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CAISO LMPM Enhancements Working Group Meeting

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October 10th, 2018

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CAISO LMPM / DEB Improvements

CAISO is considering three areas of improvement

1. **Reduce inaccurate triggering and misapplication of LMPM**

2. **Limit volume that is subject to mitigation**
   - Recognize EIM is a **voluntary market**
   - Recognize that EIM BAAs are relying on a **defined quantity** of imports to serve load/imbalances

3. **Improve EIM Hydro Resource DEBs**
   - Requires a fair balance between:
     - Maximizing **protection** for buyers; and
     - Minimizing **harm** to hydro sellers in a voluntary market

1. Reduce Inaccurate Triggering And Misapplication Of LMPM

Powerex supports several proposed improvements

- Eliminate rules that extend mitigation to future intervals or market runs
- Calculate “competitive LMP” independently for each interval
- Improve calculation of competitive LMP

These improvements will help address

- Inaccurate “extension” of LMPM to intervals that have no potential market power
- Inefficient “flow reversal” of a BAA from a net importer to a net exporter

2. Limit Volume That Is Subject To Mitigation

Limited volume of EIM offers / exports should be subject to mitigation

- EIM is a **voluntary market**
- EIM offers / exports used for **economic displacement** should not be mitigated
- However, EIM BAAs are relying on a **defined quantity** of imports to serve load/imbalances

Powerex supports limiting increases in BAA export volumes due to mitigation

- Likely too technically challenging to limit application of mitigation to resource offer quantities
- CAISO proposal to instead **limit EIM BAA export quantities** to LMPM run export volume appears workable
  - ETSR scheduling limits already apply to every path apply and in every interval
  - CAISO already further limits ETSRs (e.g., due to RS failures)

Powerex supports an export limit conceptually, but believes the limit should be refined to

Max (LMPM run export volume, FRST Up volume required minus BAA imbalances when negative)

3. Improve EIM Hydro Resource DEBs

CAISO Straw Proposal is a good starting point:

MAX (DA Peak Index, MA Index$_{+1}$, MA Index$_{+2}$, … , MA Index$_{+N}$) x 1.10

Powerex believes two key areas of improvement are needed:

1. Adder of 10% is overly simplistic and often insufficient
   - Historical data analysis supports significantly higher percentage
   - Lower price conditions may be better addressed with a $/MWh floor
     - Consider: **Adder = Max (X%, $Y/MWh)**

2. Consideration of **multiple geographic trading locations** is necessary
   - Some sellers have transmission rights to reach multiple geographic markets
   - Physical sales at these locations are linked to the resource's output, and are relevant to its opportunity costs
   - DEB must recognize that sellers will rationally sell in the **higher priced periods** and at **higher priced locations**

3. Improve EIM Hydro Resource DEBs

Powerex believes EIM hydro resources could be categorized for DEB purposes as:

- **Short-term:** Resources with <24 hours of maximum storage
- **Within-month:** Resources with < 1 month of maximum storage
- **Long-term:** Resources with > 1 month of maximum storage

Maximum storage horizon should be based on general characteristics and general operations of participating resource at the time the new EIM Hydro DEB option is selected

- **Not workable** for a third party to attempt to precisely quantify a resource's storage horizon at a given time

DEB formula adders should be the same for all resources within a category above

- Adder must sufficiently reduce risk of inefficiently depleting water within the storage horizon
- Based on analysis of historical data

Assessing Potential DEB Adders For **Long-Term** Storage Hydro Resources

Straw Proposal DEB Approach Appears Promising For Long-Term Storage Resources

- Recognizes that hydro resources seek to maximize opportunities within available horizon
  - **On-peak daily** bilateral index price recognizes opportunities to sell outside of EIM in the same hour or day
  - **On-peak futures prices** recognize that selling limited energy now generally reflects forgone future opportunities

- Use of **single best future month** represents a **potentially workable** tradeoff between:
  - Assuming that sales in lower-priced months can be avoided; but also
  - Not recognizing ability to sell during the best hours on the best days

- A DEB for long-term storage resources may be workable with a **lower multiplier** than for other resources because of the benefit of a DEB formula that uses the **single best month** in the multi-month storage horizon

Straw Proposal Must Recognize Opportunities At Multiple Locations

- **Straw Proposal uses prices at a single location**
  - Ignores opportunities at other relevant locations
  - Powerex transacts at over **80 locations**
    - *e.g.*, Mid-C is often the lowest-priced market opportunity for Powerex (and may be a *purchase* location)

- **It is necessary to consider multiple geographic trading locations**
  - Some sellers have transmission rights to reach multiple geographic markets
  - Physical sales at these locations are dependent on resource's capabilities and are relevant to opportunity costs
  - DEB must recognize that sellers will rationally sell in the **higher priced periods** and at **higher priced locations**

- **Benefits of including multiple locations:**
  - Makes DEB more **durable** as futures prices evolve at different locations
  - Avoids need for a much higher multiplier

Straw Proposal Must Recognize Opportunities At Multiple Locations

- **Impractical to consider all locations at which an entity may potentially transact**
  - Suggest including most relevant liquid locations
  - Based on entity's actual ability to transact at those locations
  - *e.g.*, for Powerex: ***Mid-C, Alberta, CAISO Interties (COB, NOB, Sylmar), Paloverde***
    - Proxy forward prices for CAISO interties could be calculated by CAISO by examining historical relationships to Mid-C, NP15 and SP15 prices

- **Entities with access to multiple geographic regions will seek the best opportunities when and where they are available:**
  - If a particular *location* is consistently higher-priced, the entity may sell **multiple months** at that **single location**
  - If a particular *time period* is higher-priced at all locations, the entity may sell that **single period** at **multiple locations**

Straw Proposal Must Recognize Opportunities At Multiple Locations

- **Example for 12-month resource with 6 geographic locations**
  - Straw Proposal DEB = MAX (DA Peak Index, MA Index+1, MA Index+2,.., MA Index+12) x Y Adder

- **For Monthly Indices, entity will have 12 months * 6 location = 72 data points**
  - **Too generous** to allow entity to choose **single best month** and **single best location** *(best 1 of 72 data points)*
  - Instead, propose using the **average** of **top 6 prices** *(average of best 6 of 72 data points)*
    - Could be one location for 6 months, or could be 6 locations in 1 month, or another combination
    - Maintains ratio of top 1/12 of future prices, consistent with original formula for a 12-month resource

- **For Daily Indices, entity will have 6 locations**
  - **Too generous** to allow entity to choose **single best location**
  - Instead, propose using the average of top half of locations

Max (Average Top 3 (*of 6*) Daily Peak Indices, Average of top 6 (*of 72*) monthly futures prices) + Adder

Assessing Potential DEB Adders For **Short-Term** Storage Hydro Resources

Assessing An Appropriate DEB Adder

To assess whether a DEB adder is appropriate, must consider that:

- A DEB will only **reduce** an offer price, but never increase it
- Decreasing an offer price generally increases sales of energy
- These sales in the **wrong hours** will prematurely **deplete** a resource's limited water

Assessing potential DEBs requires the right analysis

- Key metric is **not** whether the DEB is equal to a resource's opportunity cost **on average**
- A DEB that is accurate **on average** will still be **too low** in many hours

Instead, key metric asks *how often* is the DEB is too low?

- Indicates risk of depleting water prematurely and inefficiently

DEB Performance ***On Average*** Is Not The Relevant Metric

Relative Value of Highest Mid-C Hours in 2017 (as % of DA Mid-C Index)	
1st	126%
2nd	120%
3rd	115%
4th	112%
5th	109%
6th	105%

Consider an EIM NW short-term hydro resource that:

- Is capable of selling **only at Mid-C**
- Has **4 hours per day** residual supply beyond native load

10% adder may *appear* reasonable *on average*

- Price of 4th or 5th highest priced hour of the day is, on average, about 10% more than on-peak index

But averages mask how often a 10% adder is too low:

- **Key metric:** In how many days were there more than 4 hours above the on-peak index plus 10%?

Note: analysis and results are preliminary and have not been thoroughly reviewed

Assessing An Appropriate DEB Adder: Short-Term Storage Resources

- Powerex used a **highly simplified** model using historical index price data to better understand the impact of various adders on a short-term storage resource at Mid-C
  1. Calculate a potential DEB for each day during 2017, where

     DEB = DA Mid-C On-Peak + X% (DA Mid-C On-Peak)
  2. For each hour, if DEB < Hourly Mid-C Real-time price, resource is dispatched
  3. If resource is dispatched more than **Y** hours in the day, water is depleted
  4. Evaluate for multiple values of adder (***X***) and hours of residual energy supply (***Y***)
- Simple analysis does **not** reflect real-world conditions:
  - Assumes a resource's only opportunity is to transact at Mid-C Hourly Real-time prices
  - Assumes Real Time prices are known in advance
  - Assumes a predetermined fixed quantity residual energy supply for each day

Assessing An Appropriate DEB Adder: Short-Term Storage Resources

*How many **days per year** would the resource's water be **inefficiently depleted?***

Adder (% of Mid-C DA Index)	Expected Surplus Energy per Day				
	4 Hours	6 Hours	8 Hour	10 Hours	12 Hours
10%	167 days	124 days	88 days	52 days	28 days
25%	108	63	41	23	9
50%	59	37	24	13	5
75%	39	24	12	8	3
100%	24	17	8	5	3
150%	18	7	5	3	2
200%	10	6	4	2	1

Short-term markets are highly volatile:

- Hourly prices in peak hours can be **much greater** than 16-hour block prices
- Real-time prices can vary dramatically from DA prices
- Real-time price expectations can change within a short period

The consequences of depleting a short-term resource's water supply can be severe:

- Economic harm
- Environmental impacts
- Violation of federal operating licenses
- Interruption to other sales commitments

An acceptable adder must be sufficiently high to minimize risk of depleting water

Note: analysis and results are preliminary and have not been thoroughly reviewed

Assessing An Appropriate DEB Adder: Short-Term Storage Resources

*Including a **$10/MWh Floor** on Adder*

Original Approach

Adder	Expected Surplus Energy per Day				
	4 Hours	6 Hours	8 Hour	10 Hours	12 Hours
10%	167	124	88	52	28
25%	108	63	41	23	9
50%	59	37	24	13	5
75%	39	24	12	8	3
100%	24	17	8	5	3
150%	18	7	5	3	2
200%	10	6	4	2	1

$78.95 Average DEB

Results with $10/MWh Floor

Adder	Expected Surplus Energy per Day				
	4 Hours	6 Hours	8 Hour	10 Hours	12 Hours
10%	51	27	13	5	2
25%	51	27	13	5	2
50%	44	23	10	5	0
75%	31	14	5	2	0
100%	18	9	3	2	0
150%	12	2	2	1	0
200%	7	2	2	1	0

Average DEB $65.89

A fixed $/MWh floor enables **greater protection to buyers** by resulting in a lower DEB on average, while also providing **greater protection to sellers** with fewer days of inefficient depletion

Note: analysis and results are preliminary and have not been thoroughly reviewed

Assessing An Appropriate DEB Adder: Short-Term Storage Resources

Conclusions

- The previous simple examples illustrate the ***inherent impossibility*** of calculating an accurate DEB using a formula, even with ***perfect information*** about future prices and available residual energy

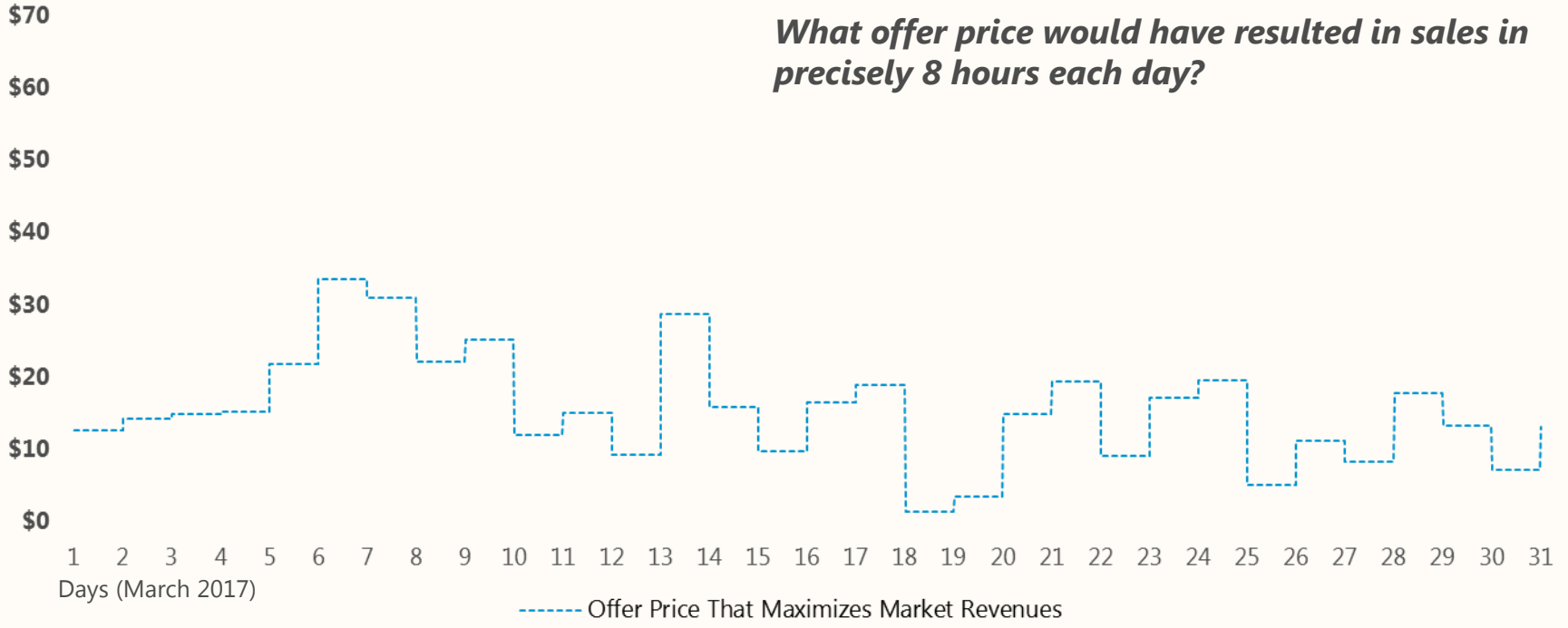
- Sellers' years of experience with the unique features of their own hydro systems enable them to minimize risk of inefficient production and sales decisions, even as conditions change
  - In organized markets, offer price is used to make the ***right quantity*** of sales in the ***right hours***
  - A DEB can interfere with this process

- An acceptable DEB adder must be sufficiently high to ***minimize risk*** of inefficient dispatch
- It appears that using a 150% adder with a floor of $10/MWh ***may be*** workable for short-term storage resources

DEB = DA Mid-C On-Peak + Max ($10/MWh, 150% * DA Mid-C On-Peak)

Closer Look At Short-Term Storage Resources

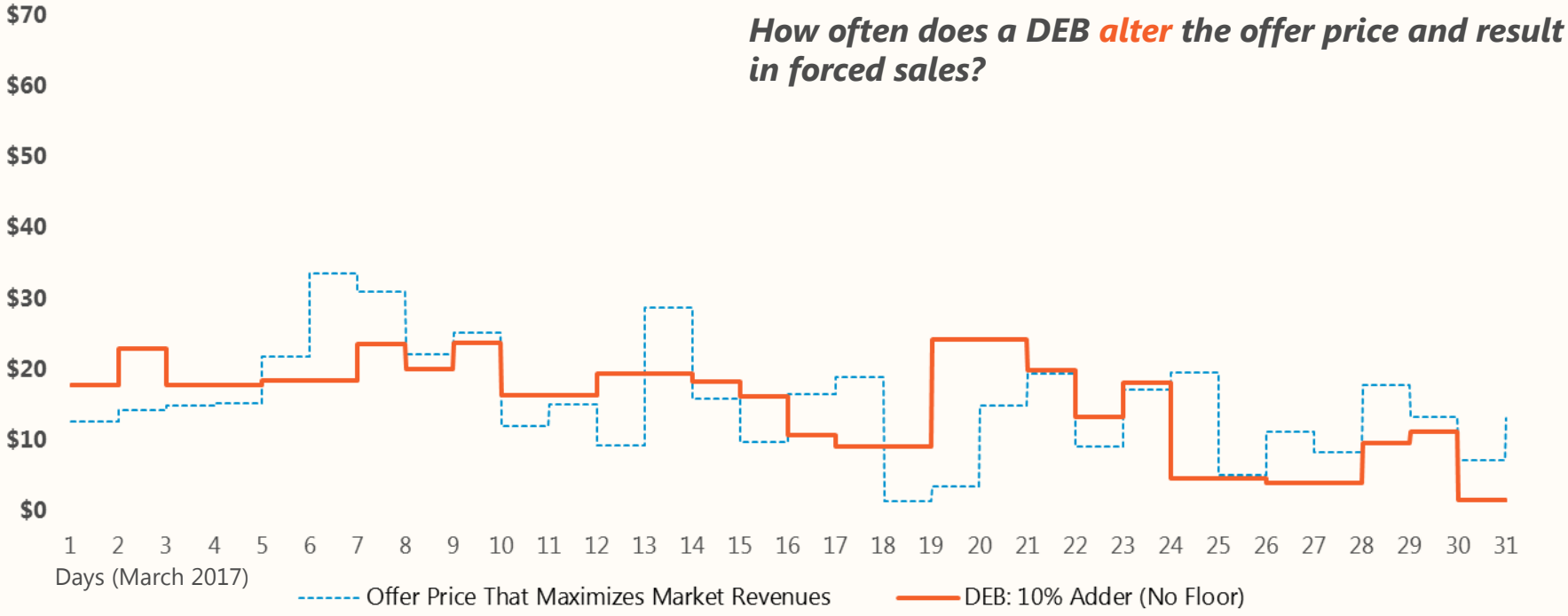
Hypothetical Example: Resource With 8 Hours Per Day Of Residual Water



Note: analysis and results are preliminary and have not been thoroughly reviewed

Hypothetical Example: Resource With 8 Hours Of Residual Water

DEB – 10% Adder, No Floor



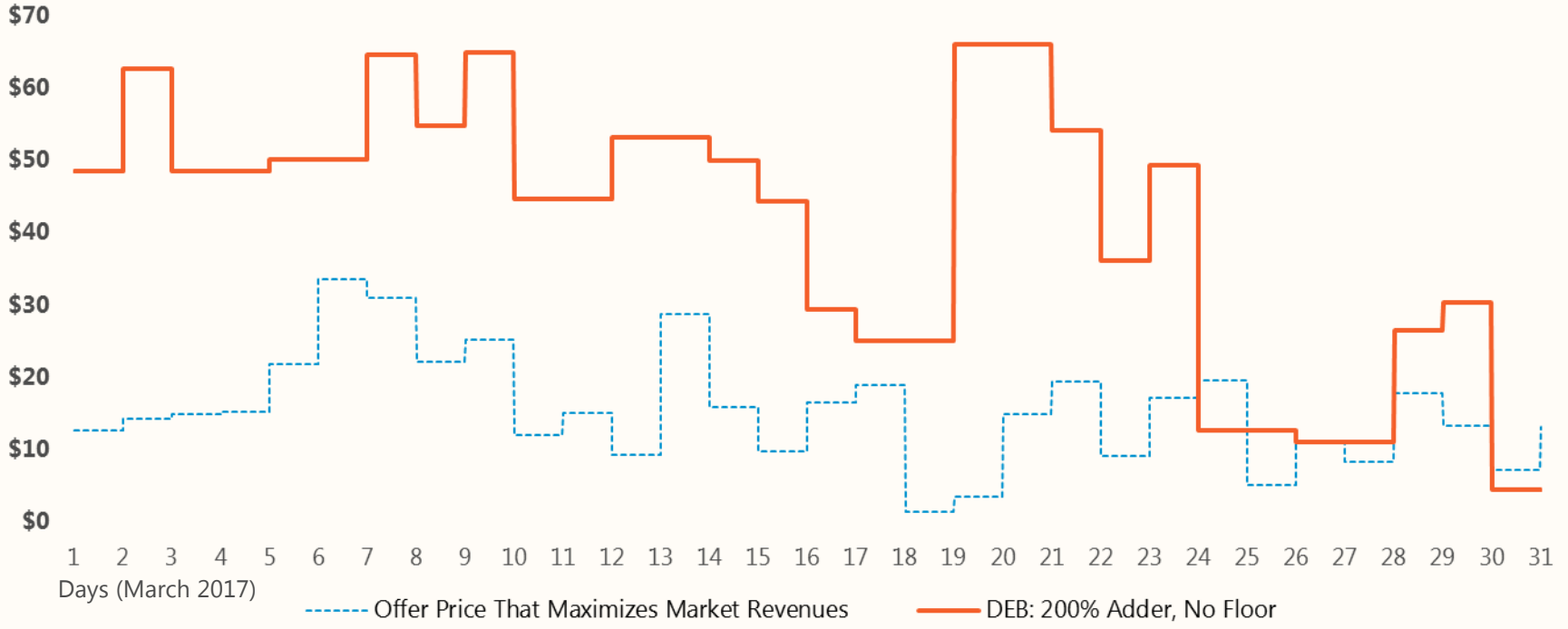
How often does a DEB alter the offer price and result in forced sales?

DEB results in forced sales in 16 days, inefficiently depleting water

Note: analysis and results are preliminary and have not been thoroughly reviewed

Hypothetical Example: Resource With 8 Hours Of Residual Water

*DEB – **200%** Adder, No Floor*



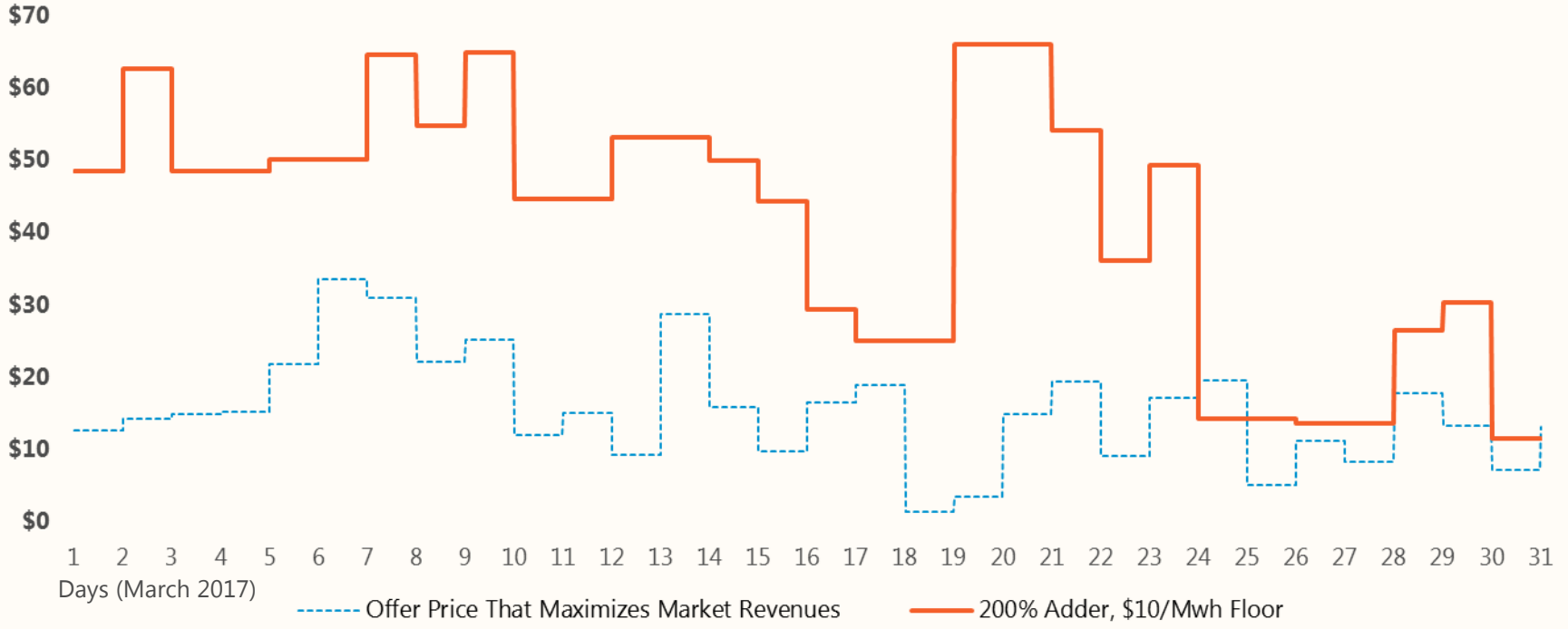
A relatively high adder reduces, but does not eliminate the problem

DEB results in forced sales in 4 days, inefficiently depleting water

Note: analysis and results are preliminary and have not been thoroughly reviewed

Hypothetical Example: Resource With 8 Hours Of Residual Water

*DEB – 200% Adder, **$10/MWh Floor***

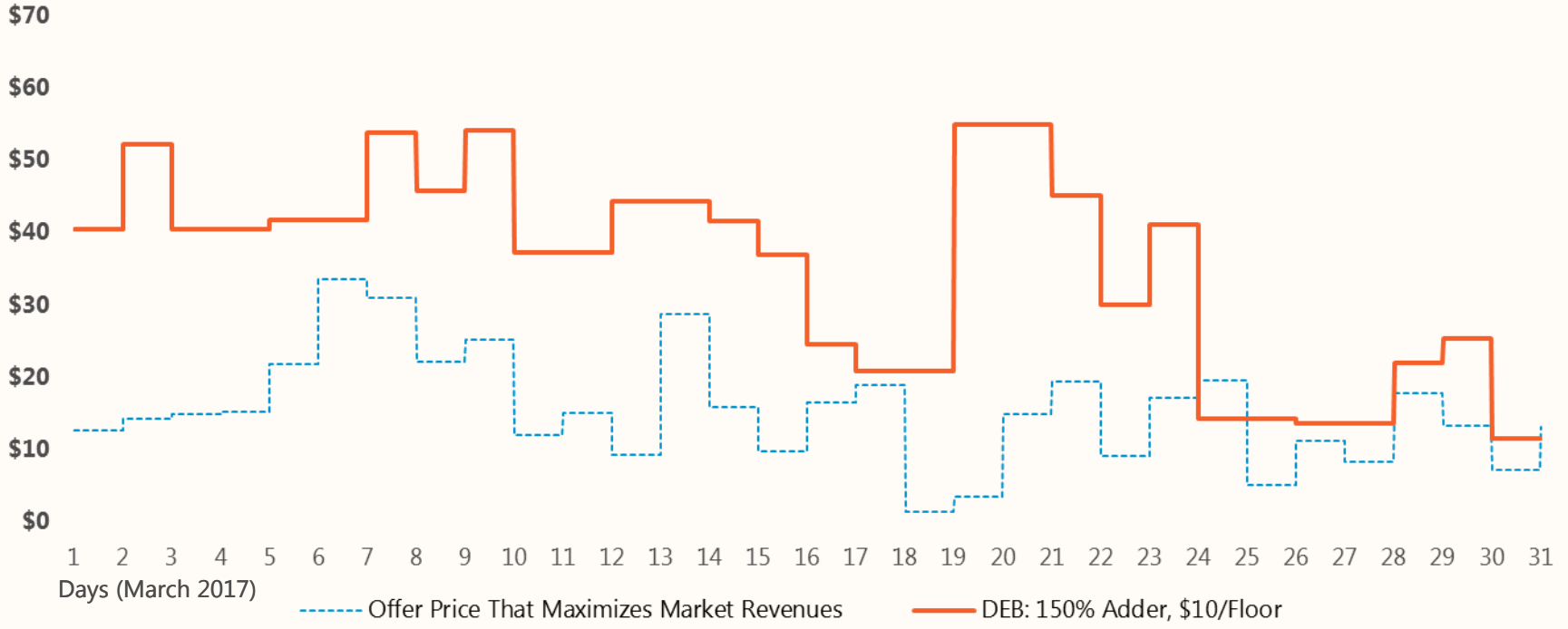


Adding a $10/MWh floor further limits harm to 2 days

Note: analysis and results are preliminary and have not been thoroughly reviewed

Hypothetical Example: Resource With 8 Hours Of Residual Water

*DEB – **150%** Adder, $10/MWh Floor*



DEB adder of 150% and $10/MWh Floor *may be* workable
DEB still results in forced sales in 2 days

Note: analysis and results are preliminary and have not been thoroughly reviewed

Assessing Potential DEB Adders For ***Within-Month*** Storage Hydro Resources

Assessing An Appropriate DEB Adder: Within-Month Storage Resources

- Powerex used a **highly simplified** model using historical index price data to better understand the impact of various adders on a within-month storage resource at Mid-C
  1. Calculate a potential DEB for each day during 2017, where:

     DEB = Max (DA Mid-C On-Peak, Prompt Month Mid-C Peak Futures Price) + X%

  2. For each hour, if DEB < Hourly Mid-C Real-time price, resource is dispatched
  3. If resource is dispatched more than ***Y*** hours in month, water is depleted for duration of the month
  4. Count the remaining days in each month that at least one potentially economic transaction was not possible because water is inefficiently depleted
  5. Evaluate for multiple values of adder (***X***) and hours of residual energy supply (***Y***)
- Simple analysis does **not** reflect real-world conditions:
  - Assumes a resource's only opportunity is to transact at Mid-C Hourly Real Time prices
  - Assumes RT prices are known in advance
  - Assumes a predetermined quantity of residual energy supply for each month

Assessing An Appropriate DEB Adder: Within-Month Storage Resources

*How many **days per year** would the resource's water be **depleted?***

Adder	Expected Surplus Energy per Month				
	40 Hours	80 Hours	120 Hours	160 Hours	200 Hours
10%	116 Days	64 Days	30 Days	9 Days	2 Days
25%	72	43	9	4	0
50%	42	13	4	0	0
75%	22	5	0	0	0
100%	7	0	0	0	0
150%	0	0	0	0	0
200%	0	0	0	0	0

Actual hourly prices within a month can vary widely from both DA and prompt month futures price

- *e.g.*, what will prices be at Mid-C for the top 6 hours of the next 5 weekdays starting in three days from today?

Seller's expectations are subjective and based on many uncertain factors, such as:

- short-term weather forecasts
- expected discharge of up-stream hydro facilities (which may be operated by a different entity)

An acceptable adder must be sufficiently high to minimize risk of inefficiently depleting water within the month

Note: analysis and results are preliminary and have not been thoroughly reviewed

Assessing An Appropriate DEB Adder: Within-Month Storage Resources

Including a $10/MWh Floor on Adder

Original Results

Adder	Expected Surplus Energy per Month				
	40 Hours	80 Hours	120 Hours	160 Hours	200 Hours
10%	116 Days	64 Days	30 Days	9 Days	2 Days
25%	72	43	9	4	0
50%	42	13	4	0	0
75%	22	5	0	0	0
100%	7	0	0	0	0
150%	0	0	0	0	0
200%	0	0	0	0	0

Average DEB $58.45

Results with $10/MWh Floor

Adder	Expected Surplus Energy per Month				
	40 Hours	80 Hours	120 Hours	160 Hours	200 Hours
10%	44 Days	6 Days	0 Days	0 Days	0 Days
25%	44	6	0	0	0
50%	36	6	0	0	0
75%	21	3	0	0	0
100%	6	0	0	0	0
150%	0	0	0	0	0
200%	0	0	0	0	0

It appears that using a 100% adder with a floor of $10/MWh could be workable for monthly storage resources

DEB = Max (DA, Prompt) + Max [$10/MWh, 100% * Max(DA, Prompt)]

Note: analysis and results are preliminary and have not been thoroughly reviewed

Summary

Straw Proposal DEB approach appears promising, with modifications:

- Historic data analysis supports significantly higher percentage
- Lower price conditions require a dollar/MWh floor
- DEB formula should reflect opportunities at **multiple locations** relevant to each supplier

A balanced DEB makes a conduct threshold exemption less necessary

Based on initial analysis, the following DEBs merit further consideration:

- Short-Term Resources: **DA Mid-C On-Peak + Max ($10/MWh, 150% * DA Mid-C On-Peak)**
- Medium-Term Resources: **Max (DA Peak, MA Index$_{+1}$) + Max [$10/MWh, 100% * Max(DA Peak, MA Index$_{+1}$)]**
- Long-Term Resources:
  - A **lower multiplier** may be possible for Long-Term Storage resources because these resources get the benefit of choosing the **single best month** in the storage horizon
  - More analysis needed with multiple geographic regions

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Thank You

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