Long-term Energy Storage Market Participation Draft Recommendation

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Alberta Electric System Operator

Calgary Place, 2500, 330-5th Avenue SW Calgary, AB T2P 0L4

Phone: 403-539-2450 | Fax: 403-539-2949

www.aeso.ca

@theaeso

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Executive Summary

On Oct 1, 2020, the AESO published the Long-Term Energy Storage Options Paper[1], which explored options to further integrate Energy Storage in the Alberta electricity market. This recommendation paper considers options, alternatives and presents draft recommendations that would allow for improved electricity market participation by energy storage assets in all aspects of the Alberta electricity market. To enable further integration of storage into the energy market, the AESO has identified the following four areas which required additional clarification, consideration, and where required, a recommendation to develop new or amend existing ISO rules. This paper examines each of these four areas, outlines the possible implementation options, summarizes stakeholder feedback of those options to date, describes the AESO's conclusions, and provides a draft recommendation:

1. Hybrid asset participation: whether to allow or disallow hybrid asset participation and compare possible implementation options designed to address the dispatch uncertainty issues caused by co-located variable energy resources (wind and solar generation) and storage operating as a single energy market "hybrid" asset.

   The AESO recommends that the ISO rules allow for hybrid asset configurations; however, include the variable energy resource block mechanism to determine the allowable dispatch variance for those assets.
2. Half-range vs Full range participation: compare the current half-range (discharge capability only) energy market participation model to a full-range participation model where storage resources submit price and quantity blocks for the charging and discharging capability, and possible implementation options for full-range participation.

   The AESO recommends optional full-range participation using the linked-assets submission mechanism for those participants that choose to submit the full operational range of the resource; and a must communicate charging levels requirement for participants that choose not to participate with their full-range.
3. State of Charge definition: the need to define State of Charge, and to adopt the use of this term within the existing ISO rules.

   The AESO recommends state of charge be defined as an aggregate measurement from the site as a percent charge ranging from zero to one hundred percent that will be provided to the AESO and updated in real-time via supervisory control and data acquisition (SCADA) systems; however, this information will not be reported publicly.
4. Commissioning ISO rule requirements: add commissioning requirements for the charge portion of an energy storage facility.

   The AESO recommends that sites with controllable inflows or outflows be required to submit 2 offer blocks during commissioning and that those offer blocks include an offer with the price of zero dollars and an offer at the price cap.

1. Background

1.1 Energy storage roadmap

In August 2019, the AESO published an Energy Storage Roadmap. This roadmap was developed to set out the plan to integrate energy storage facilities, given that current legislation, regulations, and AESO

[1] https://www.aeso.ca/assets/Uploads/Energy-Storage-Long-term-Market-Participation-Options-Paper-1OCT2020-FINAL.pdf

authoritative documents do not fully contemplate the unique attributes and challenges associated with energy storage participation. The Energy Storage Roadmap sets out the AESO's plan to facilitate the integration of energy storage technologies into the interconnected electric system and the Alberta electricity market framework. The Energy Storage Roadmap is structured around the four integration pillars of energy storage enablement – Transmission, Markets, Tools, and Regulatory. These integration pillars provide focus as the AESO progresses this complex initiative.

The markets integration pillar includes the following work streams: 1) Market design; 2) Tariff design; and 3) Operations planning & engineering. This recommendation paper focuses on the market design component of the Markets integration pillar. The market design effort includes storage participation in the energy and ancillary services markets, which includes a review of the ISO rules pertaining to offers and bids, dispatch and dispatch compliance, settlement and credit, and supply surplus and short-term adequacy.

The term "market participation" is used in this document to describe the activities a participant must perform to in order to actively, rather than passively, participate in the electricity markets. This includes submitting priced offers and bids, restating those submissions when there is an acceptable operating reason to do so, and receiving and complying with dispatch instructions and directives issued by the AESO.

What is market participation?

All resources connected to the Alberta Interconnected Electric System (AIES), which includes both transmission and distribution connections, that inject or withdraw power must exchange their energy through the power pool and are settled at pool price. For a pool participant to actively participate in the energy market their asset must be 5 MW in size or greater, regardless of their connection voltage. Assets less than 5 MW are settled using the pool price, but do not have participation obligations.

Long-term Energy Storage market participation solution design principles

The long-term solution must provide clarity for energy storage assets given their unique operating characteristics. The solution should allow operators of these energy storage facilities to be able to intuitively submit bid and offer data into and operate their assets in the energy and ancillary services markets in a manner that supports the operation of the facility while at the same time provides a coordinated approach to the market rules. The long-term participation solution must support the AIES needs for reliability, provide the AESO System Controllers the necessary software applications to monitor and control these energy storage facilities in support of power delivery and balancing across the AIES. Finally, the solution should support the facilitation of a a fair, efficient and openly competitive (FEOC) market, considering that the market design of the rules should be as technology agnostic as possible and minimize the need to grandfather assets to existing rules. To guide the design, the following design principles were developed.

Design Principles	Rationale
Technology Agnostic	In order to facilitate FEOC principles, the market treatment needs to be consistent across all participating technologies and apply to all storage applications.
Minimizes Complexity	Strive for a simple elegant solution that is effective. Allow participants to intuitively submit bid and offer data into and operate their assets in the energy and ancillary services markets in a manner that supports the operation of the facility while at the same time provides a coordinated

Design Principles	Rationale
	approach to the market rules. Complex designs lead to confusion and acts as a barrier to entry
Maximizes Participation	Maximizing participation in the market improves competition, and price fidelity/
Participation Flexibility	Allow some flexibility regarding how the asset can best participate given its technical configuration in order to remove barriers to entry and prevent overly constraining rules while maintaining the FEOC principles/
Dispatch-ability	Reduce the variability in delivered volumes resulting from System Controller dispatch. The design should give the system controller the ability to monitor and control energy storage facilities in support of power delivery and balancing across the AIES/
No Grandfathering required	The solution should avoid the need to grandfather existing assets as much as possible/

1.2 Short-term storage implementation summary

The short-term market participation solutions for storage are limited by the current ISO rules. To facilitate storage participation, in June 2020, the AESO revised existing information documents[2] to explain how the existing ISO rules apply to storage assets/facilities. The information documents explain that a storage asset should offer discharge capability into the energy market and use state of charge as an Acceptable Operational Reason ("AOR") when the state of charge is at relative zero[3].

The ISO rules require source assets with a maximum capability of 5 MW or more to "participate" in the energy market. Source assets with a maximum capability less than 5 MW do not currently have this "must offer, must comply" obligation; however, these assets are still accounted for in market settlement.

For the short-term market implementation, pool participants submit offers in the energy market for the energy storage asset's energy production (typically half of its operational range), provided the energy storage asset is capable of producing at least 5 MW of discharge energy.

Available capability (AC) reflects the physical capability of the energy storage asset. Pool participants are not permitted to restate the AC of their energy storage asset in order to restore their state of charge except under limited conditions. State of charge will only be considered a physical limitation at relative zero and relative 100 per cent charge. Pool participants are expected to manage their state of charge through their offers and manage their offers with price restatements two hours in advance of the settlement interval as per the Division 203 ISO rules, Energy Market. The AESO is proposing that this

[2] https://www.aeso.ca/grid/energy-storage/participation-under-existing-market-rules/

[3] Relative 0% is defined as the lowest a storage resource would let state of charge drop to under normal operating conditions.

aspect of market design, as it pertains to energy storage assets, remains in place for the long-term implementation.

In the event an energy storage asset cannot physically comply with a dispatch instruction, the "acceptable operational reason" (AOR) definition applies. Section (iii) of the definition allows for "re-positioning a generating source asset within the energy market to manage physical or operational constraints associated with the source asset". In other words, when the state of charge of the energy storage asset reaches relative zero or 100 per cent, the pool participant may perform a MW restatement as per subsection 4(3) of Section 203.3 of the ISO rules, Energy Restatements, and declare state of charge as the AOR. The AESO will require visibility of the energy storage asset's state of charge to confirm the legitimacy of the energy market restatement and the associated AOR.

The AESO's current authoritative documents enable an energy storage asset to operate within the full range of capability in the operating reserve (OR) market. If qualified, a pool participant will be permitted to use the full range of its operation for the provision of operating reserves, assuming the resource meets the technical requirements, as defined in Section 205.4 of the ISO rules, *Regulating Reserve Technical Requirements and Performance Standards*; Section 205.5 of the ISO rules, *Spinning Reserve Technical Requirements and Performance Standards;* and Section 205.6 of the ISO rules, *Supplemental Reserve Technical Requirements and Performance Standards*, for the reserve product in this mode of operation. If an energy storage asset is dispatched to zero MW in the energy market as a result of an OR dispatch, when the energy storage asset is directed to provide its OR capacity as energy, it will be expected to "move" from its current operating level to a new level equal to the current operating level plus the spinning reserve or supplemental reserve quantity.

1.3 Design Assumptions and Dependencies

There are a number of ongoing industry initiatives that are inter-related with the Energy Storage Roadmap. These initiatives are noted below. This paper makes certain assumptions about the outcome of each initiative. Should those assumptions be incorrect, the AESO will need to consider the market design implications to the storage implementation. The AESO believes the risk of needing to re-evaluate the draft recommendation is low because the integration of energy storage isn't expected to fundamentally change the overall design, requirements, and risk allocation of the energy only market.

1. AUC Distribution System Inquiry (DSI) and the AESO's positions

   Storage connected on the distribution system is considered a Distributed Energy Resource (DER) and was a topic of discussion in the DSI. In the DSI, the AESO stated that DER and Transmission Connected Generation (TCG) should continue to be treated consistently from a market perspective and is moving forward with the assumption that this will continue to be the case in the future. If the future proceedings justify different treatment, then the AESO's assumptions on storage will need to be re-evaluated.

   The AESO's current assumption is that DER and TCG will have consistent treatment in the market, and the energy market continues to extend into the distribution system for the dispatch and settlement of DERs.

2. AUC Decision related to self-supply and export

   In AUC Decision 23418-D01-2019 (EL Smith Decision), the Commission concluded that the Alberta legislative scheme prohibits a generating unit from supplying electricity to a load on the same property and exporting excess to the AIES, subject to limited exceptions for sites with industrial system designations, micro-generation, and municipalities. Since storage acts like a load while

charging, in response to the short-term market implementation requirements for energy storage, stakeholders have questioned whether a site with both generation and storage is a form of self-supply and export. Currently, the AESO is relying on case by case power plant application decisions to determine the market treatment of these type of facilities. Should the AUC direction change, the AESO will have to consider additional rule requirements regarding the ability of an energy storage asset to charge the storage using on-site generation.

The AESO's current assumption is that sites made up of solely a combination of generation and storage (no on-site end-use load) meet the regulatory framework regarding self-supply.

3. Alberta Department of Energy (ADOE) policy regarding storage, DER and Non-Wire Solutions (NWS)

This assumption relates to the ability for the AESO and DFOs to use non-wires solutions as part of transmission and distribution system planning. Central to the discussion is whether energy storage can be used as a substitute for traditional wires infrastructure in some circumstances. While the scope of this effort is focused on the changes needed to better facilitate NWS, these changes could have implications on the market participation of these resources.

The AESO's current assumption is storage will be a market asset that may provide non-wires solutions, rather than a regulated asset capable of participating in the energy and ancillary services markets.

4. Broader ISO tariff re-design

Central to the treatment of storage within the market is the treatment of storage within the ISO tariff. An efficient market design must consider the "all in" costs to the resource. The market and tariff signals should not conflict. As an example to illustrate the point; over peak times, market prices are high indicating a need for the energy, but the tariff signals storage not to discharge during these times.

The AESO's current assumption is the rate design applicable to storage will not result in conflicting behaviors caused by competing price signals.

2. Jurisdictional review of storage participation models

Where relevant, the AESO looks to other jurisdictions' implementation of new technology and lessons learned to help inform market design decisions. In reviewing the energy storage implementation proposals in other markets, the AESO found most of the designs could not be applied in Alberta due to fundamental structural differences between the Alberta electricity market and FERC-regulated markets. One primary structural difference is that commitment decisions in FERC markets are made by the ISO, based on participant submitted multi-part offers and bids, where Alberta's energy market allows resources to make their own commitment decisions. Alberta's implementation of the energy storage participation model, offer parameters, ancillary services provision, pricing and settlement as well as state of charge management will be distinctly different from FERC markets, which were designed under different policy frameworks. For further information on the market participation requirements proposed for the U.S. electricity markets please see the following presentation prepared by EPRI for the IESO in Ontario entitled "Storage Integration Efforts in U.S. Wholesale Electricity Markets," located here to better understand the implementations in those jurisdictions.

Of the other markets, ERCOT in Texas most closely resembles Alberta in that ERCOT does not have a capacity market. But ERCOT does have time-ahead markets and locational pricing. The Ontario and UK

electricity markets are more similar to FERC regulated markets than Alberta's market design and are therefore, less informative to the AESO in terms of market design considerations. Given the differences in the frameworks between Alberta and other jurisdictions, the AESO does not consider the market integration of storage in these jurisdictions to be informative to the Alberta design.

3. Options, Conclusions, and Recommendations

3.1 Solar/Wind & Storage Hybrid Participation

The aggregation of co-located variable energy resources (wind and solar generation) and storage as a single energy market "hybrid" asset presents operational issues for the AESO. The following sections document the issues with this type of configuration, possible implementation options designed to address the issues, stakeholder feedback received to date regarding the options, and the AESO's conclusions and recommendations.

3.1.1 Issue description

In order to better articulate the issues with the hybrid asset configuration, the following paragraphs further describe what a hybrid asset is and how it is different than co-located technologies participating independently before outlining the issues with this configuration.

What is an asset?

In this context, an asset is not the same thing as facility, site, technology. For the AESO an asset is a market construct used to facilitate financial settlement and market participation.

1. Financial Settlement: An asset that is used in financial settlement must have an association with a settlement point. A settlement point is the point at which official measurement of volume is transacted. Facilities can have energy flows in both directions, into the site and out of the site. Therefore, the AESO assigns a source asset to the outflows, and a sink asset for the inflows associated with the appropriate settlement point that captures the metered volume exchanged with the power pool.

2. Market participation: The ISO rules regarding market participation generally only apply to assets with a maximum capability greater than or equal to 5 MW. The AESO will either use the source asset ID assigned for settlement or provide additional assets to which the dispatch instruction or directive will apply if the dispatch point differs from the settlement point. Resources smaller than 5 MW will be issued non-dispatchable asset IDs that are used only for settlement. For resources greater than or equal to 5 MW in size the pool participant must offer the entire capability of the asset, manage the available capability of the asset, and comply with a dispatch instruction or directive issued by the AESO. In the Alberta electricity market, all source assets, of any technology, with maximum capability over 5 MW are considered dispatchable, including wind, solar, and energy storage resources.

   As explained above, the AESO will generally use the same source asset for settlement and dispatch; however, there are cases in which financial settlement metering may not necessarily correspond to how an asset participates and is dispatched in the energy market. A pool participant may choose to offer their energy (and be dispatched) net-to-grid rather than offering gross generation[4] if issued an

[4] Dispatched Net to Grid means all the co-located resources are dispatched as a single asset in the energy market with a common dispatch and settlement point. Dispatched gross means the individual resources co-located on site are dispatched independently and: the dispatch points are at the terminus of the generators and settlement is at the point of connection to the AIES .

appropriate Alberta Utilities Commission approval to do so. This flexibility allows the AESO to configure the facility's participation in the market to align with the participants operational needs. Extending this flexibility to energy storage facilities is critical to ensuring the facility owner can best leverage the capabilities of the facility in the market. The recommendation as to whether the AESO should allow energy storage to participate in the market on a gross dispatch or net dispatch basis is discussed in further detail below.

Asset Classifications

While all asset types are either source or sink, assets also have classifications. Classifications are often associated with the underlying technology. Some examples of asset classifications are import, export, generating unit, or wind and solar aggregated generating facility (AGF). These classifications are often used in the AESO's authoritative documents when specifying regulatory requirements for a particular asset class. Stand-alone energy storage does not fit cleanly into the current asset classifications and may justify its own "storage" classification. Classification becomes difficult when the asset is associated with multiple technologies. For ease of discussion the AESO broadly characterizes these multiple technology assets as "hybrid assets".

Hybrid Asset

A hybrid asset is created when a market participant chooses to operate co-located technologies as a single asset within the energy market. The choice of market asset configuration (hybrid or independent) comes from guidance from the pool participant and depends on what makes the most sense for the facility's operation.

Based on the feedback received from numerous stakeholders, there remains some confusion as to the differences between a hybrid asset and a hybrid facility/site. In order to prevent further confusion, the term "co-located technologies" will be used to describe the nature of the actual physical equipment installed on a customer site. Energy storage co-located with solar or wind will be described as co-located variable energy resource + energy storage (VER+ES).

Figure 1: Co-located technologies configured as independent assets (based on the ½ range participation model)

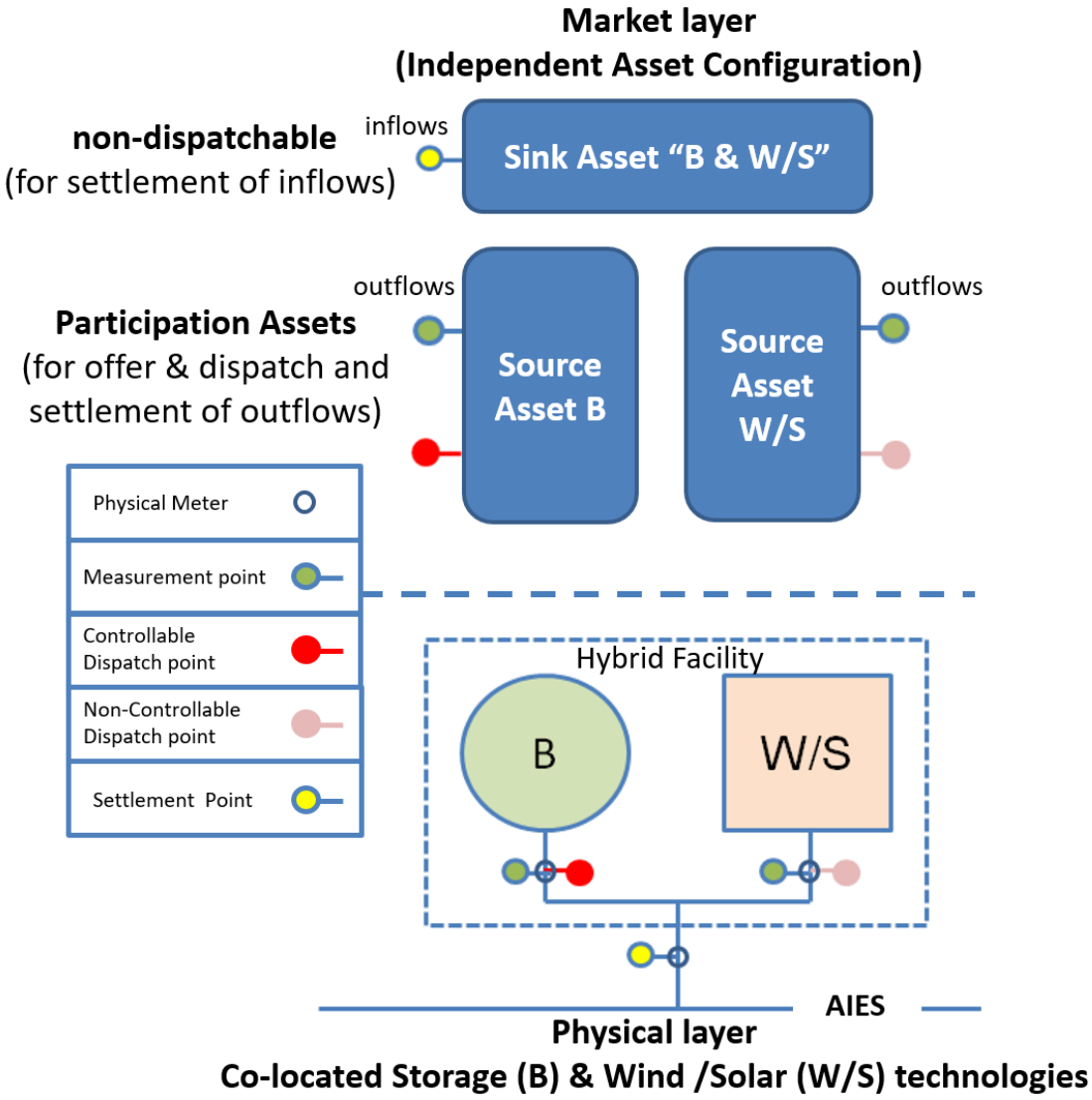
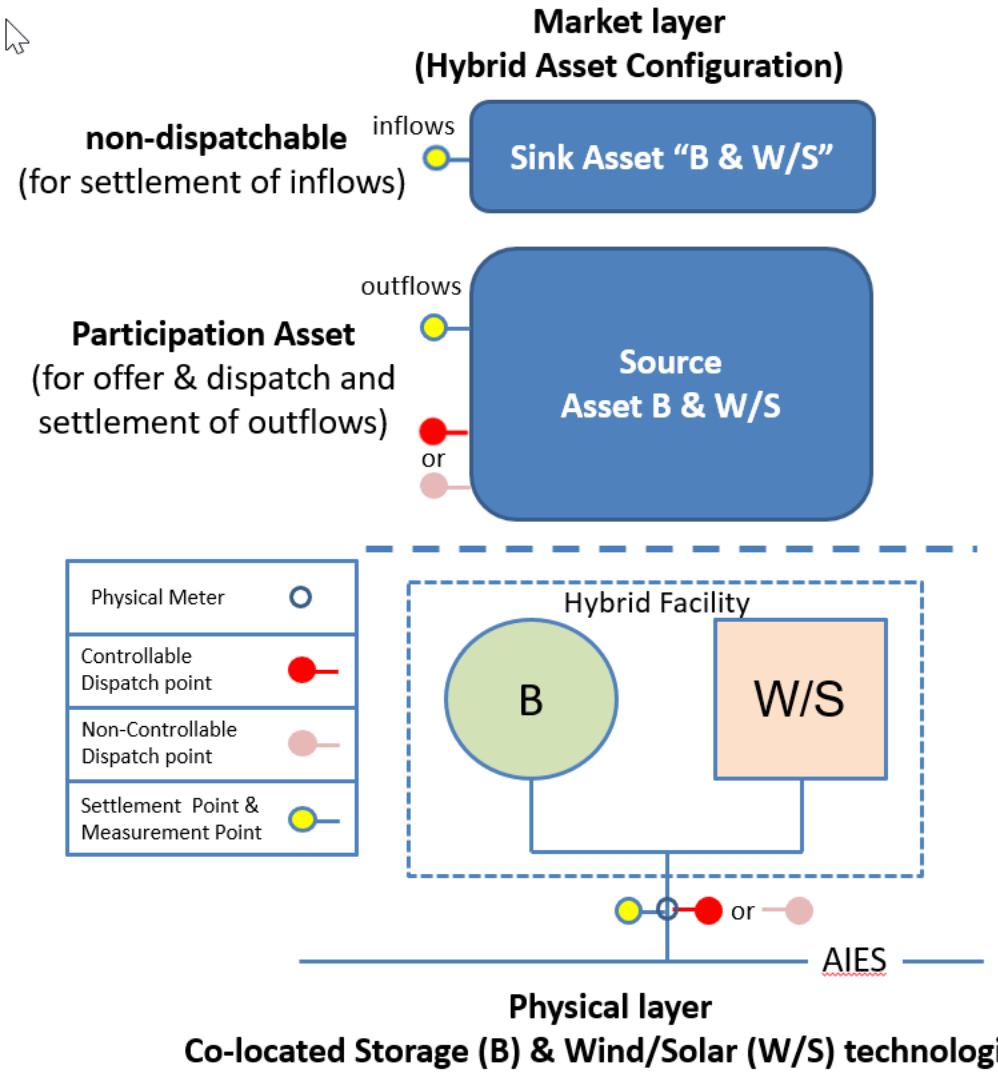


Figure 2: Co-located technologies configured as a hybrid asset (based on the ½ range participation model)



As illustrated in the figures above, co-located technologies are multiple technologies that are located on the same site behind a single point of connection (a "hybrid facility"). These co-located technologies may be configured such that each technology is operated as an independent asset in the energy market, as in *Figure 1.* Co-located technologies may also be configured as a single hybrid asset when the pool participant chooses to operate the multiple technologies co-located on the same site as a single dispatchable entity within the energy market, as shown in *Figure 2.*

The reliability concerns associated with Variable Energy Resource & ES hybrid assets

Real-time energy market dispatches are the primary mechanism for the AESO System Controller to maintain supply/demand balance. The AESO System Controller relies on the must offer-must comply and energy delivery requirements within ISO rules for assurance that the volumes dispatched will be the volumes provided or withdrawn. With the introduction of wind and solar resources, the AESO developed a secondary means to maintain the supply/demand balance by requiring all non-controllable variable energy resources to convert meteorological (MET) data into a VER power forecast which becomes the expected energy delivery from these resources. This data informs the AESO System Controller of the

adjustment they will need to make to the real-time dispatch to accommodate for changes in non-controllable output. For a hybrid asset the AESO System Controller cannot rely on the VER power forecast alone. With the addition of the controllable storage resource, there is greater variation in the possible output from the site. The AESO System Controller requires additional information to understand the behavior of the storage resource behind the hybrid asset to anticipate the output from the co-located technologies operating as a single asset. The AESO System Controller has full visibility of the storage in and out flows if the storage is an independently dispatched asset but may not if dispatched as a single VER+ES hybrid asset.

Under current ISO rules, co-located VER and storage technologies configured as a hybrid asset would be considered non-controllable from a dispatch perspective. The term non-controllable is not defined in the current ISO rules but is a simple way to indicate that the asset can be dispatched but the dispatched output is non-controllable. As part of the short-term implementation the AESO classified these new co-located VER and storage technologies configured as a hybrid asset as "wind and solar aggregated generating facilities". Wind and solar aggregated generating facilities have large allowable dispatch variances, which consider the potential generation (potential MW)[5] to set the lower end of the dispatch tolerance. The AESO can no longer rely on the potential generation as the lower end of the dispatch tolerance of VER+ES Hybrid assets because the net to grid energy production will not meet the minimum dispatch threshold if the underlying storage resource is charging. For example, co-located VER and storage technologies, each with a maximum capability of 50 MW, in a hybrid asset configuration of 100 MW maximum capability submit an offer price of $0/MWh, and quantity of 100 MW. Unlike pure wind or solar AGF assets, the AESO cannot use the wind or solar potential generation as an indicator of the low dispatch tolerance limit. If the AESO used the potential generation as the low dispatch limit the asset would never be able to charge the storage using the co-located VER. Therefore, the AESO cannot assume the asset will generate to its wind or solar potential as some or all of that energy could be redirected to charge the storage component.

This issue also exists to a lesser degree for co-located assets dispatched independently. As an independent asset the storage may only charge when "out of merit", which means the storage offer is priced above the current system marginal price and dispatched to zero MW output. As long as the storage asset offer remains out of merit it will be permitted to charge; however, without a bid indicating how much energy the storage asset will take from the VER, the AESO System Controller must make assumptions on the charge level.

Some stakeholders suggested that the AESO System Controller learn the individual behavior of storage within the hybrid VER+ES asset in order to dispatch them. As a hybrid asset, SCADA may only be available on the net of the two resources and not individually, limiting visibility to the storage asset's individual behavior. To effectively and sustainably enable increasing numbers of hybrid VER assets, the AESO has identified the need to address these visibility and dispatch concerns to maintain reliability.

Options overview

If the AESO is to include hybrid assets in the market, they must be implemented such that the concerns related to the uncertainty of the combined storage and VER energy consumption and output are appropriately addressed. It is possible to improve on the dispatch-ability of this asset type while giving

[5] Potential generation is derived from the real-time meteorological data at the site and converted to a measure of energy in MW. In other words, the potential generation equals amount of energy the site could generate under current weather conditions. Actual production could be less than the potential generation when de-rated or constrained down for reliability reasons.

participants more flexibility in their asset configurations. The AESO design team developed four mechanisms to be assessed for VER+ES hybrid participation:

- Status Quo – Allow the participant to choose whether the hybrid asset is to be considered a Generating Unit with a narrow dispatch tolerance or a Wind or Solar Aggregated Generating Facility that continues to require a large dispatch variance.
- VER block volume – Like the status quo, allow the participant to choose whether the hybrid asset is to be considered a Generating Unit or a Wind or Solar Aggregated Generating Facility. If the participant chooses to behave in a manner similar to a Wind or Solar Aggregated Generating Facility additional information will used to determine the dispatch tolerances for VER+ES hybrids;
- Controllable-only Participation – Offers are only submitted for the storage component of the hybrid asset. Wind and solar output is used as a baseline;
- No hybrid option – One possible solution is to not permit co-located technologies to aggregate and require separate offers and bids for each co-located technology.

These options are described in further detail below:

Status Quo

The status quo is to continue to classify hybrid assets as generating units or wind and solar aggregated generating facilities. This option is included because stakeholders suggest that the issues caused by hybrid assets only occur once there are significant numbers of co-located technologies configured as hybrid assets. As such, stakeholders have stated that the AESO should wait until that happens before developing new ISO rule requirements related to the treatment of hybrid assets.

Variable Block Volume

This mechanism allows the AESO to determine the possible range of output for each block of the offer and allows the AESO System Controller to forecast dispatch requirements when the data is used in combination with VER power forecast data.

The status quo approach, based on the current ISO rules, caps dispatch tolerances at 5 MW above the block MW of the offer block dispatched, but for hybrid assets the lower limit remains at zero MW. Unlike pure wind or solar AGF assets, the AESO cannot use the wind or solar potential MW as an indicator of the low dispatch tolerance limit. If the AESO used the potential MW as the low dispatch limit the asset would never be able to charge the storage using the co-located VER. Therefore, the AESO cannot assume the asset will generate to its wind or solar potential as some or all of that energy could be redirected to charge the storage component. For example, in Figure 4, the participant submits five priced blocks, for the 50 MW hybrid asset. The low limit of the dispatch is zero for all dispatched blocks. Co-located VER + Storage technologies configured as a hybrid asset could choose to charge at any price. The issue is that the AESO System Controller does not know, or can predict, based on the submission information provided, where the hybrid asset will be in its capable range once dispatched.

Figure 4 – Without VER block information*

	offer		dispatch limits (MW)	
Block	$/MWh	MW	Low limit	High limit
bk 4	220	50	0	50
bk 3	45	40	0	40
bk 2	36	30	0	30
bk 1	25	10	0	10
bk 0	0	0	0	0

* In order to simplify the example, the +5 MW allowance on the high limit was not included

The VER block approach gives some certainty as to where in the offer the storage resource will choose to charge. As shown in Figure 5 below, the hybrid asset operator has priced all the variable energy at zero dollars. This tells the AESO System Controller that if the price remains below $25/MWh the asset may charge or discharge up to the size of the first block but once the price reaches $25/MWh, the energy generated at the facility will at a minimum be 10 MW. This provides more certainty than the status quo hybrid asset approach.

Figure 5– With VER block information and VER energy at zero dollars*

	offer			dispatch limits (MW)	
Block	$/MWh	MW	VER (MW)	Low limit	High limit
bk 4	220	100	0	50	100
bk 3	45	80	0	30	80
bk 2	36	65	0	15	65
bk 1	25	60	0	10	60
bk 0	0	50	50	0	50

* In order to simplify the example, the +5 MW allowance on the high limit and the -5 MW allowance on the low limit was not included

In the example shown in figure 6, the asset operator chose to price 25 MW of the energy from the VER resource at zero and an additional 25MWs at $36/MWh. This informs the AESO System Controller that no matter what the VER can produce, if dispatched, the asset will provide at least 25 MW below $25/MWh and at least 35 MW if the price reaches or exceeds $25/MW.

Figure 6 -With VER block information and VER energy priced*

	offer			dispatch limits (MW)	
Block	$/MWh	MW	VER (MW)	Low limit	High limit
bk 4	220	100	0	50	100
bk 3	45	80	0	35	80
bk 2	36	65	25	35	65
bk 1	25	60	0	35	60
bk 0	0	50	25	25	50

* In order to simplify the example, the +5 MW allowance on the high limit and the -5 MW allowance on the low limit was not included

It is unlikely that a hybrid asset operator would offer its VER in this way (as shown in Figure 6) as it removes flexibility for the asset operator. Because of this, the AESO proposes to automatically assign the VER capacity to the lowest blocks from the bottom up rather than add an additional VER block column to storage offers, as shown in Figure 5. In doing so, no change to the structure of the offer and bid proforma is required, while still giving the AESO System Controller a sense of where in the offer the resource could be expected to use some of the VER generated energy for charging, without detrimentally limiting the flexibility of the hybrid operation. Dispatch tolerances will be applied to the dispatch limits when assessing the compliance to a dispatch instruction.

Storage-Only Participation

In the storage-only participation mechanism the variable energy component of the asset is not included in the offer (whether at $0 or above). This option was developed in recognition of the fact that VERs do not submit non-zero priced offers into the market today, even though they have the ability to do so. In this option, the market submission only includes the controllable storage component. The AESO System Controller relies on the potential MW and forecast to predict the behavior of the variable resource component of the asset and simply adds the forecast or potential MW to the dispatched block MW to understand the volume of energy to be delivered once dispatched. Under this mechanism the pool participant submits only the storage discharge levels in the offer. The AESO System Controller will have SCADA visibility of the potential MW of the site and of the net-to-grid production or consumption. Provided no offer block is in merit the asset may produce net-to-grid anywhere between zero MW and the current potential MW of the co-located VER. If any block of an offer or bid is in merit the asset is required to produce to the dispatch level plus the MW of VER potential. Using the example offer shown in Figure 7 and the same co-located 50 MW VER and 50 MW storage hybrid asset from the previous examples, the 50 MW VER component is not included in the offer. If the price remains below $25/MWh, the asset may operate anywhere between 50 MW to -50MW[6] (representing full charge of the storage component of the asset) depending what the VER is doing. Once the price reaches $25/MWh the dispatch tolerances are at a minimum 25 MW to 35MW in addition to the output of the VER. If the price reaches $28/MWh and the wind potential is 15 MW, the expected net-to-grid production is 45 MW, 15 MW from the VER and 30 MW from the storage.

[6] Example assumes only ½ range participation for simplicity

Figure 7 – Storage only offer for hybrid assets

	offer		dispatch tolerance	
Block	$/MWh	MW	Low limit	High limit
bk 4	220	50	45	55
bk 3	45	40	35	45
bk 2	36	32	27	37
bk 1	25	30	25	35
bk 0	0	0	0	5

The drawbacks to this option are that by removing the must-offer requirement from the VER resource, the participant loses the ability to respond to and set price with that component of the asset. This is inconsistent with the treatment of other source assets over 5 MW in size that have a must offer - must comply and offer control reporting requirement. If the VER component has derates or outages, there will still be a requirement to make that information available to the AESO, consistent with current practices if this mechanism where implemented.

Disallow hybrid assets

One solution is to not permit co-located technologies to configure as a hybrid asset and require separate offers and bids for each co-located technology. If a site were to have multiple technologies installed, then each technology would be required to participate if 5 MW or greater in size and be dispatched independently. As explained above, disallowing hybrid assets for the purposes of participation does not prevent these co-located technologies from settling the energy production and consumption or for purposes of the ISO tariff as a single source and sink asset. For example, any inflows to the site are settled at the settlement point, shown on Figure 1 above, not the measurement point. If the site is using the VER resource to charge the storage, the yellow settlement point would see no inflows. The settlement of outflows would also be determined at the yellow settlement point, even though the two assets behind the point are dispatched independently. The AESO has used this practice for many years for co-generation sites, giving them the choice to be dispatched gross, at the terminus of each generator, or being dispatched net, effectively at the point of connection to the AIES. Regardless of the dispatch point the settlement occurs at the yellow settlement point. As explained above, extending the choice to be dispatched net as a hybrid asset for co-located storage and VER technologies creates dispatch variability issues for the AESO System Controllers.

3.1.2 Stakeholder feedback

The AESO received stakeholder feedback in late 2020 on the AESO's Long Term Energy Storage Options Paper. The feedback indicated that most stakeholders were not in favour of disallowing hybrids, as this would remove optionality that already exists within the market. There was also a concern that co-located technologies configured as independent assets would incur more DTS charges than co-located technologies configured as single hybrid asset. As explained above, that is not the case; however, additional metering with additional associated costs may be required for independent asset configurations.

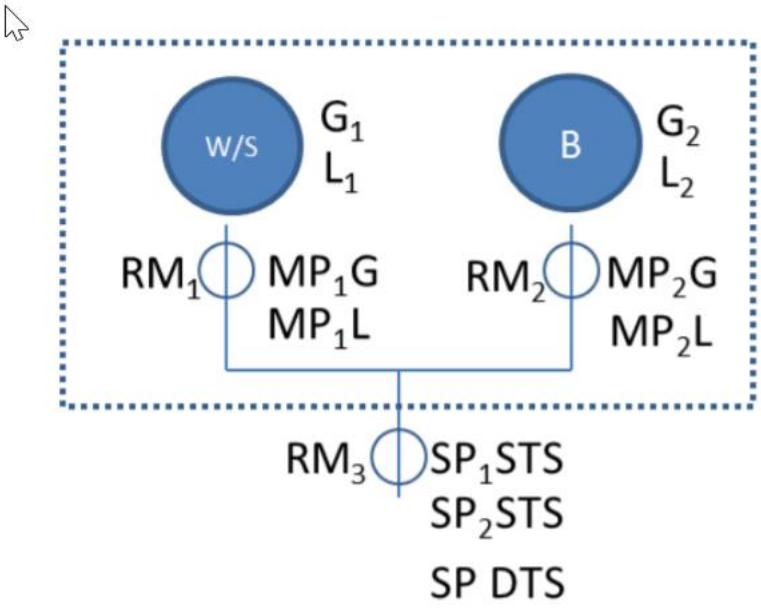
Few stakeholders were supportive of the variable block or storage only hybrid options. Participants did not see the need to modify the current bid and offer proforma to include extra data or to only include the storage component of the facility. Stakeholders also did not see a need to remove the ability to price VER energy on the Energy Market Merit Order.

3.1.3 AESO conclusions

The AESO System Controller requires reliable dispatch and participants require the flexibility within the ISO rules to support the operation of their facilities.

In the AESO's view, disallowing hybrids doesn't limit the operational flexibility as greatly as stakeholders may have perceived. Asset configurations will have no impact on the calculation of DTS charges. Co-located VER+Storage technologies configured as independent assets require additional metering and measurement points for the calculation of losses for each of the independent assets. As illustrated in Figure 8 below, the real power meters (RMx) are installed on the high voltage side of the transformer of the site as well as at the terminus of the storage (B) and the wind/solar facility (W/S). Measurement points are calculated for the outflows (MPxG) and the inflows (MPxL) from all resources at the facility. Settlement points (SPxSTS and SP DTS) are based on revenue-level metering and used for energy and DTS settlement and not the measurement points. MP_1G and MP_2G would be used for the determination of losses and the calculation of loss factors if the assets are to be dispatched independently.

Figure 8 – Energy Measurements for co-located resources that are dispatched independently



In any event, reviewing the applicability of co-located VER+Storage technologies configured as a hybrid asset as opposed to solely configured as independent assets was considered. The advantages to prohibiting hybrid configuration are as follows:

1. Less complex to implement.
2. The broad ADV would only apply to Variable Energy Resource assets and not to the storage or other generating units co-located on-site.
3. Not allowing hybrid asset configurations would avoid the complexity in attempting to classify hybrid asset configurations for the purposes of outage reporting.
4. Additionally, this option provides visibility to the AESO System Controller and market participants as to what is behind the fence.

Points supporting hybrid configurations:

1. Disallowing co-located VER+Storage technologies configured as a hybrid asset limits participant flexibility.

2. There are potential storage applications that may be difficult to operate as independent assets. For example, sites that place a separate storage device under each solar panel on the same DC circuit (DC coupled) opposed to sites that build an independent storage resource on the same site as the VER. Revenue metering of these "DC coupled" installations would be prohibitively expensive if the hybrid configuration was not permitted.

3. If hybrid assets are not permitted, there may be an over-estimation of the maximum capability of co-located technologies if limited by the inverter or the transformer. For example, a co-located 10 MW battery and a 10 MW solar farm are limited by a 10 MW inverter, the independent asset configuration would require each independent asset to have a maximum capability of 10 MW even though the combined technologies could never be dispatched over 10 MW.

4. The no-hybrid option also deviates from the AESO's design principle of making the rules as technology agonistic as possible and could have implications for aggregation in general. For example, the AESO may need to better define how assets can aggregate with consideration made for operational similarities, dispatch strategies, etc. These considerations may need to be revised as new generation or storage technologies are introduced to the market, and there will be a requirement to define which technologies are similar enough to aggregate and which ones are not.

5. Additionally, disallowing VER & Storage hybrids option requires more metering as explained above.

Relying on the status quo and current ISO rules is, in the AESO's view, unsustainable. Asset configurations should not make the electric system less reliable because of the added dispatch variability of a single hybrid asset compared to co-located technologies with independent assets. Many stakeholders have stated that they still value the ability to price VERs and disagree that that capability should be removed from the energy market, even if it is currently unused. The AESO supports providing as much flexibility and optionality for participation in order to facilitate a FEOC market, but this flexibility cannot come at the expense of reliability.

3.1.4 Recommendation

Allow for hybrid asset configurations for co-located storage + VER technologies and automatically assign the VER capacity to the lowest blocks from the bottom up for the purposes of dispatch compliance assessment.

Enabling hybrid assets would improve participation, give the market participants more flexibility, would not impact reliability, and would not require grandfathering. The VER block submission option provides a balanced approach between participant flexibility and the AESO's requirement for dispatch visibility.

A pool participant will choose the asset configuration that makes the most sense for their operation and how the pool participant intends on participating in the markets. Co-located energy storage + VER technologies may choose to aggregate the co-located technologies into a single pool asset or to keep the technologies as separate assets. Asset configurations will be limited by boundaries defined in the AESO authoritative documents and applicable Alberta Utilities Commission (AUC) approval(s). A pool participant that chooses to uncouple the co-located technologies will be configured in the electricity markets as two independent source assets, one source asset representing the energy storage resource, and another source asset for the wind or solar AGF for the purposes of dispatch.

In the case of hybrid assets, VER energy will be included in the offer and will be applied bottom up. In other words, the VER energy will be included in the lowest priced offer blocks. For example, in figure 9 below, a wind and energy storage hybrid asset with 15 MW of wind co-located with 10 MW of storage offers 5 blocks. The VER capacity is assumed to be in the bottom three blocks when assessing dispatch compliance.

Figure 9 – Application of the VER block to an energy market offer

	offer	
Block	$/MWh	MW
bk 4	220	25
bk 3	45	20
bk 2	36	15
bk 1	25 VER Block	10
bk 0	0	5

3.2 Half-range versus Full-range Energy Market Participation

3.2.1 Issue description

Half-range participation means only the discharge capability participates in the energy market. The current ISO rules require an asset of at least 5 MW maximum capability to offer that capability into the energy market. Full-range participation would require both the charge and discharge capability to participate in the energy market. The key question to this issue is if assets, with the ability to control their energy consumption, should be required to bid that capability into the energy market and participate with the full range.

As context, dispatching a block on the energy market merit order should result in a predicable response based on the size of the dispatched block. With half range participation for energy storage this is not the case. At certain price levels, dispatching up an energy storage offer block may be partnered with a large demand response. For example, block zero of a storage offer, that is 20 MW in size and priced at $15/MWh, is dispatched by the AESO System Controller. Because the price was below $15/MWh prior to the dispatch, the storage resource was charging at 30 MW. In order to comply with the dispatch instruction, the storage operator moves the asset from -30 MW to +20 MW resulting in a 50 MW energy delta. Regardless of whether the AESO System Controller anticipated the delta, the block must be dispatched according to the merit order. The AESO System Controller has now over-dispatched because only 20 MW was needed, and in order to rebalance the AESO System Controller must dispatch the block off. This delta change increases as the size of the storage resource increases. Should the storage operator resume charging because prices have dropped, this would result in saw tooth shaped volatility in real-time prices. This outcome is not ideal for system operations, the energy market, or the energy storage operator. Bids on the charge side or some other means to indicate charging behavior would be helpful to managing dispatch variability.

Without the bid information from full-range participation, the ability to forecast system marginal price and determine short-term adequacy requirements becomes more difficult. There is no ability for the AESO System Controller to specify the ramp of load reduction which could raise reliability issues and may require the AESO to procure more regulating reserve to compensate for the charge to discharge transition of a storage dispatch. This is also true for highly variable loads that do not bid in the system

today, but increased storage integration without full-range participation further exacerbates the net demand variability issues faced by the AESO System Controllers.

Another issue with the lack of bid information from half-range participation occurs when the storage device is at zero state of charge. Under the current ISO rules the asset is permitted to restate the Available Capability to zero and remain at that state for as long as the asset chooses, provided the asset does not attempt to recharge the storage. Restating Available Capability is intended to provide pool participants a tool to remove de-rated or outage capacity (MW) from the energy market merit order in the event there is a physical problem with the facility. Restating out of the market by remaining at a zero state of charge is not reflective of a physical problem and it becomes difficult to determine if the asset is purposely withholding energy from the market, which is not permitted within the current ISO rules, or simply waiting for the energy price to drop to an acceptable level in which to recharge the device. Full range participation ensures the charging capacity remains in the merit order unless there truly is a physical issue with the facility.

Beyond dispatch variability and reliability considerations, there is a market power driver for shifting to full range participation. The must offer/must comply requirement was included as a market design mechanism to prevent participants from physically withholding dispatchable capacity from the market in order to uncompetitively steer energy prices. Unlike loads, storage that is part of a portfolio of generation may be able to benefit from physically withholding dispatchable capacity by pricing out of the market and then choosing to charge at high prices to benefit the portfolio of generation. While the MSA can investigate such behavior, full range participation limits the ability for such behavior and prevents the resulting effects of this behavior on other participants.

3.2.2 Options overview

Optional participation of AIES energy withdrawals

This option reflects the status quo participation model where bidding is an option for participants wishing to receive a dispatch signal to reduce and increase consumption based on the system marginal price. However, given the reliability concerns described above, this option will include a requirement for storage resource participants to communicate to the System Controller their intended charging levels prior to executing them.

Mandatory full-range participation

This option requires all demand resources capable of controlling their consumption to bid that controllable consumption. Like offers, the must-bid requirement would be for all dispatchable sink assets greater than or equal to 5 MW in size. This would include storage and could include other price responsive loads.

3.2.3 Mechanisms to facilitate full-range participation

The following mechanisms are proposed to be used regardless of the recommendation to make full range participation mandatory or allow full-range participation to be optional. These mechanisms improve on the ability to submit consumption blocks to the AESO and ensure fair and consistent treatment when compared to the submission and restatement of energy production. While all these mechanisms could be implemented, allowing a participant to choose which proforma works best would come at the expense of increased IT system and maintenance cost. The AESO intended to choose a single mechanism based on stakeholder feedback rather than propose to implement multiple mechanisms to facilitate full-range participation.

No change to bid structure

This option proposes that no structural changes be made to the bid proforma and ISO rules governing a bid submission or restatement specifically for energy storage. The current bid ISO rules, found in Section 203.1 of the ISO rules, *Offers and Bids for Energy*, allow participants to submit up to seven bid blocks day

ahead. The volume of the bid cannot exceed the peak load of the asset. The current bidding structure lacks the ability to set the available bidding capability and requires either price or quantity (MW) restatements to manage the bid as defined in Section 203.3 of the ISO rules, *Energy Restatements*. For storage resources the source and sink assets are independent of each other so there would be no cross validation to ensure the bid and offer are compatible.

Full range participation using Absolute Zero mechanism

This submission structure is simply to convert the entire range of operation to a positive value offer. The charging capability is considered negative generation. One way to think of it is re-adjusting the starting point from which storage is dispatched. In the absolute zero mechanism the offer includes both the charge and discharge capability of the asset, potentially doubling the size of the asset in the market compared to submitting only the discharge capability. For example, when a storage asset with 10 MW of discharge capability is dispatched to zero it will be charging at -10 MW, when the asset is dispatched to 10 MW it will be operating at zero state, and when dispatched to 20 MW it will be fully discharging its capacity.

Full-range participation still requires the asset to restate when state of charge is at 0% or 100% but using this mechanism the asset does not restate to zero MW but rather to the level the participant wants to charge at. This full-range mechanism requires very little change to existing processes but compared to the other alternatives this option is not as intuitive, requiring a conversion factor to translate between the offer and the physical energy (MW) input or output. Unlike the linked assets mechanism, described below, the absolute zero mechanism submission is for a single asset that limits the submission to seven price-quantity pairs.

Full range participation using Linked-assets mechanism

This implementation option is a slight modification of the “no change” option, described above, using the current source and sink asset model to integrate storage. A source asset is created to offer energy exports from the storage asset to the grid and a sink asset is used to bid any energy imports to the storage asset due to charging. Unlike current sources and sinks in the energy market, when linked bids and offers are submitted they are validated as a pair. This means the participant cannot submit a combined bid and offer that results in infeasible or contradicting dispatches. In other words, the submission software within the Energy Trading System (ETS) ensures the bids are priced below the offers for a storage resource.

Full range participation using B-Offer mechanism

The B-OFFER is the submission of a combined bid/offer (B-OFFER) and is a cross between the absolute zero and linked asset participation options. Like the Absolute Zero option, the B-OFFER is a single submission of the entire range of the facility represented as a single asset but does not require the conversion factor when translating between the submission and the expected net-to-grid output. This mechanism requires a new asset type be defined in the market with characteristics of both a source and sink. Because this new asset type has the characteristics of sources and sinks, bids and offers, its implementation will result in unique rule treatment.

Unlike the linked assets mechanism, the B-OFFER submission is for a single asset and limits the submission to seven price-quantity pairs. Included in the submission of each block is the block price and block volume. The block volume is assigned a positive or negative sign to indicate the direction of flow. A positive value represents export from the site to the grid and a negative value indicates import from the grid.

3.2.4 Stakeholder concerns

Mandatory full-range participation

Most stakeholders that provided feedback to the AESO disagreed with a mandatory bidding requirement stating it was an unnecessary requirement that removed flexibility and added complexity to the operation of the resource and was not aligned with the current treatment for load. There was no stakeholder support for mandatory bidding in the feedback received to date.

Demand side submission mechanisms for storage

Most stakeholders indicated their preference would be to stay with the current optional bidding mechanism.

3.2.5 AESO conclusions

Mandatory full-range participation

The AESO understands the stakeholder's concerns that a full-range requirement may limit the flexibility while charging. As is the case with the short-term implementation, storage resources participating with their full range would have an acceptable operating reason (AOR) to restate should the state of charge drop to zero. The participant would restate the offers to discharge to zero but would not be permitted to recharge until the system marginal price (SMP) is lower than the price of the lowest offer block. The only difference with full range participation is that the SMP would drive the recharge rate because the recharge rate is based on the participant's bids. The AESO expects the full range dispatch would help reduce net demand variability and create rational pool prices by introducing a shape to the demand curve rather than it being a straight vertical line, providing clear and stable price signals for bidders to guide their consumption. There are other elastic conventional loads (price responsive) whose visibility of their load behavior through bids would also be helpful to the System Controller.

Mandatory full-range participation is problematic for some controllable demand resources. Some storage applications may find it difficult to comply with bid dispatches given the nature of their application. Additionally, price responsive conventional loads may find it administratively burdensome to take on a time-ahead must-bid requirement that may not align to their real-time operation. The AESO is mandated to operate a fair, efficient, and openly competitive market. It would be unfair to place formal bid requirements on resources that could not comply to the dispatch instruction associated with the bid.

The AESO also has a mandate to operate the AIES in a safe and reliable manner. The system operational risks associated with maintaining supply and demand balance increases with increases in energy storage installed capacity that does not bid their charging capacity. It was recognized within the AESO's 2020 System Flexibility Assessment[7] that the AESO Energy Storage Roadmap, among other changes, may have implications for system flexibility longer-term trends and the report suggests that potential additional approaches to provide system flexibility should be considered for exploration.

The following bullets highlight the advantages of optional bidding over mandatory bidding of controllable resources:

- Optional bidding provides participants who may benefit from a price signal and dispatch instruction to guide their operation the ability to do so. Receiving a dispatch instruction minimizes price risk and removes the requirement to continually monitor the system marginal price to determine their optimal charging level.

[7] https://www.aeso.ca/assets/Uploads/AESO-2020-System-Flexibility-Assessment-FINAL-jul-17.pdf

- Optional bidding allows facilities that rarely draw power from the grid, such as co-located storage and generation sites, to decline the option and not be burdened with the administrative responsibility to manage and maintain a bid.
- Optional bidding provides participants the ability to qualify for adjustments to load on the margin[8] for the consumption portion of the energy storage asset.

Requiring all assets capable of controlling their consumption to bid that consumption into the market in a manner similar to supply would be to the System Controller's benefit and could potentially add more liquidity to the energy market merit order. However, there are significant disadvantages in proceeding with mandatory bidding:

- Mandatory bidding may make it difficult for some storage applications and controllable loads to comply with bid dispatches.
- Introducing mandatory bidding of controllable consumers removes operational flexibility.
- Mandatory bidding may require grandfathering of existing storage and loads, if implemented
- Defining and identifying controllable demand will lead to complexity in the ISO rules.

The AESO is of the view that the answer lies in a balance between participant flexibility and System Controller visibility and control.

Mechanism for improved full range participation

While mandatory full-range participation was put forward as an option, it should be noted that the current bid mechanism is "if bid-must bid". In other words, the participant can choose to bid its consumption MW in all hours or not at all. This decision is made as part of the asset configuration prior to site commissioning and as a separate application to the AESO should the participant need to reconfigure the asset in the future. This approach provides flexibility but ensures fairness across all asset types that participate in dispatch.

The full-range options were designed to provide energy storage participants an improved method to participate with the demand side of the resource in a manner that connected the demand side participation to the production side participation. Storage may use the sink bid ISO rules as they exist today, but onus would be on the participant to ensure the full set of offers and bids result in an effective dispatch sequence for their asset, and the participant would assume the corresponding compliance risk.

Table 1 provides a feature comparison of each option.

Table 1- Feature comparison of full-range mechanisms

Feature	Current State: Unlinked	Linked Assets	Absolute Zero	B-Offer
DEMAND SIDE-SUPPLY SIDE RELATIONSHIP: the mechanism understands that there is a single underlying integrated resource associated with the market assets	N	Y	Y	Y

[8] The AESO indicated it would further explore adjustment to load on the margin out of the Sub-hourly Settlement engagement https://www.aeso.ca/market/market-related-initiatives/market-efficiency-sub-hourly-settlement/

Feature	Current State: Unlinked	Linked Assets	Absolute Zero	B-Offer
NO DISPATCH CONVERSION: there is no need to convert the volumes between the submission and the dispatch	Y	Y	N	Y
MINIMAL RULE IMPACT: in order to implement the mechanism no structural changes are required within the ISO rules	Y	Y	Y	N
SIMPLE IMPLEMENTATION: the changes to systems and user processes limited	Y	Y	Y	N
14 BLOCKS PER RESOURCE: a maximum of 14 blocks will be allocated to full range participating resources, otherwise the mechanism limits submissions to 7 blocks	Y	Y	N	Y
MULTIPLE SUBMISSIONS NOT REQUIRED: participants can submit both the charge and discharge capability as a single ETS entry rather than one for the charge and another for the discharge	N	N	Y	Y
DERATE THE CHARGING CAPABILITY: the mechanism that permits participants to derate their ability to charge within the time-ahead submission or any restatement	Y	Y	N	Y
PRICED VER FOR HYBRIDS: the mechanism will permit participants to price the VER energy	Y	Y	Y	N
ACCURATE MAX AND MIN CAPABILITY: the mechanism does not result in the Maximum Capability (MC) of the asset to be less than its maximum net to grid output for hybrids	Y	Y	Y	N

The Linked asset mechanism provides the most features and the B-OFFER provides the least.

3.2.6 Recommendation

The AESO recommends: Optional full-range participation using the linked-assets submission option and a must communicate charging levels requirement for those participants that choose not to bid.

Optional full-range participation

This recommendation allows for a flexible set of rules to accommodate a broad range of energy applications while meeting the reliability and visibility needs of the System Controller. Energy storage is

more elastic and flexible than conventional load and will charge based on prices. This behavior, when captured as bids, is helpful in maintaining the real-time balance between supply and demand. The AESO recognizes full range participation may not make sense for all storage applications. As noted in Section 3.2.1, the system controller requires charge and discharge visibility of the storage asset to effectively dispatch the merit order and maintain supply-demand balance. As an alternative to full-range participation, the AESO recommends storage resources with a charging capacity of 5 MW or greater to proactively indicate changes to their charging levels should the participant opt out of the formal bid submission process. This must communicate mechanism will be designed as part of the implementation phase of the long-term energy storage market participation work-stream.

Linked asset submissions

Optional bids are an existing feature of the current market design. The linked asset mechanism is simply an extension of the current implementation where additional submission validation is added to the Energy Trading System to ensure the offer and bid from the same facility are compatible and the resulting dispatches are feasible.

The linked asset mechanism has the following advantages over the other mechanisms:

- The linked asset mechanism is simpler to understand compared to most other options. There would be no need to convert the dispatch instruction in order to determine the output level as in the case with the absolute zero option.
- Linked-assets submission option allows for updates the bidding rules to better align with offers without changing the fundamentals of submission and dispatch.
- The Linked Asset mechanism allows the participant to independently derate the source and sink asset to align with the nature of the derate or outage, in particular for co-located technologies.
- The linked asset mechanism provides 14 blocks in total to participate in the market, seven for the source asset and seven for the sink asset. The AESO could consider limiting the submission to seven blocks in total across the bid and offer; however, this consideration adds additional complexity to rules and cost to the IT implementation.

While this option provides greater flexibility and less complexity, the participant will need to manage both the bid and offer for a single facility should they choose to participate with the full range.

3.3 State of Charge definition

3.3.1 Issue description

For the short-term implementation, the AESO stated in the information document ID #2012-009R, Restatements, that state of charge could be used as an AOR for restatement only if the state of charge is at 0% or 100%. It is at these levels the storage device can no longer discharge or charge. Percent state of charge is a relative term and the AESO currently provides no guidance to the participant to how 0% and 100% are determined nor does the AESO provide a definition as to what state of charge means with respect to compliance with the ISO rules.

3.3.2 Option overview

State of Charge represents the amount of energy stored by an energy storage resource in proportion to the limit on the amount of energy that it can store, typically expressed as a percentage. This percentage determination can be complex and is dependent on the type and nature of storage technology. To that end, there are 2 options for the provision of state of charge to the AESO: 1) the participant can derive the percent state of charge based on the real-time state in relation to the max and min and provide it as telemetry data; or 2) the participant can provide the basis data to the AESO and have the AESO derive the percentage state of charge from the telemetry data.

3.3.3 Stakeholder feedback

Some stakeholders that provided feedback are of the opinion that Available Capability should be linked to state of charge. As state of charge drops the Available Capability of the asset should also be reduced.

Stakeholders also requested clarity on how the state of charge would be used by the AESO System Controller when making dispatch decisions.

3.3.4 AESO conclusions

Use of State of charge in real-time operations

Alberta has a real-time energy only electricity market. In this type of market, the participant, rather than the AESO, makes decisions about the operation of its assets. State of change management is the responsibility of the asset operator and is managed through their energy market offers and bids, and restatements of those submissions. There is no need to include State of Charge as a bidding parameter in the energy market submission or within restatements. The AESO requires state of charge as a SCADA data point for real-time operations. The AESO will also use this data to assess the AOR for restatements provided by storage resources as part of rule compliance assessments.

Calculation of percent charge

The participant is in the best position to determine the percent charge of the site. Having the AESO determine percent charge based on the raw SCADA measurements and static parameters is not required. There is little concern from stakeholders or the AESO that participants would use state of charge as a mechanism to physically withhold capacity in an effort to manipulate market outcomes.

In order to use the term in the ISO rules, the AESO will need to define State of Charge in the AESO's Consolidated Authoritative Documents Glossary (CADG). The definition will be developed as part of the ISO rule development process.

Using state of charge to set Available Capacity

The AESO does not see the state of charge being used as an indicator of available capacity (AC). Alberta's energy market allows resources to make their own commitment decisions. For storage this means managing state of charge is the responsibility of the asset operator. State of charge will be used in the assessment of dispatch compliance where state of charge at 0% for offers and 100% for bids may be used as an acceptable operating reason for restatement.

Public reporting of state of charge

Storage operators have indicated that state of charge is commercial sensitive information and publishing this information publicly would put these assets at a competitive disadvantage compared to other resource types. Public reporting must be fair and technology agnostic. Public visibility of real-time output is required from all dispatchable resources. Requiring additional real-time public data from one technology type but not others could be considered unfair and uncompetitive. For instance, the AESO does not require co-located load and generation sites to publish the individual load information in real time or publish the real-time potential MW values from variable energy resources for similar reasons.

3.3.5 Recommendation

1. State of charge will continue to be included as a SCADA data requirement in the functional specifications of connection projects for facilities that include storage.

2. State of charge will be defined as an aggregate measurement from the site as a percent charge ranging from zero to one hundred percent that will be provided to the AESO and updated in real-time via the SCADA system.

3. State of charge cannot be used as the reason for a restatement of offers if the state of charge is greater than zero. State of charge cannot be used as the reason for a restatement of bids if the state of charge is less than 100%.

4. Individual asset state of charge will not be published publicly.

3.4 Commissioning requirements for Storage

3.4.1 Issue description

For storage assets to complete commissioning they must test both the charging and discharging capabilities of the site. Subsection 4 of Section 203.1 of the ISO rules, *Offers and Bids for Energy* does not permit multiple offer or bid blocks while source assets are commissioning. The rule requires generating units and AGFs to offer a single block and use an AC restatement to move the energy in and out of the merit order while testing the operation of the facility. The commissioning rules were designed with generators in mind and did not consider the need for charging the device while commissioning. Storage assets need to use prices and economic withholding in order to charge under the current short-term implementation.

3.4.2 Options Overview

There are two approaches to address the current deficiency within the commissioning rules for storage resources. One option is to allow two blocks, one at zero dollars and another at the offer cap and allow the participant to move the available capability between those two blocks to facilitate the commissioning tests. The other option is to create a new Acceptable Operating Reason (AOR) for restatement within the CADG definition that is only applicable while commissioning storage.

3.4.3 Stakeholder concerns

Stakeholders did not raise any concerns with recognizing the requirements of storage resources while commissioning within the ISO rules, and did not provide any feedback as to which approach the AESO should take in rectifying the rule deficiency.

3.4.4 AESO conclusions

The AOR definition is intended to set the bounds for what are acceptable reasons for changing an offer or bid within two hours of the dispatch hour. Commissioning testing is not a normal operating practice based on merit order dispatch. Based on a preliminary assessment, it seems that modifying the commissioning rules rather than changing the AOR definition will allow for a cleaner implementation, as the Commissioning rules only apply while commissioning and not during the course of normal operation.

3.4.5 Recommendation

Commissioning of sites with both controllable inflows and outflows will be required to submit two offer blocks. One at zero dollars and another at the offer cap.

4. Recommendation Summary

The AESO recommends:

a) the ISO rules allow for hybrid asset configurations; however, include the variable energy resource block mechanism to determine the allowable dispatch variance for those assets.

b) optional full-range participation using the linked-assets submission option and a must communicate charging levels requirement for those participants that choose not to bid.

c) state of charge will be defined as an aggregate measurement from the site as a percent charge ranging from zero to one hundred percent that will be provided to the AESO and updated in real-time via SCADA.

d) commissioning of sites with both controllable inflows and outflows will be required to submit 2 offer blocks. One at zero dollars and another at the offer cap.