Methodology, Risks and Drivers

Risks and Uncertainties

AESO 2024 Long-Term Outlook

MAY 2024

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Risks and Uncertainties through the Energy Transition

The *2024 Long-Term Outlook* (LTO) generation and load forecast is predicated on certain technological, policy, consumer behaviour and financial assumptions that represent variables of uncertainty. Additionally, factors such as economic shifts, shifts in social acceptability of certain technologies and their externalities, and weather uncertainty can impact both load and generation patterns. The AESO tackles this uncertainty with methods such as data enhancement, stakeholder collaboration, scenario-based forecasting and continuous refinement of predictions by monitoring key load and generation drivers.

Policy Uncertainties

Policy uncertainties can have a significant impact on Alberta's electricity demand and generation forecast, as they shape the province's energy landscape and influence consumer behavior and investment decisions. Key policies such as carbon pricing, emission caps for oil and gas, emissions performance standards for electricity generation, and incentives for carbon capture, utilization and storage (CCUS), renewable electricity projects, electric vehicles (EVs), microgeneration and energy-efficient retrofits, hold the potential to significantly shape electricity supply and demand. Some of these impacts are explained in the following paragraphs.

Significant changes are also expected in the Alberta electricity market that will increase the uncertainty for investors until direction is crystallized. This includes, but is not limited to, activities on both the Restructured Energy Market by the AESO and potential changes to the Transmission Regulation by the Government of Alberta.

In Alberta, changes in policies like carbon pricing, emission caps for oil and gas and incentives for CCUS can significantly impact electricity demand since industrial load and the oil and gas sector constitute a substantial share of Alberta Internal Load (AIL) as well as electricity supply. These policy measures encourage industries to improve energy efficiency practices, invest in emission reduction strategies and implement carbon capture and storage technologies, potentially leading to shifts in electricity consumption.

Government policies and incentives play a crucial role in shaping both EV adoption rates and energy-efficient building codes, directly affecting electricity demand in Alberta. Uncertainties in the rate of EV adoption are influenced by government measures (policies, incentives, levies, and regulations), technological advancements, consumer choice and supply availability, which can either accelerate or impede the transition to EVs. A rapid increase in EVs without adequate charging infrastructure and optimized charging strategies can result in higher electricity demand during peak charging hours. Similarly, changes in building codes that mandate or incentivize energy-efficient practices can influence electricity load in buildings. Stricter building codes can lead to reduced energy consumption, but the overall impact depends on the scale of renovations and the adoption of energy-efficient technologies. Incentives for microgeneration and energy-efficient retrofits can alter electricity demand by encouraging decentralized energy production and reducing overall consumption. Demand-side management programs efficiently manage peak loads and promote energy conservation.

Similarly, electricity generation policy is influential in determining the generation technology mixes portrayed in the 2024 LTO. The trajectory of carbon taxes serves to discourage the development of greenhouse gas-intensive generation types, while also providing monetizable incentives to low emissions and zero emissions technologies. Investment tax credits, offset and emissions performance credit programs, grant programs, regulatory approval, and accelerated depreciation provisions, provide incentives for the development of low-emitting and renewable generation resources. The influence of these policies is substantial to the modeled future resource development represented in the LTO Reference Case and scenarios. Any future changes in carbon policy or tax policy could materially impact the economics supporting the expected generation fleet, and, as such, policy change is a significant risk to the 2024 LTO Reference Case and scenarios.[1]

In conclusion, policy and regulatory uncertainties in Alberta have far-reaching consequences on electricity supply and demand. Carbon pricing, emission caps and performance standards, incentives for CCUS and renewable and low-emitting electricity projects, EV adoption, building codes, microgeneration and energy efficiency initiatives, all play crucial roles in shaping the province's electricity consumption patterns and generation technology mixes.

Technology Uncertainties

As Alberta navigates its future energy landscape, the evolution of technology emerges as a critical variable impacting electricity load and generation trends. The onset of data centers in many regions outside of Alberta highlights the strong potential growth here as owners look for new geographies to invest in. The rapid advancements in various technologies, including cold climate heat pumps for building heating and advancements in hydrogen production, present both opportunities and uncertainties for electricity demand forecasting. Additionally, active management technology, advancements in battery storage, vehicle-to-grid integration and hydrogen blending with fuel for heating houses, can significantly influence electricity demand. Similarly, supply-side technologies in the early stages of commercialization, like CCUS, hydrogen-fired generation, or small modular reactors, can impact future generation technology mixes depending on their real-world development costs and operational performance.

Cold climate heat pumps offer a promising solution for efficient building heating in Alberta's harsh winters. While their adoption can lead to electricity load growth, the pace of their deployment is uncertain and dependent on factors such as cost effectiveness, consumer acceptance and government incentives. Similarly, the advancement in hydrogen production technologies introduces the possibility of using hydrogen as a low-carbon energy source for various applications, including electricity generation and heating. Hydrogen blending with fuel for heating houses can offer a low-carbon alternative for heating systems. The extent to which hydrogen integration occurs and its implications for electricity demand remain uncertain, as it hinges on technological maturity and the establishment of hydrogen infrastructure.

Active management technologies, such as demand response systems and smart grids, offer opportunities to optimize electricity consumption and reduce peak demand. These technologies empower consumers and businesses to actively manage their electricity consumption, enabling load shifting and peak demand reduction. However, the level of adoption and the effectiveness of these technologies in influencing electricity load patterns are subject to various factors, including regulatory support and consumer engagement. Simultaneously, advancements in battery storage technologies have the potential to revolutionize the energy landscape by facilitating renewable energy integration, enhancing grid stability and supporting decentralized energy resources. The scale of battery storage deployment and its effects on electricity demand will largely depend on market dynamics, policy incentives and technological breakthroughs.

[1] For more information on the policy and regulatory assumptions used in the 2024 LTO see the Policy and Regulatory Drivers section.

The advancement of vehicle-to-grid (V2G) technology would allow electric vehicles to provide power back to the grid during periods of high demand or grid instability. While V2G integration holds promise for grid balancing, its widespread implementation depends on factors like EV adoption rates, regulatory frameworks and infrastructure investments. This behavior was not modeled in as part of the 2024 LTO.

CCUS can reduce emissions from natural gas-fired generation sources, allowing them to comply with any provincial or federal net-zero regulatory obligations and avoid escalating emissions payments. However, few CCUS plants are in commercial operation today, only one of which operates on post-combustion emissions from natural gas. Early operational data suggests carbon capture rates of 90 per cent to 98 per cent, but uncertainty remains surrounding the effectiveness of existing technologies when scaled up for use on large combined-cycle or simple-cycle facilities. The adoption of CCUS depends on its development, effectiveness, and cost with respect to large-scale, gas turbine generation facilities. A potential shift of the timing and magnitude of CCUS from the 2024 LTO is highlighted by Capital Power announcing on May 1, 2024, that they are cancelling their CCUS projects due to economics.

Hydrogen-fired generation facilities are a low or no-emitting alternative to natural gas-fired facilities. However, hydrogen-fired generation will be dependent on the availability of supporting infrastructure and long-term trends in hydrogen production price. Costs for hydrogen fuel are based on early or first-of-kind production facilities. Actual production trends may differ from estimates and new production methods, like turquoise hydrogen, may offer hydrogen fuel at lower costs and emissions than blue or green hydrogen.

Nuclear small modular reactors (SMRs) have the potential to provide non-emitting baseload power on shorter construction timelines and lower costs than traditional nuclear facilities. The 2024 LTO forecast for nuclear SMRs utilized next-of-kind cost estimates for the GE-Hitachi BWRX-300 published by the manufacturer. Actual development costs may differ from these estimates, particularly if adoption of nuclear SMRs is not widespread and manufacturers are unable to achieve modularity.

In Alberta's evolving energy landscape, technology's evolution is a pivotal variable impacting supply and demand electricity trends. Advancements like cold climate heat pumps, hydrogen production and hydrogen-fired generation, active management, battery storage and vehicle-to-grid integration have potential to change electricity generation and demand.[2]

Cost Uncertainties

The 2024 LTO assumes that merchant generation capital can be financed with a 10.5 per cent weighted average cost of capital and that fully contracted generation capital projects can be financed with a 7 per cent weighted average cost of capital. However, changing debt and equity financing costs could result in deviations from these capital requirements, particularly considering recent increases in interest rates. Debt and equity financing could be more challenging for capital intensive projects if interest rates increase. Conversely, financing constraints could be alleviated with lower rates.

Technological cost and operational assumptions in the 2024 LTO generation forecast rely on publicly available expert references, wherever possible. However, many of the forecast generation technologies are based on the best information available at the time the analysis was conducted. As necessary, the AESO has adjusted costs to represent Canadian dollars with a base year of 2022. The estimates for technological

[2] For more information on the technology assumptions used in the 2024 LTO see the Emerging Technology Drivers section.

costs are not site specific and are intended to represent capital and operating costs of generic facilities. However, several of the technologies represented in this report are not at a mature technological readiness level or are in the early stages of commercialization. As such real-world development costs and operational performance could deviate substantially from the estimates used in the 2024 LTO.

Economic and Forecast Uncertainty

Aside from technology enhancements and policy uncertainties, numerous factors contribute to the long-term electricity supply and demand in Alberta. Economic expansion and population growth drive electricity consumption as industries thrive and urbanization advances. Additionally, global economic trends, international energy markets, shifts in social values, climate changes and weather uncertainty, play pivotal roles in shaping Alberta's future electricity load and generation profiles.

Economic expansion and population growth directly influence electricity demand in Alberta. The growing industries and urbanization lead to an increasing demand for electricity to power commercial activities, homes, and infrastructure. Notably, the level of industrial and commercial activity significantly impacts electricity demand, with energy-intensive sectors such as manufacturing, mining and heavy machinery requiring substantial power. Commercial areas primed for growth such as data centers and offices may also contribute significantly to overall electricity consumption.

Beyond domestic factors, global economic trends and international energy markets have an impact on Alberta's electricity supply and demand. Shifts in global economic conditions can affect export opportunities, industrial production and resource extraction, subsequently influencing electricity consumption and generation within the province. Fluctuations in oil, gas and other energy prices can influence electricity demand in energy-intensive industries. Geopolitical events and conflicts also play a role in global energy markets, leading to fluctuations in energy prices and supply. Foreign investments in Alberta's energy sector and trade partnerships influence energy production and consumption, thereby affecting electricity demand within the province.

Climate change and weather uncertainty significantly affect Alberta's electricity demand. Extreme temperatures drive up usage for heating or cooling, spiking demand for HVAC systems and climate control appliances. Lastly, social acceptability of power generation projects is an increasingly prominent concern. Each of the generation technologies modeled in the 2024 LTO present externalities that may be met with resistance from members of society. As examples, fossil fuel generation presents concerns regarding atmospheric emissions, hydroelectric generation presents concerns regarding water use and ecosystem change, nuclear generation presents waste management concerns and renewable generation can present land use concerns. As social attitudes shift over time, certain technologies may be favoured over others more broadly.

The uncertainty in future electricity prices can have significant implications for long-term supply and demand forecasts. Fluctuations in energy markets, geopolitical events, technological advancements and shifts in energy policies can all contribute to price volatility. These uncertainties make it challenging to assess electricity consumption patterns and overall load demand.

Navigating Uncertainty and Scenarios Forecasting: Strategies for Long-Term Electricity Projection

Effectively addressing electricity forecast uncertainties in long-term projections demands a multifaceted approach. The implementation of scenario planning empowers electricity system operators to envision a diverse range of potential future scenarios. This enables the development of adaptable and resilient strategies that can navigate uncertainties and challenges that may arise. Collaborating with various stakeholders and sharing data insights fosters a deeper understanding of emerging trends.

Decomposing load into multiple components such as base load, EV load, new projects load, and building heating electrification allows for conducting sensitivity analyses on each of these components. Possible scenarios can be generated by selecting various combinations of these sensitivities. Creating Reference case scenarios with both managed and unmanaged EV charging profiles, along with high electrification scenarios, is some of our efforts in capturing potential electricity consumption in Alberta. Additionally, several sensitivity analyses have been performed by examining 25 different weather profiles for load forecasting. Simultaneously, five distinct economic projections are considered alongside the weather to evaluate the combined impacts of weather and economic variations on load consumption. The AESO is dedicated to the continual monitoring and thorough review of long-term forecasts which enables us to proactively address potential deviations and emerging trends.

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