

Addressing LMPM / DEB Challenges for Energy-Limited EIM Participating Resources

CAISO April 30 Workshop

Overview

- **LMPM / DEB Challenges For Energy-Limited Resources have emerged in the EIM**
 - Four specific areas for improvement have been identified
 - Challenges of estimating marginal costs of energy-limited storage hydro resources
 - Harmful consequences of applying inaccurate DEB values
- **Recent Examples from Powerex's EIM Experience**
- **Potential Solutions**

CAISO's Existing LMPM Framework – Four Areas For Improvement

- **“Flow Reversal”**
 - Import constrained region is *purchasing surplus energy* for economic displacement in LMPM run
 - Becomes *uneconomic forced seller* in binding market run, as inaccurate DEB replaces bids and offers
 - **Interim solution:** Block exports during intervals that applicable BAA is mitigated due to purchases in LMPM run
- **“Extension”**
 - When LMPM is triggered in one interval, it automatically applies to subsequent intervals
 - No reason to apply this to resources that are not ramp-constrained
 - **Interim solution:** Apply LMPM only in intervals that it is triggered; CAISO Waiver
- **“Misapplication”**
 - LMPM applies to all EIM transfer paths *except paths into the CAISO BAA* (which is deemed competitive)
 - Is it appropriate to apply LMPM to EIM transfer paths to locations where there is *no potential for local market power?*
 - **Potential solution:** Permit entities with no customers exposed to EIM prices to “opt out” of LMPM application on their import transfer paths (LMPM would still apply if triggered due to transfers on *other* paths)
- **Inaccurate DEB**
 - The above issues cause harm when the seller's DEB < seller's estimate of its marginal opportunity costs
 - **Potential solution:** Develop a fourth DEB Option that provides sellers of energy-limited resources sufficient flexibility

Effectiveness Of CAISO LMPM Design Hinges On DEBs That Reflect An Accurate Estimate Of A Resource's Marginal Opportunity Costs

- **When $DEB \geq$ seller's estimated marginal cost, CAISO's LMPM design *is workable***
 - Appears generally workable for resources within the CAISO BAA
 - Appears generally workable for EIM participating resources that are not energy-limited
- **When $DEB <$ seller's estimated marginal cost, CAISO's LMPM is *not workable***
 - Inefficient dispatch
 - Economic losses for seller
 - Discourages voluntary participation
- **What factors make it more or less workable to use external estimates of marginal costs as a DEB?**
 1. Are marginal costs driven by variable production costs or by opportunity costs?
 2. Is the relevant information limited to a few inputs, with a simple relationship (e.g., fuel price, heat rate) or does it involve a large number of inputs that interact in a complex way?
 3. Is the relevant information reliably available (e.g., liquid price indices) or must it be subjectively derived from coarser information?
 4. Is the estimated marginal cost relatively stable from day to day, and from hour to hour, or is it highly dynamic?

CAISO Tariff Currently Has Three Options For Calculating A Resource's Default Energy Bid

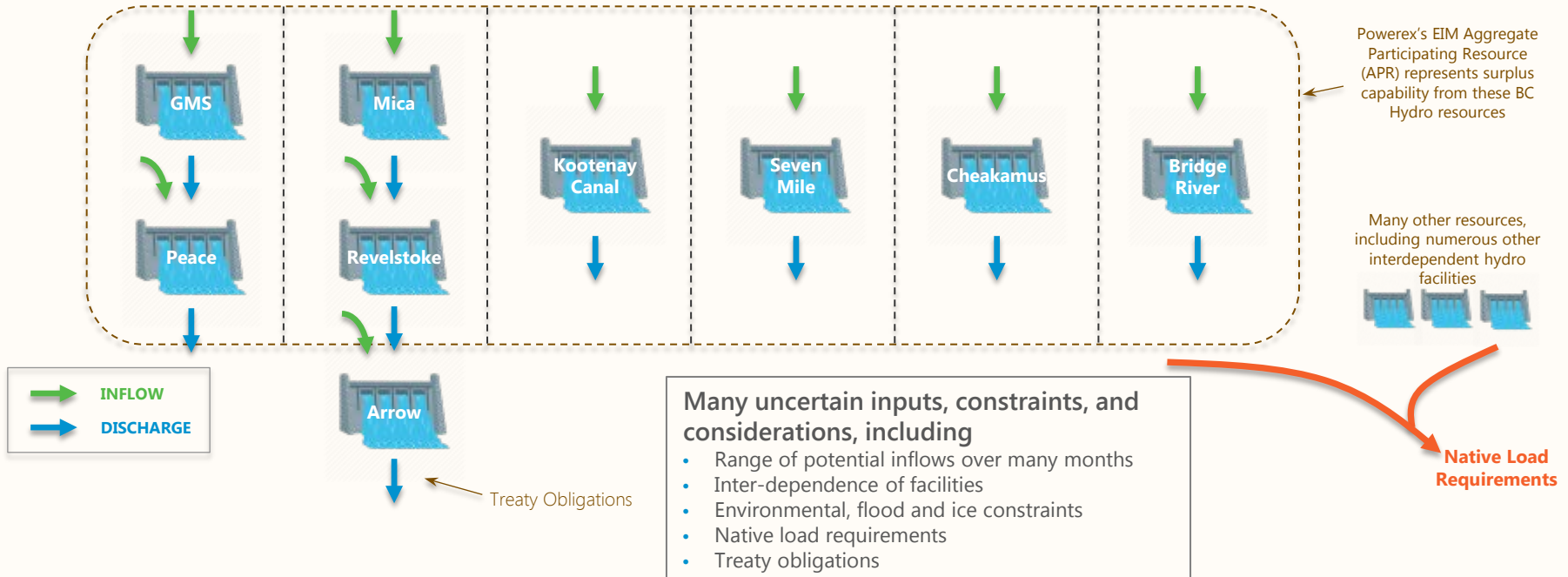
1. Variable Cost Option - based on heat rate, fuel price, GHG costs, etc.
 - o *Not relevant* for hydro resources
 - whose marginal costs are driven largely by **opportunity costs** rather than variable production costs
2. LMP Option - based on lowest 25th percentile of LMPs at which resource was dispatched in the last 90 days
 - o *Not workable* for hydro resources
 - Backward looking, whereas opportunity costs are driven by **current** and expected **future** conditions
3. Negotiated Rate Option – formula negotiated between the resource's scheduling coordinator and CAISO / DMM
 - o *Theoretically workable* for all resources in CAISO BAA and EIM
 - o *Not workable in practice* for hydro resources located outside CAISO BAA
 - Requires ability to accurately determine methodology / formula to estimate "expected marginal costs", **which are complex, dynamic, and involve both objective and subjective variables**

Challenges Of Estimating Marginal Opportunity Costs For Energy-Limited Storage Hydro Resources

- **Key Consideration 1: What quantity of energy will be available to sell or to purchase?**
 1. Will depend on weather (inflows) and on native load, on treaty obligations, on interdependence of facilities, etc.
 2. Will also depend on many constraints, which change over time – min/max elevations, discharge, environmental, safety, etc.
- **Key Consideration 2: What are the opportunities to make sales or purchases?**
 1. Hourly opportunities may exist over many months, at a large number of geographic locations
 2. Forward market data is generally available only for monthly products, and only at a few market hub locations
- **Each of these considerations and inputs is subject to:**
 1. A range of possible outcomes, requiring subjective estimations
 2. Continual change from day to day and often within each day
- **This results in marginal opportunity costs being complex, dynamic and subjective**
- **Any decision to sell or purchase energy carries risk (and this risk may be asymmetrical)**

** The above describes the general decision-making challenge when a resource is energy-limited, but in certain hours or conditions it may also be **capacity-constrained** (due to generation limits, transmission limits, etc.)*

Key Consideration 1: What Quantity of Energy Will Be Available To Sell Or To Purchase?

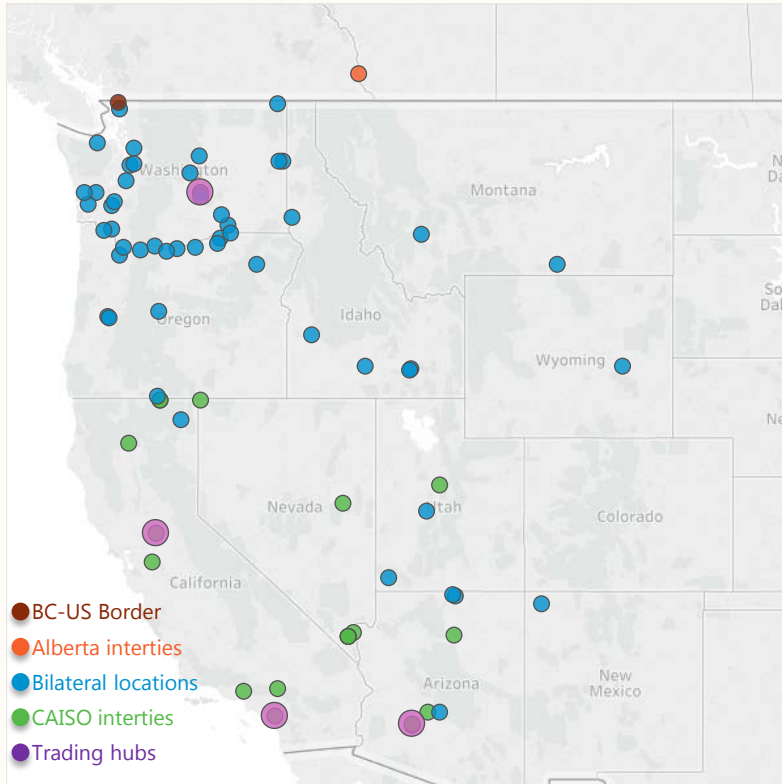


How much surplus energy will be available for sale this year at each facility?

How much flexibility will be available to decide when to sell it?

Key Consideration 2:

What Are The Opportunities To Make Sales Or Purchases?



- Powerex buys and sells electricity at over 80 locations across Western North America:
 - BC-US border
 - Alberta intertie locations
 - Bilateral market locations
 - CAISO intertie locations
- Forward prices are only available at a few trading hubs and only with monthly granularity
- Extensive analysis and experience is required to estimate future hourly prices over many months and many locations

When and where will the marginal sales opportunity arise?

Is it economic to sell (an uncertain quantity of) energy only above \$25/MWh, \$37/MWh or \$48/MWh?

Source: Locations in Powerex's FERC EQR reports from 2016 and 2017

Challenges Of Estimating Marginal Costs For Energy-Limited Storage Hydro Resources

- *It is implausible* that a third-party, *no matter how sophisticated*, will consistently arrive at the same numerical estimate of marginal opportunity costs as the seller
- This is not a critique of the analytical capabilities of different entities
- Rather, it reflects the inherent impossibility of relying exclusively on a formula to estimate hydro system marginal opportunity costs
- This is compounded by the constraints on DEB calculations
 - Completed the day prior to operations (cannot respond to new information during the day) and
 - Do not have hour-by-hour granularity (cannot reflect different operating configurations, limitations intra-day)
- This is further compounded by external third-parties lacking all relevant information, considerations, and the many years of experience necessary to evaluate the numerous inputs, considerations, interdependencies and risks

An externally-determined formula will *always differ* from a seller's estimate, except by coincidence

These Are New Challenges, Not Previously Faced In CAISO Markets

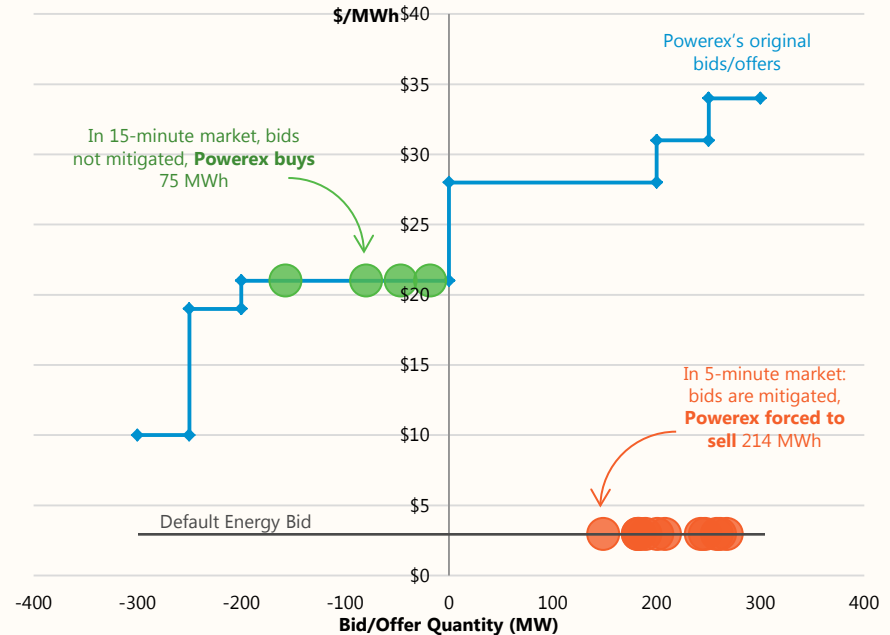
- The challenges faced by energy-limited hydro resources in the EIM *are new*, and generally *not experienced* by generators within the CAISO BAA footprint
- Resources in an RTO footprint:
 1. Sell all output at a single generator bus
 - Not 80+ destination market locations
 2. Market operator has extensive information about conditions on its own grid
 - Does not need information to forecast external market opportunities each hour in the future
 3. In-state resources have been separated from load-service obligations; can offer full unit capacity
 - Rather than needing to determine the amount that is surplus to native load needs
 4. In-state hydro resources are not subject to the same treaty obligations or the same operational and environmental restrictions
 - e.g., BC Hydro must consider treaty obligations, ice flow restrictions, and other unique considerations in the operation of its facilities, and in the determination of surplus capabilities made available to Powerex

Recent Examples From Powerex's EIM Experience

- Powerex has experienced numerous instances in which LMPM was triggered for its APR
- This can happen when there is a:
 - **True Positive:** *e.g.*, when imbalance demand is high within a constrained area
 - **False Positive:** *e.g.*, when there is abundant surplus energy outside the constrained area
 - Fast-ramping hydro resource DEC bids, even if only slightly “in merit”, can quickly fill EIM import transmission
- Mitigation to a DEB level below Powerex's own estimates of its marginal opportunity cost results in:
 - 1. Harm to Powerex**
 - Forced uneconomic sales and lost economic purchases
 - 2. Harm to market efficiency in current hour**
 - Market solution does not represent least-cost dispatch
 - 3. Harm to market efficiency in future hours**
 - Less water available to serve load, imbalances, and to displace resources in more valuable hours later
 - 4. Discouraging EIM participation**

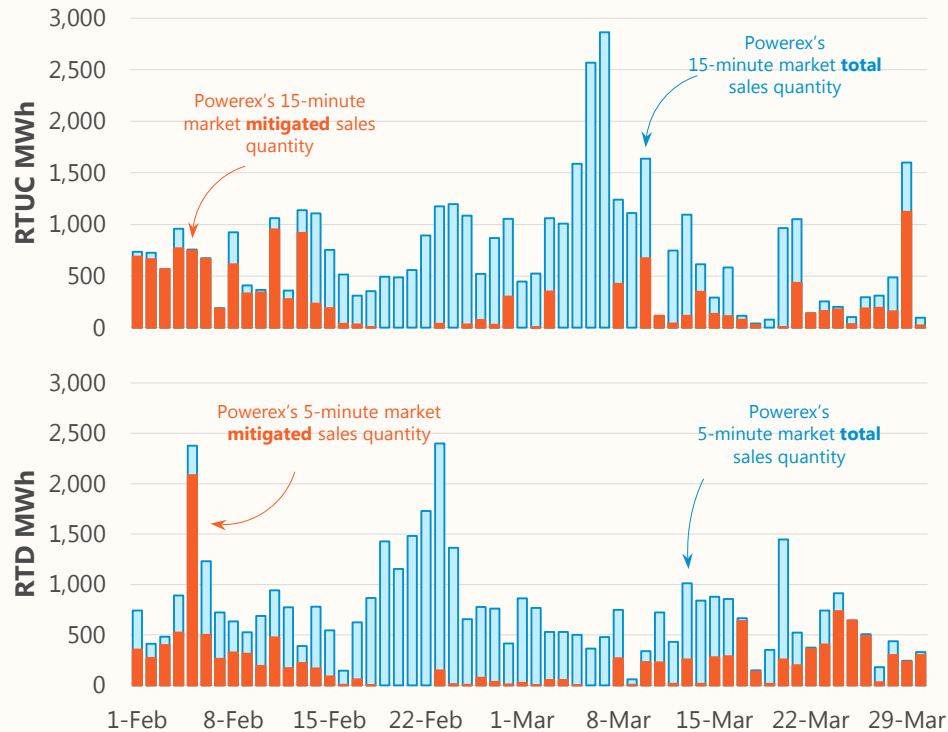
Parallel Operations Example: February 5, 2018 HE 12

- February 5 provides several clear examples of outcomes with and without bid mitigation
 - Data from parallel operations, not binding operations, and used for illustrative purposes only
 - DEB was an initial “default” value
- Powerex’s bids and offers (blue line) were not mitigated in the 15-minute market
 - Bids to purchase were in merit to *purchase* energy
 - Powerex purchased 75 MWh at an average price of \$21/MWh (green circles)
- But those same bids and offers were mitigated in the 5-minute market
 - Bids/offers re-priced to DEB of \$2.96/MWh (grey line)
 - Powerex’s mitigated offers were then in merit to *sell* energy
 - Powerex sold 214 MWh at an average price of \$2.96/MWh (orange circles)



Summary Of Bid Mitigation During Parallel Operations

February 1 – March 30, 2018



- Mitigation occurred in one or more intervals during **52 of 58 days** of parallel operations
- **Roughly 30%** of the volume of sales from Powerex's participating resource were at **uneconomic** mitigated prices
- Mitigation also **inefficiently blocked** a significant quantity of Powerex purchases
 - Have been unable to quantify the volume or value of "blocked purchases"
- Mitigation is more frequent during periods when the calculated DEB is lower (early Feb)

Powerex notes that results from parallel operations may differ from results under binding market operations, and may or may not predict future outcomes

Summary Of Problems With Applying Existing LMPM/DEB Design To Energy-Limited Storage Hydro Resources In EIM

- Current LMPM/DEB framework is **unworkable** for external energy-limited storage hydro resources
 - Core assumption—that marginal opportunity costs can be accurately calculated by an external entity—is not valid
 - Any external calculation will inevitably differ from seller's own assessment in virtually every hour (other than by coincidence)
 - Means that in a large number of hours, DEB will be below seller's own assessment of its marginal opportunity cost
- Harms sellers through **forced uneconomic sales** and **blocked economic purchases**
- Results in **inefficient use** of hydro resources, depleting water in the **wrong periods**
- **Discourages EIM participation** by external hydro resources, which are exactly the types of resources that can best help integrate renewables and balance load in the EIM
 - Powerex's EIM business case has been harmed
 - Powerex appreciates CAISO's efforts on this issue
 - If unaddressed, may also impact:
 - Expansion of the EIM, particularly in the Pacific Northwest
 - Business case for EDAM participation

Potential Solutions

What is the most appropriate approach to LMPM and DEBs for EIM energy-limited participating resources (located outside the CAISO BAA)? Given that:

- Third-party estimates of marginal opportunity costs will always be inaccurate
- Sellers are best positioned to estimate their own marginal opportunity costs
- The EIM is a voluntary market

Whenever LMPM is triggered (and the potential exists for seller's offers to reflect the exercise of market power):

- *Status Quo*: Automatically over-ride the seller's offers with a DEB that represents a third-party formulaic estimate of marginal opportunity cost and dispatch the resource using its replaced bids and offers
- **Option 1 (Fourth DEB Option)**: Add a DEB option under Tariff that provides *enough flexibility* to allow suppliers to determine their own bid/offer prices *without being overridden*, while still protecting against local market power
- **Option 2 (Blocked Exports)**: *Do not dispatch* offers that are above the DEB, when the dispatch results in exports from the applicable BAA
- **Option 3 (Hybrid Approach)**: Combine elements of Option 1 and Option 2

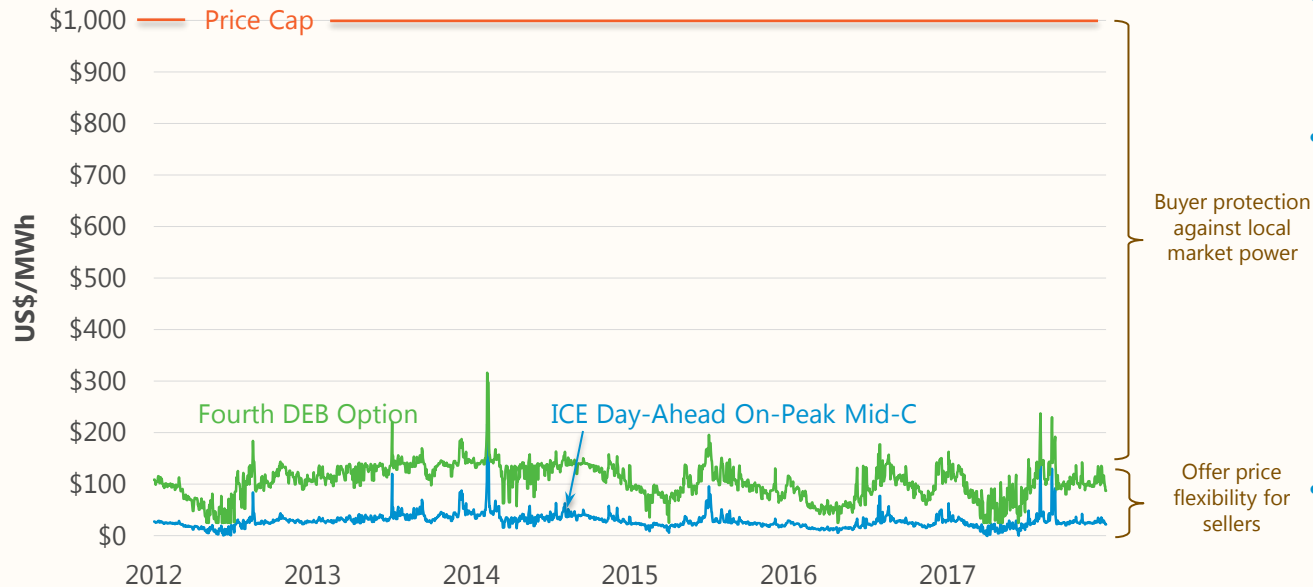
Fourth DEB Option: Threshold-Based Approach

Option 1: Fourth DEB Option (for Energy-Limited Storage Hydro Resources Located Outside CAISO BAA)

- Add a DEB option under Tariff that provides external hydro suppliers with *enough flexibility* to allow them to determine their own bid/offer prices *without being overridden*, while protecting against local market power
- Based on conduct thresholds that have been **approved** for generally unconstrained areas in MISO, NYISO and ISO-NE
 - Bids below \$25/MWh never mitigated;
 - Bids that do not exceed a reference price by the lesser of \$100 or 300% of reference price are also not mitigated
 - Fourth DEB = $\text{Max} (\$25/\text{MWh}, \text{Reference Price} + \text{Min} (300\% \times \text{Reference Price}, \$100/\text{MWh}))$
 - Reference price could be set at
 - ICE Day Ahead On-Peak Mid-C Index for BC / NW energy limited resources
 - ICE Day Ahead On-Peak PV Index for SW energy limited resources
 - Each of these indices represent one available opportunity for hydro resources, and are readily available
- Powerex believes these thresholds would be workable, reasonable, and would generally not prevent it from reflecting its opportunity costs in its bids.

Fourth DEB Option: Application in 2012-2017

Option 1: Fourth DEB Option (for Energy-Limited Storage Hydro Resources Located Outside CAISO BAA)

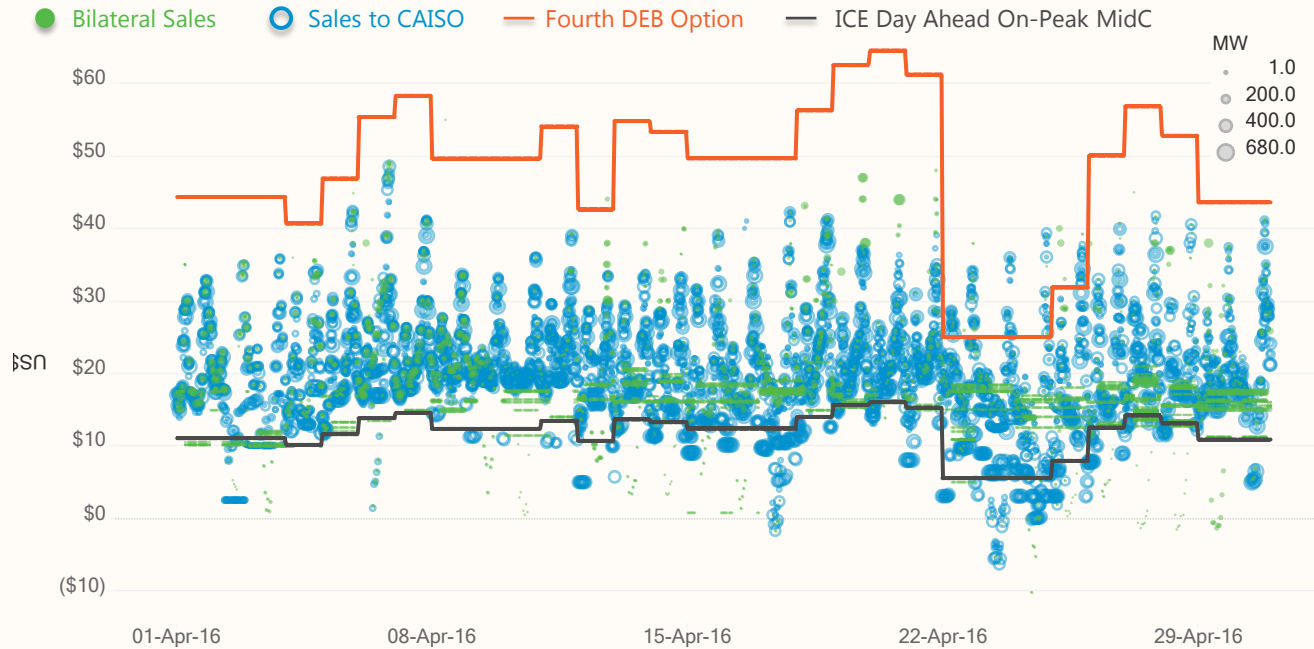


- Proposed Fourth DEB adjusts to reflect **near-term grid conditions**
- Historical data shows that proposed Fourth DEB would provide **extensive protection** against potential exercise of local market power by removing **most of** seller's flexibility under the **\$1,000/MWh price cap**
- Powerex believes flexibility provided would likely be sufficient under most conditions

Fourth DEB Option Provides Flexibility To Reflect Opportunity Costs

Powerex Sales in Western U.S.

April 2016 – Daily and Hourly from FERC EQR

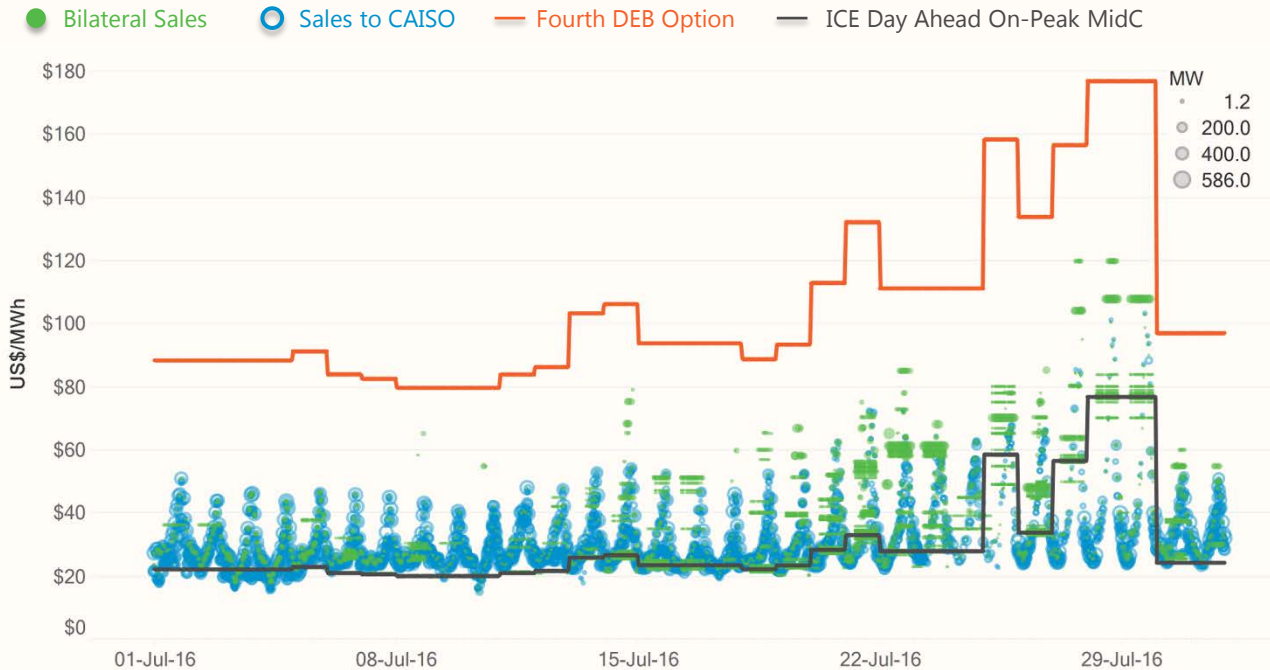


- Powerex's reported daily and hourly sales (FERC EQR)
- Excludes:
 - Forward sales
 - BC-US Border sales
 - Alberta sales
- Illustrates the suitability of the proposed Fourth DEB Option, relative to Powerex's alternative sales opportunities

Fourth DEB Option Provides Flexibility To Reflect Opportunity Costs

Powerex Sales in Western U.S.

July 2016 – Daily and Hourly from FERC EQR

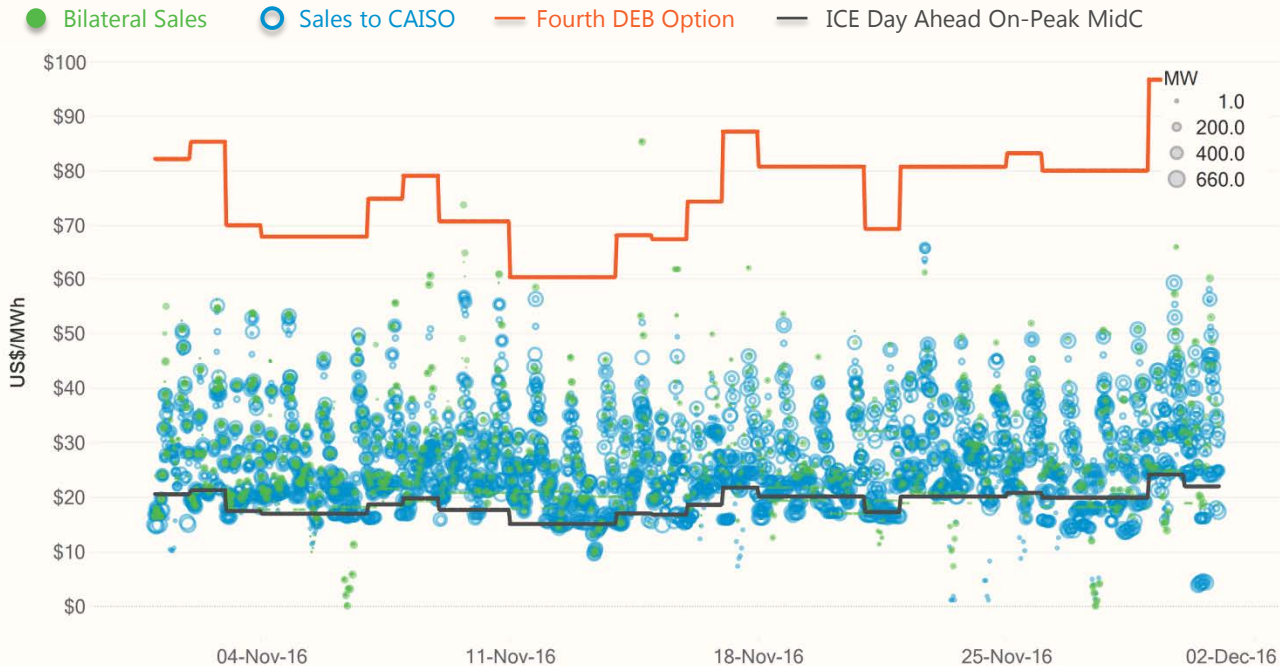


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Fourth DEB Option Provides Flexibility To Reflect Opportunity Costs

Powerex Sales in Western U.S.

November 2016 – Daily and Hourly from FERC EQR

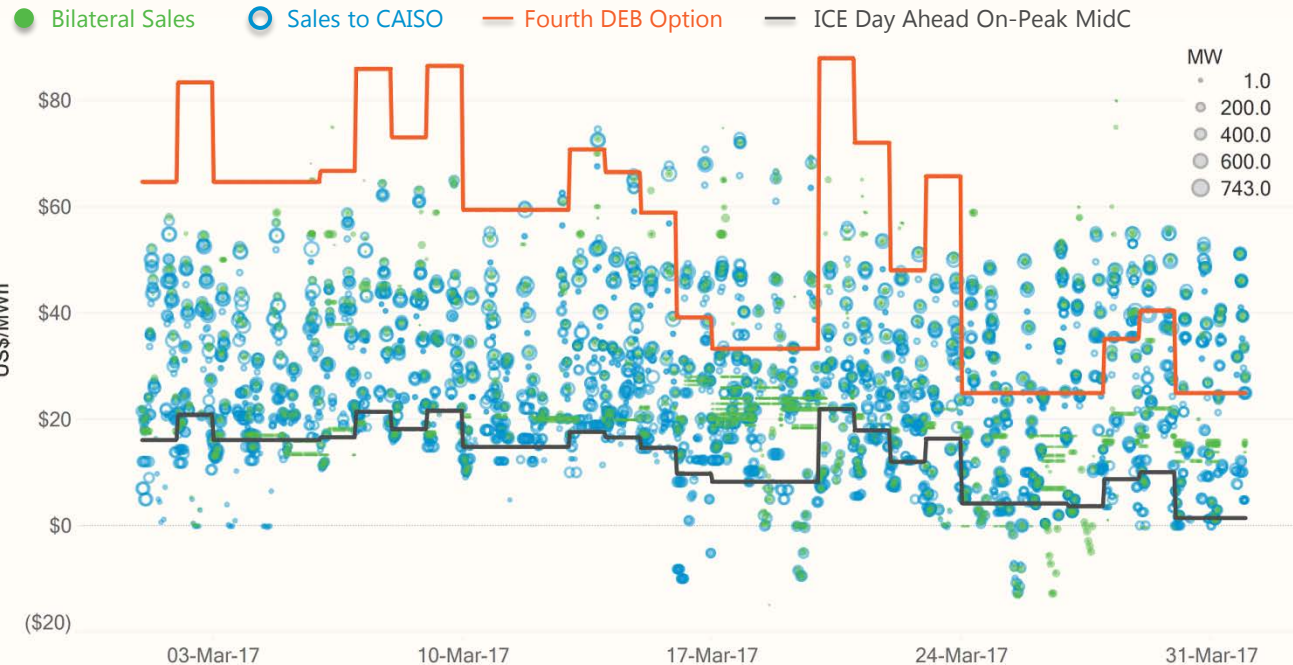


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Fourth DEB Option Provides Flexibility To Reflect Opportunity Costs

Powerex Sales in Western U.S.

March 2017 – Daily and Hourly from FERC EQR



- Powerex's reported daily and hourly sales (FERC EQR)
- Excludes:
 - Forward sales
 - BC-US Border sales
 - Alberta sales
- Illustrates the suitability of the proposed Fourth DEB Option, relative to Powerex's alternative sales opportunities

Fourth DEB Option: Summary

Option 1: Fourth DEB Option (for Energy-Limited Storage Hydro Resources Located Outside CAISO BAA)

- **Historical data indicates that Powerex's proposed Fourth DEB Option would**
 - Generally provide **sufficient flexibility** for sellers from energy-limited participating resources to participate in the EIM without being mitigated below their alternative current and future market opportunities, which drive marginal opportunity costs
 - Provide EIM purchasers with sufficient protection against the exercise of local market power
 - Based on data from the last five calendar years (2013-2017), Fourth DEB would have been:
 - Below \$150/MWh in 95.8% of hours
 - Below \$250/MWh in 99.8% of hours
 - Well below the offer price cap of \$1,000 / MWh in all hours
- **EIM sellers also have incentives to bid at their marginal opportunity costs, even if DEB is higher**
 - EIM is highly competitive, sales offers above marginal opportunity costs risks foregoing economic transactions
 - Entities with hydro resources also typically have load and generation imbalances
 - Offer prices above a seller's estimate of marginal opportunity costs creates risk of the seller's own imbalances being served uneconomically from imports

Limit EIM Exports

Option 2: Ensure Mitigated Offers Are Not Used To Support Exports

- When mitigation is triggered, resources would not be dispatched to the extent it resulted in exports to other EIM BAAs (or CAISO BAA)
- Reduces extent of inefficient depletion of limited energy, and reduces harm of uneconomic sales
- Should not be problematic for rest of EIM
 1. EIM is strictly voluntary
 - *i.e.*, no worse than if participant declined to submit economic offers, or to make transmission available
 2. EIM entities are required to be Resource Sufficient, and hence do not rely on energy being available from others
- **May be workable as a near-term solution, but with important shortcomings**
 1. Seller continues to be harmed if mitigation blocks its bids to purchase energy
 2. Seller still exposed to selling imbalance energy in its own BAA at inaccurately low prices
 3. Incompatible with any future voluntary must-offer arrangements entered into
 - *e.g.*, if seller voluntarily transacts RA, FRAC-MOO, ... etc., it will need a DEB

Hybrid Approach

Option 3: Hybrid Approach

- **For locations where either**
 - Mitigation is triggered in fewer than a defined number of hours per year, **or**
 - No third-party customers are exposed to EIM prices in the constrained location
 - Apply Fourth DEB as per Option 1
- **But apply a more restrictive DEB and/or block exports (Option 2) *if*:**
 1. Mitigation is triggered more frequently than the defined value; **and**
 2. Third-party customers in the constrained region are exposed to EIM prices

Interim Measures

Powerex appreciates CAISO's efforts to address this urgent issue in the near-term:

- **CAISO Waiver Request**
 - Will prevent LMPM from automatically extending throughout the operating hour (for Powerex APR)
- **CAISO Business Practice Changes**
 - Will prevent Powerex's APR from being dispatched for exports, when in "purchase" bid range prior to LMPM
 - Will prevent Powerex from providing Flexible Ramping Up to Other BAAs, when exports limited

But these measures are neither comprehensive, nor durable

- Powerex's economic purchase opportunities are still blocked
- Powerex's sales are still mitigated to uneconomic prices when LMPM is triggered
- Waiver limited to 18 months

Powerex agrees with CAISO's statements on the need for supplier pricing flexibility:

"Management believes a core design principle should be that suppliers are much more able than the ISO to determine their costs."

- Keith Casey Memo to CAISO Board, CCDEBE Proposal, March 14, 2018 at 9-10.

Stakeholder Process Governance

- The development of a Fourth DEB option, or other measures to make LMPM workable for energy-limited resources participating in the EIM, must be under the *primary decisional authority of the EIM Governing Body*
 - The proposed enhancements would apply to energy-limited resources located ***outside*** the CAISO BAA
 - Resources located ***outside*** CAISO BAA are not mitigated in order to address local market power concerns ***inside*** the CAISO BAA
 - Hence local market power concerns ***inside*** the CAISO BAA would be unaffected by this proposal
- EIM Governing Body is the **appropriate body** to balance the competing interests of differently-situated participants and regions
 - Suppliers prefer maximum bidding flexibility
 - Buyers prefer maximum protection from local market power, and some may oppose additional bidding flexibility

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Thank You

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