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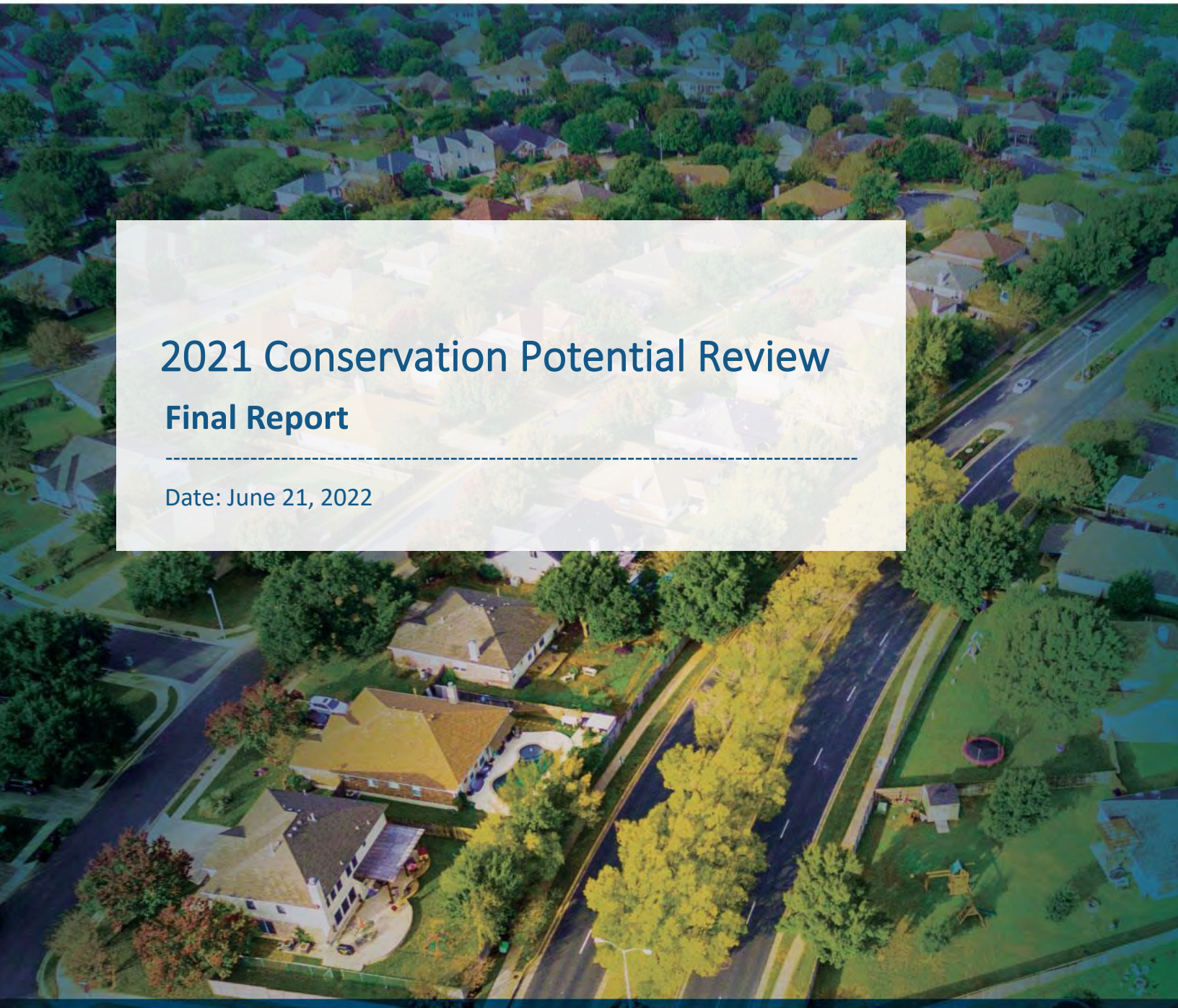

2021 Conservation Potential Review

Final Report

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Contents

List of Exhibits

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.

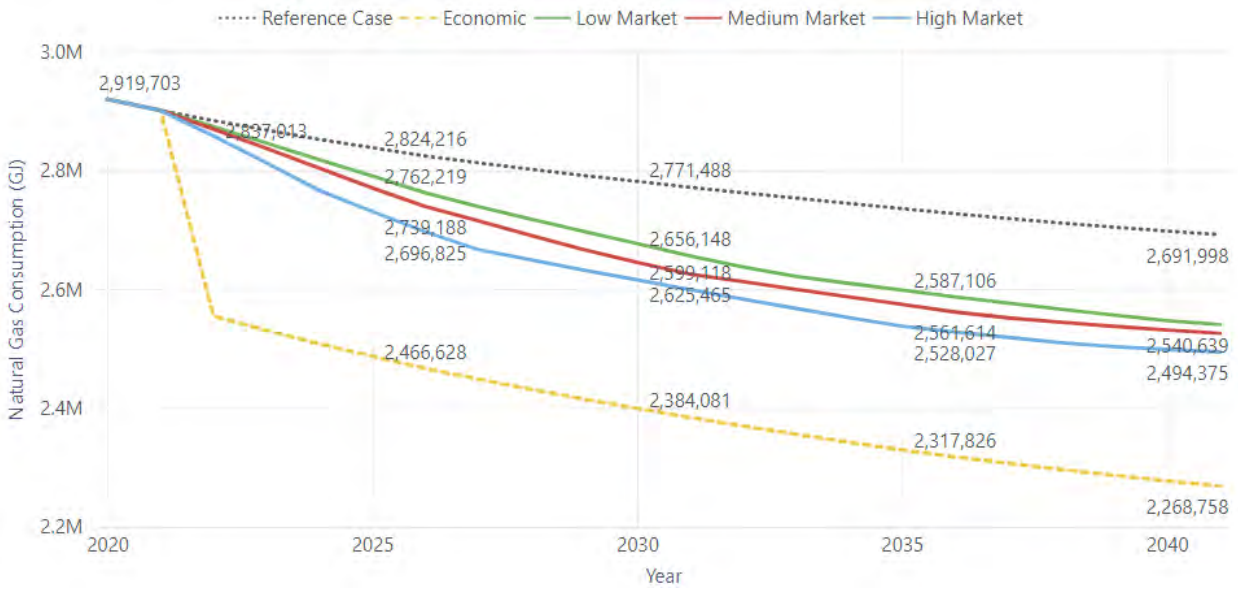
[2] See Exhibit 3 for an overview of the constraints considered in an economic potential scenario.
[3] Generic adoption curves primarily consider two things: the current market penetration of the measure, and its simple payback. Based on these factors, the curves are applied to each measure to estimate 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

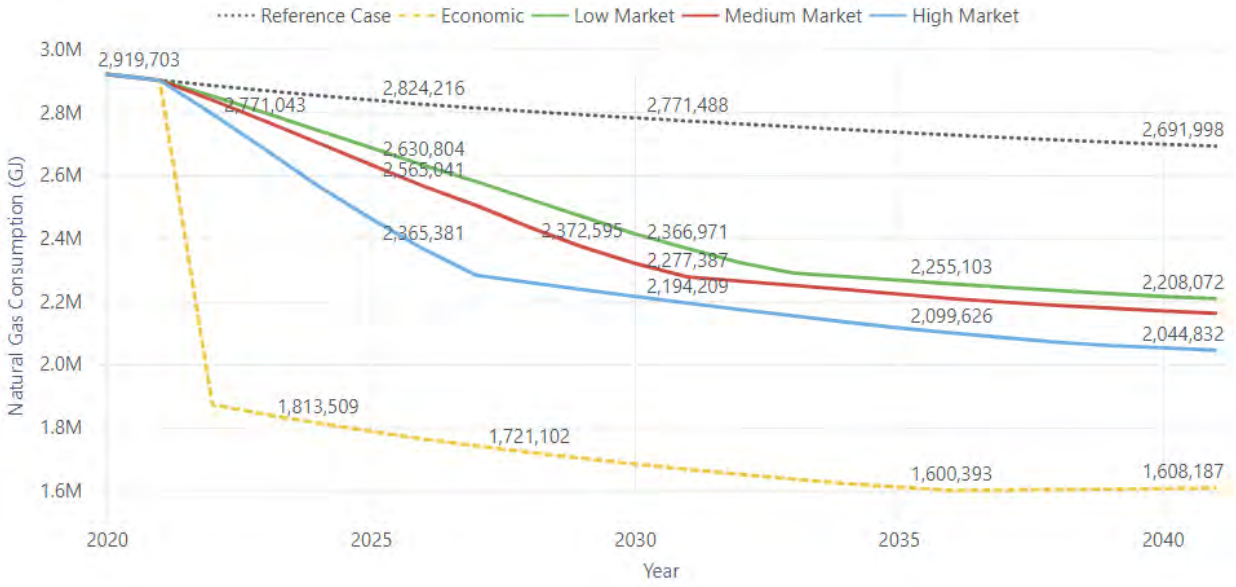
Residential

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**

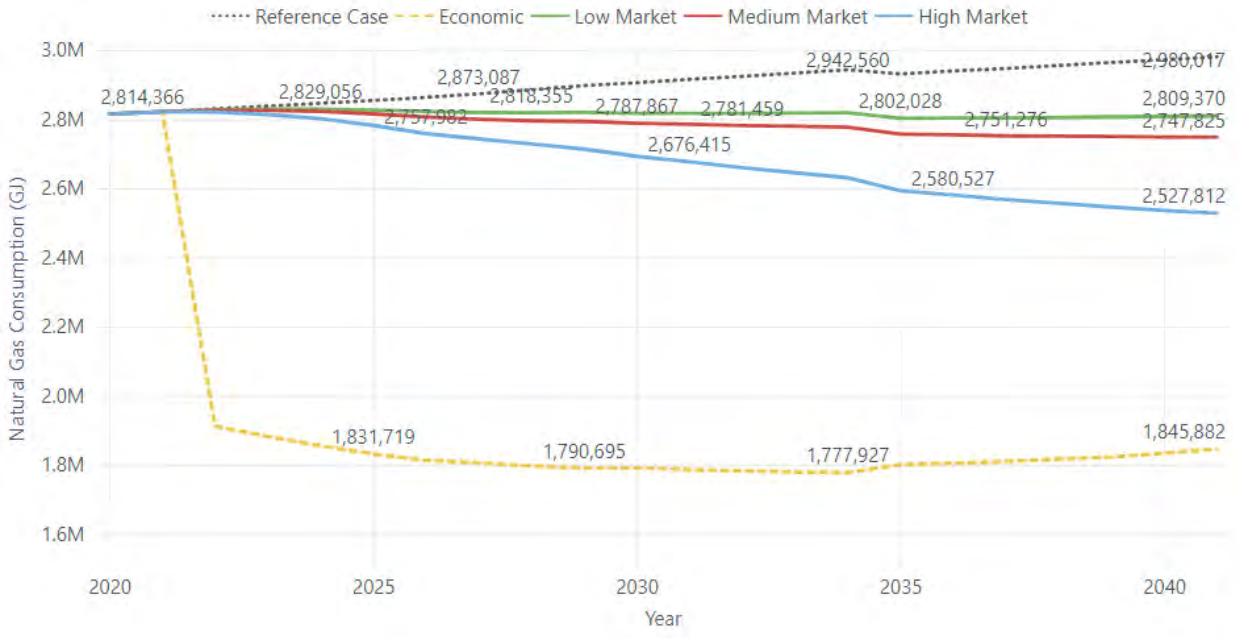
EX 6 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, MTRC

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**

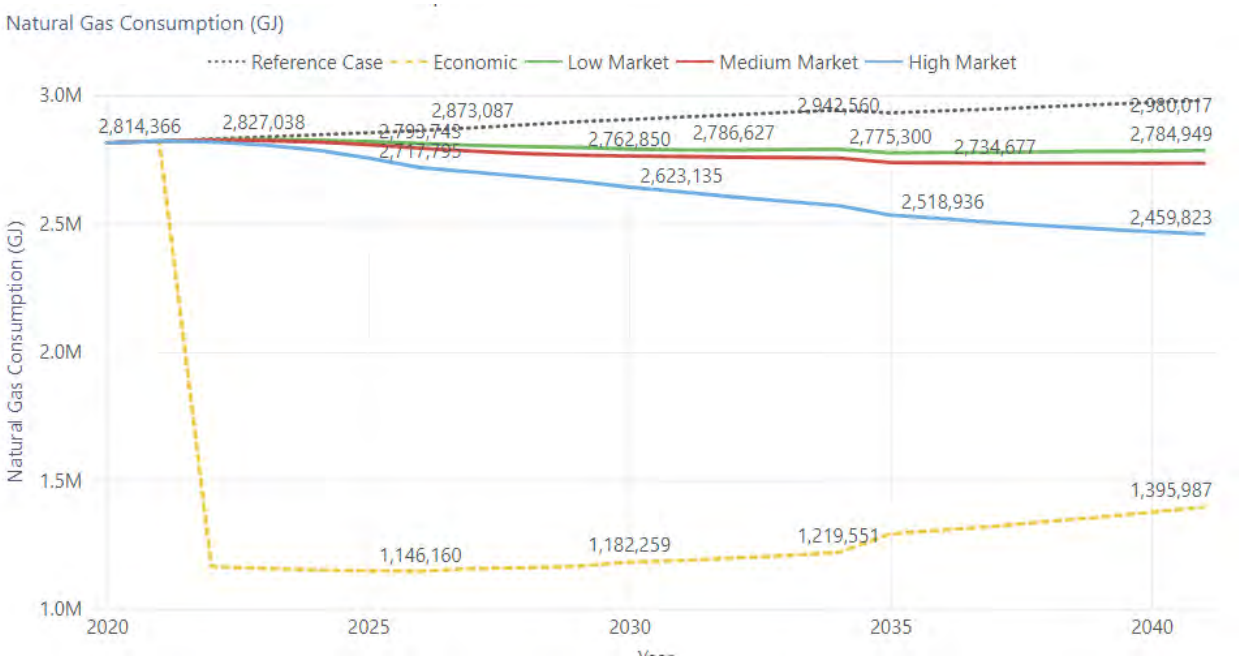
Commercial

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

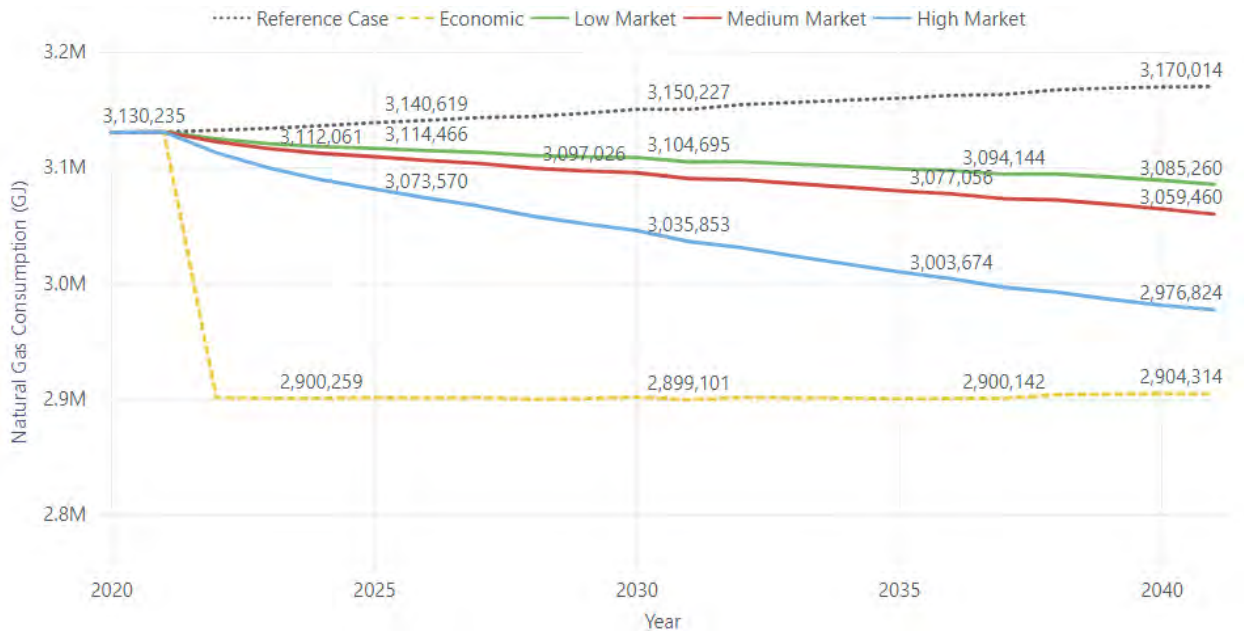
Year	Medium Market Incentive Cost	Medium Market Non-Incentive Cost	Medium Market Total Costs	Medium Market Potential Savings (GJ)	Medium Incremental Savings (Year-over-Year, GJ)	Medium Market Total Cost / Potential Savings (GJ)	High Market Incentive Cost	High Market Non-Incentive Cost	High Market Total 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

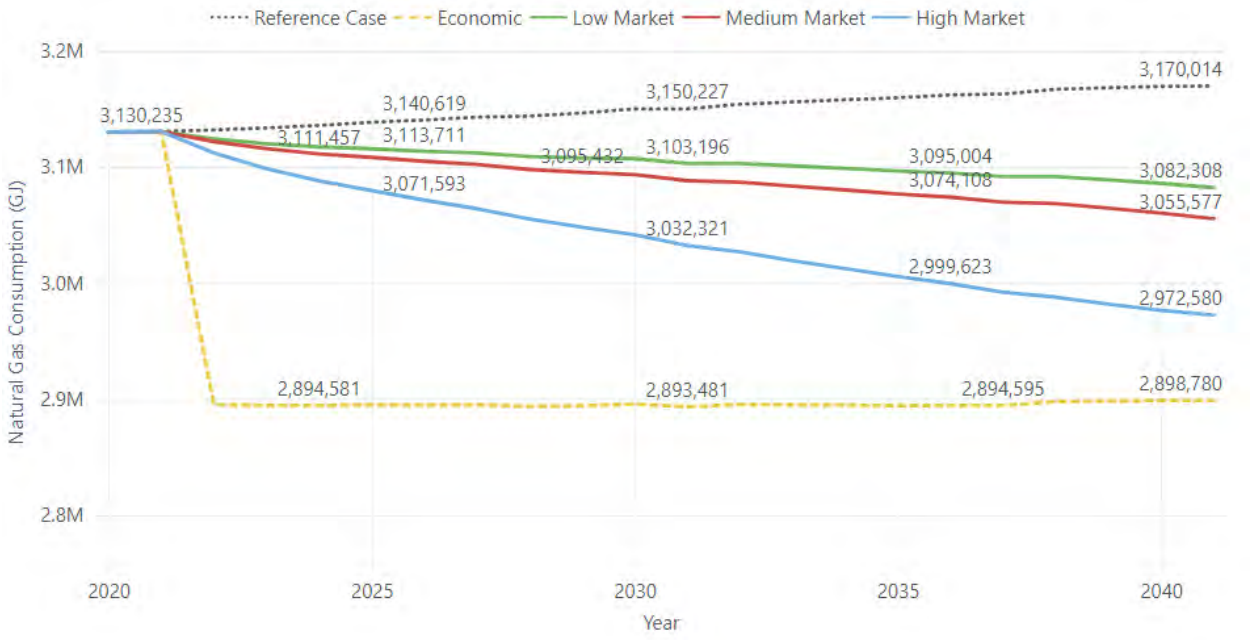
The market potential consumption results are shown in EX 11 and EX 12. The results for the TRC and MTRC screens appear quite similar because of the 38 measures included in the assessment, 36 pass the TRC and 38 pass the MTRC.

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.

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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.

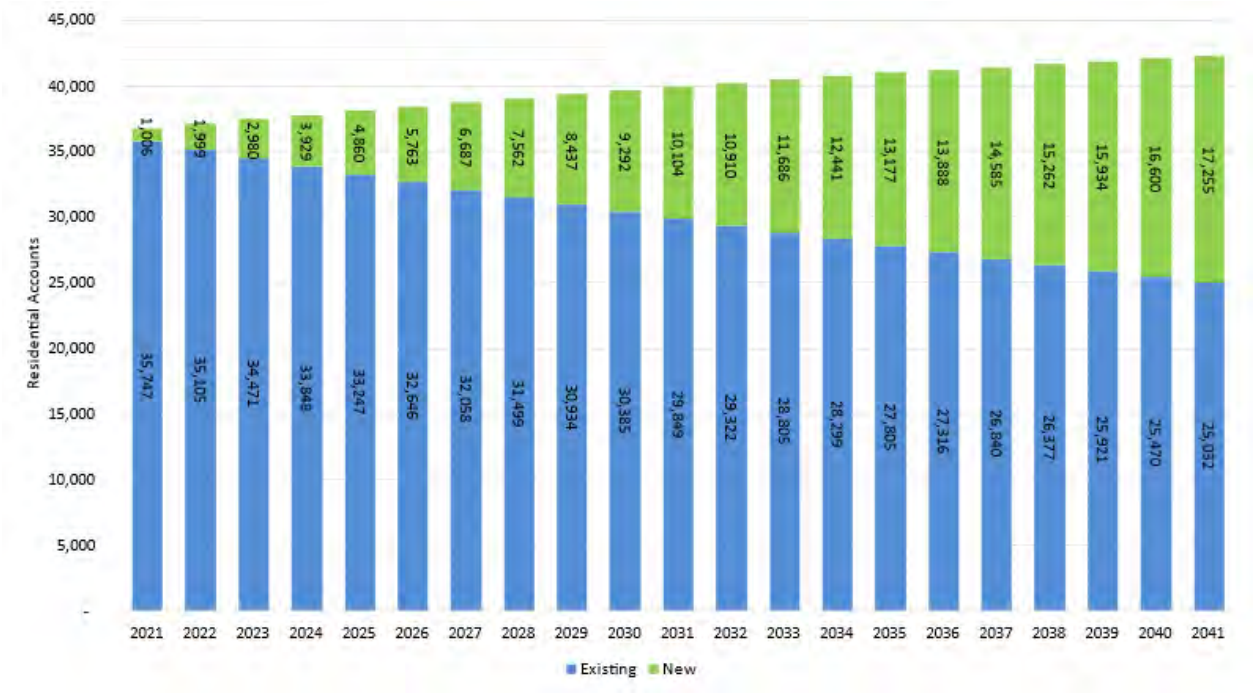
Exhibit 22 - 2021-2041 Gas Consumption (GJ) by New and Existing and Segment

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)

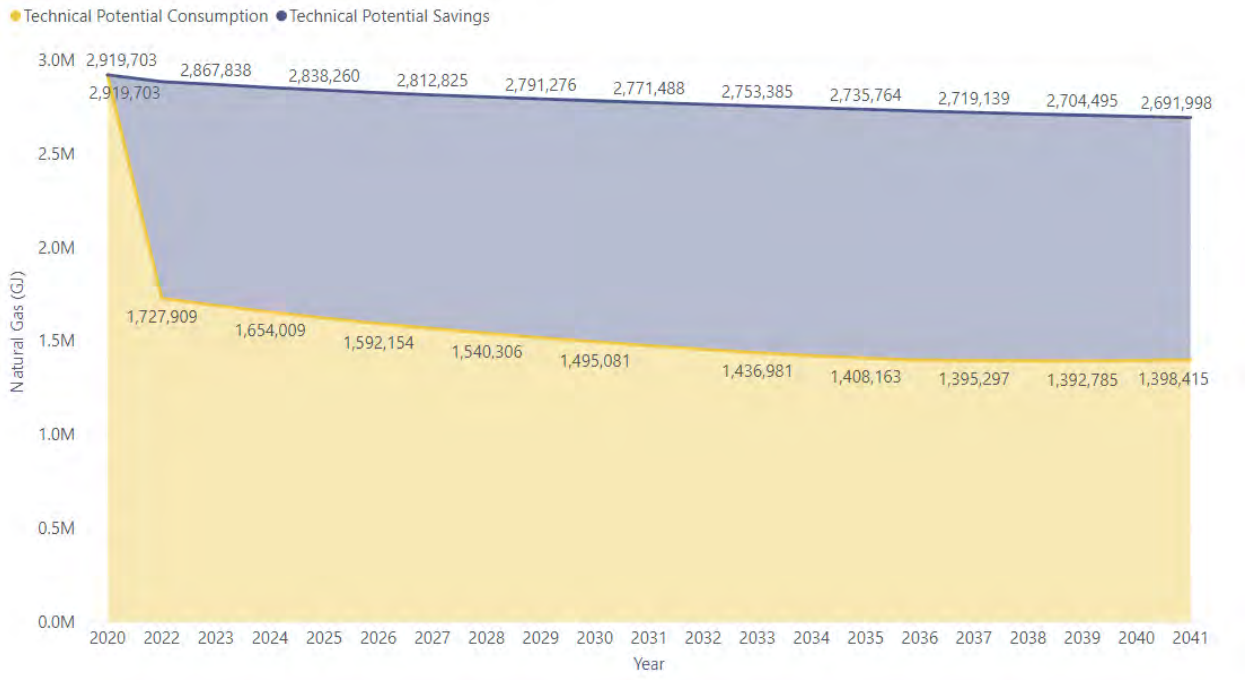
4.5 Technical Potential

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.

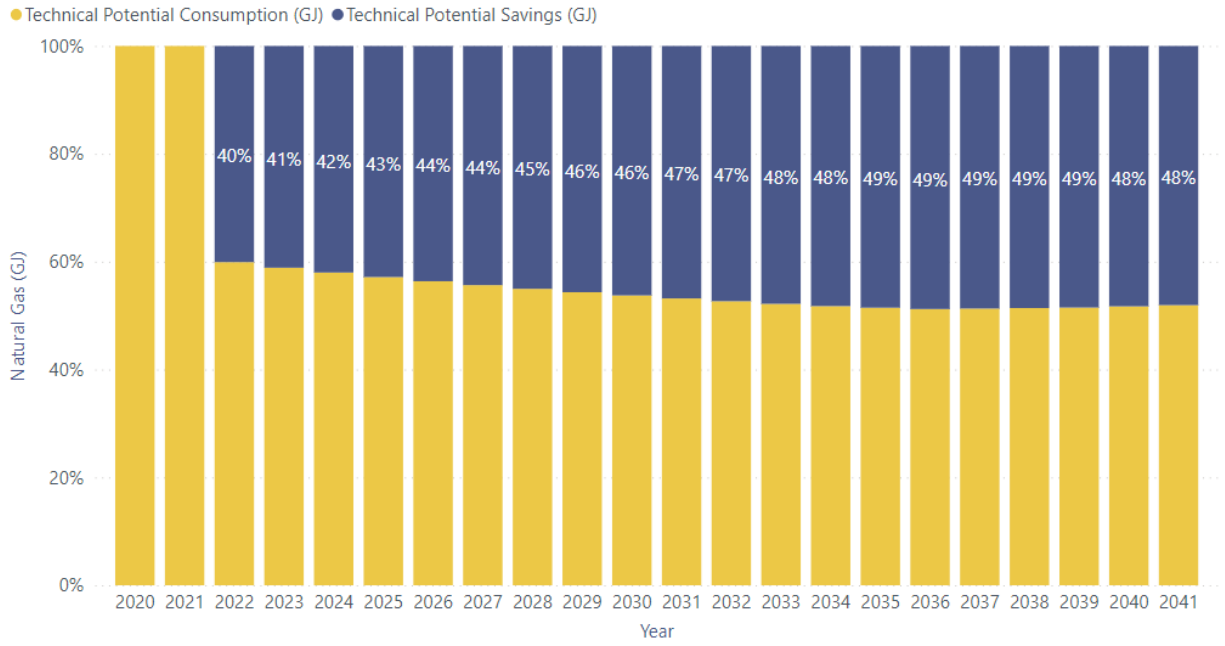
As shown in Exhibit 26, most of the residential technical potential (1,160 TJ) would be available in 2022 and would increase to 1290 TJ in 2041. This indicates that a small amount of the potential, approximately 130 TJ, would come from replace on burnout measures over the next two decades. The forecasted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

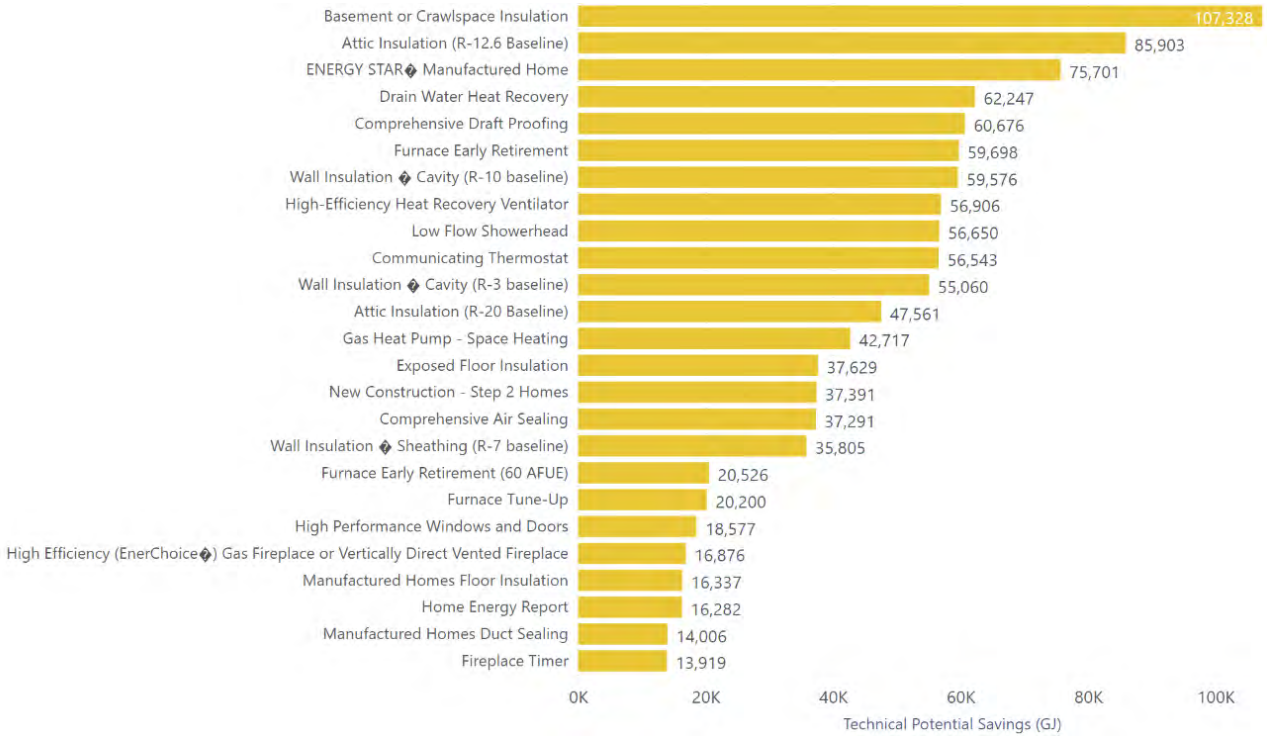


Exhibit 29 shows the cumulative residential sector technical potential savings in 2041, arranged as a supply curve, with measures ordered by decreasing TRC ratio from left to right. The graph shows that approximately 33% (approximately 430 out of 1290 TJ) of the residential sector's technical potential 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

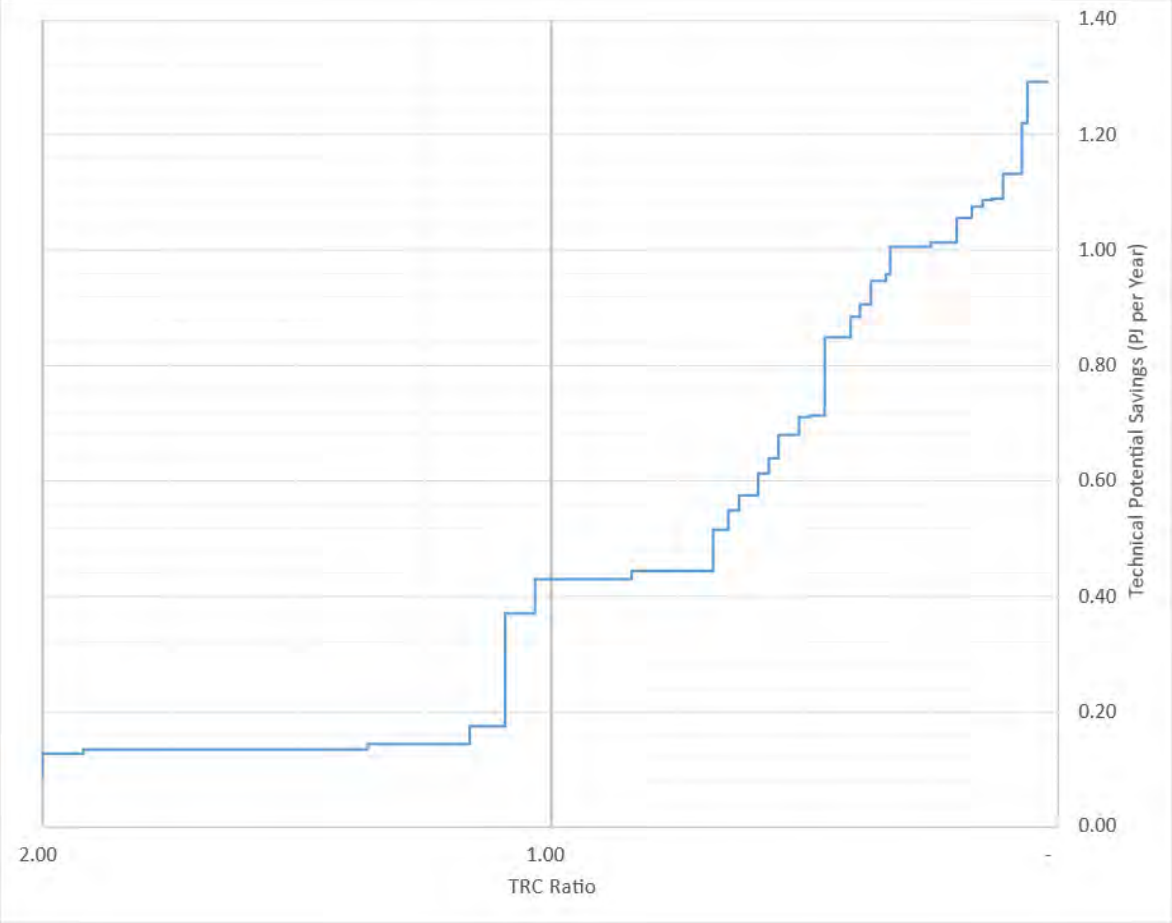
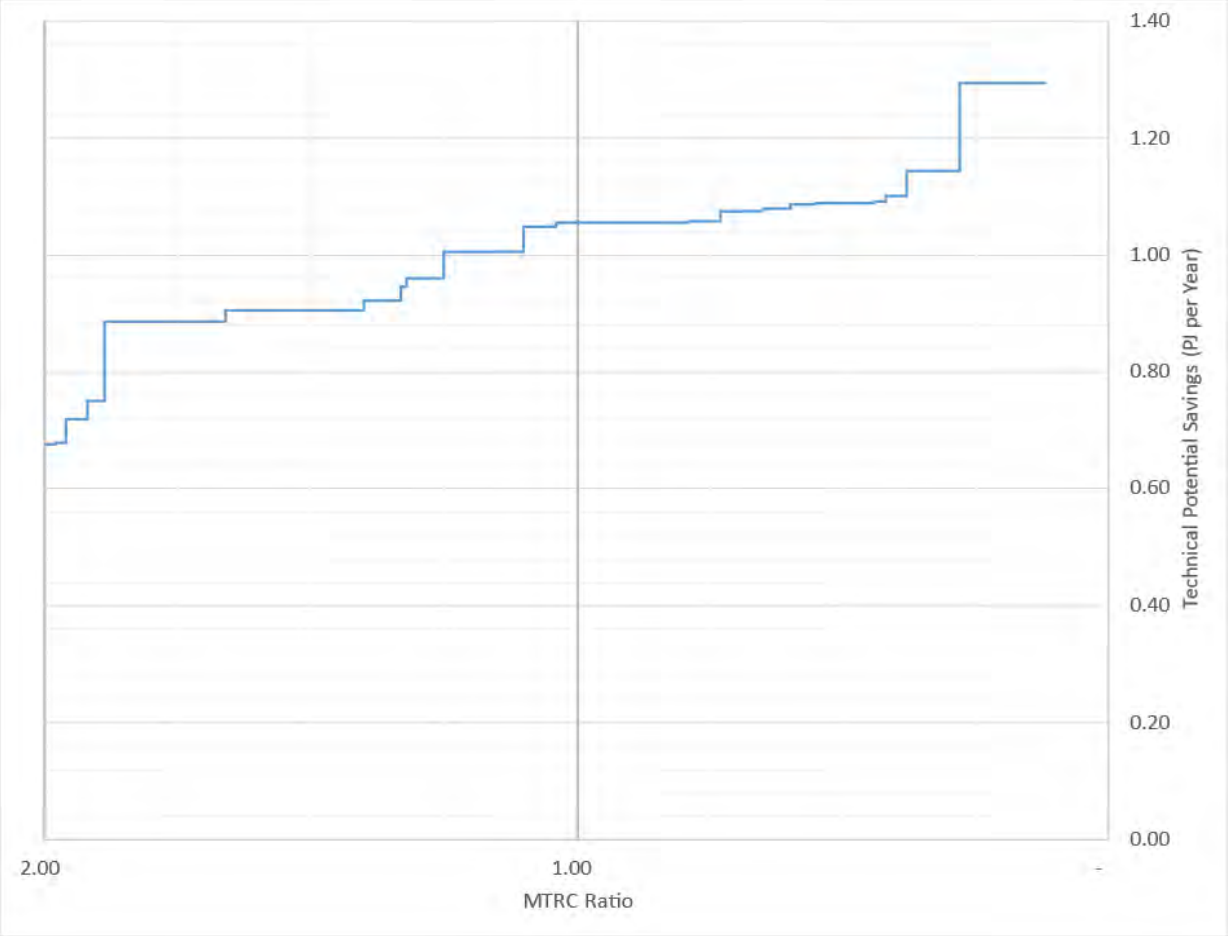


Exhibit 30 shows a similar supply curve, but with measures ordered by decreasing MTRC ratio from left to right. The graph shows that 82% (approximately 1060 out of 1290 TJ) of the residential sector's technical potential by 2041 comes from cost-effective measures with an MTRC of 1.0 or higher. Approximately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

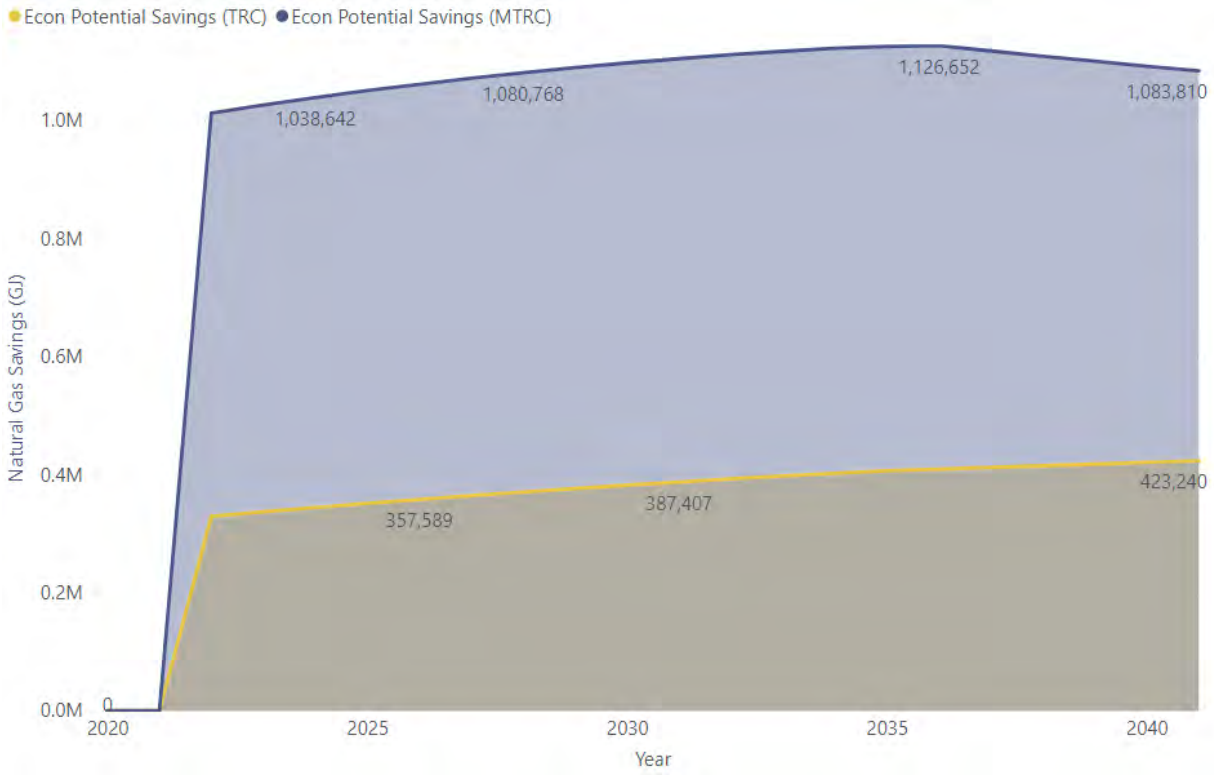


4.6 Economic Potential

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.

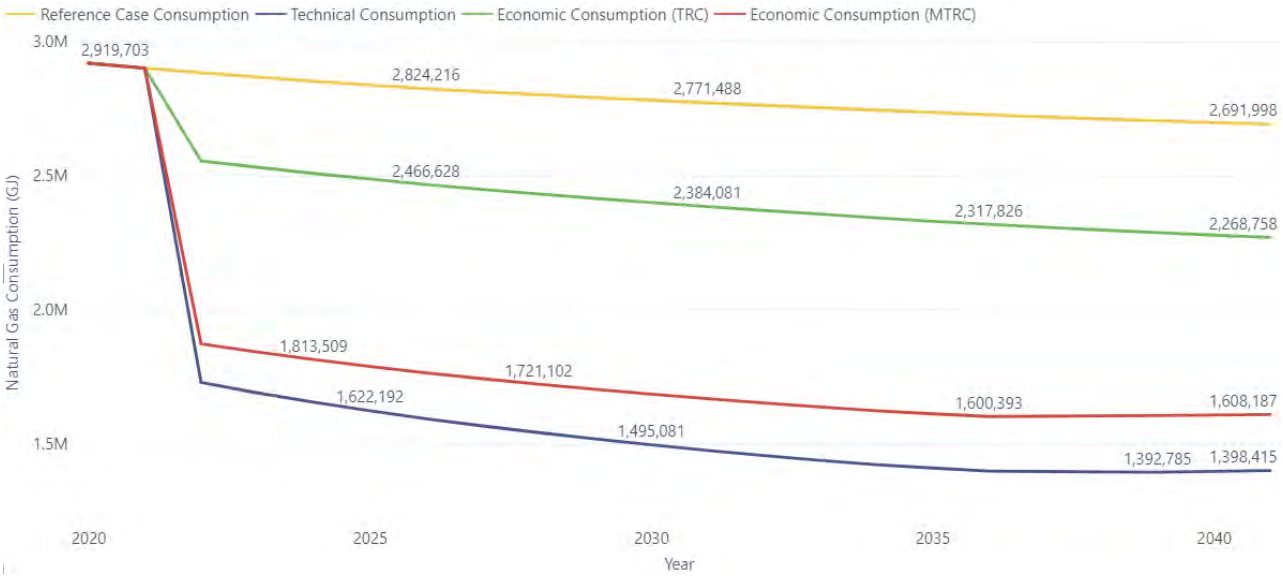
The residential sector economic potential savings with a TRC screen and with an MTRC screen are shown in Exhibit 31. Of the 48 measures included in the assessment, only 13 pass the TRC screen whereas 33 measures pass the MTRC screen. Those 20 measures that pass the MTRC but fail the TRC make up the difference 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)

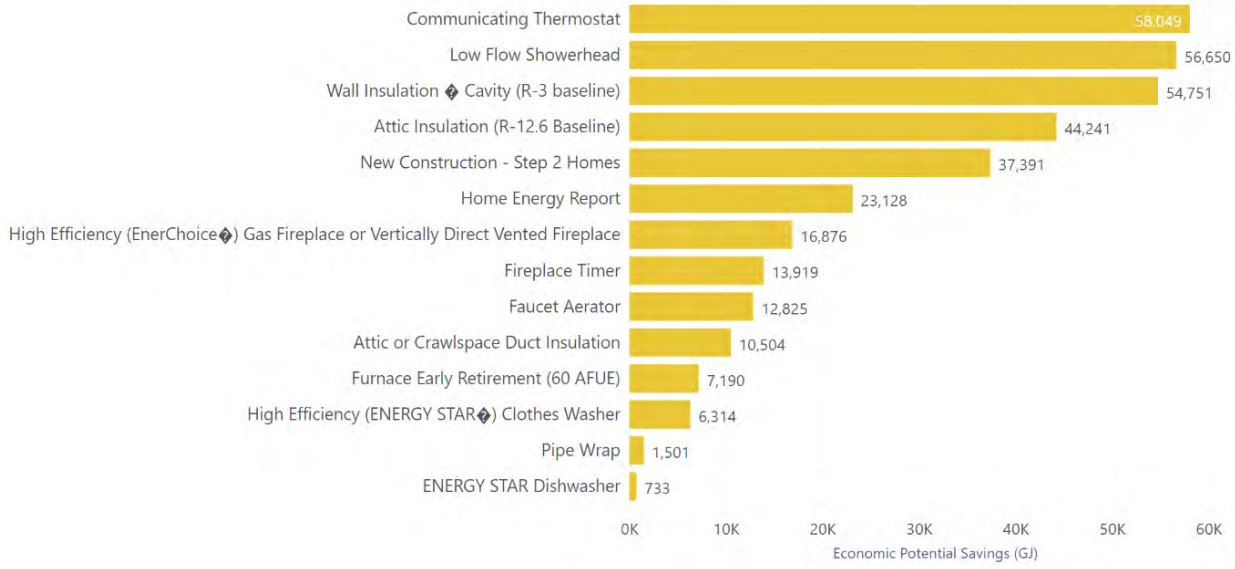
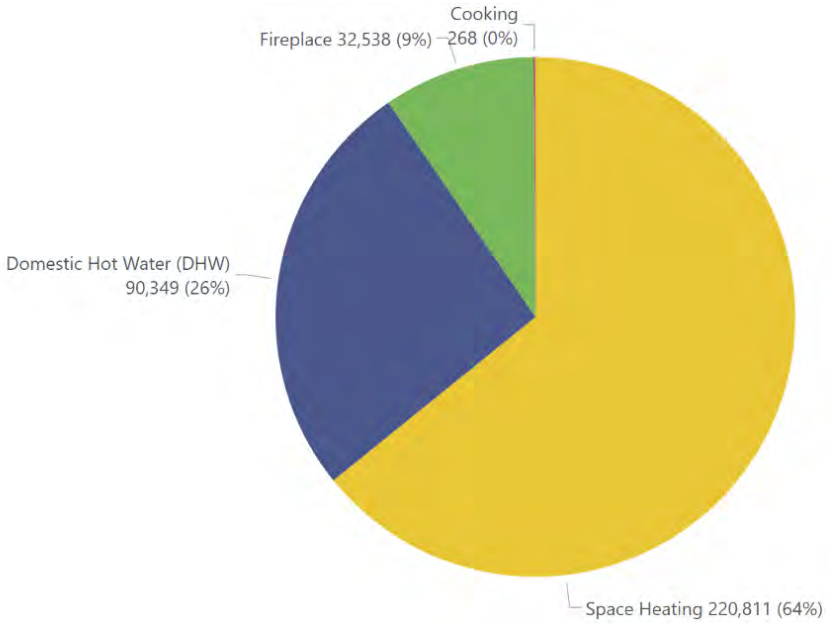


Exhibit 41 – Economic Potential in 2024 (GJ) By End Use – Residential, TRC



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)

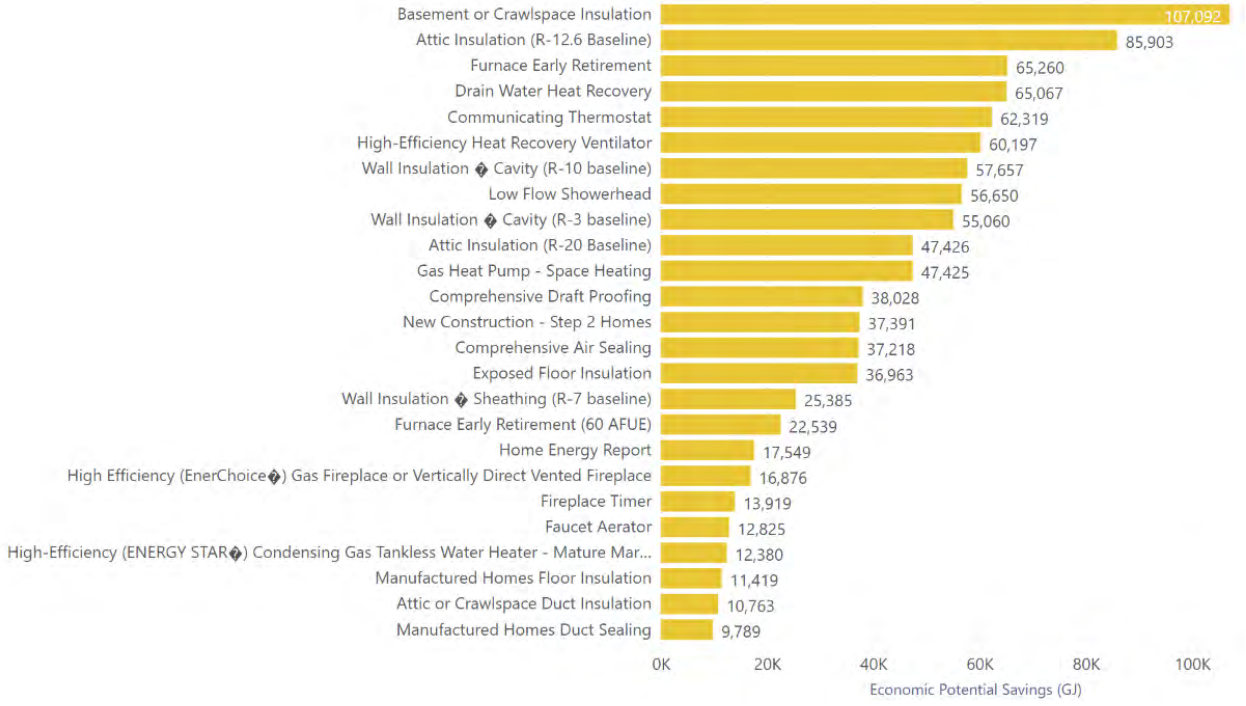
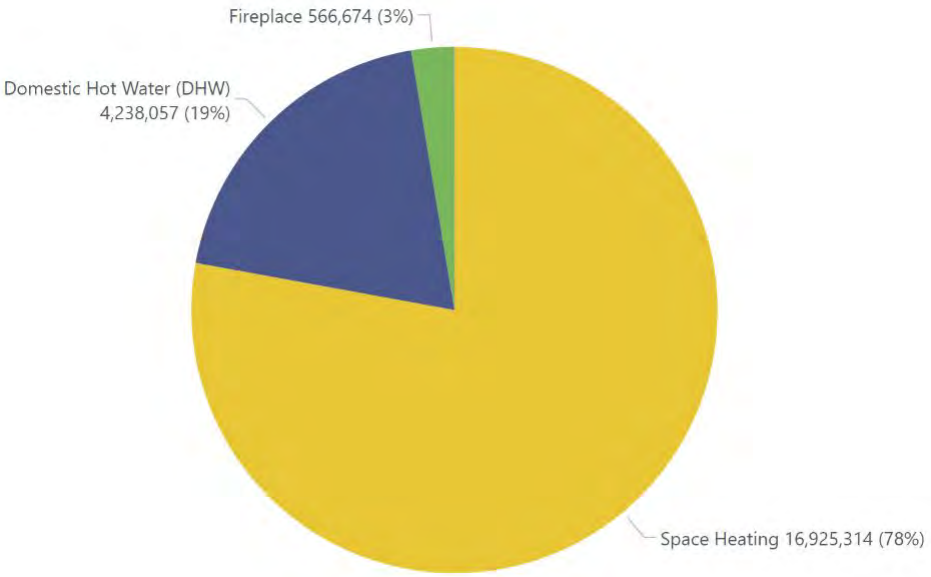


Exhibit 43 – Economic Potential (GJ) in 2024 By End Use – Residential, MTRC



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

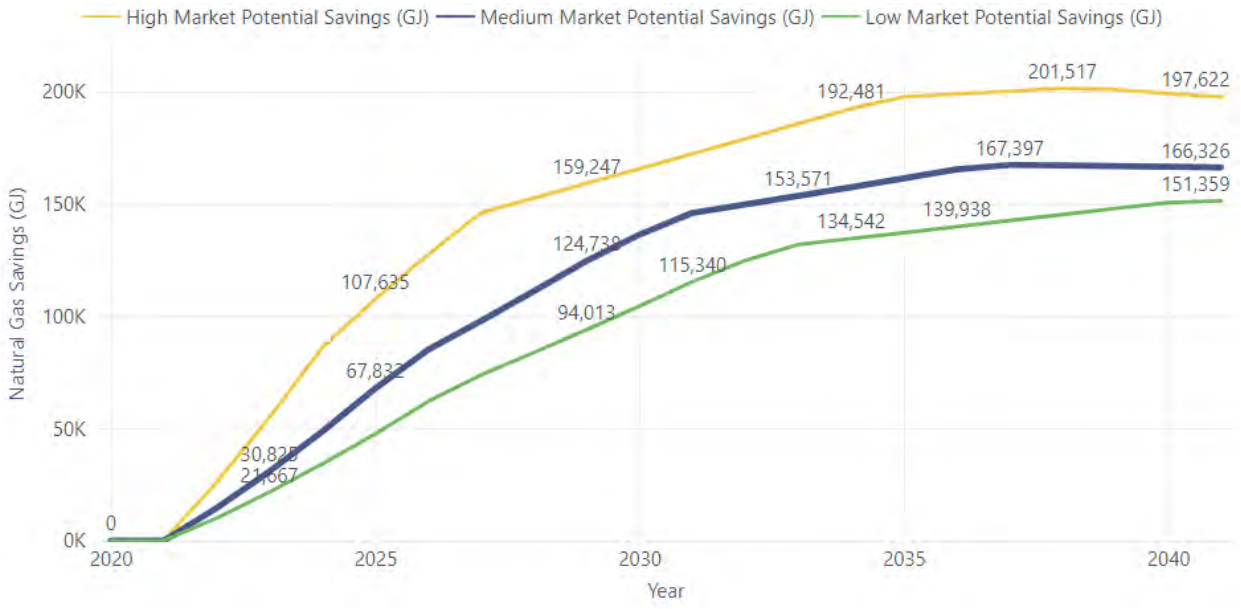
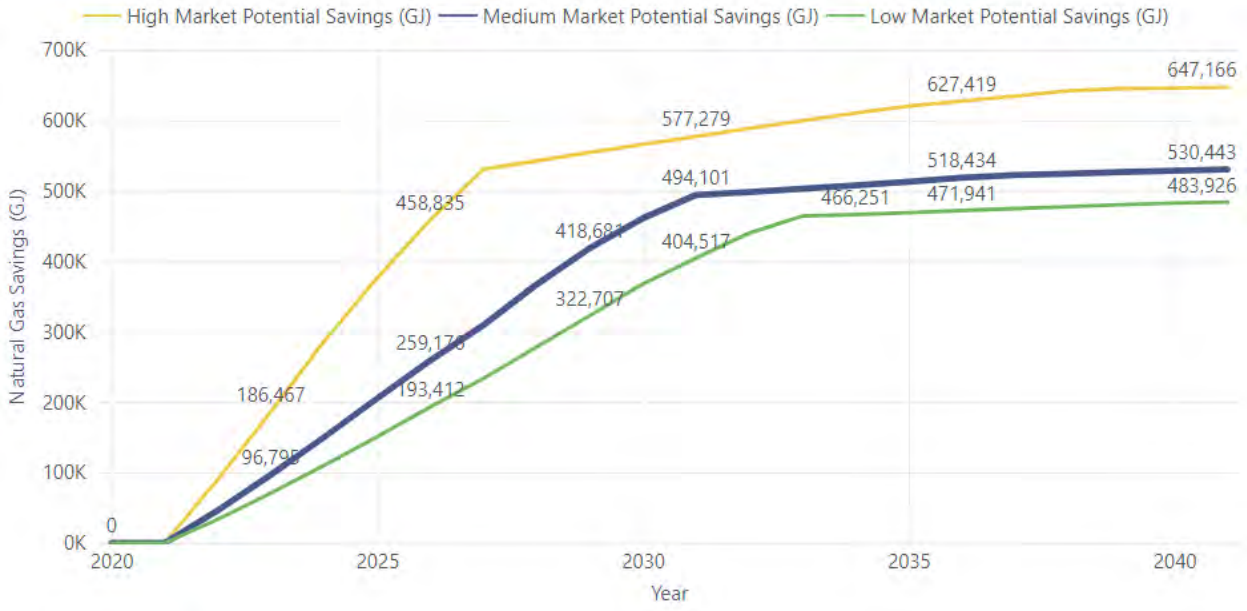


Exhibit 45 – Market Potential Savings (GJ) – Residential, MTRC



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

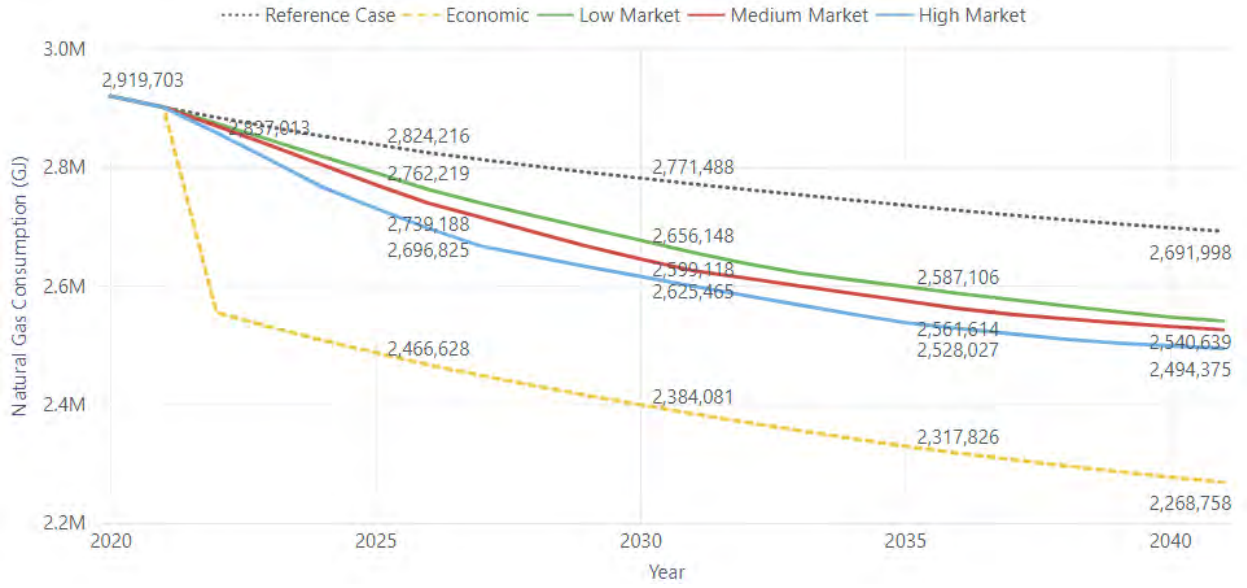
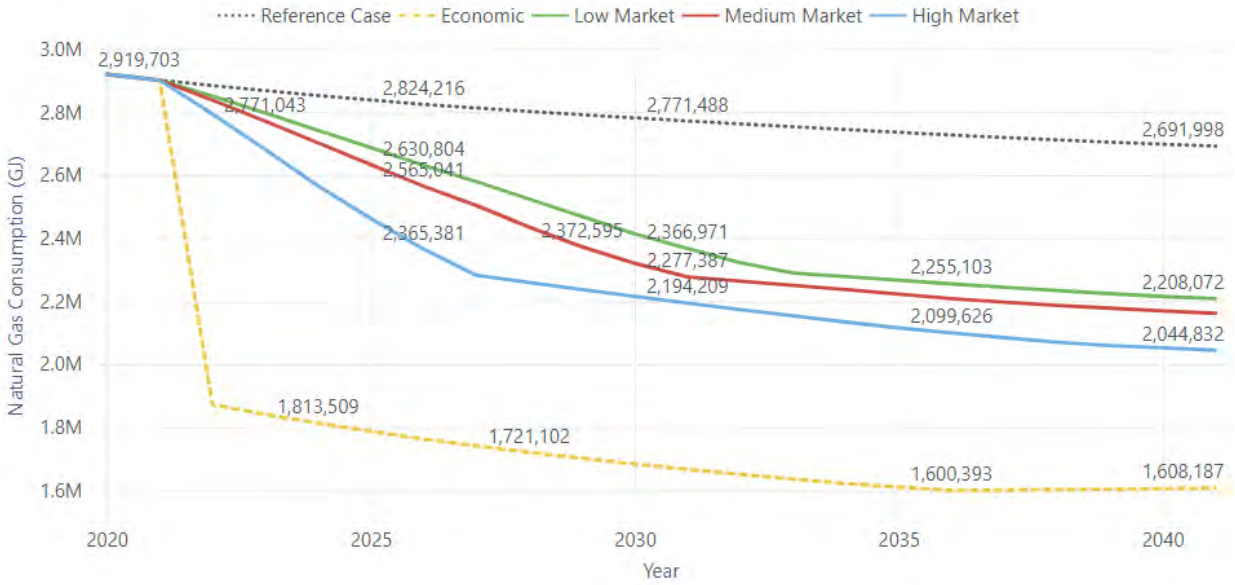


Exhibit 47 – Market Potential Consumption (GJ) Forecasts – Residential, MTRC



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.

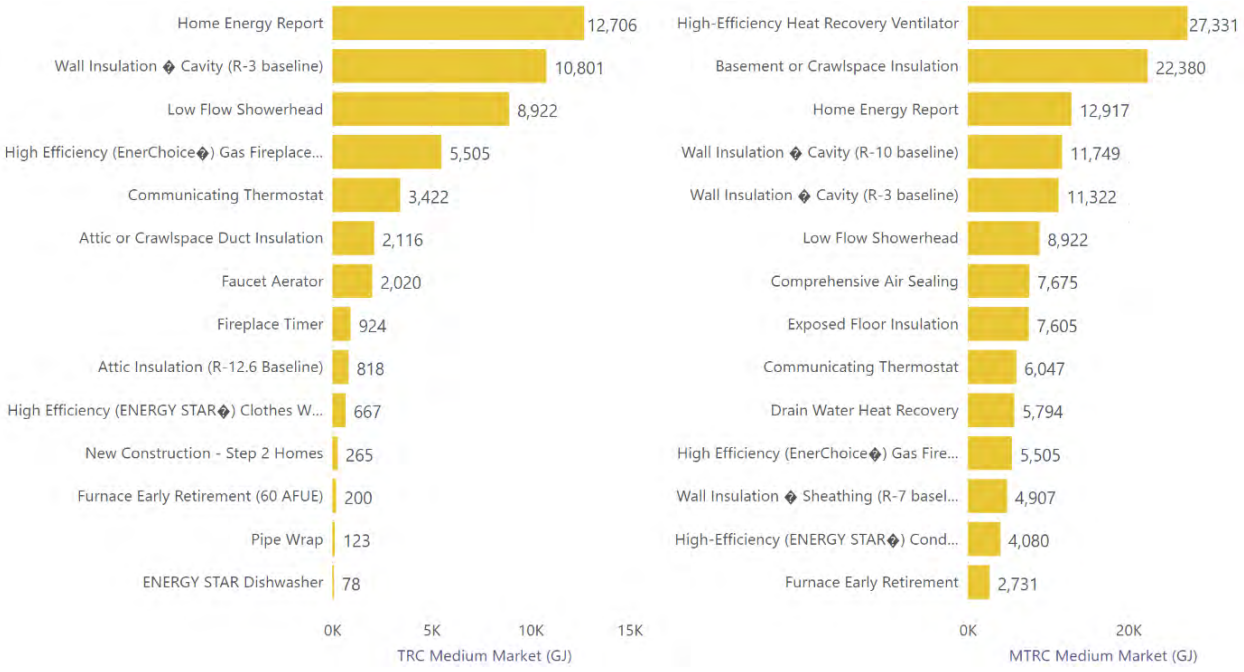
Exhibit 54 – Medium Market Potential Savings by End Use in 2041 – Residential, TRC and MTRC

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

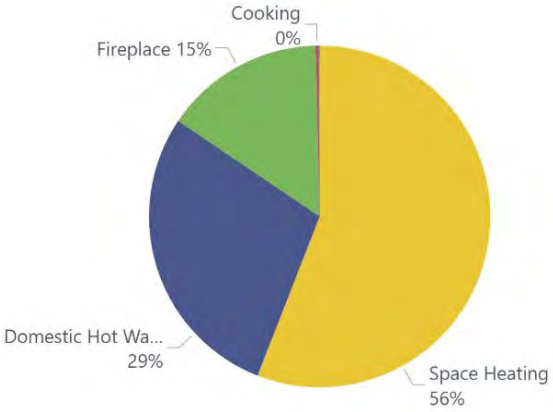
The medium market potential savings in 2024 of the top 14 residential measures are shown in Exhibit 55. The top measures in the TRC medium market potential are shown on the left and top measures in the MTRC scenario are shown on the right. Home energy reports and wall cavity insulation rank high in both 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.

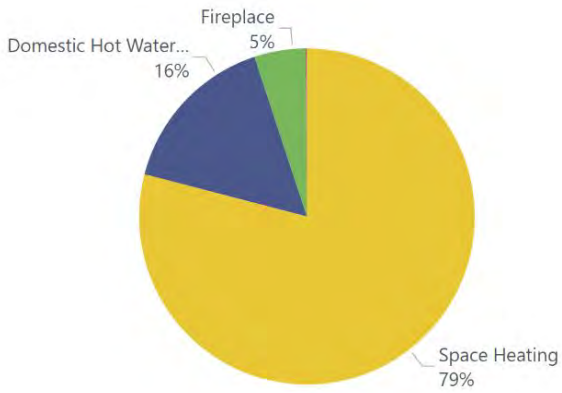
Exhibit 55 – Medium Market Potential (TRC on Left, MTRC on Right) - Top 14 Residential Measures in 2024 (GJ)[32]



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

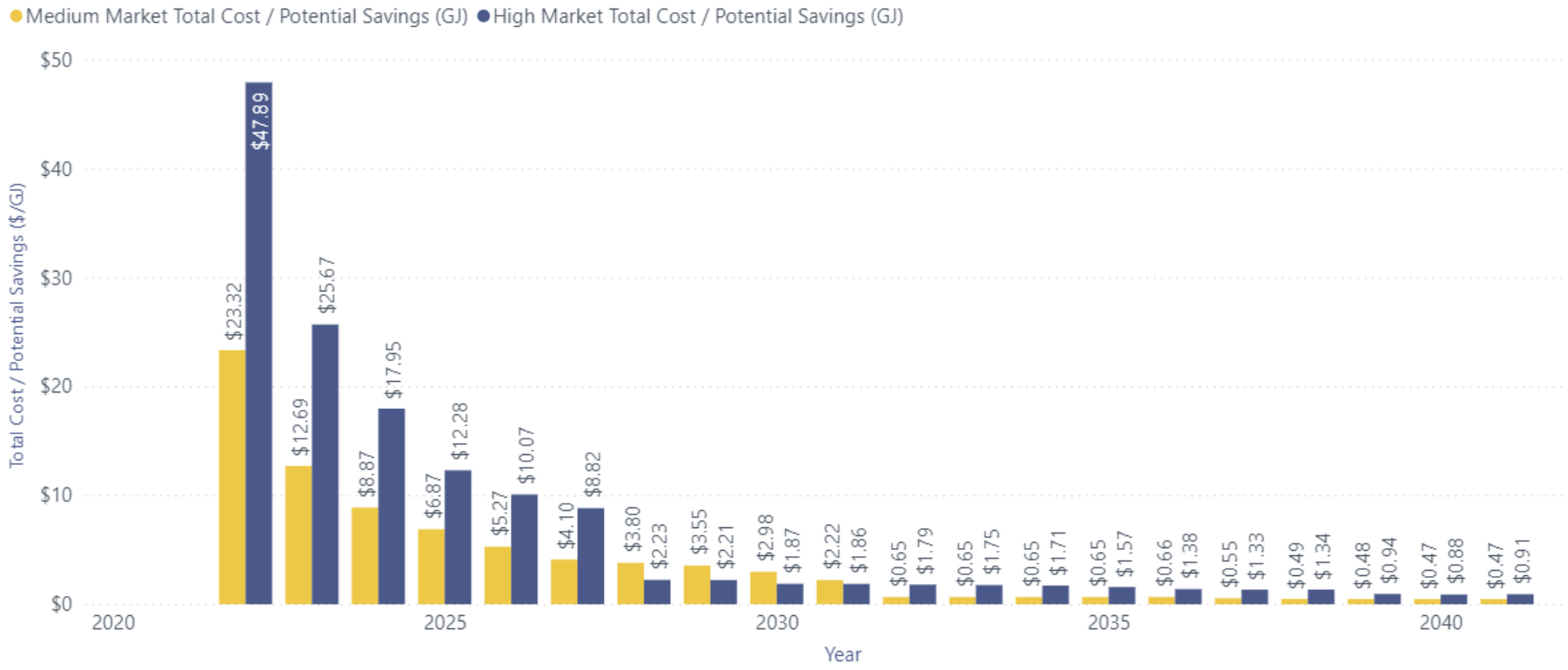
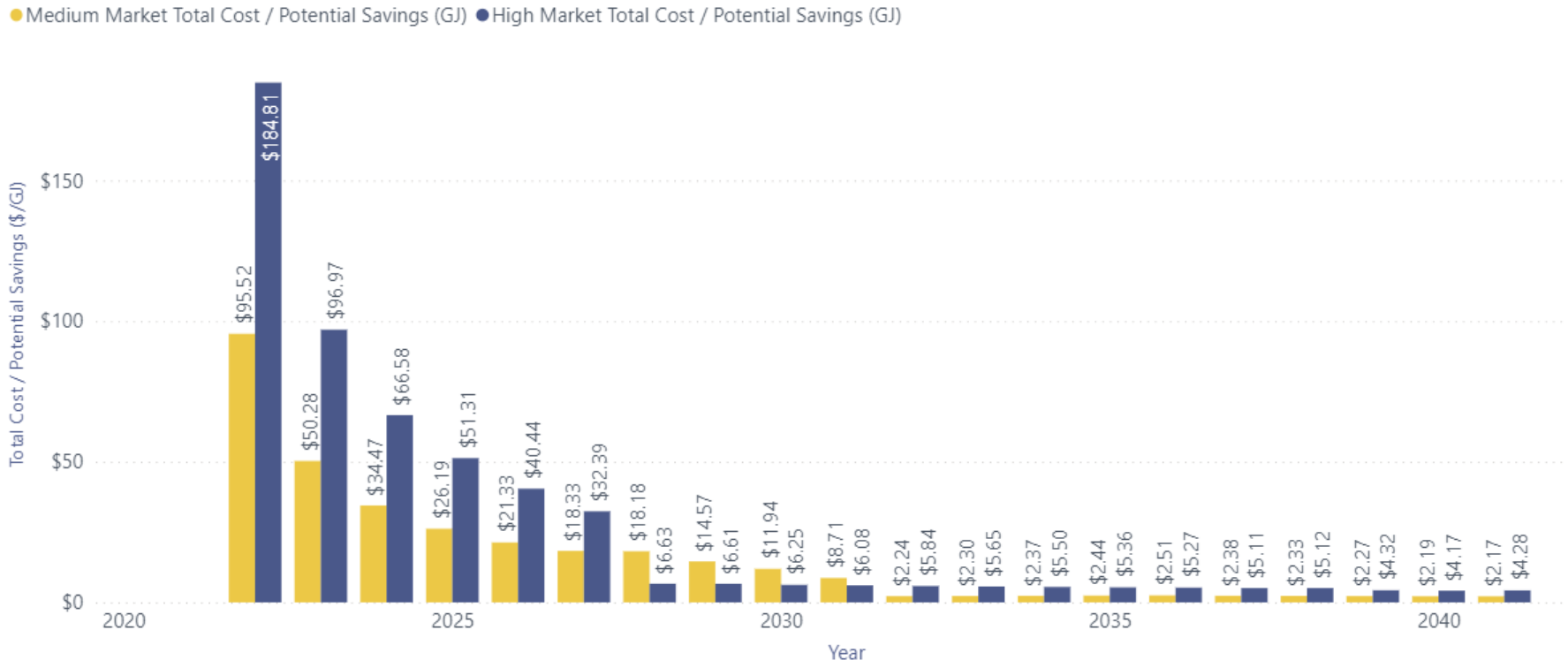


Exhibit 59 – Medium and High Market Incentive Costs and Natural Gas Savings – Residential, MTRC

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.

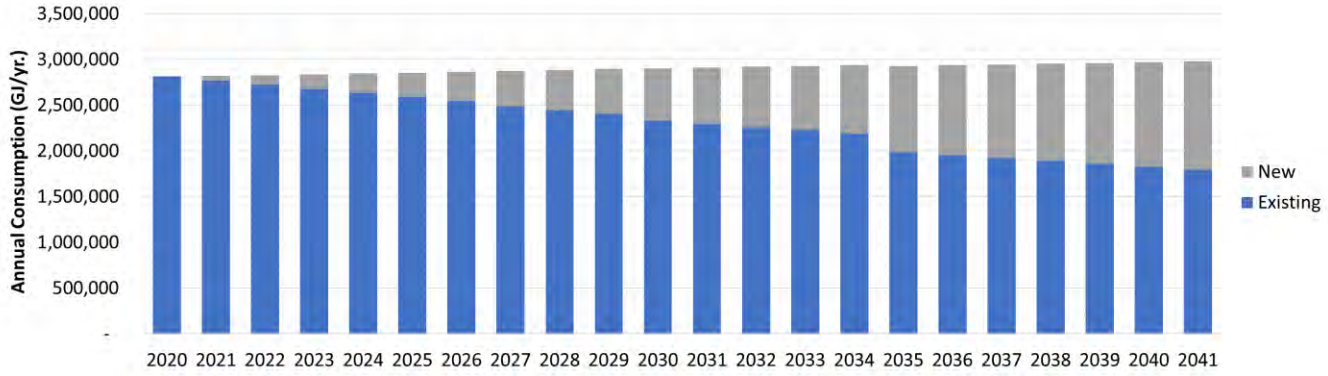
In 2021, natural gas consumption from new buildings was approximately 53 thousand GJ, or 2% of the total commercial sector consumption. By 2041, new buildings are forecasted to use 1.1 million GJ (39% of total sector), as shown in Exhibit 77.

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)

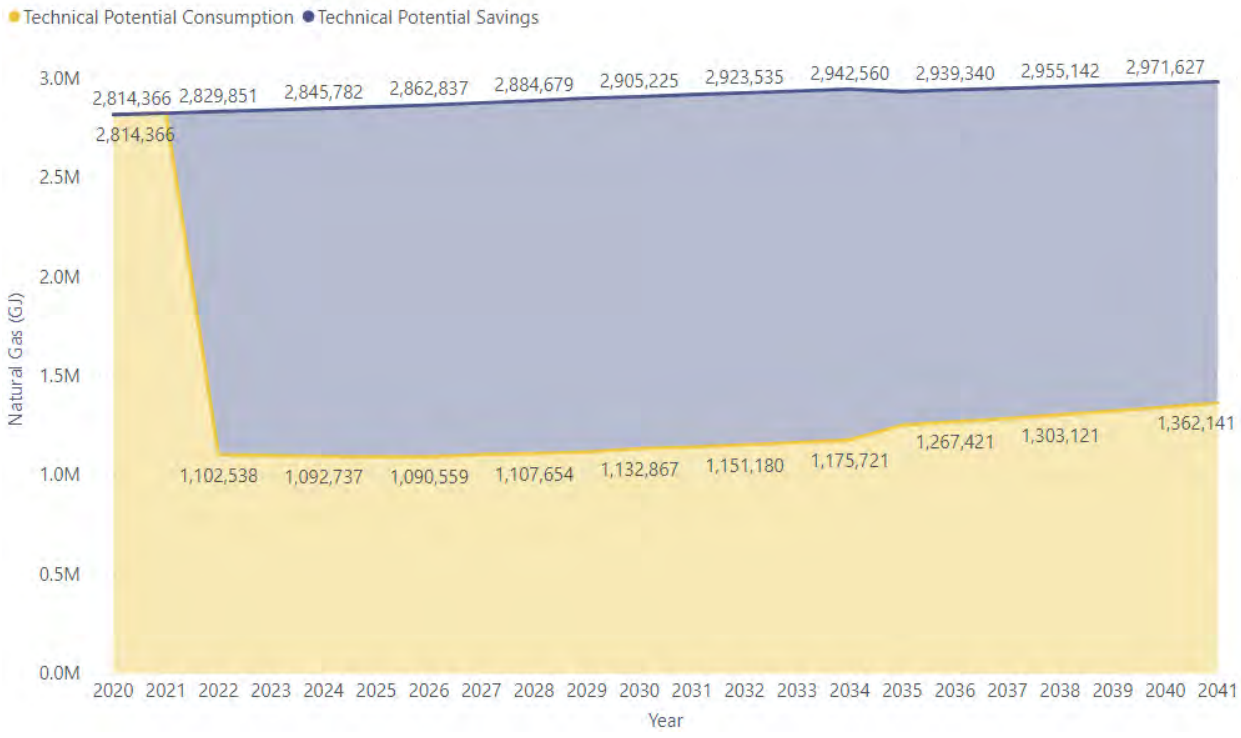
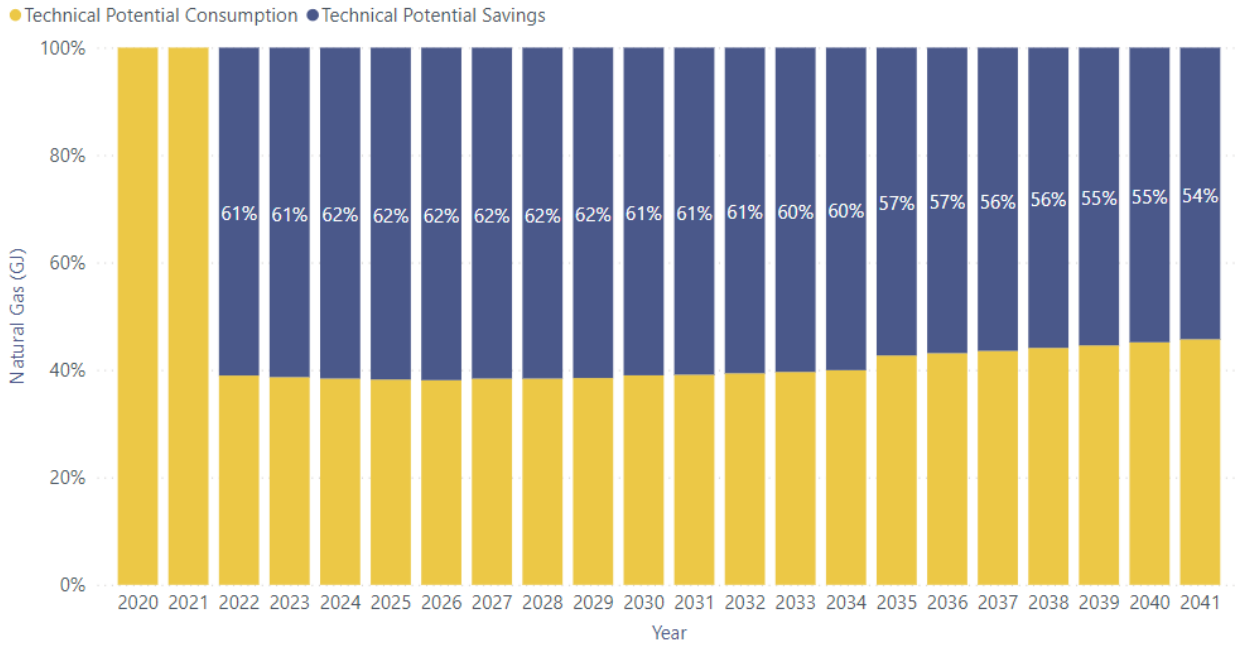


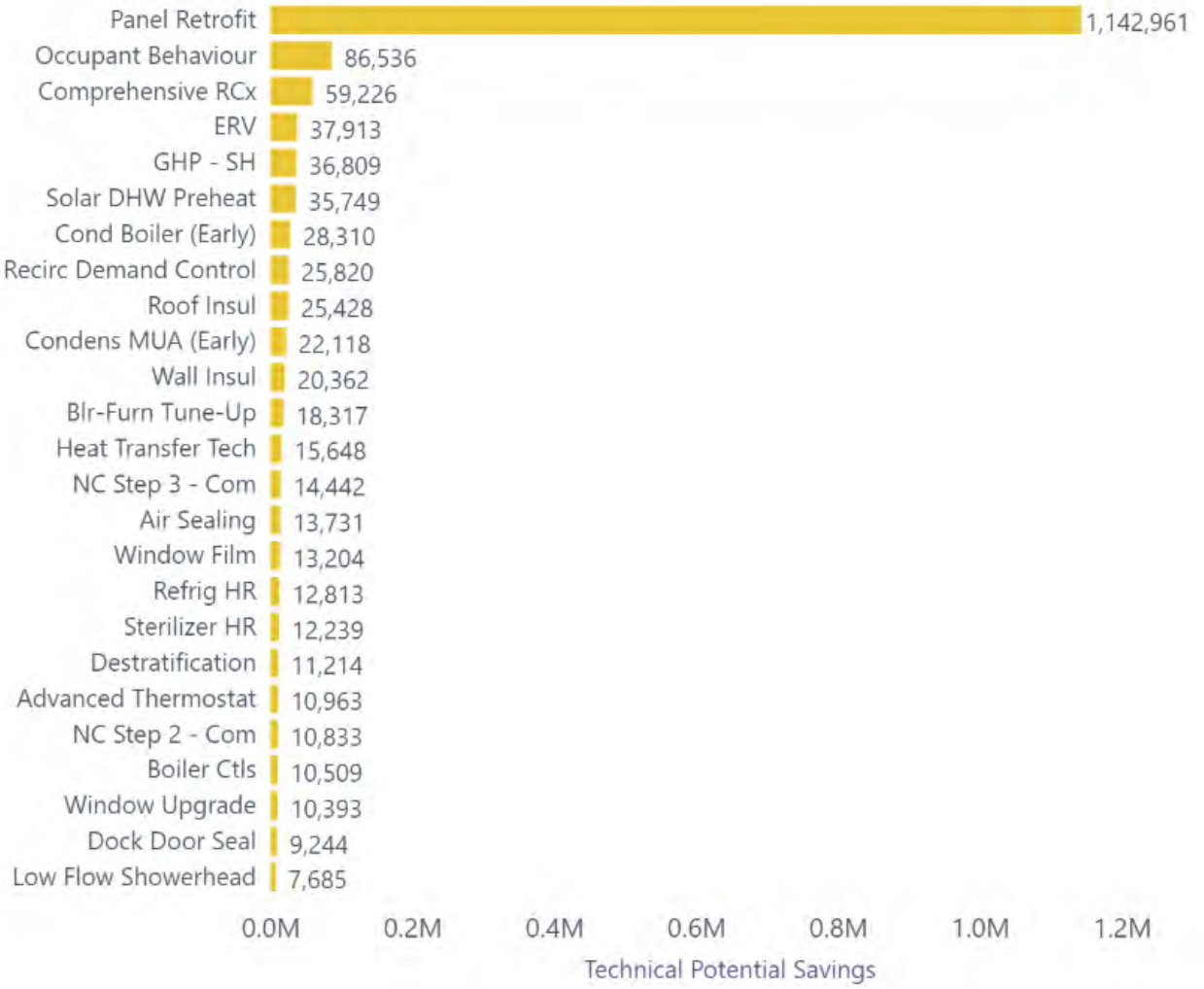
Exhibit 81 – Technical Savings Potential as a Percent of Commercial Reference Case Consumption (%)



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.

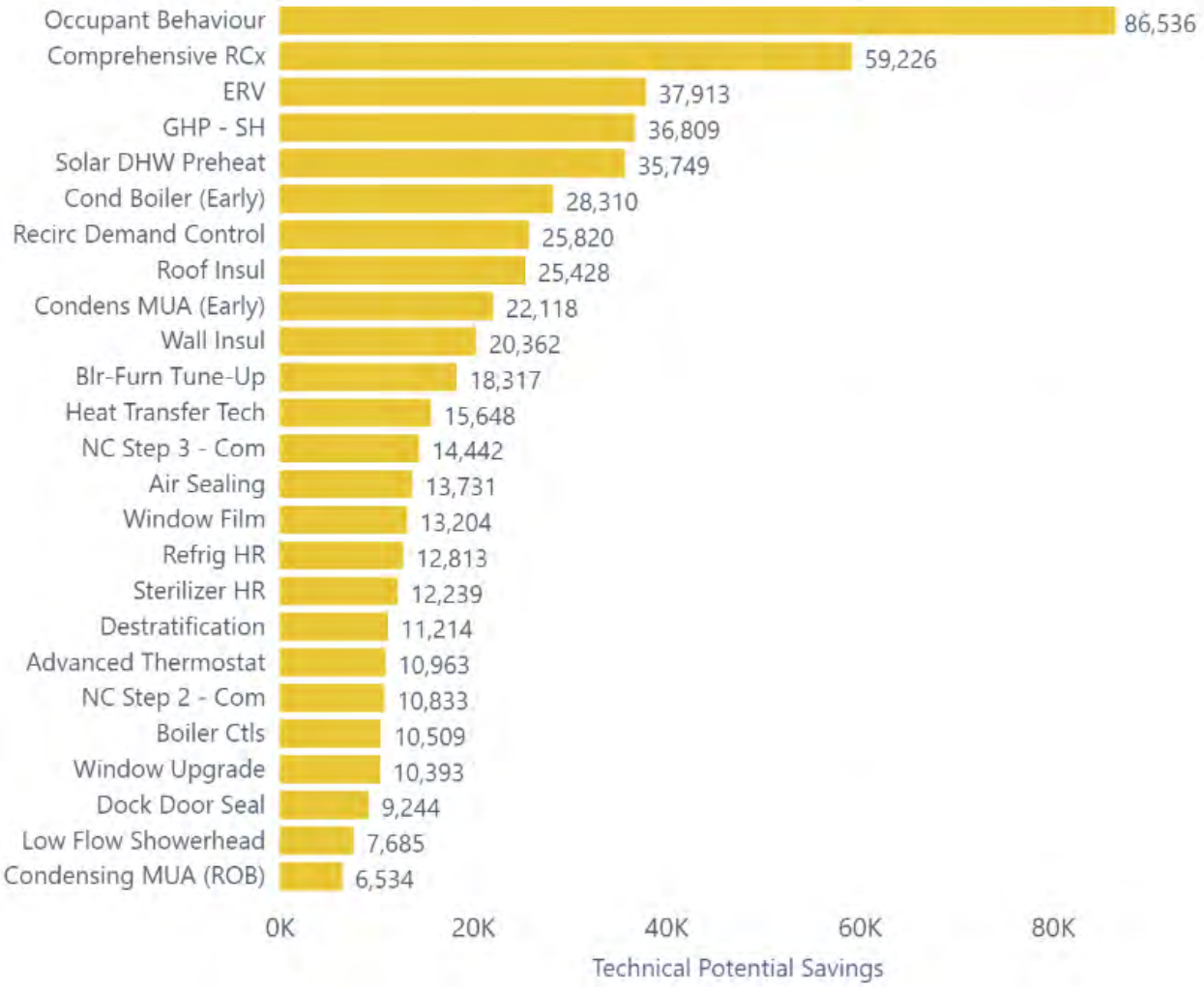
The technical potential savings in 2024 broken down by the top 25 measures are presented in Exhibit 82. Of the top 5 measures that are expected to contribute most of the technical potential savings, only Panel Retrofit does not pass the TRC test in all regions and segments (average TRC of 0.90)[40] but 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.

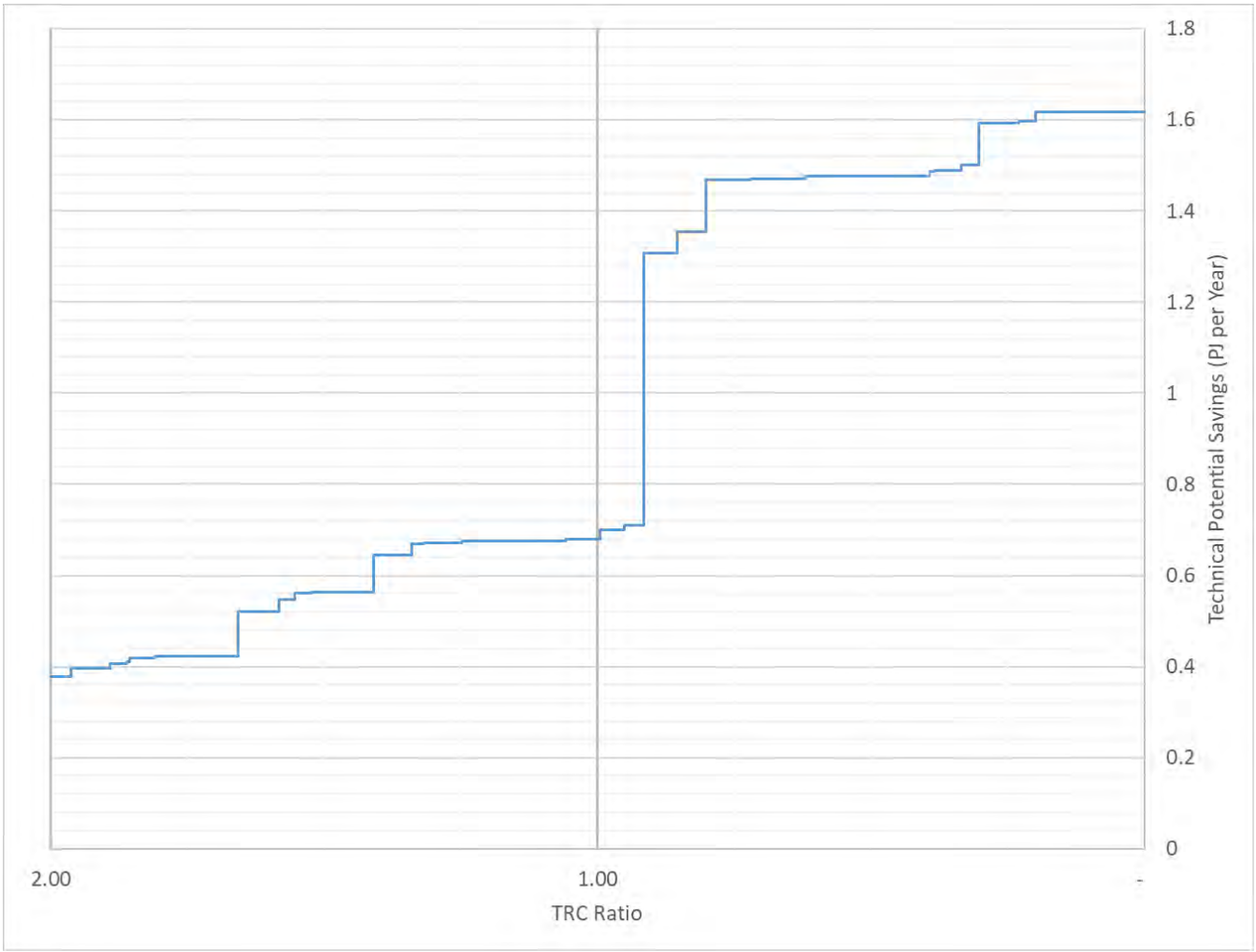
Exhibit 83 - Technical Potential - Top 25 Commercial Measures in 2024 (GJ) excluding Panel Retrofit



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.

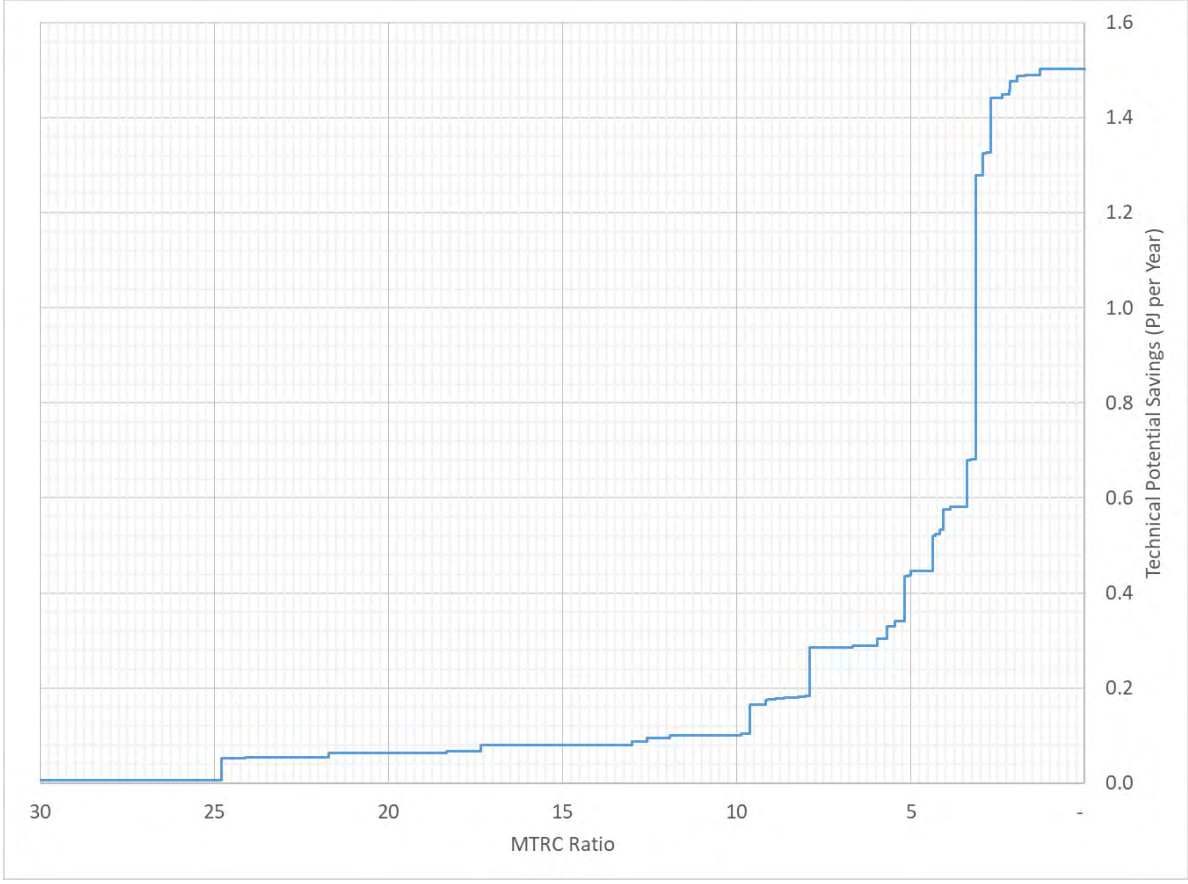
Exhibit 84 – Commercial Sector: Technical Potential Gas Supply Curve in 2041 – TRC



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

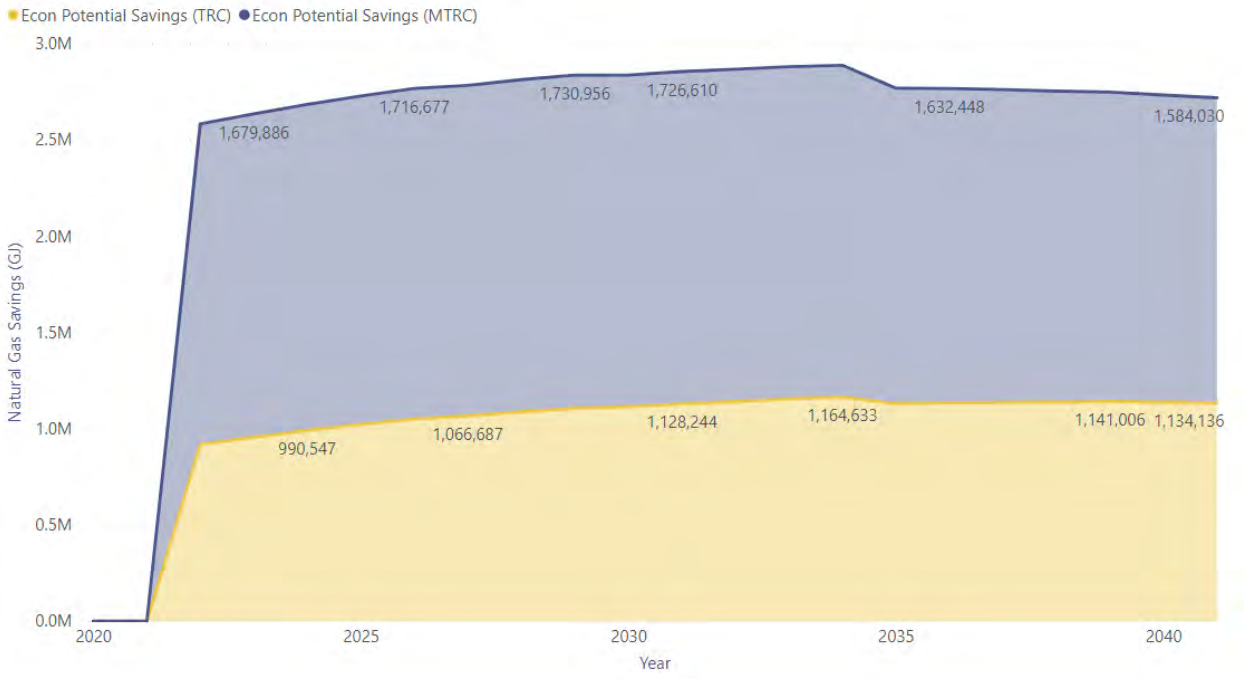


5.6 Economic Potential

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.

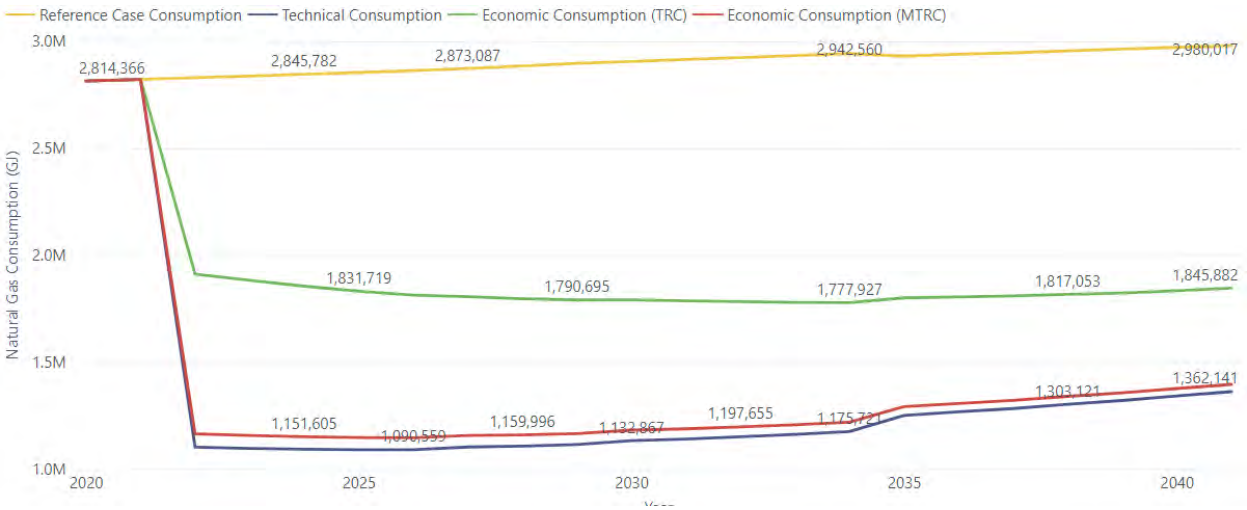
The commercial sector economic potential savings with a TRC screen and with an MTRC screen are shown in Exhibit 86. Of the 61 measures included in the assessment, 46 pass the TRC screen and 59 pass the MTRC screen. The 13 measures that that pass the MTRC but fail the TRC make up the difference between 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

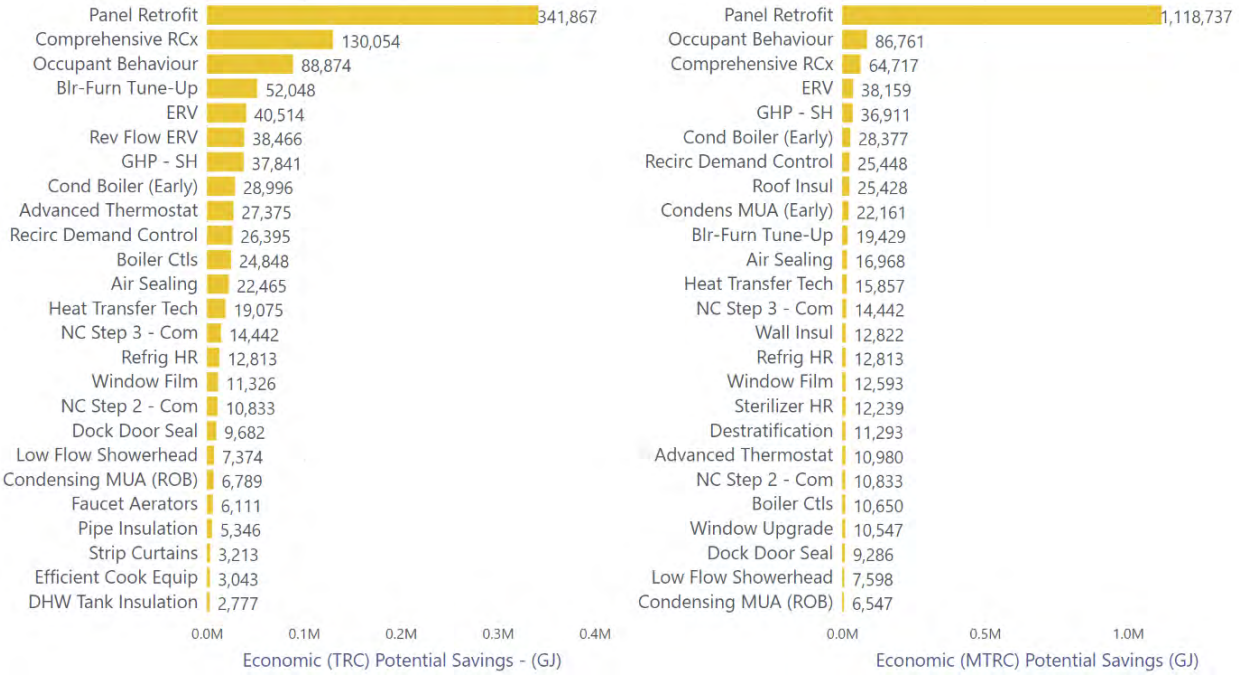
Parent End Use	Economic Savings (GJ) - TRC	Economic Savings (GJ) - MTRC	Difference (GJ)
Space Heating	1,013,151	1,449,535	436,384
Water heating	112,302	125,813	13,511
Food Service	8,683	8,683	0
Other	0	0	0
Pools; Spas & Hot Tubs	0	0	0
Total	**1,134,136**	**1,584,030**	**449,895**

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

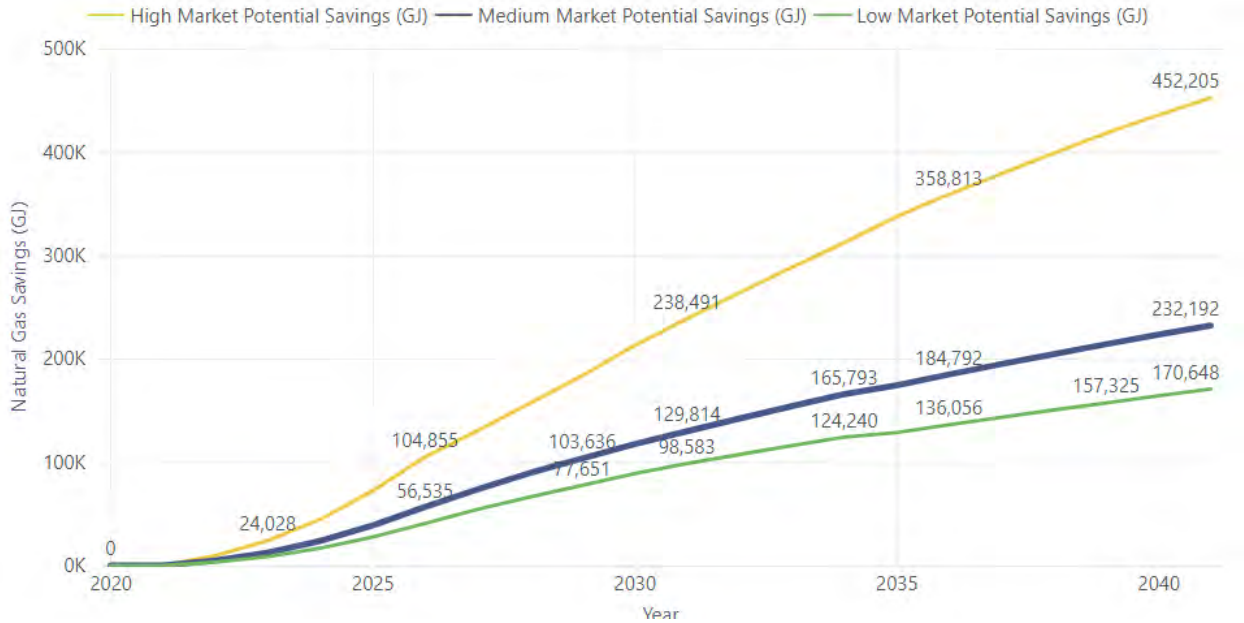
This section provides an overview of the low, medium, and high market potential results for the commercial sector.

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.

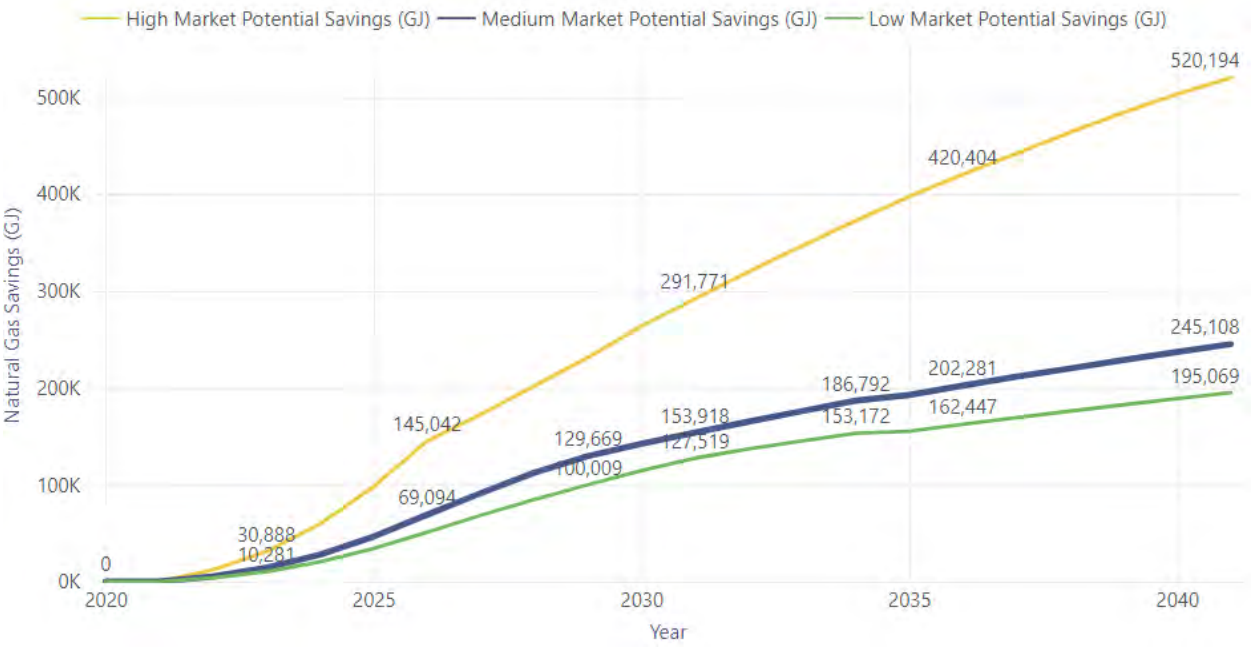
By 2040, the commercial low, medium, and high market TRC potential savings are estimated to be 171 TJ, 232 TJ, and 452 TJ, respectively.

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

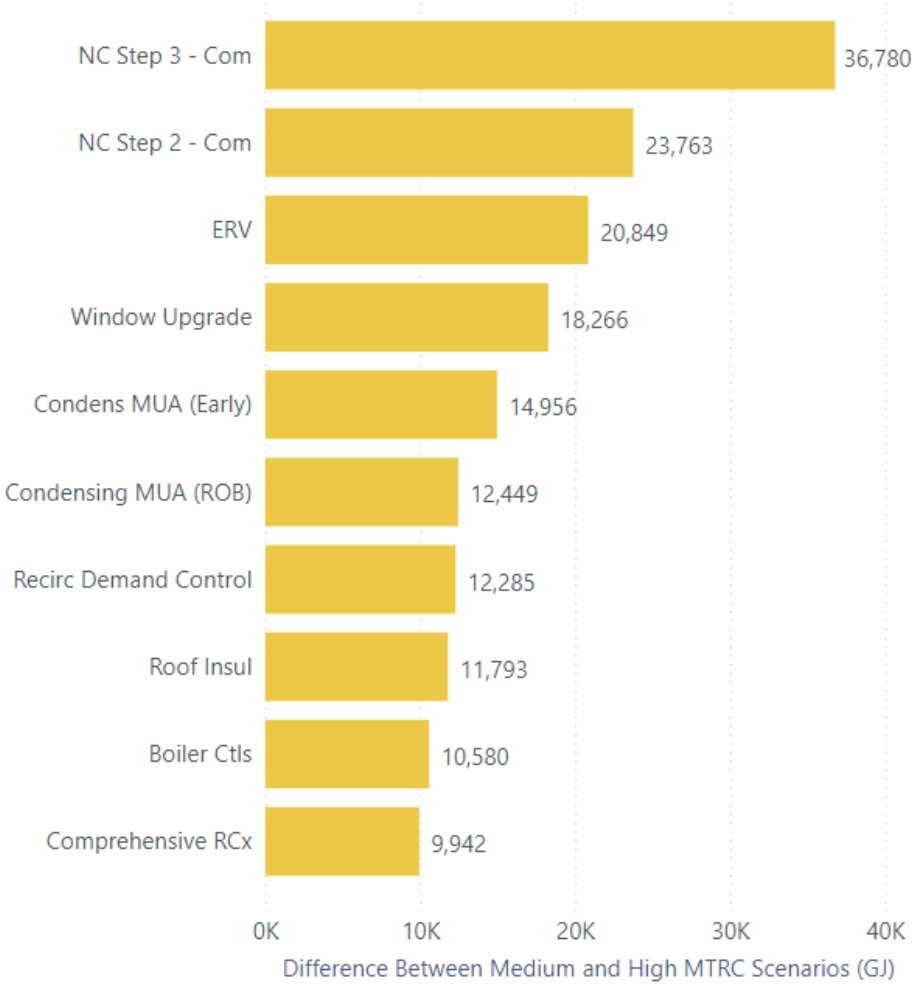
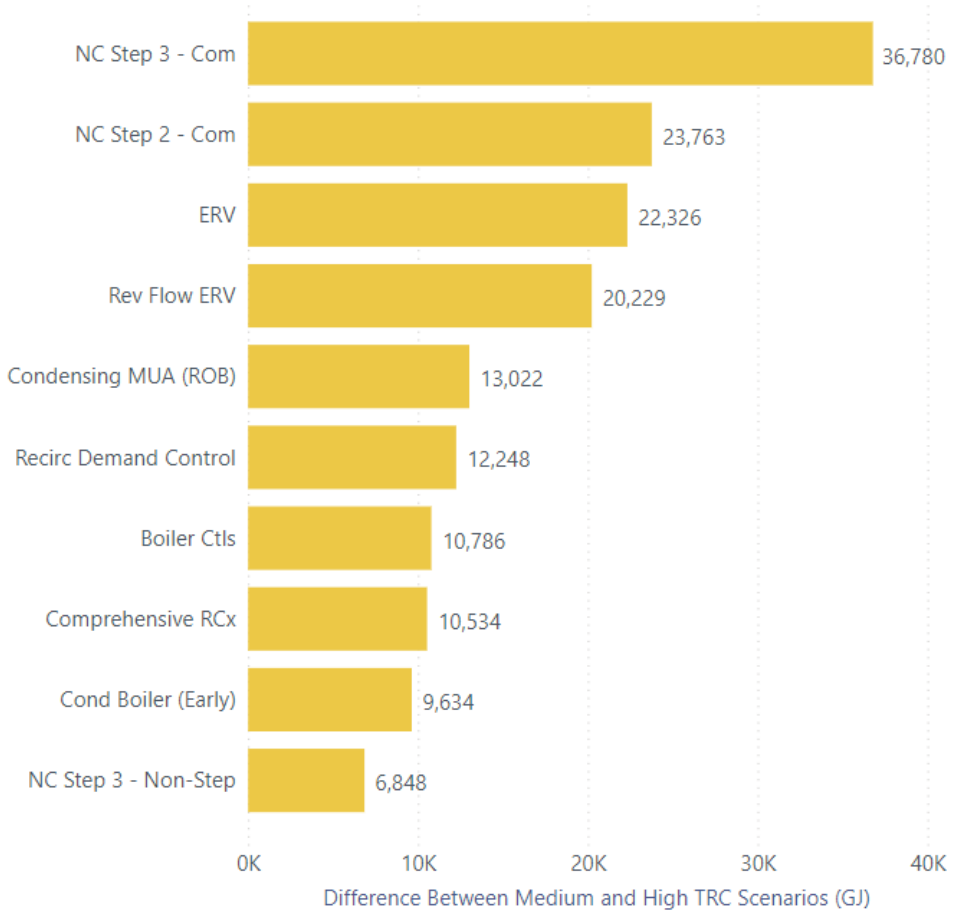


Exhibit 99 – Top 10 Commercial Measures Contributing to Difference in Medium and High Market Potential Scenarios (Using TRC Screen) by 2040



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

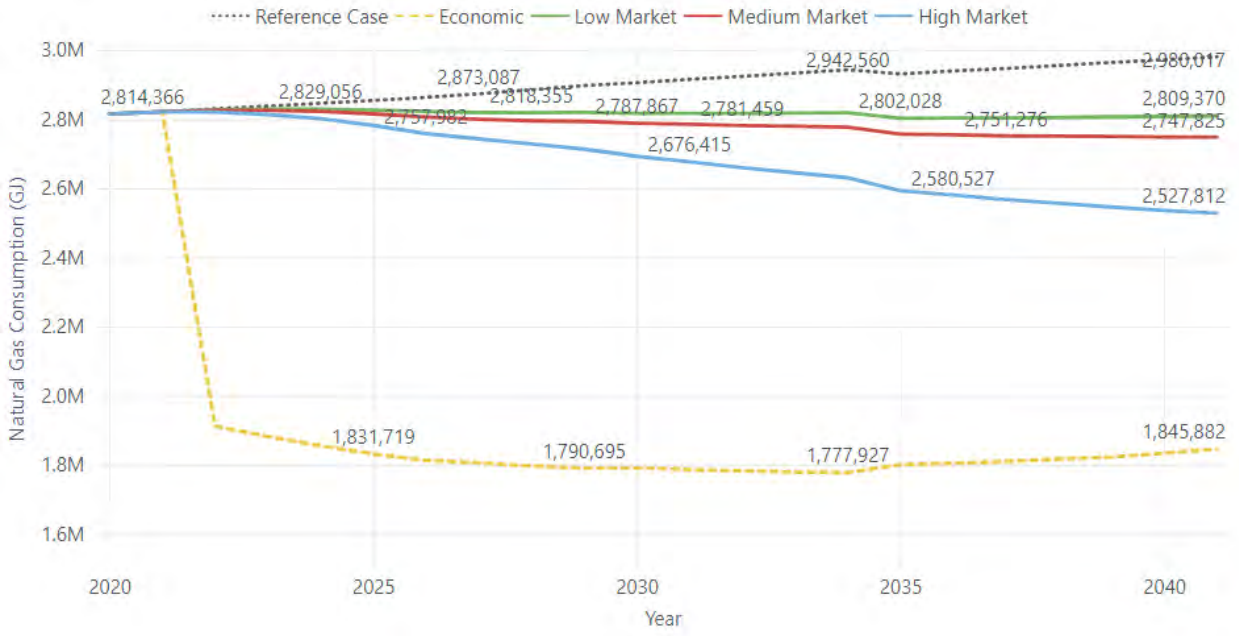
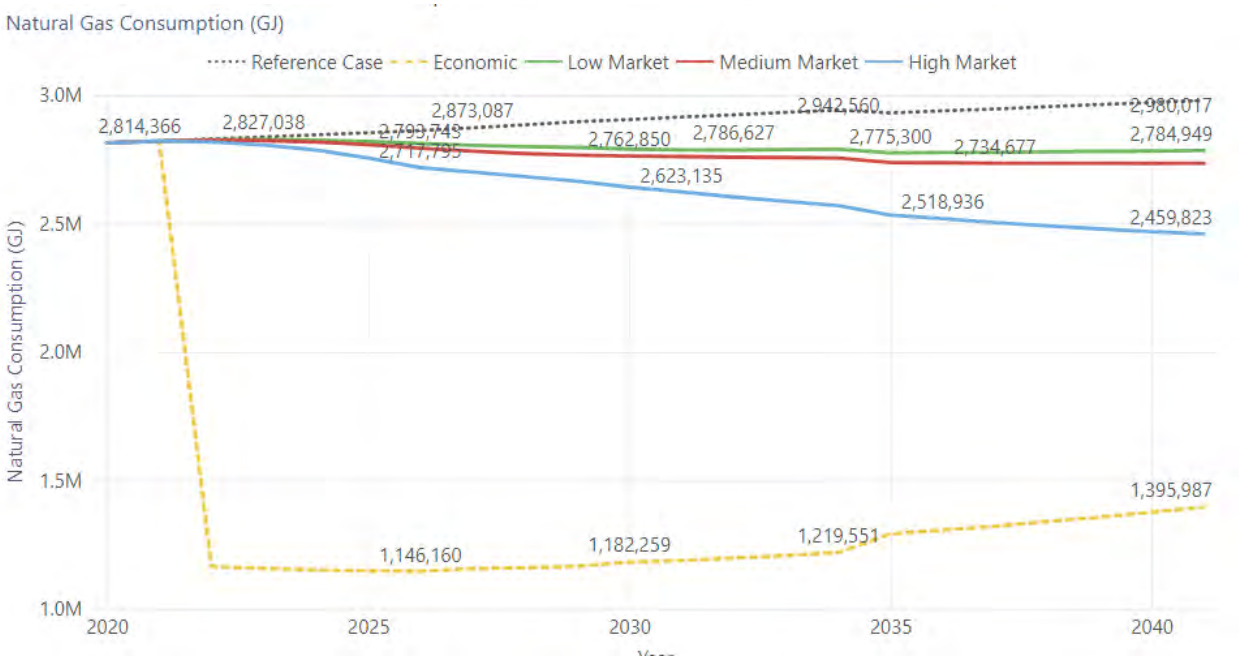


Exhibit 101 – Commercial Market Potential Consumption (GJ) Forecasts – Commercial, MTRC



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.

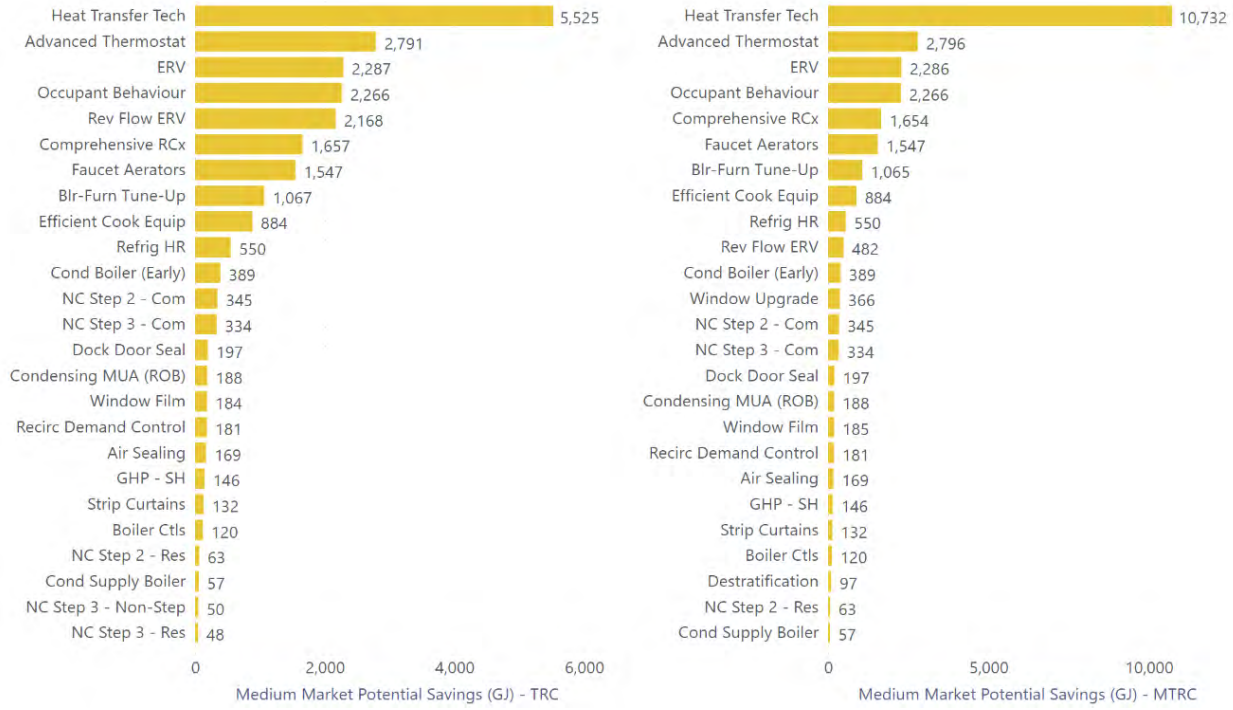
Exhibit 108 – Medium Market Potential Savings by End Use in 2040 – Commercial, TRC and MTRC

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

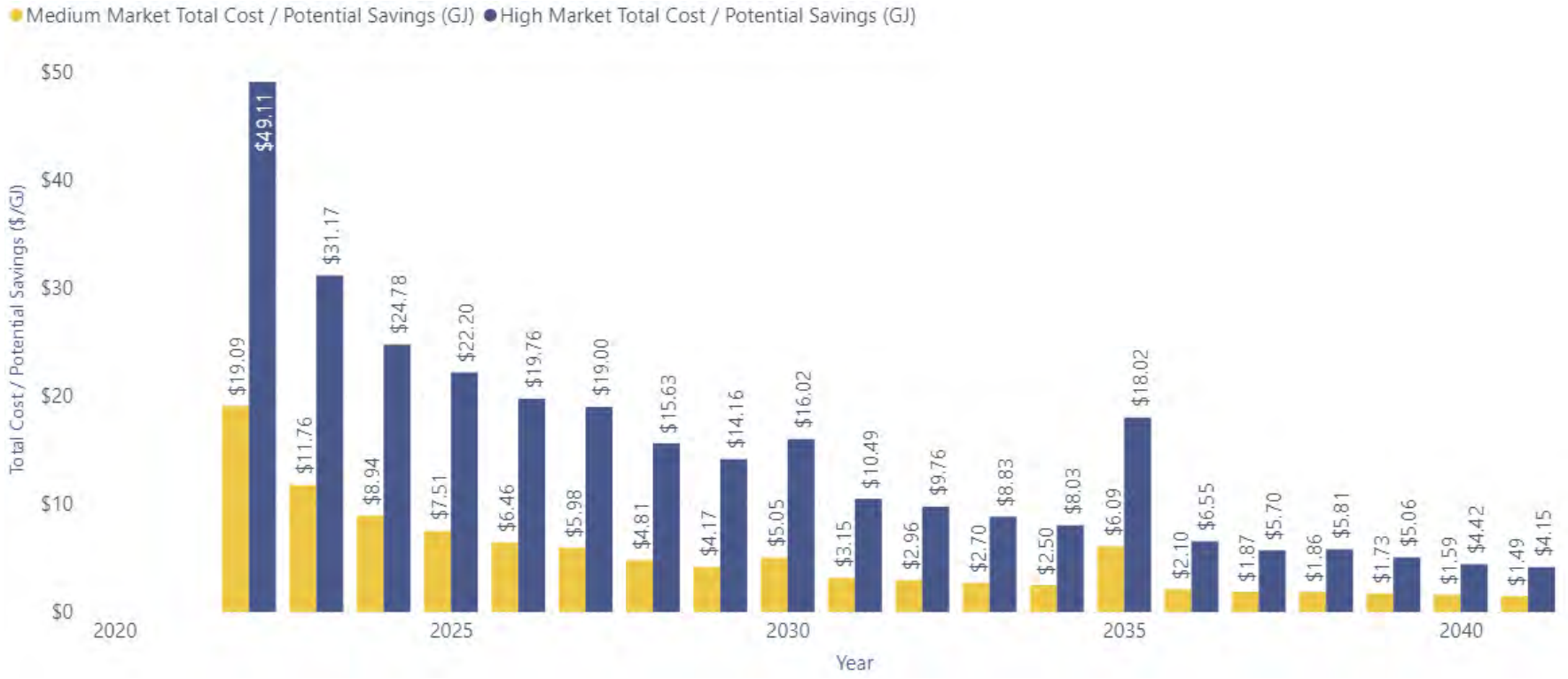
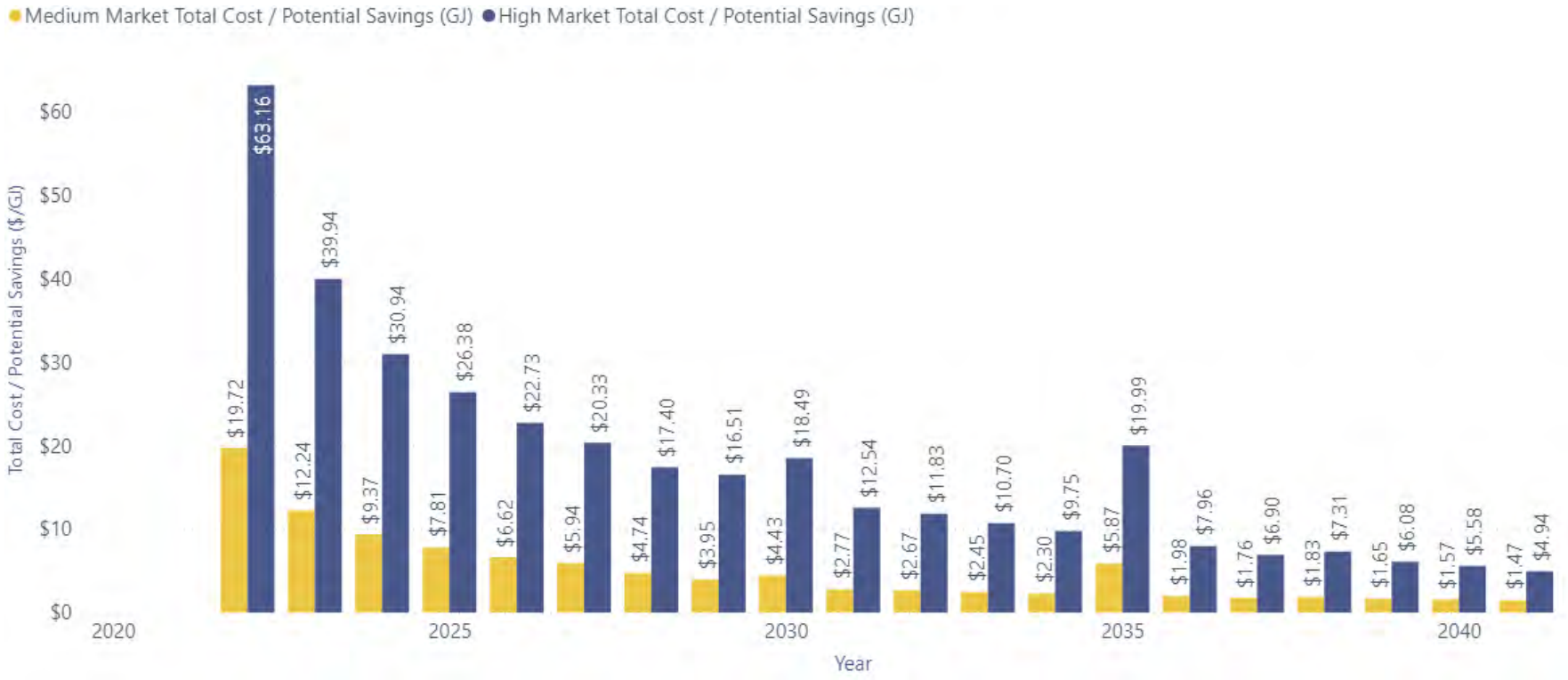


Exhibit 112 – Medium and High Market Incentive Costs and Natural Gas Savings – Commercial, MTRC Ratio

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)

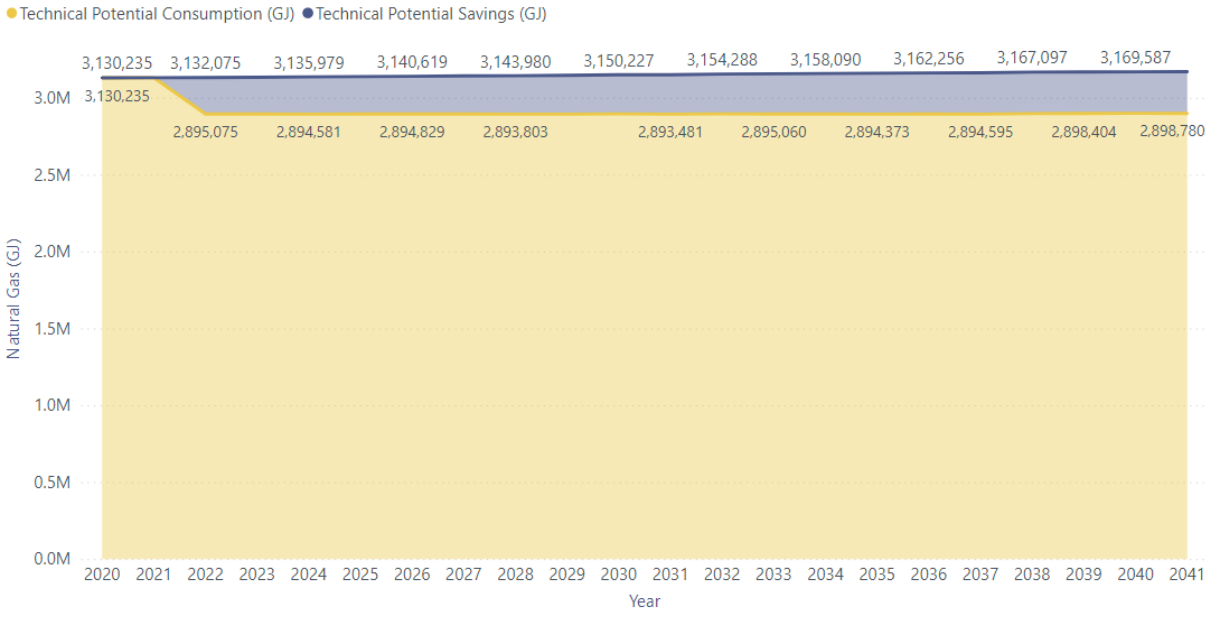
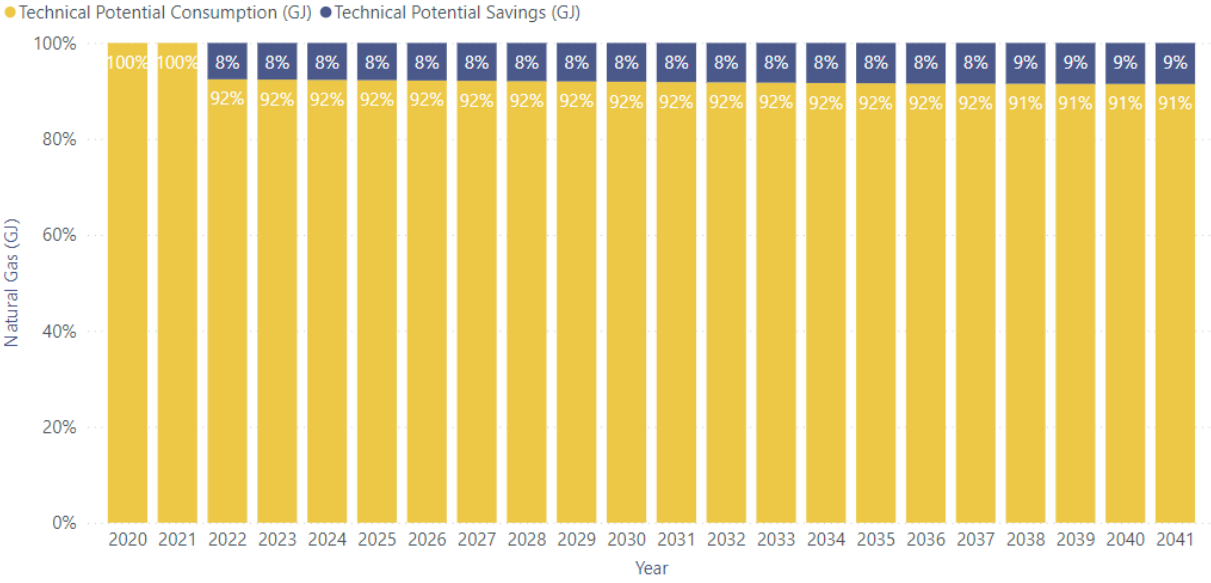


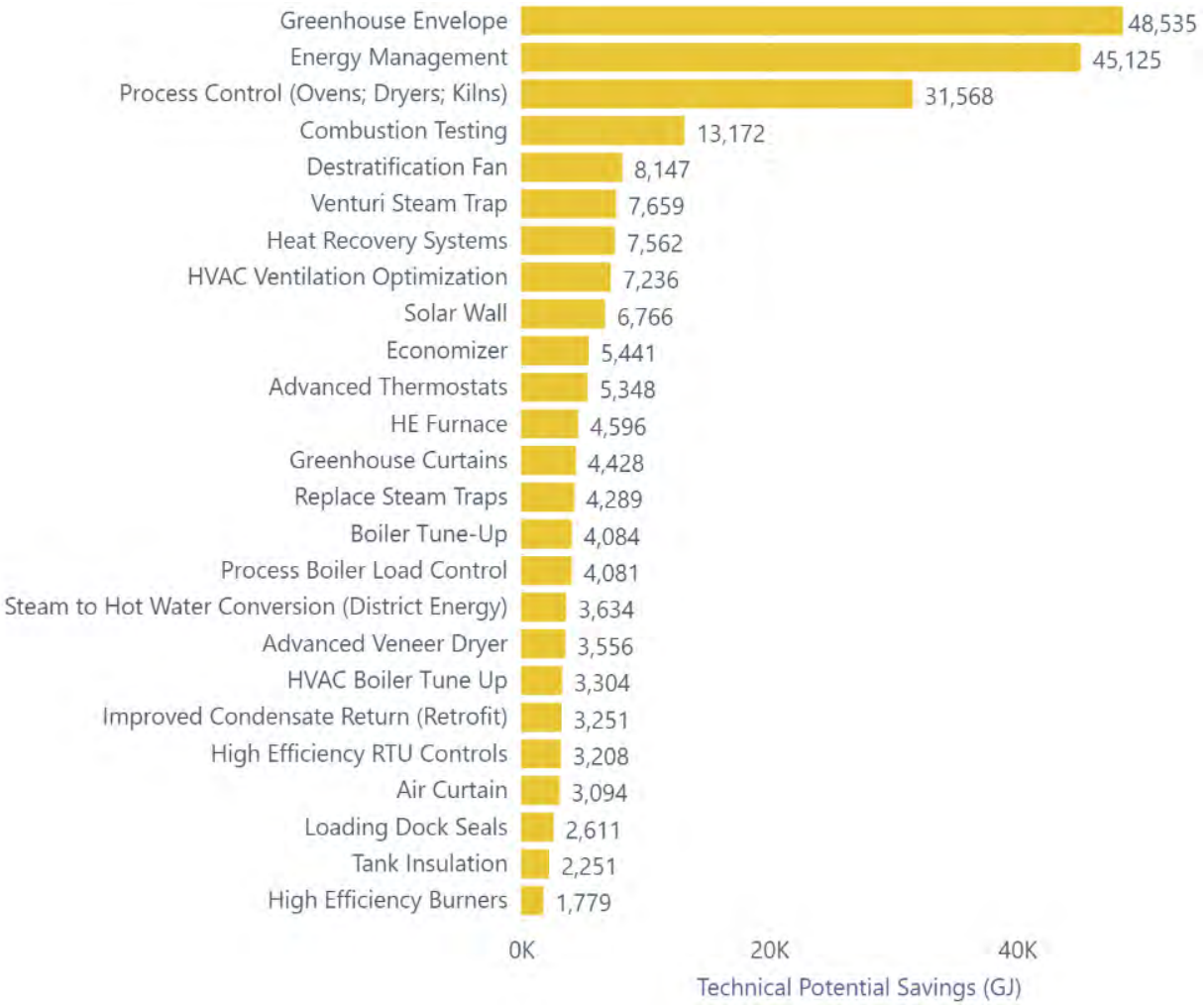
Exhibit 130 – Technical Potential Savings as a Percent of Industrial Reference Case Consumption (%)



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).

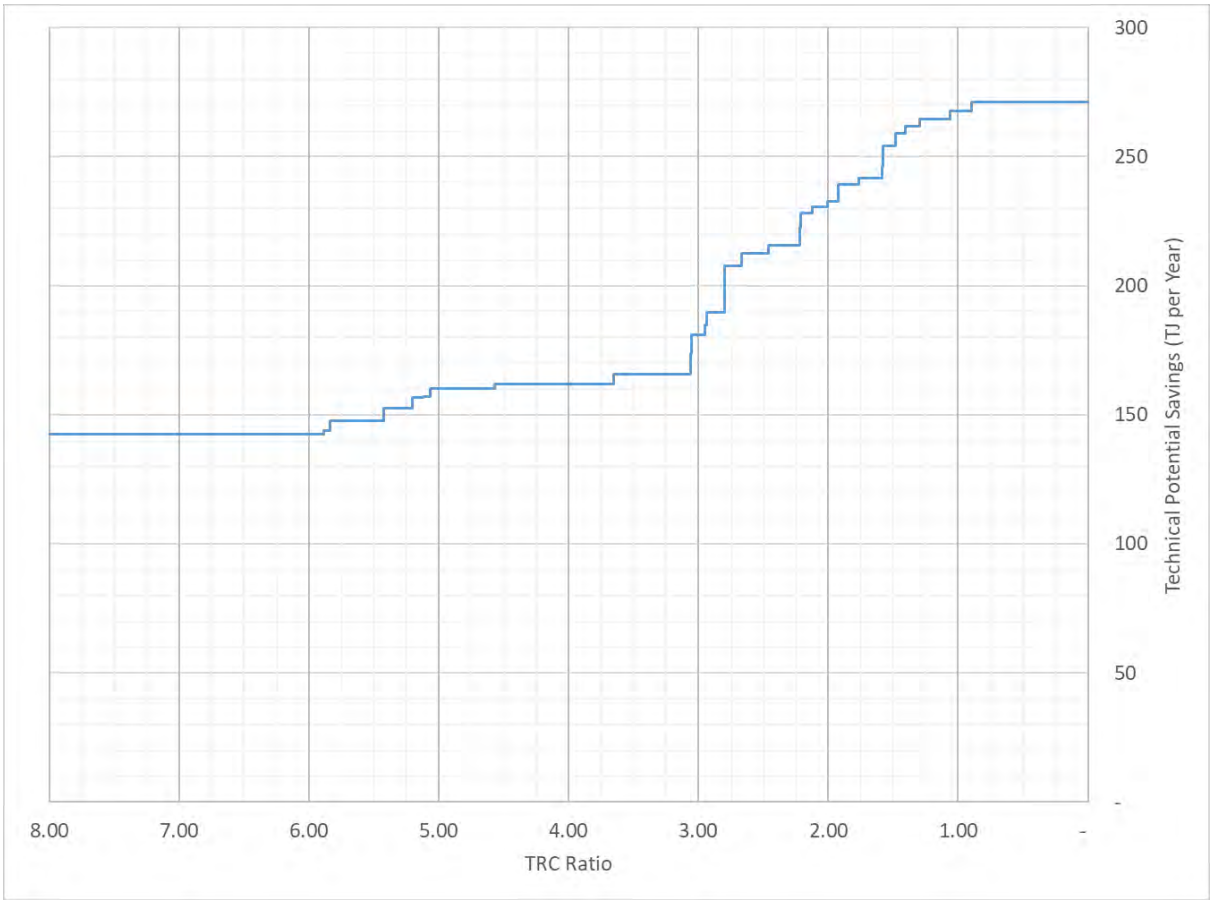
Exhibit 131 – Technical Potential – Top 25 Industrial Measures in 2024 (GJ)



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.

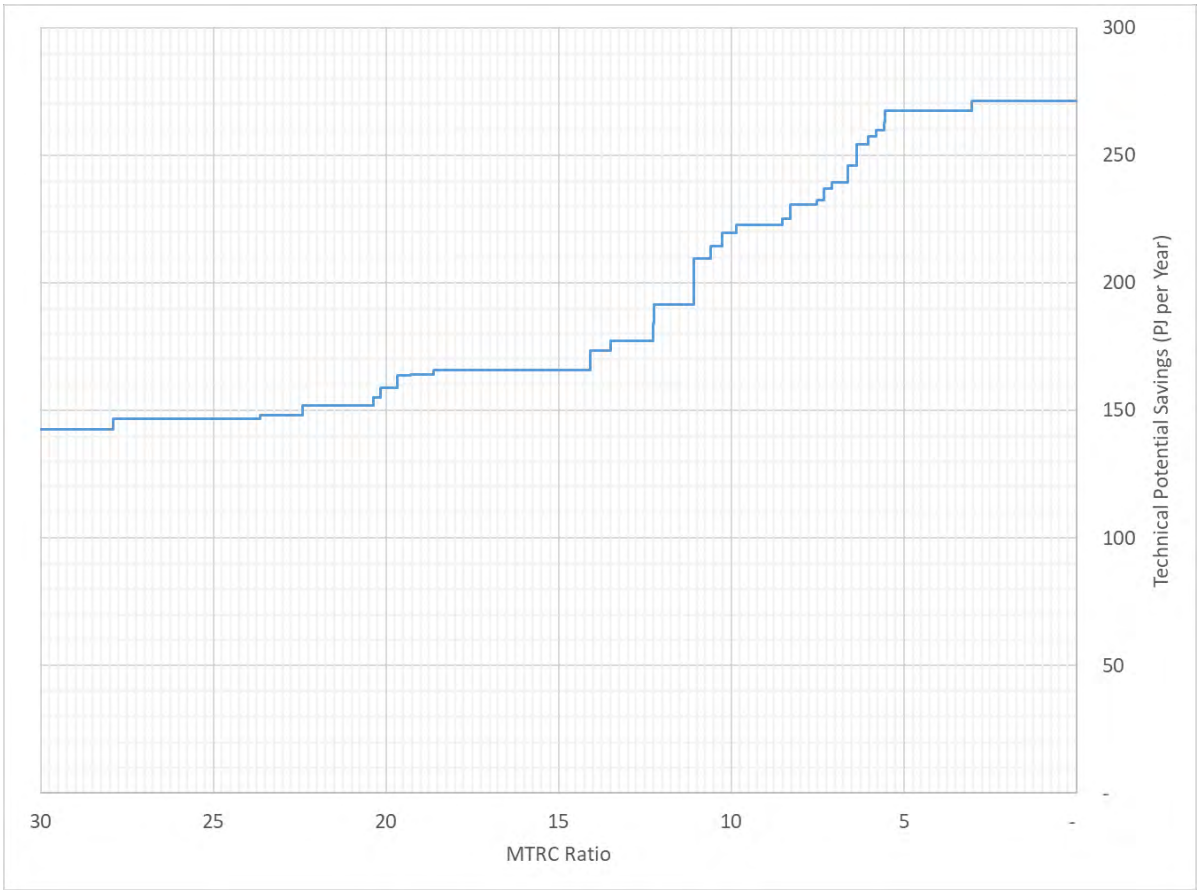
Exhibit 132 – Industrial Sector: Technical Potential Supply Curve, 2041 – TRC



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

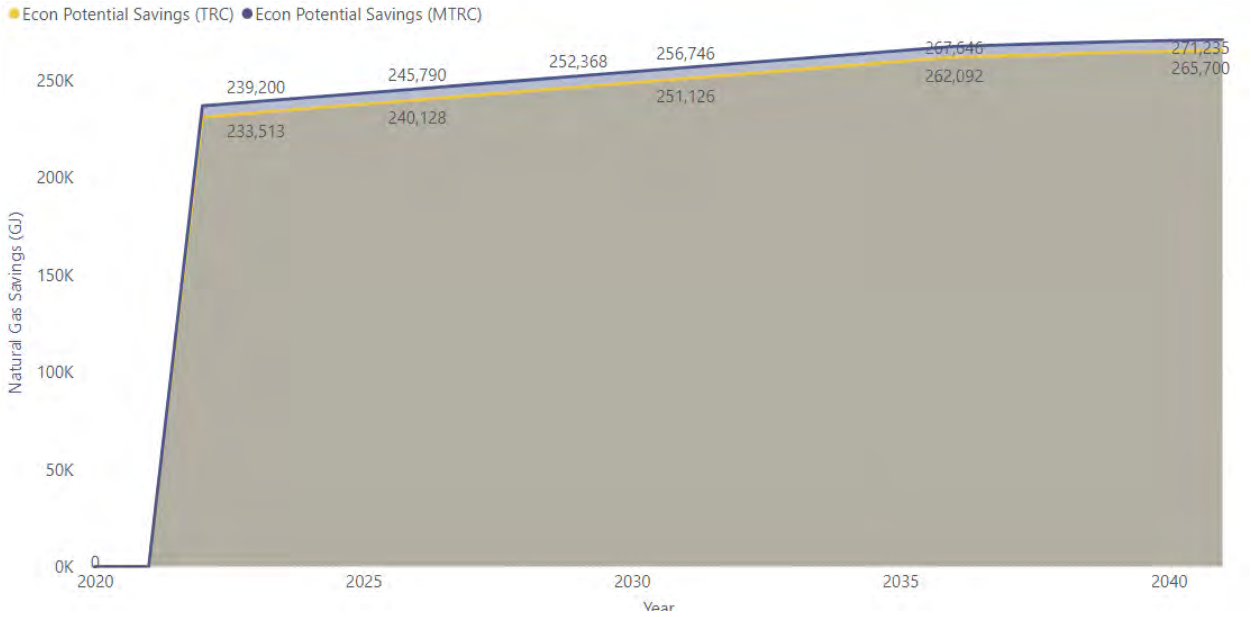


6.6 Economic Potential

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.

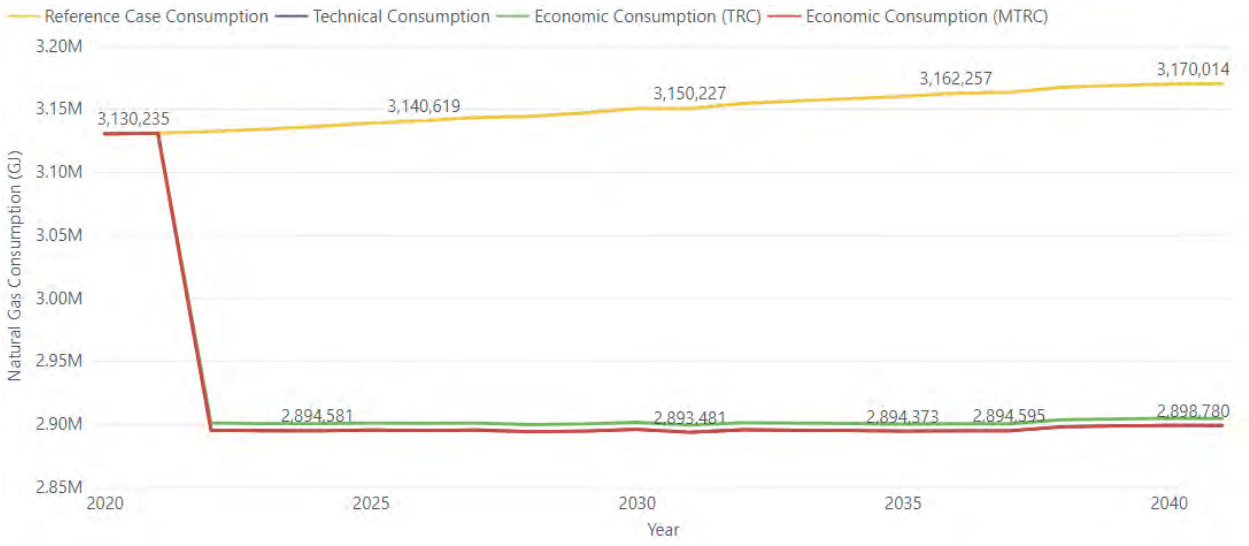
The industrial sector economic potential savings with a TRC screen and with an MTRC screen are shown in Exhibit 134. Although only two measures failed the TRC but pass the MTRC, the economic potential savings with an MTRC screen are approximately 5.7 TJ higher than with the TRC screen in 2024. This is 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

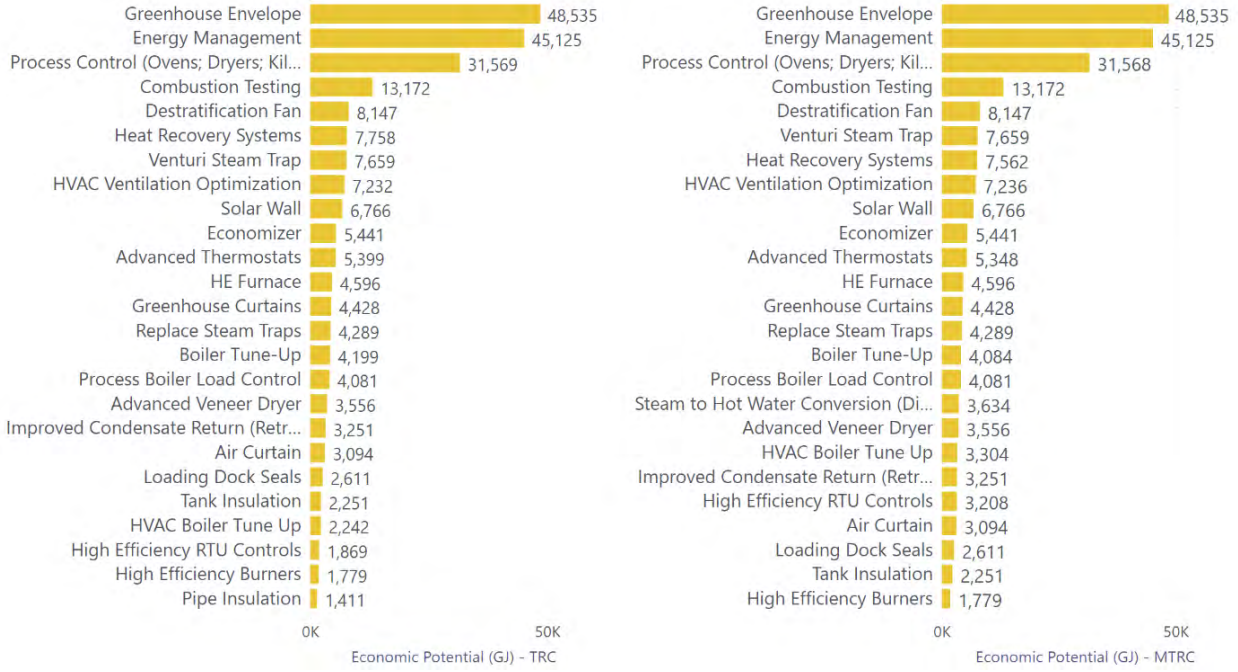
Parent End Use	Economic Savings (GJ) - TRC	Economic Savings (GJ) - MTRC	Difference (GJ)
Process Boilers	108,248	111,511	3,263
Space Heating	47,168	49,389	2,221
Kilns	132	183	51
Direct Gas Use	0	0	0
Direct-fired Heating	10,372	10,372	0
Heat Treating	2,439	2,439	0
On-Site Generation	5,266	5,266	0
Other	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

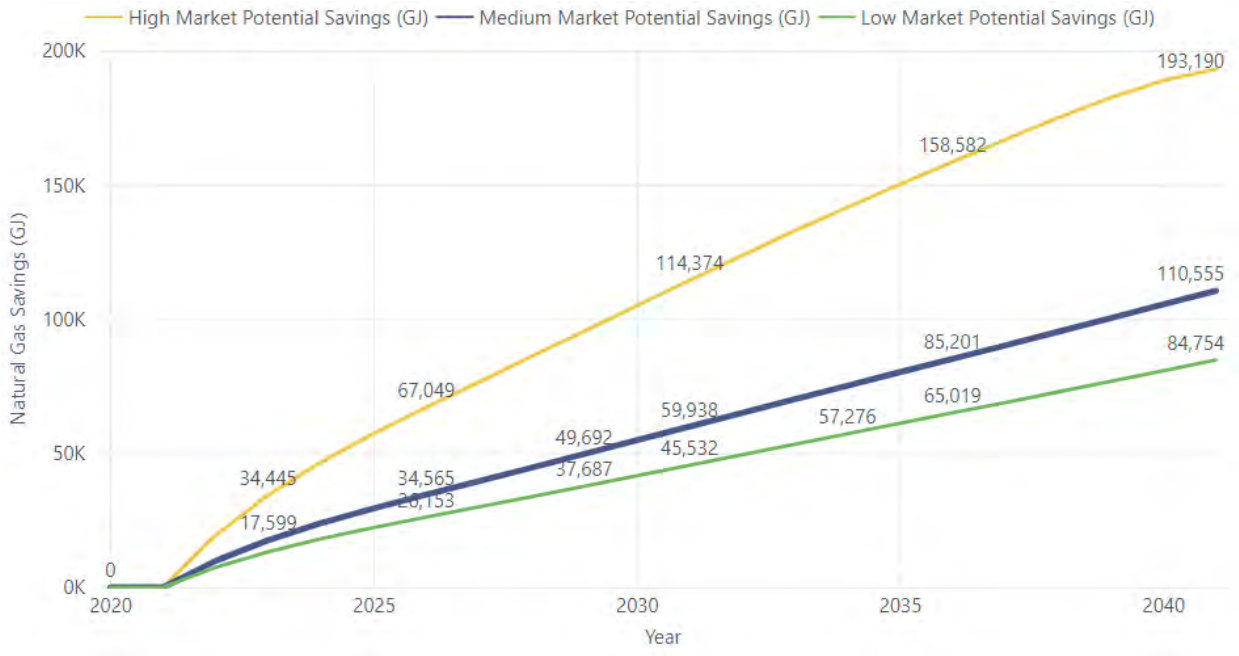
This section provides an overview of the low, medium, and high market potential results for the industrial sector.

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.

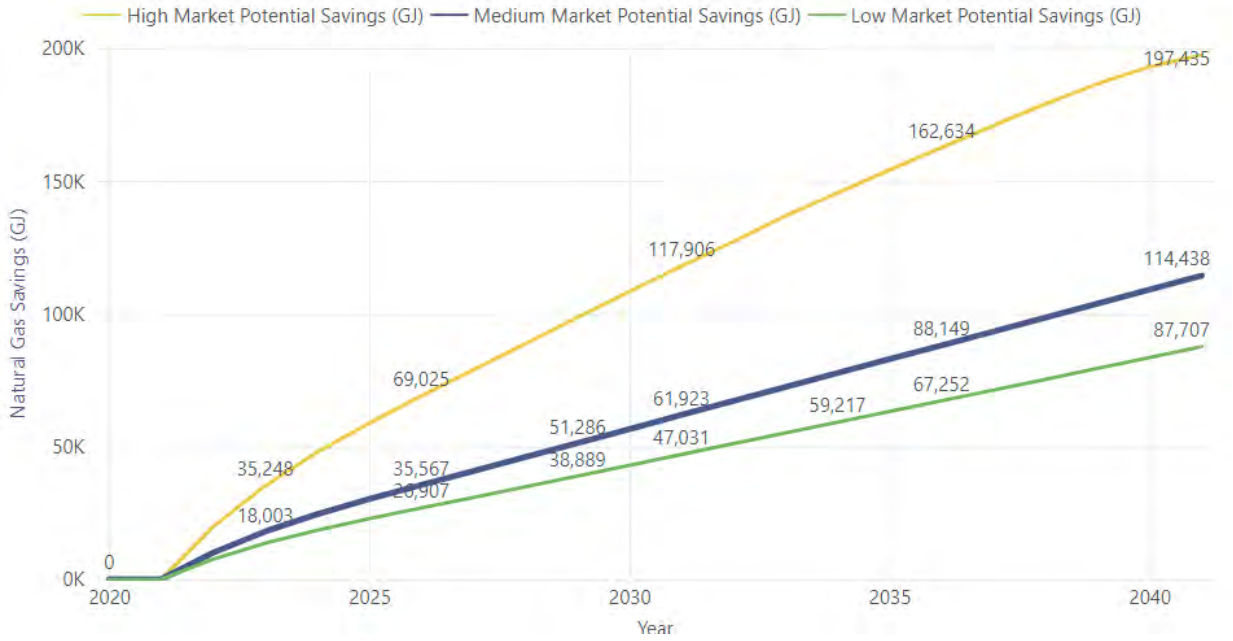
By 2040, the industrial low, medium, and high market TRC potential savings are estimated to be 80.7 TJ, 105.5 TJ, and 188.9 TJ, respectively.

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

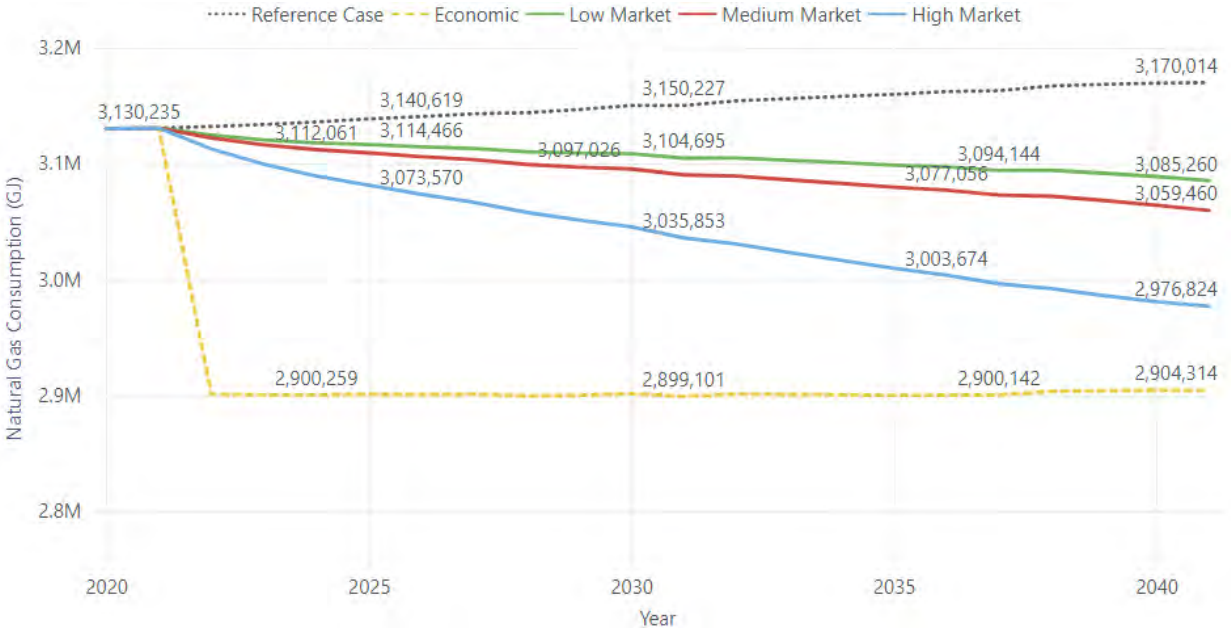
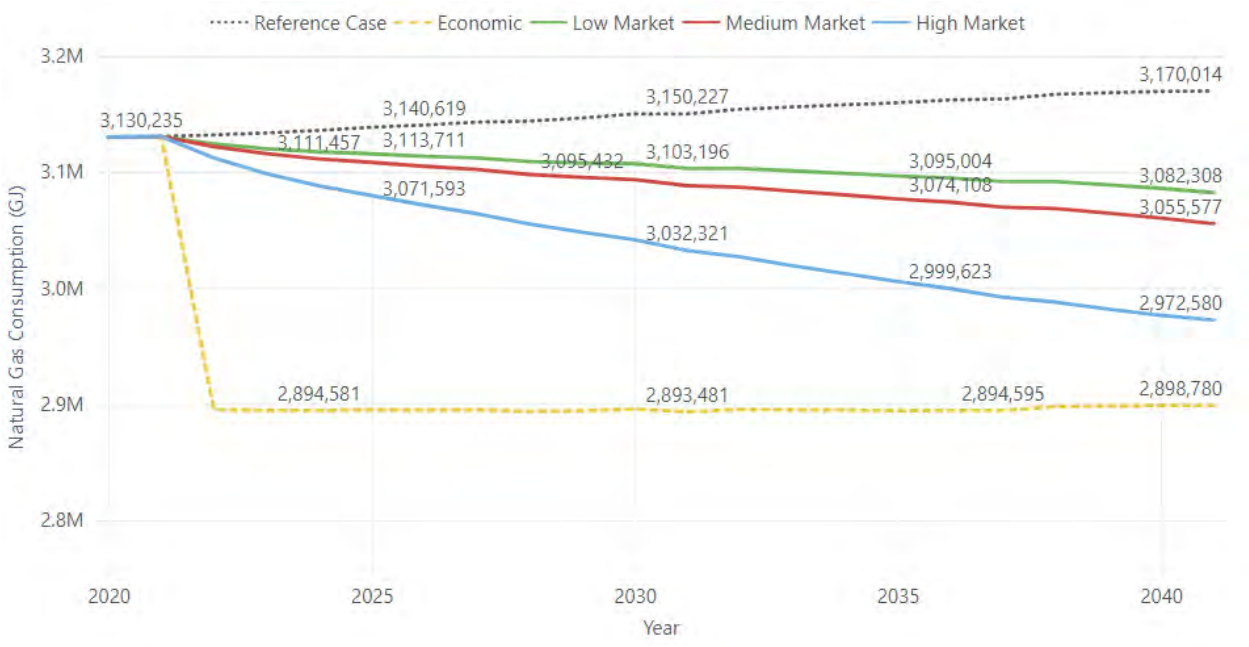


Exhibit 147 – Market Potential Consumption (GJ) Forecasts – Industrial, MTRC



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).

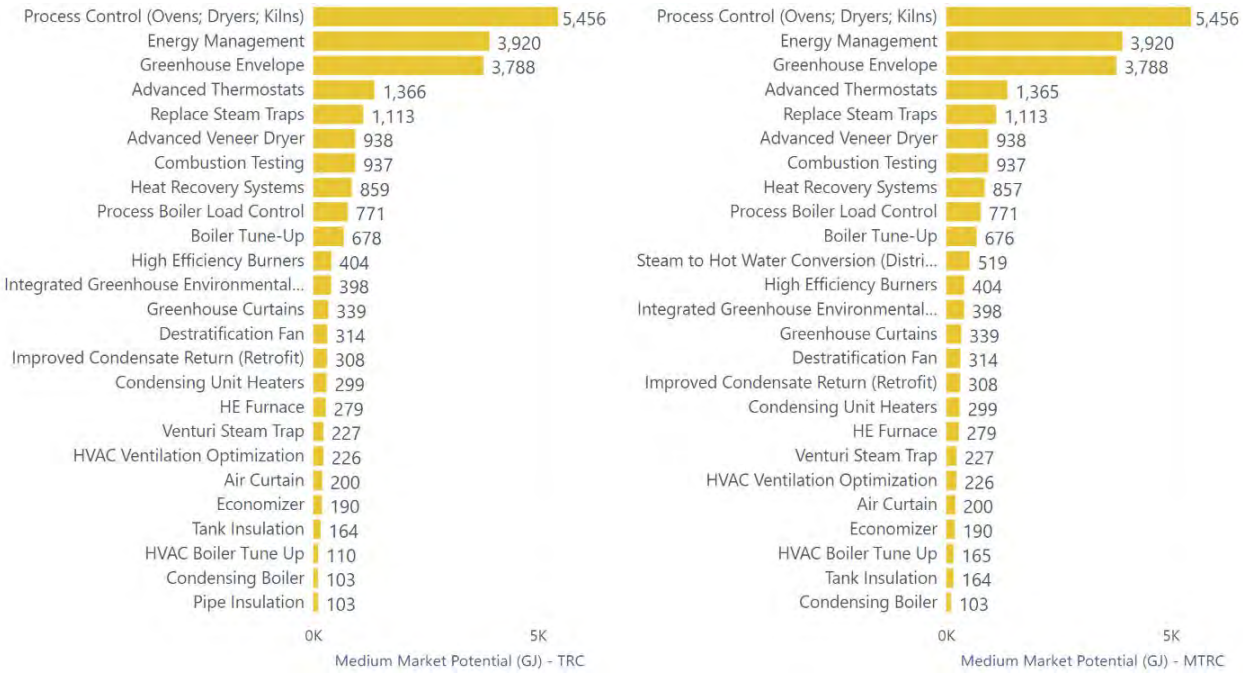
Exhibit 154 – Medium Market Potential Savings by End Use in 2040 – Industrial, TRC and MTRC

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

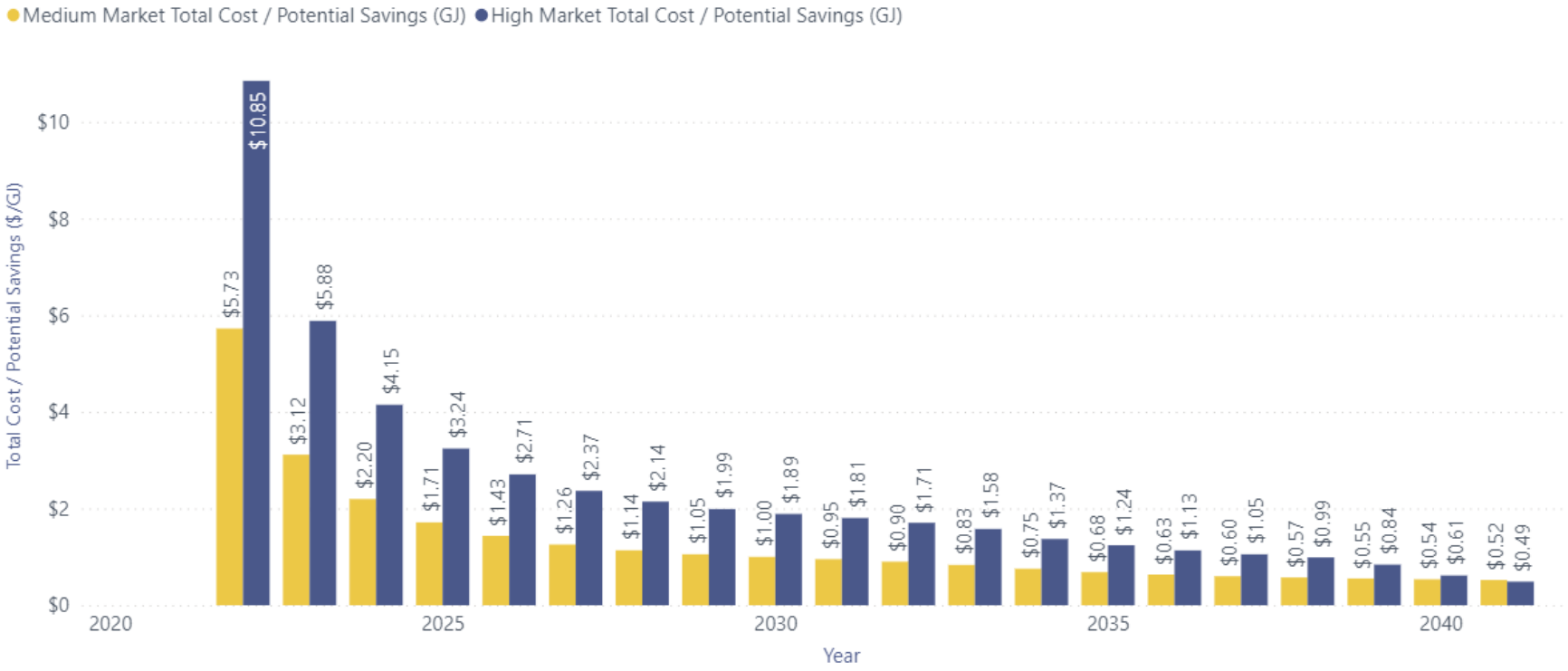


Exhibit 158 – Medium and High Market Incentive Costs and Natural Gas Savings – Industrial, MTRC

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