Lindsay Hunter: Welcome to Manitoba Hydro's information session on our modelling process that we're using to support our 2023 Integrated Resource Plan or IRP development.

Ryan Bernier: Thank you, Lindsay. I'm Ryan Bernier from Energy Resource Planning, and I will be going over the modelling process that Manitoba Hydro utilizes in this next section of the presentation. Here is a flow chart showing the overall IRP modelling process. I know there's a lot on this slide. Don't worry, we'll go through each of these boxes to explain what they mean and how they fit into our modelling process. The purpose of this modelling process is to simulate the electrical system so that we can explore how best to meet our future energy needs for a range of different future scenarios. The modelling process is mainly focused on the electrical system, although assumptions for natural gas have been factored in. The key components of this process include: existing electrical system, planning criteria, transmission and distribution costs, new resource options, scenario specific key inputs with a focus on customer demand for electricity and natural gas, energy prices for imported and exported energy, the optimization model itself, and the modelling outputs.

Overall, this process results in outputs for each scenario, including a portfolio of potential resource options, costs, and greenhouse gas emissions. We'll now walk through each part of this modelling process to explain the components. This section will provide an overview of Manitoba Hydro's existing electrical system, which is a key component of the overall planning process. Here is a quick snapshot of Manitoba Hydro's existing generating system. Manitoba Hydro operates 16 hydropower stations, one natural gas fuel station, and has power purchase agreements with two wind farms. As you can see, the majority of our existing power system is from hydro. In fact, 95% of our generating capacity is hydropower. On the other hand, many people don't realize that we do in fact have a generating station in Brandon that uses natural gas to produce electricity. Although it's rarely used, this station has a very important role in the overall supply system.

Its’ primary role is to serve customers during the highest load period, typically during the winter, and to supply energy during extreme drought. Another key component of our system is our large reservoirs, which enables energy to be stored and released for use later out of hydropower stations. Each of our existing generating stations and each of the large reservoirs are included in the model so that it can be simulated with our system. Manitoba Hydro's system also interacts with neighboring systems in Saskatchewan, Ontario, and the United States. This interaction happens through interconnections, which are transmission lines linking Manitoba Hydro to our neighbors. The slide lists the capabilities of these interconnections, which reflects the capabilities as of this year. These interconnections serve three major roles in our hydro dominated system. First, they facilitate the export of surplus hydro to outside markets, which provides an important source of revenue.

Second, they enable energy to be imported during low water conditions to ensure reliability. Lastly, they provide a means of managing short term reliability issues when dealing with unexpected outages. During times of needs, these interconnections have helped Manitoba Hydro's system and neighboring system aid each other in minimizing the impact of various outages. In summary, these interconnections are essential for operating a reliable electrical system at the lowest cost while also at the same time maximizing its benefits. The model includes all of these interconnections, as well as projections for prices for imported and exported energy.

This section of the presentation is on our planning criteria and will explain how Manitoba Hydro plans its' electrical system. To understand some of the information we are presenting here, there are a few key terms that we want to clearly define. Manitoba Hydro's electrical generating system provides both energy and capacity, which are different ways of thinking about electricity. We've included an analogy here using transit buses to help understand these terms. In this analogy, buses represent the electrical system and passengers represent electricity. Capacity is the maximum amount of electricity that can be made by generators at a particular time measured in megawatts.

For the bus analogy, this 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. In this example, five 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. For the bus analogy, this is how many people are transported in a day using the five buses. During a course of one full day, you might move 1,000 riders.

Peak demand is the specific time of day that the single greatest requirement for energy. In Manitoba, this happens in the winter when we have customers heating with electricity. For the bus analogy, peak demand is the highest number of passengers at any given point in the day. In this case, you see peak ridership of 75 people during the morning rush hour.

All three of these need to work together when planning the electrical system, the system has to have the capacity to meet the peak demand that customers' place upon it, i.e. the number of rush hour passengers, and be able to provide energy required throughout the day. When the peak demand is greater than a system capacity or energy supply over time is short, we either need to add more generating capacity to the system, i.e. more buses during the peak, or reduce demand, have less people on the bus during the peak times. But we still need to make sure all passengers can be moved throughout the whole day. Now that we've explained capacity, energy, and peak demand, we will explain the criteria that Manitoba Hydro uses to plan the electrical system, also known as planning criteria. These planning criteria are included in the model to help determine when and how much new supply resources are needed to meet the demand in each scenario.

The first criteria is for dependable energy. The system must be planned to ensure that there is sufficient energy to meet demand during a repeat of the worst drought on record. This amount of energy is referred to as dependable energy and will be explained in more detail later in this presentation. Continuing with the bus analogy, dependable energy would be similar to the lowest number of seats that has ever been available throughout the bus fleet in a day. The second criteria is for capacity. The system must be planned to ensure there are sufficient generating capacity to meet Manitoba's peak load, plus any commitment for export contracts. In addition, generators do break down from time to time, and we do experience extreme weather events, so a planning reserve margin is utilized to increase the required capacity to ensure we are prepared for such events. For the bus analogy, capacity would be the number of buses required during the busiest rush hour of the year, taking into account the number of buses that might break down.

To summarize the planning criteria, we plan to have enough energy for a repeat of the worst drought of on record, and if you recalled earlier discussion on our demand, we plan to provide enough power on the coldest days during the winter. These requirements are included in the model to ensure the system has enough resources to reliably meet our customers' needs.

As we've recently seen in Manitoba, water conditions can vary significantly from year to year, so it is important to understand the variability within our planning processes.

The model includes over 100 years of historical system inflows to represent future water conditions. Dependable flow is the lowest system inflow on record, which corresponds with the most severe drought we've ever experienced, highlighted by the arrow on this graph. Dependable energy is the amount of electrical energy supplied during the dependable flow, but while this graphic only shows dependable flow, dependable energy also includes generation from wind turbines, natural gas generators, and imported electricity to determine the total system dependable energy. Manitoba Hydro designs the system to ensure there is sufficient electrical supply during the lowest flow on record. This dependable energy planning criteria is included in the model as a constraint. This relationship between water conditions, dependable energy, and surplus energy are all simulated in the model.

We've established that the model simulates energy for a wide range of water conditions based on over 100 years of historical flow records. The graph on this slide illustrates how the volume of energy is produced, and how that supplies varies with the water conditions. The bars show the total energy in our system for high flows, average flows, and low flow conditions. During low flow conditions, shown here on the right, there is not enough energy from hydro generation alone to meet demand. As a result, other sources of energy are required. This includes energy for wind farms, imported energy from the other markets, and utilizing Manitoba Hydro's natural gas turbines to help meet demand. On the other side of the chart, we see that during high flows there is more hydro energy than is needed to meet demand. The additional hydro energy is first used to meet demand and avoid imports or running our natural gas turbines to meet demand. Once this is met, the remaining energy, also known as surplus energy, can then be exported for revenue.

Because our system is designed to be reliable even under severe droughts, even during average water conditions, there is more hydro energy than needed to meet demand, resulting in an exportable surplus. However, there is less surplus energy for this condition, which illustrates that surplus energy cannot be relied upon each year because of the varying water conditions. All of these relationships between water condition, the different sources of energy supply and the interconnections with export markets are simulated in the model.

Next, we'll talk about the infrastructure used to deliver energy to our customers. So far, we've mainly focused on the electrical system as it's the main focus of the model. However, natural gas is also a factor in our planning, so assumptions have been made on natural gas consumption and costs. Back to the electrical system. Transmission and distribution systems are used to deliver electricity from generating resources to customers. Similar to generation expanding to meet growing demand, the transmission and distribution systems would also need to be modified to meet this growing demand. When planning the transmission and distribution system, they must avoid being overloaded, and they must also avoid interruptions to customers. These costs are included in the final modelling output when calculating the total cost for each scenario.

Also, when connecting new generating systems to the overall system, new transmissions infrastructure is also needed. This cost is specific to each new resource, and is included within the cost of each resource options, which we'll actually discuss next. Now that we've explained how the energy supply system works and how it is planned, we'll now review the resource options that are included within the model. These resource options form the inventory that the model can select from in order to meet growing demand. A broad range of supply resources are included in the model. These resources include the following: new hydropower, as well as upgrades to existing hydropower stations. Wind and solar generation are also included, as they have been shown to be a source of low cost energy while the economics of their resources continue to evolve over time. Energy efficiency is included, and refers to measures that can be implemented by customers to reduce their total demand.

Batteries are considered, and enable short-term storage of energy that can be used to help balance short-term changes in demand. Biomass steam turbines have some potential in Manitoba, and are included, as well. A couple of different types of natural gas turbines are also included. There is also an option to add carbon capture on these units to help further reduce the turbine's emissions. Turbines that are fueled with hydrogen are an emerging technology that can potentially help reduce emissions. In the model these resource options provide a way to store energy from one season to the next to help meet winter peak demand. Also included our purchases from neighboring markets, also as an option, and lastly, small modular nuclear reactors are also an emerging technology that is being explored in the model.

Each of these resources have unique characteristics that are included in the model. These characteristics define how each resource is simulated and enables the model to evaluate the potential role of each resource within the overall system. These characteristics include some of the following: rated capacity, which is the maximum power output that a generator can produce. Firm capacity is the power output that can be counted on during peak demand. In many cases, this is linked to the variability of a resource such as wind. We have operating parameters. We have dependable energy, development timelines, which is the minimum time to get a new resource in service and operating. Capital costs and operating costs, which are the cost to construct and then operate a resource over its' lifetime. Fuel costs and GHG emissions. The data for this information came from a wide range of different sources and include previous studies undertaken by Manitoba Hydro for resources such as hydro, but also a broad range of publicly available sources for resources such as wind and carbon capture.

To help better understand what is meant by each of these characteristics and the trade-offs between the different resource types, here's an example comparing wind generation and natural gas turbines. The rated capacity of both wind and natural gas turbines are effectively the same. However, the firm capacity of the two are quite different. The variability of wind blowing when it's needed to meet demand results in a reduced capacity value. In comparison, natural gas turbines has no such reduction, because it can be operated when it's needed to meet demand. Dependable energy for the two are comparable, as they both provide energy during a drought. Development timelines for building these resource are also similar. Capital costs for the natural gas turbines are very low, as they have the lowest construction cost. Wind capital costs are higher than the turbines but are still relatively modest. Similar to capital costs, the operating costs of wind farm is more than the cost to operate a natural gas turbine, excluding the fuel.

The biggest difference between the two is seen in the fuel costs and the associated GHG emissions. The turbines burn natural gas as a fuel, while wind turbines have no fuel and produce no GHG emissions. We're going to now focus in on energy efficiency measures as a supply option. This option is included in the model, because we'd like to explore how energy efficiency can reduce load, and how it can contribute to reducing the amount of overall generation required.

To achieve this, Manitoba Hydro is collaborating with Efficiency Manitoba. First, some energy efficiency measures are assumed to be achieved. This is based on Efficiency Manitoba's energy saving projections. The amount of energy is subtracted from the load projections for each scenario. This results in less load than otherwise would be seen 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 resource options. While having this in the model, it can select extra energy savings as an option to meet future energy needs. This is above and beyond what is already assumed elsewhere.

We are now going to discuss how energy prices and other forecasts are included in the modeling process. We've already talked about the role of interconnections to import and export electricity, as well as the role of natural gas generation to help meet peak demand. However, in order to simulate these components, it is necessary to incorporate various energy price projections to calculate their associated costs and revenues. As a result, Manitoba Hydro has acquired price projections for wholesale electricity from multiple independent price forecasters.

These price projections are used to simulate the revenues for exports and the cost of imports. Similarly, Manitoba Hydro has acquired price projections for natural gas. This model input is used to calculate the cost of operating natural gas turbines for both the existing system and for any new turbines added. Finally, there is a cost to running natural gas turbines, due to their associated GHG emissions. This is comprised of fees paid to the federal government for the emissions, which is dependent on how much fuel is burned. The GHG costs require their own price projections for the model to use. If natural gas turbines are not run very often, then the associated emissions costs are relatively low. The last component of the scenarios inputs are the key inputs.

We will now review these before we get into the resource options tools and the outputs. Scenarios are used in the IRP to represent a reasonable range of what the future energy might look like in Manitoba, regardless of how likely it is to occur. They are based on specific values associated with the inputs. The five key inputs: economic growth, decarbonization policy, electric vehicles, natural gas changes, and customer self-generation are a summary of the inputs creating the most uncertainty in the pace of change. Setting specific values for key inputs allows us to calculate load projections for each scenario, which the model uses to evaluate potential new resources to meet increased demand. In addition to the four scenarios, we also run sensitivities analysis or "What if," analysis to understand how individual inputs or constraints are driving outputs of the model. This "What if," modelling allows us to introduce constraints, or other interventions such as encouraging customers to charge their EVs at a specific time of day.

We'll speak more of these sensitivities and low projections in our next conversations in a few weeks time. Based on our research and feedback through our round two engagement, we associate specific values to each of these different inputs that ultimately make each scenario. This slide shows an example of that type of data used to establish the inputs, in this case for electric vehicles. There's a lot of information shown here, but the pace of change and its uncertainty are ultimately reflected in future vehicle sales that are assumed to be electric. This is necessary, as establishing the shift in consumer energy use with electric vehicle adoption will directly impact future electricity demand. Overall, you can see in the graph the pace of change established for electric vehicles throughout the 20-year IRP analysis period, as well as the difference in the levels of uptake between the scenarios. Different sources of information are used together to establish these specific values, everything from historical data to new studies by independent contractors in order to understand what future uptake might be.

A few examples of drivers of the different inputs values are: the scenario narrative previously set for each scenario assumes different amounts of change related to future decarbonization and decentralization. These drive different assumptions in uptake of electric vehicles between the scenarios. Also, proposed federal sales mandates for light, medium, and heavy duty vehicles are worked into different scenarios. Historical data is used to establish how quickly people are likely to switch to a new vehicle and when paired with a different scenario narrative, the likelihood that the new vehicle would be an electric version. There are also other drivers such as total cost of owning an electric vehicle. This process is repeated for every input, and every key input that is used within the modelling process.

We will now review the model that is being used and resulting study output, highlighted here. First off, the model itself. Modelling power systems is complicated, so Manitoba Hydro uses specialized modelling software designed specifically for electric utilities. The software was purchased from a company called PSR based in Brazil. The software is used in over 60 countries worldwide. Manitoba Hydro is using this software in particular because it specializes in modelling hydropower systems. The software that we use includes two tools. The first is that production costing model, which is used to simulate power systems to determine the cost of producing electricity. The second tool is an expansion planning model, which is used to explore adding new generation resources to an existing system to meet growing demand. Both models are integrated to work together to simulate each of the scenarios to ensure supply meets demand in the lowest cost way.

Now that we've talked about all the different modeling inputs, Manitoba Hydro's planning criteria and the modelling tools we'll bring this all together to explain how modelling establishes the portfolio of resource options for each scenario. Let's use this graph to explain how the model does this. The red line displays the amount of dependable energy and capacity that are available from our existing hydro system. This includes all hydropower, wind, natural gas generation, and imports. Dependable energy is on left and capacity is on the right. The graph also shows future projected demand, which includes Manitoba load, export contracts, and the planning reserve margin in the capacity graph.

Where these two supply and demand lines intersect, it establishes when new supply is needed for either energy or for capacity. This is when new resources are added by the model, which may be at different times 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 over the 20-year planning horizon. The model goes through several iterations to establish resources to meet this demand. The green line on the chart illustrates the amount of energy and capacity supplied with the new resources.

Once the model has all the inputs, it proceeds through a series of steps to develop an optimized solution for each scenario. Step one: as previously mentioned, the model first determines when and how much is needed to satisfy the planning criteria for both energy and capacity. Step two: model picks resources that meets the demand based on the planning criteria. Step three: model stimulates the operation of the Manitoba Hydro system over the next 20 years using 100 years of flow history. This simulation includes existing generating station, imported and exported energy, as well as the new resources. Step four: model calculates the net system costs, which is the summation of all capital costs, operating costs, export revenues, and import costs. Step five: the model then assesses whether or not the net system costs 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. On the previous slide, we showed the modelling steps required to undertake a full simulation to evaluate a single scenario. This process is then repeated for each scenario, as well as for a range of different sensitivities. Each model simulation can take several hours to complete using high-powered computers and more time is required to review the results, confirm they are correct, and interpret the results. A number of iterations is not uncommon to complete and validate each simulation.

The modelling process results in a range of outputs for each scenario simulation. These outputs include the following: a portfolio of resources that meets the defined project loads at the lowest net system cost. Net system cost is including all generation, transmission, distribution, and capital costs, operating costs, fuel costs, import costs, and export revenues, total greenhouse gas emissions for Manitoba Hydro's electrical and natural gas systems.

We are also exploring the total emissions at the provincial level to understand the impact of different scenarios. This would include emissions from other resource sectors such as the transportation sector. Overall, the modelling process results in outputs that help compare results for the different scenarios. However, further analysis and modelling results is needed to further understand the outputs before developing a roadmap and near term in actions.

That's the introduction to our modelling processes. If you have any comments or questions, please reach out at irp@hydro.mb.ca. There will be a second presentation in a couple of weeks, and it will focus on the initial results of the modelling process. This will include information on load projections, a review of key findings from initial modelling results, and the next steps to conclude the modelling process. In addition, we'll be seeking feedback in those sessions on the considerations to conclude our modelling and analysis. If you have any comments or questions, please reach out irp@hydro.mb.ca.