EIM PacifiCorp Benefits Study

Stakeholder Call – Meeting

April 1, 2013

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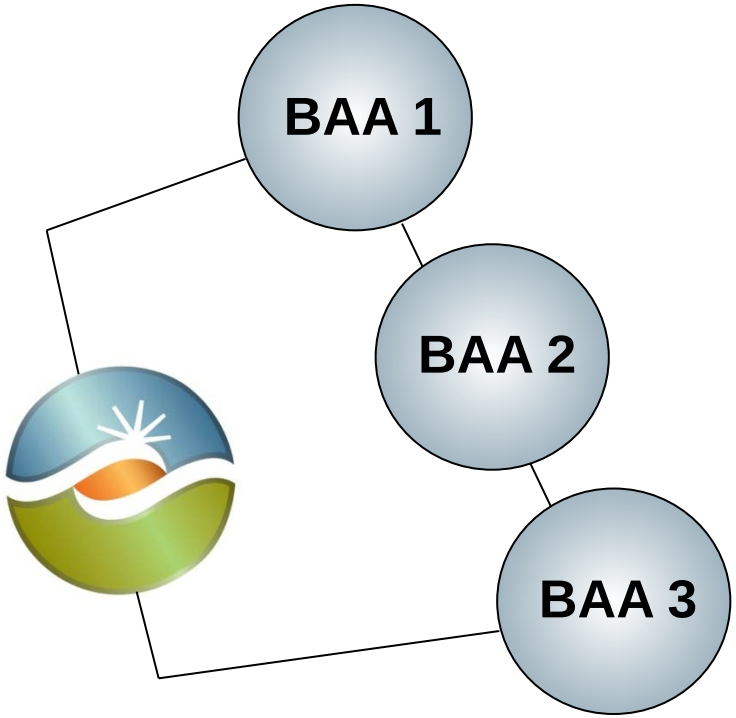
Overview

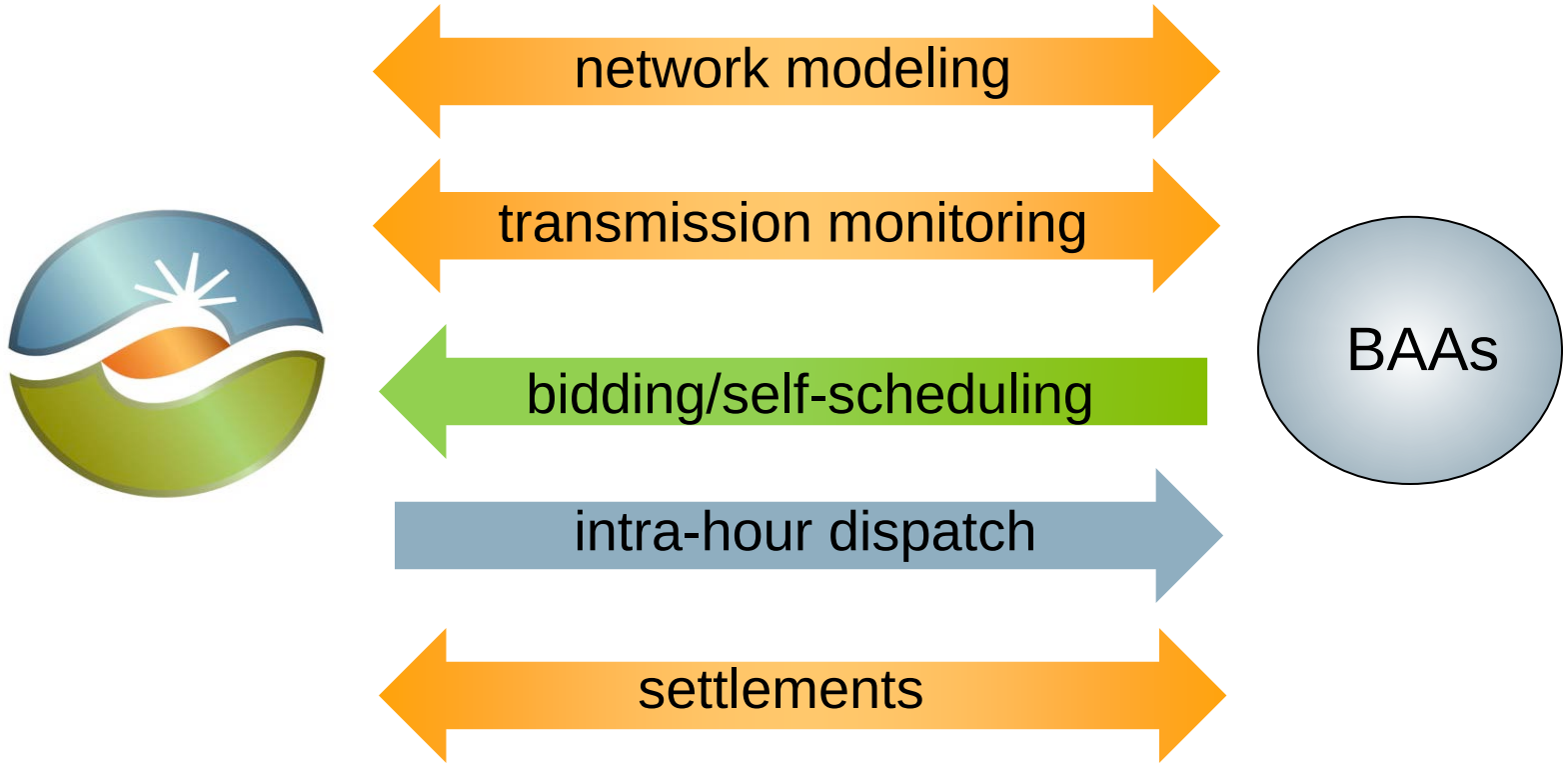
- Background
- Overview of benefits
- Methodology
- Conclusion
- Questions

March 2012, CAISO proposed a scalable approach for implementing Energy Imbalance Market (EIM)



- No critical mass required – each participant can enter EIM when ready
- Preserves participants' autonomy and current practices
  - Balancing authorities balance and provide their own ancillary services
  - Balancing authorities can trade bilaterally
  - Participants retain all physical scheduling rights
  - Flexible modes of participation are available

CAISO proposed a scalable approach for implementing Energy Imbalance Market (EIM)



Potential for significant EIM benefits quantified by others.

Study (Organization)	Annual Benefits ($MM)	Geographic Scope	Key Drivers of Differences with Study
WECC EIM (E3)	$141 in 2020	WECC excluding ISO and AESO	• WECC EIM study had similar approach to this study • WECC EIM study had larger EIM footprint than this study • WECC study excluded intraregional dispatch savings; this study includes intraregional dispatch savings • No assessment of renewable curtailment reduction in WECC study; this study includes benefits of renewable curtailment reduction
PUC EIM Group (NREL)	$349 in 2020	WECC excluding ISO and AESO	• PUC EIM study had larger EIM footprint than this study • PUC EIM study modeled 10-minute dispatch; this study models hourly dispatch • PUC EIM study required more reserve in base case due to earlier schedule lockdown, increasing EIM benefits; this study assumed later lockdown • PUC EIM study included regulation reserve savings for EIM; this study assumes no regulation reserve savings
WECC VGS (PNNL)	$755-$1,11 2 in 2020	Entire WECC	• WECC VGS study had larger EIM footprint than this study • VGS study modeled 10-minute bilateral scheduling, not EIM • In VGS study, no savings due to reduced reserves or reduced transactional friction, which means all savings due to within- hour efficiency gains; this study includes savings from reduced reserves or transactional friction
NWPP EIM (PNNL)	Pending	NWPP	• Similar approach to WECC VGS study • Detailed results pending

E3 quantified 4 benefits of PacifiCorp-CAISO EIM

- **Interregional dispatch savings**, by realizing the efficiency of combined 5-minute dispatch, which would reduce “transactional friction” (e.g., transmission charges) and alleviate structural impediments currently preventing trade between the two systems;
- **Intraregional dispatch savings**, by enabling PacifiCorp generators to be dispatched more efficiently through the ISO’s automated system (nodal dispatch software), including benefits from more efficient transmission utilization;
- **Reduced flexibility reserves,** by aggregating the two systems’ load, wind, and solar variability and forecast errors; and
- **Reduced renewable energy curtailment,** by allowing BAs to export or reduce imports of renewable generation when it would otherwise need to be curtailed.

Estimated EIM Benefits are a Function of the Following Key Variables

- Dynamic Transfer Capability
  - Low Case 100 MW
  - Medium Case 400 MW
  - High Case 800 MW
- Percent of Hydropower capability available to meet flexible reserves
  - High Case 12%
  - Low Case 25%
- Share of interregional dispatch savings achieved
  - High Case 100% of hour savings
  - Low Case 10% of hourly savings
- Reduction in renewable energy curtailment
  - High Case 100% of 2022 estimate
  - Low Case 10% of 2022 estimate

A range of assumptions were considered with focus on making low end conservative

Low and high range assumptions under low (100 MW), medium (400MW), and high (800MW) transfer cabability

Assumption	Low transfer capability		Medium transfer capability		High transfer capability	
	Low Range	High Range	Low Range	High Range	Low Range	High Range
Maximum hydropower contribution to contingency and flexibility reserves*	25%	12%	25%	12%	25%	12%
Share of intraregional dispatch savings achieved	10%	100%	10%	100%	10%	100%
Share of identified renewable energy curtailment avoided	10%	100%	10%	100%	10%	100%

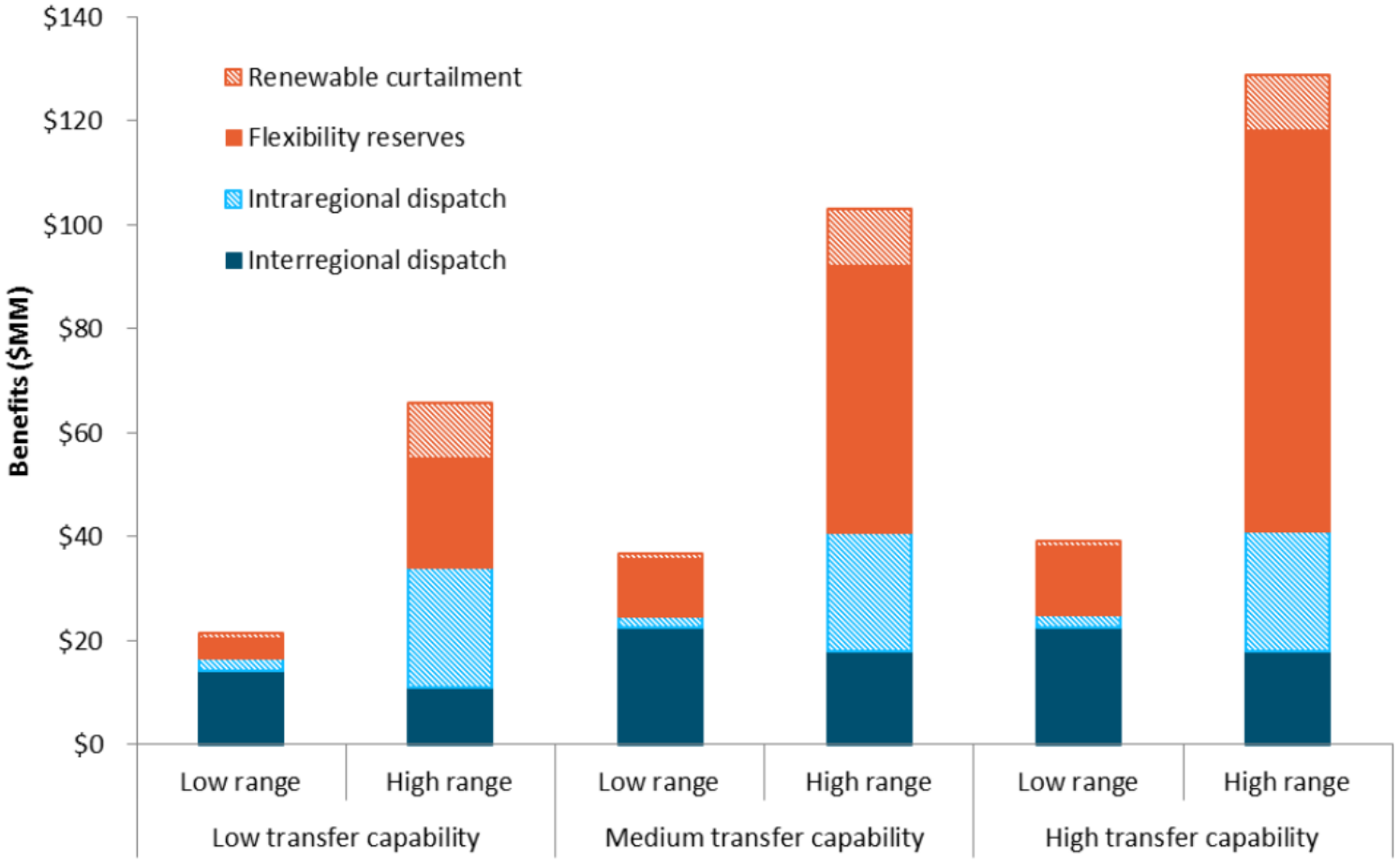
**Percent of nameplate capacity for each project*

Significant benefits observed using range of assumptions

Low and high range annual benefits (Million 2012$)
under low (100 MW), medium (400MW), and high (800MW) transfer capability

Benefit Category	Low transfer capability		Medium transfer capability		High transfer capability	
	Low Range	High Range	Low Range	High Range	Low Range	High Range
Interregional dispatch	$ 14.1	$ 11.0	$ 22.3	$ 17.7	$ 22.4	$ 17.8
Intraregional dispatch	$ 2.3	$ 23.0	$ 2.3	$ 23.0	$ 2.3	$ 23.0
Flexibility reserves	$ 4.0	$ 20.8	$ 11.0	$ 51.3	$ 13.4	$ 77.1
Renewable curtailment	$ 1.1	$ 10.8	$ 1.1	$ 10.8	$ 1.1	$ 10.8
Total benefits	**$ 21.4**	**$ 65.6**	**$ 36.7**	**$ 102.8**	**$ 39.2**	**$ 128.7**

PacifiCorp-CAISO EIM Benefits



Low and high range annual benefits under low (100 MW), medium (400MW), and high (800MW) PacifiCorp-ISO transfer capability scenarios (2012$)

Attribution of EIM benefits to PacifiCorp in 2017

Low and high range benefits attributed to PacifCorp (Million 2012$) under low (100 MW), medium (400MW), and high (800MW) transfer capability

Benefit Category	Low transfer capability		Medium transfer capability		High transfer capability	
	Low Range	High Range	Low Range	High Range	Low Range	High Range
Interregional dispatch	$ 7.0	$ 5.5	$ 11.2	$ 8.9	$ 11.2	$ 8.9
Intraregional dispatch	$ 2.3	$ 23.0	$ 2.3	$ 23.0	$ 2.3	$ 23.0
Flexibility reserves	$ 1.2	$ 6.1	$ 3.2	$ 14.9	$ 3.9	$ 22.5
Renewable curtailment	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.0
Total benefits	**$ 10.5**	**$ 34.6**	**$ 16.7**	**$ 46.8**	**$ 17.4**	**$ 54.4**

Note: Attributed values may not match totals due to independent rounding.

Attribution of EIM benefits to CAISO in 2017

Low and high range benefits attributed to CAISO (Million 2012$)
under low (100 MW), medium (400MW), and high (800MW) transfer capability

Benefit Category	Low transfer capability		Medium transfer capability		High transfer capability	
	Low Range	High Range	Low Range	High Range	Low Range	High Range
Interregional dispatch	$ 7.0	$ 5.5	$ 11.2	$ 8.9	$ 11.2	$ 8.9
Intraregional dispatch	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.0
Flexibility reserves	$ 2.8	$ 14.7	$ 7.8	$ 36.4	$ 9.5	$ 54.6
Renewable curtailment	$ 1.1	$ 10.8	$ 1.1	$ 10.8	$ 1.1	$ 10.8
Total benefits	**$ 10.9**	**$ 31.0**	**$ 20.0**	**$ 56.0**	**$ 21.8**	**$ 74.3**

Note: Attributed values may not match totals due to independent rounding.

Interregional dispatch savings assumptions

Benefit Category	Assumptions (conservative, moderate, aggressive)	Rationale
Interregional dispatch	Conservative-Moderate	• E3 limited PacifiCorp-ISO transmission transfer capability in the low transfer capability scenario to 100 MW, which limited EIM benefits • E3 used hurdle rates to inhibit interregional trade in Benchmark Case (moderate assumption) • Hourly cost differences between natural gas-fired generators are understated in production simulation models due to the use of uniform heat rates assumptions and normalized system conditions; these models understated EIM benefits

Hurdle rates between PacifiCorp-ISO to reflect removal of impediments to trade under EIM

Case	Hurdle Rate ($/MWh)			
	PACW → ISO			ISO → PACW
	CO_2-related	Non-CO_2 related	Total	
Benchmark Case	$10.76	$10.31	$21.07	$3.97
EIM Dispatch Case	$10.76	$0.00	$10.76	$0.00*

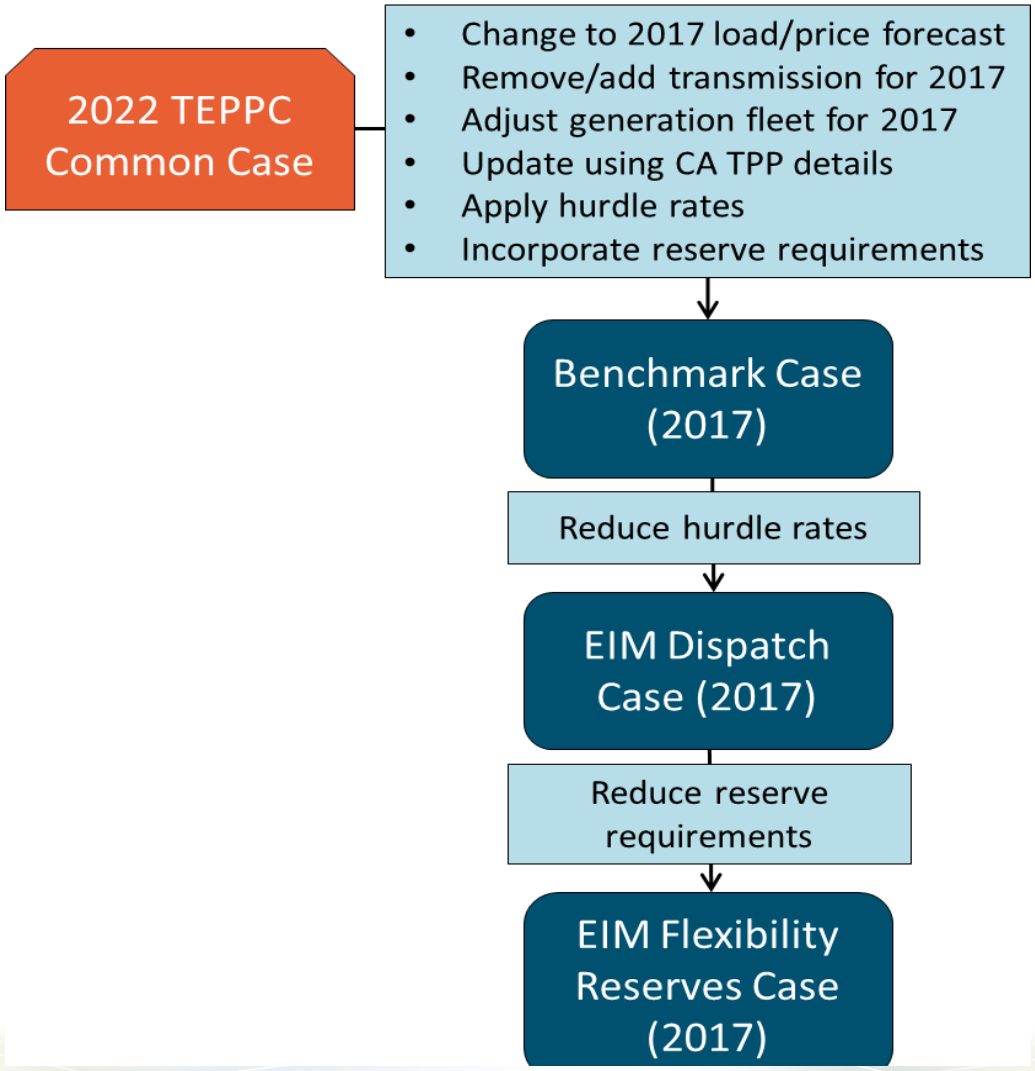
**No CO2-related hurdle rate is applied to ISO exports to PACW because CO2 permit cost under AB32 is directly modeled in the dispatch for generators located inside California.*

Gas prices based on prices used in long term procurement proceeding

(in 2012$/MMBtu)

Area	2017
PACE_ID	$3.99
PACE_UT	$3.81
PACE_WY	$3.95
PACW	$3.91
PG&E_BAY	$4.09
PG&E_VLY	$4.09
SCE	$4.18
SDG&E	$3.96

Modeling approach for calculation interregional dispatch and flexibility reserve benefits used production simulation



Intraregional and intra-hour assumptions

Benefit Category	Assumptions (conservative, moderate, aggressive)	Rationale
Within hour dispatch	Conservative	• Production simulation analysis modeled at hourly level, omitting potential benefits of sub-hourly dispatch (other studies indicate that these benefits could be substantial)
Intraregional dispatch	Conservative -Moderate	• E3 calculated nodal dispatch savings by scaling estimated ISO peak load-normalized savings by PacifiCorp peak load (moderate assumption); E3 assumed only 10% of these savings materialize for low range (conservative assumption)

Intraregional Dispatch Savings

$$\textit{PacifiCorp 2017 savings} = \text{CAISO 2009 } \textit{savings}^{1} * \frac{\textit{PAC 2017 peak load}}{\textit{CAISO 2009 peak load}}$$

or

$$\textit{PacifiCorp 2017 savings} = \frac{\$105\ \textit{MM}}{\textit{yr}} * \frac{10{,}079\ \textit{MW}}{45{,}486\ \textit{MW}} = \frac{\$23\ \textit{MM}}{\textit{yr}}$$

1. Refer to Frank A. Wolak, 2011, “Measuring the Benefits of Greater Spatial Granularity in Short-Term Pricing in Wholesale http://www.stanford.edu/group/fwolak/cgi-bin/sites/default/files/files/benefits_of_spatial_granularity_aer_wolak.pdf

Flexibility reserve assumptions

Benefit Category	Assumptions (conservative, moderate, aggressive)	Rationale
Flexibility reserves	Conservative	• E3 limited PacifiCorp-ISO transmission transfer capability in the low transfer capability scenario to 100 MW, which limited EIM benefits • E3 included operating cost only; no capacity cost savings are included, which limited EIM benefits • E3 allowed 25% of total hydropower capacity to contribute to flexibility reserves in the low range estimates, which limited EIM benefits • E3 did not require lock-down of dispatch 45 minutes prior to the operating hour, as done in other studies, which would have raised the quantity of reserves required and increased EIM benefits

Flexibility reserve assumptions

Reserve Calculation Process

1. Simulate load following
(10 minute forecasts minus hourly dispatch)

2. **LF Up = 98.5th percentile** (month-hour)

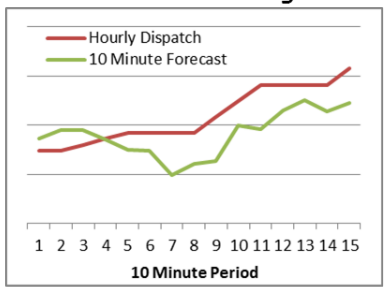
LF Down = 1.5th percentile (month-hour)

3. Sum LF residuals and regulation
(net load minus 10 minute forecast)

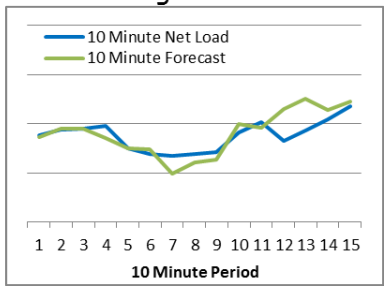
4. **Reg Up = 97th percentile** (month-hour)

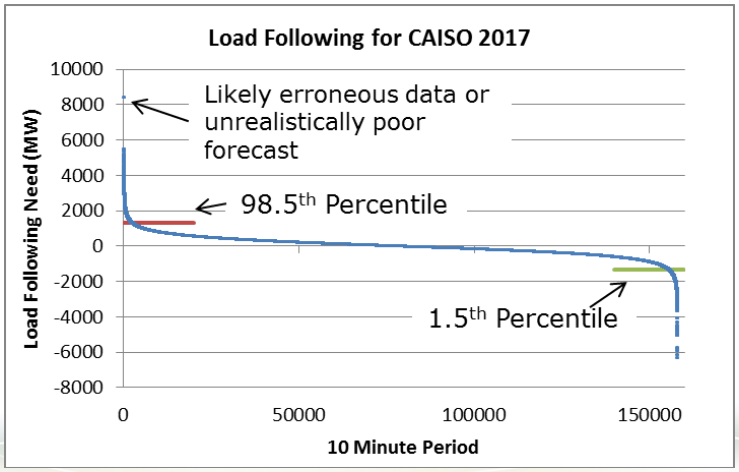
Reg Down = 3rd percentile (month-hour)

Load Following



Regulation





Flexibility reserve assumptions

10-minute flexibility reserves by transfer scenario, Standalone & EIM Cases

PacifiCorp-CAISO Transfer	Minimum Reserve Holdings (MW)
Standalone (no EIM)	2,011
100 MW, with EIM	1,932
400 MW, with EIM	1,687
800 MW, with EIM	1,583

10-minute flexibility reserve detail for 2017, Standalone Case (no EIM)

Area	Average Regulation Up (MW)	Average Load Follwing Up (MW)
PacifiCorp East	103	313
PacifiCorp West	45	146
PacifiCorp Combined	115	357
CAISO	276	1,128

Renewable curtailment assumptions

Benefit Category	Assumptions (conservative, moderate, aggressive)	Rationale
Renewable curtailment	Conservative	• E3 did not evaluate renewable curtailment for PacifiCorp. Which limited EIM benefits • In low range estimate, e# assumed wind and solar not producing significant over-generation (conservative assumption) • Production simulation models understate the frequency with which low net load/high generation events occur due to their use of idealized operating assumptions; these models limit EIM benefits

120 GWh curtailment potential based on comparison of two simulation runs:

- First run (representing unit commitment based on forecasted needs), **projected** solar, wind, and load profiles were used to estimate economic imports into ISO.

- Second run (representing real-time dispatch), **actua**l solar, wind, and load profiles were used along with minimum import limits set to the level of economic imports from the first simulation.

- Curtailment occurred in second run represents conservative estimate of renewable curtailment.

$90/MWh avoided cost of curtailment based on:

1. Renewable energy certificate (REC) value, assumed to be $50/MWh;

2. Production tax credit (PTC) value of $20/MWh; and

3. Avoided production cost of the thermal unit that an EIM enables to dispatch down, estimated to be $20/MWh.

Conclusions

- Significant benefits for PacifiCorp and ISO exist under an EIM, based on conservative assumptions.
- Higher range of potential benefits exist depending on transfer capability and operational conditions.

Questions?