# Model Process Information Session

## A Summary

### Introduction

This document is designed to explain the Integrated Resource Plan's (IRP) modelling process. It includes a summary of Manitoba's current energy systems, model inputs, available resources, and model outputs. It does not provide results from the modelling.

As we examine the modelling process, it is important to keep in mind that:

- Manitoba Hydro must ensure a sufficient supply of safe, reliable energy that responsibly meets the evolving energy needs of Manitobans.
- Integrated Resource Planning is a structured process to help Manitoba Hydro understand how the future may unfold and identify steps needed to prepare for various potential energy futures.

### Background

Manitoba Hydro has undertaken a number of engagements with the public and interested parties to get their feedback. In earlier engagement workshops, prior to the modelling process, we presented five key inputs and four scenarios for consideration in the IRP.

Key inputs are factors that will create uncertainty in Manitoba's energy future and may have the largest impacts on the shape of energy demand. The key inputs are: economic growth, decarbonization policy, electric vehicles, natural gas changes, and customer self-generation. At the earlier workshops, participants confirmed that these inputs are key in creating the most uncertainty. However, a number of other factors were suggested for consideration. We incorporated these suggestions into the five key inputs or into other parts of their modelling and analysis.

Each of the key inputs plays a role in developing the four scenarios used in the modelling. These four scenarios focus on the implications of different levels of change to each of the five key inputs over time. At the earlier workshops, participants generally agreed that the scenarios appropriately bookend the possible rate of change, so long as Scenario 4 reflected a path towards net-zero greenhouse gas (GHG) emissions. We used this feedback to ensure Scenario 4 did in fact represent such a path. As we will see below, the key inputs and scenarios feed into the model helping Manitoba Hydro to investigate possible energy futures.

## Energy Use in Manitoba

Currently, energy use in Manitoba is dominated by three energy types: electricity, natural gas and refined petroleum products. Manitoba Hydro contributes just over half of all the end-use energy: natural gas (28%) and electricity (24%). While refined petroleum products, generally used to fuel vehicles, contribute almost all of the rest of end-use energy (44%).[1] Decarbonization is one of the main forces driving the evolving energy landscape. If transportation fuels and natural gas are decarbonized through electrification, this would result in significant increases in electrical use.

Manitoba's GHG emissions come from three main sources: transportation (40%), stationary combustion (19% - mostly space heating and industrial), and other sources (41% - mostly agriculture).[2] Future energy choices can directly impact both transportation and stationary combustion, but not the "other sources" category.

The demand for energy is not a constant. Both electricity and natural gas see significant seasonal variation in demand, with the highest demand occurring in the winter months (January and February). There are also daily variations in electricity demand – as much as 30% in a single day. Manitoba's peak demand for natural gas is much higher than its peak demand for electricity. Electrifying this natural gas peak demand could have a significant impact on the overall electricity demand in Manitoba. To totally replace natural gas, Manitoba Hydro would have to more than double the size of its current electricity system.

Manitoba Hydro's role is to provide reliable electricity and natural gas to Manitobans at the lowest possible cost. Our existing generating system includes 16 hydropower stations, one natural gas fueled generating station, and purchases of power from two wind farms. On average over 99% of energy generated in Manitoba is renewable with 97% from hydropower and 2% from wind generation. Although Manitoba Hydro has a natural gas fueled generating station in Brandon, its primary role is to serve customers during the periods of highest demand only. It also supplies energy during extreme drought when hydropower generation is significantly reduced. Another key component of Manitoba Hydro's system are large reservoirs which enable energy to be stored for use later. Each of these existing generation resources and large reservoirs are included in the model to simulate our existing system.

Manitoba Hydro's system also interacts with neighboring electricity systems in Saskatchewan, Ontario, and the United States. These interconnections play major roles in our hydropower-dominated system: facilitating the export of surplus electricity to outside markets, providing an important source of revenue; enabling energy to be imported during low water conditions to ensure reliability; and, providing a means of managing short term reliability issues when dealing with unexpected outages.

## Planning Criteria and Other Model Constraints

The purpose of this modelling process is to simulate the electrical system so that we can explore how best to meet our customers' future energy needs for a range of different scenarios.
Before considering the future, Manitoba Hydro must also consider the constraints that will have an impact on how the model will function. Here are a few key terms to help understand how we plan our electrical supply system.

- **Capacity:** is the maximum amount of electricity that can be made by generators at any particular time, measured in megawatts. As a means to better understand these terms, let's use transit as an analogy. In this case, it is the **maximum** number of people that can get on the bus at any one time, limited by the number of seats on each bus. So, in this example, 5 buses with 20 seats means you have a capacity of 100 riders.

- **Energy:** speaks to both what is made and used *over a period of time*. So, the amount of electricity produced throughout a 24-hour period, for example. If we consider the bus analogy, it is how **many** people are transported in a day using the 5 buses. So, during the course of one full day, you might move 1,000 riders.

- **Peak Demand:** is the specific time of the day that has the single greatest requirement for energy. For Manitoba, this is in the winter months when customers are heating homes and businesses with electricity. Back on the bus, peak demand is the **highest** number of passengers at a given point in the day. In this example, you see peak ridership at 75 people during the morning rush hour.

The model needs to consider all these factors as it develops possible futures.
Manitoba Hydro's planning criteria below ensure there is sufficient energy supply during the worst most drought on record and sufficient capacity to meet peak demand. These planning criteria are included in the model to determine when and how much new supply resources are needed to meet the demand in each scenario:

- **Dependable energy**. Since a large amount of Manitoba's electricity comes from hydropower , the flow of water is critical. Dependable energy is the combined energy from hydropower during the worst drought on record, wind generation, natural gas fueled generation, and imported energy.
- **Capacity.** The system must be planned to ensure there is sufficient generating capacity to meet Manitoba's peak load plus any committed export contracts. Additionally, generators do break down from time to time and we experience extreme weather events, so a Planning Reserve Margin is utilized to increase the required capacity to ensure we are prepared for such events. Manitoba Hydro plans to ensure generation capacity exceeds the total of: Manitoba peak load + planning reserve margin + export capacity obligations.

Manitoba Hydro must also must consider the transmission and distribution systems used to deliver electricity from generation resources to customers. When planning transmission and distribution systems, they must avoid being overloaded and they must minimize interruptions to customers. These costs are included in the final modelling output when calculating the total cost for each scenario.

## Resource Options

The model considers various new resource options to meet growing demand, including:

- New hydropower
- Upgrading existing hydropower
- Wind
- Solar
- Energy efficiency
- Batteries (storage)
- Biomass Fueled Steam Turbine
- Natural Gas Fueled Combustion Turbine
- Natural Gas Fueled Combustion Turbine with Carbon Capture
- Hydrogen Fueled Combustion Turbine
- Market Purchases (Imports)
- Small Modular Nuclear Reactors

For each of the resource generation options, the model considers characteristics that will define how it can operate within the energy supply system. These characteristics include:

- Rated Capacity, which is the maximum power output that the generator can produce.
- Firm Capacity, which is the power output that can be counted on during peak demand.
- Operating Parameters & Dependable Energy
- Development timelines, which is the minimum time to get a new resource in-service and operating.
- Capital costs & Operating costs
- Fuel costs
- GHG emissions

The model considers each of these characteristics and the trades-offs between the different resource options.

## Energy Efficiency

As noted above, energy efficiency is included as a resource option as a means to reduce load and can contribute to delaying the need for new resources, as well as reducing the total amount of new resources.

We are collaborating with Efficiency Manitoba and using Efficiency Manitoba's energy savings projections. Energy efficiency is included within the evaluation in two different ways. The first is that some energy efficiency savings are assumed to be achieved and are included in the load projection of each scenario based on a projection of Efficiency Manitoba energy savings plan. This results in less load for each scenario.

Second, a market potential study determined that more energy efficiency could be achieved. This extra energy efficiency potential is included in the model and competes on a level playing field with other supply options. By having this in the model, it can select extra energy savings as an option to meet future energy needs.

## Energy Prices

Interconnections allow Manitoba Hydro to import and export electrical energy. When the model is simulating these, it is important for the model to calculate the associated revenues and costs based on price projections.

We have purchased price projections for electricity from independent price forecasters. These price projections are used to simulate revenue from exports and the cost of imports. Similarly, we have purchased price projections for natural gas. The model uses this information to calculate the cost of operating natural gas fueled combustion turbines both for the existing system and for additions to the system.

Another cost for running natural gas fueled combustion turbines is associated with their greenhouse gas emissions. Fees are paid to the federal government for their emissions which are dependent on how much fuel is burned. If this type of generation is not run very often, then their emissions and their costs are low.

## Key Inputs and Scenarios

As mentioned, Manitoba Hydro has received feedback from interested parties on key inputs and scenarios. These are used by the model to generate possible energy futures. For modelling purposes, specific values are associated to each of these key inputs for each of the scenarios to reflect change overtime. For example, for the key input of electric vehicles (EV), scenario 1 would see the lowest uptake of electric vehicles (e.g., cars, trucks, buses) over the next 20 years, while scenario 4 would see the highest uptake. For each scenario, load projections are generated which the model uses to evaluate new resources to meet increasing demand.

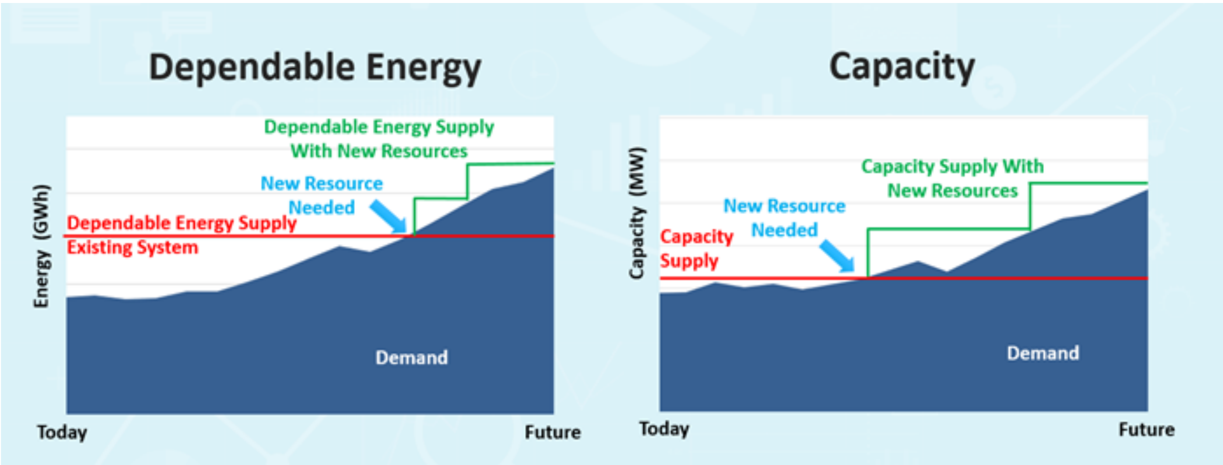
In addition to the four scenarios, Manitoba Hydro also runs sensitivity analysis, or "what if" analysis, to understand how individual inputs or constraints are driving the output of the model. This "what if" modelling allows us to introduce constraints and other interventions, such as encouraging customers to charge their EV at a specific time of day.

## Modelling Tool

Modelling hydropower systems is complicated, so Manitoba Hydro uses specialized modelling software. This software, which is used worldwide in over 60 countries, was purchased from a Brazilian company named PSR.

The software that we are using includes tools for production cost modelling and expansion planning modelling. These models are integrated to work together to simulate each of the scenarios to ensure supply meets demand in the lowest cost way.

## Determining When Energy and Capacity are Needed




One of the main purposes of the modelling tool is to establish a portfolio of resource options for each scenario when demand exceeds existing energy or capacity, as shown in the following graphs.

As shown above, the red lines display the amount of dependable energy and firm capacity that are available from Manitoba's Hydro existing supply system. This includes all hydropower, wind, natural gas fueled generation and imports. **Energy** is on the left and **Capacity** is on the right. The graphs also show future demand which includes Manitoba's load, export contracts, and the planning reserve margin in the capacity chart.

Where these two supply and demand lines intersect establishes when new supply is needed for either energy or capacity. The area above the red line is the demand that the model is attempting to solve by adding new resources. This is when the model will add new resources, which may be at different times for either energy or capacity. The model goes through several iterations to establish a portfolio of resources that meets demand.

## Model Optimization

Once the model has all inputs, it proceeds through a series of steps to develop an optimized solution.

**Step 1.** The model first determines when, and how many new resources are needed to satisfy the planning criteria for energy and capacity.

**Step 2.** The model picks resources to meet the energy and capacity demand based upon the planning criteria.

**Step 3.** The model simulates the operation of the Manitoba Hydro system over the next 20 years using over 100 years of inflow records to represent future water conditions. This simulation includes existing generating stations, imported and exported energy as well as the new resources.

**Step 4.** The model calculates the **Net System Cost**, which is the summation of all Capital Costs, Operating Costs, Export Revenues, and Import Costs.

**Step 5.** The model then assesses whether or not the Net System Cost can be reduced with different resource options. If the cost can be reduced, then the process continues. The model will continue this optimization process until it identifies a portfolio of resources that has minimized the Net System Cost.

Each model simulation uses high-powered computers and can take several hours to complete. More time is required after that to review the results, confirm they are correct, and interpret them. A number of iterations is not uncommon to complete and validate each simulation.

## Modelling Process Outputs

The modelling process results in a range of outputs for each scenario simulation. These outputs include:

- A portfolio of resources that meets the defined load projection at the lowest net system costs.
- Total Net systems costs; including all generation capital costs, transmission and distribution capital costs, operating costs, fuel costs, import costs, and export revenue.
- Total Greenhouse Gas Emissions for Manitoba Hydro's electrical and natural gas systems.

Manitoba Hydro is also exploring total emissions at the provincial level to understand the impact of different scenarios, including emissions from other energy use sectors such as the transportation sector.

Overall, the modelling process results in outputs to help compare results for the different scenarios. However, further analysis of modelling results is needed to fully understand the outputs before developing a roadmap and near-term actions, which are the next steps in the IRP.

While this document summarizes the modeling process, further information in the form of a presentation on the process is available at www.hydro.mb.ca/corporate/planning/.