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Examining Fourth DEB Options For Energy Limited EIM Participating Resources

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Overview Of LMPM/DEB Challenges For EIM Energy Limited Resources

Powerex believes there exists a fundamental gap in the market power mitigation of EIM energy limited resources

1. **Voluntary sellers require their offer quantities and offer prices to be respected in CAISO dispatch decisions**
   - **May be acceptable** to occasionally not dispatch (or "skip") a resource when its offer prices are economic, but
   - **It is generally *not* acceptable** to over-ride offer quantities and/or offer prices and dispatch the resource anyway
     - It is acknowledged that mitigation is necessary for offers that **clearly** reflect an attempt to exercise market power
2. **Eastern ISOs use a conduct and impact test approach that may be workable**
   - Sellers' offers below the conduct price threshold (which is well above estimated marginal costs) are never mitigated
   - Generally provides sellers with sufficient offer price flexibility to estimate their own marginal costs and have them respected
3. **CAISO LMPM/DEB approach that was developed for California, and extended to the EIM, is unworkable**
   - When the LMPM process identifies the potential for the exercise of local market power, sellers' offer prices may be automatically over-written with a formulaic price
   - Powerex believes it is **misguided** to pursue a formula or method to "better estimate" the specific marginal costs of energy limited EIM participating resources, and to use it to over-ride sellers' voluntary offer prices

Overview Of LMPM/DEB Challenges For EIM Energy Limited Resources

LMPM is resulting in "false positives" that should be addressed

1. "Misapplication"
   - **Potential solution:** Permit entities with no customers exposed to LMPs to "opt out" of applying LMPM to their import paths
2. "Extension"
   - **Potential solution:** Do not automatically extend mitigation to subsequent intervals for resources that are not ramp-limited
3. "Flow Reversal"
   - **Interim solution:** Block exports during intervals that applicable BAA is mitigated due to purchases in LMPM run

Improvements to the triggering of LMPM, while important, do not eliminate the need to address the broader LMPM/DEB issue

- Grid and market conditions continually change and LMPM may be triggered more frequently in the future
- Over-riding voluntary EIM offer prices with an **inaccurate** estimate of marginal costs is highly problematic, even if it is infrequent
  - Causes limited energy to be depleted in the wrong periods, raising potential operational challenges
  - Causes economic harm to both the seller and to market efficiency
  - Discourages voluntary participation
- A workable LMPM framework is of even greater importance in the context of a regional day ahead market

Addressing LMPM/DEB Challenges For EIM Energy Limited Resources

Powerex believes there are at least two potential approaches to addressing the DEB issue:

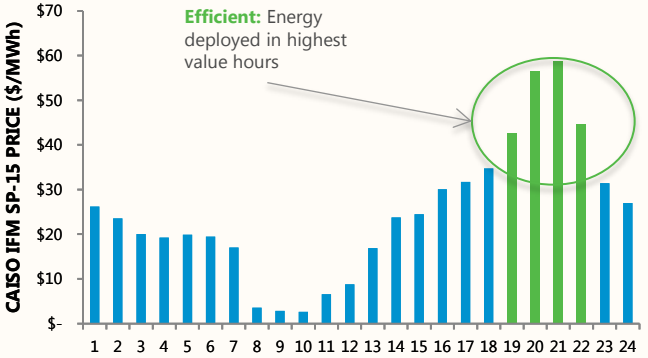
1. **Establish a Conduct Exemption from CAISO's LMPM process**
   - Do not apply LMPM process in hours that a resource's entire bid/offer curve is below a defined Conduct Threshold
   - This is a **simple solution** that is entirely consistent with approach used by Eastern ISOs, and approved by FERC
   - Eastern ISOs use Max ($25/MWh, Reference Price + Min ($100/MWh, 300% Reference Price)) for generally unconstrained areas

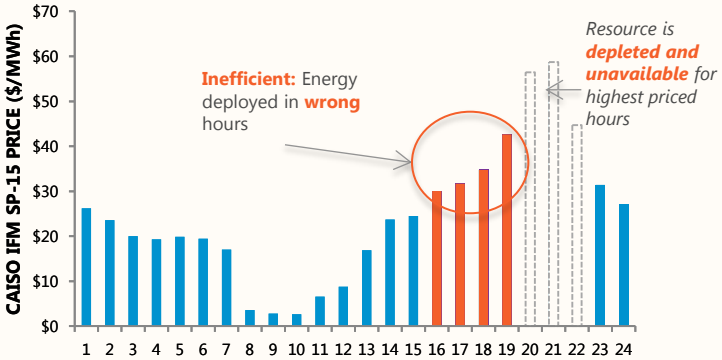
2. **Establish a Fourth DEB tariff option for Energy Limited EIM Participating Resources**
   - Focus of today's discussion
   - Objective:
     - Establish a workable DEB formula that results in DEBs that are as low as possible, **with minimal risk** that the DEB will be below the seller's dynamic and subjective estimates of its opportunity costs
     - DEB formula should **not** simply aim to estimate a "P50" of marginal opportunity costs

Simplified Conceptual Energy Limited DEB Examples: Single Day, Single Location and Known Prices: June 3rd, 2018

- **Assume an energy limited resource with 1,000 MW of generating capacity and 4,000 MWh of surplus energy in SP-15 for the day. How should the resource allocate its output in CAISO IFM?**
- **Resource should sell the 4 highest priced hours of the day**
  - Approach 1: Predict the best 4 hours and self-schedule output
  - Approach 2: Submit offers at an estimated marginal opportunity cost of **$44.00/MWh** (which is **175%** of 16-hour On-Peak SP-15 price)

- **What if instead, a DEB over-writes offers with a lower price?**
  - Example: Use DEB of **$27.50/MWh** (based on 110% of On-Peak Average Price of $25/MWh)
    - **Sub-optimal** dispatch of the resource
    - **Inefficient** (i.e., higher cost) market solution
    - Energy is **depleted** before the peak hours
    - External entity may need to make future market **purchases** to serve load





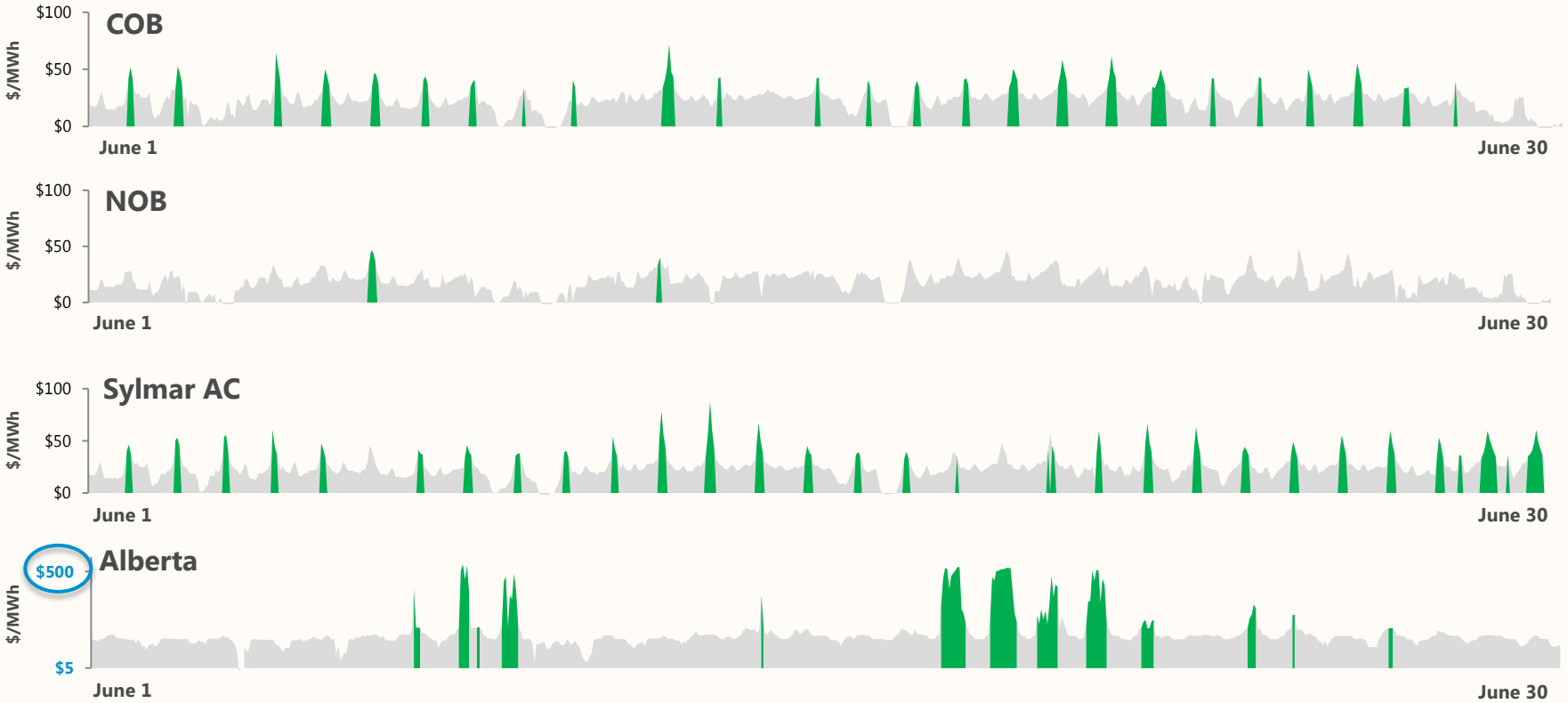
Simplified Conceptual Energy Limited DEB Examples: Single Month, Multiple Locations and Known Prices

- **External energy limited resources have market opportunities in multiple geographic regions and often over many days**
- **Assume that during June 2018, an external energy limited resource has:**
  - **1,000 MW** of hourly generating capacity
  - **144,000 MWh** of total surplus energy for the month (20% capacity factor for sales in the month, after serving native load)
  - Transmission capability to multiple locations:

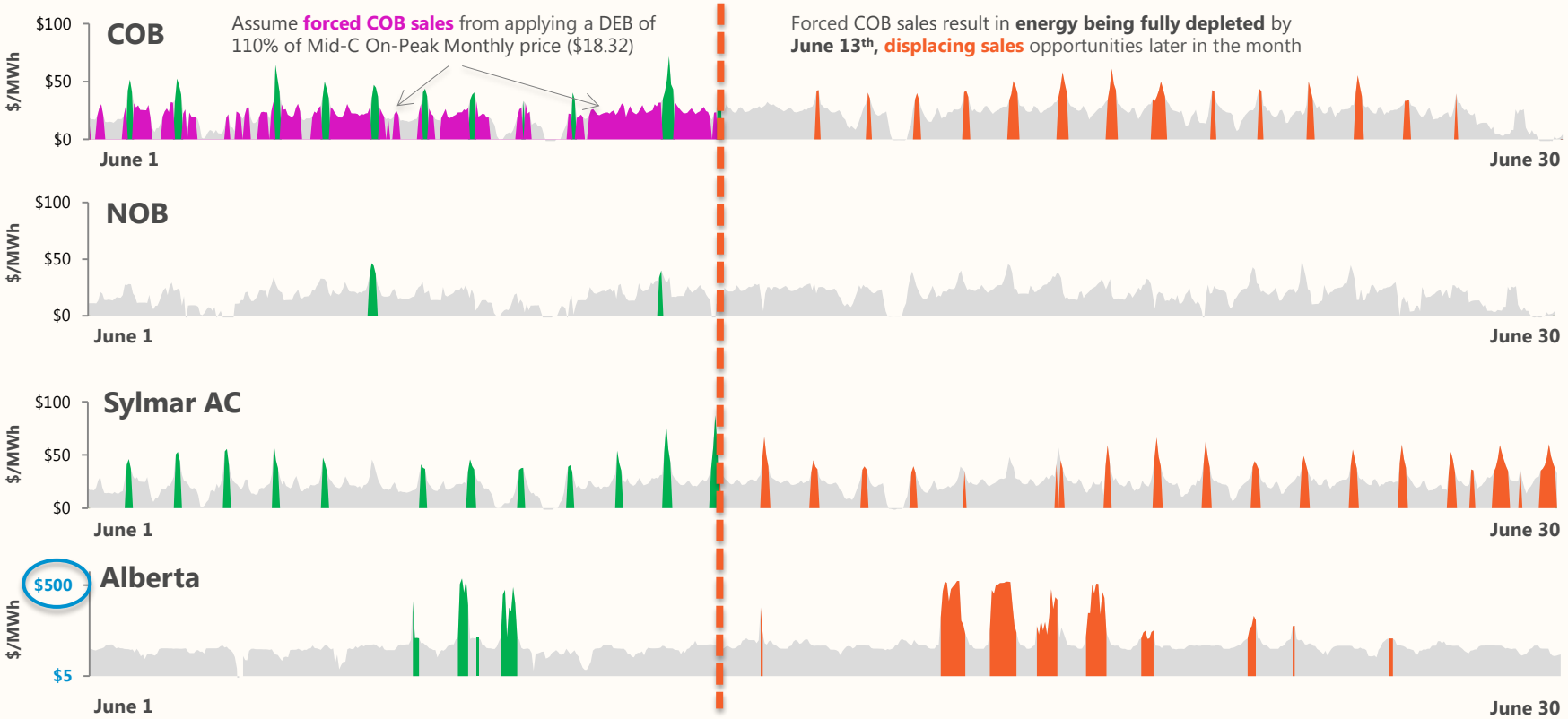
Market / Region	Hourly Transmission Capability To Each Market
COB	500 MW
NOB	500 MW
Sylmar (AC)	500 MW
Alberta	500 MW

- **When and where should the resource allocate its output?**

Simplified Conceptual Energy Limited DEB Examples: Single Month, Multiple Locations and Known Prices: Optimal Solution



Simplified Conceptual Energy Limited DEB Examples: Single Month, Multiple Locations and Known Prices: DEB Impact



No Formula Can Accurately Estimate Opportunity Costs For Storage Hydro Systems

- **Opportunity costs arise when a seller must choose between mutually-exclusive alternatives**

- **Estimating opportunity costs can be highly complex, subject to rapid intra-day and daily changes as information or conditions evolve, and is informed by considerable judgment and situation-specific experience**
  - How much energy will the hydro system be able to produce?
  - How much will be needed for native load, after deducting expected output from other resources?
  - For the residual energy available to support sales, what are the values of all of the potential sales opportunities that might arise in the future in all of the various temporal and geographic markets?
  - Which *specific* opportunity (or opportunities) will be precluded by a sale in the current hour?
  - What resource(s) will produce any additional energy in this hour? What constraints are currently applicable: Intra-day, weekly, or longer-term energy limit? Generation capacity limit binding ? Transmission limit binding ?
  - How will these conditions change for next hour?
  - ***This complexity cannot be reduced to an automated formula without very significant inaccuracy***

- **However, while there is much that cannot be reduced to an automated formula, *several key relevant factors* likely can be estimated with reasonable accuracy**

Some Key Factors Likely Can Be Estimated With Reasonable Accuracy

1. **Most hydro resources with storage face a longer-term limited-energy constraint**
   - *Specific duration of constraint is uncertain and changes over time*, but *general maximum storage horizon is often well-known and does not change* for each storage resources and/or hydro system more generally (*i.e.*, 12 months vs. 3 months vs. daily)
     - **If current prices < expected future prices**
       - Output in the current hour / day typically *will not* be maximized, and short-term constraints will not be binding.
       - Hence, opportunity costs of selling energy now generally reflect foregone sales in the best future hours and locations *over the longer-term storage horizon*
2. **All hydro systems also face short-term energy limits, generation capacity limits, and transmission limits**
   - When the short-term energy, generation capacity or transmission constraints are binding, the opportunity cost of energy now is based on foregoing sales in other markets ***in the same hour or day***
     - **If current prices > expected future prices:**
       - Output in the current hour or day typically *will* be maximized, and short-term constraints are likely to be binding.
       - Hence, opportunity costs of selling energy now generally reflect foregone sales in other markets ***in the same hour or day***

While it is not workable to attempt to forecast *which* constraint(s) will be binding in each hour or day, it is reasonable to expect that hydro systems will be managed to realize the greatest value of the resource

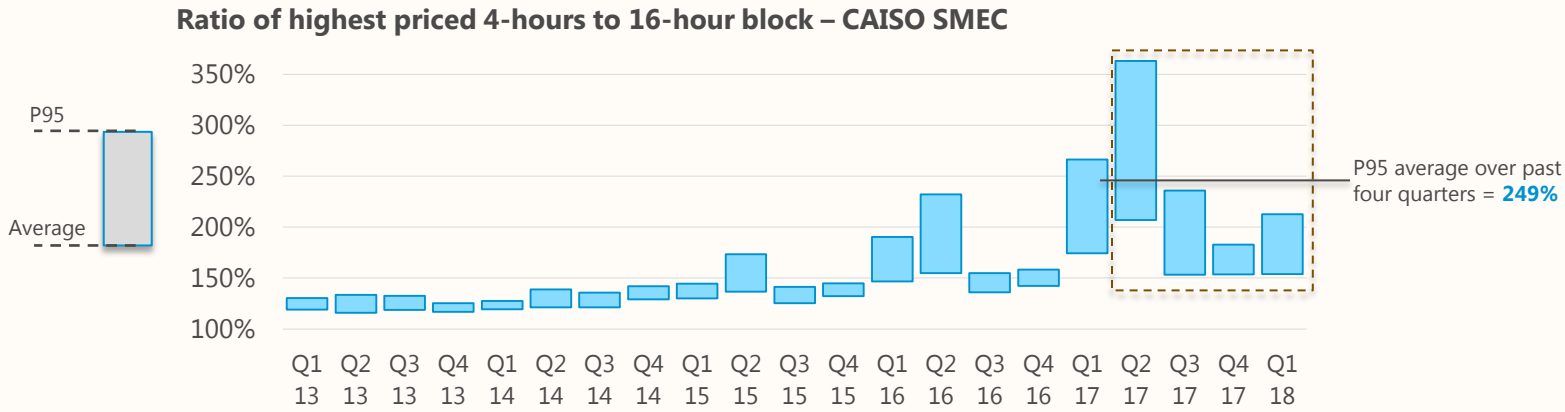
- ***Generally, opportunity costs are likely to be the greater of the shorter-term and longer-term estimated values***

Potential Alternative DEB Approach Based On Short-Term *And* Longer-Term Considerations

- **General concept: DEB = Max (intra-day sales opportunities, longer-term sales opportunities over the storage horizon)**
  - Max function appropriately reflects that
    - (i) when current day prices are higher than forward prices, it is more likely that intra-day sales opportunities will be the marginal sales opportunity foregone; and
    - (ii) when forward prices are higher than current day prices, it is more likely that longer-term sales opportunities over the longer-term storage horizon will be the marginal sales opportunity foregone
    - "Max" is also necessary since it is not workable to accurately predict *which* precise type of constraint will be binding in a given hour
- **Definition of "longer-term" is specific to each resource or system, and should reflect typical system optimization horizon**
  - For hydro systems, "longer-term" will vary by resource/system (i.e. 12-months, 3-months, 1-month, or 1-week)
  - For battery storage or pumped-storage resources that cycle within a day, the second term may not apply at all
- **Estimation of intra-day and longer-term sales opportunities must recognize optionality inherent in storage hydro systems**
  - Storage enables sales to be shaped into the highest-value hours within a day, during the highest-value days within a month, and during the highest-value months within a year.
  - Resources outside the CAISO BAA also have options of which geographic markets to sell to, which increases the number of potential high-value sales opportunities
- ***All optionality has positive value, hence it should be expected that opportunity costs for flexible resources with significant storage capabilities may be well above day-ahead 16-hour block prices, and well above forward monthly block prices***

Estimating Value Of Intra-Day Limit Term

- **Based on ICE On-Peak Index Price at closest trading hub location**
  - Active day-ahead trading in one of the most important bilateral spot market products
- **ICE Index is for 16-hour block, however, and only at a single, specified trading hub location**
  - Actual opportunities will be for *hourly* transactions, at *multiple* potential delivery locations
- **Propose using a multiple of 250% of ICE On-Peak Index Price**
  - Based on analysis of P95 of highest priced 4-hours, compared to 16-hour block (HE7-22), using CAISO day-ahead SMEC

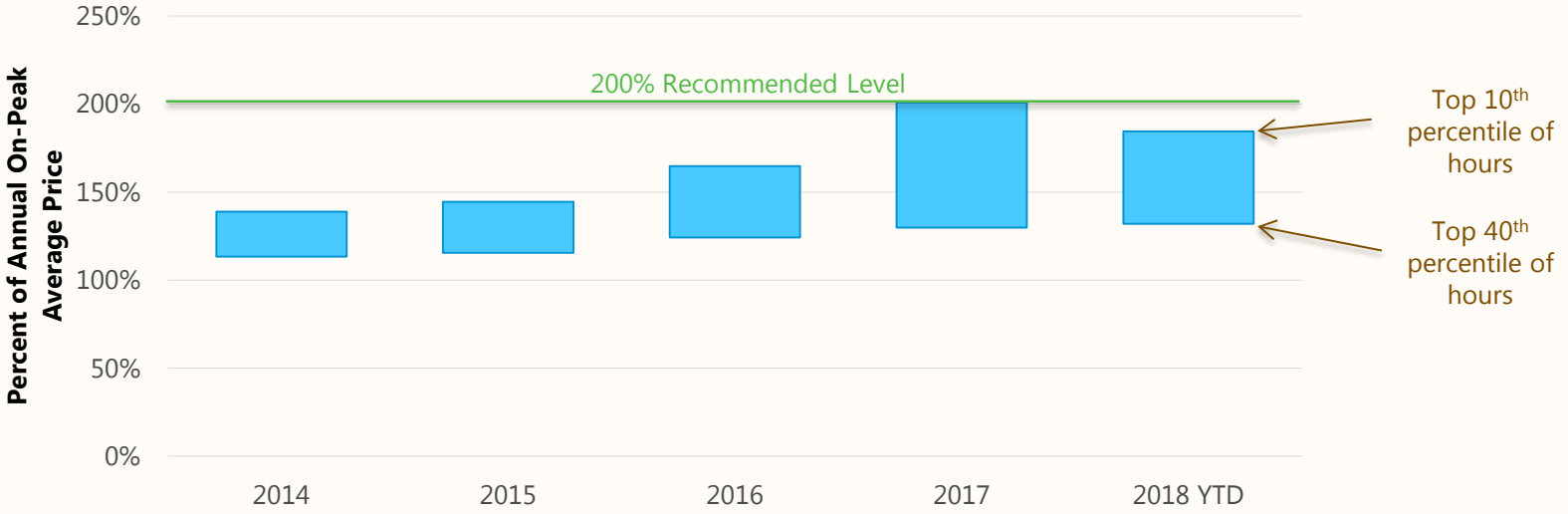


Estimating Value Of Long-Term Energy Limit Term

- **Based on average of forward on-peak monthly block prices at closest trading hub location over resource-specific maximum storage horizon**
  - Northwest energy limited resources may use ICE Day Ahead On-Peak Mid-C Index
  - Other energy limited resources may use different trading hub locations (i.e. PV, NP-15, SP-15)
- **Forward prices are for all 16 on-peak hours, of every on-peak day, of every month over the horizon, and at only one delivery location**
  - Actual opportunities will reflect optionality to save energy for the highest-value hours in the highest-value days in the highest-value months and at the highest-value locations
- **Propose using a multiple of 200% of the average on-peak forward prices over the next 12 months**
  - Based on historical relationship of CAISO day-ahead SMEC in the highest-priced *"X%"* of hours compared to all on-peak hours of the year
  - In establishing an appropriate value for *"X%"*, must consider that:
    - Energy limited systems may generally be selling only in a portion (i.e. <50%) of the hours within a month; and
    - Only a portion of those hours may reflect sales at the specific trading hub, as seller will choose to sell in other, higher-priced locations

Estimating Value Of Long-Term Energy Limit Term (2)

Highest Priced 10th to 40th Percentile of Hours Relative to Annual On-Peak Average Price (2014 to 2018 YTD)



Summary Of Potential Alternative Proposal

- **DEB = Max (250% x ICE Day Ahead On-Peak Index Price, 200% x Average On-Peak Forward Prices)**
- **Selection of trading hubs based on location of resource**
  - Northwest resources use Mid-C;
  - Southwest resources use PV;
  - California resources use NP-15 or SP-15
- **Forward horizon selected based on the specific storage capabilities of resource**
  - *e.g.,* 12 months for systems with annual storage
- **Both parameters (250% and 200%) can be updated if actual pricing relationships change materially**
  - Relationships between prices in highest hours and the average price across all hours continues to change as grid conditions evolve
  - Propose adjustments be made in 50% increments

Benefits Of Potential Alternative Proposal

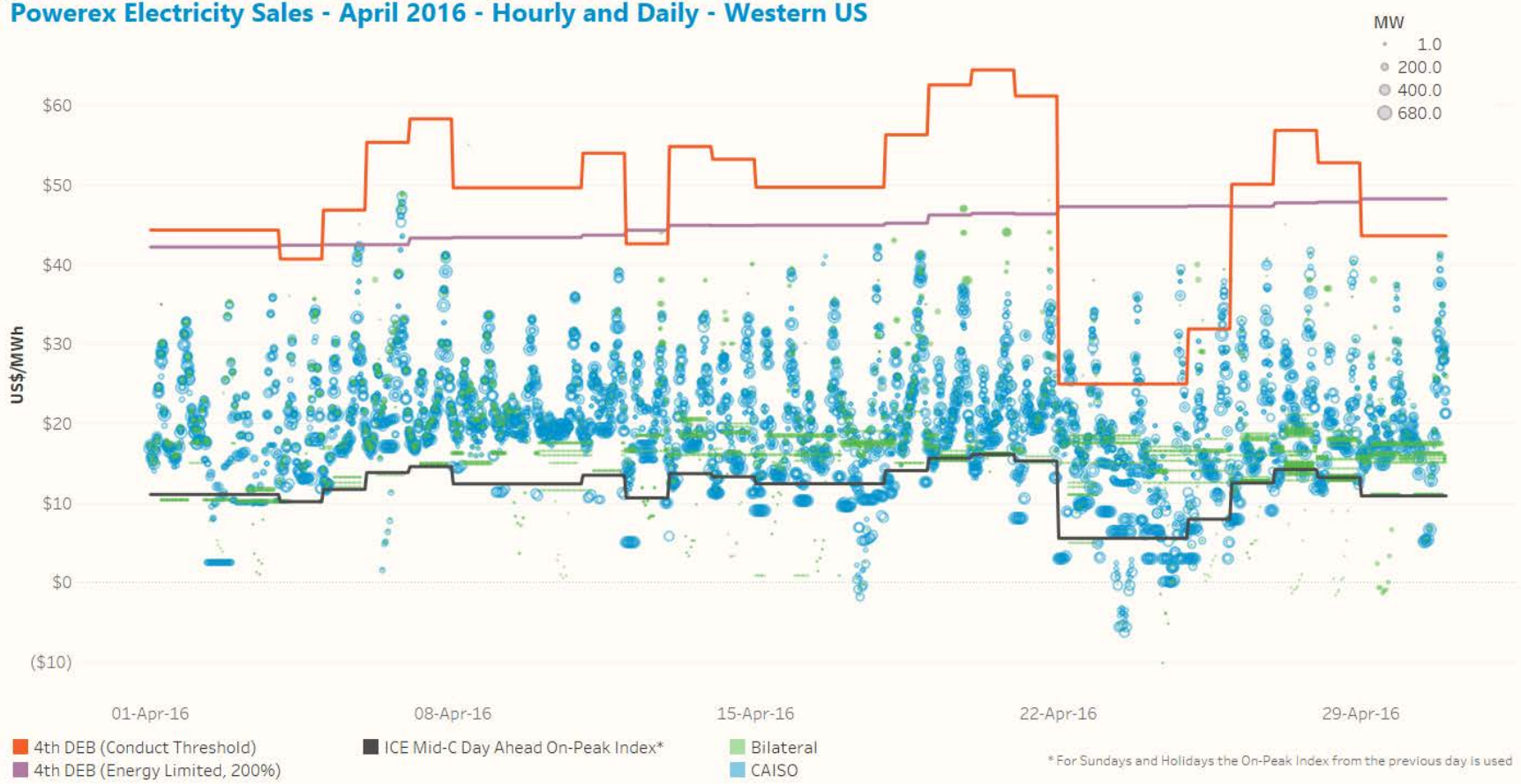
- **Alternative Proposal utilizes extensive resource-specific information:**
  1. Day-ahead index prices at the trading hub location that is closest to the resource
  2. Forward prices at the trading hub location that is closest to the resource
  3. Maximum storage horizon of the *particular* resource or system
  4. Actual historical relationships between daily multi-hour block prices and hourly prices in the best hours of the day
  5. Actual historical relationships between monthly block forward prices and hourly prices in the best hours of the maximum storage horizon
- **Alternative Proposal would result in a lower DEB than a DEB based on the conduct threshold used in Eastern markets**
  - More tailored to the specific resource, using relevant data rather than fixed (and arguably arbitrary) parameters ($25, 300%, $100)
- **Critically, Alternative Proposal provides flexibility necessary to recognize that the formula does not capture all relevant factors**
  - Does not reflect which *specific* constraints actually bind, the *actual* quantity of energy that will be available for sale, the *actual* storage horizon, or the *actual* prices of future hourly sales opportunities at various locations

Evaluating How This Alternative Fourth DEB Would Have Performed

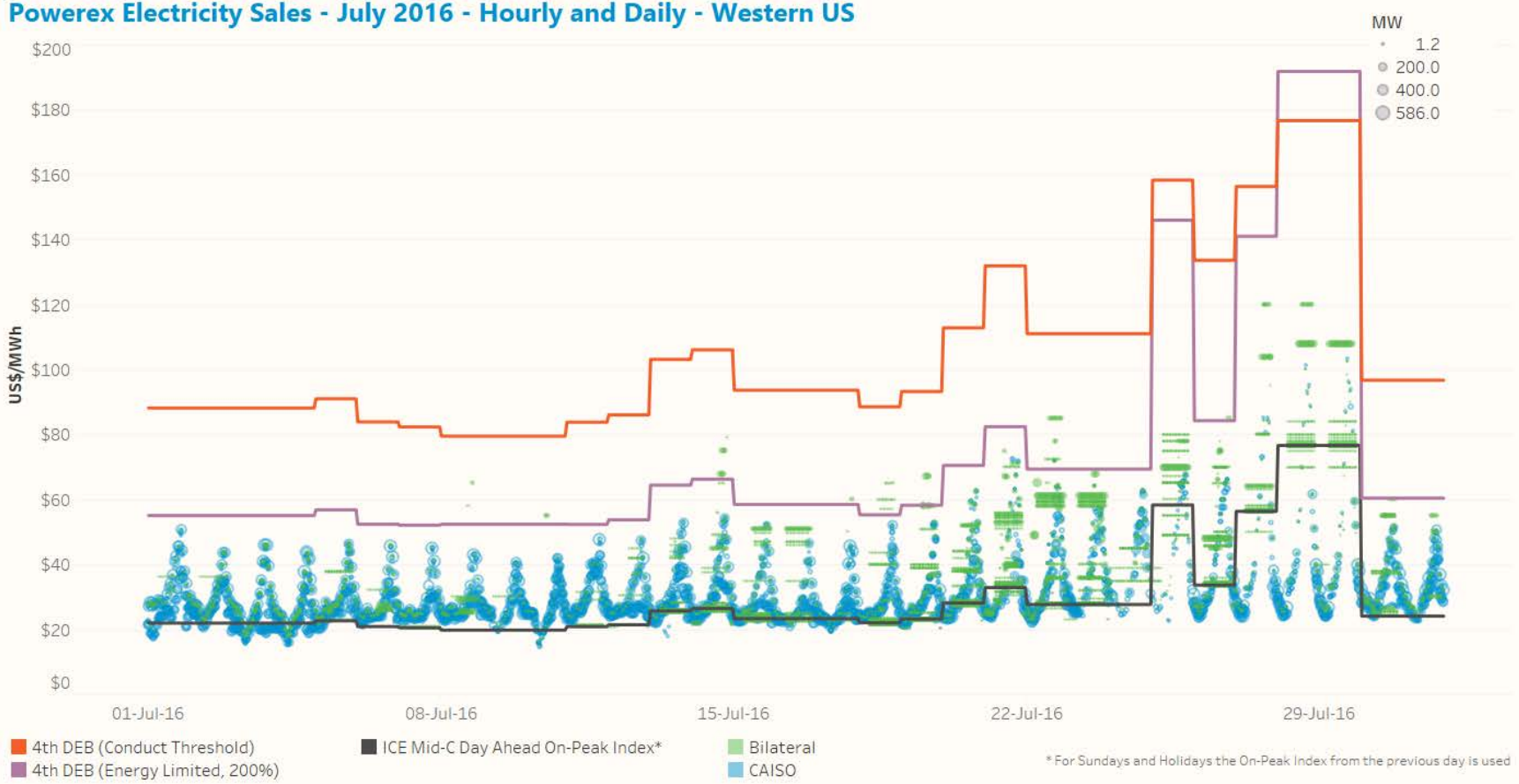
- **The following charts compare:**
  - A Fourth DEB based on the Eastern Conduct Threshold, and using local trading hub day-ahead price index
    - Max ($25/MWh, Ref Price + Min ($100/MWh, 300% Ref Price)), with the Ref Price = ICE Day Ahead On Peak Mid-C Index
    - Chart label: **"4th DEB (Conduct Threshold)"**
  - A Fourth DEB based on resource-specific parameters, using local trading hub day-ahead price index and forward price indices
    - Max (250% ICE Day Ahead On-Peak Mid-C Index, 200% Average ICE Forward On-Peak Mid-C Index for next 12 months)
    - Chart label: **"4th DEB (Energy Limited, 200%)"**
  - Powerex's Daily/Hourly Sales in Western US (January 2016 – September 2017)
    - Source: FERC EQR Data
    - Includes bilateral sales and sales to CAISO, plotted separately
    - Does not include forward sales, Alberta sales, or sales at BC-US border
    - Data includes Powerex sales delivered from BC Hydro BAA and from other source locations
  - For reference, the ICE Day Ahead On-Peak Mid-C Index is also shown

Note: for Sundays and NERC holidays, the Day Ahead On-Peak Mid-C Index for the previous day is used

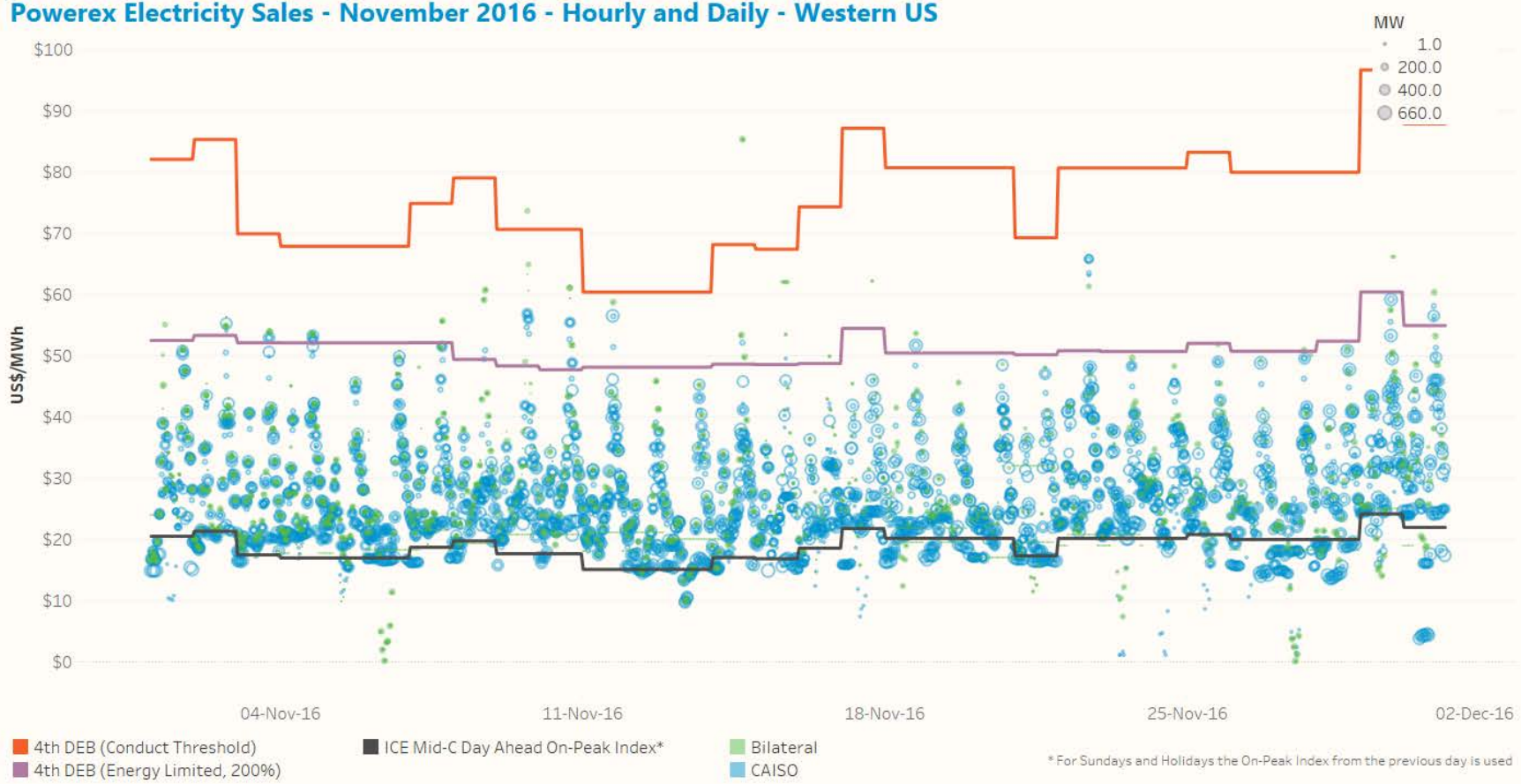
Powerex Electricity Sales - April 2016 - Hourly and Daily - Western US



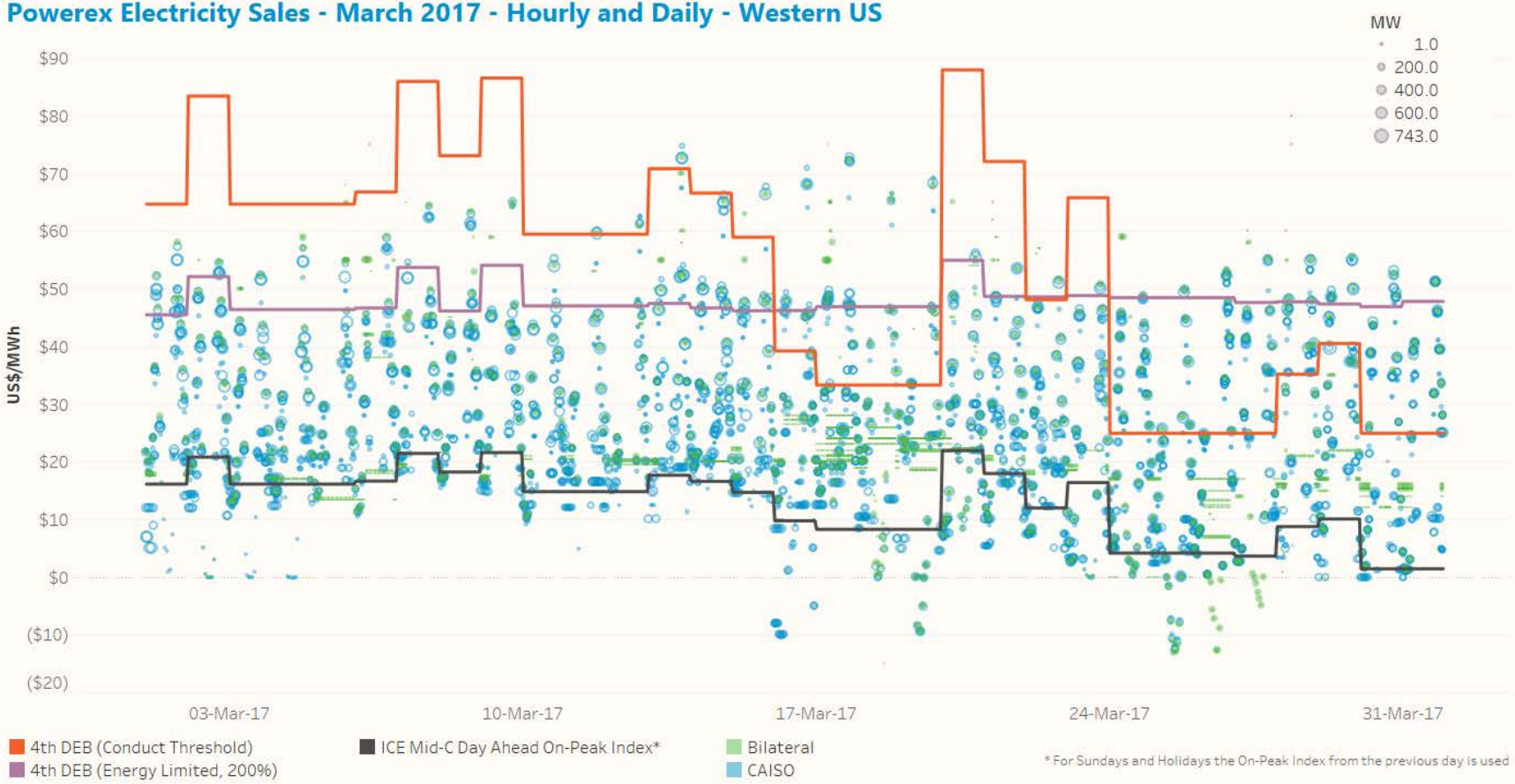
Powerex Electricity Sales - July 2016 - Hourly and Daily - Western US



Powerex Electricity Sales - November 2016 - Hourly and Daily - Western US



Powerex Electricity Sales - March 2017 - Hourly and Daily - Western US



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Thank You

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