AESO Market Pathways Primer

AUGUST 2023

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Abbreviations

Abbreviation	Term	Page Defined
ACE	area control error	12
AIES	Alberta Interconnected Electric System	1
AUC	Alberta Utilities Commission	11
DFO	distribution facility owner	3
FFR	fast frequency response	12
ISO	Independent System Operator	3
LLTE	long lead-time energy	23
LSS	load shed service	12
Net-Zero Report	AESO Net-Zero Emissions Pathways Report	1
OR	operating reserve	5
PPA	power purchase arrangement	4
Preliminary 2023 LTO	Preliminary 2023 Long-term Outlook Reference Case	2
Reliability Roadmap	AESO 2023 Reliability Requirements Roadmap	1
TCM	transmission constraint management	5
UFLS	under-frequency load shed	12

1. Introduction

Through the Market Pathways initiative, the AESO will work alongside industry to review reliability challenges and identify changes needed to maintain a safe, reliable, and affordable electricity system under a variety of future outcomes.

The Alberta Interconnected Electric System (AIES) is undergoing a period of rapid transformation. The *AESO Net-Zero Emissions Pathways Report* (Net-Zero Report) and the *AESO 2023 Reliability Requirements Roadmap* (Reliability Roadmap) note key operational and reliability challenges that are expected to have implications on the sustainability of the electricity market as currently designed in Alberta. The Alberta Electric System Operator (AESO) has established the Market Pathways initiative to develop a recommendation for a fit-for-purpose market design that will meet these challenges.

The AESO believes that a well-defined electricity framework that leverages competitive forces will yield the most efficient, lowest-cost outcomes for Albertans. This requires a well-defined policy framework, clear technical requirements, and efficient markets that deliver reliability at the lowest cost as Alberta's electric system transforms into a carbon-neutral future. The AESO is proposing a transparent and collaborative process to develop recommendations on the future power market design in Alberta.

This *AESO Market Pathways Primer* (Primer) is intended to provide key information and request feedback from stakeholders on the Market Pathways initiative:

- Purpose and guiding principles
- Issues and priorities
- Market Pathways process
- Stakeholder engagement approach

These key elements will establish the foundation for the Market Pathways initiative. The AESO is committed to maintaining a flexible approach to this initiative and related engagement. If a more effective and efficient way to manage priorities and achieve objectives is identified after considering the initial round of stakeholder feedback, the AESO will adjust the process and/or approach. The process may also evolve due to changes in the scope of issues and priorities or regulatory policy considerations.

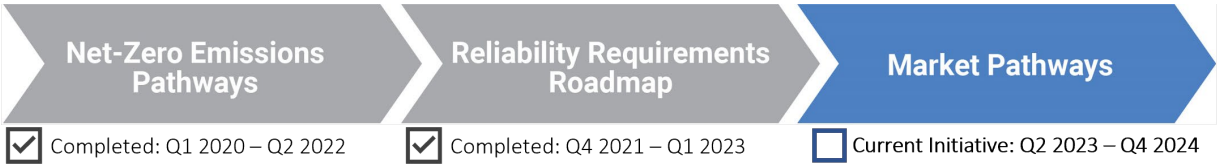
2. Background & Purpose

The purpose of the Market Pathways initiative is to identify market pathways, in collaboration with stakeholders, that inform the future evolution of Alberta's market design considering the transformational changes underway on the AIES. The future grid may require the market to incent or acquire additional attributes to maintain reliability, including:

- Energy
- Capacity
- Availability
- Controllability
- Frequency response
- Inertia
- Voltage support

The AESO has assessed the health of these attributes as part of the Net-Zero Report, the Preliminary 2023 Long-term Outlook Reference Case (Preliminary 2023 LTO), as well as the Reliability Roadmap. These studies were used as preliminary inputs to evaluate the sustainability of the existing market design. They form the basis for identifying relevant reliability issues and determining the priority of each issue for the Market Pathways initiative (see Section 4).

Figure 1: Market Pathways Evolution



Alberta's current energy market is already experiencing the impact of the transformational change occurring in the electricity system. The increased participation of zero-priced offers has led to price volatility in the market, manifested in increasingly bifurcated pool prices with some periods of high-priced hours and other periods with near zero-dollar priced hours. Further, high pool-price levels are raising questions about whether the effectiveness of the combined energy pricing and market power mitigation design is resulting in affordable power for consumers. Short-term supply adequacy issues have been identified, as resources may not be available for dispatch when they are needed, which suggests a need for a review of the ability of supply-demand forecasts to capture uncertainty and how resources are dispatched or committed.

Through the Market Pathways initiative, the AESO, in collaboration with stakeholders, will develop the fit-for-purpose long-term market vision, including specific market and rule reforms, that are anticipated to meet each identified challenge most effectively.

> The purpose of this Market Pathways Primer is to start the conversation with stakeholders by outlining the general process, issues, and key considerations that the AESO envisions will form the basis for evaluating the sustainability of the existing market design, as well as determining what needs to change.

Section 5 of this Primer outlines the AESO's proposed Market Pathways process and stakeholder engagement approach. The document will not cover all areas in depth, as the AESO's goal is to foster a collaborative process with stakeholders where mid- to long-term solutions and the reform process are co-built where feasible.

2.1 Current Market Design

Alberta currently operates a self-commitment, real-time, energy-only electricity market with a single clearing price. An energy-only market involves generators competing to deliver energy to serve load and earn the prevailing market price, which promotes the investment necessary to maintain supply adequacy. Alberta's single pool price can be subject to volatility, providing a stronger investment signal when prices are high and a weaker signal when prices are low. Having a single, province-wide price is predicated on maintaining an uncongested system, where the price for electric energy excludes any costs associated with the delivery of that energy. Wires costs are regulated and charged through the Independent System Operator (ISO) and distribution facility owner (DFO) tariffs.

Features of Alberta's wholesale electricity market include:

- Electricity is dispatched in real-time based on supply and demand conditions.
- Electricity generators submit offers indicating the price at which they are willing to supply electricity to the grid.
- The offer price floor is currently $0/MWh, and the offer price cap is currently $999.99/MWh. The price can rise to $1,000/MWh if firm customer demand must be shed to maintain supply-demand balance.
- The market operates on a merit order dispatch principle, meaning that the lowest-priced offers are dispatched first to meet demand.
- Alberta has interconnections with British Columbia (B.C.), Saskatchewan, and Montana.
- Imports and exports are required to be price takers and submit flow schedules limited by the available transfer capability of the interties.
- The electricity market is settled on an hourly basis by multiplying the energy production or consumption by the hourly pool price and billed monthly.
- The hourly pool price is determined ex-post by averaging the 60, one-minute prices (system marginal prices).

By rule, generators cannot physically withhold available generation capacity from the market and must offer their entire capability to the market. However, economic withholding by pricing capacity above marginal cost is permitted. This may result in a generator not providing energy into the market until the marginal price in the market is high enough that the generator's offer is dispatched by the AESO. To mitigate the extent to which sellers can exercise market power, the current market design includes a maximum offer control share that prevents any one entity from holding more than 30 per cent supply share.

Loads can also participate in the market by submitting bids indicating the price at which they are willing to buy electricity from the grid. However, no loads currently participate in the market in this way. In practice, some large loads respond to high pool prices by reducing electricity consumption. Additionally, some loads, including end-use electricity retailers, manage price volatility through forward contracts.

In addition to the energy market, the AESO has mechanisms in place to procure ancillary services to maintain reliability. Ancillary services include services such as operating reserves, transmission must-run, load shed service, and black-start capability. The AESO procures operating reserves through a day-ahead market, while other ancillary services are either competitively procured or conscripted when required. Currently, the cost of these ancillary services is charged to electricity consumers through the ISO tariff.

The energy-only market design has supported a sustainable balance of investment and operation signals, customer costs, and reliability outcomes for more than two decades. However, given the transformation in the system, the market structure and rules need to be revisited to ensure a robust, fair, efficient and openly competitive (FEOC) platform for attracting investment and maintaining reliability going forward.

2.2 Drivers for Change

2.2.1 Changing Supply Mix

Like other regions across the globe, Alberta is experiencing a significant change in its generation fleet with the reduction in carbon-emitting generation sources and the development of variable renewable generation resources (i.e., wind and solar) occurring at an increasing pace. Driven by the relative ease of entry into the Alberta market, declining technology costs, corporate power purchase arrangements (PPAs), and investment tax credits, it is expected that development in variable generation resources will continue at a rapid pace.

Output from wind and solar generation inherently depends on the prevailing strength of the wind and sun, which can create large changes in net demand on a moment-to-moment basis and uncertainty on the amount of energy available from these assets. This increases the need for controllable assets such as storage, demand response, hydro, thermal generation, and other potential future controllable technologies to balance the variability and meet net demand. Additionally, the decrease in conventional generators as a proportion of the fleet has resulted in the reduction of supply attributes such as inertia and primary frequency response, as those attributes have been provided as a by-product of their energy production, or through technical requirements. The changing supply mix has simultaneously increased the demand for these attributes as supply has decreased. Therefore, new affordable ways to value or acquire these attributes must be considered to support the reliability of the system.

> *Wind and solar resources are a valuable source of emission-free energy, and to maintain system reliability, these resources must be operated with an accompanying mix of controllable resources to offset the inherent characteristics of variable generation resources: variable and difficult to predict ramping of energy and the corresponding variation in power flows across the system network.*

2.2.2 Supply Integration Pace and the Impact on the Transmission System

Alberta's competitive market design, open grid access, and policy to maintain an unconstrained transmission system have enabled the rapid development of emission-free renewables where suppliers can easily connect, compete, and deliver their energy to end-use consumers. However, these new types of supply are outpacing the traditional transmission planning and development process. In turn, this is causing new challenges for tariff rate design and transmission planning and operations:

- The expansion of the transmission system is increasingly driven by the increasing penetration of variable generation resources in areas rich in wind and solar.
- Peak power flows from these resources during high wind and solar conditions do not always coincide with peak demand and the output from these resources is highly correlated (i.e., wind generation typically is at high output at the same time, particularly due to these resources being concentrated in similar geographic regions). The zero-congestion transmission policy requires the AESO to plan and develop the transmission system to accommodate peak flows. Historically, these hours were driven by peak demand; they are increasingly being driven by the windiest and sunniest hours, often uncorrelated with peak demand.

- The current transmission policy, especially the requirement for load to pay for all transmission costs, limits the effectiveness of the ISO tariff to send price signals to generators for the costs they drive on the system; these include both infrastructure and ancillary service costs.[1]

Current transmission policy requires the AESO to plan for an uncongested system. However, the pace of connection of new types of generation resources has contributed to a reality where congestion is increasing, and the AESO's use of transmission constraint management (TCM) is becoming more frequent.

The suite of options available to address strains on the transmission system is highly dependent on transmission policy. The AESO recognizes that many of these policies are outside the AESO's role and responsibility and some of these policies may be reviewed and reformed through other engagement avenues. The AESO intends to work with stakeholders to identify Market Pathways solutions while recognizing these transmission challenges.

2.2.3 Underlying Gaps in Existing Market Design

In light of the recent market observations and reliability risks presented in the Reliability Roadmap, the AESO believes that there is a need to review the existing market design in collaboration with stakeholders to better understand the underlying gaps and determine a path forward.

Recent increases in pool price indicate potential affordability concerns with a transitioning fleet. Further, as outlined in the sections above, it appears the existing market design may not be sending the right price signals for certain reliability attributes.

The AESO has already observed issues with short-term supply adequacy (elaborated on in Section 4.1.1) and ensuring that generation resources are available when the system needs them is becoming increasingly important. Issues with short-term supply adequacy indicate that there may be a concern with the way the market commits or dispatches resources to meet system needs as the amount of $0/MWh variable generation increases. Ensuring effective price signals to incent investment in technologies to maintain reliability is increasingly important as the electricity system transforms into a carbon-neutral future. Further, pool price volatility and uncertainty on the sufficiency of revenue may lead to a lack of sufficient investment in generating capacity in the long term, impacting long-term supply adequacy.

Increased volatility in net demand will require additional and potentially different ancillary services to provide certain reliability attributes in the future. One ancillary service that is currently used to manage the variability in net demand is regulating reserves, which are procured in the operating reserve (OR) market. The AESO has had to rely increasingly on regulating reserves to manage variability in net demand, driven by fluctuations in variable generation resources. Through the Market Pathways initiative, the OR market design may need to be evaluated to determine the most cost-effective way to procure active and standby OR to meet the electricity system's future reliability needs.

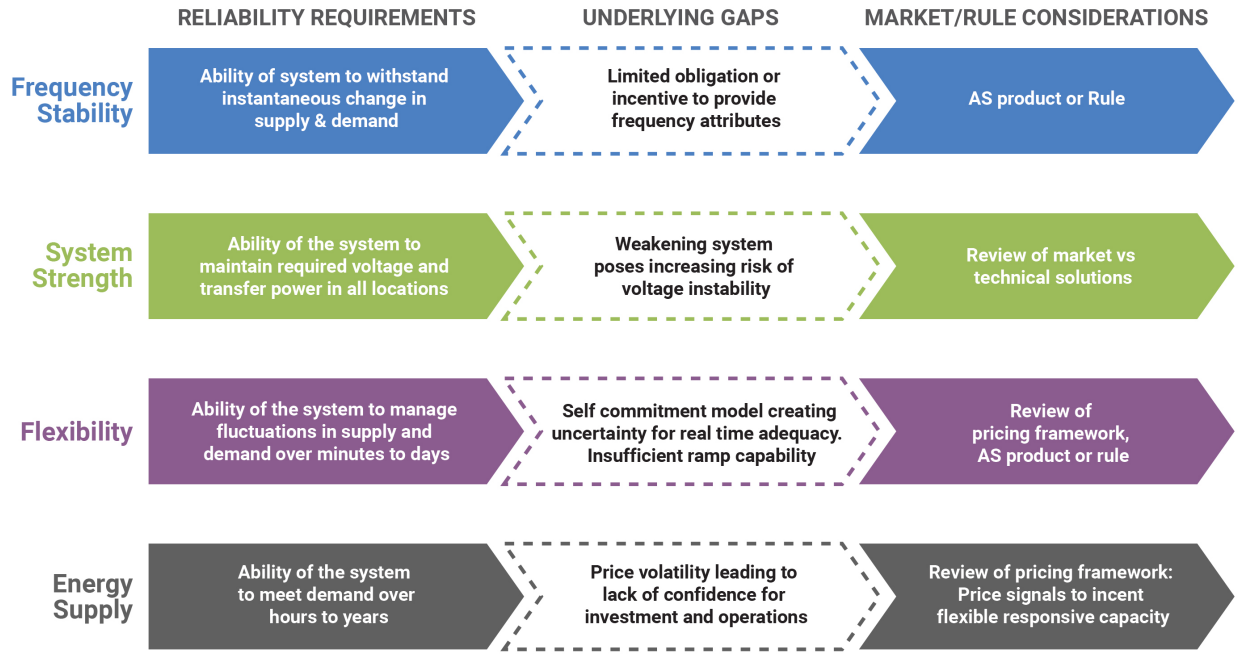
As a means to address reliability concerns, market access may need to be limited through unit curtailments, import/export access, and/or curtailments due to real-time congestion. Longer-term solutions to these issues may need to be considered through market pathways.

[1] Under the Transmission Development Policy, pricing and payment for transmission was considered as fundamentally a cost most appropriately borne by the loads that are served by the transmission system on an equal basis, regardless of location.

Solutions that strike the right balance between enabling market access, ensuring appropriate cost allocation while maintaining a reliable system, will lead to the greatest efficiency.

The following Figure 2 highlights underlying gaps and scarcity of specific requirements that present unique challenges. Throughout this Market Pathways initiative, the AESO expects to work collaboratively with stakeholders to identify what should change.

Figure 2: Reliability Requirements and Market/Rule Considerations



2.3 The Need to Act Now

There is a need to act now to evaluate the sustainability of the existing market design and explore options to reform the electricity framework and market design to meet the future needs of Alberta's system. Market redesign takes time to implement, and the vision for reform is needed now to be ready for the reliability implications that will occur as the grid approaches a carbon-neutral future.

> *Alberta faces significant challenges in achieving a carbon-neutral system, and the AESO believes that a measured and thoughtful approach to developing a pathway for market evolution, in collaboration with industry, is an important step going forward.*

In terms of scope, the AESO is considering exploring options with stakeholders to address the reliability issues identified that are both within and outside Alberta's existing policy framework, recognizing that any changes that are proposed outside of the policy framework are not within the AESO's control. Rather, these may require a separate process involving government, that is not yet determined.

Given the urgency of certain issues, the AESO may need to take immediate actions to bridge the gap through separate processes and initiatives. Additionally, as part of the Market Pathways initiative, interim solutions may need to be identified and progressed while mid-term or long-term solutions can be developed through collaborative efforts with stakeholders through the engagement process.

3. Market Design | Objective & Guiding Principles

Alberta's electricity framework seeks to deliver reliable, affordable power to Alberta's consumers. The transformation underway in the electricity sector is straining areas of the framework. At the core of the framework is the reliance on fair, efficient, openly competitive markets to guide the investment and operation of supply and demand for power, to reach the most economically efficient delivery of reliable electricity. The Market Pathways initiative will identify how the market design within the framework needs to evolve to continue to deliver on that overarching objective for Albertans.

> *The AESO has a mandate to exercise its powers and carry out its duties, responsibilities, and functions in a fair, responsible, and timely manner to provide the safe, reliable, and economic operation of the interconnected electric system and to promote a fair, efficient, and openly competitive electricity market.*[2]

The market design will need to be robust to support reliability through a fundamentally different supply and demand mix, which has different cost and operating characteristics—including the predominance of zero- and negative-marginal cost resources, greater variability, a new reliance on non-traditional sources of essential reliability services, and the capability to serve deep decarbonization policies.

However, delivering reliable and affordable power remains the objective. The AESO continues to believe this is best achieved through competition, and maximizing economic efficiency through fair, efficient, and open competition remains the core focus.

3.1 Objective for Market Design in Alberta

- Maximize economic efficiency in Alberta's electricity market design subject to reliability and legal obligations.

3.2 Guiding Principles

The following guiding principles set out considerations for evaluating solutions in the Market Pathways initiative:

- Least cost delivered energy (maximize productive efficiency[3])
  - Efficient dispatch—dispatching lowest-priced providers first, and according to economic merit
  - Level playing field for all market participants—do not unduly discriminate between market participants
  - Minimize barriers to entry

[2] Section 16(1) of the *Electric Utilities Act*

[3] Productive efficiency refers to the least cost way of procuring the desired attributes

- Proper product definition (maximize allocative efficiency[4])
  - Information transparency and communication in a timely manner
  - Well-defined products with clear price signals
  - Market participants can rely on and respond to the investment signals provided by the procurement method
  - Ensure that the benefits resulting from the chosen solution outweigh the costs
- Operate in the public interest (efficient cost allocation, affordability, and stability)
  - Determine the best fit-for-purpose solution to address the need. Rely on competitive solutions where possible

The AESO views that any solution considered to address a reliability concern should strive to meet the above guiding principles.

[4] Allocative efficiency refers to allocating resources in a way that maximizes overall welfare or utility. It occurs when resources are distributed in a manner that reflects their highest value or usefulness to society.

4. Issues Identified by the AESO

As Alberta transitions to a carbon-neutral future by 2050, the AESO is continually evaluating the needs of the electricity system to maintain reliability over the near- and long-term. Recent analysis has identified several issues to be addressed.

4.1 Background & Issues Identification

AESO NET-ZERO EMISSIONS PATHWAYS REPORT

The Net-Zero Report explored potential supply and demand combinations that may enable Alberta to reach a net-zero electricity system while considering potential implications to reliability, the market, and supply and transmission costs. The report highlighted that there is significant timing risk to achieve net-zero by 2035. The Net-Zero Report found that resource adequacy[5] may be challenging beyond 2035 under all high variable generation penetration scenarios analyzed in the report. As resource adequacy has been identified as an issue of potential concern, it has been incorporated as one of the four core topics to be addressed in the Market Pathways initiative.

Ultimately, any risk to resource adequacy will be driven by the change in attributes and operating characteristics arising from the changing supply mix. There are attributes needed to maintain resource adequacy that have historically been provided by conventional generation, that may now need to be incented and acquired from other technologies through new mechanisms. The report also notes that demand response and demand management can help reduce this supply adequacy risk.

Per findings in the Net-Zero Report, Energy Supply has been defined as a distinct reliability category.

- **Energy Supply |** Requires both energy and capacity. Energy is the physical electricity commodity that is needed to balance supply and demand in the system. Capacity is the availability of electricity supply in the province to meet demand from the operations scheduling timeframe to the investment timeframe. Energy Supply, therefore, requires a sufficient fleet of resources to effectively schedule and dispatch them to balance supply and demand.

AESO 2023 RELIABILITY REQUIREMENTS ROADMAP

The Reliability Roadmap defined new and evolving operating challenges and documented the AESO's plans for maintaining system reliability. The Reliability Roadmap focused on three areas of reliability:

- **Frequency Stability |** Refers to the ability of the grid to maintain frequency within limits and recover to normal operating frequency following the sudden loss of a large source of supply or demand, including via the interties. Frequency stability is driven by system inertia and primary frequency response from generation and load. System inertia influences how quickly frequency deviates after a contingency, while primary frequency response impacts how far the frequency deviates and how quickly the system stabilizes.

[5] Resource adequacy is determined through a Resource Adequacy Model (RAM) that determines the tradeoff between capacity (MW) and reliability (expected unserved energy in MWh) using a probabilistic approach that varies load and generation. The results are measured against the Long-Term Adequacy Threshold as outlined in Section 202.6 (5) of the ISO rules, Adequacy of Supply.

- **System Strength |** Refers to the grid's ability to maintain normal voltage at a location despite system disturbances. When a system is weak in a particular location, it is more sensitive to changes in active or reactive power injection and/or consumption.
- **Flexibility Capability |** Refers to the ability of the electric system to adapt to dynamic and changing conditions while maintaining the balance between supply and demand. Flexibility capability can be considered within several timeframes including ramping capability (hours to minutes), dispatching (hours to minutes), and regulating reserve response (minutes to seconds). The quantity and type of flexibility needed can be different for predictable versus uncertain changes.

The Reliability Roadmap found that the AESO's highest priority was ensuring sufficient frequency response capability. Existing frequency-related operational challenges meant that immediate action was required to reduce the risk of further frequency instability. The need for mitigation will continue to grow over time as the generation fleet continues to transform. With respect to System Strength, the report found that challenges are limited to a small number of local areas and are not a system-wide issue. The number of weak system locations is expected to increase in the second half of this decade. Flexibility Capability challenges are currently managed through forecasting and dispatching practices coupled with regulating reserves; however, maintaining a balance between supply and demand is becoming increasingly difficult with significant challenges emerging.

PRELIMINARY 2023 LONG-TERM OUTLOOK

The Preliminary 2023 LTO identifies renewables development occurring at a faster pace and in some cases at a larger magnitude compared to what was explored in the Net-Zero Report. This change has been driven by a variety of factors, including reduced renewables costs from the introduction of investment tax credits, which effectively reduces the capital cost of variable generation by 30 per cent, as well as an increase in the number of projects that have met the AESO's inclusion status and the expectation of continued development of corporate PPA-related projects going forward. These results were communicated to stakeholders on June 8, 2023. The AESO will incorporate the results from the Preliminary 2023 LTO when it considers the magnitude and timing of the issues facing the system and will update accordingly as new information becomes available.

The findings in relation to the degree of urgency for each of these reliability areas, as well as resource adequacy as determined based on the Net-Zero Report, form the basis for the issues that will be examined in the Market Pathways initiative.

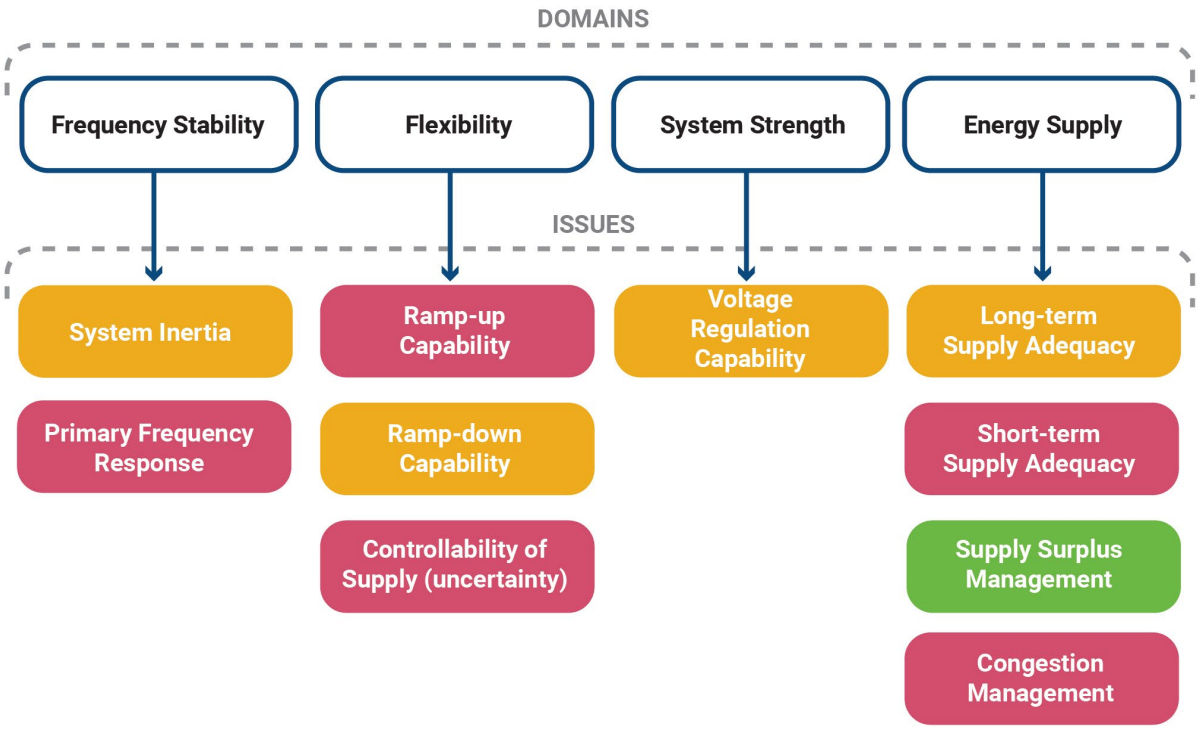
4.1.1 Description and Prioritization of Issues

Under each of the domains previously described, the AESO has identified certain issues that would impact the electricity system and market in the coming decade. These issues are further developed from the issues and considerations identified in the Reliability Roadmap and the Net-Zero Report.

The following Figure 3 shows the classification of each of the issues and how they feed back to the reliability domains, which define the reliability requirements of the system. The Preliminary 2023 LTO identifies faster renewables penetration compared to what was identified in the Net-Zero Report, which has impacted the urgency of the reliability issues communicated within the Reliability Roadmap. This change in urgency is reflected in Figure 3.

The colour assigned to each issue in Figure 3 corresponds to the urgency of the issue. Red indicates that the issue is of high urgency, yellow indicates medium urgency, and green indicates low urgency.

Figure 3: Reliability Requirements



The AESO expects wind and solar to significantly expand in the next few years with approximately 2,200 MW of Alberta Utilities Commission (AUC) approved solar developments and approximately 2,200 MW of AUC-approved wind developments coming online by the end of 2025. Wind and solar are expected to continue growing through the 2020s and early 2030s with more solar additions compared to wind.

The AESO expects that the electric system will face issues related to ramping (up and down) capability and uncertainty in short-term supply adequacy sooner than previously reported in the Reliability Roadmap due to the updated forecast predictions from the 2023 Preliminary LTO.

The following table describes the issues identified by the AESO and the urgency with which the issue needs to be addressed based on the AESO's current understanding of the reliability issues related to the performance and operation of the system.

Table 1: Issue Description and Urgency

Domain	Issue	Problem Description	Current State	Urgency
Frequency Stability	System Inertia	System inertia acts as a buffer between supply and demand imbalance, such as when contingencies occur, which provides time for other frequency stability responses to react. Lower system inertia increases the rate of change of frequency and the likelihood that protection schemes, such as under-frequency load shed (UFLS) and generator relays, will be relied on. Therefore, available inertia can limit the size of the contingency in which the system can manage.	This problem is currently solved by load shed service (LSS), which is also being used to manage primary frequency response. Currently, LSS requirements are typically larger for addressing primary frequency response, but this could change as system inertia decreases and primary frequency response is potentially addressed by other means. Please see Reliability Roadmap page 15-16 & 23 for more details.	Within 5 years
	Primary Frequency Response	Primary frequency response acts to stabilize system frequency by providing a proportional response which counteracts a supply and demand imbalance, such as when contingencies occur. Lower primary frequency response increases the likelihood that protection schemes, such as UFLS and generator relays, will be relied on. Therefore, available primary frequency response can limit the size of the contingency in which the system can manage.	This problem is partially solved by LSS. The AESO is currently exploring whether fast frequency response (FFR) could provide additional support as an interim measure. Please see Reliability Roadmap page 20-23 for more details.	Now
Flexibility	Ramp-up Capability	When the output from variable generators reduces or demand increases suddenly, there is a risk that dispatchable generators cannot ramp up quickly enough and/or there is not enough ramping capability to meet net demand, causing a ACE.	This problem is partially solved by using energy market dispatch and regulating reserve, which are used to correct ACE. But some incremental solutions are needed to improve ramping capability. Please see Reliability Roadmap pg. 47, 96-105 & 108-109 for more details.	Now
	Controllability of Supply (Uncertainty)	Uncertainty around forecast accuracy and asset response to dispatches could result in ACE events, which are expected to increase with additional variable generation.	Forecast error leads to imbalances in the system, which is generally managed by regulating reserves. As the forecast error gets larger or more frequent, more regulating reserve or other solutions will need to be implemented to efficiently manage forecast uncertainty. Please see Reliability Roadmap pg. 86 & 105-108 for more details.	Now
	Ramp-down Capability	When the output from variable generators increases or demand decreases suddenly, there is a risk that dispatchable generators cannot ramp down quickly enough, or do not have the capability to ramp down.	This is partly addressed using energy market dispatch, regulating reserve, and wind & solar power ramp management. But some incremental solutions are needed to efficiently improve ramping capability. Please see Reliability Roadmap pg. 47, 96-105 & 108-109 for more details.	Within 3 years

Domain	Issue	Problem Description	Current State	Urgency
System Strength	Voltage Regulation Capability	In some areas of the system, weak voltage support is leading to unreliable performance from “grid-following” inverter-based resources, including unstable voltages and failure to ride through faults or disturbances.	Some generating facilities are affected during specific system conditions and are being addressed on a case-by-case basis. Solutions are needed that will address the issue in advance instead of after the fact. Please see Reliability Roadmap pg. 35-45 for more details.	Within 3 years
Energy Supply	Congestion Management	There is demand from generators to connect in congested areas. They might need to be constrained down because of lack of transmission capacity.	Increasing variable generation penetration in highly concentrated regions has resulted in an increase in congestion, which, in turn, hinders the grid’s power transfer capabilities. Using transmission constraints rebalancing payments as a proxy for congestion, the AESO has observed an increase in congestion. As this continues to increase, the system’s power transfer capability will continue to decline. Please see AESO Market Statistics Report 2022 pg. 41 for more details.	Now
	Short-term Supply Adequacy	The supply of energy can be uncertain at times as there is no resource commitment in Alberta (relevant to thermal resources’ unit commitment decisions, demand response activation plans, and storage charging plans). As more variable generation comes online, energy supply becomes more volatile and some resources may not be available when needed absent improved short-term availability commitments, for example, thermal plants may have cycled off and may not be available when needed.	Without mitigation, this impacts the AESO’s ability to accommodate the peaks and troughs of the net-demand profile. The AESO's ability to react to changes in the net-demand profile is dependent on the fleet's ability to plan ahead and cycle on/off to meet system needs. Please see Reliability Roadmap pg. 46-47, 92-95 & 117 for more details.	Now
	Long-term Supply Adequacy	There is a risk the system might not have enough dispatchable generation and demand response to serve net demand.	The magnitude of this issue is driven by the economics of conventional generators being impacted by increased $0/MWh generation on the system and the continued uncertainty of the future carbon policy domain generators will be operating in. Please see Net Zero Report pg. 55-60 & 72-73 for more details.	Within 5 years
	Supply Surplus Management	There is a possibility that supply from $0/MWh sources might exceed load on an increasingly frequent basis, resulting in the need for more curtailment.	The AESO is concerned about the probability of increasing frequency of $0/MWh power, as increased renewable resources are added to the system. The increase in supply surplus events leads to an increased risk of excess curtailments or excess costs from other resources to prevent curtailments. Low prices may discourage resources with ramp-up capability from being online and available to meet demand when the supply surplus ends. Please see Reliability Roadmap pg. 92-94 for more details.	Within 10 years

The AESO is interested in understanding whether stakeholders:

- Identify additional issues beyond those listed
- View the urgency levels described by the AESO differently

Developing a comprehensive picture of the issues to be addressed is a key step before launching discussions around solutions, as many of the potential solutions may address a number of issues.

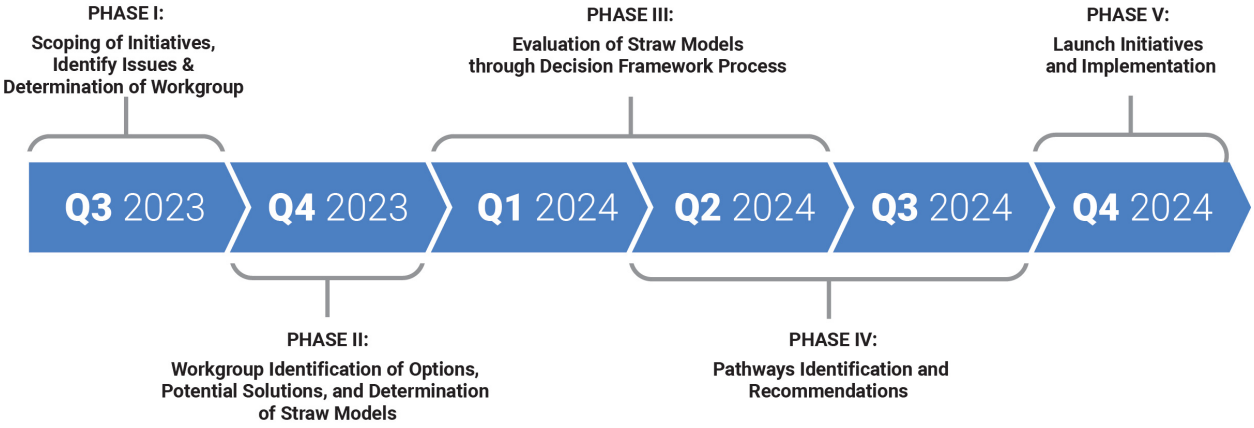
5. Market Pathways Process & Stakeholder Engagement Approach

The following sections outline the AESO's proposed Market Pathways process and stakeholder engagement approach.

5.1 Market Pathways Process

The AESO is proposing the following high-level plan to develop the Market Pathways recommendation. Stakeholder input is being requested from the outset of this initiative to collaboratively develop an effective and efficient way to manage priorities and achieve objectives; details will be determined through the course of this engagement process.

Figure 4: Market Pathways Initiative | High-Level Plan



5.1.1 PHASE I: Initiative Scoping, Issues Identification, and Workgroup Determination

The AESO is seeking feedback on the purpose and objectives of the Market Pathways initiative, issues described in this Primer, including defining priorities for evaluation as part of Market Pathways, to ensure the scope of this initiative is appropriate (an example of the Stakeholder Comment Matrix is provided in Appendix B for reference, or access the Stakeholder Comment Matrix to provide input here). The AESO is also seeking input on how stakeholders would like to engage during the Market Pathways initiative. An industry session is being planned for fall 2023 to:

- Review stakeholder feedback on this primer
- Address outstanding questions
- Work toward finalizing the list of issues and the engagement plan

5.1.2 PHASE II: Workgroup Options Identification and Straw Models Determination

Once a holistic scope is defined, the next phase of the proposed process is to identify options and potential solutions to mitigate the issues identified. Throughout Phase II, the AESO will rely on industry participants to augment the range of potential solutions and determine potential straw models or packages of solutions that address the issues. The ultimate objective in determining options and straw models is to identify the optimal path that achieves reliability at the lowest cost.

Generally, the options identified are expected to fall into one of the following buckets:

- **Requirements-based |** Adding a requirement by modifying or creating ISO rules, technical standards, or specifications.
- **Wires-based |** Altering transmission and/or intertie planning, investment, or operations.
- **Market-based |** Modifying existing services or creating new services that can be procured through ancillary service markets or competitive processes and/or changing how the energy and ancillary service markets are structured and operated.

5.1.3 PHASE III: Straw Models Evaluation through Decision Framework Process

The possible solutions identified in Phase II, which the AESO envisions will form a number of straw models, will be explored further in this phase. The AESO proposes to apply an initial screening assessment to determine which solutions, alternatives, and straw models should be prioritized for further consideration in Phase III. To assist with this evaluation process, the AESO proposes to develop and share for stakeholder input a robust decision framework that considers economic efficiency and other relevant factors such as affordability and policy.

For each identified issue or challenge, at least one—and potentially several—viable solutions could be identified for further consideration.

5.1.4 PHASE IV: Pathways Identification & Recommendation

In Phase IV, it is proposed that the AESO and stakeholders engage in an iterative process to identify the fit-for-purpose long-term market vision, including specific market and rule reforms that are anticipated to meet each identified challenge most effectively. The long-term market vision will be one that will meet reliability needs affordably throughout the transition to a carbon-neutral future.

The AESO recommends applying a prioritization and sequencing assessment relative to the long-term vision, to determine the most achievable pathway for realizing the market vision. This pathway will be revised in response to stakeholder input, considering implementation realities such as software upgrade costs, timing requirements, and other factors to be determined.

Recommendations are being targeted for Q2 or Q3 2024. This proposed timing may be adjusted based on the progress of this initiative through the stakeholder engagement process.

5.1.5 PHASE V: Launch Initiatives and Implementation

Based on the recommended Market Pathway and its proposed timeline, the AESO expects that further consultation with stakeholders on key initiatives/reforms identified in the Market Pathways initiative will be required once a final Market Pathways recommendation has been landed.

5.2 Engagement Approach

The AESO is seeking to build the Market Pathways recommendation with focused input from industry, leveraging stakeholder knowledge and perspectives throughout the process. Engagement is necessary to ensure a wide array of perspectives are considered in this holistic assessment. Stakeholder involvement will be integral to this work, whether through directly supporting design considerations, stress-testing options, or creating a Market Pathways recommendation.

The AESO is sharing preliminary thinking on the development and design of a working group (or groups). To ensure input is considered effectively, the AESO envisions relying on a working group (or groups) as the key method for engaging with stakeholders.

The working group(s) would play a key role in progressing each of the phases through sharing input on:

- Issues
- Scope and principles
- Presenting solutions
- Contributing analysis and evaluation
- Seeking areas of agreement
- Clarifying areas of misalignment amongst working group members

Design activities and information gathering through the working group(s) would be augmented with broad stakeholder engagement at key points in the process. The AESO anticipates that touchpoints between the working group(s) and industry will be required periodically to ensure that a broader range of feedback is considered in the Market Pathways recommendation.

The AESO is seeking feedback from stakeholders on how best to form the working group(s) and achieve the right level of engagement and participation among members. The AESO is contemplating an application process for the workgroups.

For example:

- Applicants will submit how their knowledge and industry experience can support the working group(s) in achieving its objectives.
- Working group(s) are envisioned to be comprised of 12-15 individuals to ensure:
  - Discussions are focused and meaningful
  - Representation from key stakeholder groups whose businesses and operations are impacted by the Market Pathways recommendation

Terms of Reference and a process description would be developed in consultation with stakeholders as part of the formation of the working group(s).

Recognizing the significant impact the Market Pathways recommendation will have on Alberta's electricity sector, the AESO will also seek insights and guidance from senior industry leadership to focus direction and priorities, as well as to augment working group input where required.

The AESO is committed to maintaining a flexible approach to this initiative and related engagement. If, after considering the initial round of stakeholder feedback, a more effective and efficient way to manage priorities and achieve objectives is identified, the AESO will adjust this process.

The process may also change due to changes in the scope of issues/priorities and regulatory policy considerations.

5.3 Policy Framework Considerations

In terms of scope, the AESO is considering exploring options with stakeholders to address the reliability issues identified both within and outside Alberta's existing policy framework, recognizing that any proposed changes that fall outside of the existing framework are not within the AESO's control to implement. Rather, these may require a separate process involving government that is not yet determined. Given this uncertainty and the various time horizons involved, the Market Pathways process will need to appropriately weigh how to resolve near-term critical issues, without losing sight of mid- and long-term solutions in the development of a holistic market vision.

Further, this Market Pathways initiative would need to be coordinated with any government review of components of the policy framework. Should such policy review occur, the scope of the Market Pathways initiative would need to be reviewed and adapted as necessary.

6. Next Steps

The AESO is requesting feedback from stakeholders on the material shared within this Market Pathways Primer through the Comment Matrix. Feedback is requested to be submitted by September 5, 2023.

The AESO will take stakeholder feedback into account when determining next steps and will establish a process for Q4 2023 and beyond accordingly. The AESO seeks to be as transparent, inclusive, and collaborative as possible throughout the Market Pathways initiative.

Thank you in advance for your time and for your contribution to Market Pathways and the collective work that needs to be done to meet the future needs of Alberta's electricity system.

Appendix A: Description of Issues Identified by the AESO

System Inertia

System inertia acts as a buffer between supply and demand imbalance, such as contingencies, which provides time for other frequency stability responses to react. Lower system inertia increases the rate of change of frequency and the likelihood that protection schemes, such as UFLS and generator relays, will be relied on. Therefore, available inertia can limit the size of the contingency in which the system can manage. This problem is currently solved by LSS, which is also being used to manage primary frequency response. As the penetration of inverter-based resources increases, the intrinsic level of system inertia is expected to decline, increasing the need for mitigations such as additional inertia or FFR. The Market Pathways initiative will explore solutions that will maintain or improve system inertia and evaluate the efficiency of procuring inertia via market or other solutions.

Primary Frequency Response

Primary frequency response acts to stabilize system frequency by providing a proportional response which counteracts a supply and demand imbalance, such as contingencies. Lower primary frequency response increases the likelihood that protection schemes, such as UFLS and generator relays, will be relied on. Therefore, available primary frequency response can limit the size of the contingency in which the system can manage. This problem is partially solved by LSS and the AESO is currently exploring whether FFR could provide additional support as an interim measure. As variable generation is typically operated at maximum production based on real-time weather conditions, these assets do not currently have the capability to provide primary frequency response for under-frequency events. As the penetration of variable generation increases, the intrinsic level of primary frequency response is expected to decline increasing the need for mitigations such as additional primary frequency response, FFR, or some other solution. The Market Pathways initiative will explore solutions that will maintain sufficient levels of primary frequency response while balancing the costs to consumers.

Ramp-up Capability

A rapid increase in demand or reduction of supply from variable generation must be managed by energy dispatched from other assets in the system. ISO System Controllers currently rely on energy dispatches and the ramping capability of assets to balance the system. With more variable generation, additional ramping capability will be required as the intrinsic ramping capability may not produce energy fast enough to manage the increase in demand or reduction in supply from variable generation.

The Market Pathways initiative will investigate efficient and cost-effective means of meeting the increased need for ramping capability as the supply mix continues to change.

Ramp-down Capability

Rapid decreases in demand or increases in variable generation can lead to difficulty balancing the electricity system. To mitigate those risks, the AESO implemented ISO Rule Section 304.3, *Wind and Solar Power Ramp Up Management* which applies ramp rate limitations to wind and solar generators in situations where wind and solar generation surpasses the electricity system's ability to accommodate it. While limiting ramp rates is a technically viable solution, it is not resource neutral and will become more costly to wind and solar generators and ratepayers as renewable resource capacity increases. Emphasizing the value of system flexibility can allow for a more efficient and optimized integration of variable generation, incenting resources such as energy storage and demand response. The Market Pathways initiative will investigate efficient and cost-effective means of meeting the increased need for ramping capability as the supply mix continues to change.

Controllability of Supply (Uncertainty)

The dynamic nature of weather patterns means that there will always be some level of uncertainty in variable generation forecasts and generation output. Uncertainty around forecast accuracy (in MWh) and asset response to dispatches can result in events when supply and demand do not materialize as expected. These uncertainties can lead to imbalances in the system which is currently managed by regulating reserves. As more variable generation is added to the system and the proportion of generation that is controllable decreases, these uncertainties have become larger or more frequent. The dynamic nature of weather patterns means that there will always be some level of uncertainty in variable generation forecasts and generation output. More accurate forecasts, more regulating reserve, or other supply balancing solutions will need to be implemented to manage uncertainty. In the future, AESO will need to rely more extensively on variable resources to provide essential grid services, including increased reliance on technologies that have not historically been visible or controllable by the AESO. The technology needed to make many variable resources such as controllable demand, distributed resources, and batteries highly visible and controllable are already technically demonstrated and commercially available, but these technologies have not been deployed in Alberta. The Market Pathways initiative will investigate solutions that decrease uncertainties in forecast accuracy or increase visibility and certainty in asset responses.

Congestion Management

The current market structure allows market participants to choose their connection location based on the market participants' needs. For supply sources there are some locational signals, however market participants are not required to locate in the most cost-effective transmission area or balance their investment costs relative to transmission and congestion management costs that they may impose on the system. Thus, the location chosen does not always align with transmission capacity available in the region. This may cause congestion which would require the AESO to constrain down generation in the short term and build transmission to relieve the congestion in the long term, as the AESO is currently required to plan a congestion-free system. The Market Pathways initiative will explore market design solutions to provide better signals for supply source location, market-based solutions that relieve congestion, non-wires solutions, and other structural changes.

Voltage Regulation Capability

System strength is the ability of the grid to maintain normal voltage at any given location despite disturbances. When the system is weak, the voltage at that location varies more as it reacts to changes in active or reactive power injection or consumption. Synchronous generators that are electrically coupled to the system are the largest contributors to system strength. Inverter-based resources with grid-following technologies are decoupled from the system and does not contribute to system strength although these resources rely on system strength to flow electricity into the system. Thus, in some areas of the system, weak voltage support is leading to unreliable performance from "grid-following" inverter-based resources, including unstable voltages and failure to ride through faults or disturbances. The Market Pathways initiative will consider if voltage issues are impacted or resolved through market design recommendations versus technical solutions.

Long Term Supply Adequacy

Alberta's electricity market relies on the energy market price signals to incent supply build and availability. The unpredictable nature of the wholesale markets can make it difficult for electricity generators to plan and invest in new capacity. Low or unpredictable prices can also make it difficult for owners to make shorter-term investment decisions regarding the startup of a generator and make it available in real-time. Other drivers outside of the electricity market such as environmental policies may also create incentives to build a supply mix that serves the policy goal of reducing emissions but does not necessarily prioritize

investment in resources that can provide reliable electricity supply to balance Alberta's electricity demand in real-time. The influx of variable resources introduces the price conditions described above which substantially changes the economics of traditional supply resources in ways that are expected to reduce prevailing reserve margins and increased reliability shortfalls. Thus, there is a risk that there may not be enough controllable generation, storage, and controllable demand to meet Alberta's resource adequacy requirements throughout the transition to a carbon neutral grid absent changes to the market design that can attract and retain such resources. The Market Pathways initiative will explore solutions that will create better price signals to incent long-term investment which will lead to a diverse supply mix to better meet Alberta's electricity demand.

Supply Surplus Management

The electric system may increasingly be in a state of supply surplus where excess $0/MWh energy must be curtailed to balance supply and demand. The AESO predicts a significant number of hours will have an oversupply of $0/MWh power as more variable generation comes online. This will result in more curtailments to balance the system. This may impact the ability of inflexible resources, which were dispatched offline due to supply surplus, to return online when required. Many hours of supply surplus may also influence future asset commitment decisions. The Market Pathways initiative will explore and determine the most efficient way to manage supply surplus situations.

Short Term Supply Adequacy

The current market structure does not have an explicit resource commitment obligation. Generating assets are required to make offers and must comply with dispatches. However, they can schedule outages at their discretion. Generation assets that have a start-up time of greater than 1 hour are considered LLTE when they are offline. When an LLTE asset owner is available for dispatch, the participant enters a start time for the asset prior to 2 hours before the start of the settlement period.

As more variable generation comes online, the energy supply becomes more volatile. This may cause more assets to cycle offline and may not be available when needed. These practices make the supply of energy uncertain. The AESO does not commit assets, no binding day-ahead schedules are given, instead, real-time energy dispatches are issued to generating assets to balance supply and demand. The AESO's ability to react to changes in the demand profile is dependent on the fleet's availability and ability to cycle off/on to meet system needs.

Though not the dominant resources in the Alberta markets today, many variable resources would also either reduce operating costs or enhance their value to the power grid if there were increased opportunities to coordinate delivery commitments across the intraday and day-ahead timeframes. Examples include storage resources that can plan their charging and discharging cycles in ways that support system risk management, some categories of demand response that require advance notice for scheduling curtailments, and vehicle or other controllable demand categories that can plan to manage consumption within specific constraints. As with thermal generation, some of the opportunities to coordinate and most cost-effectively schedule these resources are lost by the time a system need materializes in the real-time (e.g., if the battery has not been charged or the long-lead demand response has not been activated). However, coordinated delivery commitments transfer forecast uncertainty risk from generators to ratepayers who would be required to back such delivery commitments. The Market Pathways initiative will explore solutions which would create more certainty or incentives for the supply of energy in the short term to meet system demand.

Appendix B: Stakeholder Comment Matrix (Reference Only)

Stakeholder Comment Matrix – August 1, 2023

Market Pathways | Market Pathways Primer Initial Written Consultation

Comment period:	**August 1, 2023 – September 5, 2023**	Contact:	Company Representative
Comments from:	Company Name	Email:	
Date:	[yyyy/mm/dd]		

Instructions

1. Please fill out the section above as indicated.
2. Please respond to the questions below and provide your specific comments.
3. Stakeholder comment matrices will be published on aeso.ca, in their original state.
4. Please upload one completed comment matrix per organization.
5. To upload your completed comment matrix:i
   i. You will need to be registered and signed in on the AESO Engage platform
   ii. You will need to be on the Market Pathways page (https://www.aesoengage.aeso.ca/market-pathways) which can be found on the AESO website at www.aeso.ca and follow the path: AESO Engage > Market Pathways > Stakeholder Feedback > Request for Feedback | Market Pathways Primer Aug. 1-Sept. 5, 2023
   iii. Please click on the "Complete Stakeholder Feedback" box to upload your completed comment matrix

Request for Feedback

The *Market Pathways Primer* (Primer) is intended to provide information to stakeholders on the system/market issues and priorities identified to date by the AESO, as well as on the AESO's proposed Market Pathways process and engagement approach. The AESO is requesting stakeholder feedback on these key pieces to set the foundation for and to inform the Market Pathways initiative going forward. An industry session is being planned for fall 2023 to review stakeholder feedback on the Primer, to address outstanding questions, and to work toward finalizing the list of issues and the engagement plan. The AESO values stakeholder feedback and invites all interested stakeholders to provide their comments on the following questions. Please be as specific as possible with your responses.

Thank you in advance for your time and for your contribution to Market Pathways and the collective work that needs to be done to meet the future needs of Alberta's electricity system.

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	Questions	Stakeholder Comments
1	**Proposed purpose and guiding principles** To ensure a common understanding and alignment of the intent of the Market Pathways initiative, the AESO is interested in understanding if stakeholders have input on the purpose and guiding principles as described by the AESO.	
	a. Do you believe the proposed purpose of the Market Pathways initiative as described is appropriate to address key market challenges? If not, please explain how you believe it should be revised.	
	b. Do you believe the proposed guiding principles for evaluating solutions as described are appropriate? If not, please explain how you believe they should be revised.	
2	**Proposed issues and priorities** To ensure the scope of the Market Pathways initiative is holistic, the AESO is interested in understanding if stakeholders see additional issues beyond those listed in the Primer, as well as whether stakeholders have additional input on the urgency and the priorities as described by the AESO.	
	a. Do you have any input on the AESO's understanding of the urgency and the priorities as listed in the Primer?	
	b. Are there additional issues that you believe need to be considered? If so, please explain why it is an issue and provide evidence to support (e.g., What attributes/elements are missing and not currently being fulfilled in the market?)	
	c. Please provide suggestions on how the AESO can explore options with stakeholders to address the reliability issues identified that are outside Alberta's existing policy framework.	

	Questions	Stakeholder Comments
3	**Proposed Market Pathways Process** To ensure the purpose and objective of the Market Pathways initiative are obtained through a robust, effective and expeditious process the AESO is interested in understanding if stakeholders have input on the proposed Market Pathways process.	
	a. Do you believe the phases identified in Figure 4: Market Pathways Recommendation | High-Level Plan and their scopes are appropriate?	
	b. Do you believe the phases identified in the timeline (Figure 4) are sequenced appropriately?	
4	**Proposed Engagement Approach** The AESO is interested in understanding how you as a stakeholder would like to engage during the Market Pathways process. In the Primer, preliminary thoughts on the development and design of working group(s) with broader stakeholder touchpoints are proposed. Please provide your feedback on the AESO's proposed engagement approach.	
	a. Please explain how you would like to be engaged during the Market Pathways initiative, including details on what you believe an effective, efficient and collaborative engagement approach would entail.	
	b. Please provide suggestions on how you envision working group sessions could be organized to be as effective and efficient as possible. This could include everything from how often meetings should be held, what representation at the meetings could look like, whether to have separate groups/sessions to discuss the different domains or a single working group (e.g., by issue: energy supply, frequency stability, system strength, flexibility; by time domain: short-term, long-term, etc.), parallel streams in session, etc.	

	Questions	Stakeholder Comments
	c. The AESO would like the working group sessions to be as equitable as possible. Do you have any comments on potential workgroup(s) composition and the possibility of an application process for workgroup(s) selection?	
	d. Please indicate whether your organization/ association would like to be actively involved in working group sessions.	
	e. Please explain what stakeholder role and the level of commitment your organization/association would be willing to play in working group sessions (e.g., an active role in performing analysis, developing potential options/solutions, etc.).	
	f. Please indicate your organization's thoughts on having a stakeholder group representative attend working group sessions on behalf of others, who would then be responsible to report back up to those they represent and the larger stakeholder group.	
5	**Additional Feedback and Comments**	
	a. Do you have any additional feedback you would like to provide on the Market Pathways Primer?	

Thank you for your input.