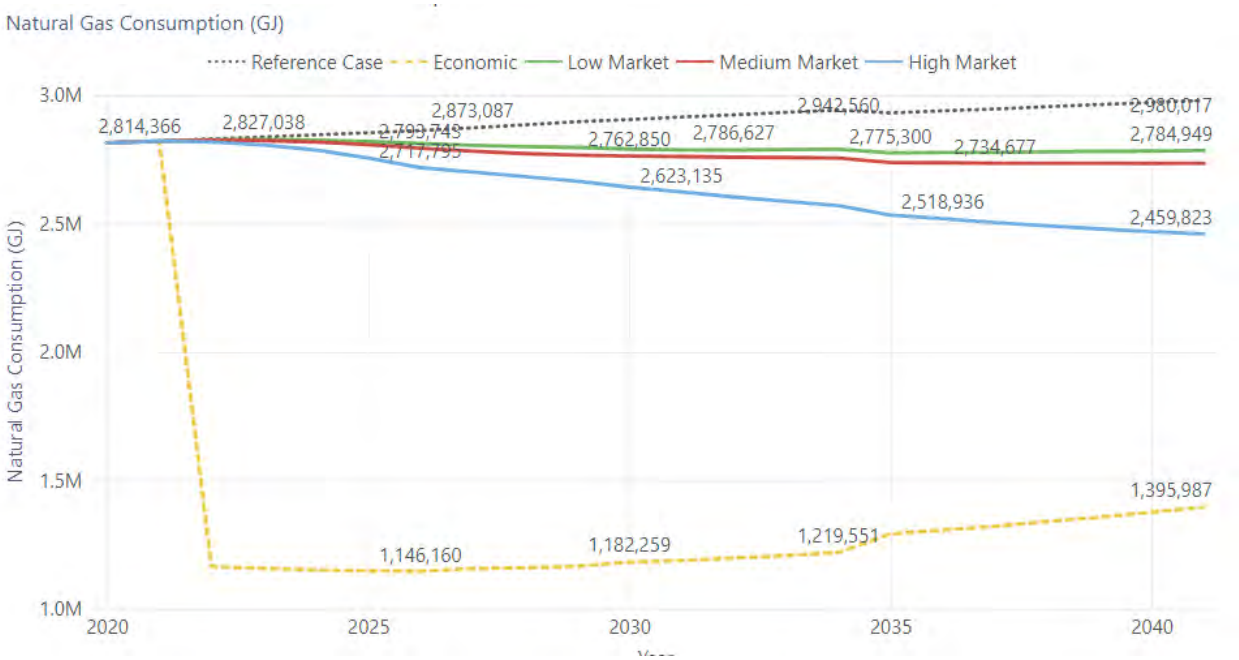


Exhibit 101 – Commercial Market Potential Consumption (GJ) Forecasts – Commercial, MTRC



The remainder of this section presents detailed results of the medium market potential scenario only. Similarly detailed results of the low and high market potential scenarios can be found on the Power BI dashboard and the Excel workbooks.

Results by Region

The medium market potential savings for 2024 are presented by region in Exhibit 102 and Exhibit 103 using TRC and MTRC screen, respectively. Medium market potential savings for 2024 are estimated to be 1% of reference case consumption in all regions in both medium market scenarios.

Exhibit 102 – Medium Market Potential Savings by Region in 2024 – Commercial, TRC

Region	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Northeast	1,689,425	14,691	1%
West (West)	700,842	5,282	1%
West (East)	455,515	3,766	1%
Total	**2,845,782**	**23,739**	**1%**

Exhibit 103 – Medium Market Potential Savings by Region in 2024 – Commercial, MTRC

Region	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Northeast	1,689,425	16,173	1%
West (West)	700,842	6,851	1%
West (East)	455,515	4,816	1%
Total	**2,845,782**	**27,839**	**1%**

Results by Segment

The medium market potential savings for 2024 are presented by segment in Exhibit 104 and Exhibit 105 using TRC and MTRC screen, respectively. The largest amounts of medium market potential savings are estimated to occur in other, office, hospital, and school segments.

Exhibit 104 – Medium Market Potential Savings by Segment in 2024 – Commercial, TRC

Segment	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Office	500,700	5,594	1%
Other	807,561	5,259	1%
Hospital	177,444	3,396	2%
School	249,863	2,042	1%
Restaurant	167,111	1,597	1%
Nursing Home	83,079	1,020	1%
Apartment	146,198	960	1%
Food Retail	115,601	866	1%
University/College	38,231	815	2%
Nonfood Retail	240,996	799	0%
Hotel	158,973	762	0%
Warehouse	160,026	628	0%
Total	**2,845,782**	**23,739**	**1%**

Exhibit 105 – Medium Market Potential Savings by Segment in 2024 – Commercial, MTRC

Segment	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Office	500,700	6,821	1%
Other	807,561	6,030	1%
School	249,863	3,559	1%
Hospital	177,444	3,424	2%
Restaurant	167,111	1,599	1%
Nursing Home	83,079	1,032	1%
Apartment	146,198	1,017	1%
Hotel	158,973	922	1%
Nonfood Retail	240,996	914	0%
Food Retail	115,601	887	1%
Warehouse	160,026	818	1%
University/College	38,231	817	2%
Total	**2,845,782**	**27,839**	**1%**

Results by End Use

The medium market potential savings for 2024 are presented by segment in Exhibit 106 and Exhibit 107 using TRC and MTRC screen, respectively. Most of the savings come from the space heating end use.

Exhibit 106 – Medium Market Potential Savings by End Use in 2024 – Commercial, TRC

Parent End Use	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Space Heating	2,106,411	19,919	1%
Water heating	419,443	2,936	1%
Food Service	190,826	884	0%
Other	110,668	0	0%
Pools; Spas & Hot Tubs	18,434	0	0%
Total	**2,845,782**	**23,739**	**1%**

Exhibit 107 – Medium Market Potential Savings by End Use in 2024 – Commercial, MTRC

Parent End Use	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Space Heating	2,106,411	23,994	1%
Water heating	419,443	2,961	1%
Food Service	190,826	884	0%
Other	110,668	0	0%
Pools; Spas & Hot Tubs	18,434	0	0%
Total	**2,845,782**	**27,839**	**1%**

The TRC and MTRC medium market potential savings for 2040 are presented by end use in Exhibit 108. The scenarios under both economic screens are close, with a difference of 13 TJ, as the majority of the measures pass both screens.

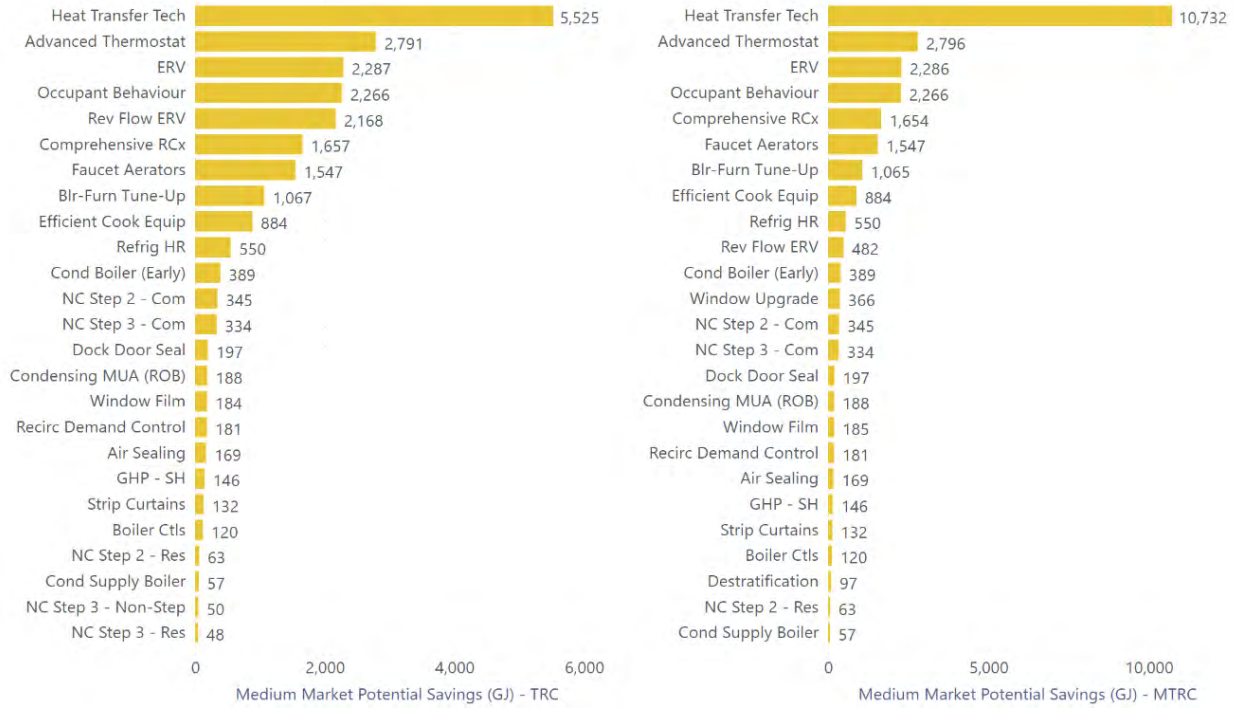
Exhibit 108 – Medium Market Potential Savings by End Use in 2040 – Commercial, TRC and MTRC

Parent End Use	Medium Potential Savings (GJ) - TRC	Medium Potential Savings (GJ) - MTRC	Difference (GJ)
Space Heating	202,019	214,082	12,063
Water heating	24,493	25,346	852
Food Service	5,680	5,680	0
Other	0	0	0
Pools; Spas & Hot Tubs	0	0	0
Total	**232,192**	**245,108**	**12,915**

Results by Measure

The medium market potential savings by 2024 of the top 25 commercial measures are shown in Exhibit 109, sorted by decreasing potential. The top measures in the TRC medium market potential are shown on the left and the top measures in the MTRC scenario are shown on the right. Heat transfer technology, advanced thermostats, occupant behavior, and ERVs top the list in both scenarios.

Exhibit 109 – Medium Market Potential (TRC on Left, MTRC on Right) - Gas Savings from Top 25 Commercial Measures in 2024 (GJ)



5.7.1 Incentive and Non-Incentive Spending

The incentive and non-incentive spending required to achieve the medium and high market potential are shown in Exhibit 110 (TRC) and Exhibit 112 (MTRC). Medium and high market incentives are assumed to be 50% and 100% of measures' incremental costs, respectively. In both medium and high scenarios, non-incentive costs are estimated to be 15% of incentive costs. The tables also show the total as well as incremental (that is, savings from new measures installed in a year) savings every year.

Exhibit 110 – Medium and High Market Incentive Costs and Natural Gas Savings – Commercial, TRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$80K	$12K	$92K	4,827	4,827	$19.09	$441K	$33K	$474K	9,656	9,656	$49.11
2023	$128K	$19K	$147K	12,476	7,649	$11.76	$697K	$52K	$749K	24,028	14,372	$31.17
2024	$184K	$28K	$212K	23,739	11,263	$8.94	$1,031K	$77K	$1,108K	44,725	20,697	$24.78
2025	$253K	$38K	$291K	38,711	14,973	$7.51	$1,489K	$112K	$1,601K	72,122	27,397	$22.20
2026	$318K	$48K	$365K	56,535	17,823	$6.46	$1,927K	$145K	$2,072K	104,855	32,733	$19.76
2027	$383K	$57K	$441K	73,693	17,158	$5.98	$2,305K	$173K	$2,478K	130,419	25,564	$19.00
2028	$374K	$56K	$430K	89,505	15,812	$4.81	$2,278K	$171K	$2,449K	156,704	26,285	$15.63
2029	$376K	$56K	$432K	103,636	14,132	$4.17	$2,418K	$181K	$2,599K	183,590	26,886	$14.16
2030	$515K	$77K	$592K	117,358	13,722	$5.05	$3,172K	$238K	$3,410K	212,912	29,322	$16.02
2031	$356K	$53K	$410K	129,814	12,455	$3.15	$2,327K	$175K	$2,502K	238,491	25,579	$10.49
2032	$366K	$55K	$421K	142,075	12,262	$2.96	$2,395K	$180K	$2,575K	263,877	25,385	$9.76
2033	$362K	$54K	$416K	154,039	11,963	$2.70	$2,368K	$178K	$2,546K	288,433	24,556	$8.83
2034	$360K	$54K	$414K	165,793	11,754	$2.50	$2,332K	$175K	$2,507K	312,148	23,715	$8.03
2035	$922K	$138K	$1,060K	174,170	8,377	$6.09	$5,657K	$424K	$6,081K	337,406	25,258	$18.02
2036	$337K	$51K	$387K	184,792	10,622	$2.10	$2,185K	$164K	$2,349K	358,813	21,407	$6.55
2037	$317K	$48K	$364K	194,921	10,130	$1.87	$2,011K	$151K	$2,162K	378,905	20,092	$5.70
2038	$331K	$50K	$380K	204,448	9,526	$1.86	$2,154K	$162K	$2,316K	398,718	19,813	$5.81
2039	$321K	$48K	$370K	214,098	9,650	$1.73	$1,968K	$148K	$2,116K	418,132	19,414	$5.06
2040	$310K	$46K	$356K	223,342	9,244	$1.59	$1,793K	$134K	$1,927K	435,694	17,563	$4.42
2041	$301K	$45K	$346K	232,192	8,850	$1.49	$1,745K	$131K	$1,876K	452,205	16,511	$4.15
Total	**$6,892K**	**$1,034K**	**$7,926K**	**2,540,163**	**232,192**	**$3.12**	**$42,694K**	**$3,202K**	**$45,896K**	**4,821,830**	**452,205**	**$9.52**

Exhibit 111 - Medium and High Market Total Costs per Natural Gas Savings – Commercial, TRC

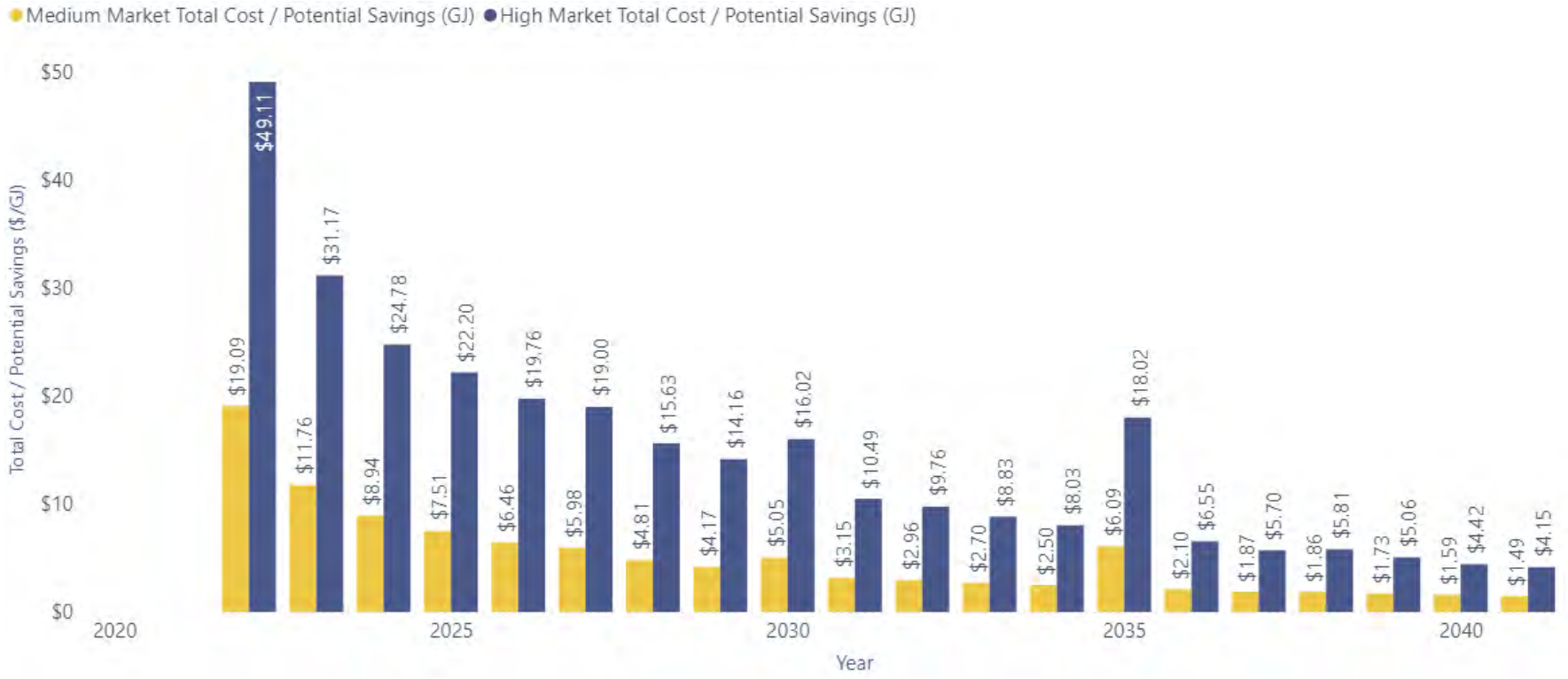
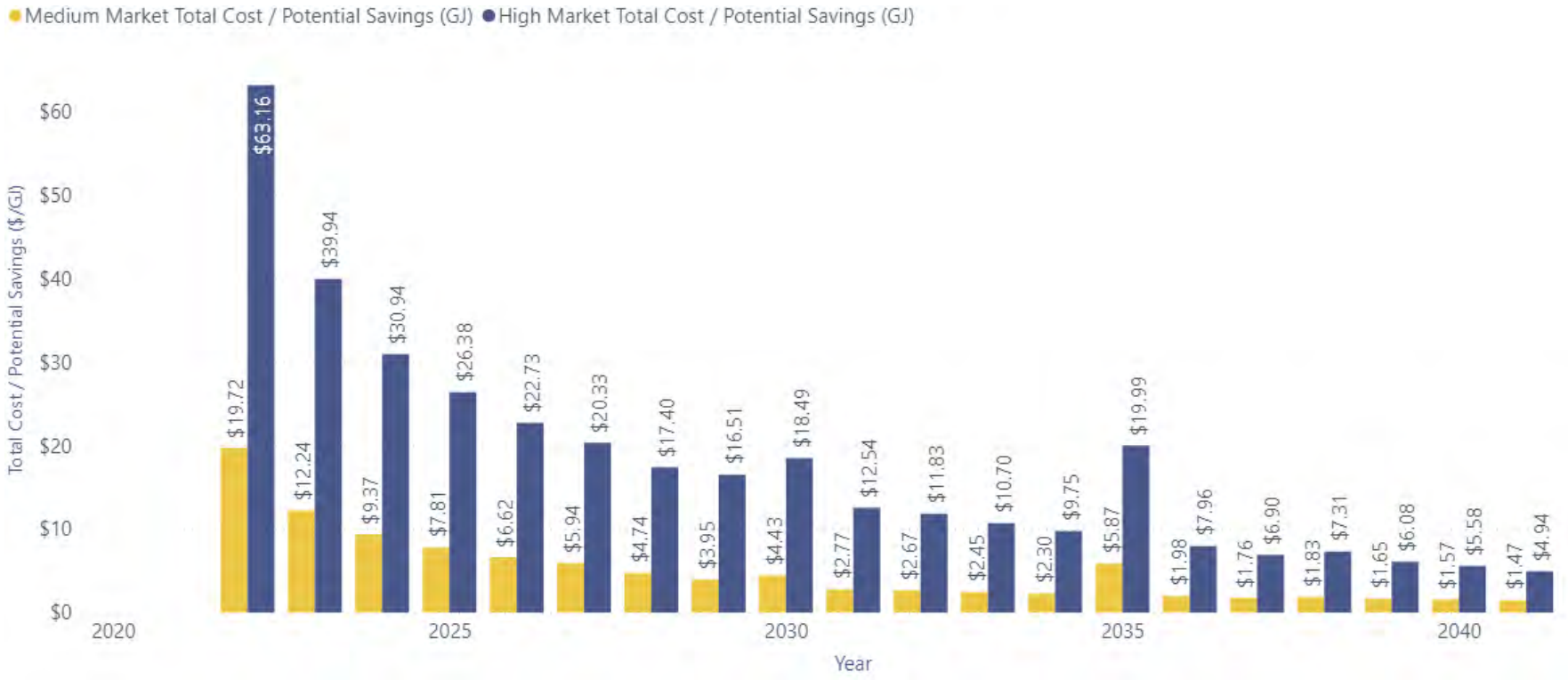


Exhibit 112 – Medium and High Market Incentive Costs and Natural Gas Savings – Commercial, MTRC Ratio

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$92K	$14K	$106K	5,366	5,366	$19.72	$706K	$53K	$759K	12,016	12,016	$63.16
2023	$151K	$23K	$174K	14,198	8,832	$12.24	$1,147K	$86K	$1,234K	30,888	18,872	$39.94
2024	$227K	$34K	$261K	27,839	13,642	$9.37	$1,709K	$128K	$1,837K	59,358	28,470	$30.94
2025	$316K	$47K	$363K	46,502	18,663	$7.81	$2,407K	$181K	$2,588K	98,096	38,738	$26.38
2026	$398K	$60K	$458K	69,094	22,592	$6.62	$3,066K	$230K	$3,296K	145,042	46,945	$22.73
2027	$472K	$71K	$543K	91,308	22,214	$5.94	$3,266K	$245K	$3,511K	172,697	27,656	$20.33
2028	$463K	$69K	$532K	112,353	21,045	$4.74	$3,264K	$245K	$3,508K	201,679	28,981	$17.40
2029	$446K	$67K	$512K	129,669	17,316	$3.95	$3,554K	$267K	$3,821K	231,460	29,781	$16.51
2030	$549K	$82K	$631K	142,375	12,706	$4.43	$4,533K	$340K	$4,873K	263,588	32,128	$18.49
2031	$371K	$56K	$427K	153,918	11,544	$2.77	$3,405K	$255K	$3,660K	291,771	28,183	$12.54
2032	$384K	$58K	$441K	165,161	11,242	$2.67	$3,518K	$264K	$3,782K	319,703	27,932	$11.83
2033	$375K	$56K	$431K	176,069	10,908	$2.45	$3,449K	$259K	$3,708K	346,591	26,888	$10.70
2034	$373K	$56K	$429K	186,792	10,722	$2.30	$3,378K	$253K	$3,632K	372,508	25,917	$9.75
2035	$982K	$147K	$1,130K	192,632	5,841	$5.87	$7,391K	$554K	$7,946K	397,398	24,890	$19.99
2036	$349K	$52K	$401K	202,281	9,649	$1.98	$3,112K	$233K	$3,345K	420,404	23,006	$7.96
2037	$324K	$49K	$373K	211,521	9,240	$1.76	$2,838K	$213K	$3,050K	442,044	21,641	$6.90
2038	$350K	$52K	$402K	220,076	8,555	$1.83	$3,153K	$237K	$3,390K	463,611	21,567	$7.31
2039	$329K	$49K	$378K	228,834	8,758	$1.65	$2,742K	$206K	$2,947K	484,406	20,794	$6.08
2040	$324K	$49K	$372K	237,114	8,281	$1.57	$2,614K	$196K	$2,810K	503,323	18,918	$5.58
2041	$313K	$47K	$360K	245,108	7,993	$1.47	$2,390K	$179K	$2,570K	520,194	16,871	$4.94
Total	**$7,586K**	**$1,138K**	**$8,723K**	**2,858,209**	**245,108**	**$3.05**	**$61,641K**	**$4,623K**	**$66,265K**	**5,776,777**	**520,194**	**$11.47**

Exhibit 113 - Medium and High Market Total Costs per Natural Gas Savings – Commercial, MTRC



6 Industrial Sector Results

This section presents the industrial sector results and key findings, including:

- Base year (2020) natural gas use
- Reference case consumption forecast (2021 – 2041)
- Measure assessment
- Technical potential
- Economic potential

6.1 Industrial Segments and End Uses

In this CPR, the industrial sector is divided into 13 segments, 11 energy end uses, and 2 vintages.

Segments (13)	End Uses (11)	Vintages (2)
Agriculture (includes greenhouses) Chemical District energy providers Fabricated Metal Food & Beverage Other Manufacturing (includes transportation[42] and other industrial) Mining Non-metallic Mineral (includes cement) Primary Metals Pulp & Paper – Kraft Upstream Oil and Gas Utilities Wood Products	Direct-fired heating Direct Consumption of Gas in Process[43] Heat Treating Kilns On-Site Power Generation[44] Other[45] Ovens Process Boilers Product Drying Space Heating [includes HVAC air heating and HVAC boilers] Water heaters	Existing New

PNG's commercial and industrial rate classes were evaluated by number of accounts and total consumption to identify high consumption categories to be manually sorted into the appropriate commercial and industrial segments. Exhibit 62 summarizes which rate classes were reviewed and sorted. Only two rate classes were not reviewed and sorted: Small Commercial <5,500 GJ and Small Commercial – First Nations. As shown in Exhibit 63, 316 accounts, representing 64% of total consumption, were reviewed and sorted.

42 In the 2015 CPR, 'transportation' pertained to facilities that supported the transportation sector.
43 No CPR measures are applied to this end use; included for accounting purposes only.
44 No CPR measures are applied to this end use; included for accounting purposes only.
45 The 'other' end use is a catch all for equipment that account for a small portion of consumption in this sector.

Exhibit 114 - PNG Rate Classes Reviewed vs Not Reviewed

	Reviewed	Not Reviewed
PNG Rate Class Description	Large Commercial Firm Sales Small Industrial Firm Sales Large Commercial IT Sales Seasonal Sales Small Commercial <5,500 GJ Transport Large Commercial Transport Commercial Transport	Small Commercial <5,500 GJ Small Commercial – First Nations

Exhibit 115 - Accounts and Consumption of Reviewed and Not Reviewed Rate Classes

	Accounts	Consumption (GJ)	% Of Total Consumption
Reviewed	316	3,811,352	64%
Not reviewed	5,286	2,133,245	36%
Total	**5,602**	**5,944,597**	**100%**

The name of each account within the reviewed rate classes was evaluated and a Google search was used, where required, to sort the accounts into the appropriate segments.

For the remaining small commercial rate classes, which were not reviewed, the following steps were used to define the number of accounts and consumption by sector and segment:

1. The percent splits between the commercial and industrial sectors by number of accounts and amount of consumption for Northern BC in the 2020 FortisBC CPR were used to define the percent split between the commercial and industrial sectors.
2. The industrial sector breakdown for Northern BC in the 2020 FortisBC CPR was used to define the account and consumption share by Industrial segment.
3. All values were rounded to whole numbers and adjusted where necessary to ensure the numbers still added up to the correct total.

It was estimated the industrial sector represented 9% of the accounts and 53% of the consumption in the rate classes that were not reviewed. The assumed account and consumption breakdowns of the rate classes that were not reviewed for the industrial sector are shown in Exhibit 116.

Exhibit 116 - Small Industrial Segment Breakdown

Segment	Account Breakdown	Consumption Breakdown
Agriculture	23.9%	18.4%
Chemical	1.8%	2.9%
Fabricated Metal	2.8%	4.6%
Food & Beverage	10.5%	8.4%
Manufacturing	33.9%	27.7%
Mining	6.9%	7.9%
Non-metallic Mineral	2.6%	3.4%
Pulp & Paper - Kraft	1.0%	1.9%
Utilities	5.1%	7.3%
Wood Products	11.3%	17.4%

6.2 Base Year Natural Gas Use

Base year (2020) industrial natural gas use is presented by segment in Exhibit 117, by end use in Exhibit 118, and by region in Exhibit 119. Natural gas consumption in the industrial sector base year is highest:

- In the mining, minerals, & metals (41%) and wood products (38%) segments
- In the product drying (37%) and direct-fired heating (35%) end uses
- In the West (West) region (53%)

Exhibit 117 – 2020 Industrial Natural Gas Consumption (GJ) by Segment

Segment	Consumption (GJ)	%
Agriculture	138,787	4%
Chemical	26,599	1%
District Energy	9,728	0%
Fabricated Metal	8,534	0%
Food & Beverage	36,285	1%
Manufacturing	52,936	2%
Mining, Minerals, & Metals[46]	1,296,637	41%
Pulp & Paper - Kraft	3,533	0%
Upstream Oil and Gas	204,708	7%
Utilities	175,528	6%
Wood Products	1,176,961	38%
Grand Total	**3,130,235**	**100%**

46 The following segments were combined to protect confidential information: Non-metallic mineral, primary metals, and mining.

Exhibit 118 – 2020 Industrial Natural Gas Consumption (GJ) by End Use

Parent End Use	Consumption (GJ)	%
Direct Gas Use	9,185	0%
Direct-fired Heating	1,106,035	35%
Heat Treating	9,885	0%
Kilns	2,884	0%
On-Site Generation	175,528	6%
Other	118,838	4%
Ovens	322	0%
Process Boilers	274,652	9%
Product Drying	1,146,455	37%
Space Heating	238,251	8%
Water Heaters	48,201	2%
Grand Total	**3,130,235**	**100%**

Exhibit 119 – 2020 Industrial Natural Gas Consumption (GJ) by Region

Regions	Consumption (GJ)	%
Northeast	435,461	14%
West (West)	1,651,732	53%
West (East)	1,043,042	33%
Grand Total	**3,130,235**	**100%**

6.2.1 Accounts

Base year industrial natural gas accounts are presented by segment in Exhibit 120 and by region in Exhibit 121. As shown in these exhibits, in 2020 the greatest number of industrial natural gas accounts were in:

- The manufacturing (27%), agriculture (20%), and utilities (18%) segments
- The Northeast region (51%)

Exhibit 120 – 2020 Industrial Accounts by Segment

Segment	Accounts	%
Agriculture	102	20%
Chemical	8	2%
District Energy	1	0%
Fabricated Metal	12	2%
Food & Beverage	43	9%
Manufacturing	137	27%
Mining, Minerals, & Metals	39	8%
Pulp & Paper - Kraft	4	1%
Upstream Oil and Gas	10	2%
Utilities	92	18%
Wood Products	56	11%
Grand Total	**504**	**100%**

Exhibit 121 – 2020 Industrial Accounts by Region

Regions	Accounts	%
Northeast	257	51%
West (East)	130	26%
West (West)	117	23%
Grand Total	**504**	**100%**

6.2.2 Unit Energy Consumption

Unit energy consumption (UEC) is the amount of energy used by each end use per unit. Defining "units" is challenging in the industrial sector. In the residential sector, consumption is typically analyzed per dwelling, while in the commercial sector, consumption is analyzed per unit of floor area. In the industrial sector, consumption per unit of production capacity (kg of product, for example) would seem to be a useful approach. Unfortunately, the concept becomes inoperable when many different industries are included in the analysis. Nonetheless, it is desirable to have a way of representing growth in industries that is independent of changes in energy consumption caused by changes in fuel share or equipment efficiency. Therefore, the 'units' in the industrial sector are base year consumption, which is used as a proxy for the production capacity of different types of plants in each region and rate class.

Also presented in this section are *unit tertiary load*, which is the average tertiary load used by each end use in a dwelling, and *stock average efficiency*, which is the average efficiency of equipment serving the tertiary load for that end use. The UEC by end use is calculated by dividing unit tertiary load with stock average efficiency.

Tertiary load is the useful energy delivered to an end use. In the context of the CPR, tertiary load is the amount energy required to be delivered as an end use *service*. This number differs from consumption of natural gas, which is impacted by the efficiency of the equipment: in the furnace example, consumption is equal to the tertiary load divided by seasonal efficiency of furnaces.

Unlike the residential or commercial sectors, the end uses in the industrial sector are not common across the segments; rather, some end uses are specific to some segments. For example, the 'on-site generation' end use is only present in the 'utilities' segment. For the purposes of this report, UEC values are shown for one segment and region only, therefore UEC values are included only for the end uses that are present in that segment.

Unit tertiary load, stock average efficiency and UEC values for the Wood Products segment in the West (West) region are presented in Exhibit 122. This combination of segment and region was selected as the example because it is a significant consumer of gas and has enough accounts to ensure consumption from one account cannot be determined through the information presented in this report, thereby protecting customer privacy.

Exhibit 122 – 2020 UEC Values by End Use, Wood Products Segment in the West (West) Region

End Use	Unit Tertiary Load (GJ/unit/yr.)	Stock Average Efficiency (%)	UEC (GJ/unit/yr.)
Space Heating	0.03	56%	0.05
Direct-fired Heating	0.05	100%	0.05
Process Boilers	0.04	55%	0.08
Product Drying	0.56	65%	0.86
Water Heaters	0.03	63%	0.04
Grand Total	**0.15**	**65%**	**0.22**

6.2.3 Average Natural Gas Use per Account

Details on natural gas consumption per account by end use are provided in Exhibit 123 for an average Wood Products account in the West (West) region. The following information is included in this exhibit:

- UEC: The amount of energy used by each end use per unit (a "unit" in the industrial sector is based on production capacity. Please see Section 0 for a discussion of a "unit" in the industrial sector.
- Fuel Share: The percentage of the energy end use that is supplied by each fuel (in this case, natural gas).
- Saturation: The extent to which an end use is present in a region, rate class and segment. In the industrial sector, saturation is either 100% or 0% because end uses are either used in a segment or are not.

Average annual gas consumption per unit would be calculated by multiplying these three variables. Similar to the UEC values presented in Section 0, only the end uses that are present in the segment and region are included.

Exhibit 123 – 2020 Average Annual Gas Use per Account by End Use,
Wood Products Account in West (West) Region

End Use	UEC (GJ/unit/yr.)	Fuel Share	Saturation	Average Annual Gas Use (GJ/yr.)
Space Heating	0.05	80%	100%	0.04
Direct-fired Heating	0.05	100%	100%	0.05
Process Boilers	0.08	93%	100%	0.07
Product Drying	0.86	93%	100%	0.81
Water Heaters	0.04	80%	100%	0.04
Grand Total	**0.22**	**89%**	**100%**	**0.20**

6.3 Reference Case Natural Gas Use

This section profiles the reference case base year (2020) and forecast (2021-2041) natural gas consumption for the industrial sector.

Reference case industrial natural gas consumption is presented by region in Exhibit 124, by segment in Exhibit 125, and by end use in Exhibit 126. These exhibits illustrate the following trends in consumption over the reference case:

- Overall gas consumption is forecasted to increase by approximately 1% between 2020 and 2041, but this increase is not evenly split between the regions, segments, or end uses. Some regions, segments, and end uses are forecasted to experience significant increases, while others are forecasted to remain stable.
- As shown in Exhibit 124, natural gas use in the Northeast region is forecasted to increase by 8%, while gas use in the West regions will remain relatively flat.
- As shown in Exhibit 125, natural gas use in the Mining, Minerals, & Metals, Fabricated Metal and Manufacturing segments are forecasted to increase by 39%, 22%, and 22%, respectively.
- As shown in Exhibit 126, natural gas use in the Ovens, Heat Treating, and Kilns end uses are forecasted to increase by 23%, 22%, and 22%, respectively.
- Despite the differences in forecasted natural gas use, the same regions, segments, and end uses as in the base year are expected to account for the largest shares of natural gas use in the industrial sector.

Exhibit 124 – 2020 vs 2041 Industrial Gas Consumption (GJ) by Region

Region	2020	2041	Change %
Northeast	435,461	469,751	8%
West (East)	1,043,042	1,045,359	0%
West (West)	1,651,732	1,654,904	0%
Grand Total	**3,130,235**	**3,170,014**	**1%**

Exhibit 125 – 2020 vs 2041 Industrial Gas Consumption (GJ) by Segment

Segment	2020	2041	Change %
Agriculture	138,787	146,884	6%
Chemical	26,599	27,659	4%
District Energy	9,728	9,728	0%
Fabricated Metal	8,534	10,370	22%
Food & Beverage	36,285	39,679	9%
Manufacturing	52,936	64,499	22%
Mining, Minerals, & Metals	1,296,637	1,301,670	39%
Pulp & Paper - Kraft	3,533	3,533	0%
Upstream Oil and Gas	204,708	204,708	0%
Utilities	175,528	177,872	1%
Wood Products	1,176,961	1,183,412	1%
Grand Total	**3,130,235**	**3,170,014**	**1%**

Exhibit 126 – 2020 vs 2041 Industrial Gas Consumption (GJ) by End Use

Parent End Use	2020	2041	Change %
Direct Gas Use	9,185	9,470	3%
Direct-fired Heating	1,106,035	1,108,452	0%
Heat Treating	9,885	12,029	22%
Kilns	2,884	3,517	22%
On-Site Generation	175,528	177,872	1%
Other	118,838	122,178	3%
Ovens	322	394	23%
Process Boilers	274,652	283,372	3%
Product Drying	1,146,455	1,154,734	1%
Space Heating	238,251	248,752	4%
Water Heaters	48,201	49,244	2%
Grand Total	**3,130,235**	**3,170,014**	**1%**

6.4 Measure Assessment

6.4.1 List of Measures

The list of industrial measures is presented in Exhibit 127 by industrial end uses.

Please see the MS Excel file titled "Ind Measure Analysis Workbook" for a description of each measure and a full analysis.

Measures were classified in four measure type categories:

- Building Envelope
- Equipment
- Controls
- Energy Management (including behavioural measures)

Exhibit 127 – Industrial Sector Conservation and Energy Management Measures

Process Boiler	Space Heating
Air Compressor Heat Recovery	Advanced Thermostat
Boiler Right-Sizing	Air Comp Heat Recovery
Condensing Boiler	Air Curtains
Direct Contact Hot Water Heater	Condensing Make Up Air Units
Economizer	Condensing Unit Heaters
Heat Recovery Systems	Destratification Fans
Improved Condensate Return	HE Rooftop Unit Controls
Pipe Insulation	HE Rooftop Units
Process Boiler Load Control	HVAC Boiler Tune-up
Process Boiler O_2 Control	HVAC Ventilation Optimization
Steam to Hot Water Conversion (District Energy)	Loading Dock Seals
Steam Traps	Solar Walls
Tank Insulation	
Venturi Steam Traps	

Other	Greenhouse
Combustion Testing	Greenhouse Curtains
Energy Management	Greenhouse Envelope
High-Efficiency Burners	Integrated Greenhouse Controls
High-Efficiency Dryers	
High-Efficiency Furnaces	
High-Efficiency Kilns	
High-Efficiency Ovens	
Process Control	
Regenerative Catalytic Oxidizer	
Veneer Dryers	

6.4.2 Results

Exhibit 128 shows measure-level results for the industrial sector in order of decreasing cost effectiveness. Measures were assessed based on their replacement type: **retrofit** (immediate replacement at full cost) or **replace on burnout** (end of life replacement at incremental cost).

The TRC and MTRC are presented at the measure-level and exclude program costs and free ridership.

Some key findings of the measure assessment for the industrial sector include:

- Of the 38 measures included in the assessment, 36 pass the TRC screen and 38 pass the MTRC screen.
- The most attractive equipment replacement measure is boiler right-sizing, with a TRC of 198.9. This measure involves replacing an oversized boiler at equipment end of life, with a smaller, right-sized boiler. The measure TRC is exceptionally high because the incremental measure cost is either negligible or may even be negative in some cases.
- The most attractive energy management measure is process control, which has the potential for significant energy savings at a moderate capital cost.
- The most attractive building envelope measure is the greenhouse envelope measure (#5), which, as shown in Exhibit 127, only applies to the greenhouse end use. The most attractive building envelope measure that applies to the space heating end use is the air curtain measure (#13).

Exhibit 128 – Industrial Sector Measures with Average TRC and MTRC Results

#	Measure	Measure Type	Replacement Type	TRC	MTRC	Simple Payback (yr.)
1	Boiler Right-Sizing	Equipment	ROB	198.9	717.1	0.1
2	Process Control (Ovens; Dryers; Kilns)	Energy Management	RET	52.3	237.3	0.1
3	Condensing Boiler	Equipment	ROB	11.3	40.9	1.4
4	Energy Management	Energy Management	RET	10.6	59.3	0.1
5	Tank Insulation	Equipment	RET	10.5	46.6	0.6
6	Greenhouse Envelope	Building Shell	RET	9.5	43.7	0.6
7	Combustion Testing	Energy Management	RET	9.3	50.5	0.2
8	Regenerative Catalytic Oxidizer	Energy Management	RET	8.8	35.9	1.1
9	Integrated Greenhouse Environmental Controls	Energy Management	RET	7.7	31.0	1.1

#	Measure	Measure Type	Replacement Type	TRC	MTRC	Simple Payback (yr.)
10	Pipe Insulation	Energy Management	RET	5.5	22.0	1.6
11	High Efficiency Dryers	Equipment	ROB	5.4	20.8	2.7
12	Replace Steam Traps	Equipment	RET	4.8	25.9	0.6
13	Air Curtain	Building Shell	RET	4.8	19.2	1.5
14	Condensing MAU Unit	Equipment	ROB	4.8	17.9	2.5
15	High Efficiency Ovens	Equipment	ROB	4.3	17.3	2.3
16	High Efficiency Burners	Equipment	RET	4.3	17.3	2.3
17	Direct Contact Hot Water Heater	Equipment	ROB	4.1	15.5	2.8
18	Boiler Tune-Up	Energy Management	RET	3.4	18.7	0.7
19	Venturi Steam Trap	Equipment	RET	2.8	13.1	1.8
20	Heat Recovery Systems	Energy Management	RET	2.8	11.4	3.0
21	Process Boiler Load Control	Controls	RET	2.7	12.6	1.9
22	Advanced Thermostats	Energy Management	RET	2.7	9.9	2.3
23	Advanced Veneer Dryer	Equipment	ROB	2.6	10.3	2.9
24	Condensing Unit Heaters	Equipment	ROB	2.5	9.5	4.3
25	Improved Condensate Return (Retrofit)	Energy Management	RET	2.3	9.2	3.7
26	HVAC Ventilation Optimization	Energy Management	RET	2.1	11.4	1.1
27	Economizer	Equipment	RET	2.1	7.7	5.5
28	Air Compressor Heat Recovery (Process Heating)	Equipment	ROB	2.0	7.9	4.3
29	Solar Wall	Energy Management	RET	1.8	6.2	11.7
30	Air Compressor Heat Recovery (Space Heating)	Equipment	ROB	1.6	6.6	5.2
31	Greenhouse Curtains	Building Shell	RET	1.5	6.8	3.6
32	Destratification Fan	Energy Management	RET	1.5	5.9	5.9
33	HE Furnace	Equipment	RET	1.4	5.2	7.9

#	Measure	Measure Type	Replacement Type	TRC	MTRC	Simple Payback (yr.)
34	High Efficiency RTU Controls	Energy Management	RET	1.3	5.2	4.7
35	Loading Dock Seals	Building Shell	RET	1.2	5.4	4.3
36	HVAC Boiler Tune Up	Energy Management	RET	1.0	5.6	1.3
37	High Efficiency Lumber Kilns	Equipment	ROB	0.9	4.0	6.7
38	Steam to Hot Water Conversion (District Energy)	Energy Management	RET	0.8	2.8	61.5

6.4.3 Measure Cost Sensitivity Analysis

Measure costs were originally developed for southern BC, which may have lower measure costs than in the PNG territory. As such, a sensitivity analysis of the measure costs was conducted, using a 30% price adder to reflect the potentially higher costs in the PNG service territory and determine to what extent achieving cost effective DSM may be more challenging in remote and smaller markets. The results of this sensitivity analysis are not reflected in the potential scenarios presented in this report.

Only two measure that previously passed the TRC test does not pass it in any region or segment with a 30% cost adder, HVAC boiler tune-up and loading dock seals. Two other measures previously passed the TRC test in all regions and segments but do not pass it with a 30% adder in at least one or more region or segment: destratification fan and high efficiency RTU controls.

All industrial measures pass the MTR test, including with the 30% price adder.

6.5 Technical Potential

This section provides an overview of the technical potential savings results for the industrial sector. The technical potential forecast includes the installation of all conservation measures that are technically feasible. Technical potential estimates ignore all non-engineering and financial constraints, such as cost-effectiveness and the willingness of end users to adopt measures. This scenario is included to estimate the theoretical maximum amount of energy use that could be captured by all energy efficiency measures.

Overall results are presented below, followed by measure level results and supply curves for the TRC and MTRC results.

As shown in Exhibit 129, the majority of the industrial technical potential (237 TJ) would be available in 2021 and would increase slowly until reaching 271 TJ in 2041, indicating most of the available potential would be from retrofit measures as opposed to replace on burnout measures. The forecasted industrial natural gas consumption for the industrial sector is included for reference.

Exhibit 129 – Industrial Technical Potential Savings (GJ)

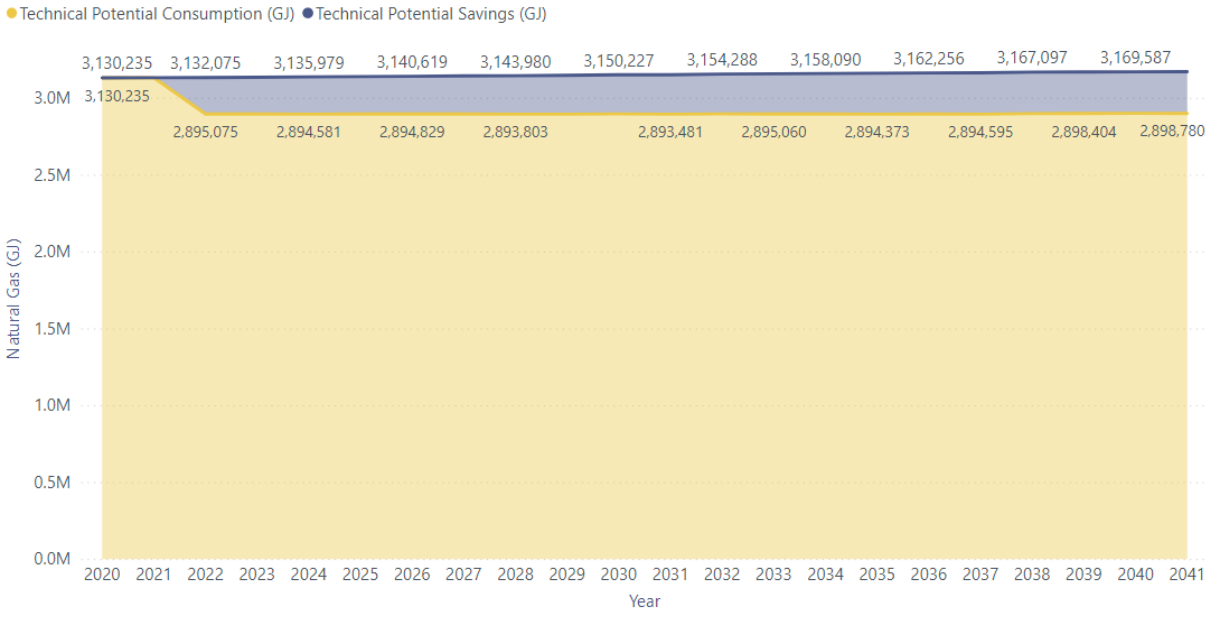
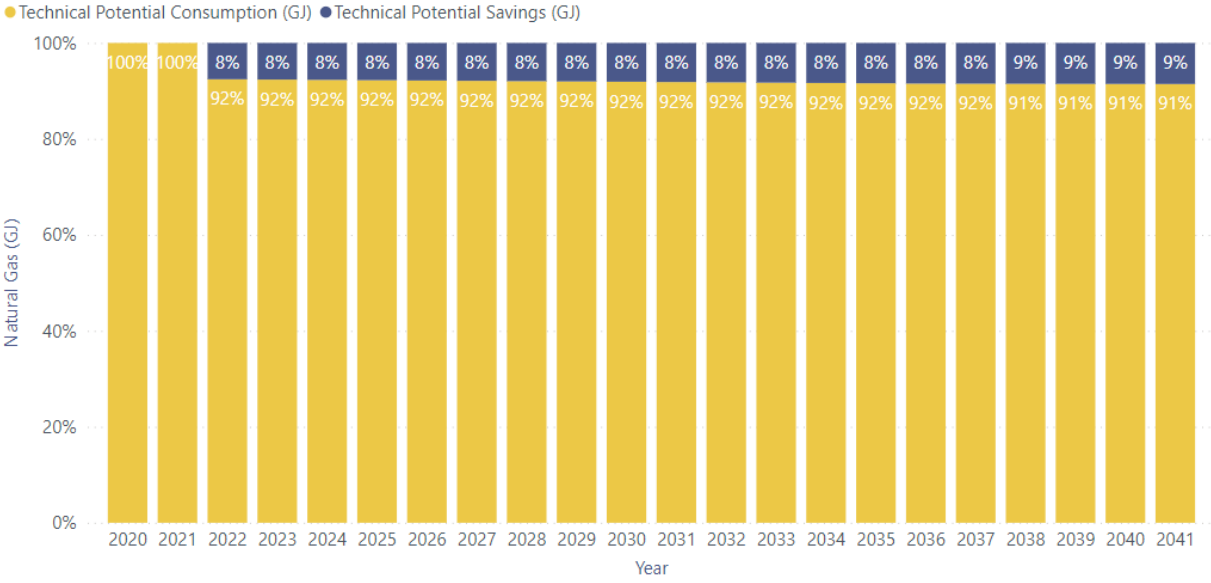


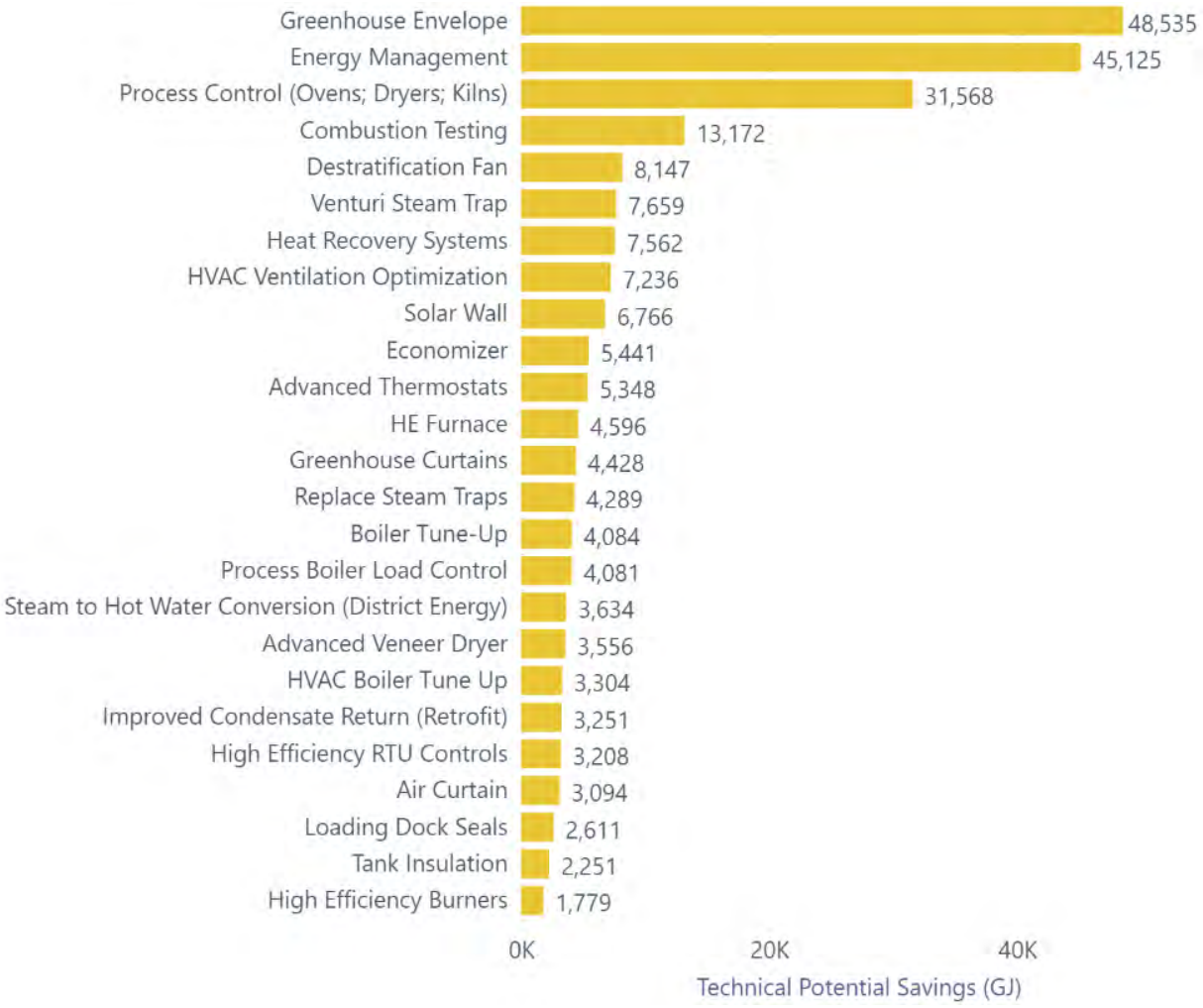
Exhibit 130 – Technical Potential Savings as a Percent of Industrial Reference Case Consumption (%)



As shown in Exhibit 130, the technical potential savings is about 8% of industrial reference case consumption in 2022 and increases to 9% by 2041, further indicating that most of the available potential would be from retrofit measures as opposed to replace on burnout measures.

The technical potential savings in 2024 broken down by the top 25 measures are presented in Exhibit 131. The top three measures (greenhouse envelope, energy management, and process control) are expected to contribute substantially to technical potential savings (approximately 49 TJ, 45 TJ, and 32 TJ by 2024). As shown in Exhibit 128, all three measures pass the TRC test, so they will also be expected to contribute to economic potential savings, as described in the following section. The one measure that passes the MTRC but fails the TRC, Steam to Hot Water Conversion, is in the top 25 of technical potential (#17 on the list below).

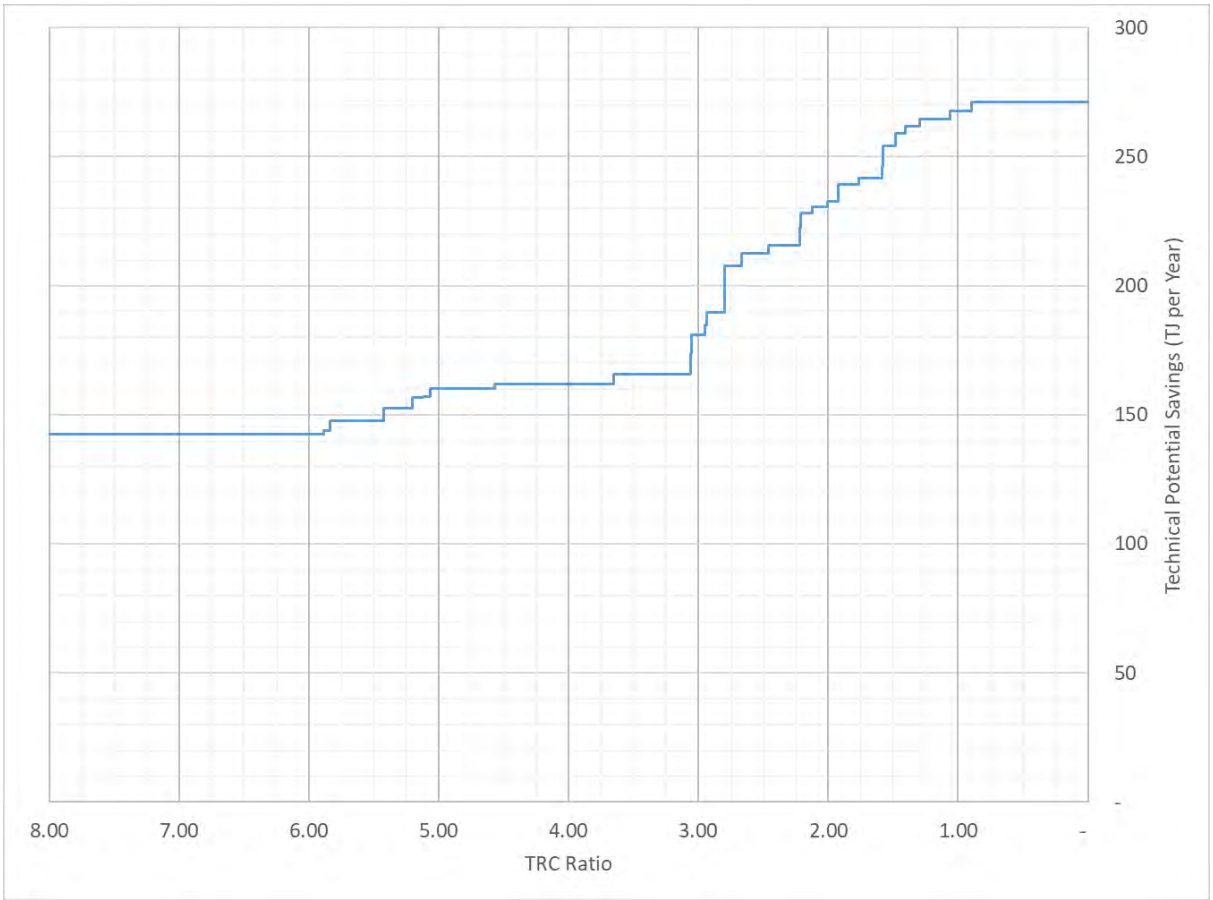
Exhibit 131 – Technical Potential – Top 25 Industrial Measures in 2024 (GJ)



The cumulative industrial sector technical potential savings in 2041 are presented in Exhibit 132 as a supply curve, with measures ordered by decreasing TRC ratio from left to right.

As shown, approximately 96% (260 out of 271 TJ) of the industrial sector technical potential savings by 2041 come from measures with a TRC of 1.0 or higher. Approximately 142 TJ of savings come from measures with a TRC ratio of greater than 8. These are shown in aggregate.

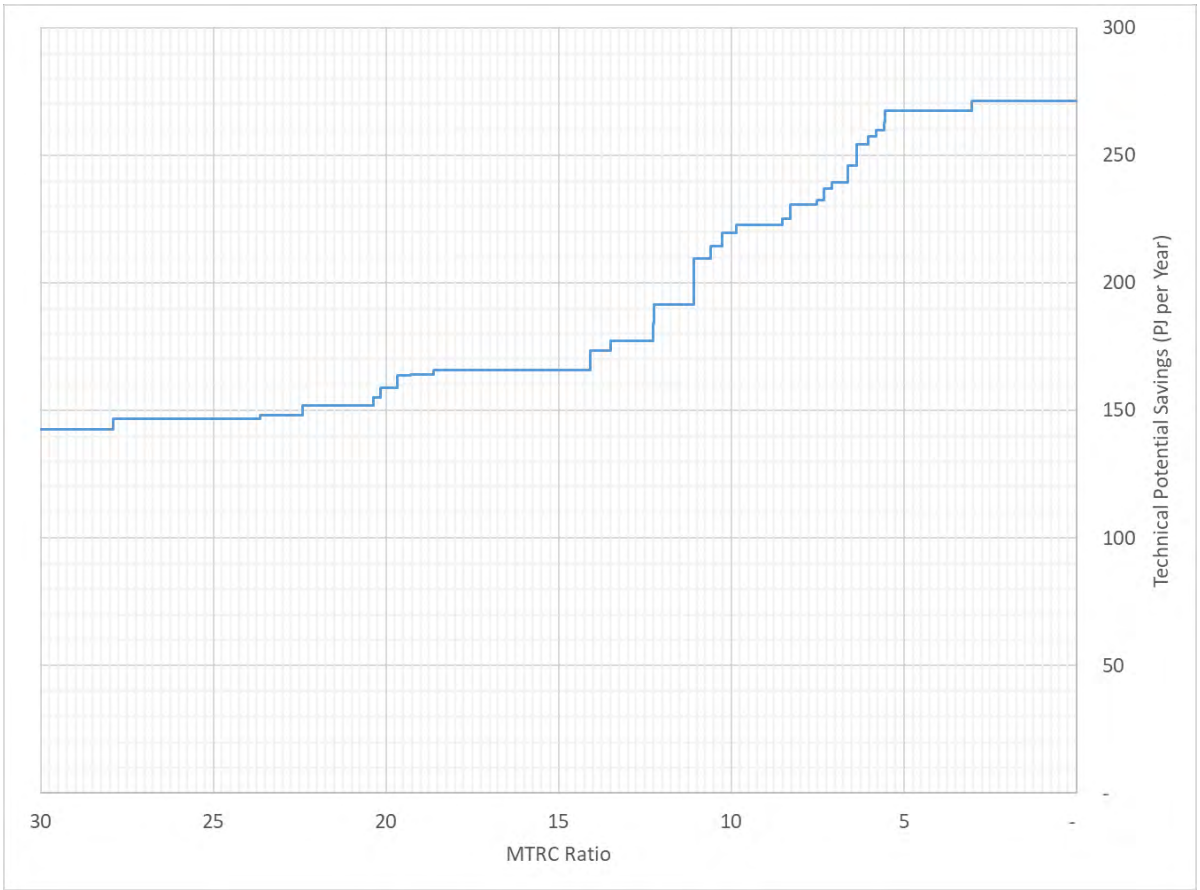
Exhibit 132 – Industrial Sector: Technical Potential Supply Curve, 2041 – TRC



Similar to Exhibit 132, the cumulative Industrial sector technical potential savings in 2041 are presented in Exhibit 133 as a supply curve, with measures ordered by decreasing MTRC ratio from left to right.

As shown, all the industrial sector technical potential savings (approximately 271 TJ) by 2041 come from measures with an MTRC of 1.0 or higher. Approximately 142 TJ of savings come from measures with an MTRC ratio of greater than 30. These results are shown in aggregate in Exhibit 133.

Exhibit 133 – Industrial Sector: Technical Potential Supply Curve, 2041 – MTRC

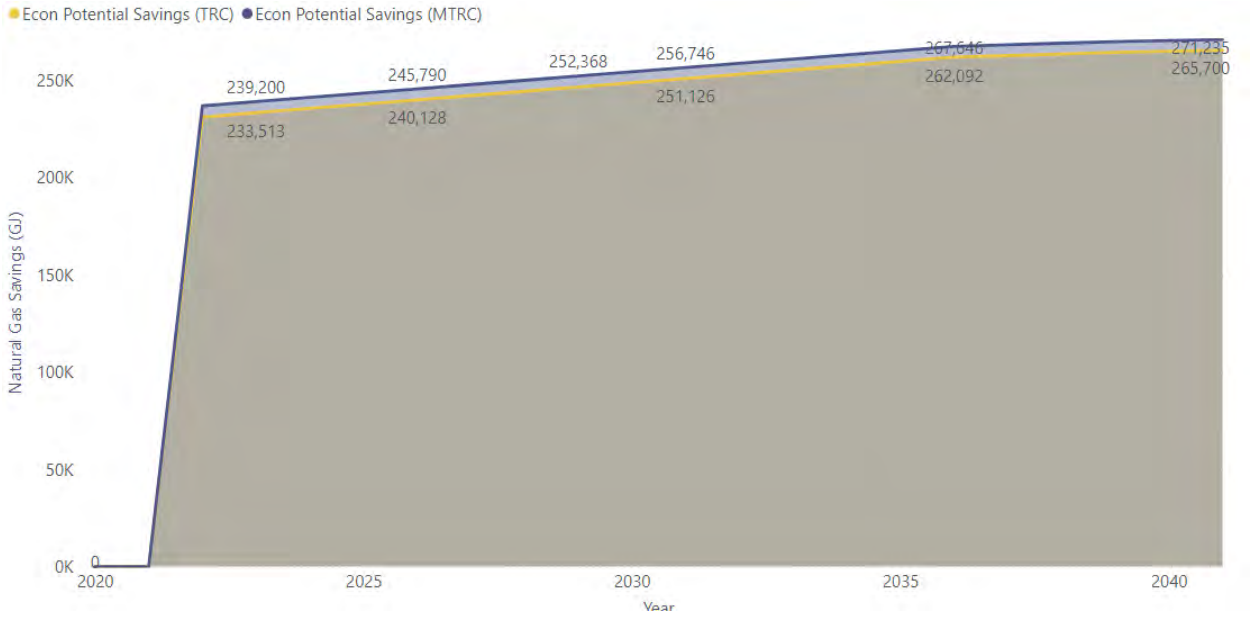


6.6 Economic Potential

This section provides an overview of the economic potential savings results. As was noted in section 6.3.2, 36 of the 38 measures examined have a TRC ratio over 1.0, so the difference between TRC and MTRC economic potential results for the Industrial sector is small.

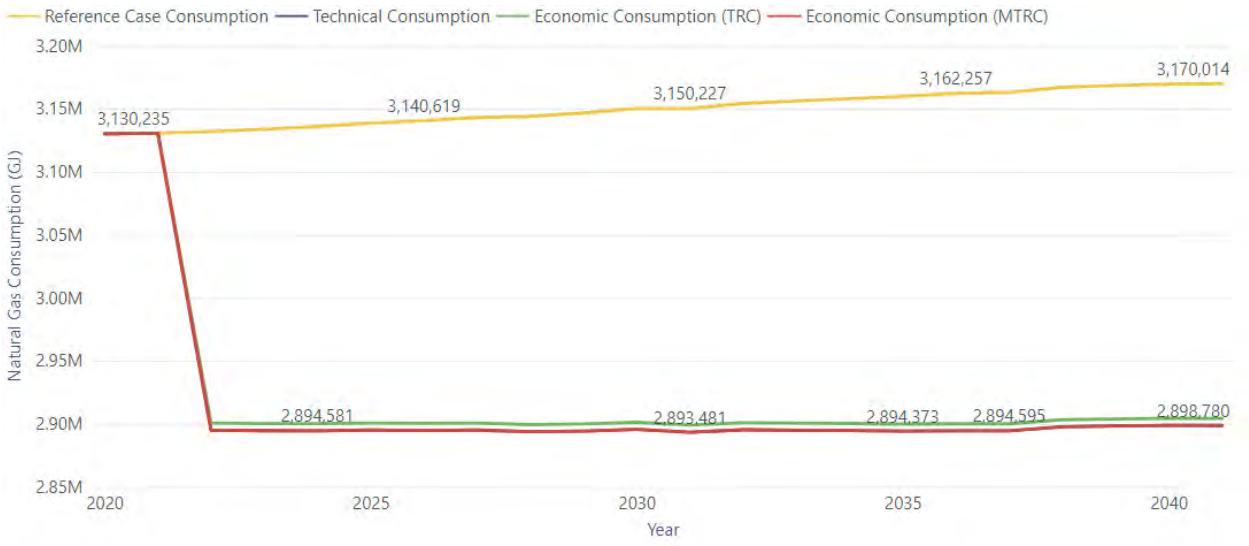
The industrial sector economic potential savings with a TRC screen and with an MTRC screen are shown in Exhibit 134. Although only two measures failed the TRC but pass the MTRC, the economic potential savings with an MTRC screen are approximately 5.7 TJ higher than with the TRC screen in 2024. This is because steam to hot water conversion (district energy) has a large technical potential (3.6 TJ) in 2024, as shown in Exhibit 131. Another way to look at it is that the 98% of the MTRC economic potential comes from measures that pass the TRC as well.

Exhibit 134 – Economic Potential Savings (GJ) - Industrial, TRC and MTRC



The forecasted gas consumption under the technical potential, economic potential with a TRC screen, economic potential with an MTRC screen, and reference case scenarios for the industrial sector are shown in Exhibit 135. The potential curves follow the shape of the reference case curve, as the replace on burnout measures are implemented at equipment end of life.

Exhibit 135 – Economic Potential Consumption (GJ) Forecasts – Industrial, TRC, and MTRC[47]



Results by Region

The economic potential savings in 2024 are presented by region in Exhibit 136 (TRC) and Exhibit 137 (MTRC). The highest level of economic potential savings (13%) is estimated to occur in the West (East) region.

Exhibit 136 – Economic Potential Savings by Region in 2024 – Industrial, TRC

Region	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
West (West)	1,652,083	41,814	3%
West (East)	1,043,293	138,386	13%
Northeast	440,603	55,520	13%
Total	**3,135,979**	**235,720**	**8%**

47 Because all measures pass the MTRC test, the economic consumption (MTRC) is the same as the technical consumption, so that line is hidden on the graph.

Exhibit 137 – Economic Potential Savings by Region in 2024 – Industrial, MTRC

Region	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
West (West)	1,652,083	41,817	3%
West (East)	1,043,293	139,688	13%
Northeast	440,603	59,892	14%
Total	**3,135,979**	**241,398**	**8%**

Results by Segment

The economic potential savings in 2024 are presented by segment in Exhibit 138 (TRC) and Exhibit 139 (MTRC). The highest percentage of economic potential savings are estimated to occur in the agriculture segment. The largest absolute economic potential savings are estimated to occur in the wood products segment.

Exhibit 138 – Economic Potential Savings by Segment in 2024 – Industrial, TRC

Segment	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Wood Products	1,177,825	119,057	10%
Agriculture	140,104	76,769	55%
Manufacturing	55,401	12,294	22%
Food & Beverage	36,732	8,990	24%
Utilities	175,528	5,266	3%
Chemical	26,599	4,572	17%
Mining	25,003	3,370	13%
Fabricated Metal	8,534	2,271	27%
District Energy	9,728	1,528	16%
Pulp & Paper - Kraft	3,533	889	25%
Non-metallic Mineral	6,381	714	11%
Primary Metals	1,265,903	0	0%
Upstream Oil and Gas	204,708	0	0%
Total	**3,135,979**	**235,720**	**8%**

Exhibit 139 – Economic Potential Savings by Segment in 2024 – Industrial, MTRC

Segment	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Wood Products	1,177,825	119,709	10%
Agriculture	140,104	77,778	56%
Manufacturing	55,401	12,759	23%
Food & Beverage	36,732	9,111	25%
Utilities	175,528	5,266	3%
District Energy	9,728	4,839	50%
Chemical	26,599	4,617	17%
Mining	25,003	3,374	13%
Fabricated Metal	8,534	2,322	27%
Pulp & Paper - Kraft	3,533	906	26%
Non-metallic Mineral	6,381	717	11%
Primary Metals	1,265,903	0	0%
Upstream Oil and Gas	204,708	0	0%
Total	**3,135,979**	**241,398**	**8%**

Results by End Use

The economic potential savings in 2024 are presented by end use in Exhibit 140 (TRC) and Exhibit 141 (MTRC). The highest percentages of economic potential savings are estimated to occur in the process boilers, heat treating, and space heating end uses.

Approximately 40% of the savings are attributable to the largest end uses: process boilers (distributed across all segments except utilities).

Exhibit 140 – Economic Potential Savings by End Use in 2024 – Industrial, TRC

Parent End Use	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Process Boilers	261,116	99,803	38%
Product Drying	971,472	73,725	8%
Space Heating	231,755	41,911	18%
Direct-fired Heating	1,102,948	10,372	1%
On-Site Generation	175,528	5,266	3%
Heat Treating	10,139	2,439	24%
Water Heaters	48,379	1,446	3%
Other	324,258	592	0%
Kilns	2,884	132	5%
Ovens	333	34	10%
Direct Gas Use	7,166	0	0%
Total	**3,135,979**	**235,720**	**8%**

Exhibit 141 – Economic Potential Savings by End Use in 2024 – Industrial, MTRC

Parent End Use	Ref Case Consumption (GJ)	Economic Potential Savings (GJ)	% of Consumption
Process Boilers	261,116	103,113	39%
Product Drying	971,472	73,725	8%
Space Heating	231,755	44,263	19%
Direct-fired Heating	1,102,948	10,372	1%
On-Site Generation	175,528	5,266	3%
Heat Treating	10,139	2,439	24%
Water Heaters	48,379	1,446	3%
Other	324,258	592	0%
Kilns	2,884	148	5%
Ovens	333	34	10%
Direct Gas Use	7,166	0	0%
Total	**3,135,979**	**241,398**	**8%**

The TRC and MTRC economic potential savings for 2041 are presented by end use in Exhibit 142. As only one measure passes the MTRC but not the TRC screen, most savings totals are the same, except for the process boilers end use and space heating (3.2 TJ and 2.2 TJ higher in MTRC respectively).

Exhibit 142 – Economic Potential Savings by End Use in 2041 – Industrial, TRC and MTRC

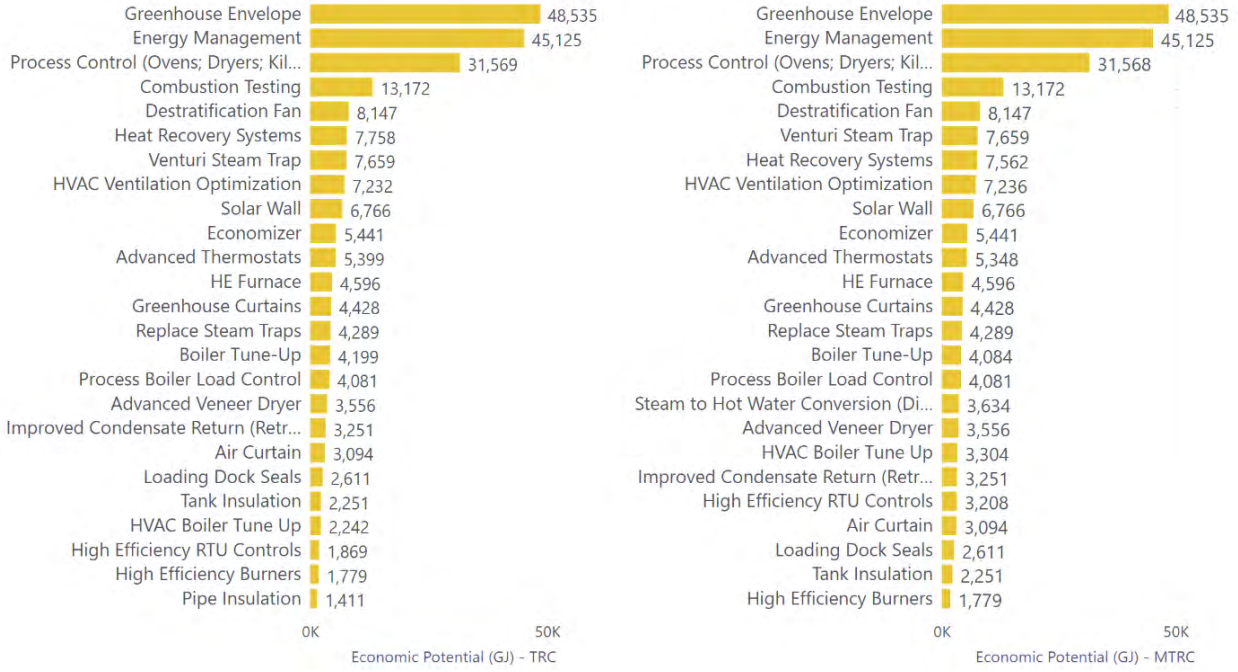
Parent End Use	Economic Savings (GJ) - TRC	Economic Savings (GJ) - MTRC	Difference (GJ)
Process Boilers	108,248	111,511	3,263
Space Heating	47,168	49,389	2,221
Kilns	132	183	51
Direct Gas Use	0	0	0
Direct-fired Heating	10,372	10,372	0
Heat Treating	2,439	2,439	0
On-Site Generation	5,266	5,266	0
Other	592	592	0
Ovens	78	78	0
Product Drying	89,958	89,958	0
Water Heaters	1,446	1,446	0
Total	**265,700**	**271,235**	**5,534**

Results by Measure

The economic potential savings in 2024 broken down by measure (only the top 25 measures are shown) are shown in Exhibit 143. The top measures in the TRC economic potential are shown on the left and the top measures in the MTRC scenario are shown on the right. As in the technical potential scenario, the top three measures (greenhouse envelope, energy management, and process control) are expected to contribute substantially to economic potential savings (approximately 48.5 TJ, 45.1 TJ, and 31.6 TJ by 2024).

The main difference between the two lists is the contribution of steam to hot water conversion (district energy) measure in the MTRC economic potential.

Exhibit 143 – Economic Potential (TRC on Left, MTRC on Right) - Top 25 Industrial Measures in 2024 (GJ)



6.7 Market Potential

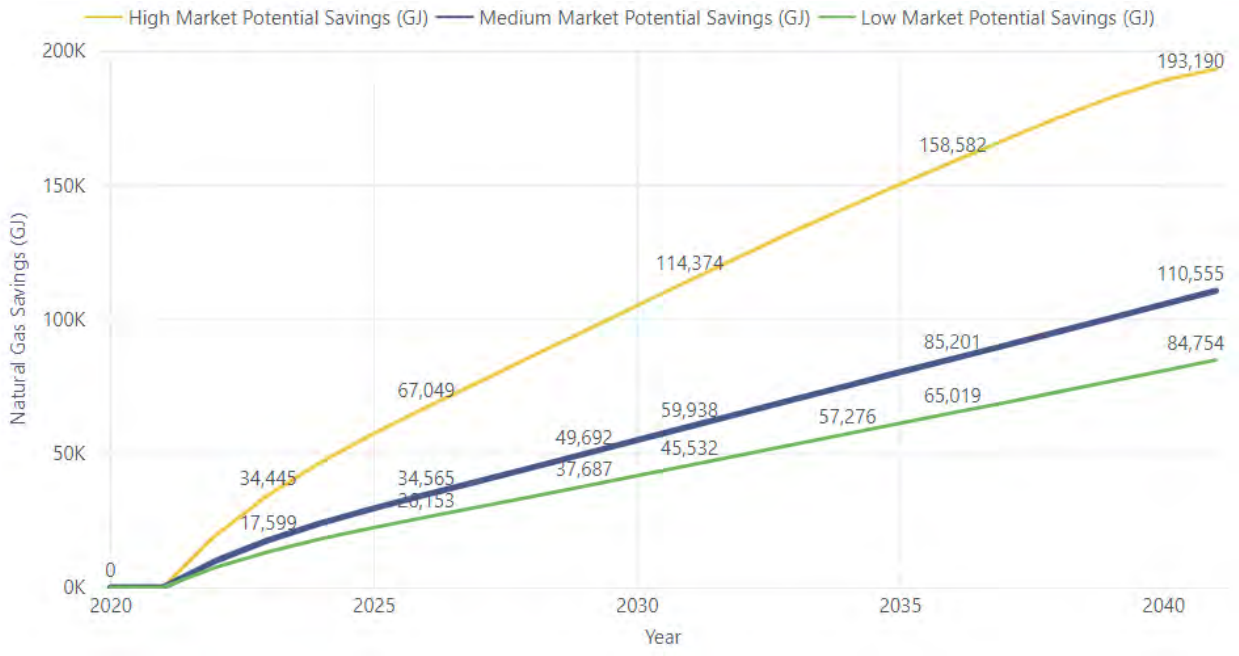
This section provides an overview of the low, medium, and high market potential results for the industrial sector.

Low, medium, and high scenarios assume that measure incentive levels will be 25%, 50% and 100% of incremental costs, respectively. For example, assume that a high-efficiency boiler may cost $10,000 more than a standard boiler, meaning the boiler would have an incremental cost of $10,000. In the medium scenario, this measure's hypothetical incentive from PNG would be $5,000. The other $5,000 would be paid by the end user. In all scenarios, the non-incentive program costs are assumed to be 15% of the incentive cost. In the example above, PNG's non-incentive spending would be $750. PNG's total cost for providing the measure to an end user would be $5,750.

The market potential savings results, with a TRC screen and with an MTRC screen, are shown in Exhibit 144 and Exhibit 145, respectively. These graphs are very similar because of the 38 measures included in the assessment, 36 pass the TRC screen and 38 pass the MTRC screen.

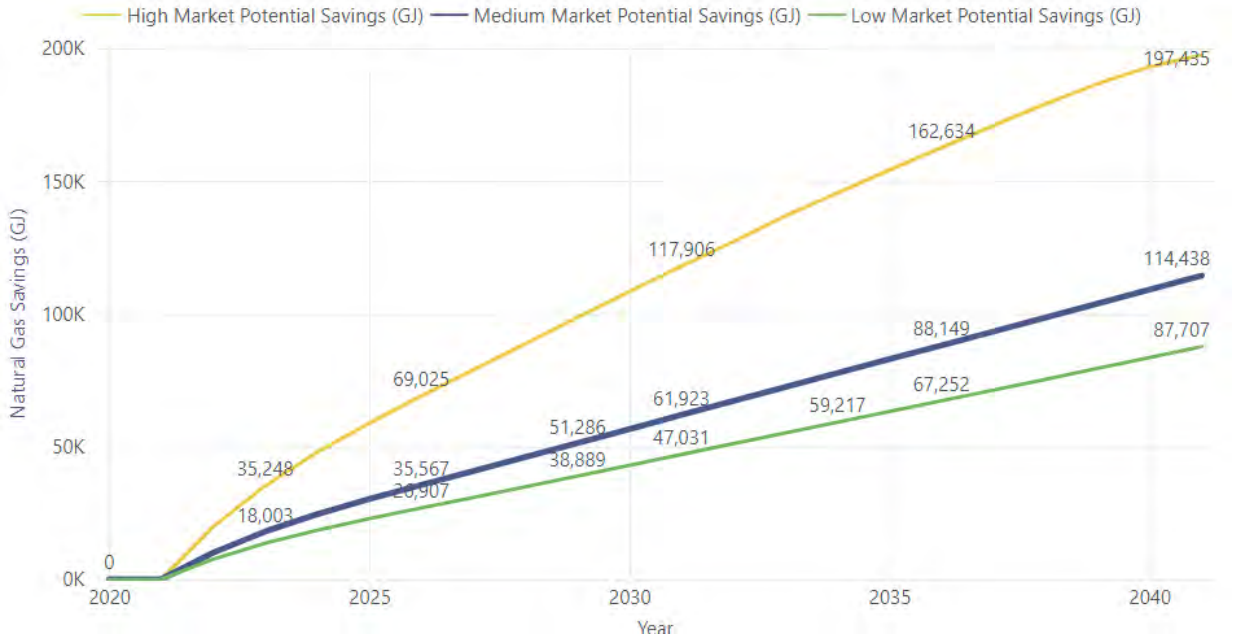
By 2040, the industrial low, medium, and high market TRC potential savings are estimated to be 80.7 TJ, 105.5 TJ, and 188.9 TJ, respectively.

Exhibit 144 – Market Potential Savings (GJ) – Industrial, TRC



By 2040, the industrial low, medium, and high market MTRC potential savings are estimated to be 83.5 TJ, 109.1 TJ, and 193.1 TJ, respectively.

Exhibit 145 – Market Potential Savings (GJ) – Industrial, MTRC



The market potential consumption results, with a TRC screen and with an MTRC screen, are shown in Exhibit 146 and Exhibit 147, respectively. These graphs are very similar because of the 38 measures included in the assessment, 36 pass the TRC screen and 38 pass the MTRC screen.

By 2040, the industrial low, medium, and high market TRC potential consumption levels are estimated to be 3090 TJ, 3060 TJ, and 2980 TJ, respectively, while reference consumption is forecasted to reach 3170 TJ.

By 2040, the industrial low, medium, and high market MTRC potential consumption levels are estimated to be 3090 TJ, 3060 TJ, and 2980 TJ, respectively, while reference consumption is forecasted to reach 3170 TJ.

Exhibit 146 – Market Potential Consumption (GJ) Forecasts – Industrial, TRC

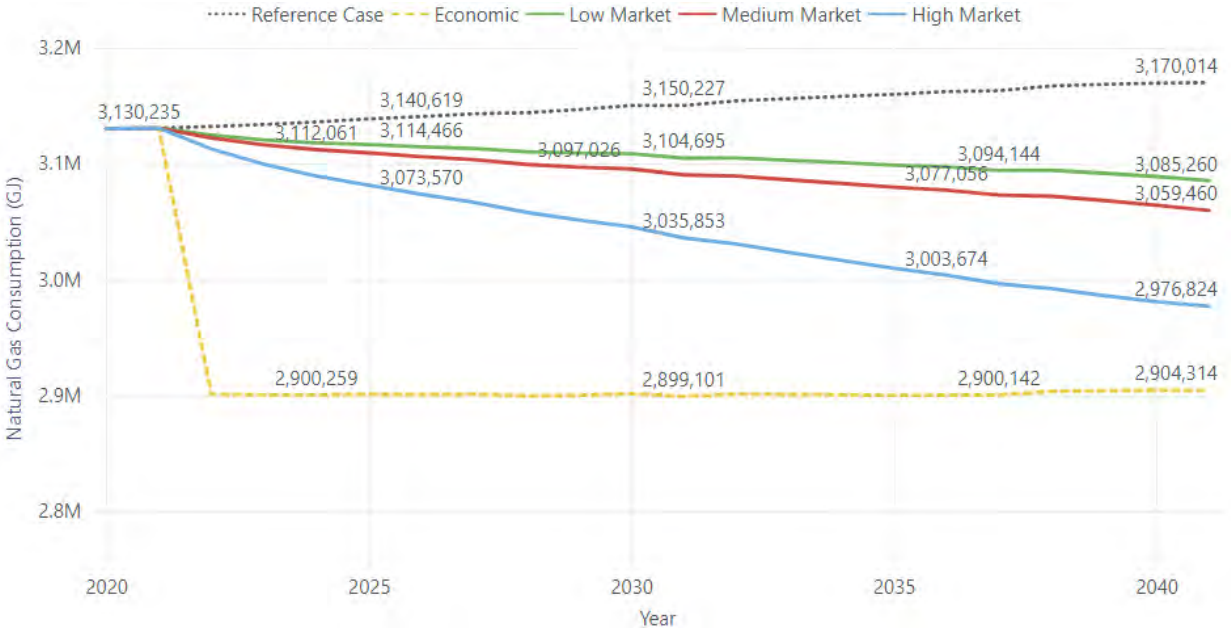
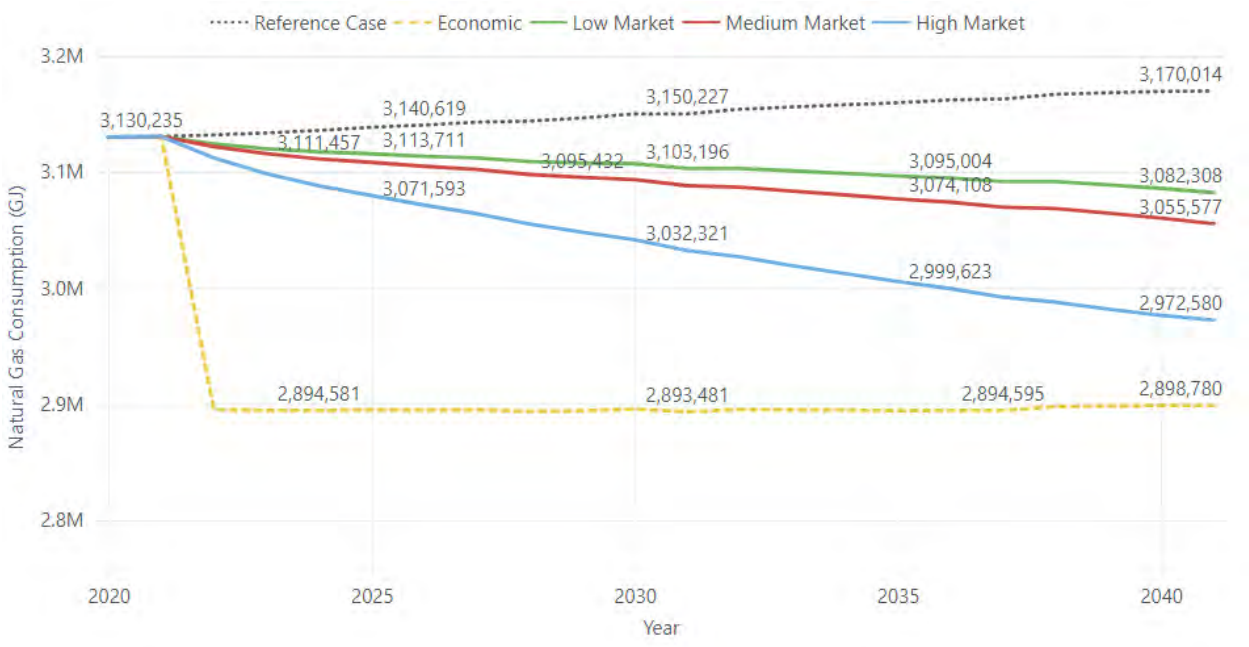


Exhibit 147 – Market Potential Consumption (GJ) Forecasts – Industrial, MTRC



The remainder of this section presents detailed results of the medium market potential scenario only. Similarly detailed results of the low and high market potential scenarios can be found on the Power BI dashboard and the Excel workbooks.

Results by Region

The medium market potential savings for 2024 are presented by region in Exhibit 148 (TRC) and Exhibit 149 (MTRC). TRC medium market potential savings for 2024 are estimated to be 1% of reference case consumption in all regions, other than West (West), where they are estimated to be less than 1%. The MTRC medium market potential percentages are the same as the TRC results.

Exhibit 148 – Medium Market Potential Savings by Region in 2024 – Industrial, TRC

Region	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
West (East)	1,043,293	14,374	1%
Northeast	440,603	5,319	1%
West (West)	1,652,083	4,225	0%
Total	**3,135,979**	**23,918**	**1%**

Exhibit 149 – Medium Market Potential Savings by Region in 2024 – Industrial, MTRC

Region	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
West (East)	1,043,293	14,407	1%
Northeast	440,603	5,890	1%
West (West)	1,652,083	4,226	0%
Total	**3,135,979**	**24,522**	**1%**

Results by Segment

The medium market potential savings for 2024 are presented by segment in Exhibit 150 (TRC) and Exhibit 151 (MTRC). In TRC medium market potential, the highest percentages savings are estimated to occur in the agriculture (5%) segment. The largest medium market potential savings (12.7 TJ) is estimated to occur in the wood products segment. In MTRC medium market potential, the highest percentages savings are estimated to occur in the agriculture (5%) and district energy (7%) segments. The largest medium market potential savings (12.7 TJ) is still from the wood products segment.

Exhibit 150 – Medium Market Potential Savings by Segment in 2024 – Industrial, TRC

Segment	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Wood Products	1,177,825	12,684	1%
Agriculture	140,104	7,414	5%
Manufacturing	55,401	1,090	2%
Food & Beverage	36,732	806	2%
Chemical	26,599	456	2%
Mining	25,003	424	2%
Utilities	175,528	378	0%
Fabricated Metal	8,534	296	3%
District Energy	9,728	152	2%
Pulp & Paper - Kraft	3,533	116	3%
Non-metallic Mineral	6,381	102	2%
Primary Metals	1,265,903	0	0%
Upstream Oil and Gas	204,708	0	0%
Total	**3,135,979**	**23,918**	**1%**

Exhibit 151 – Medium Market Potential Savings by Segment in 2024 – Industrial, MTRC

Segment	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Wood Products	1,177,825	12,703	1%
Agriculture	140,104	7,448	5%
Manufacturing	55,401	1,113	2%
Food & Beverage	36,732	812	2%
District Energy	9,728	667	7%
Chemical	26,599	457	2%
Mining	25,003	425	2%
Utilities	175,528	378	0%
Fabricated Metal	8,534	299	4%
Pulp & Paper - Kraft	3,533	118	3%
Non-metallic Mineral	6,381	102	2%
Primary Metals	1,265,903	0	0%
Upstream Oil and Gas	204,708	0	0%
Total	**3,135,979**	**24,522**	**1%**

Results by End Use

The medium market potential savings for 2024 are presented by end use in Exhibit 152 (TRC) and Exhibit 153 (MTRC). The highest percentages of economic potential savings are estimated to occur in heat treating (5% in both TRC and MTRC scenarios).

Under both economic screens, the majority of savings are attributable to the process boilers end uses (10.0 TJ for TRC and 10.5 TJ for MTRC, distributed across all segments except utilities).

Exhibit 152 – Medium Market Potential Savings by End Use in 2024 – Industrial, TRC

Parent End Use	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Process Boilers	261,116	9,995	4%
Product Drying	971,472	8,958	1%
Space Heating	231,755	2,980	1%
Direct-fired Heating	1,102,948	948	0%
Heat Treating	10,139	483	5%
On-Site Generation	175,528	378	0%
Water Heaters	48,379	104	0%
Other	324,258	58	0%
Kilns	2,884	10	0%
Ovens	333	5	1%
Direct Gas Use	7,166	0	0%
Total	**3,135,979**	**23,918**	**1%**

Exhibit 153 – Medium Market Potential Savings by End Use in 2024 – Industrial, MTRC

Parent End Use	Ref Case Consumption (GJ)	Medium Market Potential Savings (GJ)	% of Consumption
Process Boilers	261,116	10,510	4%
Product Drying	971,472	8,958	1%
Space Heating	231,755	3,067	1%
Direct-fired Heating	1,102,948	948	0%
Heat Treating	10,139	483	5%
On-Site Generation	175,528	378	0%
Water Heaters	48,379	104	0%
Other	324,258	58	0%
Kilns	2,884	13	0%
Ovens	333	5	1%
Direct Gas Use	7,166	0	0%
Total	**3,135,979**	**24,522**	**1%**

The TRC and MTRC medium market potential savings for 2040 are presented by end use in Exhibit 154. As only two measures pass the MTRC but not the TRC screen, most savings totals are the same, except for the process boilers end use (685 GJ higher in MTRC), space heating end use (116 GJ higher in MTRC), and the kilns end use (3 GJ higher in MTRC).

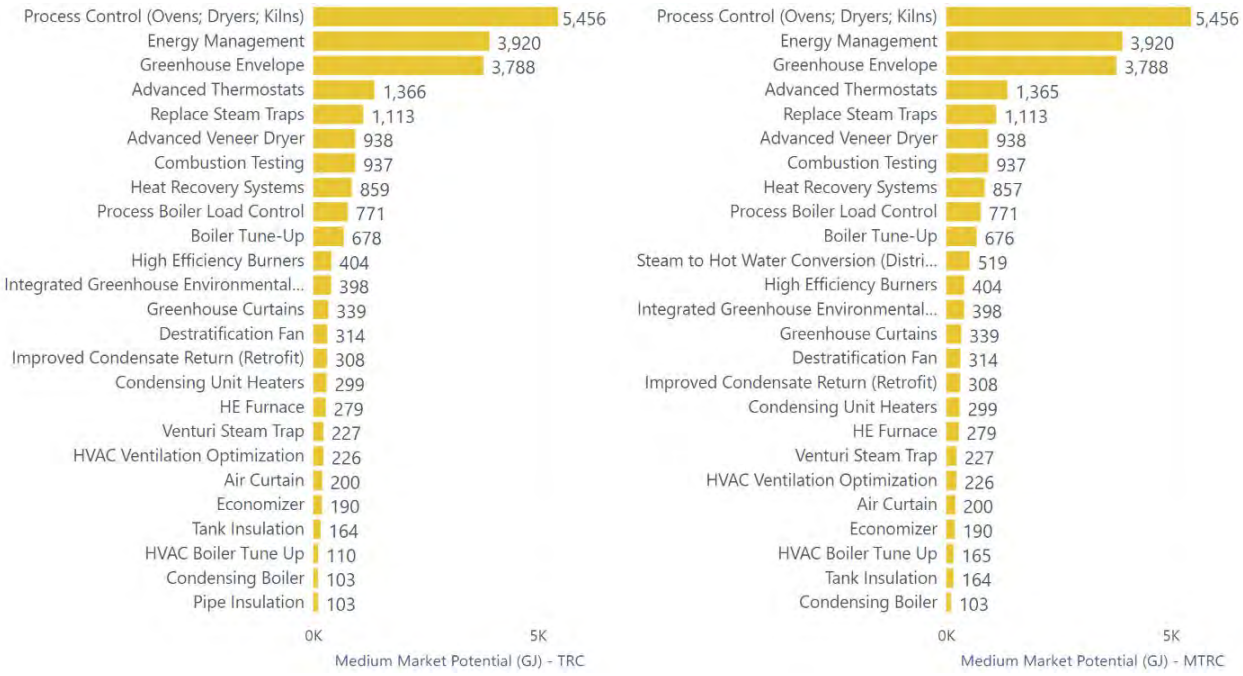
Exhibit 154 – Medium Market Potential Savings by End Use in 2040 – Industrial, TRC and MTRC

Parent End Use	Medium Potential Savings (GJ) - TRC	Medium Potential Savings (GJ) - MTRC	Difference (GJ)
Process Boilers	12,929	13,614	685
Space Heating	3,718	3,834	116
Kilns	13	16	3
Direct Gas Use	0	0	0
Direct-fired Heating	1,122	1,122	0
Heat Treating	574	574	0
On-Site Generation	466	466	0
Other	73	73	0
Ovens	6	6	0
Product Drying	10,425	10,425	0
Water Heaters	128	128	0
Total	**29,454**	**30,257**	**804**

Results by Measure

The total medium market potential savings (GJ per year) in 2024 of each of the top 25 industrial measures are shown in Exhibit 155, sorted by decreasing potential. As in the technical and economic potential scenarios, the top three measures (process control, greenhouse envelope, and energy management) are expected to contribute a large portion of the medium market potential savings (approximately 5.46 TJ, 3.92 TJ, and 3.79 TJ in 2024).

Exhibit 155 – Medium Market Potential (TRC on Left, MTRC on Right) - Gas Savings from Top 25 Industrial Measures in 2024 (GJ)



6.7.1 Incentive and Non-Incentive Spending

The incentive and non-incentive spending required to achieve the medium and high market potential are shown in Exhibit 156 (TRC) and Exhibit 158 (MTRC). Medium and high market incentives are assumed to be 50% and 100% of measures' incremental costs, respectively. In both medium and high scenarios, non-incentive costs are estimated to be 15% of incentive costs. The tables also show the total as well as incremental savings every year (that is, savings from new measures installed in a year).

Exhibit 156 – Medium and High Market Incentive Costs and Natural Gas Savings – Industrial, TRC

Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$49K	$7K	$57K	9,869	9,869	$5.73	$196K	$15K	$210K	19,385	19,385	$10.85
2023	$48K	$7K	$55K	17,599	7,730	$3.12	$189K	$14K	$203K	34,445	15,060	$5.88
2024	$46K	$7K	$53K	23,918	6,318	$2.20	$180K	$14K	$194K	46,666	12,221	$4.15
2025	$44K	$7K	$50K	29,454	5,536	$1.71	$173K	$13K	$186K	57,298	10,632	$3.24
2026	$43K	$6K	$50K	34,565	5,111	$1.43	$169K	$13K	$182K	67,049	9,750	$2.71
2027	$43K	$6K	$50K	39,590	5,025	$1.26	$169K	$13K	$181K	76,559	9,510	$2.37
2028	$44K	$7K	$51K	44,623	5,033	$1.14	$172K	$13K	$184K	86,014	9,455	$2.14
2029	$46K	$7K	$52K	49,692	5,069	$1.05	$177K	$13K	$190K	95,470	9,455	$1.99
2030	$48K	$7K	$55K	54,820	5,128	$1.00	$184K	$14K	$198K	104,963	9,494	$1.89
2031	$50K	$7K	$57K	59,938	5,118	$0.95	$192K	$14K	$206K	114,374	9,411	$1.81
2032	$51K	$8K	$59K	65,036	5,097	$0.90	$196K	$15K	$211K	123,684	9,309	$1.71
2033	$51K	$8K	$58K	70,127	5,092	$0.83	$195K	$15K	$210K	132,923	9,239	$1.58
2034	$49K	$7K	$57K	75,187	5,060	$0.75	$181K	$14K	$194K	141,621	8,698	$1.37
2035	$48K	$7K	$55K	80,207	5,020	$0.68	$173K	$13K	$186K	150,190	8,569	$1.24
2036	$47K	$7K	$54K	85,201	4,994	$0.63	$167K	$13K	$180K	158,582	8,392	$1.13
2037	$47K	$7K	$54K	90,218	5,017	$0.60	$163K	$12K	$176K	166,857	8,275	$1.05
2038	$48K	$7K	$55K	95,265	5,047	$0.57	$161K	$12K	$173K	175,020	8,163	$0.99
2039	$48K	$7K	$55K	100,338	5,073	$0.55	$142K	$11K	$153K	182,499	7,479	$0.84
2040	$49K	$7K	$57K	105,450	5,112	$0.54	$108K	$8K	$116K	188,886	6,387	$0.61
2041	$50K	$8K	$58K	110,555	5,105	$0.52	$87K	$7K	$94K	193,190	4,305	$0.49
Total	**$948K**	**$142K**	**$1,090K**	**1,241,652**	**110,555**	**$0.88**	**$3,374K**	**$253K**	**$3,627K**	**2,315,675**	**193,190**	**$1.57**

Exhibit 157 – Medium and High Market Total Costs per Natural Gas Savings – Industrial, TRC

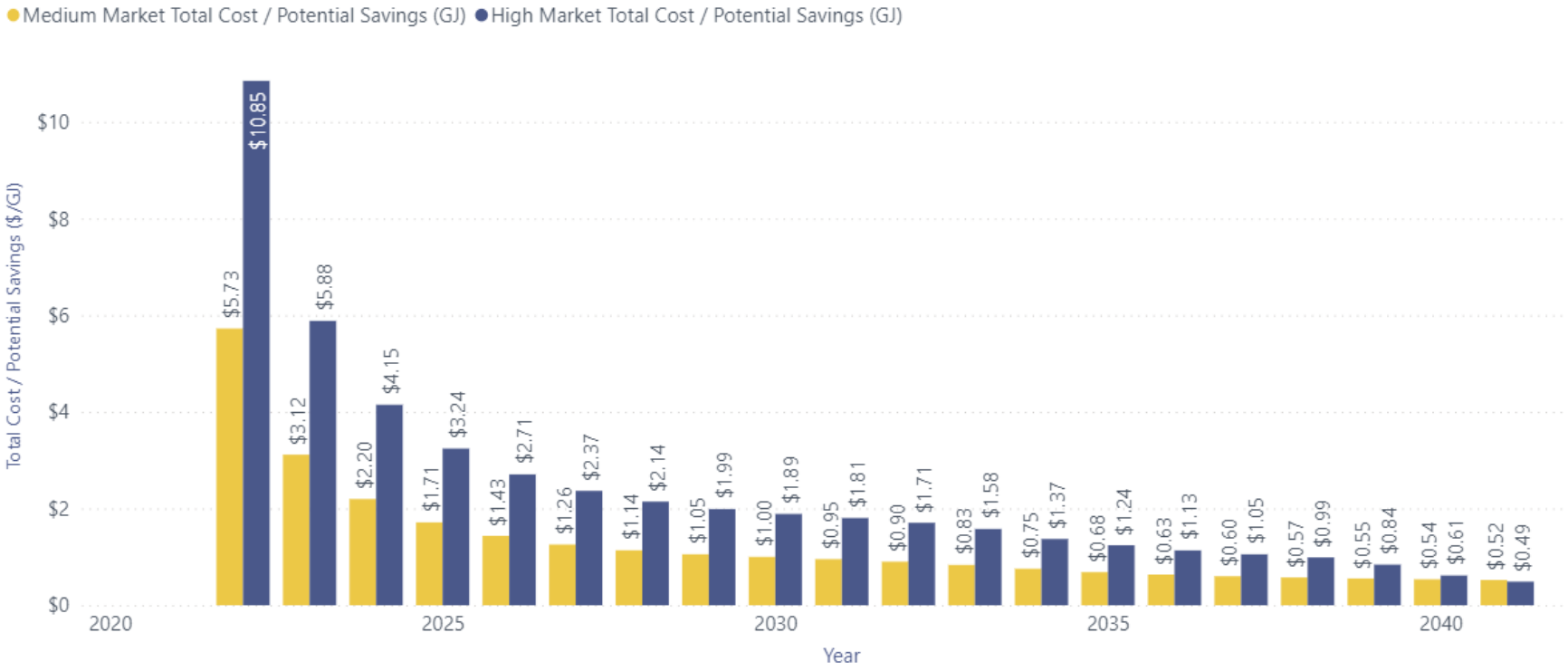
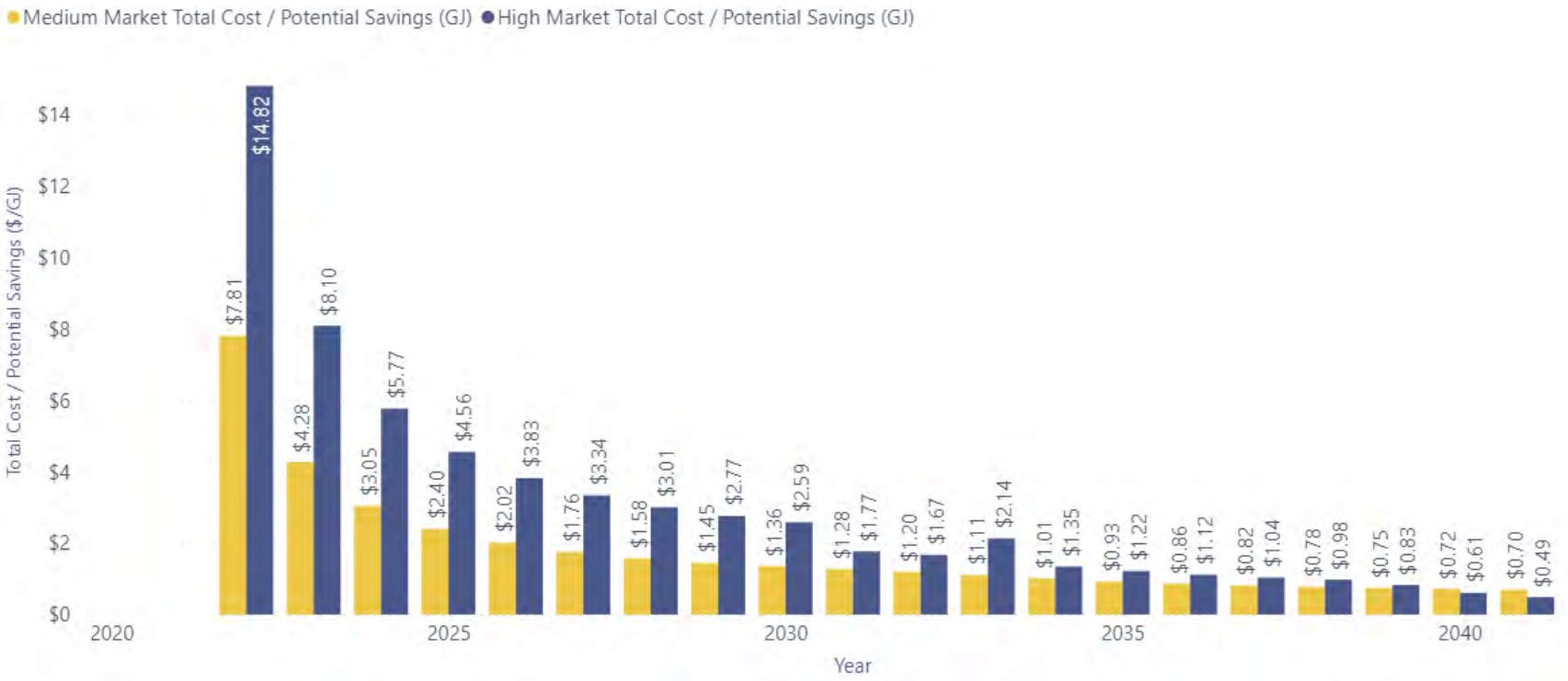


Exhibit 158 – Medium and High Market Incentive Costs and Natural Gas Savings – Industrial, MTRC

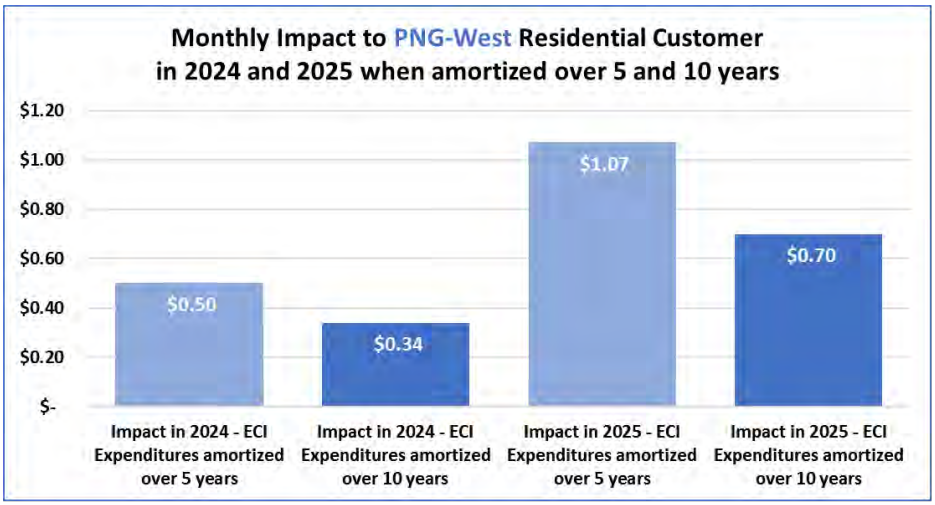
Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total Costs	High Market Potential Savings (GJ)	High Incremental Savings (Year-over-Year, GJ)	High Market Total Cost / Potential Savings (GJ)
2022	$68K	$10K	$79K	10,072	10,072	$7.81	$273K	$20K	$293K	19,789	19,789	$14.82
2023	$67K	$10K	$77K	18,003	7,931	$4.28	$266K	$20K	$285K	35,248	15,459	$8.10
2024	$65K	$10K	$75K	24,522	6,519	$3.05	$257K	$19K	$276K	47,864	12,616	$5.77
2025	$63K	$9K	$73K	30,257	5,735	$2.40	$250K	$19K	$268K	58,888	11,023	$4.56
2026	$62K	$9K	$72K	35,567	5,310	$2.02	$246K	$18K	$264K	69,025	10,138	$3.83
2027	$62K	$9K	$72K	40,791	5,223	$1.76	$245K	$18K	$264K	78,919	9,894	$3.34
2028	$63K	$9K	$73K	46,021	5,230	$1.58	$248K	$19K	$267K	88,755	9,836	$3.01
2029	$65K	$10K	$75K	51,286	5,265	$1.45	$254K	$19K	$273K	98,587	9,832	$2.77
2030	$67K	$10K	$77K	56,610	5,324	$1.36	$261K	$20K	$281K	108,454	9,867	$2.59
2031	$69K	$10K	$79K	61,923	5,313	$1.28	$194K	$15K	$209K	117,906	9,452	$1.77
2032	$70K	$11K	$81K	67,214	5,291	$1.20	$198K	$15K	$213K	127,256	9,350	$1.67
2033	$70K	$11K	$81K	72,499	5,285	$1.11	$272K	$20K	$292K	136,860	9,605	$2.14
2034	$69K	$10K	$79K	77,752	5,252	$1.01	$182K	$14K	$196K	145,596	8,736	$1.35
2035	$67K	$10K	$77K	82,964	5,213	$0.93	$175K	$13K	$188K	154,204	8,607	$1.22
2036	$66K	$10K	$76K	88,149	5,184	$0.86	$169K	$13K	$182K	162,634	8,430	$1.12
2037	$66K	$10K	$76K	93,355	5,206	$0.82	$165K	$12K	$178K	170,946	8,312	$1.04
2038	$67K	$10K	$77K	98,591	5,236	$0.78	$163K	$12K	$175K	179,146	8,200	$0.98
2039	$67K	$10K	$78K	103,851	5,260	$0.75	$144K	$11K	$155K	186,659	7,513	$0.83
2040	$68K	$10K	$79K	109,149	5,298	$0.72	$110K	$8K	$118K	193,087	6,429	$0.61
2041	$69K	$10K	$80K	114,438	5,289	$0.70	$89K	$7K	$96K	197,435	4,347	$0.49
Total	**$1,332K**	**$200K**	**$1,532K**	**1,283,016**	**114,438**	**$1.19**	**$4,162K**	**$312K**	**$4,474K**	**2,377,257**	**197,435**	**$1.88**

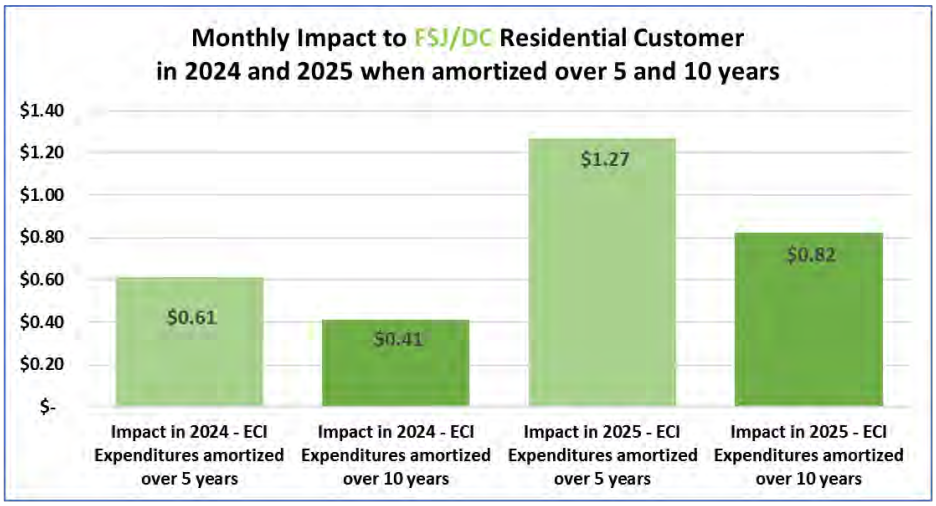
Exhibit 159 – Medium and High Market Total Costs per Natural Gas Savings – Industrial, MTRC

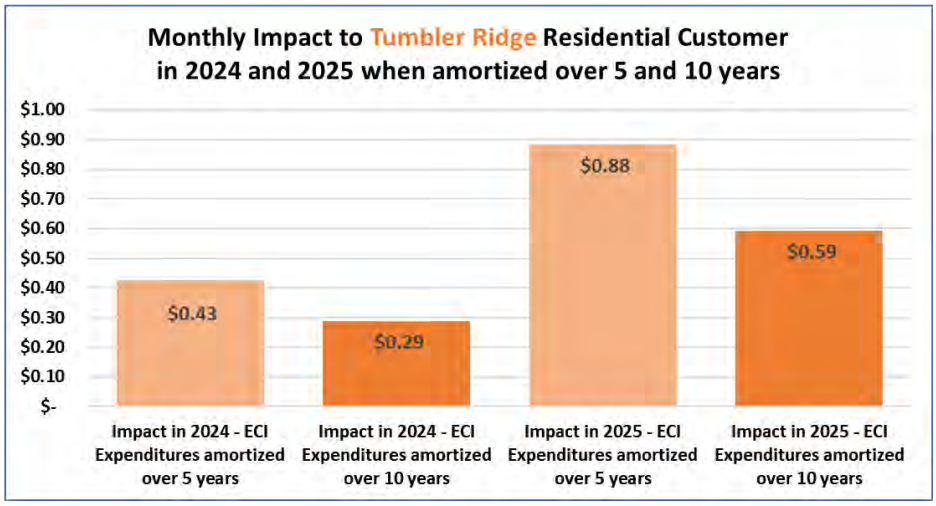


APPENDIX C: CUSTOMER BILL IMPACTS

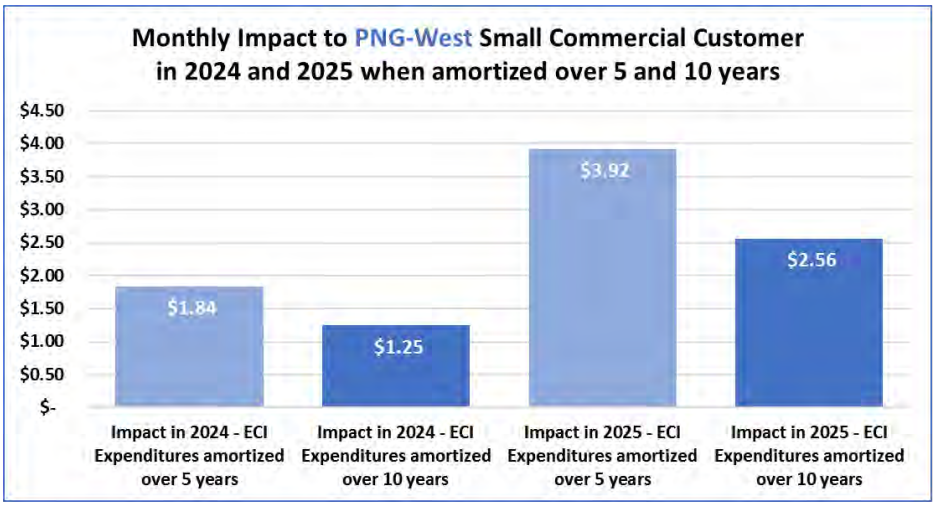
Residential Customers

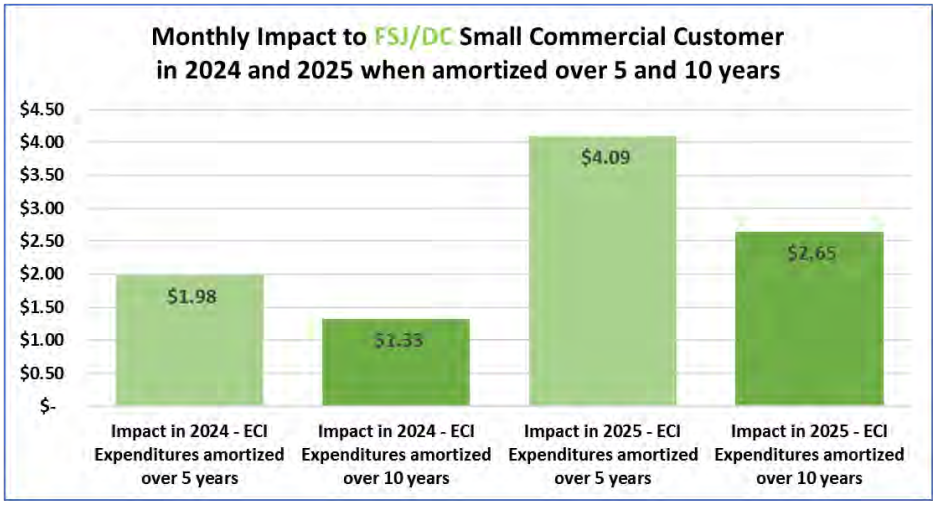


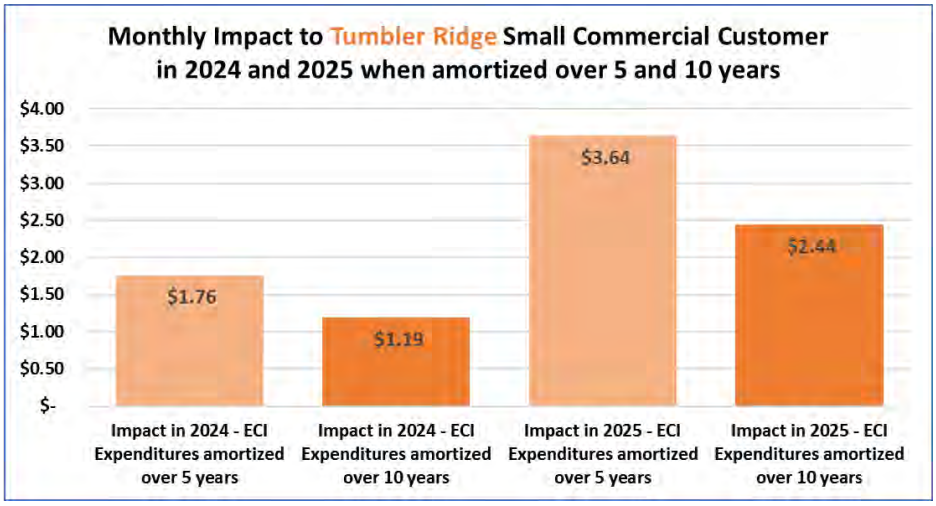




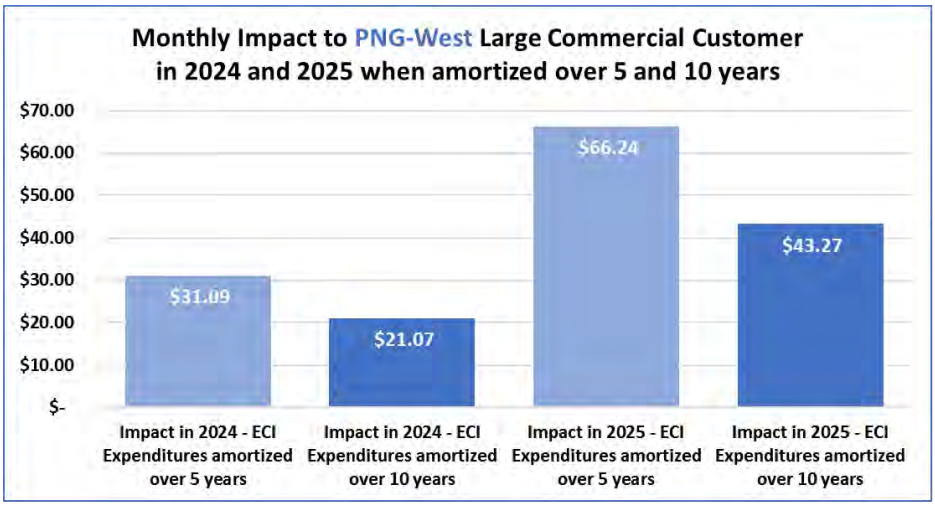
Small Commercial Customers

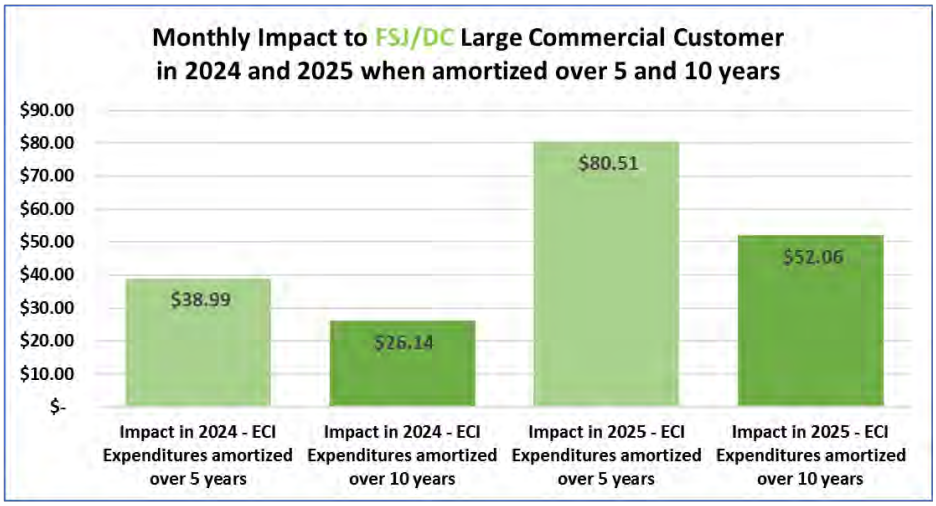


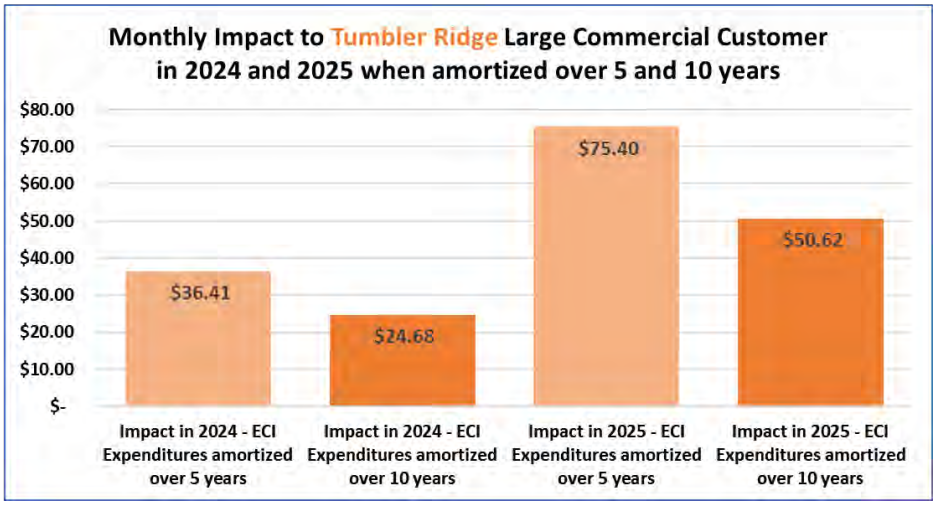




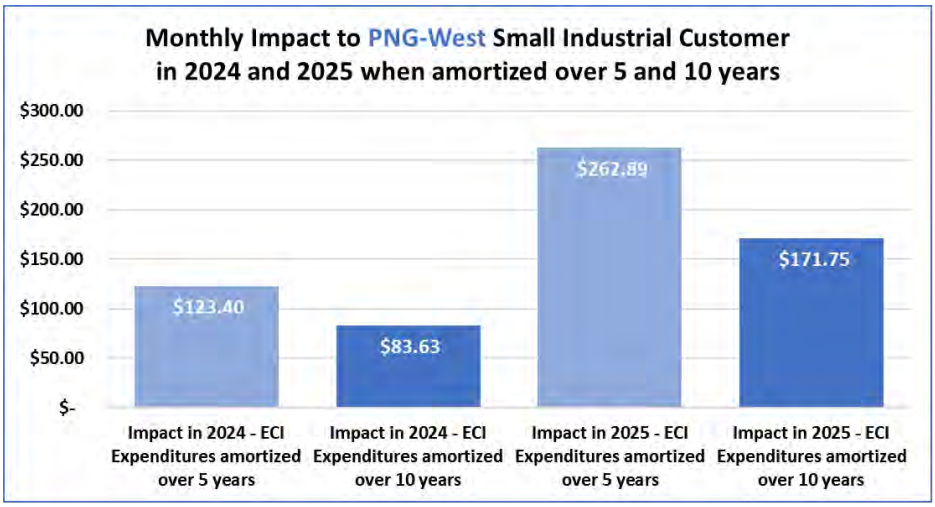
Large Commercial Customers

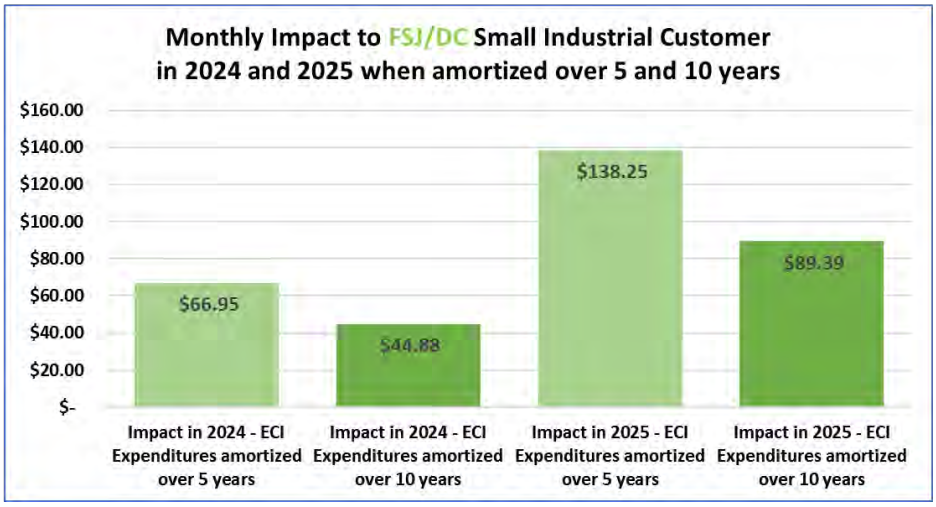






Small Industrial Customers





APPENDIX D: AVERAGE MEASURE LIFE OF THE 2023-2024 ECI PORTFOLIO

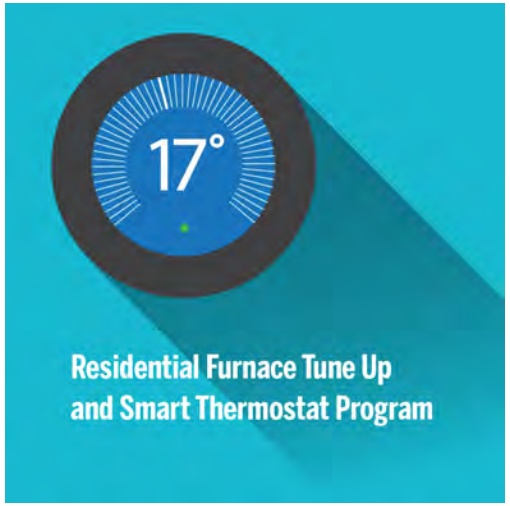
ANALYSIS OF THE BUDGET-WEIGHTED MEASURE LIFE FOR EACH PROGRAM AND THE PORTFOLIO WEIGHTED AVERAGE LIFE

Measure	2023-2024 Budget	Measure Life (years)	Cost-Years
Home heating tune-up	$ 10,000	2	$ 20,000
Home heating tune-up (Income Qualified)	$ 50,000	2	$ 100,000
Smart thermostat	$ 250,000	10	$ 2,500,000
Res. Hybrid heating with existing furnace	$ 150,000	15	$ 2,250,000
Res. Hybrid heating with new furnace	$ 180,000	15	$ 2,700,000
Heat Recovery Ventilator (HRV) - Retrofit	$ 60,000	14	$ 840,000
Heat Recovery Ventilator (HRV) - New Construction	$ 30,000	14	$ 420,000
Exterior wall cavity insulation	$ 4,800	30	$ 144,000
Attic – flat and cathedral ceiling insulation	$ 5,880	30	$ 176,400
HP windows and doors	$ 20,000	18	$ 360,000
Pipe Wrap	$ 238	15	$ 3,563
Low Flow Showerhead	$ 629	10	$ 6,288
Faucet Aerator	$ 71	10	$ 706
ENERGY STAR Clothes Washer	$ 6,750	14	$ 94,500
ENERGY STAR Dish Washer	$ 6,750	11	$ 74,250
Water Heater Wrap	$ 1,440	5	$ 7,200
Home heating equipment early replacement (Income Qualified)	$ 250,000	6	$ 1,500,000
ECAP	$ 63,000	12	$ 756,000
ESK	$ 24,323	10	$ 243,230
Early Efficient Boiler Replacement	$ 87,280	7	$ 610,961
Early Efficient Boiler Replacement for Non-Profits	$ 20,000	7	$ 140,000
Com. Hybrid heating with existing furnace	$ 81,000	15	$ 1,215,000
Com. Hybrid heating with new furnace	$ 72,900	15	$ 1,093,500
Gas Heat Pump	$ 50,000	18	$ 900,000
Efficient Water Heaters	$ 32,000	15	$ 480,000
Commercial - Pipe Wrap	$ 9,883	15	$ 148,238
Commercial - Low Flow Showerhead	$ 6,086	10	$ 60,864
Commercial - Faucet Aerator	$ 6,935	10	$ 69,354
Commercial - Water Heater Wrap	$ 1,440	5	$ 7,200
Pre-rinse spray valve	$ 3,500	5	$ 17,500
Commercial - Kitchen Aerator	$ 760	10	$ 7,600
Advanced Rooftop Unit Controls	$ 19,500	15	$ 292,500
Outdoor Boiler Reset Controls	$ 9,000	20	$ 180,000
Space Heating Boiler Tune Up	$ 4,800	3	$ 14,400
Automatic Blowdown Valve	$ 39,000	5	$ 195,000
Commercial - Advanced Thermostats	$ 3,750	15	$ 56,250
Energy Recovery Ventilator (ERV)	$ 61,238	14	$ 857,325
Reverse Flow Energy Recovery Ventilator (RF-ERV)	$ 70,000	14	$ 980,000
Custom with Payback Period	$ 400,000	15	$ 6,000,000
CEO (Elementary School)	$ 120,000	0	$ -
CEO (Post Secondary)	$ 60,000	0	$ -
CEO (General)	$ 180,000	0	$ -
Codes and Standards Support and Adoption	$ 70,000	0	$ -
Innovation (Hydrogen - Natural Gas Blending Study)	$ 600,000	0	$ -
Innovation (Deep Energy Retrofits)	$ 300,000	25	$ 7,500,000
Innovation (Other Miscellaneous)	$ 100,000	0	$ -
Enabling Activities	$ 287,500	0	$ -
Total	**$ 3,810,452**	**8.67**	**$33,021,829**
Budget-weighted Average (Cost-years/Budget)			

ANALYSIS OF THE GHG-SAVINGS-WEIGHTED MEASURE LIFE FOR EACH PROGRAM AND THE PORTFOLIO WEIGHTED AVERAGE LIFE

Measure	GHG Annual Savings (tCO2e)	Measure Life (years)	tCO2e-Years
Home heating tune-up	18	2	36
Home heating tune-up (Income Qualified)	36	2	72
Smart thermostat	188	10	1,879
Res. Hybrid heating with existing furnace	142	15	2,132
Res. Hybrid heating with new furnace	205	15	3,079
Heat Recovery Ventilator (HRV) - Retrofit	39	14	553
Heat Recovery Ventilator (HRV) - New Construction	13	14	186
Exterior wall cavity insulation	15	30	455
Attic – flat and cathedral ceiling insulation	4	30	126
HP windows and doors	4	18	70
Pipe Wrap	2	15	34
Low Flow Showerhead	2	10	20
Faucet Aerator	0	10	3
ENERGY STAR Clothes Washer	5	14	73
ENERGY STAR Dish Washer	1	11	8
Water Heater Wrap	1	5	5
Home heating equipment early replacement (Income Qualified)	106	6	638
ECAP	77	12	925
ESK	109	10	1,091
Early Efficient Boiler Replacement	278	7	1,943
Early Efficient Boiler Replacement for Non-Profits	20	7	137
Com. Hybrid heating with existing furnace	107	15	1,599
Com. Hybrid heating with new furnace	148	15	2,217
Gas Heat Pump	40	18	720
Efficient Water Heaters	53	15	796
Commercial - Pipe Wrap	13	15	200
Commercial - Low Flow Showerhead	7	10	73
Commercial - Faucet Aerator	1	10	9
Commercial - Water Heater Wrap	1	5	5
Pre-rinse spray valve	17	5	84
Commercial - Kitchen Aerator	0	10	1
Advanced Rooftop Unit Controls	12	15	182
Outdoor Boiler Reset Controls	16	20	316
Space Heating Boiler Tune Up	52	3	155
Automatic Blowdown Valve	55	5	275
Commercial - Advanced Thermostats	11	15	166
Energy Recovery Ventilator (ERV)	138	14	1,935
Reverse Flow Energy Recovery Ventilator (RF-ERV)	159	14	2,229
Custom with Payback Period	468	15	7,018
CEO (Elementary School)	-	0	-
CEO (Post Secondary)	-	0	-
CEO (General)	-	0	-
Codes and Standards Support and Adoption	-	0	-
Innovation (Hydrogen - Natural Gas Blending Study)	-	0	-
Innovation (Deep Energy Retrofits)	5	25	123
Innovation (Other Miscellaneous)	-	0	-
Enabling Activities	-	0	-
Total	**2,569**		**31,568**
GHG-weighted Average		**12.29**	

APPENDIX E: FALL 2021 MEDIA CAMPAIGN REPORT



Pacific Northern Gas

Fall 2021 Campaign

October 4 - December 23, 2021

Issued: January 25, 2022

Prepared by: MW360 Media

Objectives

Campaign Objective

• Position PNG as an innovative organization offering rebates and incentives to home and business owners.
• Communicate how these rebates and incentives will make their lives more efficient, allowing them to save money and consume less energy.

Role of Media

• Create and reinforce awareness of key messages.
• Drive interest and visits to png.ca/smartenergysolutions and applicable product pages where visitors can download applications.

Target Audiences

• Adults 25+
    • Commercial Businesses, including institutional/industrial customers (60%)
    • Residential Homeowners including contractors (40%).
• Secondary:
    • Not-for-profit housing providers (Societies, Associations, First Nations).
    • Municipalities, regional districts, health districts, school districts.

Media Plan

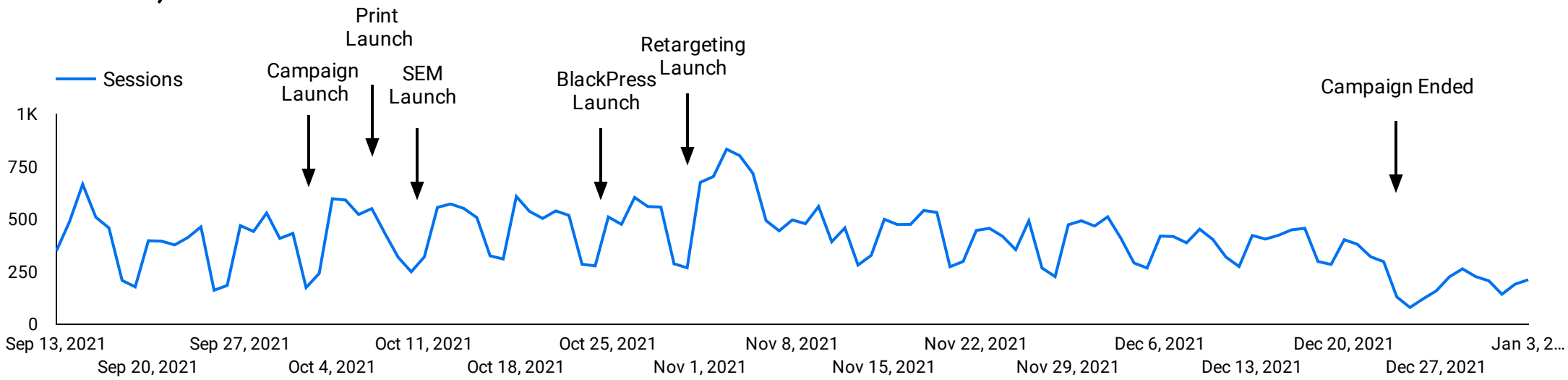
	FALL 2021 MEDIA CAMPAIGN				October					November				December				
		Targeting	Total	%	27	4	11	18	25	1	8	15	22	29	6	13	20	27
	Social Media – Est'd # of impressions = 1.95 Million																	
	Facebook – Newsfeed Ads	Business / Commercial Audience	$22,999.31	85%													23	
		Residential / Homeowners / Contractors															23	
		Retargeting Website Users															23	
		Lookalike Targeting															23	
		:15 sec Video															23	
★	Black Press – Standard Display Ads	RON															23	
★	Black Press – Mobile Footer	RON																
★	Black Press – Mobile Interstitial	BC North																
	Programmatic – Standard Display Ads	Business / Commercial Audience															23	
		Residential / Homeowners / Contractors															23	
	Programmatic – Weather Triggered Ads	Residential / Homeowners																
★	SEM – Text Ads	Residential and Business Keywords															23	
	Print – 1/4 Page, Full Colour																	
	Smithers Interior News	All audiences – Est'd Circulation = 2,013	$3,907.72	15%		7												
	Terrace Standard	All audiences – Est'd Circulation = 7,776				7												
	Alaska Highway News	All audiences – Est'd Circulation = 9,516				7												
	Total Media Investment (Including Fees)		**$26,907.03**	**100%**														

★ = New Tactic in Fall

MW360 MEDIA

Website Overview

Users	% New Sessions	Avg. Session Duration	Pages / Session
25,704	66.07%	00:01:16	1.57



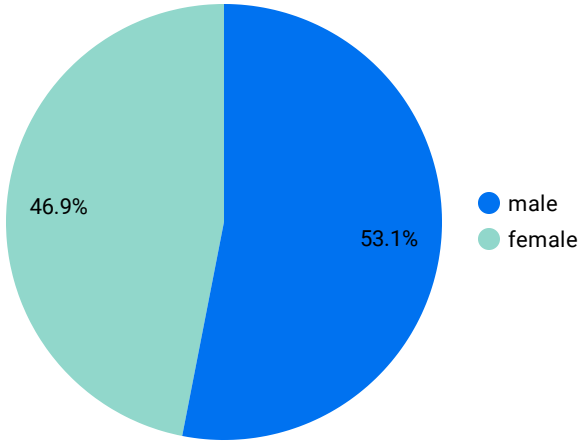
Channel Grouping	Sessions	% Change
Referral	765	152.48%
Paid Media	11,933	null
Organic Social	1,788	215.9%
Organic Search	14,921	114.13%
Direct	7,024	-16.49%
Grand total	**36,431**	**116.51%**

The chart above indicates a steady interest over the campaign timeframe with peaks significantly above out-of-market traffic volumes. As the campaign came to a close we saw a gradual decrease in traffic.

An overall 116% increase in sessions YOY indicates that paid media was successful in driving awareness, impacting other source channels, and driving traffic. Media was the second highest source of activity during the campaign period.

Audience Demographics

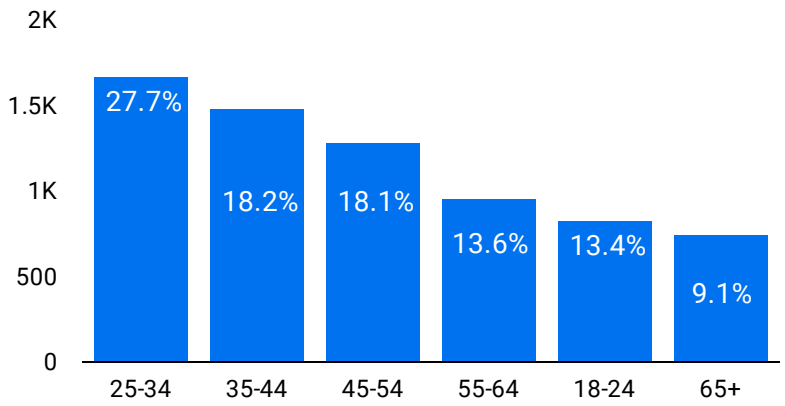
Gender of users



Website visits and engagement skewed slightly male.

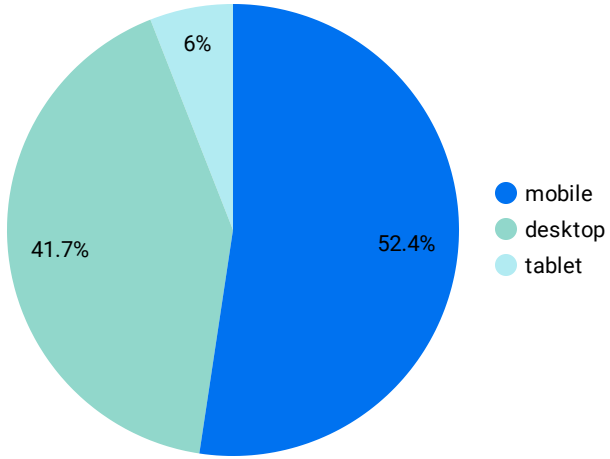
Both Males and Females were highly engaged with the website, however males were spending slightly more time and viewing more pages.

Age of users



Age segments were more evenly split during the Fall campaign, but, as in the Spring campaign, 25-34 drove the highest traffic during the campaign period, at 27.7%.

Devices used



Desktop users accounted for 33% of the total conversions and mobile users accounted for 63% of the total conversions.

Key Results Summary

The campaign was successful in creating awareness of Pacific Northern Gas, facilitating engagement, conversion and driving website traffic.

Served **4,420,600** Digital Impressions

Programmatic Display made up over 68% of the total digital Impressions.

Generated **11,933** sessions on the website

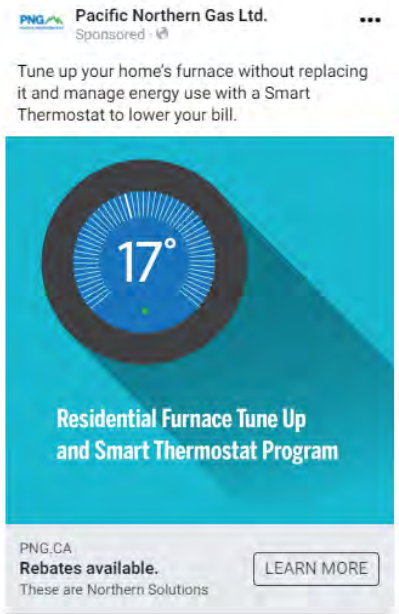
Both audiences clicked through to a variety of landing pages related to products and rebates.

Resulted in **223** Social Engagements

The **Smart Thermostat** Ad had the highest number of engagements, making up **25%** of total social engagements.

Creative Overview

Facebook



Top traffic and engagement driver, also drove the most conversions closely followed by the Smart Thermostat Retargeting.

Programmatic

HVAC messaging in the 728x90 size drove the highest volume of traffic, closely followed by the custom controls program messaging in the same size.

BlackPress

Mobile Interstitial was the top traffic driver with the second highest likelihood of a click of all tactics.

Media Highlights

11 Energy Saving Kit Applications direct from media tactics.

Social tactics drove strong website traffic and conversions

Facebook drove **57%** of the total website **conversions.**

Facebook Newsfeed users were the most likely to apply for an Energy Savings Kit

Smart Thermostat ads resulted in the most Energy Savings Kit Applications.

Search Ads users were the most engaged

Users coming from SEM were most likely to click on the ad compared to all other platforms, and also spent the most time; more than **3X the campaign average**.

Top Performing Content

Pageviews
58,177

- **/smartenergysolutions/furnace-tune-up-program** was the most viewed campaign landing page.
- Using the product pages in the ads for Fall helped improve visitation to the business pages, highlighting interest particularly in the .commercial-custom-controls page.
- The **Contact** page was the second most viewed page overall during the campaign period indicating customers wanting to connect with PNG for more information.

Top pages visited:

Page	Pageviews ▾
/ home	19,135
/contact/	4,776
/account/	4,467
/smartenergysolutions/furnace-tune-up-program/	3,894
/smartenergysolutions/	3,067
/smartenergysolutions/commercial-custom-controls/	2,976
/smartenergysolutions/commercial-efficient-hvac-controls/	2,862
/business/product-rebates/boilers/	1,757
/business/product-rebates/water-heaters/	1,441
/about-png/work-with-png/	963
/account/open-residential-account/	945
/account/pay-your-bill-your-bill-explained/	899
/projects/customeradvantage/	686
/account/update-your-account/	602
/residential/residential-rates/	589
/get-in-touch/	561
/smartenergysolutions/preferred-contractor-program/	473

1 - 100 / 199

Colours represent a heatmap. The higher the number, the darker the colour.

Search Ads

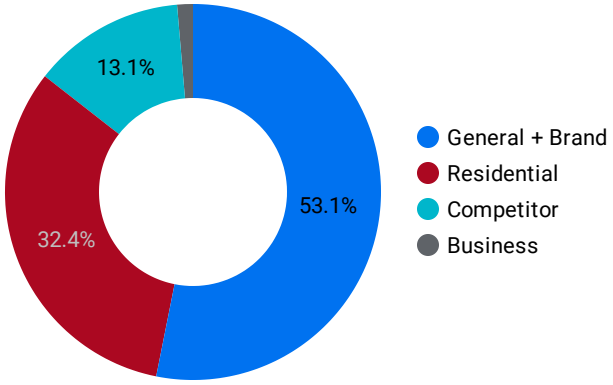
- Branded keywords showed the strongest likelihood of a click, followed by more general keywords related to home heating and natural gas showing a strong audience in the intent/consideration phase.

- Strongest performance came from the General + Brand ad group. The Responsive ad drove the most traffic to the website.

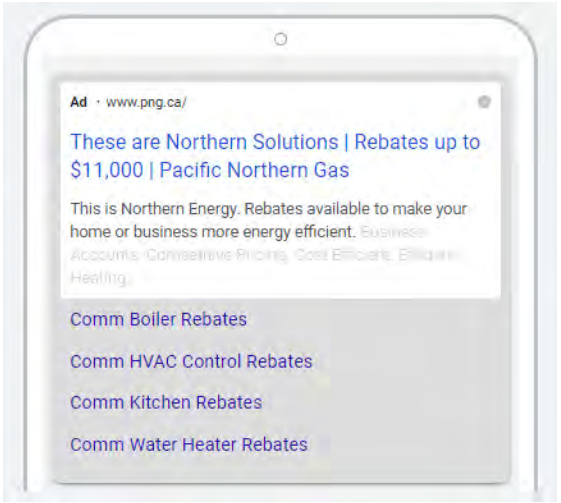
- Majority of competitor interceptions were for BC Hydro and Terasen Gas.

367 searches intercepted from competitors

Clicks by Ad Group:



Top Performing Ad:



Top Keywords:

	Search keyword	Impressions	Clicks ▾
1.	pacific natural gas	3,598	822
2.	home heating	10,237	516
3.	natural gas	5,588	485
4.	bc hydro	4,443	307
5.	natural gas for home	982	142
6.	energy efficiency	1,160	117
7.	gas fireplace	1,705	61
8.	energy saving kit	347	55
9.	gas water heater	1,324	50
10.	home heating options	829	44
	Grand total	**34,635**	**2,804**

Conversions Overview

11
Energy Saving Kit Applications

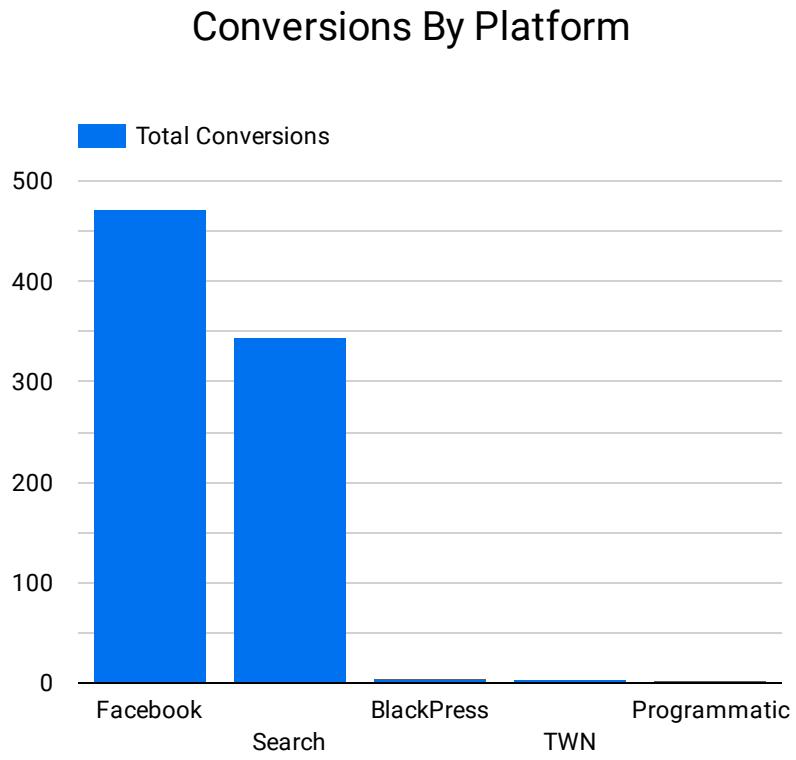
586
External Link Clicks

2
eNewsletter Signup

68
PDF Downloads

158
Contacts

1
Social Link Clicks



Conclusions

The campaign was successful in generating awareness of the PNG brand, and driving engaged users to site with:
- **4,420,600** digital impressions
- **11,933** Pageviews of campaign landing pages
- **223** Social Engagements

The mix of digital channels and tactics provided multiple touch points and reached users at various stages of their journey:

- Programmatic worked to create awareness, driving the second highest volume of users to site, responsible for over 33% of all traffic.
- Facebook was a top performer, driving the largest volume of users to site, and responsible for 57% of conversions from paid media channels.
- Retargeting and Lookalike audiences on Facebook provided a second touchpoint for interested users to return to the site.
- SEM was also a significant traffic driver, and users on this lower-funnel channel were most likely to click on an ad, and most likely to convert.
- BlackPress intercepted users as they consumed local news and content, with the impactful Mobile Interstitial creative driving the most traffic in this platform.

For the product specific messaging, Business Owners connected most with the HVAC and Custom Controls, while Homeowners connected most with Smart Thermostat.

While there were fewer Energy Savings Kit Applications compared to the Spring campaign, there was a 74% increase in Contact Us, showing that more users may have been in the consideration phase, and wanted to reach out for more information before converting. We also saw more than 2X the number of External Link Clicks on the landing page content compared to the Spring campaign.

Recommendations:

- Continue to use SEM as a compliment to campaigns, and potentially throughout the year, to drive cost-effective qualified traffic from lower in the funnel.

PNG
PACIFIC NORTHERN GAS

Thank you!

MN360 MEDIA