Energy Imbalance Market Outline

- Daily operations and bid submission
- California Independent System Operator (ISO) EIM benefit explanation
- EIM revenue/cost calculation of the import/export
- EIM dispatch cost to facilitate the import/export
- Total EIM benefit calculation
- Market Performance Reports

EIM Day-Ahead Setup

- Variables considered in the day-ahead setup
  - Reserve requirement
  - Load
  - EIM flex requirements
  - Plant operating costs ($/MWh)
- The day-ahead schedule includes known updates for ramp capability, max and min capacity, outages and unit testing requirements
- Bids are submitted by end-of-day for all participating resources in EIM
  - Includes fuel price, unit heat rate, variable operation and maintenance and a ten percent adder

Participating Resources

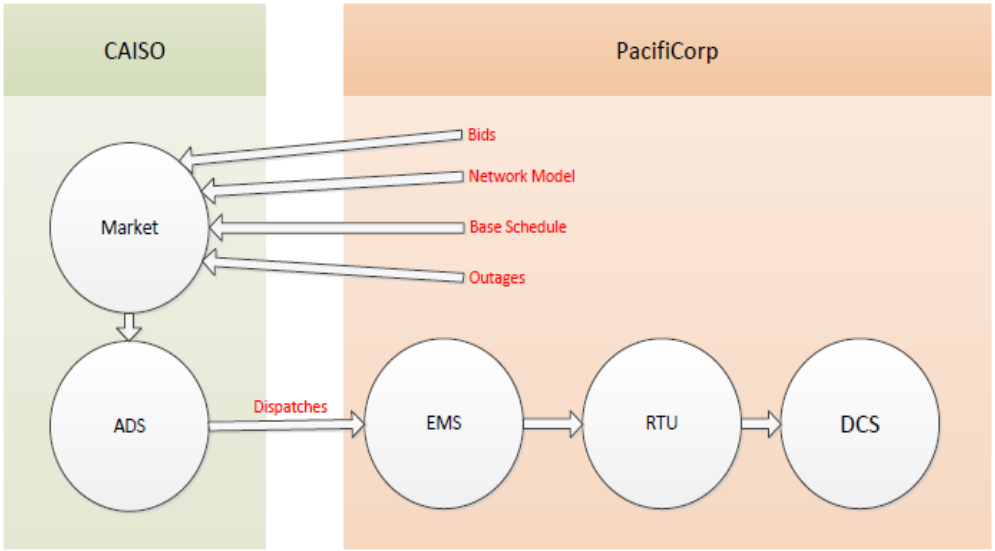
- Participating resources are optimized by the ISO market model every fifteen minutes and again every five minutes to achieve the least-cost dispatch to serve load across the EIM footprint
  - PacifiCorp has chosen to maximize its participating resources to allow the most efficient optimization of the system within the hour
- Non-participating resources are not optimized by the ISO market model within the hour and maintain an hourly base schedule
  - Non-participating resources include resources that are shared units and not under PacifiCorp's operational control as well as run-of-river and constrained hydro resources
    - Hunter 1&2
    - Cholla
    - Craig
    - Hayden
    - Hydro resources other than Swift 1 and Yale

Market Timeline

- Base Schedule Balancing Test
- Capacity Test
- Flex Ramp Required Sufficiency Test

EIM Plant Dispatch

- Coordinating dispatches with plant operators
- Plant status feedback
- Data flow and generation control



Daily Bid Prices

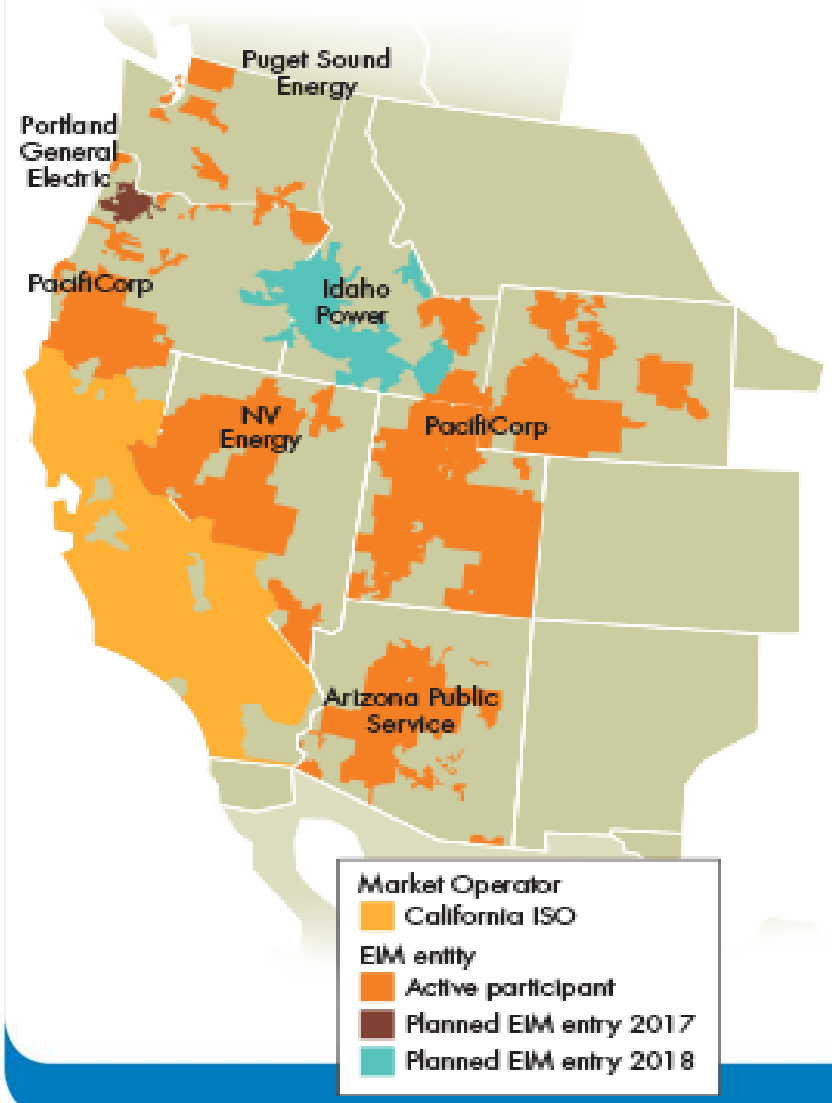
- PacifiCorp is currently bidding in its thermal resources consistent with the DEB to accurately reflect the operating cost of its units
- Resource operating requirements for hydro facilities requires PacifiCorp to provide the market a correct price signal that can be at or below the DEB
  - During high run-off conditions PacifiCorp may submit a bid for the hydro resources that reflect a lower incremental cost and allow the resource to be dispatched first and decremented last in the PacifiCorp stack of resources
  - During periods of normal hydro operations PacifiCorp will maximize its hydro resource bid to the DEB price
- It is in the best interest of PacifiCorp to accurately reflect its cost of operations at each plant in order to achieve the most efficient market outcome in the reliable operation of the system.
- The ISO utilizes PacifiCorp's resource bids to create a "stack" of resources that is used by the market model to solve for a least-cost dispatch solution to meet demand

PacifiCorp EIM Benefits

BAA	Nov-Dec 2014	Jan-Mar 2015	Apr-Jun 2015	Jul-Sep 2015	Oct-Dec 2015	Jan-Mar 2016	Apr-Jun 2016	Jul-Sep 2016	Total
ISO	$1.24 M	$1.45 M	$2.46 M	$3.48 M	$5.28 M	$6.35 M	$7.89 M	$5.44 M	$33.58 M
PacifiCorp	$4.73 M	$3.81 M	$7.72 M	$8.52 M	$6.17 M	$10.85 M	$10.51 M	$15.12 M	$67.44 M
NV Energy					$0.84 M	$1.70 M	$5.20 M	$5.60 M	$13.34 M
Total	**$5.97 M**	**$5.26 M**	**$10.18 M**	**$12.00 M**	**$12.29 M**	**$18.90 M**	**$23.60 M**	**$26.16 M**	**$114.36 M**

The California ISO estimated the total third quarter benefits of EIM at $26.2m, with PacifiCorp's share of the benefits at $15.1m, a 77% increase in EIM benefits from the same quarter in 2015. Total benefits of the energy imbalance market since November 1, 2014, are $114.4m, with PacifiCorp's share of the benefits at $67.4m.

Energy Imbalance Market Expansion



- Arizona Public Service Company and Puget Sound Energy went live October 1, 2016
- Portland General Electric - Fall 2017
- Idaho Power - Spring 2018
- Entities exploring future entry
  - CENACE
  - Baja CA
  - Balancing Authority of Northern California (BANC)
  - Los Angeles Department of Water & Power (LADWP)
  - Seattle City Light (SCL)

ISO EIM Benefit Calculation

- The California ISO utilizes a counter-factual analysis to calculate the EIM Benefits of each participant
  - The ISO estimates both intra and inter-regional EIM benefits in its analysis
- The intra-regional EIM benefit calculates what the costs would have been to serve load within each Balancing Area if the EIM did not exist
  - The ISO determines the load change within each area and utilizes the “stack” of resources within each area to determine what the dispatch would have been

EIM Benefits

- PacifiCorp calculates its EIM benefits based on the transfers that occur in the market and does not calculate the inter-regional benefits
  - All resources in the EIM footprint are put into a “stack” with highest cost resources at the top and lowest cost resources at the bottom. Dispatch of the stack of resources moves from bottom to top in order to serve demand at the lowest cost.
  - EIM Imports allow PacifiCorp to avoid dispatching more expensive resources
  - EIM Exports allow PacifiCorp to earn a margin on available capacity on its resources

EIM Stack and Dispatch Example

Day	hour	Interval	BAA	Price	Segment (MW)	Resource	Unit mimimum (MW)	Unit maximum (MW)	Base Schedule (MW)	EIM Dispatch (MW)	Difference (MW)
1-Jul-15	16	6	ISO	$80.0	200	California Resource	100	200	200	100	(100)
1-Jul-15	16	6	ISO	$70.0	200	California Resource	100	200	200	100	(100)
1-Jul-15	16	6	ISO	$60.0	300	California Resource	100	300	150	100	(50)
1-Jul-15	16	6	PACW	$45.0	150	Yale	80	150	99	80	(19)
1-Jul-15	16	6	PACW	$45.0	150	Swift	80	150	80	80	0
1-Jul-15	16	6	PACE	$25.0	600	Lake Side 2	300	600	450	300	(150)
1-Jul-15	16	6	ISO	$24.8	600	California Resource	550	600	600	550	(50)
1-Jul-15	16	6	PACE	$24.0	500	Current Creek	250	500	300	250	(50)
1-Jul-15	16	6	PACE	$23.3	550	Lake Side 1	320	550	300	334	34
1-Jul-15	16	6	PACW	$22.4	500	Chehalis	250	500	357	500	143
1-Jul-15	16	6	PACW	$15.0	1400	Jim Bridger	300	1,400	1,200	1,400	200
1-Jul-15	16	6	PACE	$14.0	300	Dave Johnston	100	300	200	300	100
1-Jul-15	16	6	PACW	($10.0)	99	Goodnoe Hills	5	99	69	75	6
1-Jul-15	16	6	PACW	($10.0)	99	Leaning Juniper	5	99	78	82	4
1-Jul-15	16	6	ISO	($15.0)	500	California Resource	5	500	123	124	1
1-Jul-15	16	6	ISO	($15.0)	500	California Resource	5	500	357	388	31
								Total MW	4,763	4,763	0
								Total Cost	$107,471	$90,241	($17,229)

- Illustrative example of one five-minute interval in the EIM where the load did not change from the base schedule of 4,763 MW to the EIM dispatch of 4,763 MW
- All resources in the EIM Footprint are re-dispatched within their operating constraints to produce the least-cost dispatch solution, taking into consideration transmission constraints, resource ramping constraints and reserve requirements
- Renewable resources increased 42 MW in a five-minute period and the most expensive resources were decremented to accommodate the additional generation

EIM Transfers

Day	hour	Interval	BAA	Price	Segment (MW)	Resource	Unit mimimum (MW)	Unit maximum (MW)	Base Schedule (MW)	EIM Dispatch (MW)	Difference (MW)
1-Jul-15	16	6	ISO	$80.0	200	California Resource	100	200	200	100	(100)
1-Jul-15	16	6	ISO	$70.0	200	California Resource	100	200	200	100	(100)
1-Jul-15	16	6	ISO	$60.0	300	California Resource	100	300	150	100	(50)
1-Jul-15	16	6	PACW	$45.0	150	Yale	80	150	99	80	(19)
1-Jul-15	16	6	PACW	$45.0	150	Swift	80	150	80	80	0
1-Jul-15	16	6	PACE	$25.0	600	Lake Side 2	300	600	450	300	(150)
1-Jul-15	16	6	ISO	$24.8	600	California Resource	550	600	600	550	(50)
1-Jul-15	16	6	PACE	$24.0	500	Current Creek	250	500	300	250	(50)
1-Jul-15	16	6	PACE	$23.3	550	Lake Side 1	320	550	300	334	34
1-Jul-15	16	6	PACW	$22.4	500	Chehalis	250	500	357	500	143
1-Jul-15	16	6	PACW	$15.0	1400	Jim Bridger	300	1,400	1,200	1,400	200
1-Jul-15	16	6	PACE	$14.0	300	Dave Johnston	100	300	200	300	100
1-Jul-15	16	6	PACW	($10.0)	99	Goodnoe Hills	5	99	69	75	6
1-Jul-15	16	6	PACW	($10.0)	99	Leaning Juniper	5	99	78	82	4
1-Jul-15	16	6	ISO	($15.0)	500	California Resource	5	500	123	124	1
1-Jul-15	16	6	ISO	($15.0)	500	California Resource	5	500	357	388	31
								Total MW	4,763	4,763	0
								Total Cost	$107,471	$90,241	($17,229)

- The above dispatch example shows that ISO resources decreased (net) in EIM 268 MW, PACW increased 334 MW and PACE decreased 66 MW
- Looking at resource disatch that correspond with the changes in EIM, PACW would have transferred 268 MW to ISO and PACE would have transferred 19 MW to PACW so that all systems would have balanced
- Decreases and increases of resources within each balancing area, without a corresponding import or export, reflect re-optimization of the system through the CAISO nodal model that provides a least-cost dispatch solution every five minutes

EIM Revenue Calculation of Transfer

- PacifiCorp uses the 15-minute (FMM) and 5-minute (rtd) prices and volumes to calculate the EIM Revenue of the transfer
- Using the previous slides EIM Dispatch example, the following table shows prices and transfers that correspond with the actual EIM dispatch

	PACE FMM	PACW FMM	CAISO FMM
Price	$23.30	$23.30	$24.80
Transfer Volume	19	200	-200
Revenue	$36.89	$400.83	-$400.83

	PACE rtd	PACW rtd	CAISO rtd
Price	$23.30	$23.30	$24.80
Transfer Volume	0	68	-68
Revenue	$0.00	$136.28	-$136.28

	PACE RTD	PACW RTD	CAISO RTD
Actual Transfer Volume	19	268	-268
Total Revenue	$36.89	$537.12	-$537.12

PACE FMM Revenue =(($23.30 + $23.30)/2) * 19/12 = $36.89
PACW FMM Revenue =(($23.30 + $24.80)/2)*200/12 = $400.83
CAISO FMM Revenue =(($23.30 + $24.80)/2)*-200/12 = -$400.84

PACE rtd Revenue =(($23.30 + $23.30)/2) * 0/12 = $0
PACW rtd Revenue =(($23.30 + $24.80)/2)*68/12 =$136.28
CAISO rtd Cost =(($23.30 + $24.80)/2)*-68/12 =-$136.28

PACE RTD Revenue = $36.89 + $0 = $36.89
PACW RTD Revenue = $400.83 + 136.28 = $537.12
CAISO RTD Revenue = -$400.83 + -136.28 = -$537.12

Marginal Resource Cost

Day	hour	Interval	BAA	Price	Segment (MW)	Resource	Unit mimimum (MW)	Unit maximum (MW)	Base Schedule (MW)	EIM Dispatch (MW)	Difference (MW)
1-Jul-15	16	6	ISO	$80.0	200	California Resource	100	200	200	100	(100)
1-Jul-15	16	6	ISO	$70.0	200	California Resource	100	200	200	100	(100)
1-Jul-15	16	6	ISO	$60.0	300	California Resource	100	300	150	100	(50)
1-Jul-15	16	6	PACW	$45.0	150	Yale	80	150	99	80	(19)
1-Jul-15	16	6	PACW	$45.0	150	Swift	80	150	80	80	0
1-Jul-15	16	6	PACE	$25.0	600	Lake Side 2	300	600	450	300	(150)
1-Jul-15	16	6	ISO	$24.8	600	California Resource	550	600	600	550	(50)
1-Jul-15	16	6	PACE	$24.0	500	Current Creek	250	500	300	250	(50)
1-Jul-15	16	6	PACE	$23.3	550	Lake Side 1	320	550	300	334	34
1-Jul-15	16	6	PACW	$22.4	500	Chehalis	250	500	357	500	143
1-Jul-15	16	6	PACW	$15.0	1400	Jim Bridger	300	1,400	1,200	1,400	200
1-Jul-15	16	6	PACE	$14.0	300	Dave Johnston	100	300	200	300	100
1-Jul-15	16	6	PACW	($10.0)	99	Goodnoe Hills	5	99	69	75	6
1-Jul-15	16	6	PACW	($10.0)	99	Leaning Juniper	5	99	78	82	4
1-Jul-15	16	6	ISO	($15.0)	500	California Resource	5	500	123	124	1
1-Jul-15	16	6	ISO	($15.0)	500	California Resource	5	500	357	388	31

Total MW	4,763	4,763	0
Total Cost	$107,471	$90,241	($17,229)

- Using the 5-minute (rtd) prices to determine the resource that supported the export or was decremented to facilitate the import is identified
- Lake Side 1 was the Marginal Resource for PACE and Chehalis was the marginal resource for PACW. However, since PACW can transfer energy from PACE its transfer price will reflect the cost of the PACE transfer price up to the transmission constraint of 400 MW
- The California marginal resource, that it would need to serve load, is the $24.80 resource highlighted above

PACW EIM Dispatch Cost

- In the example provided PACW exported 268 MW to ISO and was paid $23.30 + $24.80 / 2 = $24.05/MWh
- The cost to serve that export was the cost it paid to PACE for the transfer of 19 MW ($36.89) and the remaining transfer (249 MW) was supported by resources in the PACW BAA
- To determine the marginal resource in PACW that was used to support the transfer the $23.30/MWh price is used to determine what the marginal resource was, which was Chehalis
- Once the capacity from Chehalis is exhausted (143 MW) to generate the transfer Jim Bridger is the next resource that would have supported the transfer for the additional 106 MW

Price	Segment (MW)	Resource	Unit mimimum (MW)	Unit maximum (MW)	Base Schedule (MW)	EIM Transfer Dispatch (MW)	Transfer (MW)	Transfer
$22.4	500	Chehalis	250	500	357	500	143	143
$15.0	1400	Jim Bridger	300	1,400	1,200	1,306	106	106

Transfer MW	1,557	1,806	249
Transfer Cost	$25,996.80	$30,790.00	$4,793.20
Five-Minute Transfer Cost	$2,166.40	$2,565.83	$399.43

PACE EIM Dispatch Cost

- In the example provided PACE exported 19 MW to PACW and was paid ($23.30 + $23.30)/2 = $23.30/MWh
- The cost to serve that 19 MW export to PACW was the marginal resource in PACE equal to or below the price of $23.30/MWh, which was Lake Side 1

Price	Segment (MW)	Resource	Unit mimimum (MW)	Unit maximum (MW)	Base Schedule (MW)	EIM Transfer Dispatch (MW)	Transfer (MW)	Transfer
$23.3	550	Lake Side 1	320	550	300	319	19	19

Transfer MW	300	319	19
Transfer Cost	$6,987.00	$7,429.51	$442.51
Five-Minute Total Cost	$582.25	$619.13	$36.88

EIM Benefit Calculation

- The transfer revenue that was calculated for PACW and PACE is added together and the dispatch Cost to facilitate the transfer is subtracted to calculate the marginal revenue or EIM benefit for the five-minute interval

	Revenue	Cost	EIM Benefit
PACW	$537.12	$399.43	$137.68
PACE	$36.89	$36.88	$0.02
Total	$574.01	$436.31	$137.70

Market Performance Reports

1. Please explain what a flexible ramping constraint is and please elaborate on the finding that PacifiCorp had an increase in the 2nd quarter of 2016.

- A flexible ramping constraint is the ISO's previous requirement to hold flexible ramping capability in the 15-minute market. The CAISO enforces a flexible ramping constraint in the optimization of the real-time market to ensure the availability of requisite capacity for unit commitment or dispatch of resources for real-time dispatch intervals between the applicable commitment or dispatch period.

2. The 2nd Quarter EIM report also mentions that the EIM experienced a high occurrence of negative load adjustments in PAC East during the second quarter of 2016 (2nd Quarter EIM Report, p. 59; Figures 4.1. and 4.2, p. 60). Please explain what a negative load adjustment is and discuss the implications of this finding.

- A load adjustment is used by PacifiCorp grid operators to inform the market of forecast errors, generation unit changes and reliability requirements. A negative load adjustment was used more by PacifiCorp in the 2nd quarter due to the increased solar generation on the system and forecast error during the morning ramp.

3. The 3rd Quarter EIM Report notes that since the EIM's inception, internal congestion has been relatively low for all areas "except in PacifiCorp East where internal congestion was somewhat more frequent during some quarters" (3nd Quarter EIM Report, p. 30). Please briefly discuss what internal congestion is and explain why it was more frequent in PacifiCorp East.

- Congestion is indicated when transmission is constrained between two areas. PacifiCorp East incurred increased congestion in the 3rd quarter due to transmission constraints in North East Wyoming. There are high levels of wind and thermal generation behind the constraint as well as interconnection and construction projects that limited transmission during this time frame.