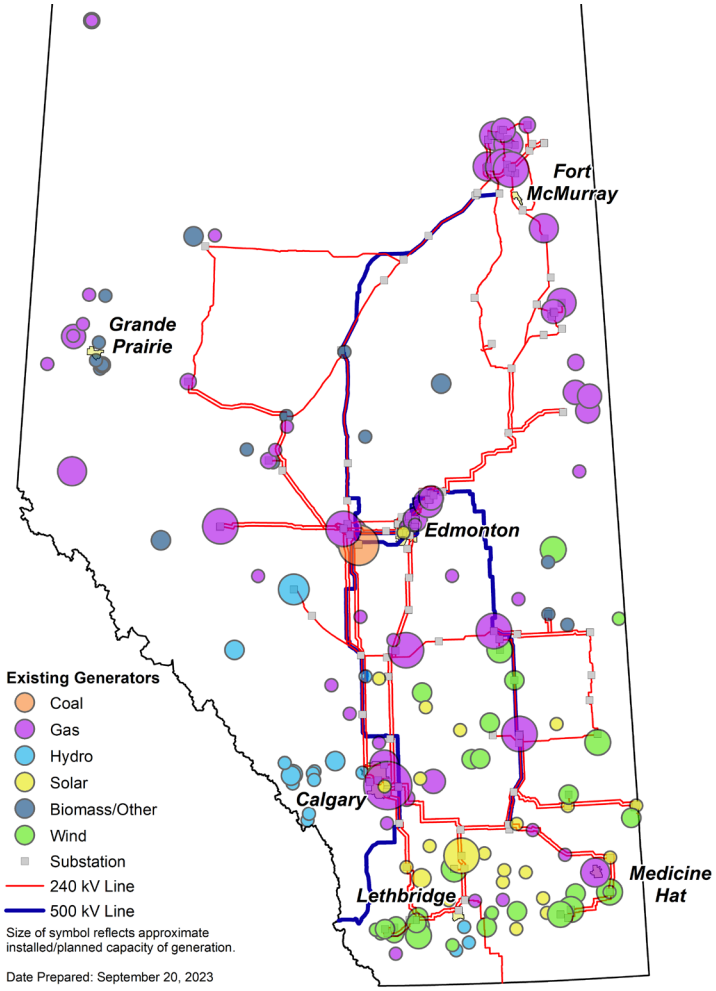
CER CGI Reliability Assessment

September 2023

System Evolution and Reliability Impacts

- Transmission system was developed for large baseload assets, energy development and load centers with commensurate reliability attributes
- Renewables are sited in weakly connected locations and changing the system supply mix
- Reliability is being negatively impacted



Reliability is Multi-faceted

- The AESO assesses many aspects of system reliability, including
  - Resource adequacy
  - Frequency stability
  - System strength (resilience to contingencies; fault ride-through)
  - Balancing capability (flexibility)
  - Transmission capacity (meeting North American standards for reliable operation under normal and contingency conditions)

- The AESO must always keep the system in a reliable state considering all of these reliability domains, and plan for continued reliability
- Resource Adequacy is one aspect of reliability, and a more fulsome analysis of all attributes is required to determine whether a system will be reliable

Current Reliability Issues

- Occurring today, primarily driven by increased renewables and the changing supply mix
- Urgency is increasing due to higher-than-expected renewables pace and penetration

Frequency

- Overview
  - The system needs adequate frequency response to recover from contingencies, especially loss of interties
  - Inertia is needed to help generators stay synchronized after contingencies
- Urgency
  - The AESO recently implemented measures to reduce reliability and compliance risks
- Challenges
  - Wind and solar generators do not contribute frequency response
  - IBRs can only provide "synthetic inertia" and may need to be supplemented with synchronous condensers at added cost

Flexibility

- Overview
  - We need dispatchable generation to cover load as wind and solar output varies
  - Capacity, startup time, and ramp rate constraints apply
- Urgency
  - We can meet balancing performance objectives for now, but risk is increasing as more intermittent generation is connected
  - Planned projects exceed the capabilities of the system
- Challenges
  - We need dispatchable resources to compensate for wind and solar ramps
  - Dispatchable generators may not be able to start up quickly enough to meet demand

System strength

- Overview
  - Wind, solar and storage (IBRs) typically need support from synchronous machines to operate reliably
  - Without that support, disturbances could cause IBRs to trip when they should not, leading to load loss and unstable voltage
- Urgency
  - We have already experienced unreliable operation due to lack of system strength; other jurisdictions in the U.S. have similar problems
- Challenges
  - IBR owners may need to invest in equipment with enhanced capabilities (e.g., "grid forming")
  - The AESO may need to buy synchronous condensers to increase system strength

Resource Adequacy Metrics

Reserve Margin (Simple and Directional)

- Annual metric showing available supply for expected peak demand, taking one value of supply against one value of demand
- Not to be taken as a fulsome resource adequacy/reliability assessment

Supply Cushion

- A supply cushion provides a deterministic hourly view of available supply with expected peak demand

Expected Unserved Energy (Robust)

- An hourly probabilistic assessment of supply shortfall, including a number uncertainties such as unit availability, economic and weather uncertainties (AESO uses this method, as do other ISOs)

CER Parameter Considerations

Peak Firing (Flexibility)	• A 450-annual-run-hour restriction will not enable flexible natural gas assets to respond to increasing system demands and to the loss of intermittent generation • Peak demand hours in January may be adequately supplied, while units will not be able to operate by December • Efficient units would be curtailed, requiring the use of less-efficient, higher-emitting units to support resource adequacy

Emission Performance Standard	• Implied capture rate is approximately 92% to 95% of generation, with the threat of incarceration for non-compliance
	  • Technology may be challenged to meet this level of stringency, despite best efforts and significant investment
	  • Retrofits may be discouraged since legacy unit are less efficient than best in class new units → Retrofits may not meet 30 t/GWh
	• Flexible operations may become restricted by capture rate requirements

CER Parameter Considerations

25 MW Minimum Threshold	• The 25 MW exemption level reduces optionality for managing the intermittent nature of renewables in a cost-effective manner as larger peaking assets are excluded • May provide a perverse incentive to build simple-cycle turbines or engines that are under 25 MW and generally less efficient, resulting in higher emissions than larger more efficient simple-cycle and combined-cycle units
Regulatory Standard is a Physical Limit	• This strict limitation ensures that generation providers need to take a conservative approach to the application of new and emerging technologies (carbon capture, hydrogen) with uncertain technological operational parameters

CER Parameter Considerations

Emergency Procedure (extraordinary, unforeseen and irresistible event)	• What is considered an emergency circumstance?
	  • Threat to reliability (lost load, system flexibility, system strength, frequency, etc.)
	  • Who is held responsible when deemed not an emergency circumstance? System operator or facility operator that may or may not have followed directives

Application of Performance Standard	• End of Prescribed Life (EoPL) – Remaining Combined Cycle and Simple Cycle:
	  • 20-year EoPL will create a capacity cliff with approximately 2,600 MW of existing natural gas coming under regulation in 2035, without the required dispatchable ramping capacity that can reliably replace it.
	  • This represents ~32% of forecast average system load

Behind-the-Fence Generation

- The regulation applies to any units with net exports on annual basis to the electricity system
  - Alberta has a significant cogeneration fleet, which also supplies the rest of the electric system, and the CER could put this supply at risk of retirement or disconnection from the grid
    - 40% of total generation in Alberta is sourced from high efficiency cogeneration
  - A significant portion of Alberta's existing generation assets are integrated into industrial processes spanning multiple economic sectors, including oil and gas, forestry and pulp/paper, materials, chemical production, and institutional combined heat and power
  - Generation facilities were built at sites that consume significant amounts of thermal and electrical energy via the most efficient utilization of natural gas/waste heat available (cogeneration and combined-heat-and-power).
  - These make up a significant part of the Alberta Supply Mix, with nearly 6 GW (under construction and installed) and exports on a net basis of around 1.6 GW (~23% of Alberta system load of 7 GW)

2023 LTO and Resource Adequacy Modelling

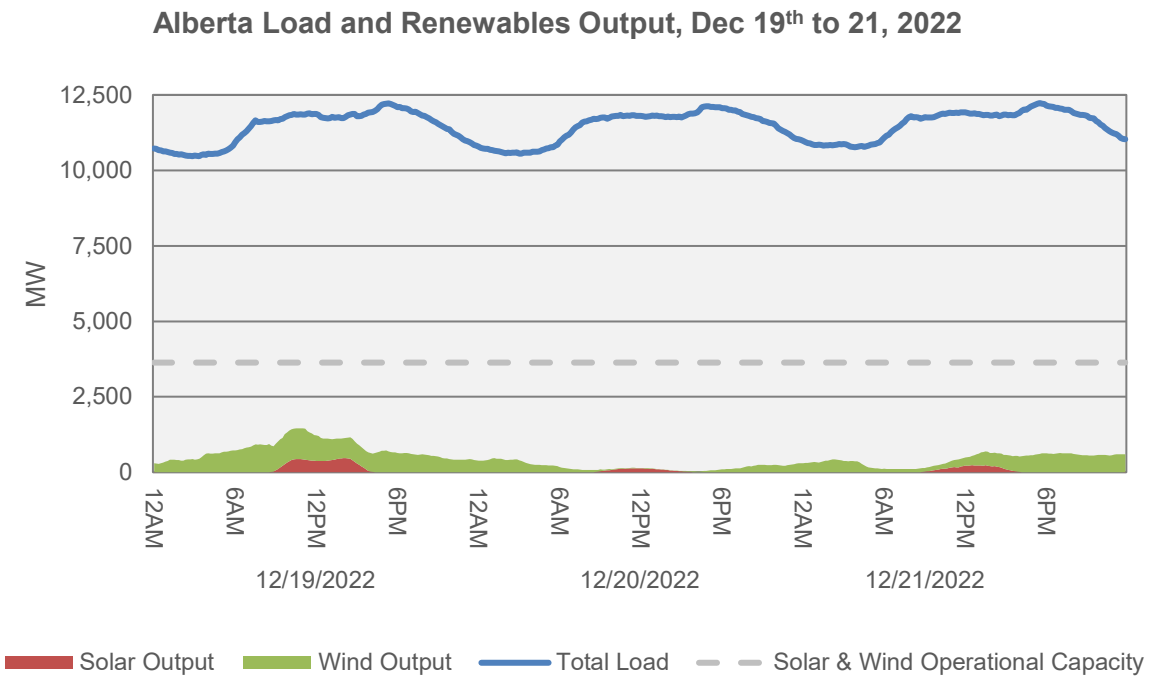
- The AESO's 2023 LTO Decarbonization by 2035 forecast results (originally called the preliminary Reference Case) released in June 2023 assumed CER parameters nearly identical to those released in the August draft CER
  - The input assumptions and resulting supply mix for this case are detailed in 2023 LTO Preliminary Results Engagement Session
  - At a high level, the 2023 LTO Decarbonization by 2035 forecast assumes the current market structure, an unconstrained transmission system and current carbon policies (carbon price, ERP, TIER)
  - The reference resource mix is determined by economic builds under current market structure with no reserve margin assumed (i.e., model adds/subtracts units based on their forecasted economics)
- The AESO's reliability assessment utilizes a sophisticated resource adequacy model (RAM) to evaluate the generation and load forecasts constructed for this 2023 LTO Decarbonization by 2035 case
- The RAM determines the impact of the modelled supply mix capacity (MW) on resource adequacy (EUE MWh) using a probabilistic approach that varies load and generation
  - Hourly chronological dispatch using a stochastic (Monte Carlo) simulation
  - **Distribution for load/weather, load growth uncertainty, outages, intermittent renewable output, intertie, and emergency operating procedures**
- The results are measured against the Long-Term Adequacy Threshold as outlined in Section 202.6 (5) of the ISO rules, Adequacy of Supply. The EUE threshold is calculated as the one-hour average Alberta Internal Load for a year divided by 10.

Resource Adequacy Results – 2023 CER

Forecast Year	EUE (MWh)	LOLH (hrs)
2028	1.1	0
2033	0.8	0
2035	36,000	77
2038	1,400,000	1,473

- Expected Unserved Energy (EUE): The expected amount of load (MWh) that will not be served in a given forecast year
- Loss of Load Hours (LOLH): The expected number of hours that will experience unserved energy in a given forecast year
- The resource adequacy threshold for the forecast year 2035 is **1,118 MWh** and for 2038 is **1,167 MWh**
- The CER regulations create a significant violation of the threshold as we progress past 2035

December 2022 Close-Up



- During extreme weather events, intermittent renewable capacity is often unavailable
  - During extreme heat periods, a heat dome is formed where wind is minimal
  - During extreme cold periods, wind generation is low and solar is offline during system peak events
- December 2022 shown above provides examples during cold and dark periods
  - Temperatures were -25C to -32C in most of the province
  - Intermittent wind and solar generated 12% of its installed capacity and less than 4% of load requirements

Summary - Why the CER Does Not Work in Alberta

- Alberta is reliant on peaking natural-gas generation, which enables reliability and balances intermittency of other assets. The CER creates significant operational restrictions to Alberta's flexible generation fleet that cannot be easily met with cost-effective decarbonized technologies presently available in Alberta

- CER does not create a workable framework to allow an orderly transition of retiring generation infrastructure, or sufficient timelines for development of emerging low-emission technologies such as carbon capture, small modular nuclear reactors, hydrogen and energy storage

- CER threatens electricity supply reliability, while other federal government initiatives (e.g., EVs, heating electrification) increase reliance on electricity systems and electricity demand, creating increased risk to the economy and a degradation of a safe and reliable system