Energy Storage for Market Operations

EPIC Project 1.01 Overview

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EPIC Summer Workshop

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EPIC 1.01 Energy Storage for Market Operations: Batteries

Vaca Dixon
2 MW / 14 MWh NAS Battery
Vaca-Dixon Substation

Project Initiation: 2007
Operational Date: August 2012
Commenced CAISO Market Ops: Aug 2014

Current Use Cases:
- 100% dedicated to CAISO wholesale market participation

Yerba Buena
4 MW / 28 MWh NAS Battery
Customer R&D Facility, San Jose

Project Initiation: 2007
Operational Date: May 2013
Commenced CAISO Market Ops: Jan 2016

Current Use Cases:
- Half energy reserved for islanding/backup for the adjacent customer facility

NAS Battery Current Use Cases

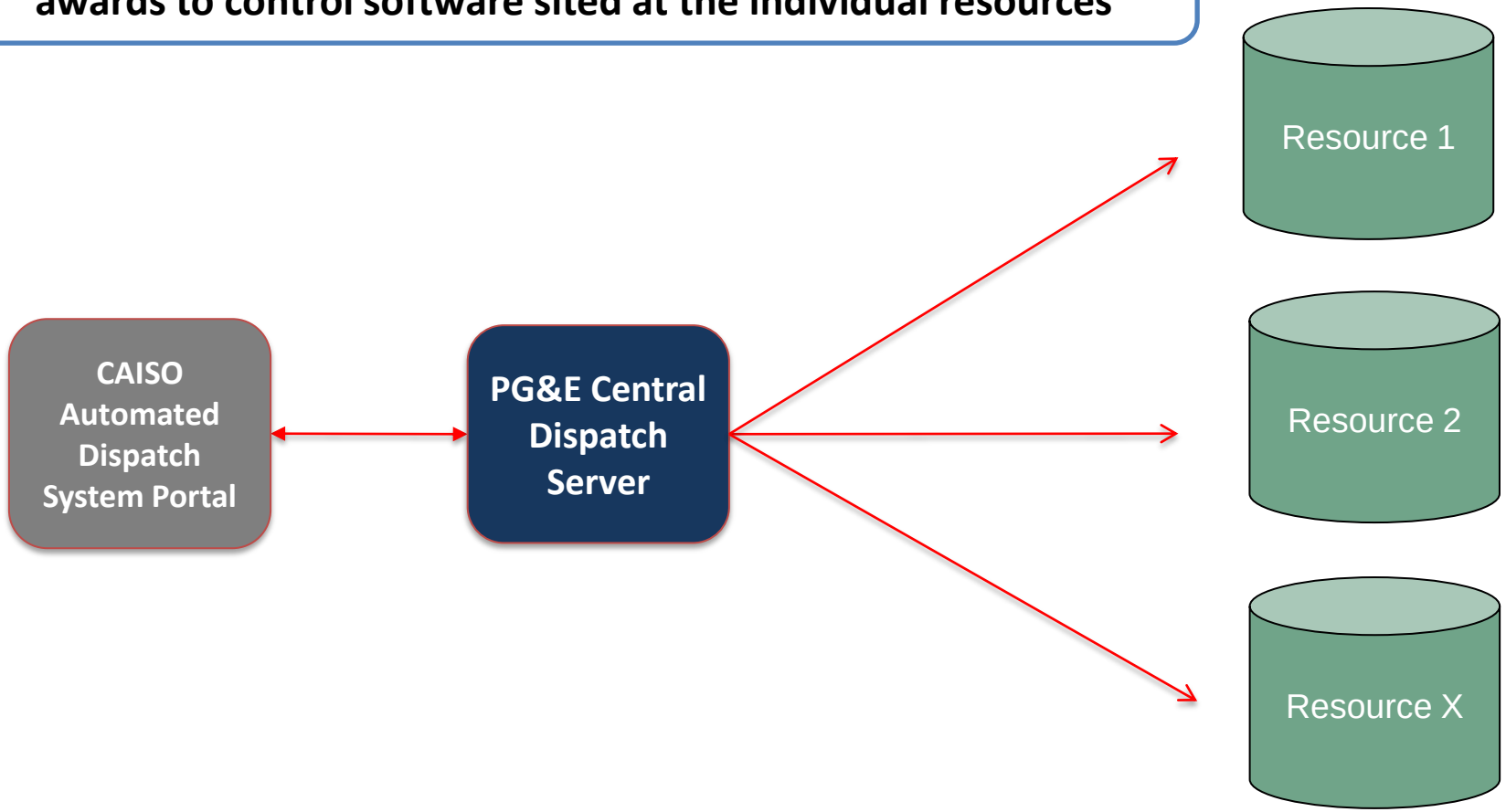
	Vaca Dixon	Yerba Buena
DA, RT Energy		
DA, RT Regulation (AGC)		
Regulation Energy Management (REM)		
Spin / Non-Spin		
Customer Islanding		

= Capable and currently used **= Capable but not currently used** **= Not capable**

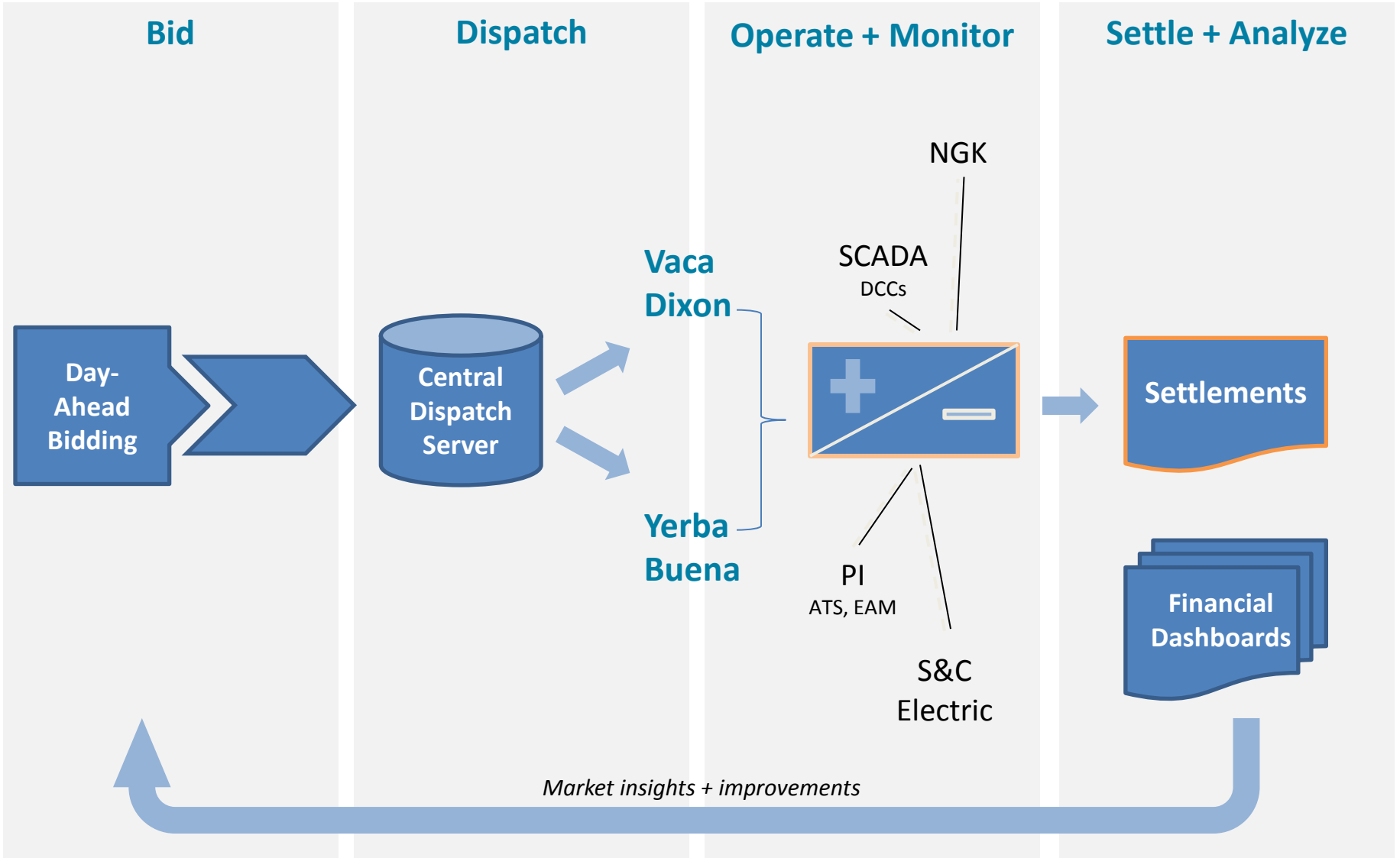
Commentary	▪ Day-Ahead bidding of capacity for REM, CAISO manages SOC ▪ Not offered during 'String Balancing' (few hours, once per month)	▪ Day-Ahead bidding of energy and regulation, PG&E manages SOC ▪ Real-Time self-scheduling as needed to manage SOC (few hours per day) ▪ Deviation risk during islanding

EPIC 1.01 – Energy Storage for Market Operations
CAISO Automation Platform

Platform automatically fetches schedules from CAISO and sends awards to control software sited at the individual resources



Day in the Life of the NAS Batteries



Significant Accomplishments

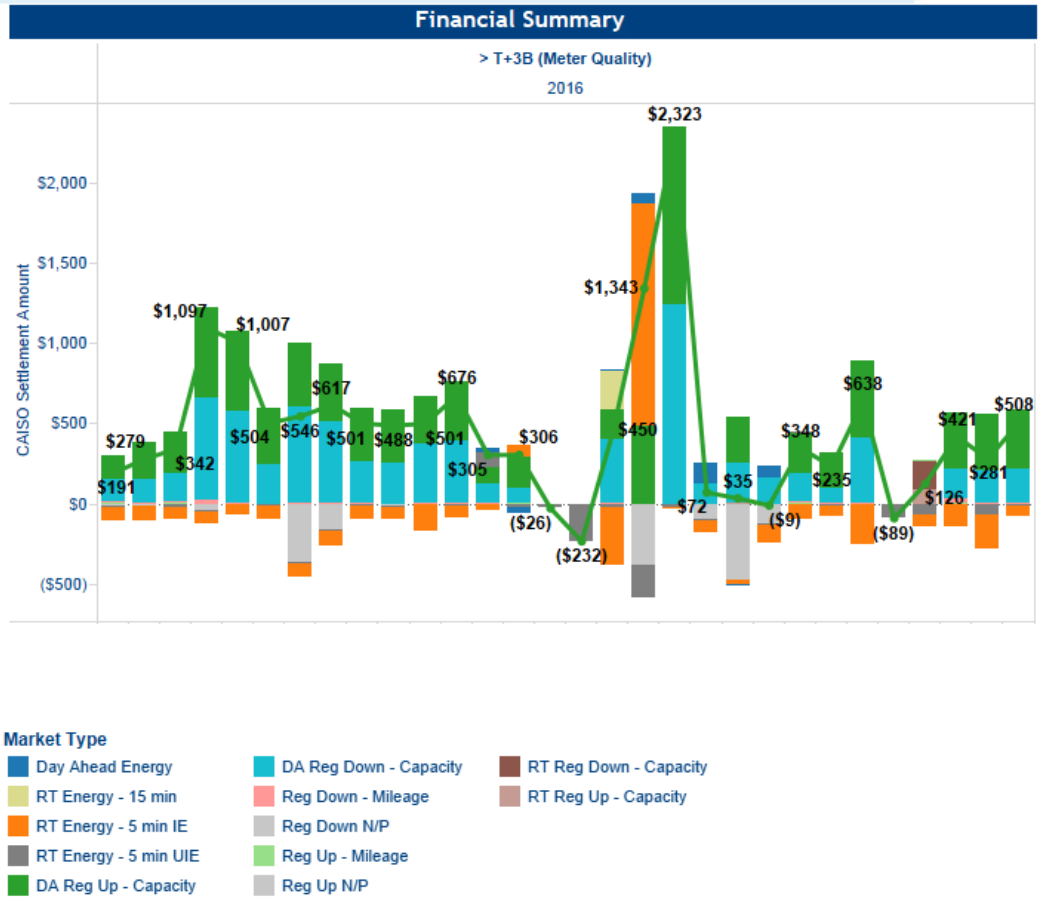
Timely and Accurate Visibility	• State of charge, charge/discharge rates, readiness
AGC and ADS Capability	• Automatic Generation Control (AGC), 4-second regulation signals. Automatic Dispatch System (ADS), 5-minute real-time dispatch instructions.
Identified & supported resolution of CAISO Software Errors	• Identified undue awards and missing market awards
Ongoing Market Participation	• Daily bidding into the CAISO markets for both Vaca Dixon and Yerba Buena

Observations

- Resources respond very well with respect to adherence to energy schedules, AGC and ADS signals
- Most CAISO market revenues come from regulation

Market Participation Example Results

Vaca BESS used primarily for frequency regulation

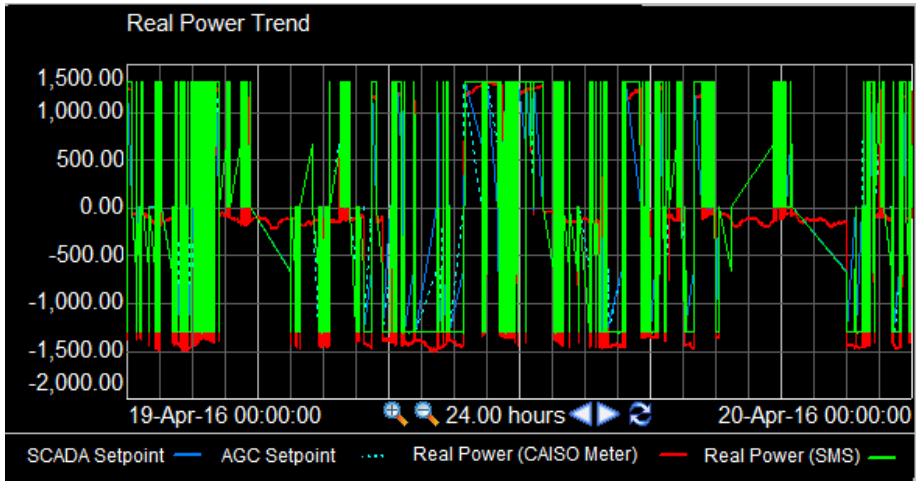


Totals for Period	
Day Ahead Energy	$254
RT Energy - 15 min	$245
RT Energy - 5 min IE	($1,103)
RT Energy - 5 min UIE	($828)
DA Reg Up - Capacity	$8,560
DA Reg Down - Capacity	$7,971
Reg Up - Mileage	$60
Reg Down - Mileage	$96
Reg Down N/P	($1,051)
Reg Up N/P	($648)
RT Reg Down - Capacity	$172
RT Reg Up - Capacity	$97
Grand Total	**$13,824**

Primary revenue drivers are **regulation capacity**

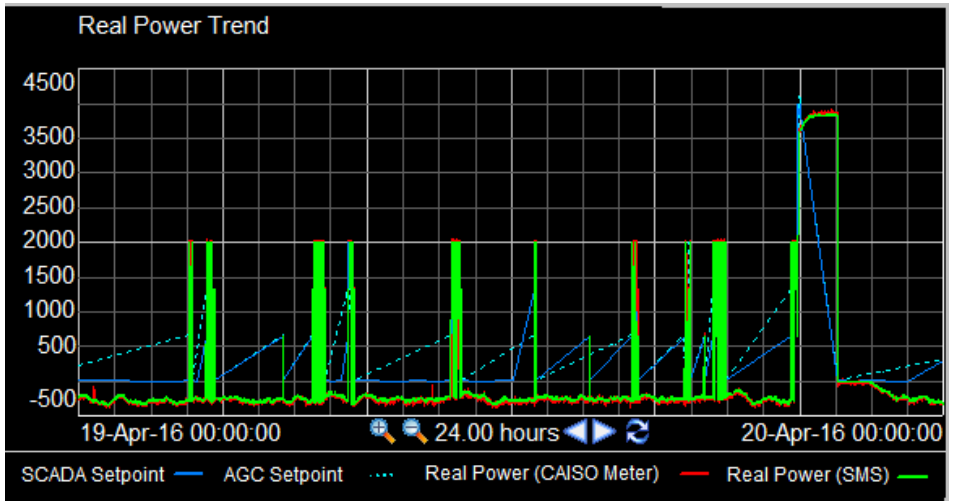
Sample Regulation Signals

Vaca Dixon



- Resources are highly responsive
- Can be locational differences in CAISO signals/usage

Yerba Buena



Challenge: Yerba Buena Interconnection Limitations

Interconnection limitations have been challenging to incorporate in CAISO bids in a way that maximizes resource abilities

Interconnection Agreement Summary:

- *Year round, no more than 2MW discharge between 23:00 and 9:00*
- *From May 1 – Sep 1, no more than 2.5MW charge between 15:00 and 23:00*

Per CAISO, now using hourly outage cards submitted daily to maximize output

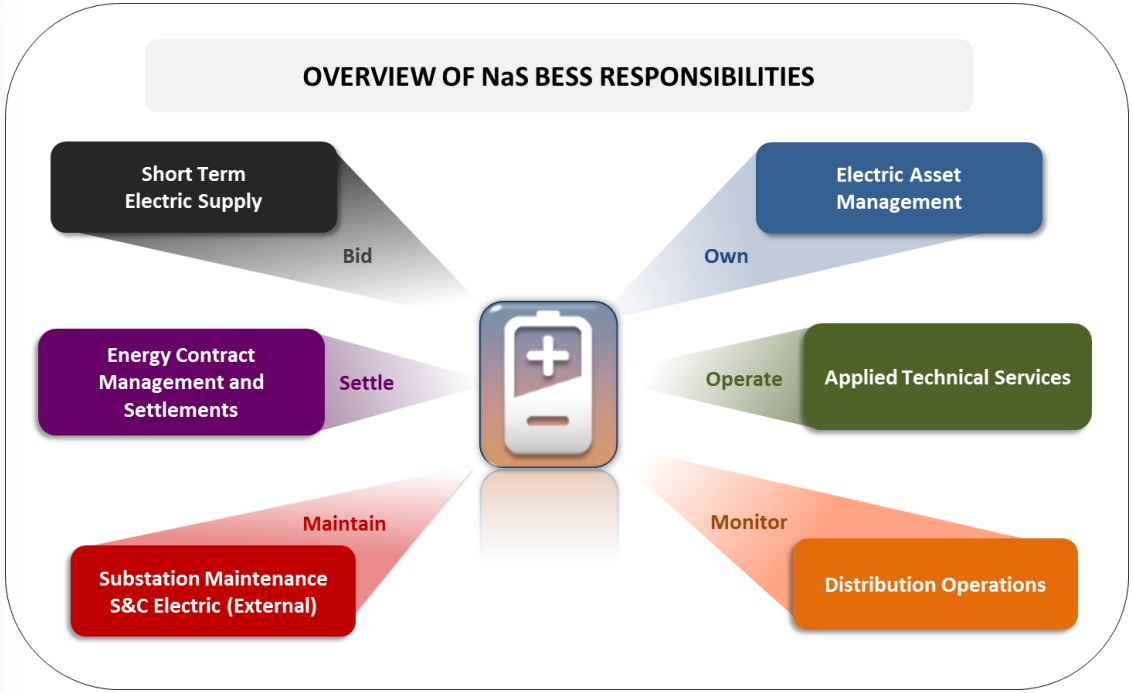
Example Bid (April 2016)

	SWIFT_1_NAS		
HE	ENERGY	REGDOWN	REGUP
1	2	3.98	0
2	2	3.98	0
3	-4.51	0	0
4	-4.8	0	0
5	2	0	0
6	0.98	3.98	1.01
7	0	3.98	2
8	0	3.98	2
9	0	3.98	2
10	0	3.98	2
11	0	3.98	2
12	0	3.98	2
13	0	3.98	2
14	0	3.98	2
15	0	3.98	2
16	0	3.98	2
17	0	3.98	2
18	0	3.98	2
19	0	3.98	2
20	0	3.98	2
21	0	3.98	2
22	0	0	0
23	0	3.98	2
24	0	3.98	2

Utility Considerations: Roles and Responsibilities

Pacific Gas and Electric Company®

SODIUM SULFUR (NAS) BATTERY ENERGY STORAGE SYSTEMS
OPERATIONAL ROLES AND RESPONSIBILITIES



Post-EPIC Project Plans

Continue CAISO market operations to:

1. Improve test dispatching processes to offer and be awarded spinning reserve product
2. Provide new CAISO flex ramp product to market after introduction in late 2016

Questions?