Appendix 3 – Scenario Specific Inputs

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1 Introduction

This appendix describes the key inputs used to develop the scenarios, provides an overview of the scenarios themselves, including resulting customer electric and natural gas demand projections, and offers details on some additional inputs specific to each scenario. The components of the modelling process addressed in this appendix are shown in dark blue in the Figure A3.1 below.

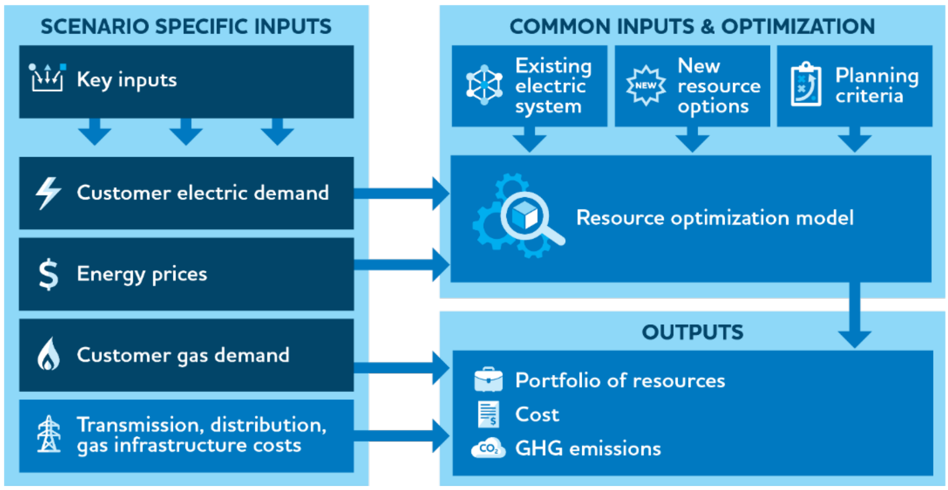


Figure A3.1 – Modelling Process Overview

2 Key Inputs

Key inputs were identified as inputs to the modelling and analysis with the most potential to influence (or be influenced by) the evolving energy landscape as it pertains to Manitoba. Key inputs are also those with significant uncertainty, thereby requiring open discussion and exploration to better understand. Key inputs are not an exhaustive list of all inputs in the modelling and analysis. Figure A3.2 below provides a summary of the key inputs and the detailed factors considered in defining the pace of change for each key input.

Economic Growth	Decarbonization Policy	Electric Vehicles	Natural Gas Changes	Customer Self-Generation
•Global economic environment •Population growth/ immigration •Business development (including community and First Nations investment)	•International climate change commitments •Government policy, mandates and regulations •Codes & standards •Viability and availability of new technologies •Available incentives	•Total Cost of EV ownership •Availability of charging infrastructure •Technology capability •Supply availability •Policy/mandates/ standards/ regulations •Available incentives	•Building energy and space heating changes (includes geothermal) •Cost of natural gas vs. electricity •Availability & cost of alternative fuels (ex: Hydrogen, Renewable Natural Gas) •Cost of alternative natural gas infrastructure •Dual fuel programs •Viability of industrial process energy alternatives •Technology availability •Codes & standards •Available incentives	•Cost of behind the meter resources •Cost of electricity •Purchase price of excess electricity •Electric rate structure •Building energy use •Technology availability •Policy/mandates/ standards •Available incentives

Figure A3.2 – Key Inputs and Factors

To develop the key inputs, Manitoba Hydro considered areas of the Manitoba energy landscape where material change could occur over the 2023 IRP study period. Outlooks related to the energy landscape were informed by the customer survey conducted as part of round 1 external engagement, which had nearly 15,000 responses from across the province. The survey findings provided a starting point to develop key inputs proposed for discussion in round 2 external engagement. Feedback from round 2 engagement confirmed no additional key inputs were required. However, additional factors and clarification of the drivers for key inputs were suggested and incorporated to shape the scenarios. Engagement participants identified additional potential key inputs including reconciliation with Indigenous Peoples, sustainable development, grid resiliency and reliability, energy efficiency and additional economic factors such as the possibility of a recession. This feedback was considered as part of refining the key inputs and also how it could help inform the modelling and analysis of how different drivers may impact the modelling results.

More detail on the feedback received through IRP engagement is included in the IRP Engagement Report.

The scale and rate of change for each key input is unknown and could vary significantly during the study period, creating uncertainty in Manitoba's energy future. The following sections describe each key input in detail and its associated factors creating uncertainty. Specific assumption values are detailed starting on page 11 of this appendix. There are five key inputs; however, it is observed that some key inputs are interconnected and have a relationship between them. That is, changes in one factor or key input impacts changes in another.

2.1 Economic Growth

Economic growth is a key input because it captures several factors which influence energy use from all sources and has an underlying impact on other key inputs. Economic growth impacts energy use at a fundamental level as increased production generally requires more energy and additional income creates additional demand for goods and services. Examples include new or expanding manufacturing facilities, increased production, new services, and new housing developments.

Factors creating uncertainty in this key input are global economic growth as well as Manitoba specific indicators such as gross domestic product (GDP), population growth, disposable income, and business development. "Commodity prices" was originally included as a factor but removed as feedback from round 2 external engagement indicated that it was unclear if this meant commodities more than electricity and natural gas prices. Feedback was also shared that the factors were missing "business development including community and First Nation investment", so this was added.

2.2 Decarbonization Policy

Decarbonization refers to lowering greenhouse gas (GHG) emissions and although decarbonization can occur in multiple ways, government policy has the highest potential to drive decarbonization across multiple sectors. Various levels of government are focusing on climate change and reducing GHG emissions; however, there remains uncertainty in the timing and extent to which decarbonization policy may be implemented. Proposed and enacted policies were considered in the 2023 IRP. Further description of specific policies can be found in Appendix 6 – Policy Landscape.

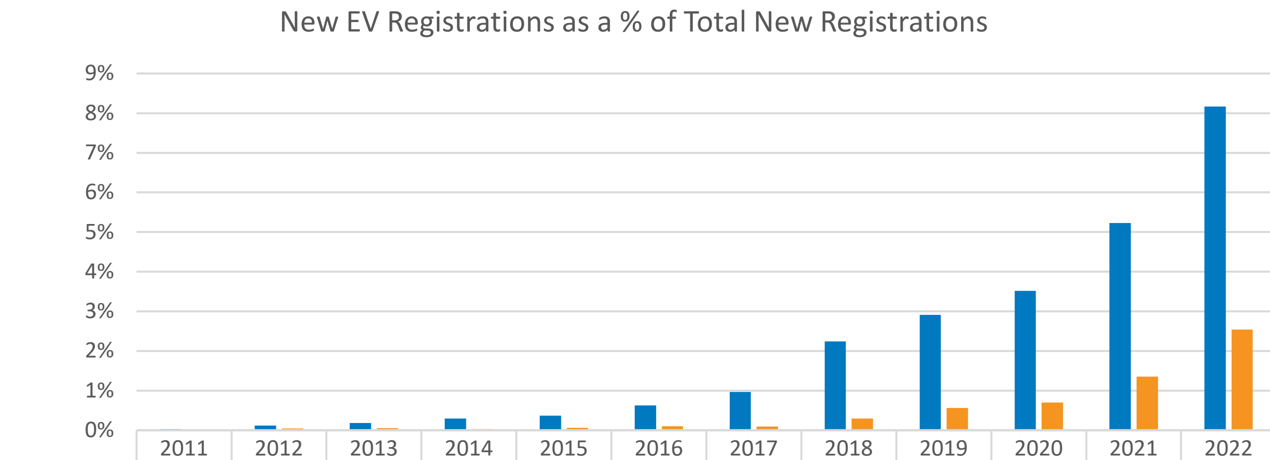
Decarbonization policy factors creating uncertainty in the pace of change include international climate change commitments, government policy, viability of new technologies, customer preferences and attitudes, market developments, and available incentives. Based on feedback from round 2 external engagement, "mandates and regulations" was added to "government policy", and "availability" was added to the "viability of new technologies" factor.

2.3 Electric Vehicles

For the purpose of this study, electric vehicles (EVs) focus on battery electric and plug-in hybrid vehicles, including light duty, medium duty, and heavy-duty vehicles. Hydrogen vehicles were not considered at this time because of lack of vehicle availability, infrastructure, and cost. As shown in Appendix 1 – Existing System & Load, the transportation sector is a major end-use of energy and source of GHG emissions in Manitoba. EVs are identified as a key input because they have the potential to transform energy use in the transportation sector. Also, external engagement through the round 1 customer survey identified that EVs are increasingly in the near-term plans for Manitobans.

Electric vehicles related factors creating uncertainty in the pace of change include availability of charging infrastructure, policy/mandates/standards, and available incentives. The list of factors originally included "cost of new EV" but was updated to be "total cost of EV ownership" based on feedback heard through round 2 external engagement. "Regulations" was added to the "policy/mandates/standards" factor, and "technology capability" and "supply availability" were added as new factors based on feedback that these were missing as part of the electric vehicles key input.

Figure A3.3 shows the proportion of new EV registrations in Canada and Manitoba and demonstrates that some adoption of EVs is occurring. The future rate of adoption is unknown and will depend on multiple factors, including EV cost, incentives, charging infrastructure, EV availability, and EV capability such as range and functionality. Policy, mandates, and standards, such as sales mandates or incentives, could also be a catalyst to cause a step change in the adoption of EVs.



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Canada	0.03%	0.12%	0.18%	0.29%	0.37%	0.63%	0.97%	2.24%	2.91%	3.52%	5.22%	8.17%
Manitoba	0.01%	0.05%	0.05%	0.03%	0.06%	0.11%	0.09%	0.29%	0.56%	0.70%	1.36%	2.54%

Figure A3.3 – Proportion of EV Registrations in Canada[1]

2.4 Natural Gas Changes

The natural gas changes key input captures broad considerations for the role of natural gas to potentially evolve in Manitoba's energy landscape. Natural gas changes can refer to the end-use of natural gas but is also intended to capture the role of the natural gas system including its infrastructure and its role in meeting peak space heating in Manitoba. As shown in Appendix 1, natural gas is one of several major sources of end-use energy in Manitoba, providing 28% of total energy. Natural gas changes include potential alternative fuels (e.g., renewable natural gas, hydrogen) that could be used in place of natural gas and the current end-uses of natural gas (e.g., space heating, water heating) that could be transitioned to another fuel source. External engagement through the round 1 customer survey indicated that customers are not actively looking to switch from using natural gas to electricity in the near term.

Factors influencing changes in natural gas use include the cost of natural gas alternative infrastructure, the availability and cost of alternatives including electricity and renewable fuels, incentives, promotion of dual fuel systems, viability of alternatives for industrial processes. Feedback from round 2 external engagement included several changes and additions. It was identified that further clarification was needed for the "availability & cost of alternative fuels" factor, so it was further expanded to include examples including "e.g. hydrogen, renewable natural gas". Engagement feedback also suggested additional factors which resulted in the addition of several factors, including "building energy and space heating changes (includes ground source heat pumps)", "technology availability", and "codes & standards".

2.5 Customer Self-Generation

Electricity in Manitoba is provided by numerous sources as described in Appendix 1, most of which are generated by Manitoba Hydro. Customer self-generation refers to customers owning and operating

[1] Statistics Canada. Table 20-10-0024-01 New motor vehicle registrations, quarterly (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010002401)

equipment to generate electricity and serve all or a portion of their energy needs. This can also be referred to as "behind-the-meter generation" when the energy is generated and used on a customer's site without passing through a meter. One example of this is a solar photovoltaic (PV) system located on a customer's property and connected to their home. External engagement, through the round 1 customer survey, identified that self-generation is not anticipated to be adopted quickly on a large scale due to cost and return on investment. Therefore, it was deemed that additional research would be required to further explore this key input and therefore the input was proposed for discussion with engagement participants.

Factors creating uncertainty in the rate at which customers choose to generate their own energy include electricity rate structures, the cost of electricity, the purchase price of excess electricity, costs of behind the meter resources, available incentives, and applicable policies, mandates, and standards. Based on feedback from round 2 external engagement, additional factors were incorporated including "building energy use" and "technology availability".

3 Scenarios

The use of scenarios is a common method to modelling and analysis when faced with uncertainty. The scenarios in this analysis are not intended to describe every possible future, nor are they intended to predict the most likely future, rather they provide a range of futures to study. Scenarios are very different from a forecast or figuring out which future is likely to occur. Four scenarios were developed for the 2023 IRP which all have the potential to become the future in Manitoba, either individually or as a combination.

The four 2023 IRP scenarios were developed with the primary objective of identifying a reasonable range of futures for Manitoba; they are not intended to identify and analyze every possible future. Therefore, each scenario is a combination of specific inputs, including key inputs, grouped together to describe a potential future. As each key input can vary due to the timing and pace of change for various factors impacting that input, the scenarios included four distinct characterizations of change. These characterizations were developed to indicate what that pace of change may look like: slow change, modest change, steady change, and accelerated change. The final driver for the development of the scenarios was identifying which of the 3Ds with the biggest potential for impact in Manitoba: decarbonization and decentralization.

The pace of change for each scenario was framed in the drivers of decarbonization and decentralization as shown in Figure A3.4 below. Each scenario was developed using specific assumptions for each of the key inputs to align with the overall pace of change for the scenario. The scenarios were also developed relative to one another. Scenario 1, slow decarbonization and slow decentralization, represents the slowest rate of change; there is still some change, but it is slow compared to other scenarios. Scenario 4 represents the opposite end of the spectrum, where it describes a future with accelerated decarbonization and steady decentralization. Scenarios 1 and 4 are bookends for the possible futures and each scenario in between represents an incremental difference in the amount of change happening in the landscape.

	Scenario 1: Slow decarbonization & slow decentralization	Scenario 2: Modest decarbonization & modest decentralization	Scenario 3: Steady decarbonization & modest decentralization	Scenario 4: Accelerated decarbonization & steady decentralization
Economic growth	●	●●	●●	●●●
Decarbonization policy	●	●●	●●●	●●●●
Electric vehicles	●	●●	●●●	●●●●
Natural gas changes	●	●●	●●●	●●●●
Customer self-generation	●	●●	●●	●●●

● represents amount of change

Figure A3.4 – Key Input Comparison Across Scenarios

Feedback from participants in round 2 external engagement supported the five key inputs and four scenarios proposed, generally agreeing they captured the most influential factors and range of potential energy futures for Manitoba. More specifically, the feedback confirmed the scenarios were appropriate bookends for the 2023 IRP, so long as scenario 4 reflected a path towards net-zero GHG emissions. The detailed inputs of scenario 4 were then developed to allow scenario 4 to represent such a path. Participants also indicated further review may be needed to ensure the scenarios were flexible and could accommodate more combinations of inputs; this was accomplished through the sensitivity analyses and is further described in Appendix 5.

A description overview of the key input assumptions by scenario is provided in Figure A3.5. The following sections provide more detail on the assumptions for each key input and how those assumptions were incorporated into the electric and natural gas demand projections.

Scenario 1: Slow decarbonization & slow decentralization	**Scenario 2:** Modest decarbonization & modest decentralization	**Scenario 3:** Steady decarbonization & modest decentralization	**Scenario 4:** Accelerated decarbonization & steady decentralization
Economy – lower growth **Decarbonization policy** – reduced ambition **Electric vehicles** – delays or reductions **Natural gas changes** – limited **Customer self-generation** – limited uptake	**Economy** – growth continues **Decarbonization policy** – one of the priorities **Electric vehicles** – many light-duty **Natural gas changes** – growth decreases **Customer self-generation** – economics not favourable	**Economy** – growth continues **Decarbonization policy** – a priority **Electric vehicles** – light and medium-duty **Natural gas changes** – reduced use; some RNG **Customer self-generation** – economics not favourable.	**Economy** – new load attracted **Decarbonization policy** – key focus **Electric vehicles** – highest switching **Natural gas changes** – limited use; more RNG **Customer self-generation** – economics improve

Figure A3.5 – Key Input Description by Scenario

4 Energy Pricing

4.1 Energy Prices

Wholesale electricity and natural gas prices are important inputs for each scenario. Electricity prices impact projected revenue from electricity opportunity exports and the cost of electricity import purchases. Natural gas price outlooks impact Manitoba Hydro's cost to operate natural gas-fueled combustion turbines when present within the modelling. Natural gas prices also impact the cost of natural gas purchased for delivery to customers.

Manitoba Hydro purchases energy price outlooks from multiple independent consultants, which reflect a independent assumptions on future market dynamics. For electricity and natural gas used for electricity generation price outlooks were chosen to generally align with the key input assumptions in each scenario. For example, scenario 4 reflects accelerated decarbonization and uses a consultant outlook that also generally reflects the impacts of accelerated decarbonization on neighbouring markets and energy prices. For natural gas supplied for customer direct use, an average of several forecasts was used.

Energy price outlooks are commercially sensitivity information and therefore not disclosed in this report.

4.2 Carbon (GHG Emission) Price

All scenarios include an assumption on carbon price that incorporates the federal government's legislated nominal increases in the current carbon price to 2030 (discussed in Appendix 6). Beyond 2030, a reference case projection was used for all scenarios where the carbon price reaches \$170/tCO_2e nominal by 2030/31 and then proceeds to stay constant in real dollars (i.e., maintains its value with inflation). While the federal government has not specifically indicated it would tie the carbon price to inflation, it is assumed either this would be the case post-2030/31, or comparable nominal dollar increases would be applied to maintain a consistent carbon price signal.

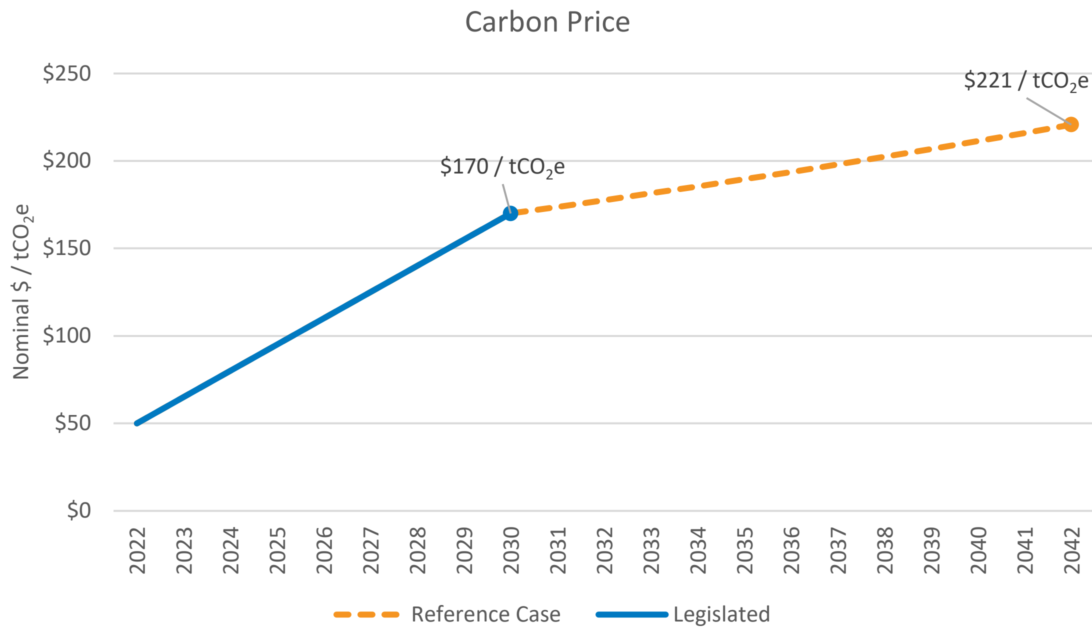


Figure A3.6 – Carbon Price Projection – Reference Case

5 Customer Electric Demand and Customer Natural Gas Demand

5.1 Introduction

For the 2023 IRP Manitoba Hydro prepared 20-year demand projections for each scenario to provide general long-term future electrical demand and natural gas demand requirements in Manitoba. Manitoba Hydro continues to advance its forecasting methodology and this section describes the methodology used to develop the 20-year demand projections. The evolving energy landscape brings unprecedented uncertainty related to long-term energy forecasting. Manitoba Hydro applies industry standard forecast models by customer sector across all scenarios, including econometric modelling, end use forecasts, and individual customer forecasts. The following sections will outline the methods which were consistently applied across all scenarios and how assumptions related to the key inputs were incorporated in each scenario.

5.2 Methodology Across All Scenarios

The following methods were applied consistently across all four scenarios to develop the individual demand projections:

Econometric Modelling

Econometric modelling leverages weather adjusted historic consumption trends, considers future predictions for economic factors including population, income, GDP, and energy price, and projects future electricity and natural gas load for residential, commercial, and industrial sectors. The models used are consistent across all scenarios, but the individual economic inputs vary for each scenario.

End Use Forecast

Manitoba Hydro employs an end use forecast methodology for the residential basic sector, referred to as the residential end use forecast. The primary objective of this forecast is to project the space heating, water heating, and air-cooling systems of residential customers. Projections are separated into groups by new or existing dwelling, by region, and by dwelling type. Regions are separated for Winnipeg, because of its denser population in Manitoba, and areas where natural gas is available and where it is not available. Dwelling types are separated into single detached, multi-attached, and apartments.

Econometric equations are used to forecast the number of electric space heating systems in new single detached and multi attached dwellings by region. The results of the 2017 Residential Energy Use Survey serves as a basis for projections and provides the average age of space heating and water heating systems in the province. The quantity of annual replacements of each heating system type are then estimated and the type of heating systems installed depend on the scenario assumptions, which include fuel switching.

All four scenarios have different levels of decarbonization and decentralization, for which varying levels of electrification have been assumed. New technology adoption models were used to determine the rate by which and when conversions to new technologies took place.

Peak Demand Forecast Methodology

Manitoba Hydro develops the annual and monthly peak demand projections using load factors, which represent the relationship between average electrical demand during the winter months (December to February) and the peak demand for the existing system load. The load factor methodology is used to forecast the peak demand across two groupings, the General Service Large customers (which tend to have flatter load profiles and higher load factors) and the remaining customers (Residential, General Service Small and Medium & miscellaneous) which are combined to form the peak demand. Emerging technologies such as electrification of transportation will change the way Manitobans use electricity and the relationship between average and peak electrical demand into the future. To capture the respective system peak impacts from emerging technologies, hourly load shapes were developed and incorporated within the demand projections.

Miscellaneous Sectors

The miscellaneous sectors consist of the smaller sales sectors that make up less than 1% of electricity consumed in Manitoba and include Seasonal customers, Flat Rate Water Heating and Area and Roadway Lighting. These sectors were forecast by analysis of the changes in the number of customers or services and average use per customer or service. Growth rates were applied based on history and a best estimate as to what the future will bring.

Energy Efficiency

Each scenario includes a base level of energy efficiency (also called demand side management or DSM). Efficiency Manitoba in collaboration with Manitoba Hydro prepared a longer-term extrapolation of future energy efficiency savings adhering to the mandated minimum average annual target of 1.5% of the previous years' electricity load, as outlined in the Efficiency Manitoba Act. The energy efficiency savings are provided for both program-based energy efficiency initiatives and the savings due to codes and standards assumed to reduce electricity and natural gas forecasts in all cases. The base energy efficiency cumulative savings for electrical energy, electrical demand, and natural gas are shown in Figure A3.7 through Figure A3.9.

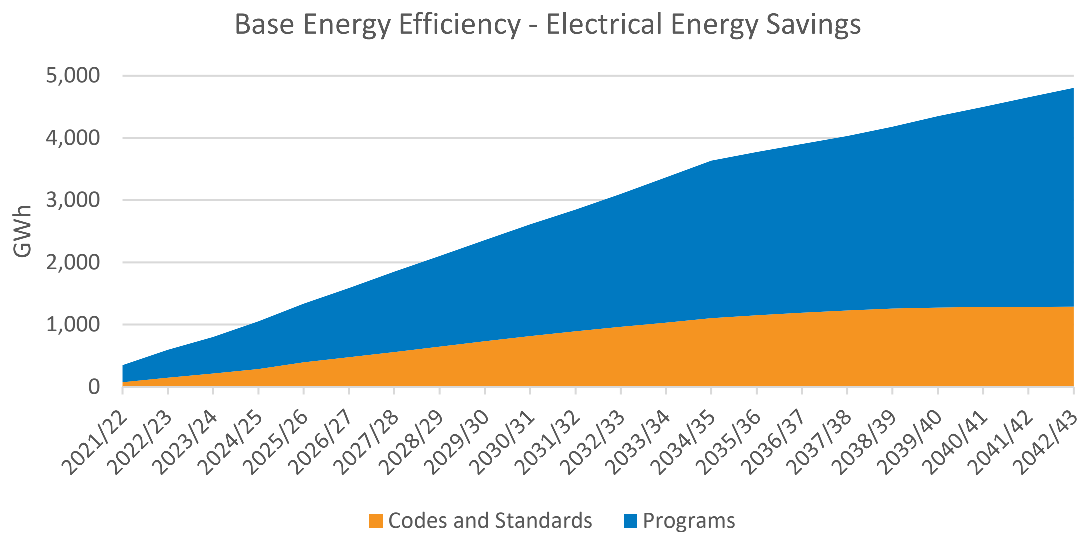


Figure A3.7 – Base Energy Efficiency – Electrical Energy

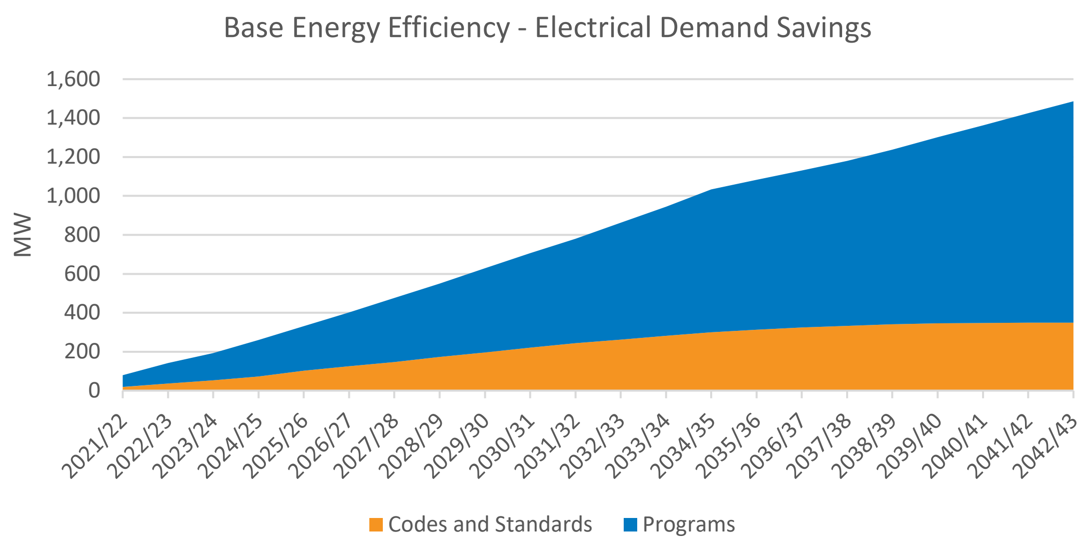


Figure A3.8 – Base Energy Efficiency – Electrical Demand

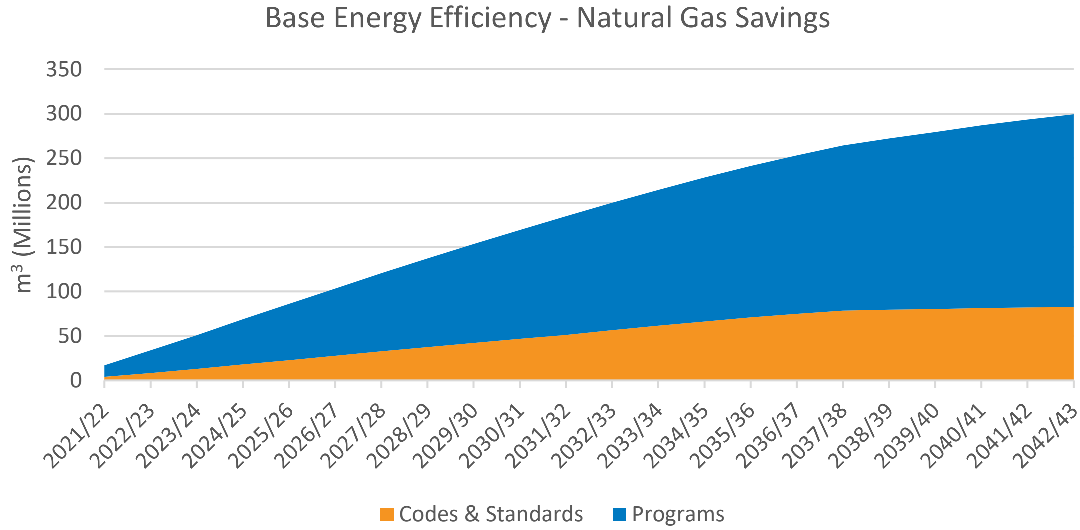


Figure A3.9 – Base Energy Efficiency – Natural Gas

The 2023 IRP also considered additional energy efficiency measures as selectable resources. More details on how base and selectable energy efficiency measures are modelled are provided in Appendix 2 and Appendix 4.

5.3 Key Inputs Affecting Scenario Customer Electric and Customer Natural Gas Demand Projections

Manitoba Hydro developed load scenarios by altering values for key inputs. The following section describes the assumptions and load projection impacts for the key inputs by scenario.

Economic Growth

Economic growth is cyclical in nature and includes uncertainty as demonstrated by recent global conflicts and the current interest rate environment. Due to the long study period of the 2023 IRP, rather than trying to predict economic cycles, economic growth has been simplified to average growth rates over the study period.

Manitoba Hydro uses independent consultant economic forecasts to establish high and low economic growth rates. The most recent forecasts were used for scenarios 2 and 3 whereas the lowest and highest growth rate projections received over the last 10 years were used in scenarios 1 and 4 respectively. A summary of the assumptions used for each scenario are provided in Figure A3.10 below.

Scenario 1: Slow decarbonization & slow decentralization	Scenario 2: Modest decarbonization & modest decentralization	Scenario 3: Steady decarbonization & modest decentralization	Scenario 4: Accelerated decarbonization & steady decentralization
Real GDP: 1.3% MB Population: 0.8% Income: 1.3%	Real GDP: 1.7% MB Population: 1.0% Income: 1.3%	Real GDP: 1.7% MB Population: 1.0% Income: 1.3%	Real GDP: 2.0% MB Population: 1.1% Income: 2.2%
			*All values are 20-year averages

Figure A3.10 – Economic Growth Assumptions by Scenario

The economic growth assumptions for Manitoba GDP, population, and real disposable income are shown in Figure A3.11. An example of how these assumptions directly impact demand projections includes the number of new dwellings constructed each year to meet population needs. In addition, the economic growth assumptions indirectly affect the demand projections related to other key inputs. In the electric vehicles key input, total vehicles sales are related to population growth and in the natural gas changes key input new installations are also related to population growth and real disposable income.

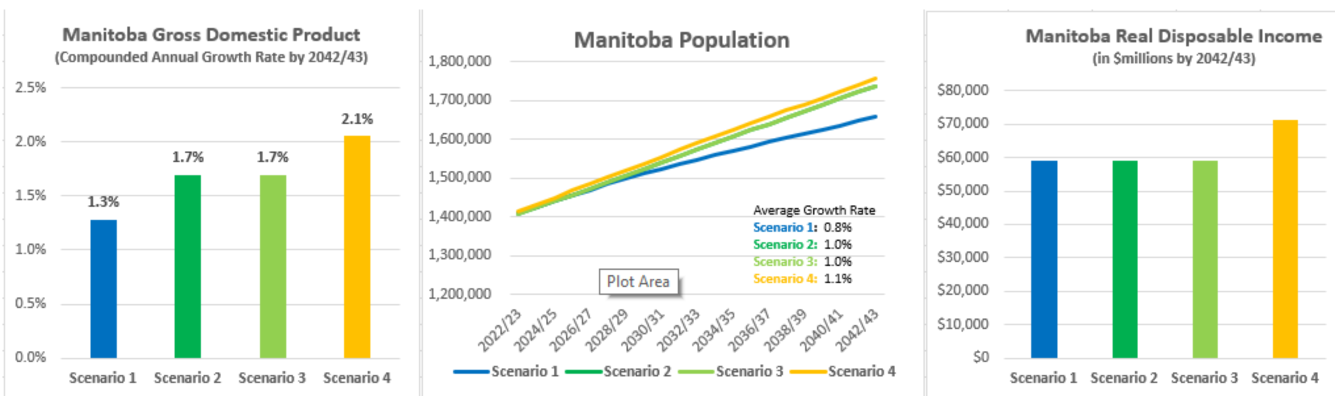


Figure A3.11 – Economic Growth Values by Scenario

Decarbonization Policy

While scenario 4 is trending toward a net-zero GHG emissions future, scenarios 1 through 3 capture the outcome of a less aggressive pace of decarbonization. Decarbonization policy is an over-arching input and the assumptions made here are primarily reflected within the electric vehicles and natural gas changes key inputs. A summary of the assumptions used for each scenario are provided in Figure A3.12 below:

Scenario 1: Slow decarbonization & slow decentralization	Scenario 2: Modest decarbonization & modest decentralization	Scenario 3: Steady decarbonization & modest decentralization	Scenario 4: Accelerated decarbonization & steady decentralization
Reduced ambition to address climate change.	Addressing climate change is one of several priorities for governments.	Addressing climate change is a priority for governments.	Addressing climate change is an urgent and key focus for governments.

Figure A3.12 – Decarbonization Policy Assumptions by Scenario

Decarbonization policy is reflected in Electric Vehicles and Natural Gas Changes key inputs. GHG emission pricing was incorporated into the cost of space heating systems in residential new dwellings. Econometric equations were developed to forecast the number of electric space heating systems in new single detached and multi attached dwellings by region. In general, increases in GHG emission pricing increases the rate at which residential customers choose electric heating systems over natural gas heating systems.

Electric Vehicles

The methodology to develop the EV demand projections is consistent across each scenario and is the product of the following factors:

Vehicle Type: Ratios were estimated using historical data supplied by Statistics Canada and Manitoba Public Insurance on vehicle purchases and registrations per year in Manitoba. Vehicle types include passenger car, light truck (including SUVs), medium-duty truck, heavy-duty truck, and bus.

Annual Electricity Consumption: The distance driven per vehicle type and the associated electricity consumption is shown in Table A3.1 are constant across scenarios.

Table A3.1 – Annual Electricity Use by Vehicle Type

Vehicle Type	KMs per Year	Total kWh per Year
Passenger Cars	15,000	3,225
Light Trucks	15,000	4,473
Medium Duty Trucks	14,259	7,812
Heavy Duty Trucks	88,615	135,612
Buses	55,000	78,160

Total Vehicle Sales: Future trends in vehicles sales are projected based on assumptions from recent relevant literature applied to Manitoba, as well as population growth assumptions for each scenario.

EV Sales %: EV sales as a percentage of total sales are adjusted for each scenario depending on assumptions as previously discussed.

Across scenarios, EV sales as a percentage of total sales were adjusted based on projections corresponding to the level of decarbonization assumed. The ratio of vehicle type was determined using historical data from Statistics Canada and Manitoba Public Insurance. As described in Appendix 6, the Federal government has proposed all new vehicle sales be zero emission by 2035 for cars and light trucks, and 2040 for medium and heavy vehicles (including buses) where possible. This target has been reflected for cars in scenarios 3 and 4 and for all other vehicles in scenario 4. A summary of the adoption rates used for each scenario are shown in Figure A3.13 through Figure A3.16. When combined, these assumptions result in the cumulative electricity consumption per scenario as shown in Figure A3.17.

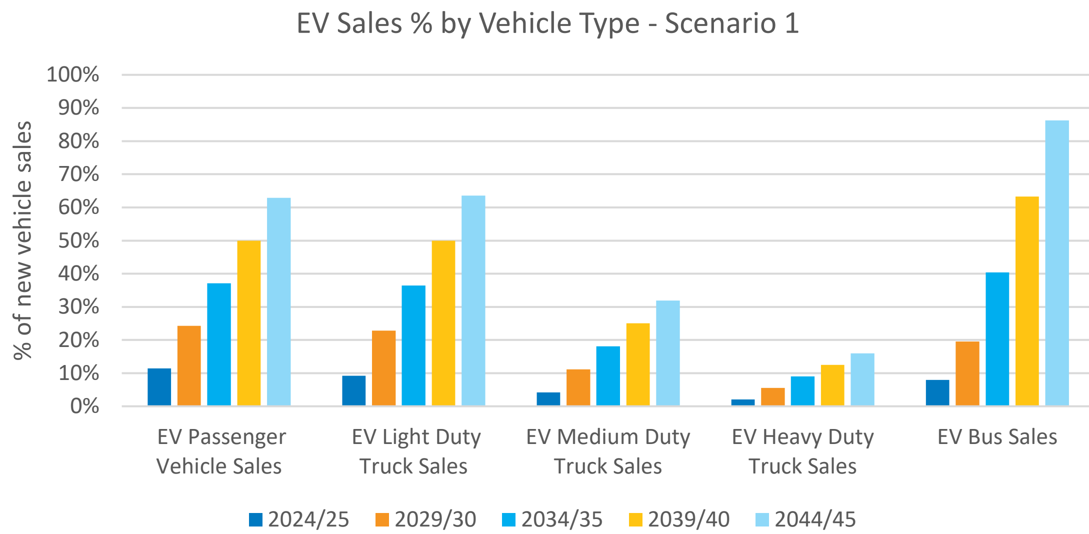


Figure A3.13 – EV Sales % by Vehicle Type – Scenario 1

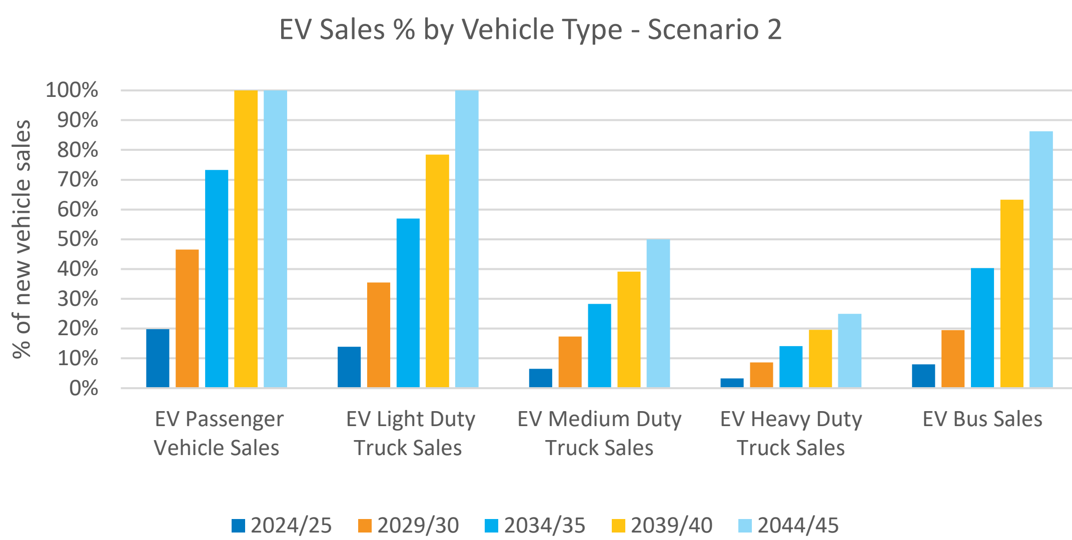


Figure A3.14 – EV Sales % by Vehicle Type – Scenario 2

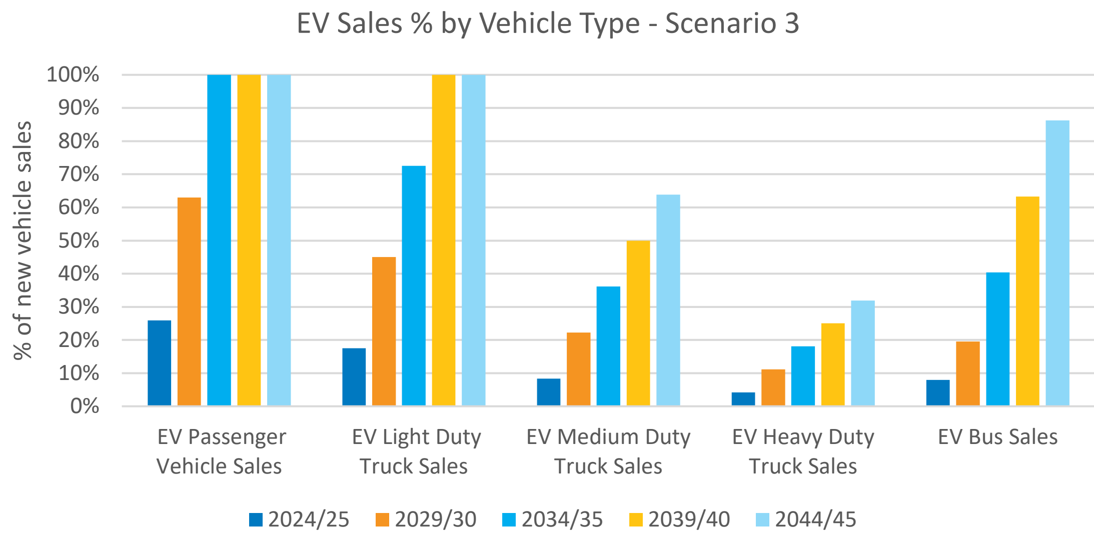


Figure A3.15 – EV Sales % by Vehicle Type – Scenario 3

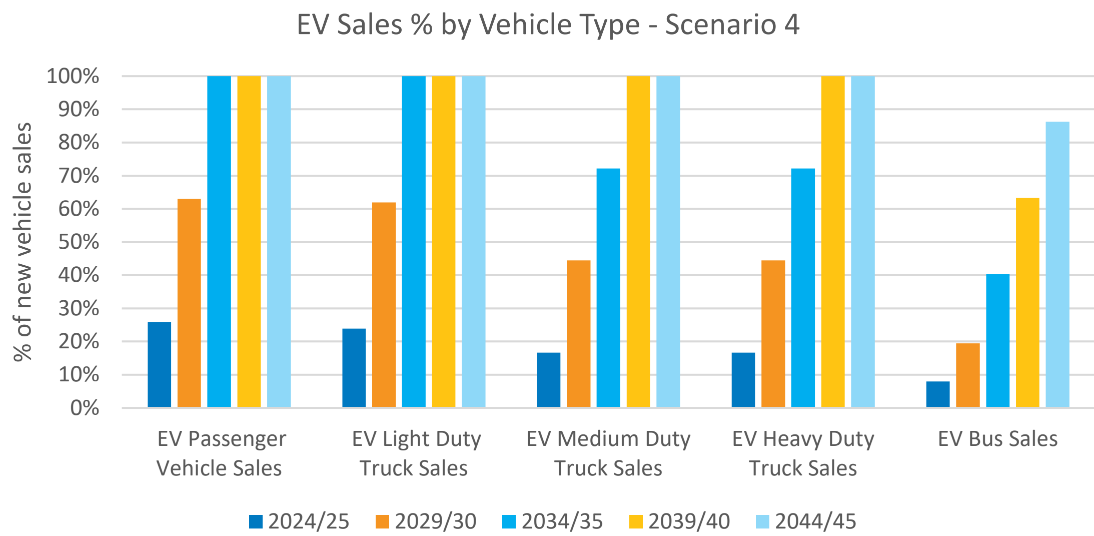


Figure A3.16 – EV Sales % by Vehicle Type – Scenario 4

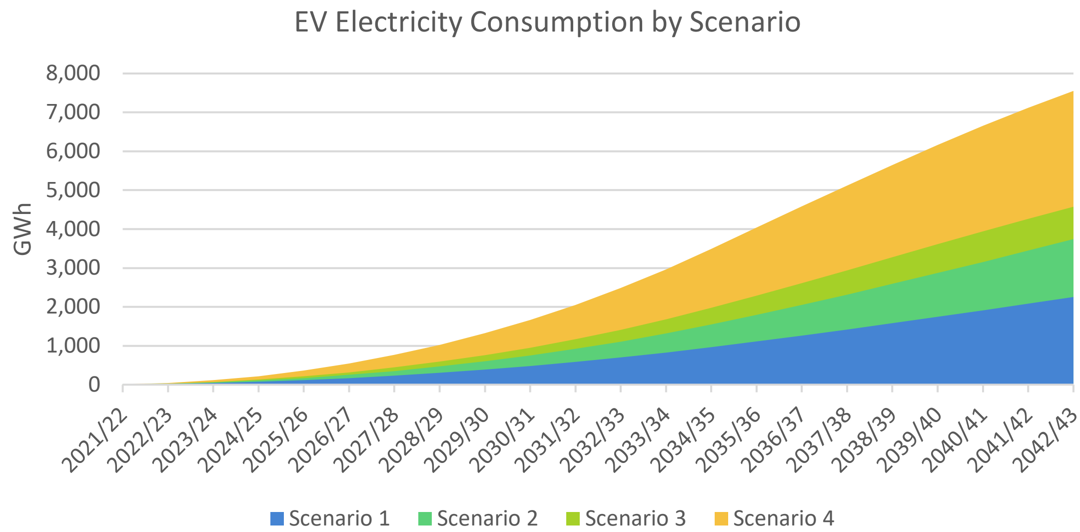


Figure A3.17 – EV Electricity Consumption by Scenario

Natural Gas Changes

For natural gas changes, a range of assumptions were made for both new and existing customers in the residential and commercial sector with respect to space heating decisions. In addition to space heating, the natural gas changes key input includes different rates of industrial electrification for each scenario. A summary of the assumptions is provided in Figure A3.18.

Scenario 1: Slow decarbonization & slow decentralization	Scenario 2: Modest decarbonization & modest decentralization	Scenario 3: Steady decarbonization & modest decentralization	Scenario 4: Accelerated decarbonization & steady decentralization
Residential/Commercial			
New buildings use natural gas for heating (where available)	New buildings use dual fuel	New buildings use dual fuel in the near term and all electric in the long term	New buildings use electric starting 2025 (All or dual electric) with some uptake of GSHP
Existing customers with natural gas furnaces continue to use natural gas furnaces	Existing customers with natural gas furnaces continue to use natural gas furnaces	Existing customers with natural gas furnaces convert to dual fuel when air conditioners reach end of life in the near term and use all electric in the long term	Existing customers with natural gas furnaces replace them with electric at end of life as of 2030
Industrial			
No specific assumption	No specific assumption	Steady increase every 5 years starting in 2026	Escalating increases every 5 years starting in 2026

Figure A3.18 – Natural Gas Changes Assumptions by Scenario

Electrification of Space Heating

Space heating fuel choice used within each scenario leads to different levels of electric and natural gas consumption. The space heating systems included within the IRP analysis are:

- All Electric
- Dual Electric
- Ground Source Heat Pumps
- Dual Fuel System
- Natural Gas
- Other

All electric space heating systems include those powered by electricity such as electric central forced air (CFA) furnace, electric baseboard, and electric boiler. Electric furnaces or baseboard heaters use electric resistance heating elements to generate heat. As long as the electric heating system is located within the home, almost 100% of the electricity consumed by the heating system contributes to heating the house.

A dual electric system consists of an air source heat pump (ASHP) with an electric CFA furnace. The ASHP is used for both heating and cooling at outdoor temperatures above -10°C and switches to the electric CFA furnace below -10°C. Manufacturer performance information for a range of operating temperatures was used in combination with additional considerations which affect performance such as defrost cycles. Manitoba Hydro uses a seasonal coefficient of performance (SCOP) of 1.72 which was determined using weather information for Manitoba and a changeover temperature of -10°C.

Ground source heat pumps (GSHP), sometimes referred to as geothermal heat pumps, are used for both heating and cooling across all outdoor temperatures. Manitoba Hydro uses a SCOP of 2.0 for ground source heat pumps.

Dual fuel systems use an ASHP with a high efficiency natural gas furnace. Similar to the dual electric system the ASHP provides both heating and cooling at outdoor temperatures above -10°C then switches to a high efficiency natural gas furnace below -10°C. A SCOP of 1.72 is used for the ASHP. Natural gas furnace efficiencies are discussed in the following paragraph.

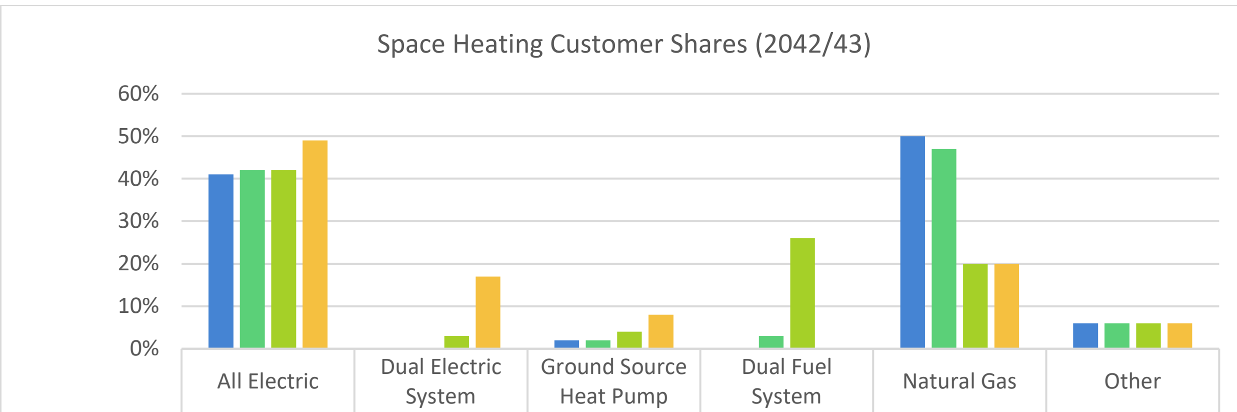
Natural gas heating systems are rated by their annual fuel utilization efficiency (AFUE), which describes how efficient a heating system is over the entire heating season. High efficiency natural gas furnaces are the primary system moving forward and have AFUE ratings of 92% and above. Mid efficiency furnaces have an AFUE rating between 78% - 84% and have not been available for sale since 2009. Standard or conventional furnaces have an estimated AFUE rating of 60% and have not been available for sale since 1995. Gas boilers (high efficiency/mid efficiency/conventional) also use natural gas for space heating.

Other space heating systems include wood stove, fuel oil furnace, diesel, propane furnace, and shared heat.

The following describes how the space heating systems described above are applied for each scenario:

- Scenario 1 assumes slow decarbonization and slow decentralization and no dual fuel systems are introduced.
- Scenario 2 is the first scenario to include dual fuel space heating systems. A combination of policy, incentives, and rates results in new system installations that were previously assumed to be natural gas fueled to go to a dual fuel system. The result is the same number of total space heating system installations but a reduction in natural gas consumption as compared to not including dual fuel systems in this scenario.
- Scenario 3 builds on scenario 2 and the use of dual fuel systems is extended to existing customers. In scenario 3 it is assumed that as air conditioning (A/C) units reach their end of life, they are replaced with ASHPs. New installations also start to see a shift to dual electric heating system. Scenario 3 results in increased installations and a reduction in natural gas consumption compared to scenarios 1 and 2.
- In scenario 4 it is assumed that new buildings use electric heating equipment as of 2025, and existing customers with natural gas furnaces replace them with electric at end of life as of 2030. Also, as CFA furnaces begin to fail, more customers begin to switch over to ground source heat pumps.

The following chart reflects the percentage of customers by space heating system type for each scenario.



	All Electric	Dual Electric System	Ground Source Heat Pump	Dual Fuel System	Natural Gas	Other
Scenario 1	41%	0%	2%	0%	50%	6%
Scenario 2	42%	0%	2%	3%	47%	6%
Scenario 3	42%	3%	4%	26%	20%	6%
Scenario 4	49%	17%	8%	0%	20%	6%

Figure A3.19 – Heating System Breakdown by Scenario

Electrification of Industrial processes

A proxy value was used based on the theme of each scenario to account for new industries located in Manitoba, the possible reduction in consumption for existing customers, and the potential electrification of some existing industrial processes (e.g., moving to electric boilers). In scenario 3, an increase of 50 MW of additional average electrical demand was added every 5 years starting in 2026. In scenario 4, an escalating increase was added every 5 years starting in 2026, as shown in Figure A3.20. The magnitude and pace of electrification is based on what was heard from industrial customers and represents approximately 1-2 customers switching from natural gas to electricity in each five-year period.

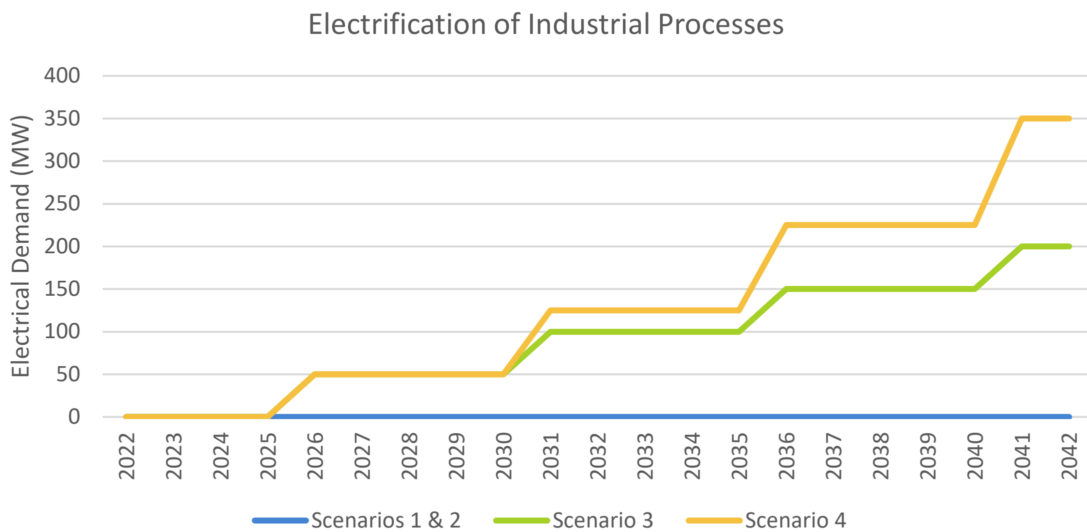


Figure A3.20 – Increase in Electrical Demand due to Electrification of Industrial Processes by Scenario

Customer Self-Generation

Customer self-generation can include multiple different types of electrical energy systems. Examples of customer self-generation include solar PV, small wind turbines, gasoline-powered or biomass generators, on-site energy storage systems, and microgrids. These systems generate electricity for customers' use and when customer demand is less than the electricity produced, the electricity is sent to the grid. The 2023 IRP uses solar PV technology to represent future customer self-generation and varying rates of solar PV adoption are applied to different scenarios. A summary of the assumptions is provided in Figure A3.21.

Scenario 1: Slow decarbonization & slow decentralization	Scenario 2: Modest decarbonization & modest decentralization	Scenario 3: Steady decarbonization & modest decentralization	Scenario 4: Accelerated decarbonization & steady decentralization
142 MW of installed capacity by 2040 Equivalent to 0.9% of Residential and GS Mass Market by 2042	288 MW of installed capacity by 2040 Equivalent to 1.5% of Residential and GS Mass Market by 2042	573 MW of installed capacity by 2040 Equivalent to 2.5% of Residential and GS Mass Market by 2042	1,154 MW of installed capacity by 2040 Equivalent to 4.7% of Residential and GS Mass Market by 2042

Figure A3.21 – Customer Self-Generation Assumptions by Scenario

To determine these assumptions, the 2023 IRP uses a Bass diffusion model to estimate how solar PV is adopted throughout the study period. The 2023 IRP assumes an average solar PV installation size of 10 kW where each system generates 11,680 kWh per year. Based on information collected from the Solar PV

Generation Performance Load Research study,[2] it is assumed that for an average system size of 10 kW, 25% of the electricity generated by solar PV installations is sold back to the grid. Customer self-generation impacts are determined across an hourly (8760 hours per year) load profile. Table A3.2 shows the total installed capacity and annual electrical energy produced by solar PV installations at the end of the study period.

Table A3.2 – Solar PV Installations in 2042/43 by Scenario

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Number of Installations	15,345	29,857	58,441	116,529
Total Installed Capacity (MW)	142	288	573	1,154
Annual Electrical Energy (GWh)	166	336	670	1,348
Total Consumed by Customer (GWh)	125	252	502	1,011
Total Sold Back to Grid (GWh)	42	84	167	337

5.4 Customer Electric and Natural Gas Demand Projections by Scenario

Using the methodology and assumptions described, individual demand projections for each scenario were developed. Figure A3.22 shows the annual electrical energy needs over the study period for each scenario, while Figure A3.23 shows annual peak electrical demand for each scenario.

In all scenarios, customers require more electricity in the future as they adopt EVs and start to use more electricity to heat their homes and businesses. This is most pronounced in scenario 4 where, by the end of the study period, customers required approximately double the electrical energy consumed today.

Electrical demand increases across scenarios 1, 2, and 3, with a significant step change in scenario 4. This step change is due to assumptions of accelerated decarbonization in scenario 4 as a pathway towards net-zero. The annual peak electrical demand for scenario 4 in 2042 is approximately two and a half times the current demand.

The following electrical and natural gas demand projections are net of energy efficiency and serve as the inputs for the resource optimization modelling.

[2] https://www.hydro.mb.ca/your_home/pdf/solar_pv_generation_performance_load_research_study.pdf

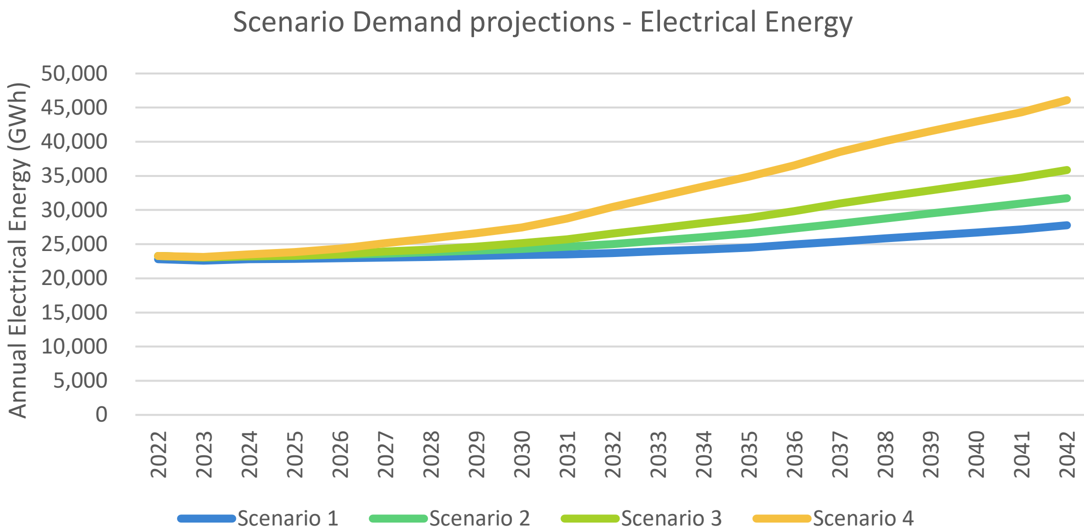


Figure A3.22 – Scenario Demand projections – Electrical Energy

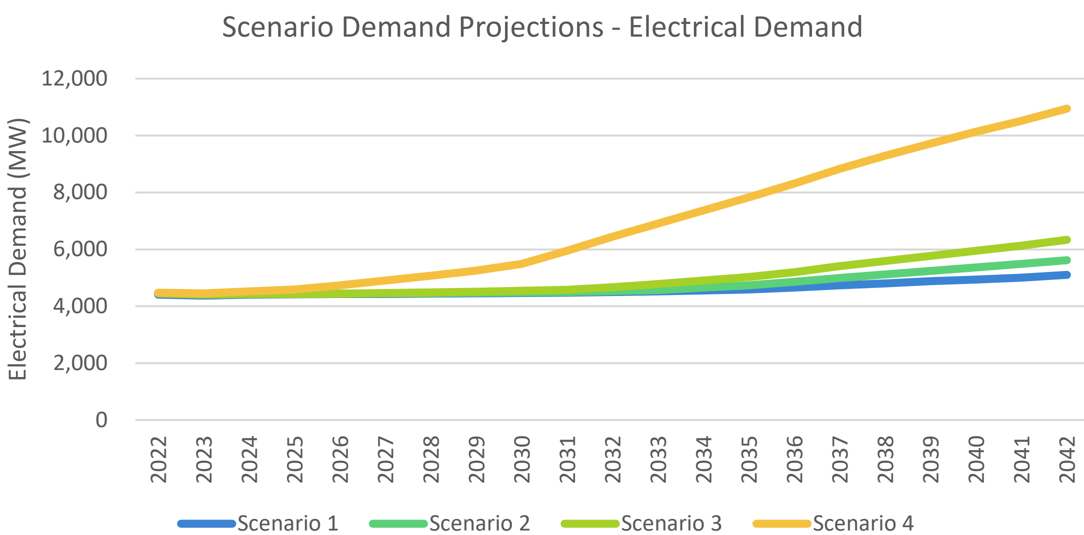


Figure A3.23 – Scenario Demand projections – Electrical Demand

Figure A3.24 shows the monthly peak electrical demand profile for each scenario in the final study year (2042), highlighting the increase in peak electrical demand required when converting large amounts of natural gas heating to electricity, as assumed in scenario 4.

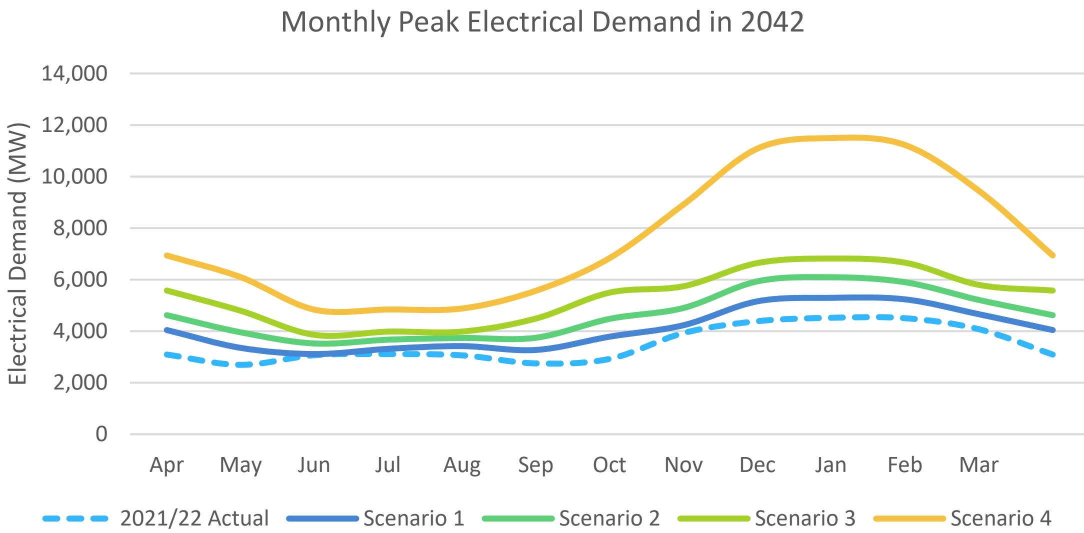


Figure A3.24 – Scenario Demand projections – 2042 Electrical Demand

Finally, Figure A3.25 shows the total annual natural gas consumption for each scenario. As expected, as the assumptions related to decarbonization become more aggressive in scenarios 3 and 4, natural gas consumption decreases. Natural gas consumption increases in scenario 2 compared to scenario 1 due to the increased rate of population growth and only modest fuel switching assumptions.

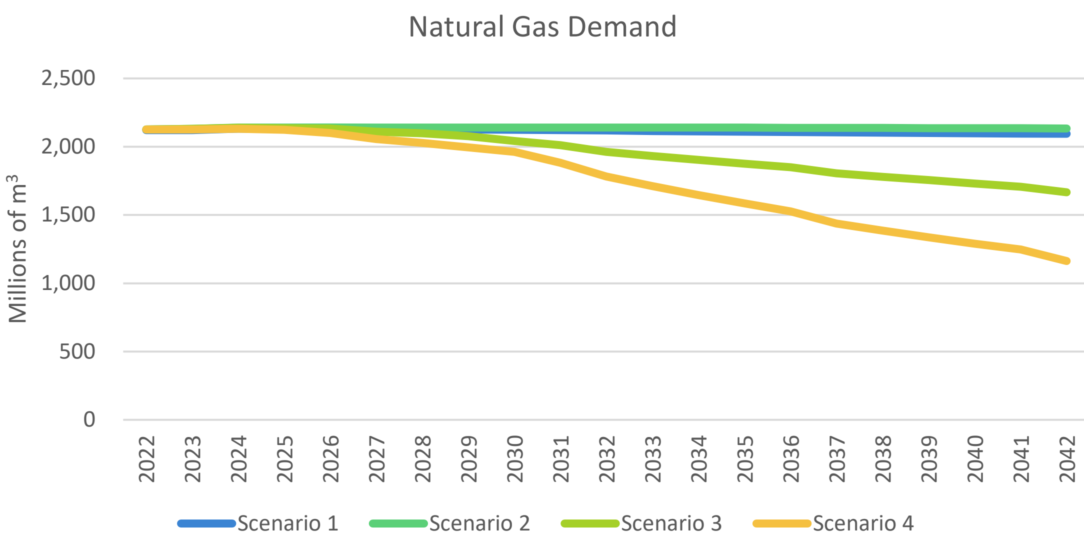


Figure A3.25 – Scenario Demand projections – Natural Gas Demand

END OF APPENDIX