Comments of Powerex Corp. on
Local Market Power Mitigation Enhancements
Revised Straw Proposal

Submitted by	Company	Date Submitted
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Powerex appreciates the opportunity to comment on the November 16, 2018 Local Market Power Mitigation Enhancements Revised Straw Proposal and related stakeholder discussion ("Revised Straw Proposal").

Powerex believes the Revised Straw Proposal represents a significant step forward on this critical topic. Powerex appreciates the sustained engagement by CAISO staff in working with stakeholders to more fully understand the operational challenges and objectives of storage hydro systems. Powerex believes the Revised Straw Proposal reflects this constructive dialogue and offers a framework that, with limited further refinements, will be generally workable for hydro entities participating in the EIM.

As discussed more fully below:

- Powerex supports the proposed mitigation framework enhancements to address flow reversal and economic displacement;
- Powerex supports the general framework of the proposed hydro resource default energy bid ("DEB"); and
- Powerex requests further clarification of, and proposes limited refinements to, specific technical parameters or processes related to the proposed Hydro Resource DEB.

I. Powerex supports the proposed mitigation framework enhancements address flow reversal and economic displacement

The Revised Straw Proposal includes enhancements to address flow reversal and economic displacement. Powerex supports these enhancements.

The first set of proposed enhancements are designed to address so-called "flow reversal," which occurs when an EIM entity (or group of EIM entities) is import-constrained in the market power mitigation run, triggering mitigation, which then results in the entity becoming an exporter at mitigated prices. The Revised Straw Proposal explains that flow reversal can occur "when the competitive locational marginal price used for mitigation in one market run is restricted from increasing in subsequent market runs."[1] The Revised Straw Proposal would eliminate the tariff provisions that currently prevent determination of the need for mitigation—and calculation of the mitigated price—independently in each interval and for each market timeframe (*i.e.,* RTPD and RTD). Furthermore, the Revised Straw Proposal would apply a nominal adder to the calculation of the competitive LMP for EIM entity areas as a further safeguard against local market power mitigation resulting in a change in the direction or quantity of aggregate EIM transfers <u>into</u> a mitigated EIM entity (or group of EIM entities). Powerex supports these elements of the Revised Straw Proposal.

The Revised Straw Proposal also contains enhancements that would limit the potential for bid mitigation to <u>cause</u> an increase in EIM transfers out of one mitigated entity to another mitigated EIM entity. More specifically, the EIM transfers out of an EIM entity in the binding market solution would be constrained to not exceed the greater of (1) the pre-mitigation transfer quantity; and (2) the exporting entity's flexible ramping requirement adjusted by its imbalance energy need.[2] The Revised Straw Proposal would allocate the congestion rents associated with this new constraint to the exporting EIM entity. Powerex also supports these elements of the Revised Straw Proposal as a workable approach to limiting the potential for local market power mitigation to result in forced sales of energy from resources voluntarily offered into the EIM.[3]

The Revised Straw Proposal states that the limitation on EIM transfers in the binding run "would be implemented by using the flexible ramping product award quantity and would also consider transfers attributable to base schedules."[4] In the stakeholder meeting, the CAISO presentation formulated the limit as the greater of (1) base transfers; (2) pre-mitigation transfers; or (3) flexible ramping up awards.[5] Powerex would appreciate greater clarification on this formulation, at it is not clear how this achieves the objective of not exceeding "the exporting entity's flexible ramping requirement adjusted by its imbalance energy needs."

II. Powerex generally supports the proposed Hydro Resource DEB framework

The Revised Straw Proposal includes a refined proposed formula for a DEB option that may be selected by any hydro resource with storage capability. The proposed formula consists of several terms, as follows:

$$LT\ DEB = MAX(ST\ DEB, MAX(M\ Index_{+4}, M\ Index_{+5}, \ldots, M\ Index_{+12}) * 1.1\ )$$

[1] Revised Straw Proposal at 15.

[2] Revised Straw Proposal at 20.

[3] As explained more fully in Powerex's comments on the Issue Paper, even under the proposed enhancements voluntary supply is still exposed to the risk of forced sales below its offer price as a result of mitigation. The proposal, however, limits the quantity of voluntary supply exposed to this risk (and partially offsets the financial consequences of forced sales through allocation of congestion rents); hence Powerex believes the proposal is an improvement over the unbounded risk that exists under the *status quo.*

[4] Revised Straw Proposal at 20, fn. 12.

[5] CAISO presentation at 22.

$$ST\ DEB = MAX(Gas\ Floor, DA\ Index, BOM\ Index, M\ Index_{+1}, M\ Index_{+2}, M\ Index_{+3}) * 1.35$$

$$Gas\ Floor = Gas\ Heat\ Rate * Gas\ Price\ Index$$

The proposed formula reflects several important concepts, and Powerex believes the overall framework generally incorporates the most important considerations relevant to opportunity costs for storage hydro resources. In particular, Powerex supports the proposed formula's recognition of the following key principles:

- **The formula is based on a resource's *maximum* storage horizon**, which is established upon the initial election of a resource for this DEB option. This is a workable approach to characterizing the storage attributes of a participating resource while avoiding complex, inaccurate and unworkable attempts to externally determine an estimate of the actual effective storage in any given hour. Appendix A includes a presentation prepared by Powerex discussing in greater detail the reasons why a DEB based on a participating resource's maximum storage horizon is workable and appropriate. The presentation also describes a potential process for substantiating the maximum storage horizon of a participating resource, using Powerex's EIM Aggregate Participating Resource as an example.
- **The formula includes both short-term and long-term components.** A storage hydro resource must make tradeoffs over time; under certain conditions those tradeoffs are in a relatively near term time horizon, whereas under certain other conditions the tradeoffs may be over a longer-term time horizon. It is therefore important for the proposed formula to consider factors across the full maximum storage horizon of the resource.
- **The formula is based on the maximum of the short-term and long-term components.** Even resources with relatively long maximum storage horizons face conditions from time to time that require it to make short-term production tradeoffs. This is particularly true when the highest value for the resource's limited energy occurs in the near term, as the resource will seek to maximize its near-term production under those conditions, often until it encounters a near-term constraint.
- **The formula applies a different scalar to short-term factors and to long-term factors.** When resources are facing short-term constraints, they will often also face greater volatility in the hour-to-hour and day-to-day value of potential market opportunities, and hence may require a greater DEB scalar to be applied to the short-term daily, balance-of-month and prompt month market index prices that are used. In contrast, a relatively lower scalar may be appropriate when resources are facing longer-term constraints, since there may be less volatility in the value of potential market opportunities, and the scalar will also be applied to the single best month of monthly index prices over the longer-term maximum storage horizon.
- **The formula considers multiple geographic market locations that can be accessed by a resource.** In the bilateral markets outside the CAISO BAA, hydro-based sellers must choose not only *when* to produce energy, but also the *geographic markets* where the output will be sold.

- **The formula includes a floor price.** A price floor provides an important protection against inefficient depletion of limited energy under certain conditions.

Powerex supports each of the above design attributes of the proposed hydro resource DEB formula, as they are reflective of the range of considerations faced by hydro-based sellers when determining the most efficient allocation of their limited supply.

The Revised Straw Proposal also introduces an analytical framework for determining the appropriate scalar to be applied to the short-term components of the formula (*i.e.,* the 1.35 multiplier in the proposed formula). Powerex supports this approach as an important and appropriate component of the hydro resource DEB proposal. Critically, the CAISO's analytical framework seeks to quantify the core basis for gauging appropriateness of an energy-limited DEB formula: its ability to protect against the risk that a hydro resource will be inadvertently depleted beyond its energy availability. Multiple stakeholders have repeatedly stated throughout this process that the current DEB options are problematic precisely because they expose their resources to the risk of being dispatched beyond their available energy. By calibrating the proposed hydro resource DEB specifically to achieve an acceptably low risk of inefficient resource depletion, the Revised Straw Proposal takes a major step toward addressing those concerns.

Finally, Powerex agrees that the general concepts of opportunity costs, storage, and the uncertainty associated with hydro resources are not unique to hydro resources located outside the CAISO BAA. Powerex therefore supports the re-casting of the EIM energy-limited resource DEB option as a hydro resource DEB available to all hydro resources with at least some storage.[6]

In summary, Powerex believes that the structure of the proposed DEB formula, together with the analytical framework for assessing the appropriate scalars needed to manage the risk of excessive depletion, provide a sound basis for a hydro resource DEB. The following sections provide suggested refinements to the proposed DEB formula, and to the process for determining eligible geographic market indices.

III. Refinements Are Needed To Specific Details Of The Proposed Hydro Resource DEB Formula

Powerex believes there are certain areas where the Revised Straw Proposal should be refined, or where additional clarification is needed. Critically, however, Powerex emphasizes that its proposed suggestions would **not** have the primary effect of increasing the overall level of the DEB, since the overall formula would still be subject to a calibration of the scalars to achieve a

[6] The Revised Straw Proposal states that this DEB option "excludes run-of-river" resources. Powerex agrees that this DEB is not appropriate for resource with no storage capability at all. However, Powerex notes that the term "run of river" may at times apply to resources with *limited* storage, as opposed to resource without any storage. Powerex believes that whether a resource is eligible for the hydro resource DEB option should be based on whether it can store inflows in one hour to enable increased production in a subsequent hour, even if that resource is described as "run of river" in other contexts.

stated benchmark. Rather, the proposed refinements to the DEB formula are intended to improve the accuracy of the DEB values by more closely reflecting the considerations typical of hydro-based sellers.

1. *Annual assessment and adjustment of scalars to protect against inefficient depletion of a resource*

The Revised Straw Proposal includes a short-term scalar of 1.35, applicable to the short-term price components (*i.e.,* day-ahead, balance-of-month, and monthly forward index prices of between one and three months). This scalar was selected based on CAISO's analysis of the number of intervals in which the DEB would have resulted in the resource being dispatched beyond their energy availability, at a predetermined confidence level. Powerex believes this analytical approach is useful, as it directly analyzes the potential risk of a resource being depleted beyond its available energy. As discussed more fully below, Powerex suggests that this analytical framework be refined and implemented as an annual review process to assess whether adjustments to the scalar may be necessary in order to continue to achieve an acceptably low risk of inefficient resource depletion.

a. *Refinements to the analysis of hydro resource DEB scalars*

Powerex believes that the CAISO's analysis can be strengthened in three key ways:

- Is the design standard of dispatching a resource "too frequently" 1 day out of 20 (or 95%) appropriate? Under this standard, a hydro resource could be inefficiently depleted approximately 18 days per year, which entities may or may not view as acceptable. The analysis may need to consider a more stringent benchmark, such as perhaps 1 day per quarter, or 98.8%.
- Are historical EIM prices in PACW an appropriate proxy for estimating market dispatch for the first year that this new DEB is made available? Powerex notes that historic EIM prices during the analysis period reflect the composition of the EIM at that time, including the number and location of participants, the availability of transmission to support EIM transfers, the application of current LMPM provisions and current DEBs, transitional pricing mechanisms, and FERC requirements on certain entities that resource offers not exceed existing DEBs. A potential alternative Northwest market price that could be used as a proxy to forecast future EIM prices, including EIM price volatility, and against which the dispatch of a resource under the proposed DEB could be tested, is the Mid-C bilateral real-time hourly price index, such as published by Powerdex.[7]
- If an Extended Day Ahead Market moves forward, it may be more appropriate to conduct this type of annual analysis using hourly day-ahead prices in the EDAM.

[7] Powerdex publishes price indices of real-time hourly bilateral transactions at various locations in the WECC. See http://www.powerdexindexes.com/

b. Annual process to assess and, if necessary, adjust hydro resource DEB scalars

The short- and long-term scalars serve as a means to "bridge the gap" between the limited market price data that can be readily observed and the far more granular specific opportunities that may be faced by hydro-based sellers in any particular hour. That is, the value of the scalars are driven in part by the relationships between, among others, monthly futures prices and the distribution of daily prices, or multi-hour on-peak block prices and prices in a subset of hours within that block. Recent years have seen an increase in the volatility of prices, such that the distribution of individual daily prices around a monthly average has grown, as has the distribution of individual hourly prices around the multi-hour block price. Price volatility may continue to increase, reflecting ongoing integration of larger amounts of variable energy resources and other factors.

For this reason, Powerex suggests that the hydro resource DEB provisions in the tariff define minimum values for the short-term and long-term scalars, perhaps at a value of 110%, but also provide for a well-defined annual process to re-calculate those scalars based on more recent price data. Powerex believes the tariff could direct CAISO to update its analysis on the risk of inefficient resource depletion, for example, specifying the appropriate percent of permissible exceedance (*e.g.,* 5% or 1.2%), price inputs, and values for storage and energy availability. This would preserve the design principles articulated by CAISO in the Revised Straw Proposal, without locking in the numerical scalar values, which may become stale in future years.

2. Floor price based on natural gas peaker unit, with discrete scalar

Powerex supports including a price floor in the proposed DEB formula based on the estimated production cost of a natural gas resource; this refinement would provide a mechanism to reduce potentially significant inaccuracy under two specific scenarios.

The first challenging scenario is for a resource facing a daily storage limitation during a very high-priced day, perhaps associated with hot summer weather or very cold winter weather. Such a resource may only have sufficient energy to produce in a limited subset of hours of the day, yet the value of these limited hours cannot be reflected by the proposed formula, which has a 16-hour on-peak block price as its shortest-term pricing component. Absent a DEB price floor, the proposed DEB formula could lead to the excessive dispatch and depletion of the resource, making it unavailable to produce energy in the very highest priced hours of the day. A price floor can reduce this risk if it reflects either the market price expected during the highest-value hours, or the potential price at which the participant with the depleted resource will need to buy energy to meet its own needs. While there is no robust index price for the highest-value individual hours of a day, a potentially workable proxy for the potential cost of replacement energy and/or the potential market price in the highest priced hours may be to apply the heat rate of a natural gas peaking unit to the applicable daily natural gas price index, plus a typical cost scalar of 1.1.

The second challenging scenario involves a resource with several days of available energy anticipating high prices in the upcoming days (such as during a cold snap or heat wave). The terms of the proposed DEB formula include a daily price and a balance-of-month price, but nothing in between. In other words, daily prices will likely not yet reflect an upcoming cold snap of several days, which is also more than a day in the future, but balance-of-month prices may reflect a multi-week average that includes the cold snap *as well as a return to more normal conditions thereafter.* As in the first scenario, absent a floor price the proposed DEB formula could lead to the resource being dispatched—and its limited energy depleted—too soon, rather than being appropriately conserved for the upcoming multi-day period of most efficient use. A DEB price floor could help protect against such an outcome by at least reflecting the potential cost to replace the resource's depleted energy and/or the estimated market price during the upcoming high-priced period. A workable proxy in this situation could perhaps be to apply the heat rate of a natural gas peaking unit to an applicable balance-of-month natural gas price index, plus a typical cost scalar of 1.1.

In both scenarios, Powerex believes that it would be more appropriate to apply the heat rate of a natural gas peaking unit, rather than that of a combined cycle facility. This is because the replacement energy may need to be procured precisely during the higher-price periods in which combined-cycle and other efficient units are most likely to already be dispatched. Powerex also believes that the scalar applied to this component should be 1.1 not 1.35. Powerex therefore suggests applying the heat rate for natural gas turbines for the most recent year reported by the Energy Information Administration. For 2017, the EIA reported an average gas turbine heat rate of 11,176 btu/kWh.[8]

Powerex therefore recommends that the proposed hydro resource DEB formula be revised as follows:

$$ST\ DEB = MAX(Gas\ Floor * 1.1, (DA\ Index, BOM\ Index, M\ Index_{+1}, M\ Index_{+2}, M\ Index_{+3}) * 1.35)$$

$$Gas\ Floor = Gas\ Peaker\ Heat\ Rate * MAX(Daily\ Gas\ Price\ Index, BOM\ Gas\ Price\ Index)$$

3. Decisional classification

Powerex supports extending the new hydro resource DEB to all hydro entities with at least some multi-hour storage capability, including hydro resources located within the CAISO BAA. Since this change will mean that the hydro resource DEB is no longer a proposal that applies uniquely to the EIM area outside of the CAISO BAA, Powerex does not disagree that the current decisional classification guidelines give the EIM Governing Body "advisory" rather than "primary" authority. While this change appears consistent with the existing governance arrangements under the CAISO tariff, it does highlight how those arrangements can result in the EIM Governing Body having only a secondary role on an issue of primary importance to—and initiated by—entities outside of the CAISO BAA.

[8] https://www.eia.gov/electricity/annual/html/epa_08_02.html

IV. Implementation Of Multiple Geographic Locations In Hydro Resource DEB

Powerex believes the Revised Straw Proposal's consideration of multiple geographic market hub locations is a significant improvement to the proposal. The consideration of multiple geographic market locations appropriately reflects that hydro-based sellers can and generally do seek to allocate their limited energy to not only the highest-value *days and hours,* but also to the highest-value *locations*. This latter consideration would be omitted from the DEB proposal if the DEB formula only considered market price indices from a single "default" location.

The Revised Straw Proposal sets forward proposed criteria for including additional geographic market locations in the calculation of a resource's DEB. Specifically, the Revised Straw Proposal would require an annual showing of forward transmission reservations to the requested additional locations. Where an EIM entity showed forward transmission reservations to multiple locations, the Revised Straw Proposal would calculate a weighted blend of prices. The Revised Straw Proposal describes a manual process by which an EIM entity would contact CAISO and request any changes to the relative preference, and thus weighting, among different geographic market locations; this revised preference order would remain until the next time the EIM entity requests a modification.

Powerex strongly supports the inclusion of additional geographic market locations in the hydro resource DEB. As discussed more fully below, Powerex believes there are specific targeted refinements that will improve the proposal.

1. *All external resources should have an opportunity to demonstrate access to multiple geographic markets*

Under the Revised Draft Proposal, an entity would "have the opportunity to select a different bilateral hub, or weighted average of hubs, ***for use in the long-term component*** of the default energy bid calculation."[9] However, geographic markets present transaction opportunities—and are potentially relevant to opportunity costs—of hydro resources even if their maximum storage horizon is less than three months. Therefore, Powerex believes that all hydro resources, regardless of maximum storage horizon, need an opportunity to include multiple geographic market locations in both the short-term and long-term components of the proposed DEB.

The proposal to limit the inclusion of multiple geographic market hubs only to long-term resources appears to be due to the mistaken view short-term geographic price differences can always be captured by purchasing energy at the lower-price location and simultaneously selling an equal amount at the higher-price location. This is generally not correct in the case of bilateral transactions outside of organized markets. For example, an entity with a hydro resource at Mid-Columbia and reserved transmission service to COB or NOB can produce energy for sale as low- or zero-GHG emitting energy, in hourly increments, at COB and NOB. But it is generally ***<u>not</u>*** possible to realize the value of the transmission independently of the resource, as this would require purchasing hourly clean energy in the Northwest to match the

[9] Revised Straw Proposal at 29 (emphasis added).

hourly clean energy sold at COB and NOB. Currently, however, there is no robust hourly market for clean energy products in the Northwest; the available robust markets are for 8- and 16-hour blocks of unspecified-source energy. Consequently, the hourly sale of clean energy at COB and NOB is directly linked to the operation of the clean resource in the Northwest, and the operation of the resource is directly linked to the sales commitments at COB and NOB.

This linkage between sales commitments and the operation of a physical resource does not exist for resources located entirely within the footprint of an ISO or RTO, such as resources located within the CAISO BAA. This is because the CAISO provides for a liquid and robust market to purchase hourly or sub-hourly energy at the boundary of the CAISO grid, which can then be used to deliver on a bilateral sale to other parties at external locations. Such activity does not directly require the seller to dispatch a specific resource to produce additional energy.

For the foregoing reasons, Powerex believes that ***all*** hydro resources located outside of the CAISO BAA should have an opportunity to include multiple geographic market hubs in the DEB for their resource (subject to a showing of transmission reservations, as discussed further below).

2. Alberta should be an eligible geographic market location

The Revised Straw Proposal mentions Mid-Columbia, NP15, SP15 and Palo Verde as potential geographic market locations that could be incorporated into the hydro resource DEB. Powerex supports the need to limit the additional geographic market locations to a manageable number, and to locations with sufficient liquidity to provide robust price indices across the various time horizons relevant to the proposed DEB formula. Powerex agrees that the four locations proposed by CAISO satisfy this goal.

However, Powerex believes one additional location should be considered, representing the Alberta market. Alberta is interconnected to other portions of the WECC at its border with British Columbia and with Montana. Market participants regularly buy and sell energy at these border locations, and Powerex understands price index data is consistently available for real-time, day-ahead, balance-of-the-month, and monthly futures prices. In the case of Powerex, specifically, a DEB framework that excluded consideration of Alberta market opportunities would be missing an important market that is highly relevant to any assessment of its potential sales opportunities.

3. Eligibility requirements for additional geographic market locations

The Revised Straw Proposal would first assign each hydro resource to a "default location." In the case of Northwest hydro resources, for example, the default market location would be Mid-Columbia. Powerex supports this approach, as entities in the region are generally able to transact at prices represented by Mid-Columbia index prices, and deliver energy by procuring long-term and/or short-term transmission service from Bonneville and other transmission providers in the region.

In order to be eligible to include prices from other geographic markets, in addition to its default location, Powerex believes it is appropriate to require an entity to demonstrate, on a forward basis, that is has procured transmission service from the boundary of its default market region to a delivery point that is better represented by one of the other geographic market indices proposed by CAISO. For example, John Day and Big Eddy are locations on the boundary of Bonneville's primary transmission network. An entity that has reserved transmission from Big Eddy to NOB is able to sell energy at a location (NOB) that is better represented by market indices at SP15 than at Mid-Columbia. Similarly, an entity that has reserved transmission from John Day to COB is able to sell energy at a location that is better represented by market indices at NP15 than at Mid-Columbia. Powerex therefore agrees with CAISO's clarification on the stakeholder call that entities with transmission to COB would be eligible to include the NP15 index prices in the DEB calculation, and entities with transmission to NOB would be eligible to include the SP15 index prices.

Entities with transmission to other locations outside of their default geographic region and associated market hub pricing index will require a determination by CAISO of which of the potential market hubs (*i.e.,* Mid-Columbia, NP15, SP15, Palo Verde and, as proposed above, Alberta) is most relevant to the particular location.

4. Dynamic weighting of multiple geographic locations

The Revised Straw Proposal appears to contemplate that the EIM entity would be able to request a particular weighting of market hub locations, subject to sufficient transmission reservations. This weighting would remain in place until modified by a subsequent request, or a reduction in the required transmission reservations.

Powerex suggests that CAISO consider a simple, automated process for developing the weighted prices used in a hydro resource's DEB involving multiple geographic locations. This would provide much more timely reflection of evolving market conditions in a resource's DEB, and would also reduce the CAISO's administrative burden of responding to potentially frequent requests to update the pricing weights each day.

A potential automated weighting approach is outlined below:

- Participant provides information to CAISO on forward transmission reservations on key segments (as discussed above). Transmission to the resource's default location is assumed to be equal to the resource's capacity;
- Each day, CAISO retrieves on-peak data on all settled prices at all eligible locations and time periods (daily, balance-of-month, and monthly futures up to the maximum storage horizon of the facility);
- For each time period, the locations are ranked in descending order of price;
- The weight for the highest-priced location is the minimum of the resource size or the transmission reservations to that location;
- The weight for the second-highest-price location is the minimum of the transmission reservations to that location, or the remaining resource capacity after the prior step;

- This process continues until the quantity weight for all eligible locations is equal to the resource capacity.

This process is aligned with the rational decision making process one would expect of an energy-limited seller. That is, it would prioritize sales to the highest-value opportunities, limited by available transmission service and by the capacity of the resource. Powerex believes improved alignment between the DEB formula and the considerations of a hydro-based seller can reduce the need for larger scalars, and can make the DEB proposal sustainable and workable under a range of evolving market conditions in the various relevant geographic markets.

In Appendix B to these comments, Powerex provides a sample Excel workbook illustrating how data on daily and forward prices at the proposed market hub locations and information on an entity's transmission reservations can be automatically updated daily and applied to the proposed DEB formula.

Appendix A

Storage Horizon Discussion

November 2018

EIM Use-Limited DEB Option Requires Determining Storage Horizon

- Key conceptual question: How does an additional EIM sale **today** impact **future** sales?
  - A **precise** answer is highly complex, subjective, and can change rapidly
  - Not workable for CAISO or any external entity to perform such a calculation
- But it **is** possible to "book-end" the potential range of answers:
  - **Minimum Storage Horizon:**
    - Zero storage; a sale now displaces other sales in the same hour
    - Most energy-limited resources may encounter periods of energy "spill"
  - **Maximum Storage Horizon:**
    - How long can surplus energy expected available for sale potentially be stored?
- **Maximum storage horizon** for a particular resource can be established from existing information
  - Descriptions of capabilities and operations included in regulatory filings
  - Historical cycling of reservoirs

Optimal Use Of A Hydro Resource Requires Balancing Multiple Factors

- **"Storage horizon" is better seen as the functional period over which production decisions are mutually exclusive**
  - Increased production today ***requires*** reduced production at some other point within the storage horizon
  - Reduced production today does ***not*** enable increased production at a time ***beyond*** the storage horizon

- **The storage horizon for surplus energy is driven by multiple key inputs and constraints, including most commonly:**
  - Inflows, both natural and due to upstream discharges (range of potential inflow scenarios)
  - Starting reservoir level
  - Minimum and maximum reservoir levels (can vary over time)
  - Minimum and maximum discharge (can vary over time)
  - Generating capacity (can vary over time due to outages)
  - Domestic load requirements ***net*** of other expected generation output (range of potential scenarios)

Refining Concept Of "Storage Horizon"

- **Storage horizon is dependent on many complex factors, in addition to reservoir size:**
  - Facilities with small reservoirs may have long or short storage horizons
  - Facilities with large reservoirs may have long or short storage horizons
- **Long storage horizon examples:**
  - A very large reservoir may be able to absorb all inflows expected over a year even if it does not generate at all
  - A large resource may have sufficient generation and discharge flexibility to *more than keep up* with inflows over an extensive time horizon
  - A small reservoir with very small inflows that occur seasonally with significant generation capacity
- **Short storage horizon examples:**
  - A large reservoir with high inflows year-round and insufficient generation capacity to *keep up* with inflows
  - A small reservoir with insufficient generation capacity to *keep up* with inflows
  - A large or small reservoir with near-term discharge limits that prevent it from selling all hours during a higher-priced period
  - A large or small reservoir with reservoir level restrictions that require prescriptive generation output and/or prescriptive discharge levels

Planning Requires Forecasts Of Inputs And Constraints, Which Are Inherently Uncertain, Subjective, And Subject To Change

- **Inflows:**
  - Range of forecasts of amount, timing, and form (rain vs. snow) of precipitation
  - Range of forecasts of timing and rate of snowmelt
  - Range of forecasts of upstream discharges, which may be under control of other entities
- **Discharge constraints:**
  - Release of water is subject to restrictions, which vary over time
  - Releases may have upper and lower limits, or may be required to follow a prescribed schedule
  - Release constraints change as conditions evolve to meet underlying goals (safety, environmental, recreational, treaties, downstream facility inflow/reservoir/discharge constraints)
- **Generating capacity**
  - Can vary based on timing and duration of planned and unplanned outages (maintenance, upgrades, expansion)
- **Domestic load service**
  - Range of forecasts, which in turn depend on forecasts of key drivers (weather, economic activity, … etc.), as well as other generation serving load

Small Changes In Inputs Or Constraints Can Have Major Impacts

- Hydro utilities make sales based on ***residual supply***, reflecting the difference between total available supply and domestic load needs (net of other generation)
- This can greatly magnify the impact of changes in forecasts:

MWh	Production	Domestic Needs	Residual Supply
Initial	80,000	70,000	10,000
Revised	79,200	70,700	8,500
Change	***-1%***	***1%***	***-15%***

Multi-Facility Systems Are Even More Challenging

- Systems with multiple facilities require input and constraint forecasts for each facility, but must also must consider ***complex interactions between facilities***
  - Discharge at one facility affects inflows into downstream facilities
  - Production from a facility with long-term storage may need to be sharply restricted to avoid causing spill at downstream facilities with limited storage (or violating discharge or reservoir levels at downstream facilities)
- Production at different facilities also considers ***hydraulic efficiency of individual units***, as well as ***project efficiency*** such as head gains/losses associated with impacts to reservoir levels (including impacts to reservoir levels at upstream/downstream facilities)
- Safety requirements
- Environmental requirements
- Each consideration may be subject to different levels of uncertainty, and ***difference levels of risk tolerance***
- Aggregation of capability of multiple resources into a participating resource adds ***further complexity***

Pursue Pragmatism Over False Precision

- The complexity, uncertainty, and judgment involved in planning hydro system operations makes it ***unworkable*** for a third party to independently evaluate the forward-looking storage horizon of a resource ***at any given point in time***
  - Process would be labor-intensive, require many simplifying assumptions, involve sharing of extensive non-public data, and require the third party to apply its own judgment to many subjective aspects of the planning process
  - Results can be expected to differ substantially from the internal evaluation of the entities with extensive direct knowledge and many years of expertise
- But it likely *is* possible to identify the *general limits* of a hydro resource's storage horizon
  - What is the ***minimum storage horizon*** of the resource?
  - What is the ***maximum storage horizon*** of the resource?

Minimum And Maximum Storage Horizons

- **Minimum horizon:** hydro resources are likely to face conditions from time to time that imply an effective storage horizon of zero
  - Production may be at its limit for the current hour, and a sale to one counterparty (or market) requires foregoing a sale to another counterparty (or into another market) in the same hour
  - Resource must generate *now*, due to risk of spill or risk of violating minimum discharge requirements, etc.
  - How often these conditions arise will vary between resources, and over time

- **Maximum horizon:** hydro resources are also likely to face conditions that enable it to access its maximum storage capability, which will vary from resource to resource
  - Can typically be directly observed in *past* operations, which reflects the *result* of the hydro operator's own evaluation of the multiple inputs, constraints, and uncertainty, without need to reconstruct how those decisions were made
    - Very long-term storage resources generally reach minimum and maximum levels once per year
    - Short-term storage resources generally cycle between minimum and maximum levels more frequently
  - Maximum storage horizon is also often one of the general attributes included in descriptions of hydro resources or systems in public documents and regulatory filings

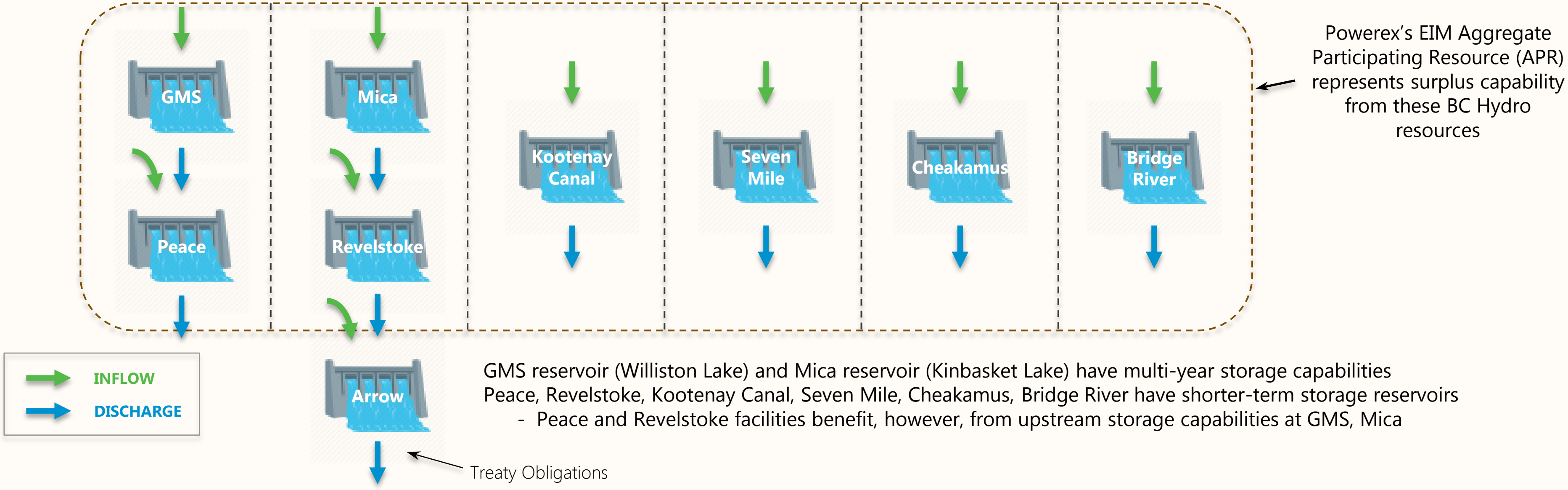
Proposed Process For Registering A Use-Limited EIM Resources

EIM entity would apply for use-limited resource status

- EIM entity specifies the number of forward months it seeks to be used in its DEB
- EIM entity provides supporting material to demonstrate maximum storage horizon
  - Supporting material may include:
    - Evidence of how frequently applicable reservoir(s) cycle between relatively low levels to relatively high levels
    - Evidence of how frequently applicable reservoir(s) spill (as a result of meeting maximum reservoir levels)
    - Public documents discussing the storage horizon of the applicable resource(s)
  - No supporting material required if default storage horizon of 1 month is requested
- CAISO evaluates sufficiency of supporting material; **accepts** or **rejects** application
- Once status as use-limited resource and specific DEB parameters are accepted, updates likely to be needed only in limited circumstances
  - Maximum storage horizon of hydro resources generally will not change absent major changes to facilities (*e.g.*, removal of a dam); such a change would trigger an informational update to the CAISO
  - If CAISO believes resource no longer qualifies, can request to shorten and/or terminate use-limited status consistent with established procedures

Example: Demonstration of Powerex APR Storage Of At Least One Year, Eligible For DEB Using 12 Forward Monthly Prices

Powerex APR Has A Maximum Storage Horizon That Is Based On Maximum Potential Storage Capabilities at GMS, MICA



GMS reservoir (Williston Lake) and Mica reservoir (Kinbasket Lake) have multi-year storage capabilities

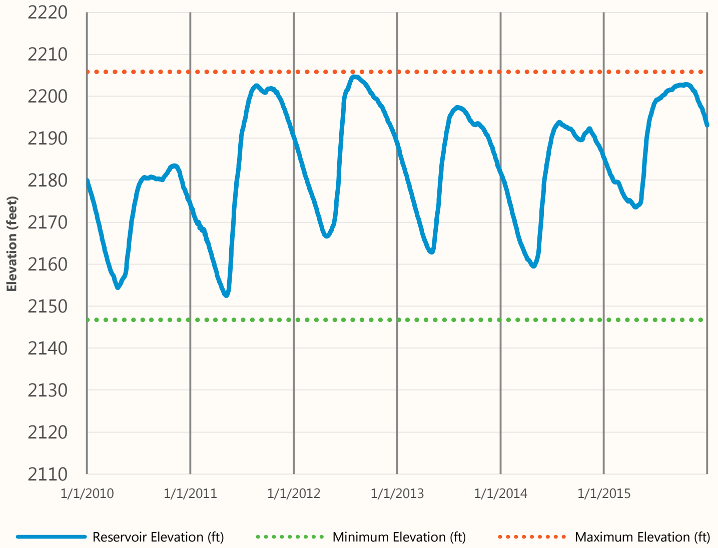
Peace, Revelstoke, Kootenay Canal, Seven Mile, Cheakamus, Bridge River have shorter-term storage reservoirs

- Peace and Revelstoke facilities benefit, however, from upstream storage capabilities at GMS, Mica

Maximum storage horizon for aggregate resources should be based on the underlying physical resource with longest maximum storage horizon

Public Data Shows Annual Cycling Of Largest BC Hydro Reservoirs

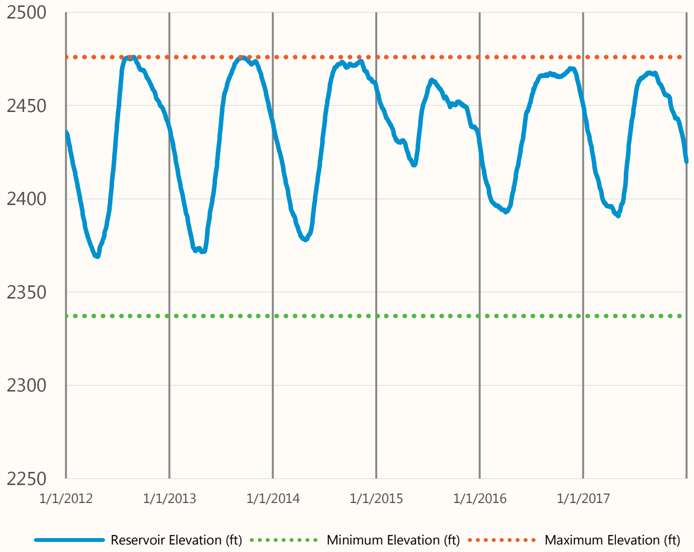
Williston (2010-2015)



Source: *Daily Water Level Data for WILLISTON LAKE AT LOST CABIN CREEK*
https://wateroffice.ec.gc.ca/report/historical_e.html?stn=07EF002

Notes: Elevation data are adjusted for datum at 2067.06 feet (630.040 m)
Elevations are converted from meters to feet
Minimum and maximum elevations are from 1976 to 2015
CAISO to verify Powerex analysis using data from above noted link

Kinbasket (2012-2017)



Source: *Daily Water Level Graph for KINBASKET LAKE AT MICA DAM*
https://wateroffice.ec.gc.ca/report/historical_e.html?stn=08ND017

Notes: Elevation data are absolute values and are not adjusted for a datum
Elevations are converted from meters to feet
Minimum and maximum elevations are from 1976 to 2017
CAISO to verify Powerex analysis using data from above noted link

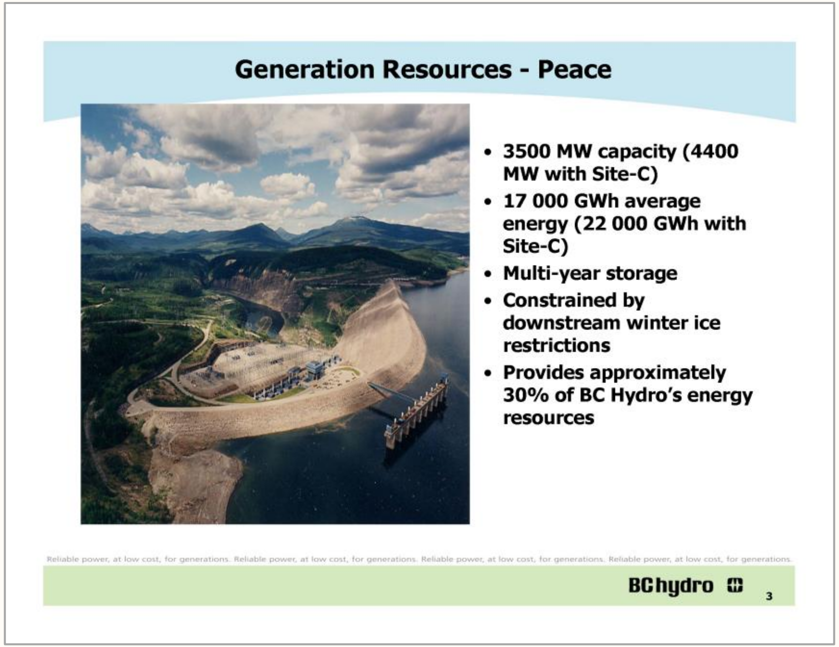
Filings And Documents Describe BC Hydro System As Having Multi-Year Storage

The hydroelectric facilities on the Peace and Columbia Rivers also provide a significant portion of the energy capability of BC Hydro’s Heritage resources. The GM Shrum and Peace Canyon generating stations on the Peace River produce 29 per cent of BC Hydro's Heritage energy, while Mica and Revelstoke hydroelectric plants on the Columbia River together produce 25 per cent. ***Both of the hydroelectric systems on the Columbia and the Peace River have large reservoirs that provide multi-year storage.*** Williston Reservoir on the Peace River is 1773 km^2 while the Kinbasket Reservoir behind Mica Dam on the Columbia is 425 km^2.

The generation system must be operated in a way that protects consumers from a shortage of electricity in periods of low inflows and makes the best use of the water available when inflows are at average or higher levels. In general, ***BC Hydro’s storage reservoirs are drawn down in the winter months*** and are at their lowest point in the spring before the freshet. The large water volume from ***snowmelt in the spring and summer then refills the reservoirs***. The large storage reservoirs on the Peace and Columbia Rivers ***allow water from wet years (above average snow and rain) to be stored and used in subsequent drier years.*** Operation of reservoirs on the Columbia River is partly constrained by the Columbia River Treaty, which is a treaty between Canada and the U.S. signed in 1961 when the hydroelectric development of the Columbia basin was initiated.

BC Hydro Provincial Integrated Electricity Planning Committee Information Sheet #4, Introduction to BC Hydro’s Integrated Electric System
https://www.bchydro.com/content/dam/hydro/medialib/internet/documents/info/pdf/info_iep_pre_reading_4.pdf

Filings And Documents Describe BC Hydro System As Having Multi-Year Storage *(cont'd)*



BC Generation Overview, (January 2013 presentation by Canadian Entity Secretary Doug Robinson)
https://www.usea.org/sites/default/files/event-/BC_Generation_Overview_REV.pdf

Filings And Documents Describe BC Hydro System As Having Multi-Year Storage *(cont'd)*

Because ***Williston Reservoir has multi-year storage capability*** annual inflow/discharge volumes may vary. For example, in years of high inflows, extra water may be stored to fill or recharge the reservoir resulting in the discharge for those years being less than the inflow. The ***available storage at Williston Reservoir is approximately 14 per cent greater than the average annual inflow***.

BC Hydro, Peace Project Water Use Plan (pg. 5)
https://www.acee-ceaa.gc.ca/050/documents/p63919/97604E.pdf

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Thank You

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Appendix B

See Excel file submitted separately