EIM Stakeholder Meeting

May 15, 2019
9am – Noon
Rates Hearing Room

For our WebEx and phone participants:

- We have muted all calls on entry, if you have a question, you will need to unmute by using *6. Then please identify yourself by name and let us know who you represent.
- Please do not put this call on hold OR take other calls while you are dialed into this one.
- If we identify a noisy line, you may be disconnected from the meeting.

Agenda

9:00-9:05	• Welcome, Safety Moment, Introductions
9:05 – 9:20	• Review of BPAs EIM Principles, EIM Process, Timeline
9:20- 11:45	• Cost Benefit Analysis
11:45 – Noon	• Next Steps, Q&A

Statement of BPA's Principles:

1. Participation is consistent with statutory, regulatory, and contractual obligations.

2. Maintain reliable delivery of power and transmission to our customers.

3. Resource participation in the EIM is and always will be voluntary.

4. BPA's decision to participate in the EIM will be based on a sound business rationale.

If BPA signs the EIM Implementation Agreement it would obligate BPA to begin spending on EIM implementation projects with the CAISO and signals BPA's intent to join the EIM as long as BPA's EIM principles continue to be met. However, it does not bind BPA to join the EIM.

Market Context

- A well designed electricity market is built on a foundation of resource adequacy and has features that:
  - Provide for intra-hour energy balancing
  - Compensate explicitly for capacity resources that provide system reliability and flexibility

- BPA views the EIM as *one piece* of a well-designed market
  - Additional market functions are required to fully compensate BPA for the capacity value of the flexible and carbon-free federal power system

- BPA will continue to work with CAISO and stakeholders to enhance regional resource adequacy by ensuring that flexible resources are appropriately compensated for the services that they provide

Timeline Leading up to the ROD

Agendas for previous and future monthly EIM Stakeholder meetings:

July 24	•Grid Modernization Overview, Strategic Plan Connection, Intro to 8 Issues BPA is Reviewing, Initial Cost Benefit Analysis
September 13	•EIM 101
October 11	•Process Plan, Transmission, Generation, Governance
November 14	•Process Plan, Market Power
December 18	•Settlements, Non-Federal Generation Participation
January 16	•Resource Sufficiency, Emerging Markets
February 20	•Base Case Structured Scenario, Market Mitigation
March 13	•EIM Issues and Venues, Oversupply Management Protocol, Settlements, Structured Scenario
April 10	•Carbon in the EIM, Cost Benefit Analysis Status Update, Structured Scenario
May 15	• Cost Benefit Analysis
June 12	• Cost Benefit Analysis Update, EIM Issues Summary Review
Late June / Early July	•Letter to the Region with a 30 day public comment
August	•BPA drafts Record of Decision (ROD)
September	•Final ROD for signing the EIM Implementation Agreement

Previous EIM Stakeholder Meeting Materials are available here: www.bpa.gov/goto/EIM

EIM Decision Process

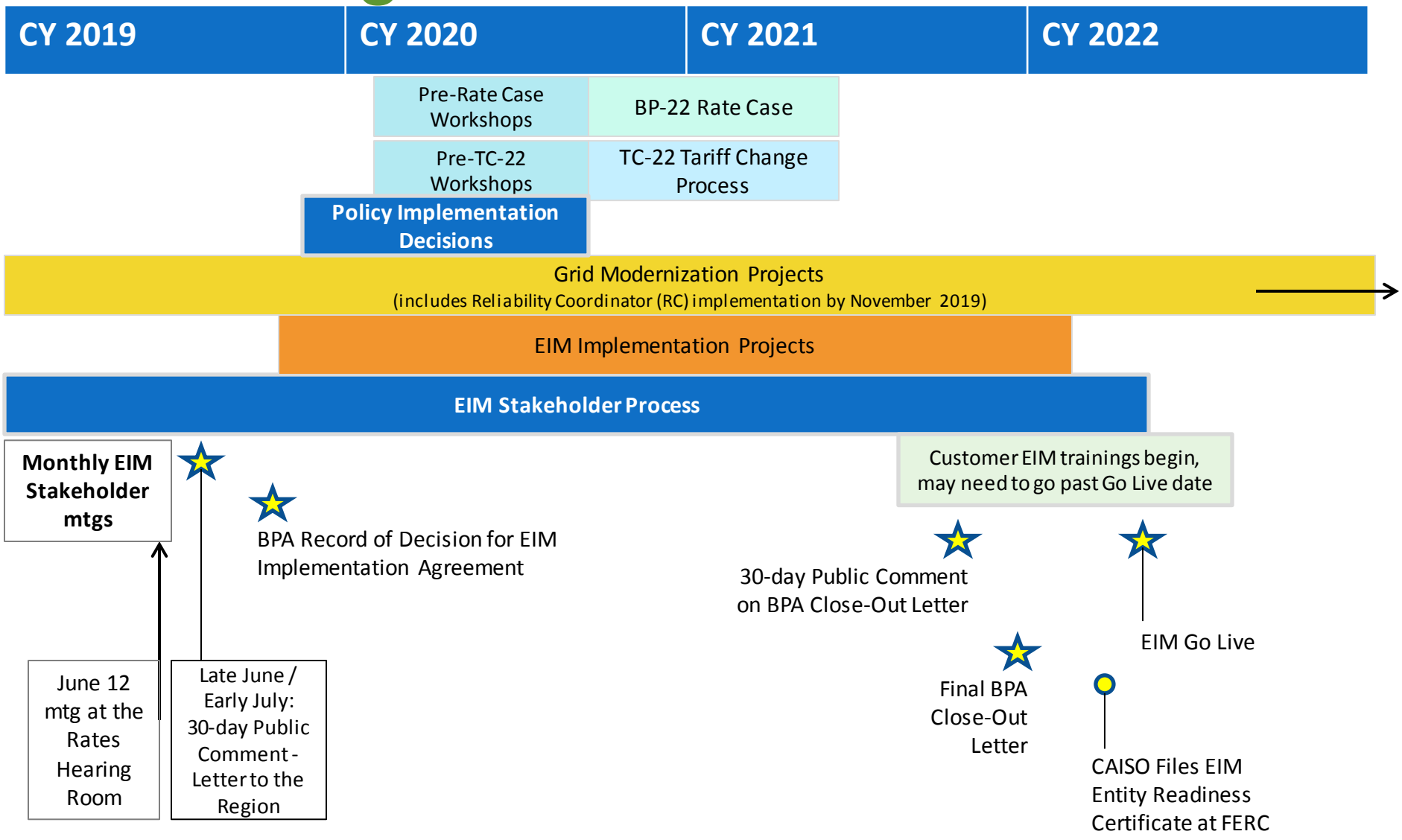
1. Letter to Region and Record of Decision — June 2019 – September 2019
   - Solicit stakeholder feedback on: Draft Implementation Agreement, Cost Benefit Analysis, Legal considerations, Roadmap of process/issues, Proposed Decisions on Certain Policy Issues, Principles for Joining
   - 30-day comment period
   - Final decision to sign Implementation Agreement, and on other items covered in Letter to Region

2. Policy Implementation Decisions — October 2019 – August 2020
   - Discuss all remaining policy issues with stakeholders.
   - Provide written proposal, solicit written stakeholder comment, and make final written decision(s) on policy issues
   - Final decisions on these policy issues

3. BP-22 and TC-22 Cases — October 2020 – July 2021
   - Settlement discussions August – October 2020
   - Follow 7(i) process and conclude with ROD / final decision

4. Draft and Final Close-Out Letters — October 2021 – December 2021
   - Draft Close-Out Letter addressing: principles for joining the EIM, any additional policy issues that have arisen, propose final decision whether to join the EIM, and incorporate final decisions made in steps 1 and 2 above.
   - 30-day comment period
   - Final Close-Out Letter: Address comments raised, Final Decision whether to join EIM, if decision is to join - move forward to sign relevant EIM Agreements

BPA's High Level EIM Timeline



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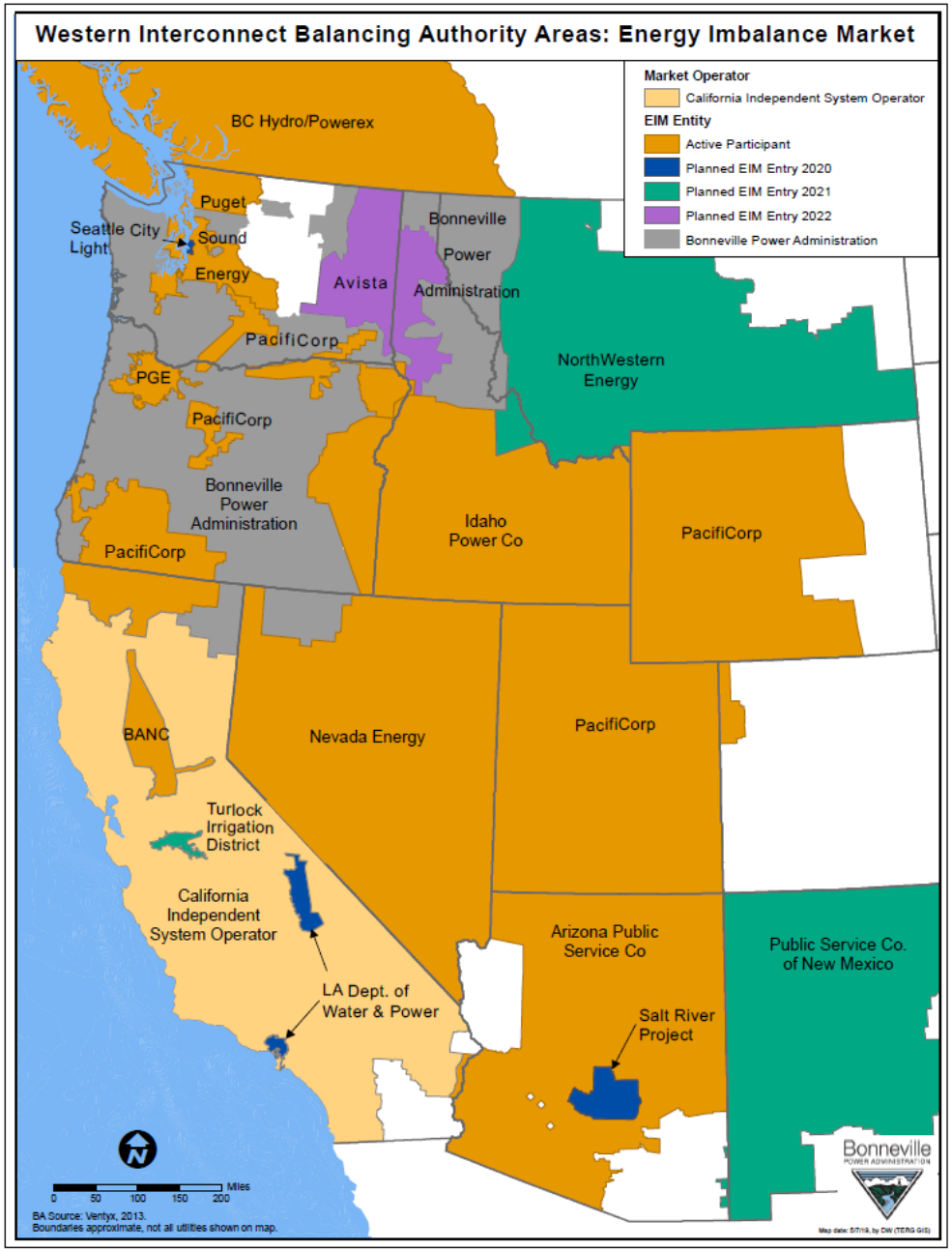
EIM Issues and Venues

This shows BPA's current thinking but the matrix will evolve over time

Legend:
F = Final Decision
I = Implementation

Issue	Letter to Region / ROD (July 2019 – September 2019)	Policy Implementation Decisions (October 2019 – August 2020)	TC-22 Tariff Terms & Conditions Case (October 2020 – July 2021)	BP-22 Rate Case (October 2020 – July 2021)	Close-Out Letter (October 2021 – December 2021)
BPA's EIM Principles Development / Evaluation	F – Development	I	I	I	F – Evaluation of the issues against the principles
Statutory Authority for Joining the EIM	F				Confirm consistency with the principles.
EIM Impacts on BPA Contractual Commitments	F				
NEPA and Environmental Obligations	F				
EIM Governance	F				
Cost Benefit Analysis	F				
Carbon Obligations	F				
Market Power (LMPM, DEB)	F				
Oversupply Management Protocol	F				
OCBR and other Reliability Tools	F				
Federal Generation Participation Plan	F				
Load Zone (LAP)	F		I	I	Final action regarding decision to join.
Resource Sufficiency — BAA Level	F				
Transmission — Interchange	F		I	I	
Transmission — Network		F	I	I	
Allocation of EIM Charge Codes		F		I	
Resource Sufficiency — Sub-BAA Level		F	I	I	
Transmission Losses		F	I	I	
Nonfederal Resource Participation Requirements		F	I	I	
Settlements/Billing (Mechanics)		F	I		
Data Submission Requirements		F	I		
Metering Requirements		F	I		



EIM Entity Map

- Active and planned EIM participants
- BPA shown in grey

EIM
Cost Benefit Analysis

5/15/2019

Rates Hearing Room

Purpose

- We're updating the business case to achieve multiple objectives
  - Utilize an approach consistent with almost all potential and current EIM participants
  - Evaluate benefits in multiple scenarios
  - Refresh market assumptions and cost estimates
  - Flesh out Transmission benefits, potentially quantifying some of them
  - Provide more comprehensive support for an EIM-related ROD
- Steps taken to date
  - Contracted with E3 to perform an "industry standard" Benefits Analysis
  - Reviewed and updated cost estimates initially provided by Utilicast in 2017
- Expected timeline at upcoming EIM stakeholder meetings:
  - May 2019 (today): Share draft results and request feedback
  - June 2019: Discuss stakeholder comments
  - July 2019: Reflect results in Letter to the Region

Annual Net Benefits

- Modeled net dispatch benefits indicate significant financial benefits to BPA participation in the Western EIM

Net EIM Benefits ($M)

	Base Case
Gross Dispatch Benefits	48.9
Annual Ongoing Costs	6.2
Net Annual Dispatch Benefit	**42.7**

- Base Case results would quickly recover expected startup costs

- In addition to net dispatch benefits, EIM participation also brings considerable qualitative and illustrative Transmission benefits

Startup Cost Update

- BPA reviewed (and updated) Utilicast startup cost estimates to incorporate increased EIM-related knowledge within BPA
  - "One BPA" approach taken
    - Costs not allocated by business line
    - Focus on financial viability for BPA as a whole
  - Verify that costs are truly EIM Incremental
    - Spending that BPA would only undertake if we join the EIM
  - BPA's startup costs are higher than many other entities' but commensurate with BPA's relative size, complexity, and existing infrastructure

EIM Category	Cost* ($M)	CFTE	BFTE
Infrastructure	13.3	5.0	3.1
Operation	17.2	4.2	5.6
After-the-Fact	4.6	1.9	1.7
Total	**35.1**	**11.0**	**10.4**

*Startup costs include roughly $10M in existing BFTE costs that will be offset by cost reductions elsewhere in BPA due to temporary reallocation of resources.

Ongoing Cost Update

- BPA leveraged previous estimates of ongoing costs with an evolving understanding of EIM participation to estimate annual costs

EIM Category	Cost* ($M)
Infrastructure	N/A
Operation	5.0
After-the-Fact	1.2
Total	**6.2**

- Major cost drivers include:
  - Resource plan creation/submission
  - O&M Costs for IT systems
  - EIM Desk
  - Settlements
  - CAISO fees

*New staffing costs ($4.4M of the total) will be offset by cost reductions elsewhere in BPA due to reallocation of resources.

Net Benefits Sensitivities

- We tested the robustness of the benefits, by analyzing additional sensitivities; two have been completed and reflected below

Net EIM Benefits Sensitivities ($M)

	Base Case	Reduce Volatility by 50%	No Direct CA Deliveries
Gross Dispatch Benefits	48.9	44.6	44.5
Annual Ongoing Costs	6.2	6.2	6.2
Net Annual Dispatch Benefit	**42.7**	**38.4**	**38.3**

- Reduction in market volatility: Assumes intra-hour price volatility is reduced by 50%
- To reflect no direct CA deliveries, and avoid GHG compliance fee, we modeled that BPA receives lower LMP when selling during intervals where marginal GHG component is nonzero

BPA-Specific Modeling (CY16-18)

Constraints

- 24-hour energy neutrality is required (avoid river management issues)
- System feasible min/max limits (from the Slice Computer Application) are enforced
- Only residual INC/DEC spin capacity at Big 10 projects can be dispatched in EIM (eliminate simulated unit start/stops)
- All non-Big-10 generation in BPA's BAA is treated as non-dispatchable/fixed
- BPA-estimated operational spinning needs and Resource Sufficiency (RS) requirements resulted in RS failure ~15% of the time (no EIM benefits)

Feasibility Verification

- Verified model compliance with all constraints
- Verified simulated EIM net sales positions are within available transmission expectations
- Reviewed sensitivities and resulting effects
- Confirmed that historical spin capability was sufficient to pass EIM RS requirements the vast majority of the time
- 75% success rate applied to offset perfect foresight

Today's Agenda

- EIM Overview
- Production Cost Benefits Analysis
  - Methodology & Assumptions
  - Initial Scenario Results
- Stakeholder Sensitivities Discussion
- Transmission Benefits
- Summary and Next Steps

What Are EIM Benefits?

What EIM Is

- An **intra-hour real-time** energy market to serve load and imbalance across participating Balancing Authorities (EIM Entities) and the CAISO (a.k.a. the EIM Area)
- A tool for centralized 5-minute dispatch of resources that have been **voluntarily offered** to the market (at a price)
- **Economically dispatches** offered resources
- **Security-constrained**, meaning transmission and reliability constraints are not exceeded, improving grid reliability, reducing energy supply cost and enhancing integration of renewable resources

What EIM Is Not

- An RTO (with planning, day-ahead markets, BA consolidation)
- A centralized unit commitment tool
- A capacity market
- A replacement for the current contractual bilateral business structure

EIM Benefits to Date

- Currently, 10 BAAs participating in EIM
- By end of 2021, public power entities (BANC/SMUD, LADWP, SCL, TID, and SRP) plan to be participating in the EIM

Western EIM Gross Benefits – Through 3/31/2019

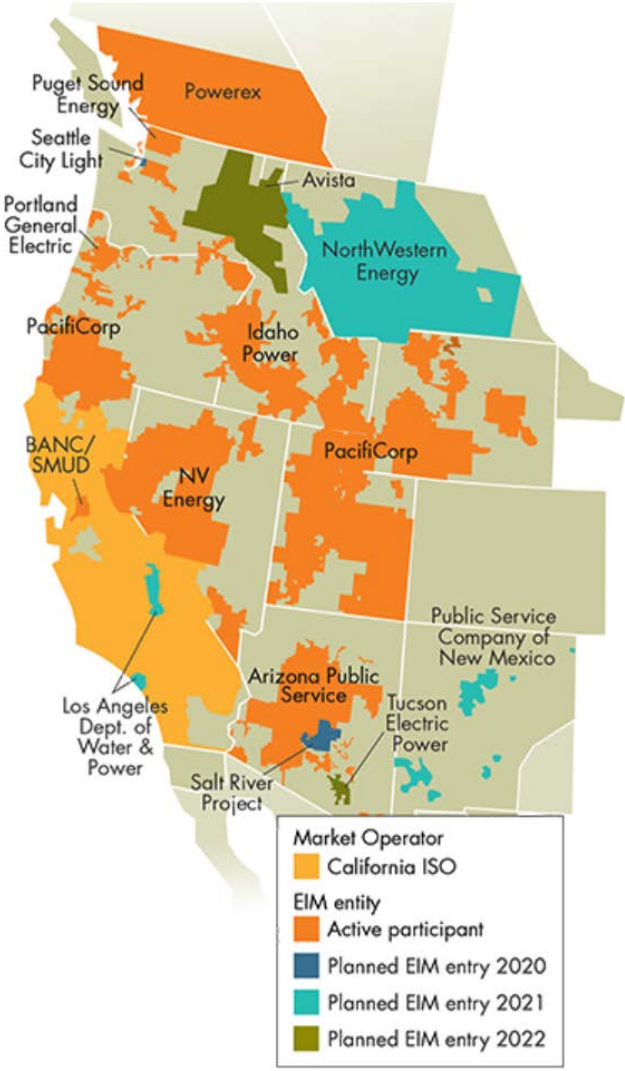
EIM PARTICIPANTS	2014	2015	2016	2017	2018	2019 Q1	TOTAL
Arizona Public Service Entered 10/2016			$5.98	$34.56	$45.30	$8.20	$94.04
California ISO Entered 11/2014	$1.24	$12.66	$28.34	$36.96	$67.94	$13.08	$160.22
Idaho Power Company Entered 04/2018					$26.88	$8.45	$35.33
NV Energy Entered 12/2015		$0.84	$15.57	$24.20	$25.55	$5.71	$71.87
PacifiCorp Entered 11/2014	$4.73	$26.23	$45.47	$37.41	$61.68	$23.76	$199.28
Portland General Electric Entered 10/2017				$2.83	$27.57	$11.74	$42.14
Powerex Entered 04/2018					$7.84	$7.23	$15.07
Puget Sound Energy Entered 10/2016			$1.56	$9.86	$13.68	$7.21	$32.31
TOTAL	$5.97	$39.73	$96.92	$145.82	$276.44	$85.38	**$650.26**

Source: Western EIM

E3 EIM Benefits Analyses

- EIM benefits analyses are intended as an **initial screen** for economic feasibility
  - Not a detailed analysis of all operating constraints and market interactions
- E3 has performed nearly all the EIM benefits studies to date
  - Market has matured and grown in size significantly since start
  - Migrated to **price-taker model**

GridView	WECC-Wide PLEXOS	Price-Taker Hydro	Price-Taker PLEXOS
• PacifiCorp (2013)	• PSE (2014)	• SCL (2016)	• BANC (2016)
• NVE (2014)	• APS (2015)	• Chelan (2016)	• PNM (2018)
	• IPC (2015)		• CENACE (2018)
	• PGE (2015)		• **BPA (2019)**
	• LADWP (2016)		
	• NWE (2017)		
	• SRP (2017)		



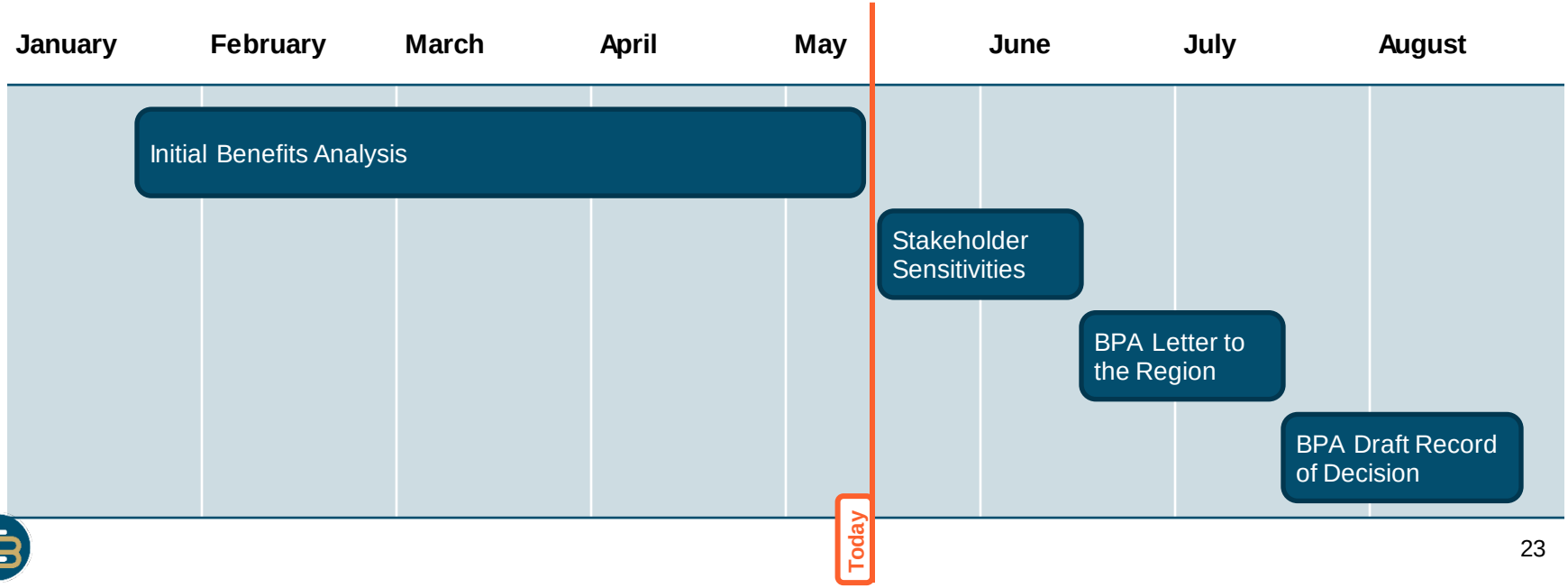
E3 "Pocket Guide" to Flexible Operations

	Solution	How it Helps Integrate Renewables
Net benefits even w/o renewables	**Regional coordination**	**More efficient dispatch and reduced curtailment**
Low-cost solutions with potentially large benefits	Time of use rates	Shifts energy consumption toward daylight hours
	Sub-hourly renewable dispatch	Allows system to operate with fewer thermal resources during overgeneration events
	Renewable portfolio diversity	Avoids curtailment by spreading renewable production over more hours of the year
Costs and benefits should be evaluated on project- or program- specific basis	Flexible loads/ Advanced DR	Shifts energy consumption toward hours with overgeneration, but cost and potential are unknown
	Additional storage	Reduces curtailment but requires significant investment
	Gas retrofits	Makes existing resources more flexible at a low cost
	New flexible gas resources	Provides limited dispatch flexibility at a high cost
Valuable, though not as much for integration	Energy efficiency	Provides significant cost and GHG savings but may not reduce curtailment
	Conventional demand response	Provides cost savings but does not significantly reduce curtailment

EIM

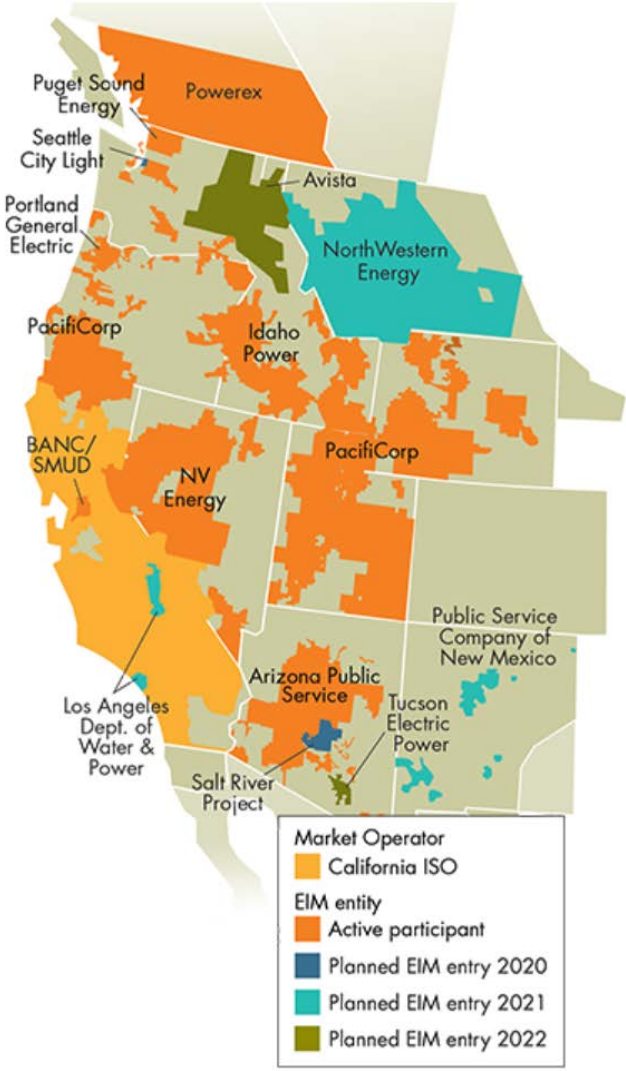
Where We Are in the Analysis Process

- BPA and E3 have been working on initial benefits analysis presented today
- Based on today's feedback, we will develop a suite of sensitivities and updates for June stakeholder meeting



BPA EIM Study Overview

- Following methodology from previous benefits studies with adjustments to reflect BPA's system
- Initial Base Scenario shows **$49 million/year** of incremental gross dispatch benefit due to EIM participation
  - 2 initial sensitivities modeled, volatility reduction & GHG compliance, both of which modestly reduced benefits
- EIM security-constrained economic dispatch provides congestion management and flow relief across entire BPA system
  - Alternative to existing solutions (e.g., transmission build or redispatch)



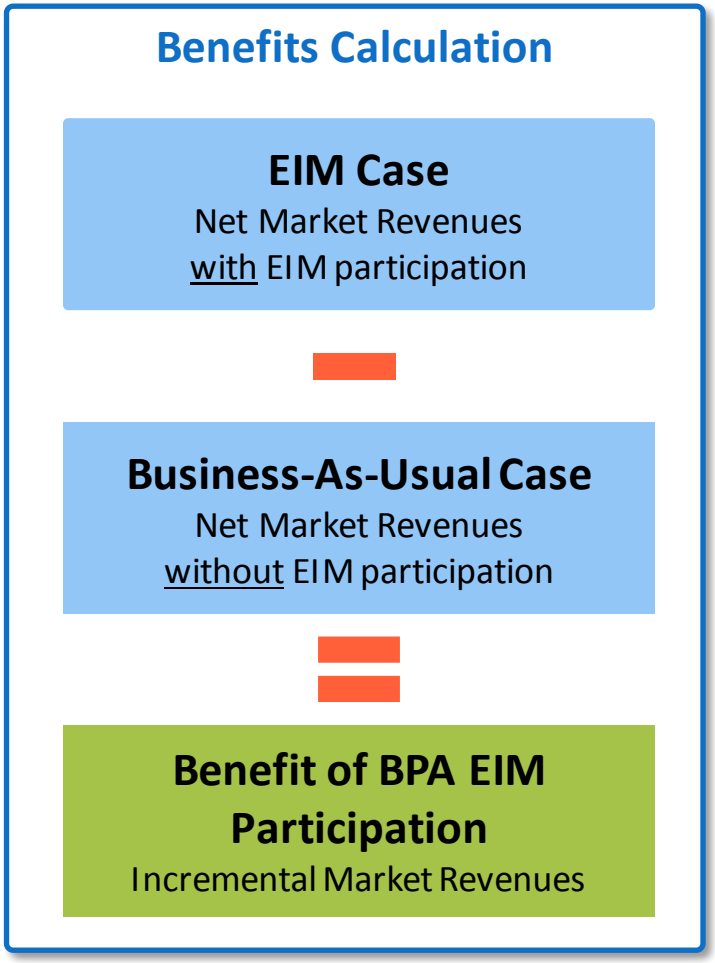
Dispatch Benefits Analysis

Initial Scenarios

Modeling Approach

Framework for Value Assessment

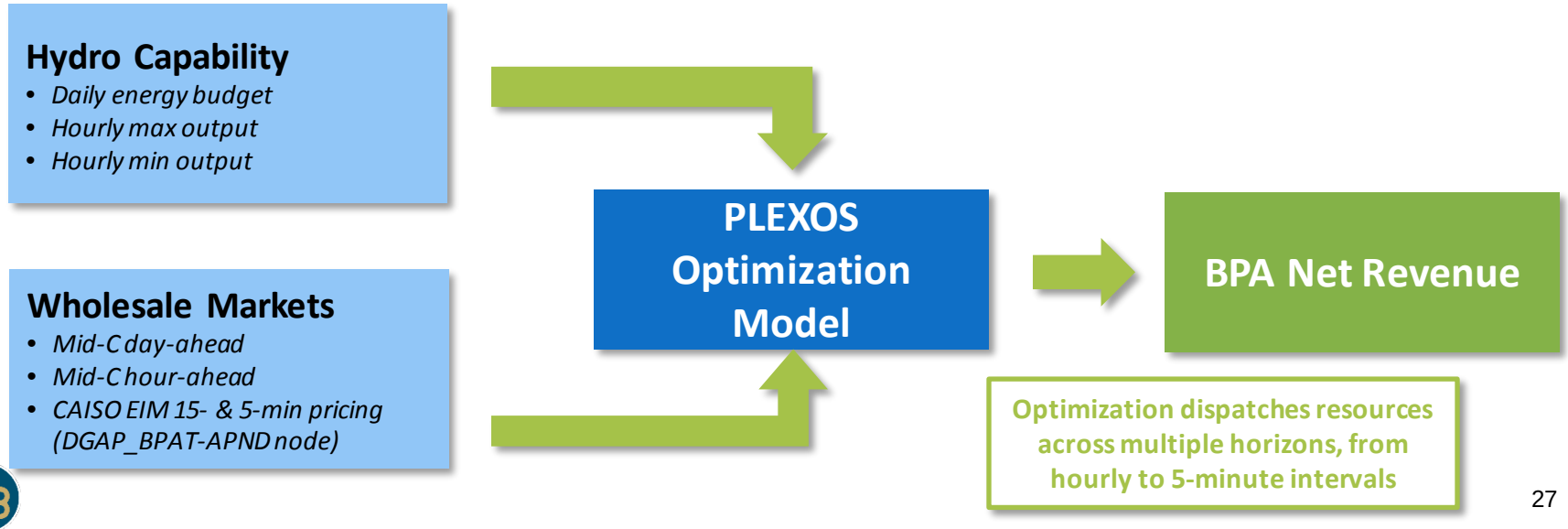
- E3's modeling will seek to estimate BPA's **net market revenues** with and without EIM participation
  - Will capture BPA's market behavior under different wholesale price streams
  - Model will assume BPA is a price-taker, but sensitivities can reflect potential price changes
- Flexible modeling approach allows streamlined development of new scenarios and sensitivity analysis



Modeling Approach

Dispatch Overview

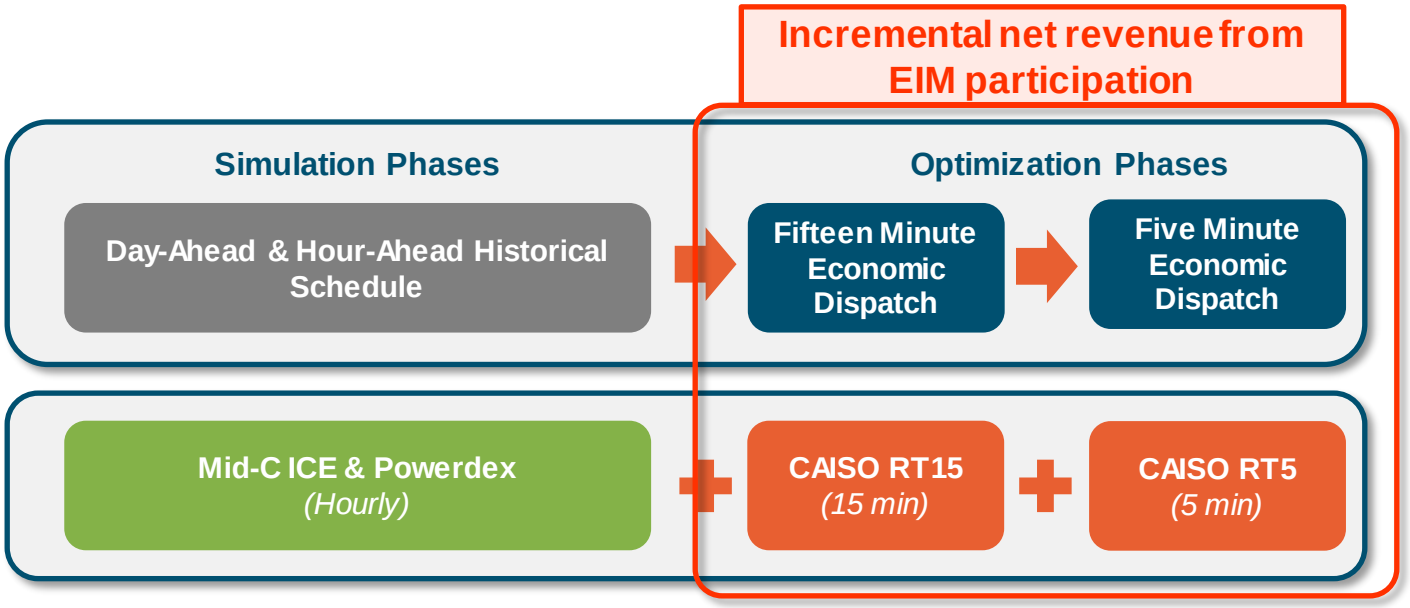
- E3 utilizes a PLEXOS model to **maximize BPA's net revenue** in wholesale markets subject to the constraints of hydroelectric dispatch
  - Utilizing 2016-2018 actual data for BPA BAA operations and wholesale market prices
- To account for model's perfect foresight, we discount reported benefits by 25%
  - Reflects assumption that BPA's imperfect knowledge of prices will result in only 75% success rate of its bids clearing the EIM



Modeling Approach

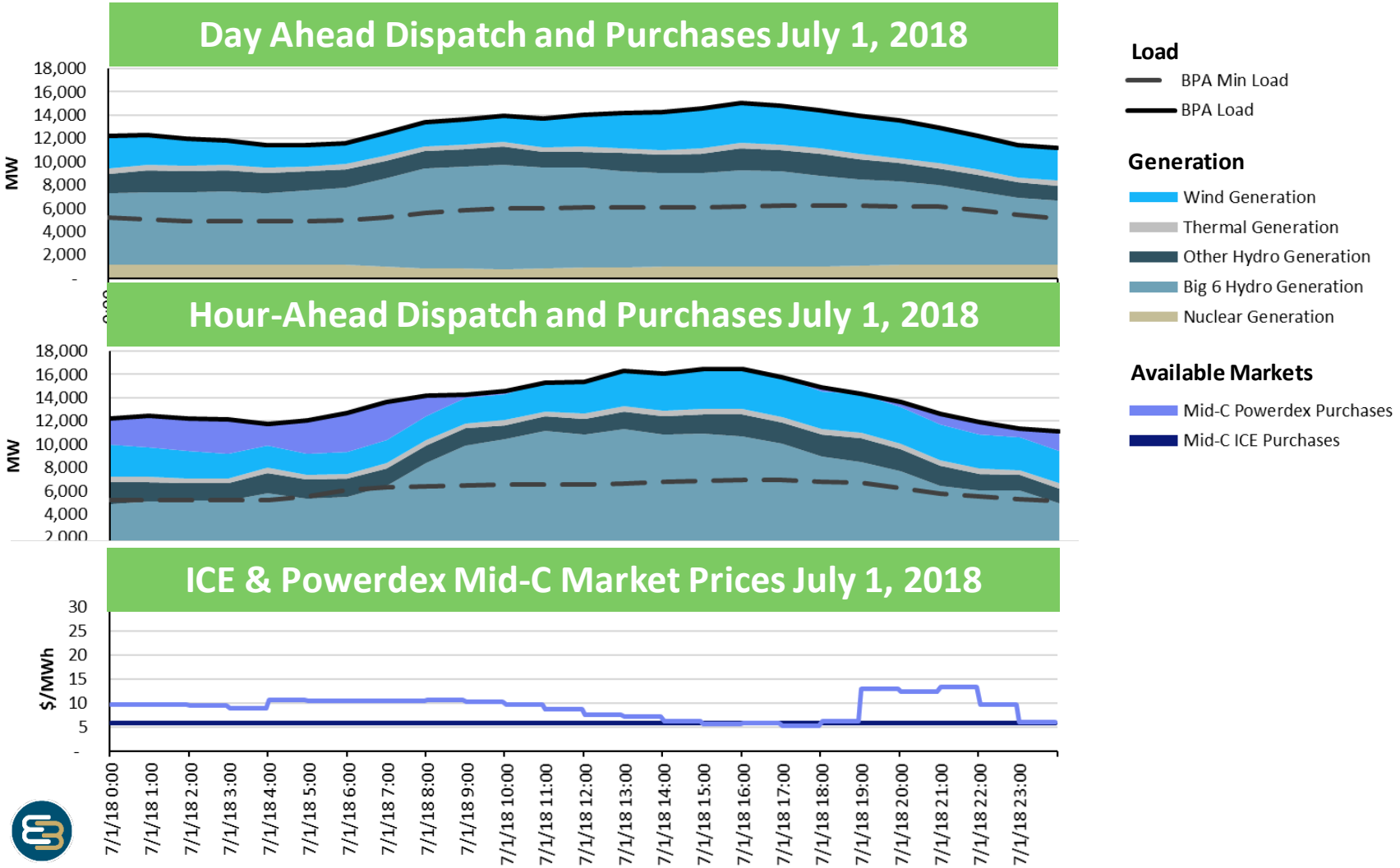
Four-Stage PLEXOS Production Cost Model

- Model quantifies the market value attributed to BPA's resources in four sequential stages:
  - Revenues captured in DA & HA dispatch reflect estimated market value of **all bilateral contracts and other out-of-market transactions**
  - Incremental revenues captured in 15- and 5-minute dispatch reflect **additional value of EIM participation** using BPA's selected hydro resources



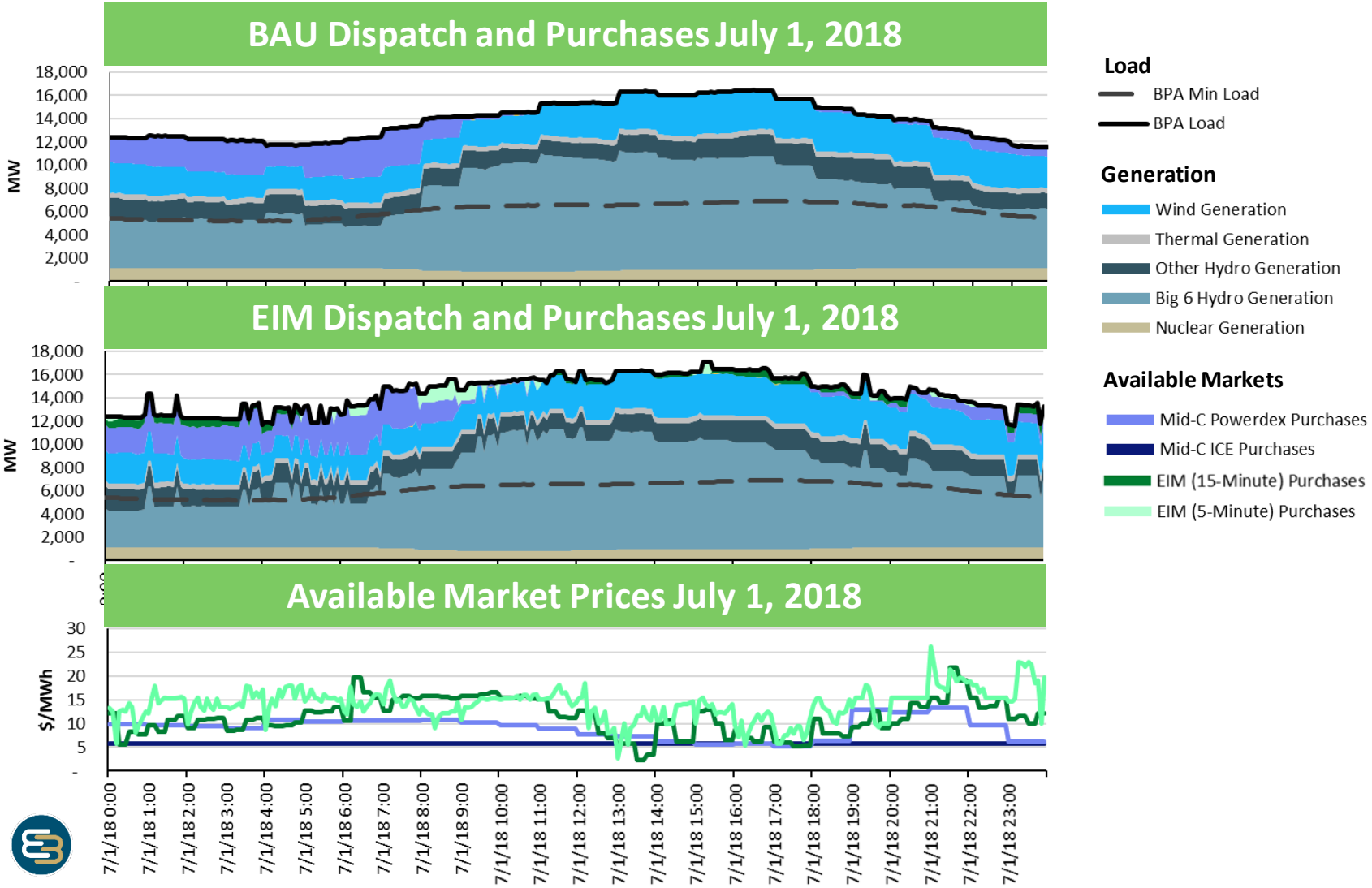
Base Scenario Results

Historical Hourly Schedules and Prices



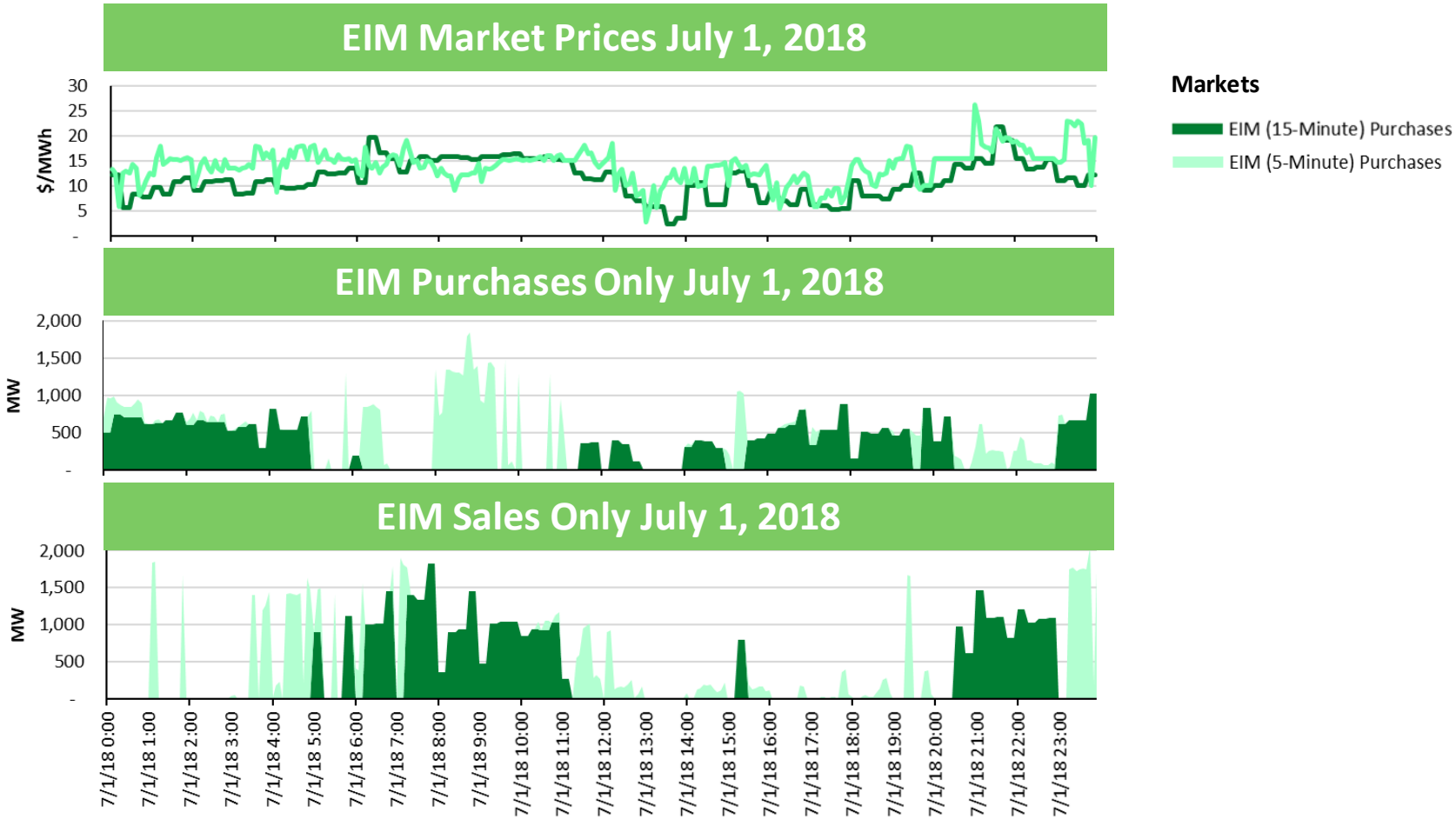
Base Scenario Results

5-Minute Real Time Dispatch and Prices



Base Scenario Results

EIM Market Prices, Purchases and Sales



Input Assumptions

Participating Resources

- **"Big 10 Hydro"** generators are the only participating resources
- Big 10 Hydro is fixed to BPA simulated schedule in DA and HA
- In RT stages, Big 10 constrained by:
  - Maximum feasible min/max output from Big 6 Hydro
  - INC and DEC flexibility relative to simulated HA setpoint
  - Daily energy balance from HA schedule
  - Operational spinning needs
- All other resources are non-participating and fixed to **historical output**

Input Assumptions

Flexible Ramping Sufficiency Test

- To be eligible to trade in the EIM, BPA must be able to meet CAISO flexible ramping sufficiency test (FRST)
  - With diversity benefits applied in its participating resources INC and DEC flexibility
- The Base Scenario showed that that BPA can meet the FRST and is eligible to trade in the majority of hours
  - In approximately 15% of the intervals, BPA did not meet the FRST in the upward or downward direction. To be conservative, the analysis did not assign BPA EIM trading benefits in those periods

Input Assumptions

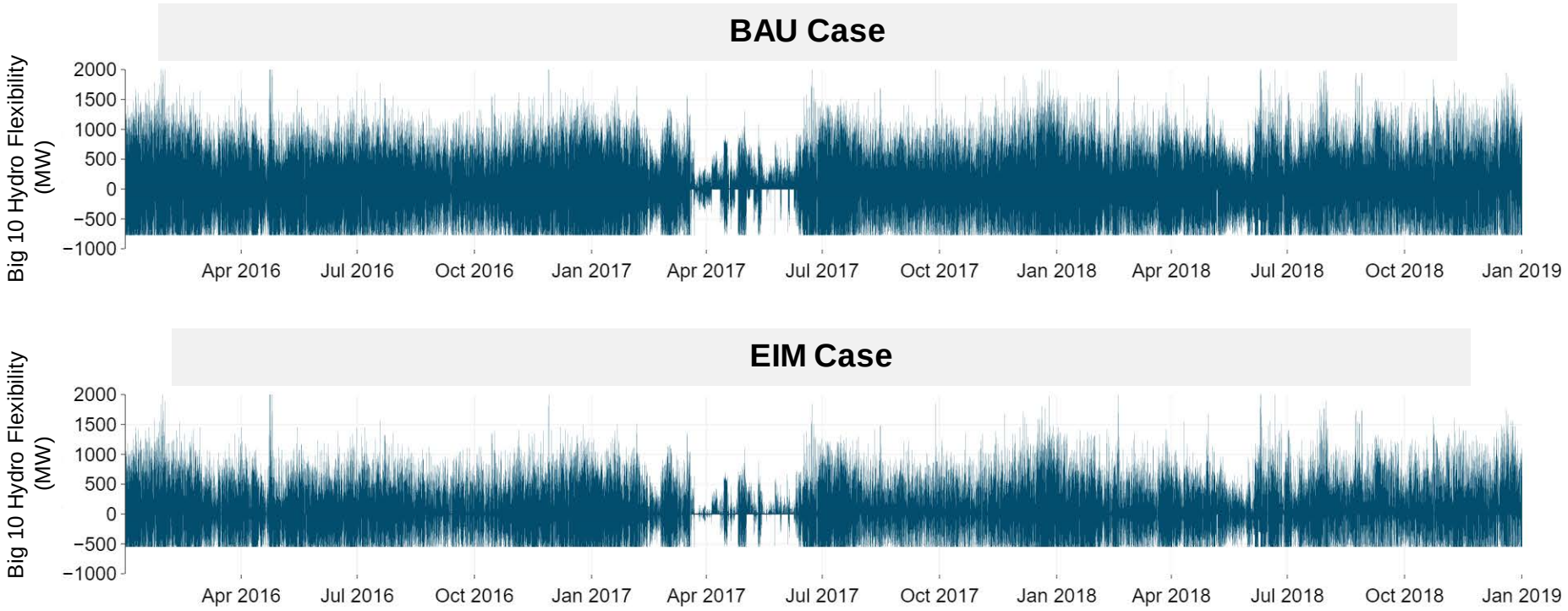
Available Spinning Capability

- We model the Big 10 Hydro spinning capability to meet BA operational needs in all hours
- Headroom and footroom held for BA operational needs cannot be used for EIM transactions
- EIM case deducts a more conservative amount for BA operational needs than BAU case
  - In effect, this deduction results in a decreased opportunity to monetize capacity in order to account for potential differences in operational assumptions between BAU and EIM cases

Input Assumptions

Big 10 Hydro Spinning Capability

- After operational needs and flexibility constraints taken into account, we give Big 10 Hydro INC/DEC flexibility bounds



Input Assumptions

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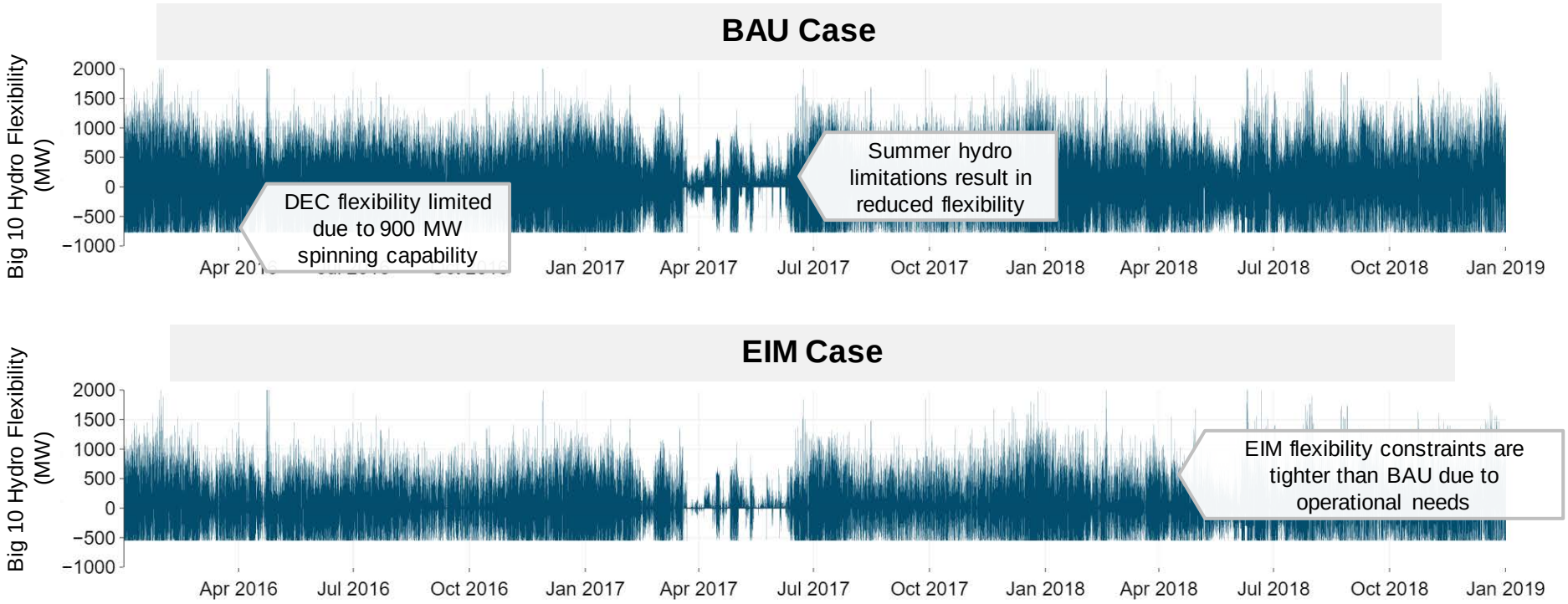
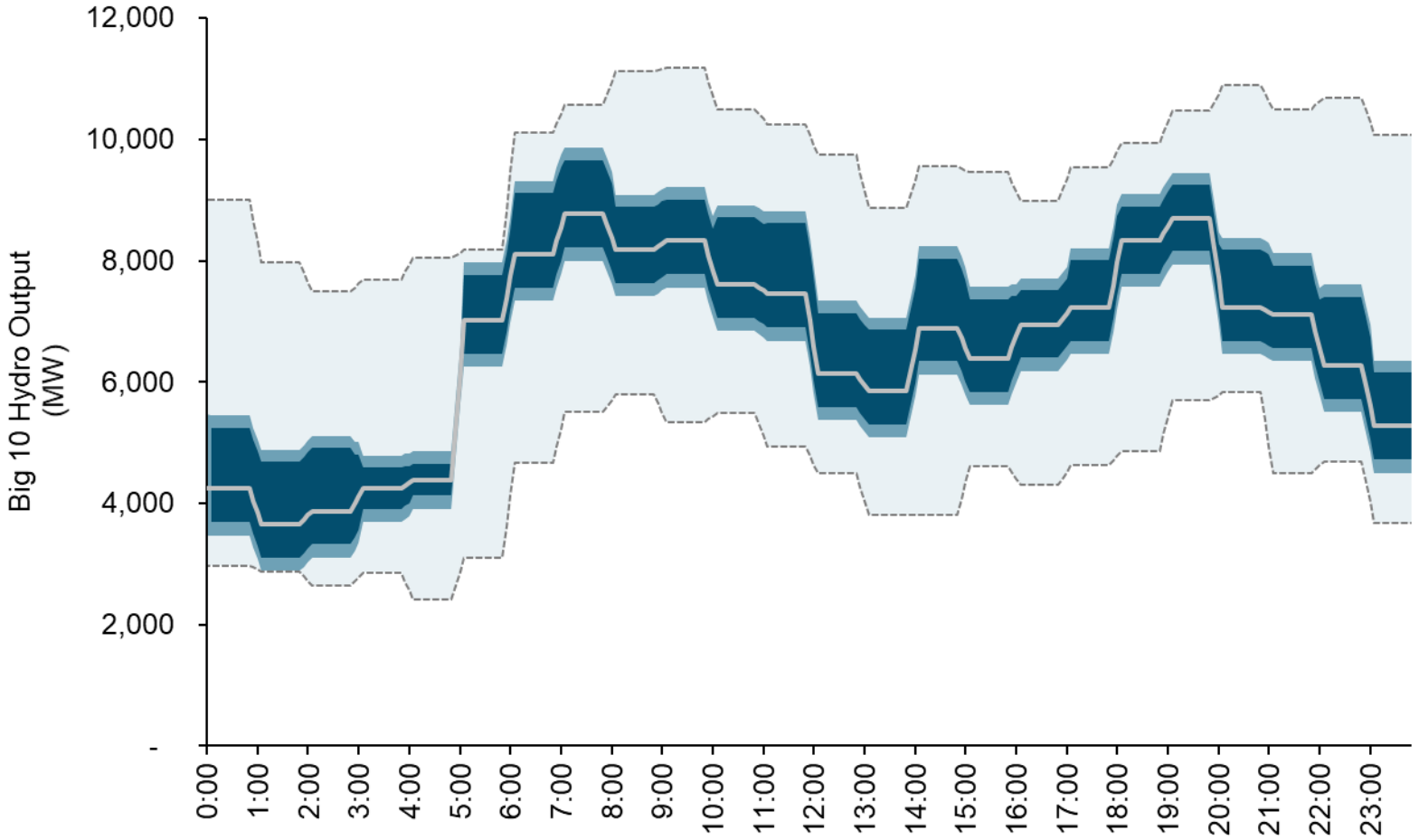


Input Assumptions

Big 10 Hydro Flexibility Example



Input Assumptions

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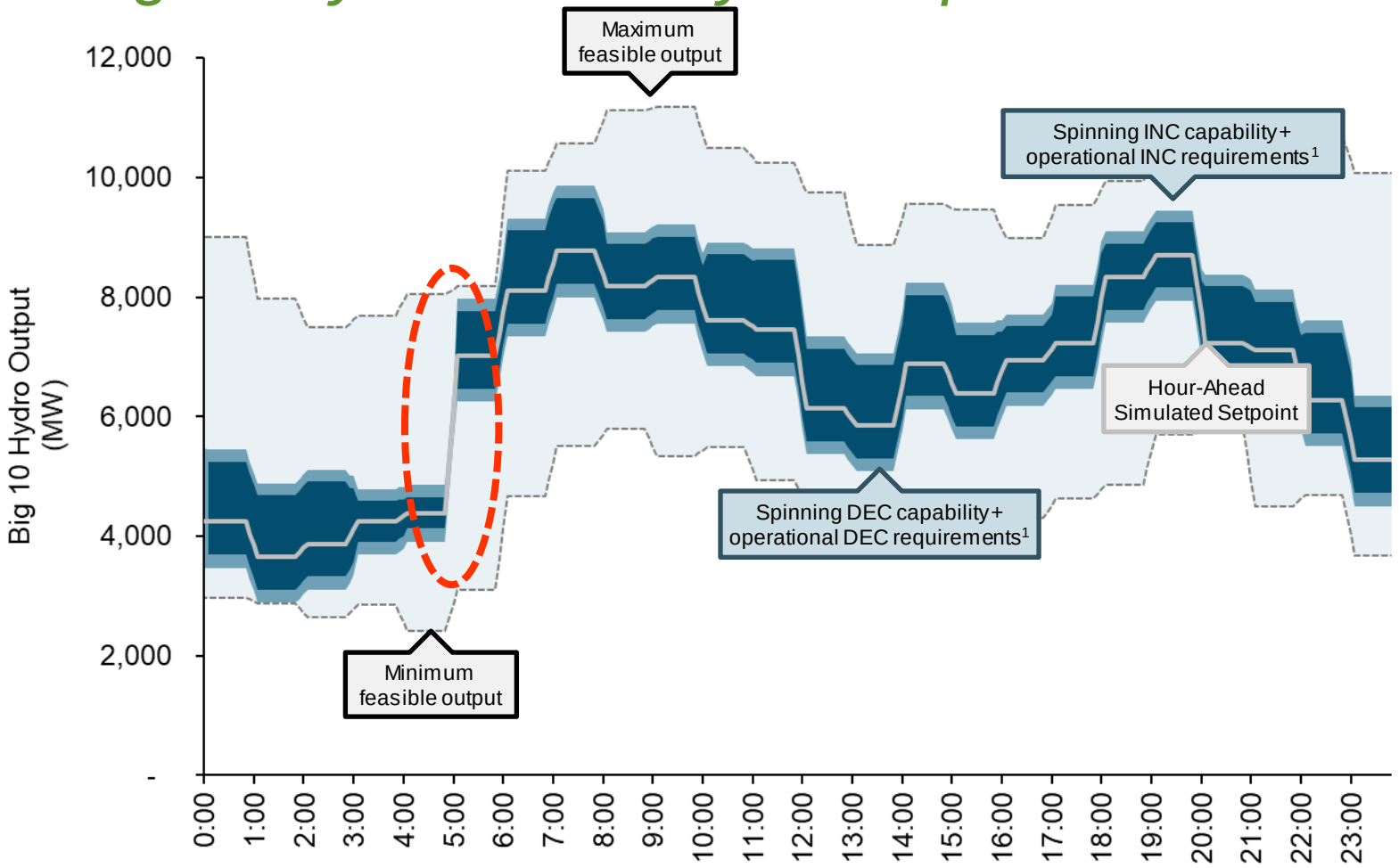
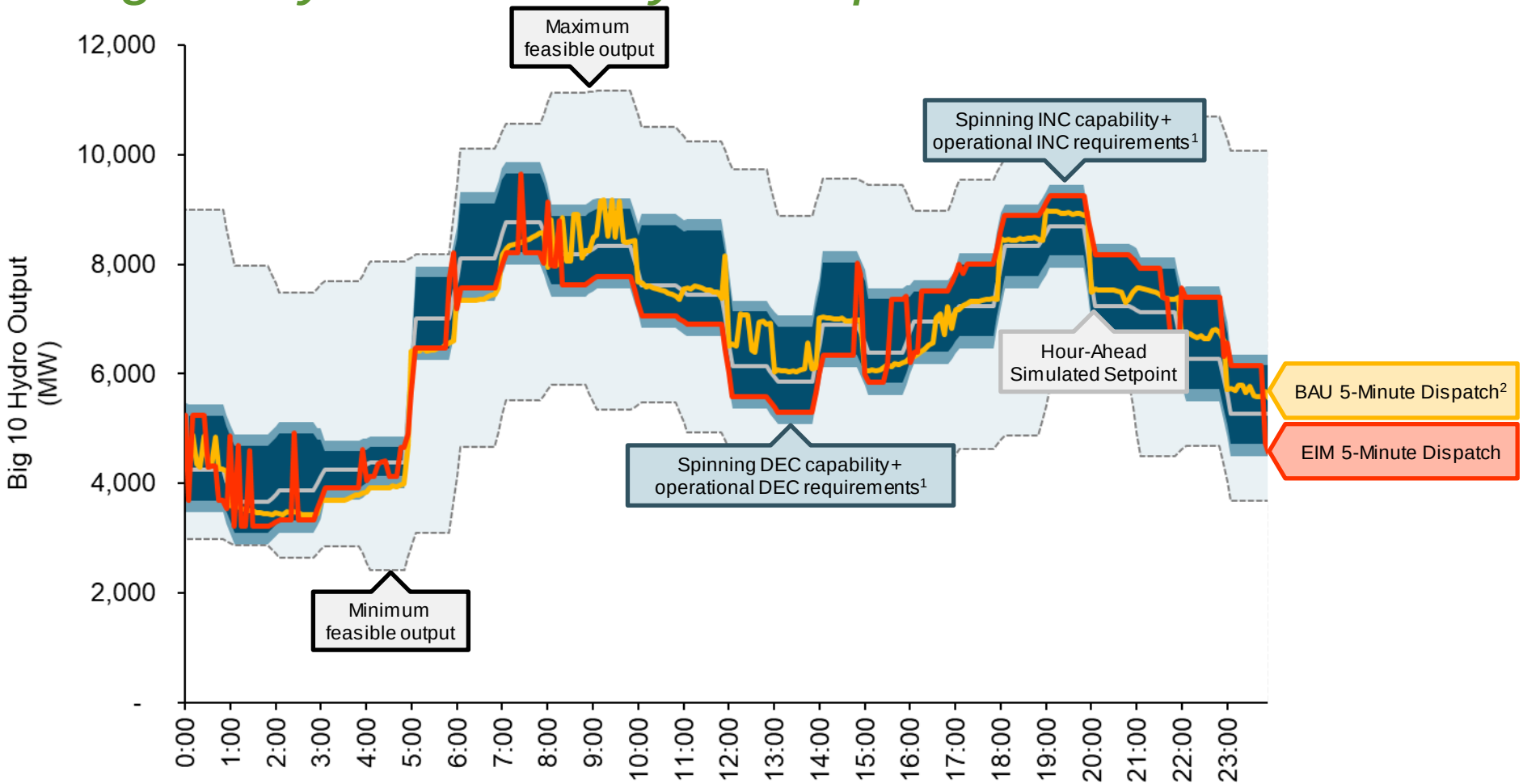


[1] Operational requirements assumptions are more conservative in EIM case than BAU case, resulting in tighter flexibility bounds

Input Assumptions

Big 10 Hydro Flexibility Example



[1] Operational requirements assumptions are more conservative in EIM case than BAU case, resulting in tighter flexibility bounds

[2] BAU dispatch shows subhourly spikes due to balancing net load (load – wind) variability

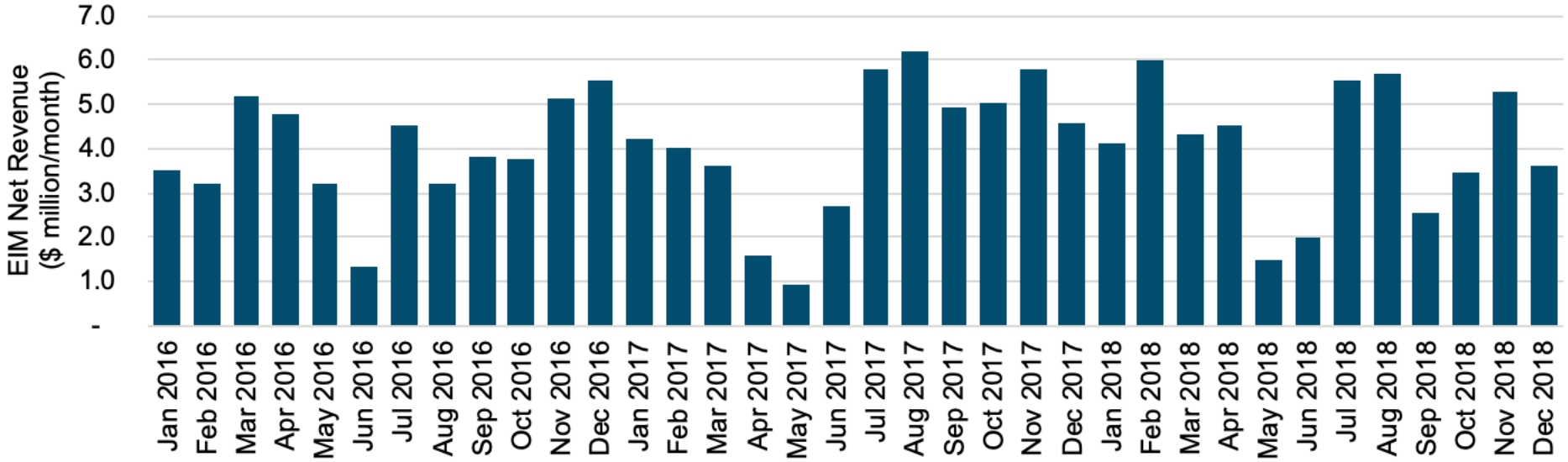
Benefits Analysis

Initial Scenario Results

Base Scenario Results

Net EIM Revenues

- Gross dispatch benefits of **$49* million/year**
  - Wide EIM spreads ($20-25/MWh) in most months
  - Net EIM revenues vary from $0.9-6.2* million/month
    - Driven by available hydro spinning capability in each month

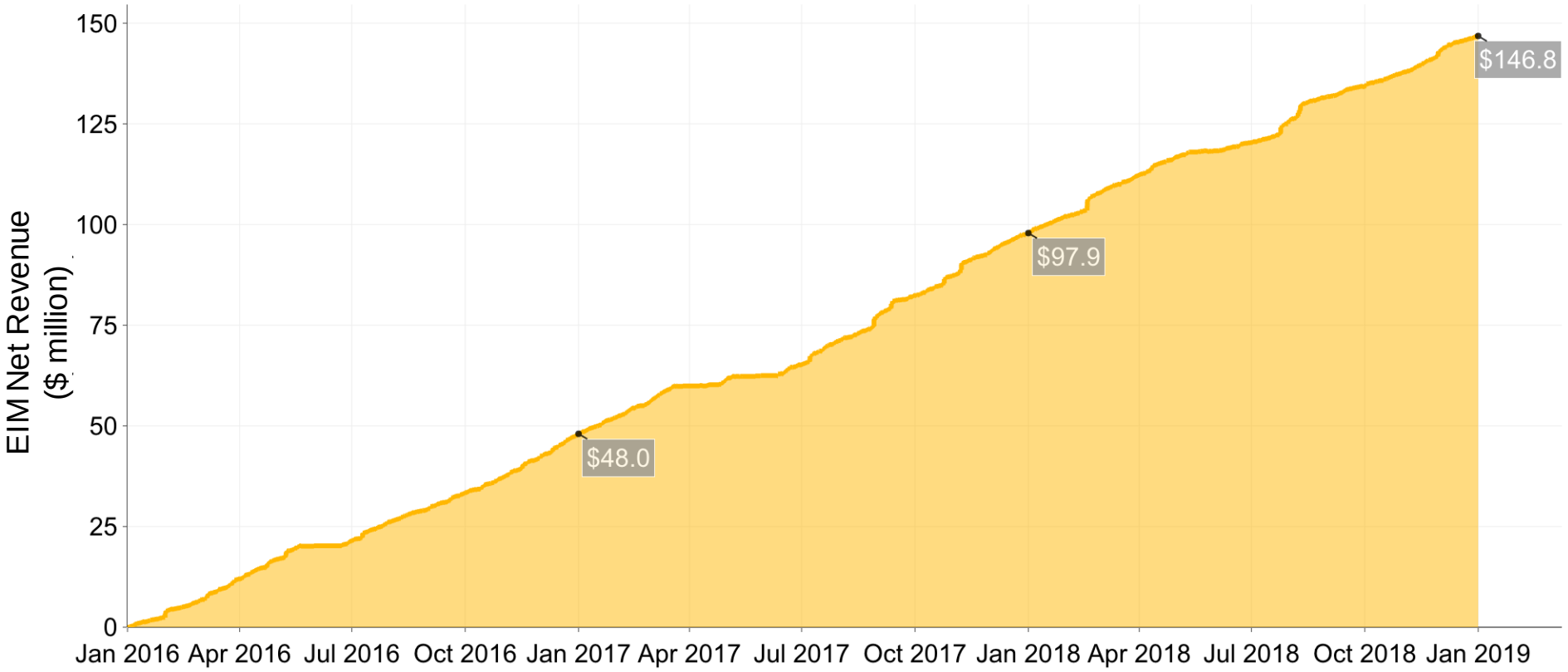


* Reported EIM benefit value includes a 75% "success rate" of BPA bids into EIM

Base Scenario Results

Cumulative EIM Gross Dispatch Benefits

- From 2016-2018, net EIM revenues average **$49* million/year**

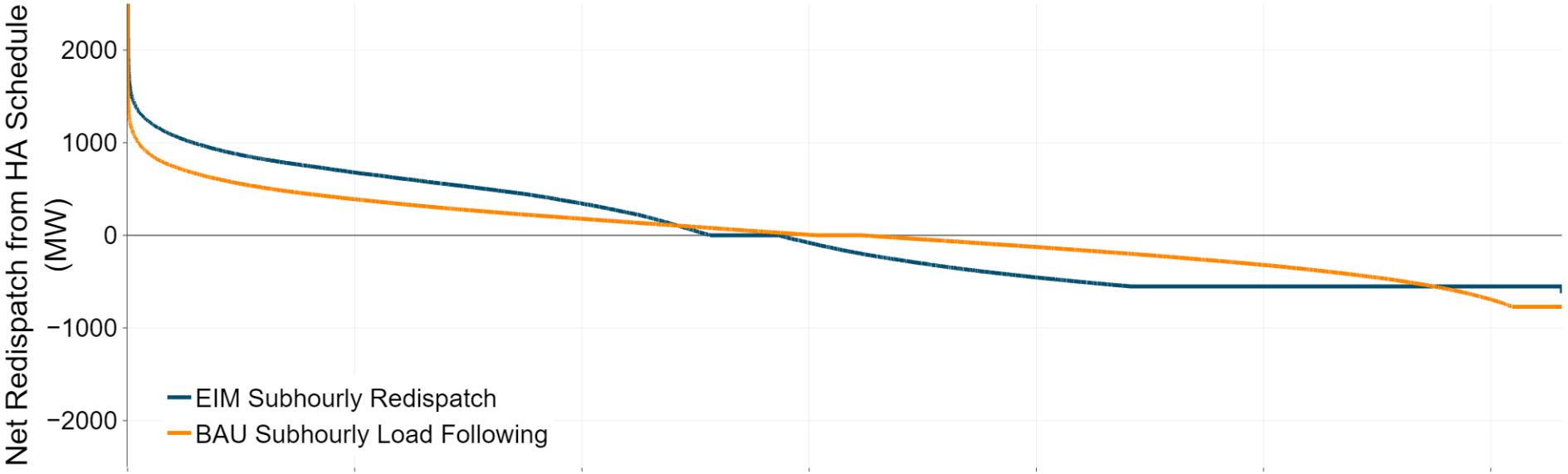


* Reported EIM benefit value includes a 75% "success rate" of BPA bids into EIM

Base Scenario Results

Big 10 Hydro Redispatch Duration Curve

- Under Business-As-Usual subhourly dispatch, BPA's hydro can only be used for **load-following within the BAA**
- EIM provides an **additional source/sink for hydro flexibility**, allowing Big 10 Hydro to dispatch to greater magnitude than in BAU
  - Increases monetized value of BPA's hydro flexibility



* EIM subhourly redispatch duration curve does not differ significantly with lower price volatility

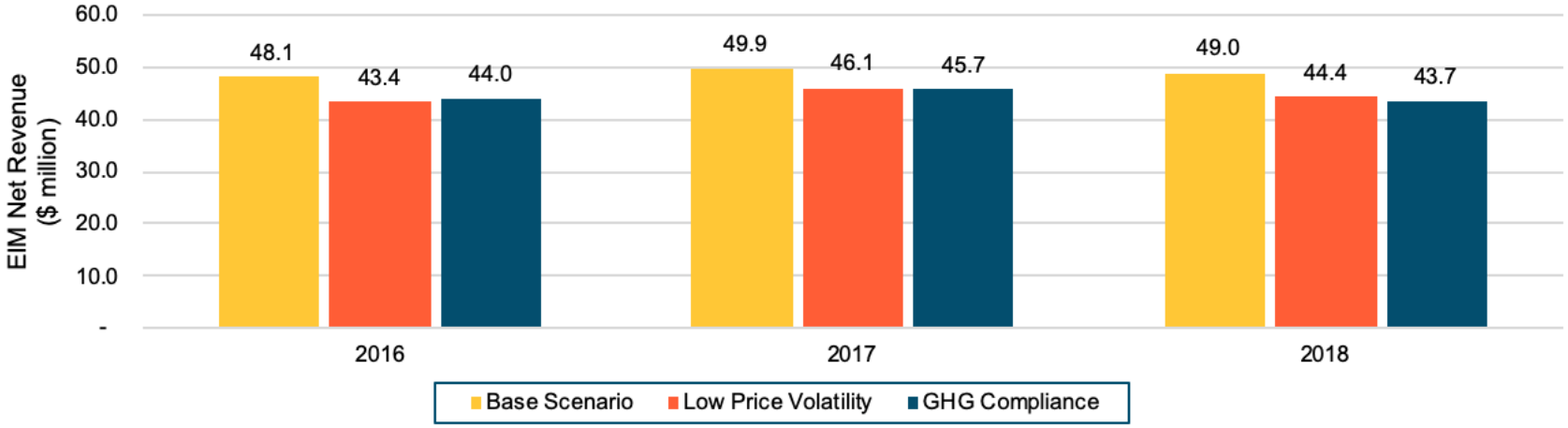
Benefits Analysis

Sensitivities Discussion

Initial Base Scenario Sensitivities

- Initial sensitivities tested:
  1. 50% lower intra-hour price volatility
  2. California GHG fee compliance
- Each sensitivity results in approximately $5 million/year less dispatch benefit than Base Scenario

Net EIM Revenues by Year* ($ million)



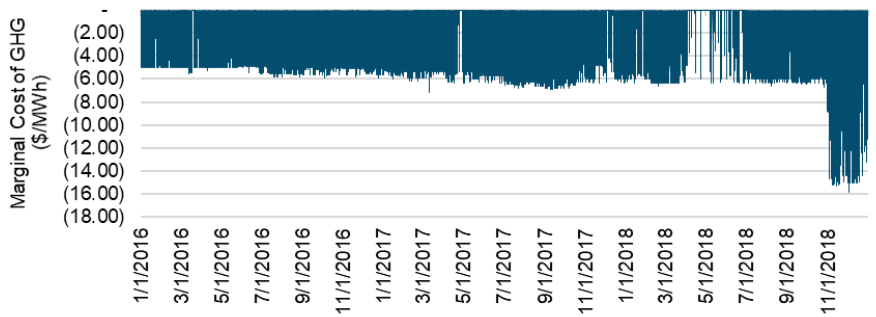
* Reported EIM benefit value includes a 75% "success rate" of BPA bids into EIM

Initial Base Scenario Sensitivities

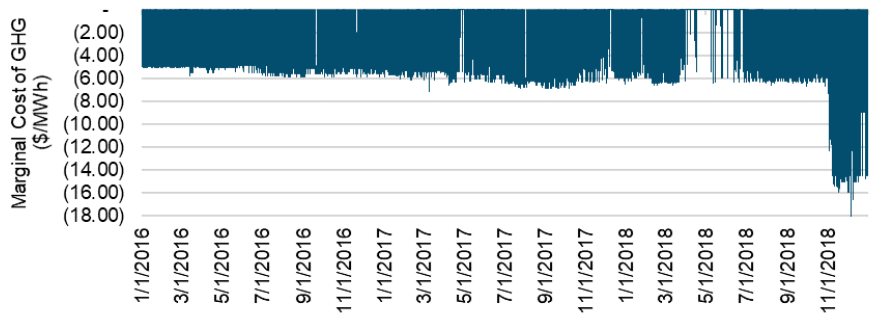
California GHG Compliance

- CAISO updated marginal GHG methodology for EIM in November 2018
- In LMPs, marginal GHG cost is nonzero only when all non-California entities as a group are exporting to California
  - CAISO collects GHG revenues for imbalance energy settlements and redistributes based on optimal export allocation

RT15 LMPs (from DGAP_PACW-APND)



RT5 LMPs (DGAP_PACW-APND)



Initial Base Scenario Sensitivities

California GHG Compliance

- To account for GHG compliance fee (which BPA cannot currently pay), we run a sensitivity where BPA receives lower LMP when selling during intervals where marginal GHG component is nonzero
- Accounting for historical marginal cost of GHG, incremental revenue from EIM participation is **$44.5 million/year**
  - BPA's GHG compliance needs further investigation, as CAISO's GHG methodology for EIM transfers changed in November 2018
  - Increased incidence of nonzero marginal GHG component after November 2018 results in greater impact to calculated EIM benefit

Transmission Benefits Discussion

Transmission Qualitative Benefits

- **Benefits accessible through EIM participation**:
  - Congestion management functions that are more economically efficient than present curtailment and bilateral redispatch capabilities
  - Optimized day to day operation of the power system

Improved Controls	Improved State Awareness	Improved Modeling & Coordination
• Proactive congestion management • Reactive congestion management • Proactive voltage control • Higher transmission utilization	• Increased accuracy and frequency of operational information • New visual displays of (near) real-time data, allowing operators to better predict operational issues • Access CAISO EIM dispatchers tools	• Improved network modeling • Improved outage modeling & coordination • Improved Power & Transmission coordination

1. Transmission Curtailment

Schedule Curtailments

- BPA curtails schedules pro-rata according to NERC Curtailment priority
- Curtailments are non-optimal as more schedules need to be curtailed to attain desired flow reductions
- Curtailments are limited to schedules where BPA is the TSP or TOP
- Curtailments result in imbalances that need to be resolved separately by each impacted BAA further reducing the effectiveness of curtailments

Energy Imbalance Market

- The EIM's Security-constrained economic dispatch (SCED) finds optimal solution to minimize cost given transmission constraints
  - Price signals incentivize resources closest to constraints to dispatch with higher $/MWh congestion value
  - Redispatch requests can be fulfilled by any EIM participant, potentially reducing burden on Transmission customers and reducing the likelihood of curtailments or scheduling restrictions
  - Existing scheduling practices/rights are unchanged by EIM
- Market model provides advisory dispatches ahead of real-time

- BPA tested EIM Area Total Flow (ETF) constraint compared to South-of-Allston curtailments to achieve flow relief
  - ETF constraint was able to provide in one 5-minute market run an amount of flow relief that would have required over 1200 MW of schedule curtailments

2. EIM as a Non-Wires Solution

- EIM is a **wide-area solution** that manages flows near real-time across the entire system based on **operating limits** and **system congestion**
  - EIM provides benefits across the entire footprint, whereas other options for relieving transmission flows are targeted local options
  - EIM dispatch is a precise method of achieving flow relief needed
- EIM can provide a **complementary tool** for BPA to use for grid management
  - EIM does not completely replace the need for transmission builds
  - Potentially defers the cost of building transmission or implementing other non-wires solutions
- In many situations, **BPA will still need to build transmission** (e.g., long-term load growth or replacing aging transmission assets)
  - Transmission may be a less applicable option to address short-term, moderate needs

2. EIM as a Non-Wires Solution

– A tool used to delay or avoid transmission expansion investment decisions to address congestion issues.

Categories of capital projects that the EIM could help defer or avoid:

- As a system-wide non-wires solution, network congestion driven projects could be remediated with security constrained economic dispatch, *for example*:
  - I-5 Corridor Reinforcement

Categories of capital projects that are driven by other needs that the EIM would *NOT* be expected to displace:

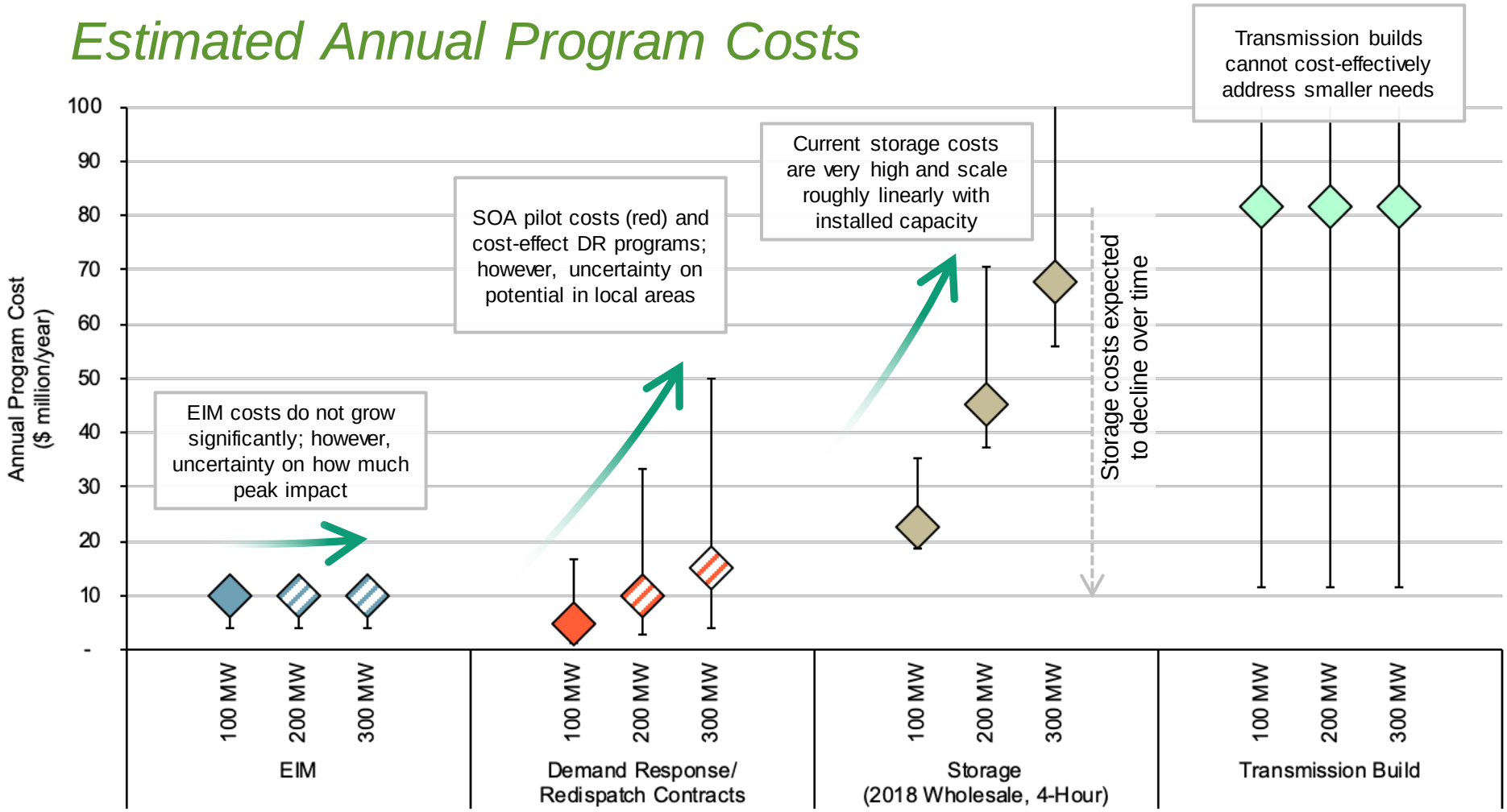
- Sustain Program projects for safe and reliable operation of existing facilities, *for example:*
  - wood pole replacement or transformers that have reached end of life
- Generation Interconnection, Line & Load Interconnection projects that are driven by requests from customers, *for example*:
  - data center loads
- Load Service Area Reinforcement projects required to mitigate reliability criteria violations, *for example*:
  - Hooper Springs project in SE Idaho

2. EIM as a Non-Wires Solution

	EIM	DR	Storage	Transmission Build
Generation Capacity Value	No	Yes	Yes	No
Energy Value	Yes	Yes	Yes	No
Transmission Capacity Value	Low	Low	Low	High
Congestion Area	Wide	Local	Local	Local
Congestion Value	High	Medium	Medium	High
Effort to Provision	Low	Medium	Medium	High
Levelized Costs	$	$$$	$$$$	$$
Call Option Timing	N/A	0-2 Days	0-2 days	N/A
Response Time	8-12 Minutes	0-4 hours	0-4 hours	N/A
Duration	5-240 Minutes	1-4 hours	1-4 hours	30-50 Years
Uses	Load Service Imbalance Energy Economic Dispatch Congestion Management Renewable Integration Energy Arbitrage	Load Service Peak Shaving	Load Service Renewable Integration Energy Arbitrage Operating Reserves	Load Service Renewable Integration

2. EIM as a Non-Wires Solution

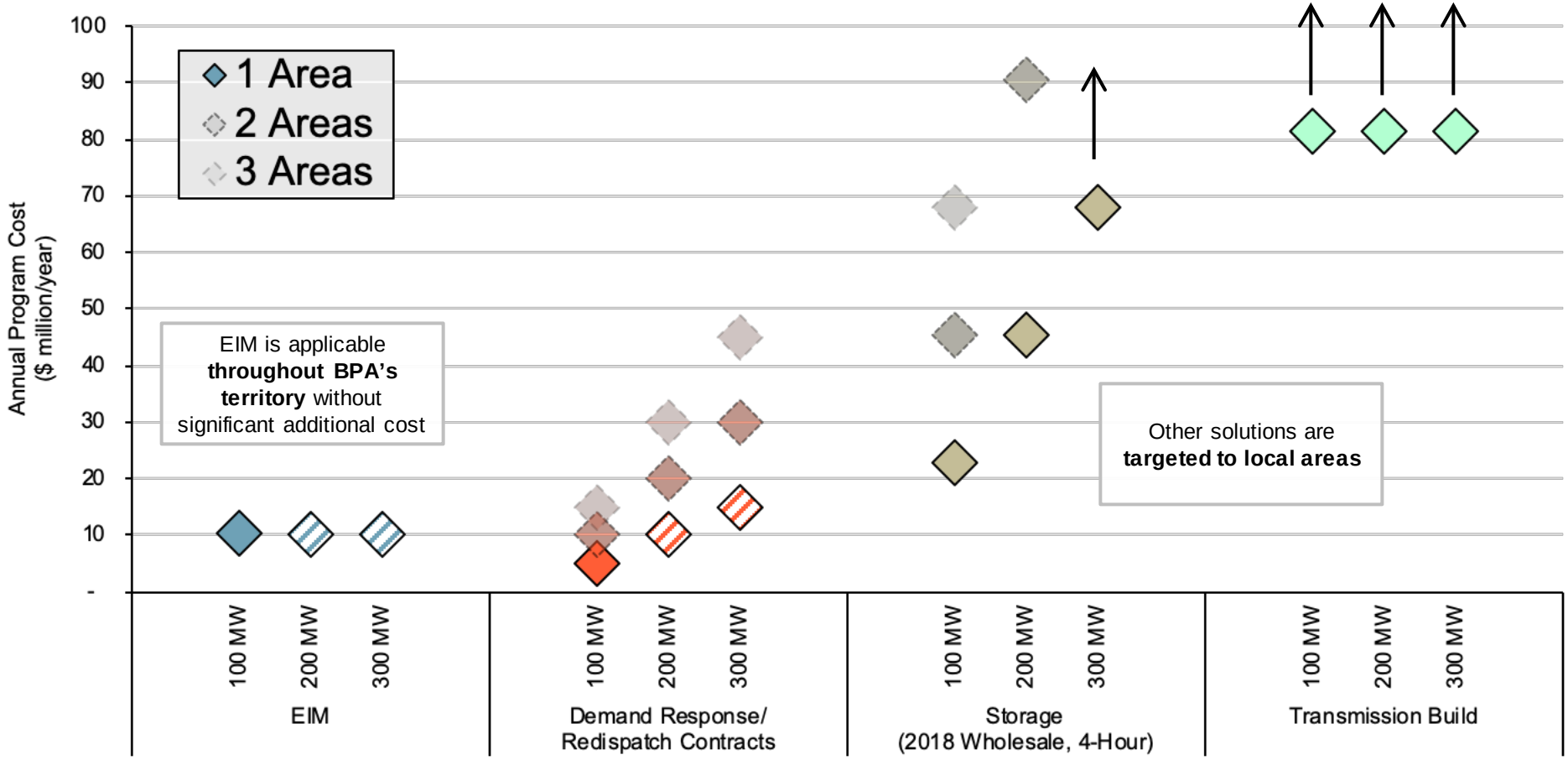
Estimated Annual Program Costs



Colored and striped diamonds represent sample middle costs from publicly available data

2. EIM as a Non-Wires Solution

Scaling Costs Over Multiple Project Areas



Colored and striped diamonds represent sample middle costs from publicly available data

2. EIM as a Non-Wires Solution

Illustrative Quantitative Example with Current Costs

- 2 flowgates, each needing 100 MW of intra-hour flow relief
  - Business-As-Usual Case: Assume that relief comes from 50/50 mix of battery storage and Redispatch contracts or DR
  - Assumed Redispatch/DR cost based on South of Allston Redispatch Pilot
  - EIM case: based on total estimated levelized EIM program cost

Business-As-Usual Case		EIM Case	
100 MW battery @ $226/kW-year	$22.6 million/year	$10 million/year (levelized startup and ongoing costs)	$10 million/year
100 MW Redispatch Contract / DR @ $50/kW-year	+ $5.0 million/year		
Annual Cost	**= $27.6 million/year**		**= $10 million/year**

Transmission Benefits Summary

- EIM provides many **qualitative benefits**
- EIM dispatch is an **additional tool** for BPA to use for grid management that produces **optimal economic dispatch** subject to transmission constraints
  - EIM may provide **more precision and higher effectiveness** compared to BPA's current practice of transmission schedule curtailments (non-optimized) to address events where intra-hour flow relief is needed
- EIM is a **complementary, low cost non-wires option** (among other non-wires options as well as new transmission build) for transmission congestion relief needs
  - EIM provides locational flexibility for addressing modest transmission relief needs that arise **across** the BPA system
  - EIM does not replace the need for all new transmission builds

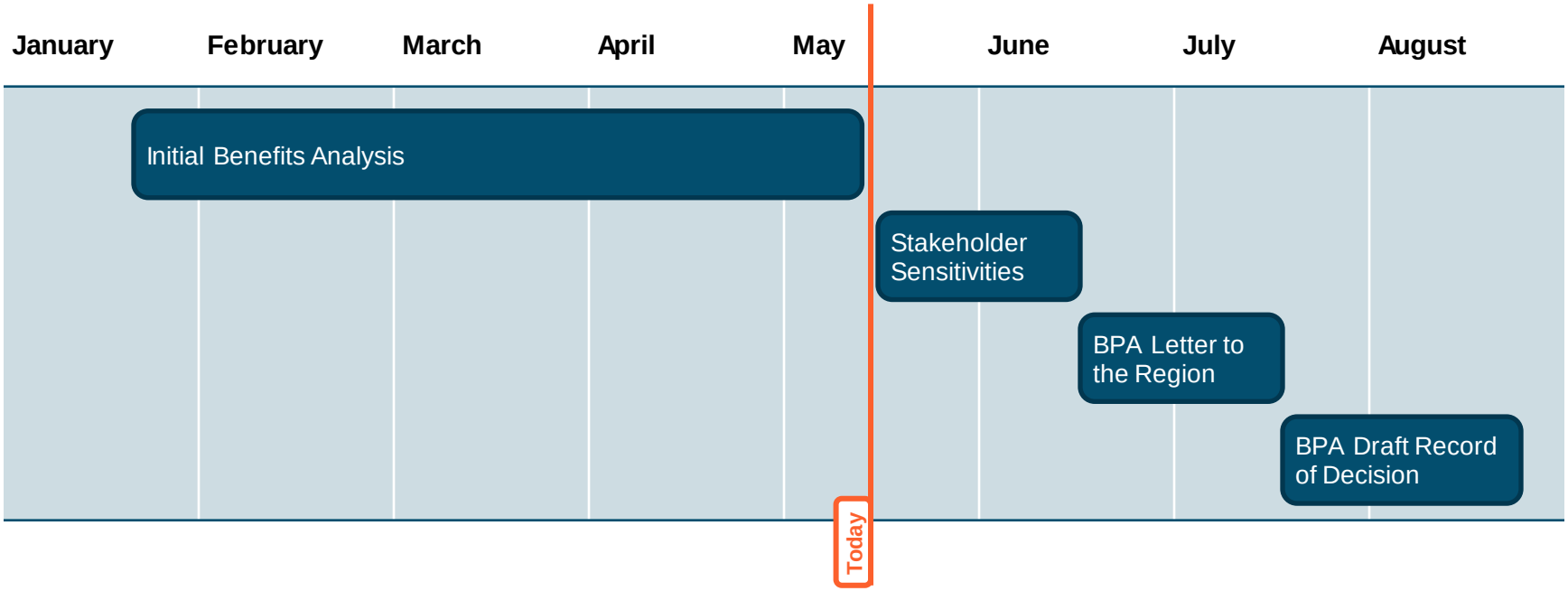
Summary & Next Steps

Wrap-Up

- E3 modeling suggests that dispatch benefits from EIM participation will quickly pay for itself and result in significant ongoing benefits:
  - Two sensitivities that were evaluated did not fundamentally change this conclusion
- E3 modeling suggests that EIM participation is a cost-effective non-wires solution and an effective intra-hour congestion management tool
- EIM participation will also:
  - Result in an efficient dispatch of generation to meet load across the entire EIM footprint
  - Provide increased visibility and discipline in the dispatch and marketing of FCRPS
  - Create additional visibility of conditions across the grid which will enhance reliability
  - Allow BPA to effectively participate in the development of future markets to enhance regional resource adequacy by ensuring that flexible resources are appropriately compensated for the services that they provide

Next Steps

- Based on today's feedback, we will develop a suite of sensitivities and updates for June stakeholder meeting



Next Steps

Next Steps

- Next meeting scheduled for **Wednesday June 12th** at the Rates Hearing Room.
  - WebEx and Phone participation will be available
  - Agenda and materials will be distributed in advance via Tech Forum

- We welcome feedback on this meeting. Your comments will help shape future EIM Stakeholder Meetings, please email us at techforum@bpa.gov and reference "EIM Stakeholder Meeting" in the subject. Comments are due by May 29th Wednesday.

- For more information on BPA's EIM Stakeholder process and meetings please visit:
  https://www.bpa.gov/Projects/Initiatives/EIM/Pages/Energy-Imbalance-Market.aspx

- For more information on BPA's Grid Modernization Initiative please visit:
  https://www.bpa.gov/goto/GridModernization

Question and Answer Session

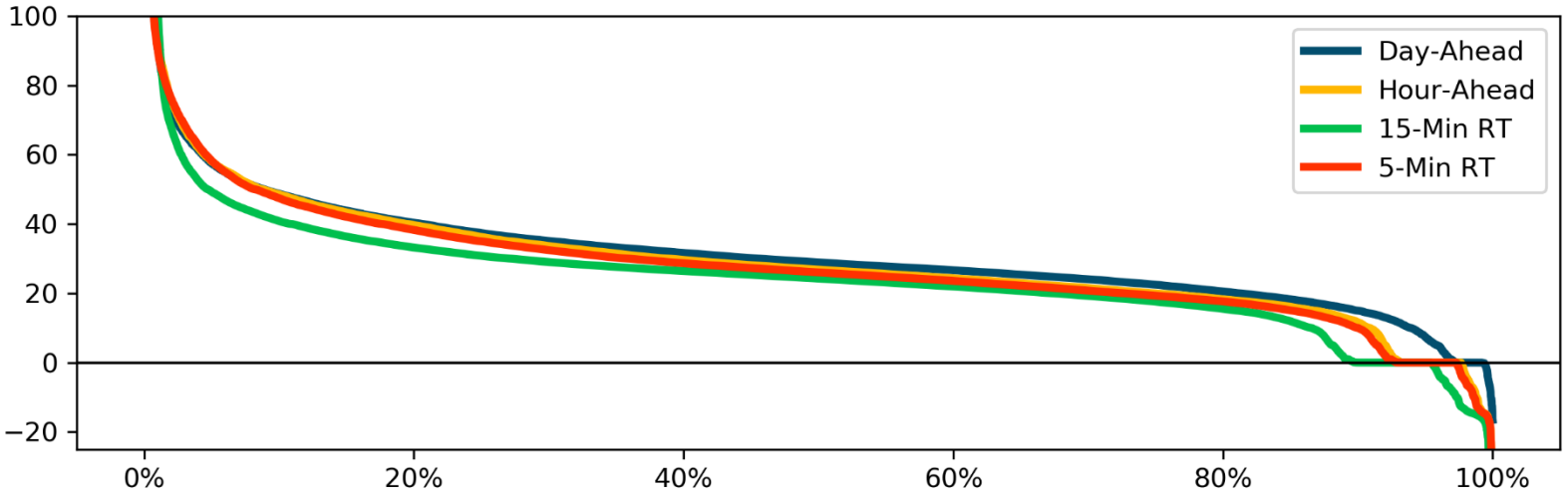
Appendix A. Benefits Analysis

Additional Material

Input Assumptions

Market Prices

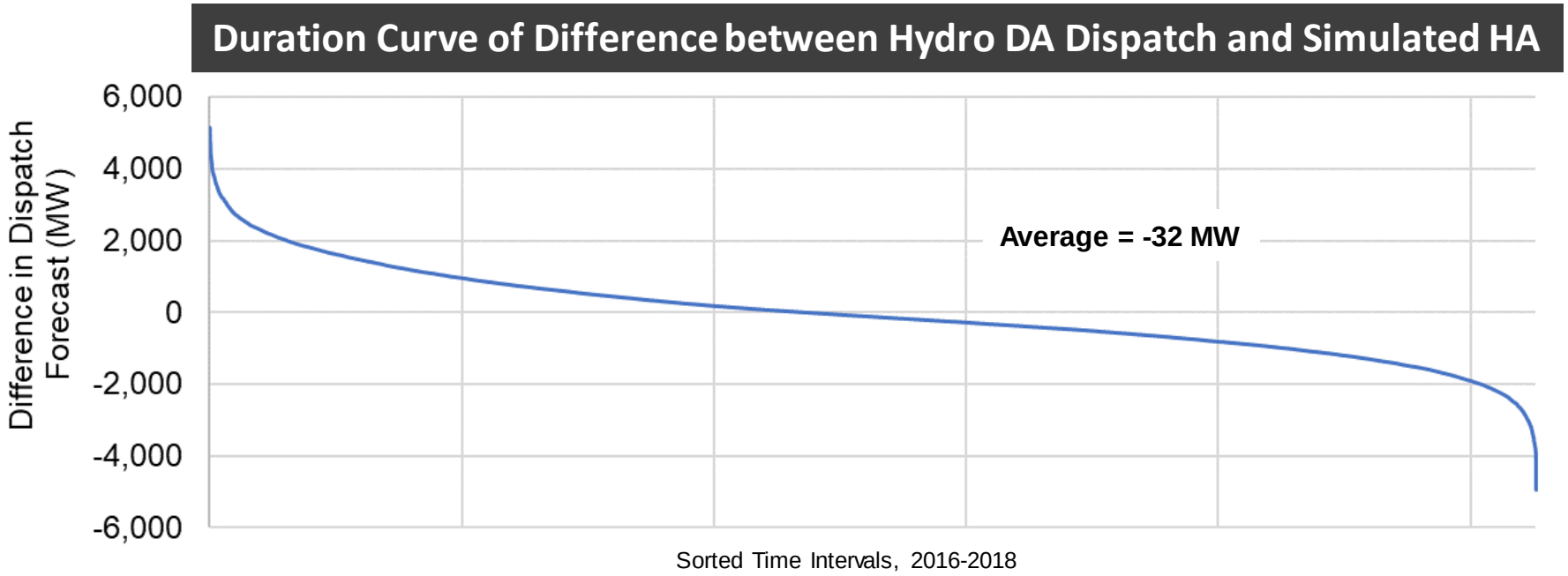
- Mid-C and EIM prices are based on historical for 2016-2018:
  - **Day-Ahead:** ICE Mid-C
  - **Hour Ahead:** Powerdex Mid-C
  - **EIM:** DGAP_BPAT-APND RTPD and RTM



Input Assumptions

Day-Ahead vs. Hour-Ahead Big 10 Hydro Setpoint

- Between 2016-2018, 45% of hours of day-ahead hydro tags are greater than the hour-ahead simulated hydro dispatch



Input Assumptions

Non-hydro BAA Generators

- All generators are given fixed loads in DA and HA
- By 2018 non-hydro BPA generators with fixed loads in real time include:

Generator Type	Max Output (MW)
Gas	2,949
Wind	2,760
Nuclear	1,191
Biomass	284
Coal	61
Geothermal	16
Solar	15

Input Assumptions

Hydro BAA Generators

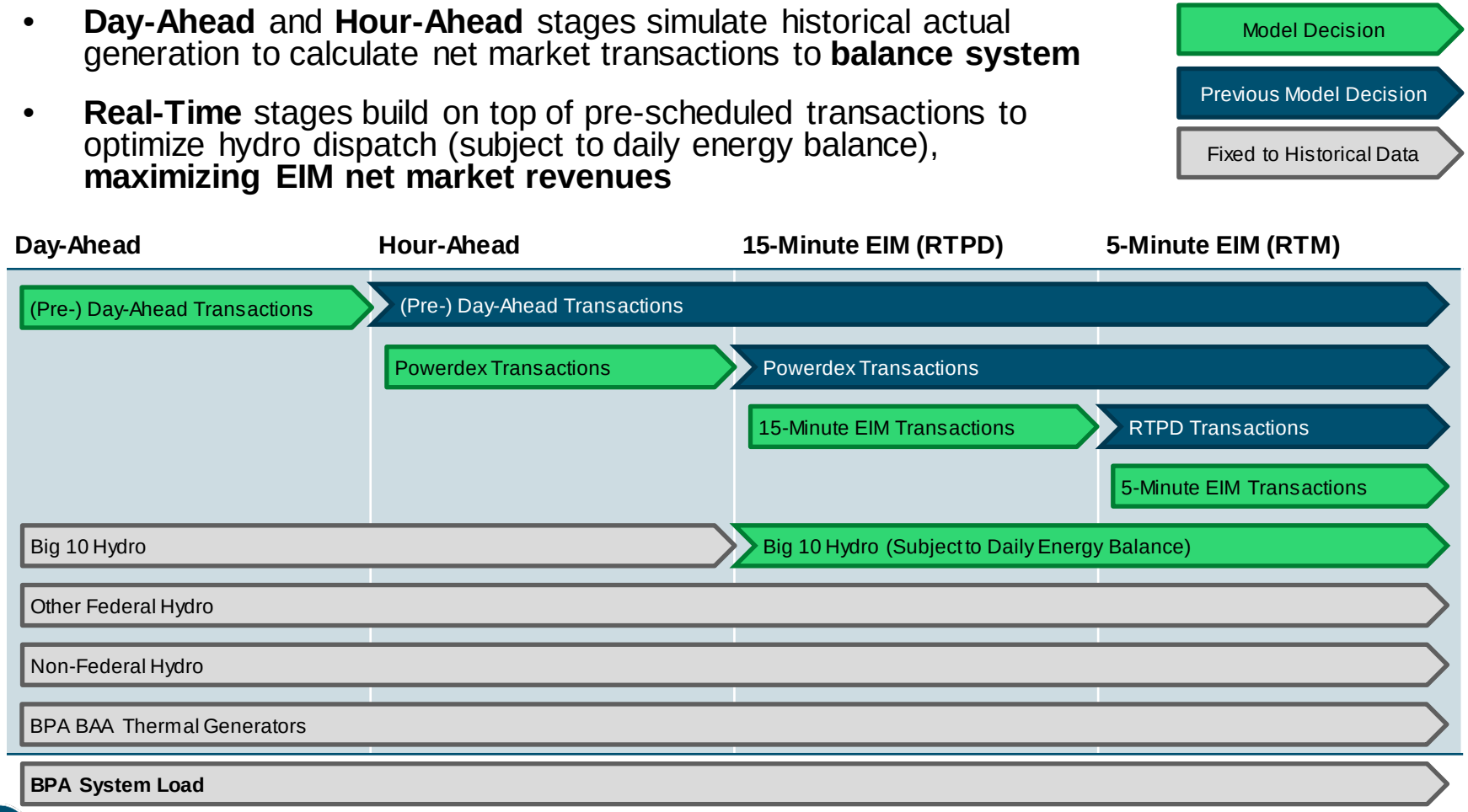
- **Hydro generation in BPA's BAA is categorized as Federal and Non-Federal:**
  - **Federal:**
    - **Big 6:** Bonneville, Grand Coulee, The Dalles, John Day, Chief Joseph, McNary
    - **4 of 10 largest federal hydro:** Lower Monumental, Lower Granite, Little Goose, Ice Harbor
    - **Other federal hydro:** Includes Libby, Hungry Horse, Dworshak
  - **Non-Federal:**
    - Dispatchable
    - Non-dispatchable (run of river)
- **All are given fixed load except for "Big 10" hydro**

Hydro Category	Max Capacity (MW)
Big 6	16,190
4 of 10	3,483
Other Federal	2,152
Non-Federal Dispatchable	43
Non-Federal Non-Dispatchable	306

Modeling Approach

Model Decisions

- **Day-Ahead** and **Hour-Ahead** stages simulate historical actual generation to calculate net market transactions to **balance system**
- **Real-Time** stages build on top of pre-scheduled transactions to optimize hydro dispatch (subject to daily energy balance), **maximizing EIM net market revenues**



Base Scenario Results

Annual Energy by Resource Category

- Half of energy generated in BPA BAA is traded/exported at Mid-C
- 5-7% of annual load is served by purchases in the EIM from 2016 to 2018

Annual Energy Balance by Resource Category (GWh)

		2016		2017		2018	
Category	**Resource**	**EIM**	**Non-EIM**	**EIM**	**Non-EIM**	**EIM**	**Non-EIM**
Generation	**Thermal**	9,443	9,443	9,141	9,141	8,837	8,837
	Nuclear	9,624	9,624	8,161	8,161	9,728	9,728
	Other Hydro	15,486	15,486	18,480	18,480	16,332	16,332
	Big 10 Hydro	59,303	59,303	63,199	63,199	62,163	62,163
	Wind & Solar	11,139	11,208	9,542	9,516	8,564	8,450
Purchases	**Mid-C ICE**	-	-	-	-	-	-
	Mid-C Powerdex	4,278	4,278	4,280	4,280	4,913	4,913
	EIM (15-Minute)	2,147	-	1,795	-	2,205	-
	EIM (5-Minute)	1,647	-	1,288	-	1,533	-
Sales	**Mid-C ICE**	(50,517)	(50,517)	(52,243)	(52,243)	(50,472)	(50,472)
	Mid-C Powerdex	(4,947)	(4,947)	(4,464)	(4,464)	(4,689)	(4,689)
	EIM (15-Minute)	(2,128)	-	(1,780)	-	(2,199)	-
	EIM (5-Minute)	(1,528)	-	(1,266)	-	(1,537)	-
Native Load		53,970	53,970	56,426	56,426	55,447	55,447

Base Scenario Results

Annual Energy Cost by Resource Category

- Average prices at Mid-C and EIM increase significantly from 2016 to 2018
- ~8% of sales revenue in every year is attributed to sales in the EIM

Annual Energy Cost by Resource Category ($M)							
		2016		2017		2018	
Category	Resource	EIM	Non-EIM	EIM	Non-EIM	EIM	Non-EIM
Generation	Thermal	188	188	201.3	201.3	206.1	206.1
	Nuclear	7.8	7.8	6.6	6.6	7.9	7.9
	Other Hydro	-	-	-	-	-	-
	Big 10 Hydro	-	-	-	-	-	-
	Wind & Solar	-	-	-	-	-	-
Purchase Cost	Mid-C ICE	-	-	-	-	-	-
	Mid-C Powerdex	74.2	74.2	81.3	81.3	120.4	120.4
	EIM (15-Minute)*	28.1	-	28.7	-	40.4	-
	EIM (5-Minute)*	19.8	-	21.5	-	32.9	-
Sales Revenue	Mid-C ICE	934.4	934.4	958.4	958.4	1,242	1,242
	Mid-C Powerdex	97.9	97.9	109.2	109.2	151.5	151.5
	EIM (15-Minute)*	56.6	-	65.0	-	77.6	-
	EIM (5-Minute)*	39.4	-	35.1	-	44.6	-
Net Revenue of 15-minute		**28.5**		**36.3**		**37.3**	
Net Revenue of 5-minute		**19.6**		**13.6**		**11.7**	

* Reported EIM benefit value includes a 75% "success rate" of BPA bids into EIM

Base Scenario Results

EIM Transaction Volume Comparison

- For 2016-2018 period, average simulated BPA EIM transactions (MW) are on the high end of other BAAs' **historical EIM transfers**
  - PLEXOS model's perfect foresight and optimal dispatch allows larger volumes of redispatch (subject to hydro feasibility constraints)

BAA	15-Minute Sales (Average MW)	15-Minute Purchases (Average MW)	5-Minute Sales (Average MW)	5-Minute Purchases (Average MW)
AZPS	244	250	234	249
BCHA	77	121	89	151
CISO	631	487	715	471
IPCO	320	63	310	67
NEVP	128	299	142	305
PACE	389	718	376	749
PACW	501	133	493	147
PGE	116	138	117	146
PSEI	97	96	109	105
BPA	**647**	**533**	**397**	**416**

Source: CAISO OASIS EIM Transfer

Appendix B. Transmission Benefits

Assumptions and Examples

1. Transmission Curtailment

South-of-Allston Curtailment vs. ETF Constraint

- Performed three simulated curtailments with different flow relief requirements: **100 MW**, **300 MW**, and **500 MW** on South-of-Allston
  - **Curtailment:** Need to curtail **455 MW**, **1085 MW**, and **1711 MW** of schedules would be curtailed, respectively
  - **ETF Constraint:** EIM Area relief obligation would be **70.7 MW**, **208.0 MW**, and **344.9 MW** respectively
- Curtailments do not resupply energy to balance BAAs or control for the dispatch of resources that could reload the path/flowgate

Relief Required	Schedules to Curtail (Total)	Schedules to Curtail (EIM)	EIM Area Allocation
100	455	289	70.7
300	1085	780	208
500	1711	1270	344.9

1. Transmission Curtailment

South-of-Allston Curtailment vs. ETF Constraint

- The ETF constraint was able to provide up to **~335 MW** of flow reductions without relaxation in one 5-minute RTD run
- Shadow prices were **$14** and **$25** for the first two simulations (70.7MW and 208MW reductions)
- Compared to curtailments, fewer MW of resources were redispatched using ETF while simultaneously maintaining power balance.

2. EIM as a Non-Wires Solution

Example Transmission Build Costs

- **McNary—John Day 500 kV** (completed)
  - ~$192 million ≈ $19 million/year*
- **Central Ferry-Lower Monumental** (completed)
  - ~$112M ≈ $11 million/year*
- **Big Eddy – Knight** (completed)
  - ~$202M ≈ $20 million/year*
- **I-5 Reinforcement** (canceled)
  - ~$800 million ≈ $80 million/year*
- **Boardman to Hemingway** (planning)
  - ~$1,200 million ≈ $120 million/year*

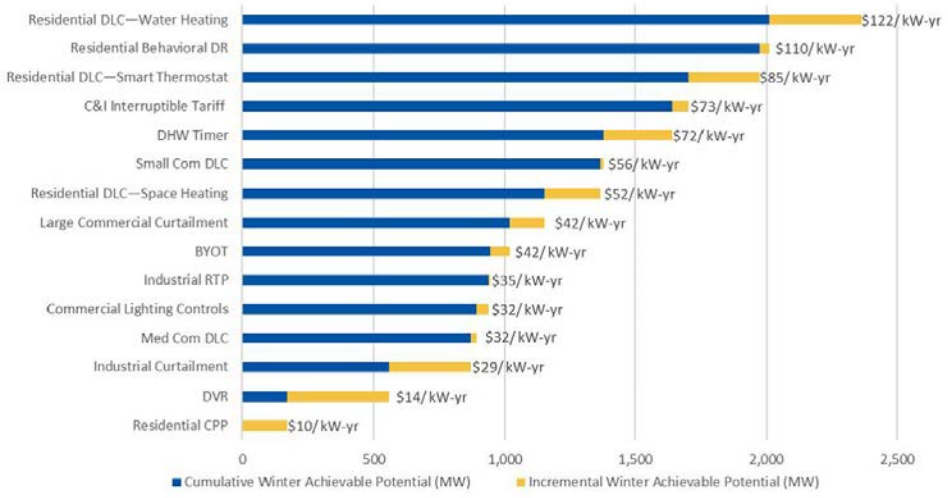
* Estimated levelized cost represents costs discounted over 40 years

2. EIM as a Non-Wires Solution

BPA Demand Response Potential & Costs

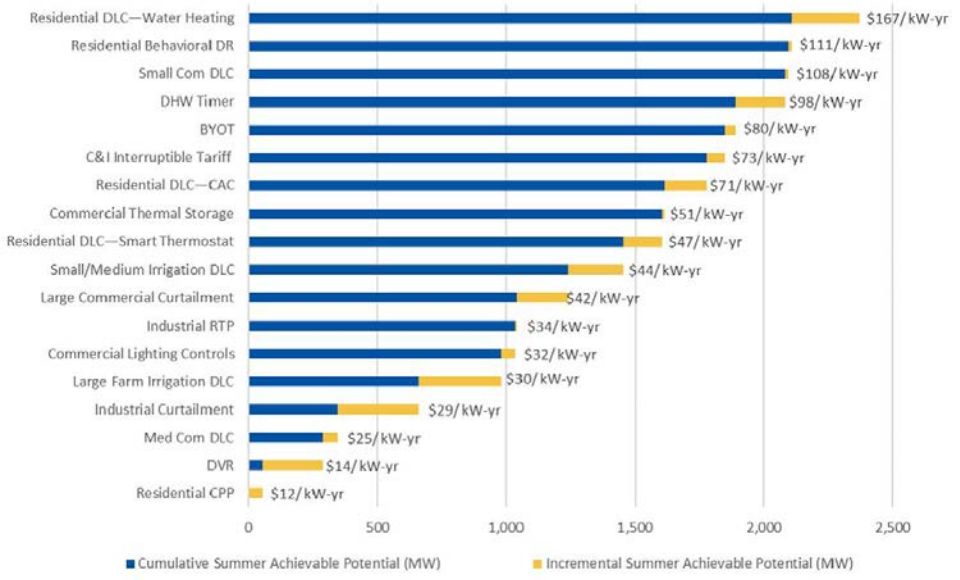
Winter Peak

Figure 4. 20-Year Supply Curve for Combined DR Products, Winter, with Levelized Costs



Summer Peak

Figure 3. 20-Year Supply Curve for Combined DR Products, Summer, with Levelized Costs



- BPA's DR costs are in line with neighboring BAAs (PacifiCorp and PSE)
  - Direct load control options in the range of **$29-$167/kW-year**
  - Pricing mechanisms in the **$10-$35/kW-year** range
- Over 2,000 MW of peak contribution across various measures

2. EIM as a Non-Wires Solution

South-of-Allston Redispatch Pilot

- Total cost for 2 years: $8.8 million
  - Does not include implementation cost for internal bid evaluation tool
- Pilot required BPA staff to notify participants day-ahead of redispatch and manually coordinate redispatch among participants

	SOA Non-Wires Pilot	FY17	FY18
A	SOA Pilot Budget	$ 5,000,000	$ 5,000,000
B	Capacity Costs	$ 3,393,053	$ 3,608,050
C	Energy + Other Costs	$ 180,370	$ 194,940
D	PTP TX Costs	$ 769,575	$ 690,525
E	**Total Budget - Total Cost**	**$ 657,002**	**$ 506,485**

2. EIM as a Non-Wires Solution

Battery Energy Storage Costs

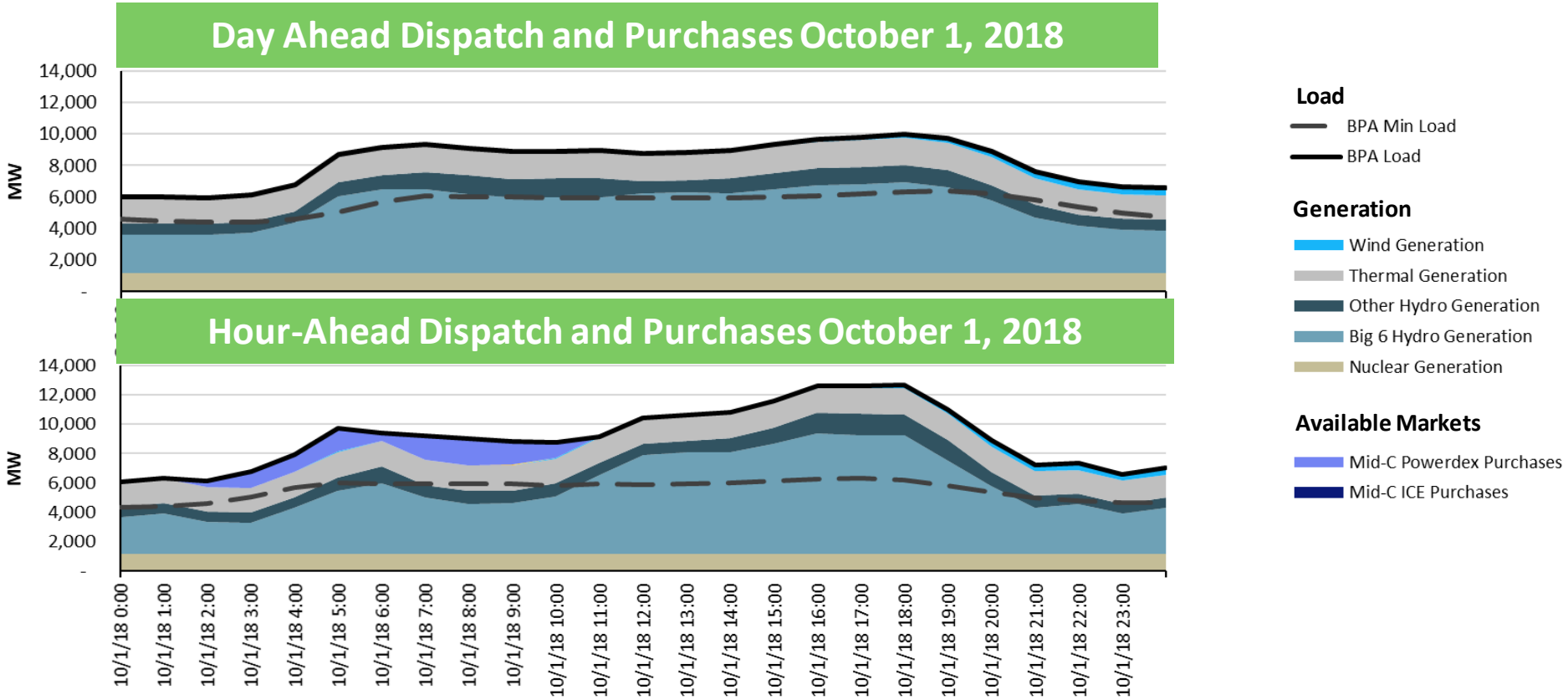
- E3 uses Lazard's latest Levelized Cost of Storage 4.0 analysis as basis of a in-house financial pro forma to calculate cost of new storage build
- We estimate cost of storage in 2018 to be $226/kW-year for a 4-hour lithium-ion battery
  - Lazard's estimated CAGR for cost declines is 8%

Source: Lazard's Levelized Cost of Storage Analysis – Version 4.0

Appendix C.
Example Dispatch Days

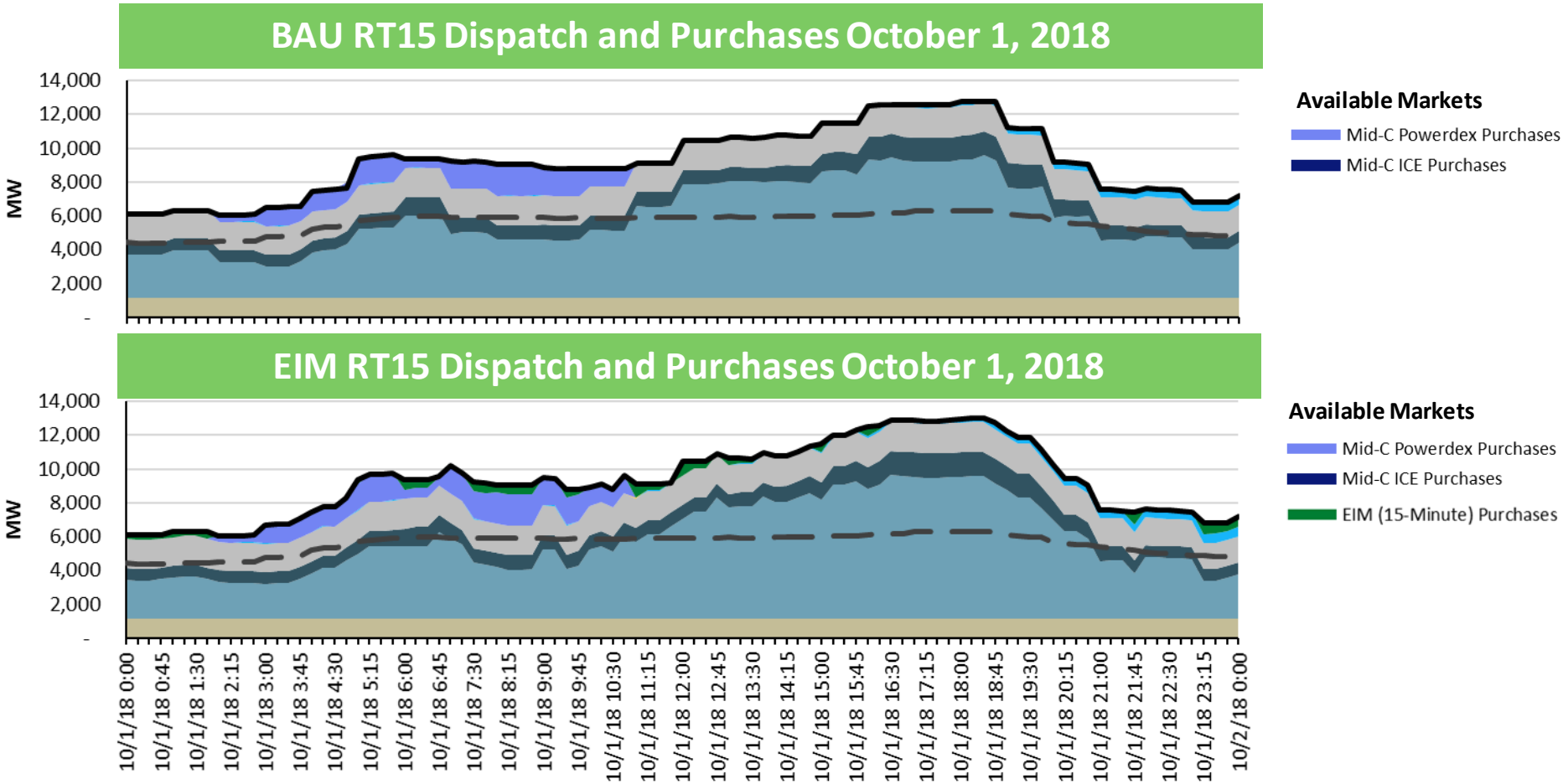
Base Scenario Results

Four-Stage Dispatch: Pre-Real-Time (DA and HA)



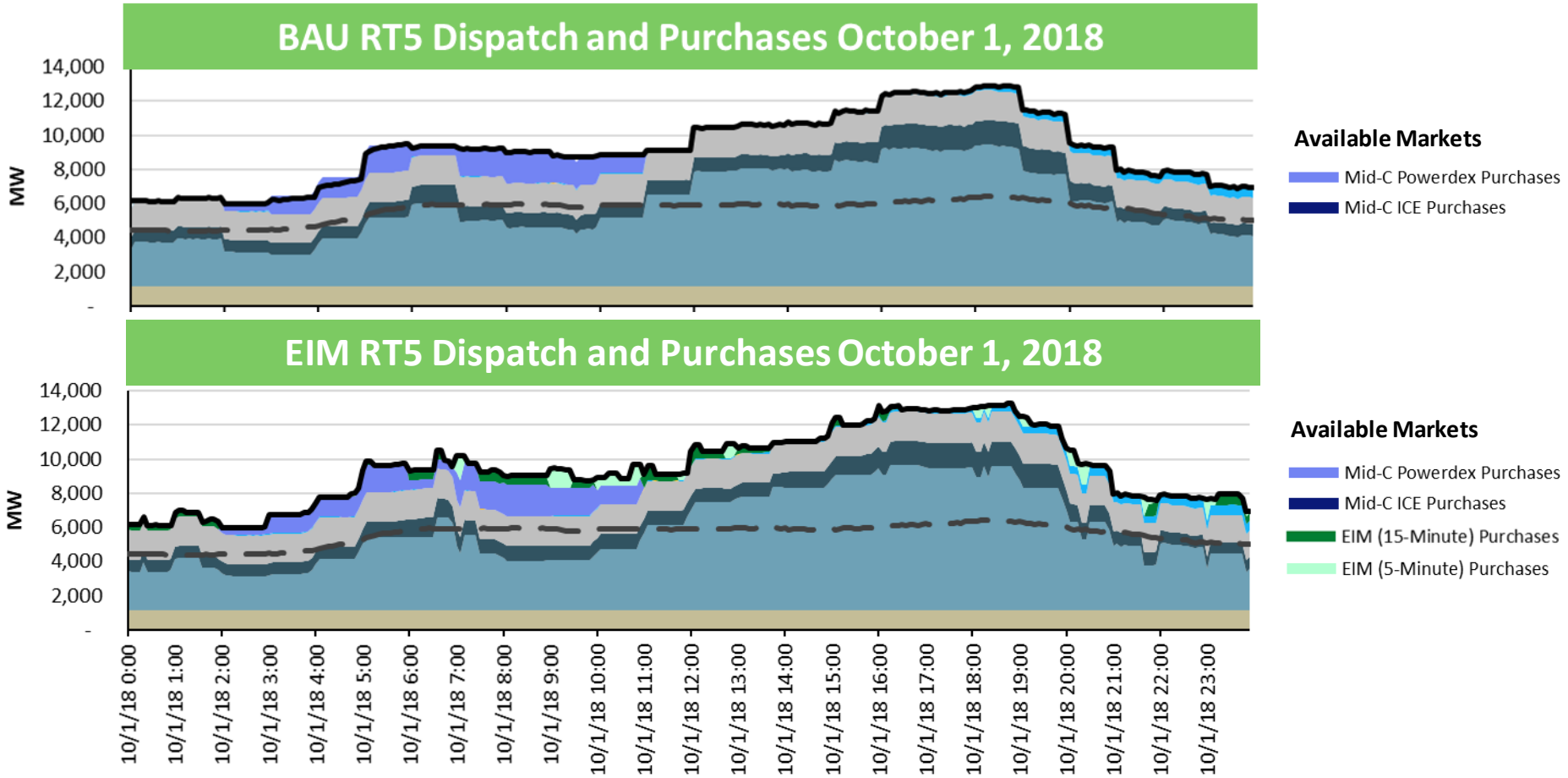
Base Scenario Results

Four-Stage Dispatch: RT15 BAU & EIM



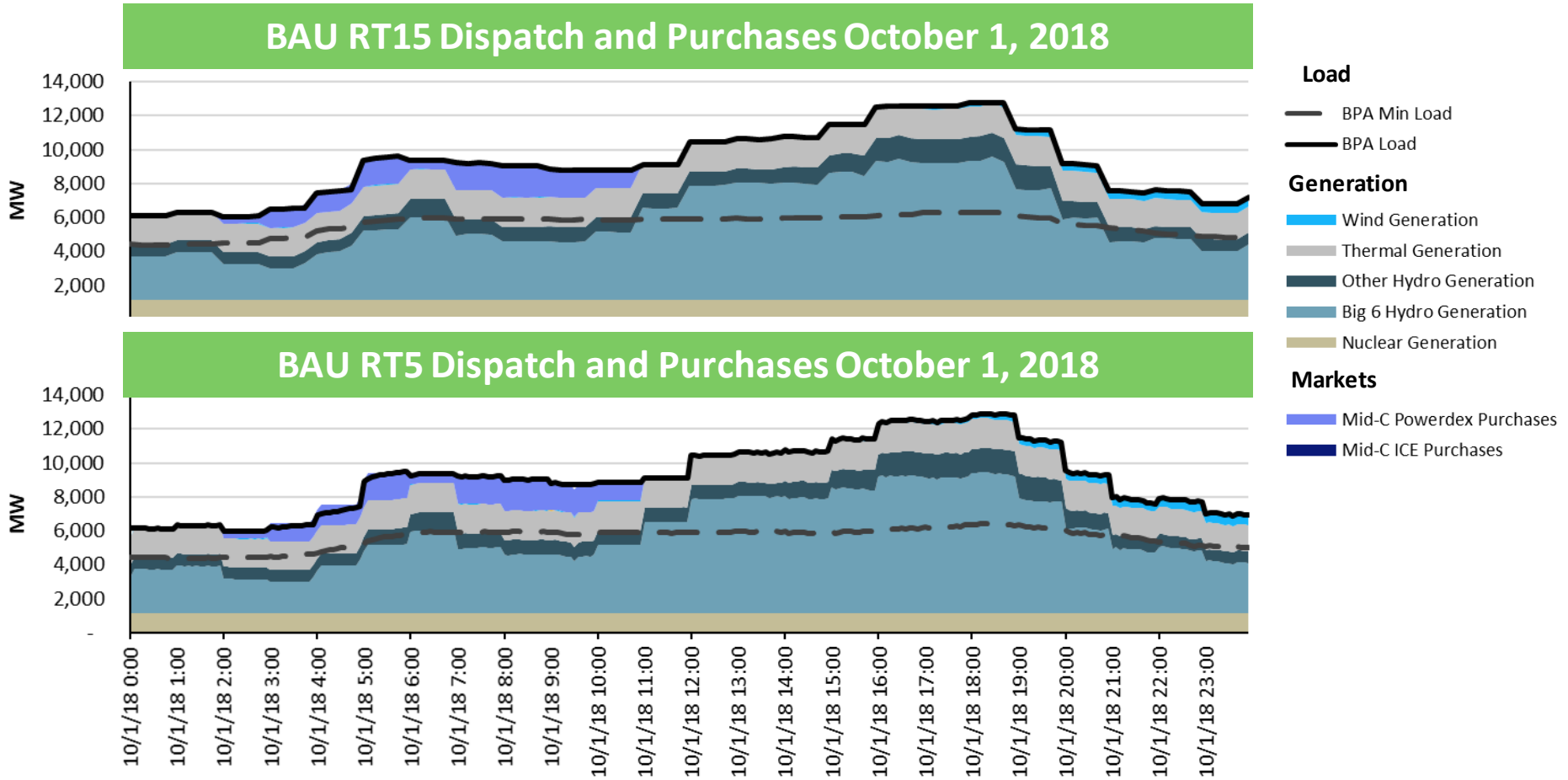
Base Scenario Results

Four-Stage Dispatch: RT5 BAU & EIM



Base Scenario Results

Four-Stage Dispatch: RT15 & RT5 Non-EIM



Base Scenario Results

Dispatch, EIM Net Sales and Market Prices