

California ISO View on Energy Storage

Near-Term & Long-Term Renewables Projections and Implications for Energy Storage

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Hosted by PJM and EPRI

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Potential Portfolio of Renewables for 20% & 33%

Accurate predictions of Renewable Additions is Impossible.

Best estimates based on CPUC and Interconnection Queue data

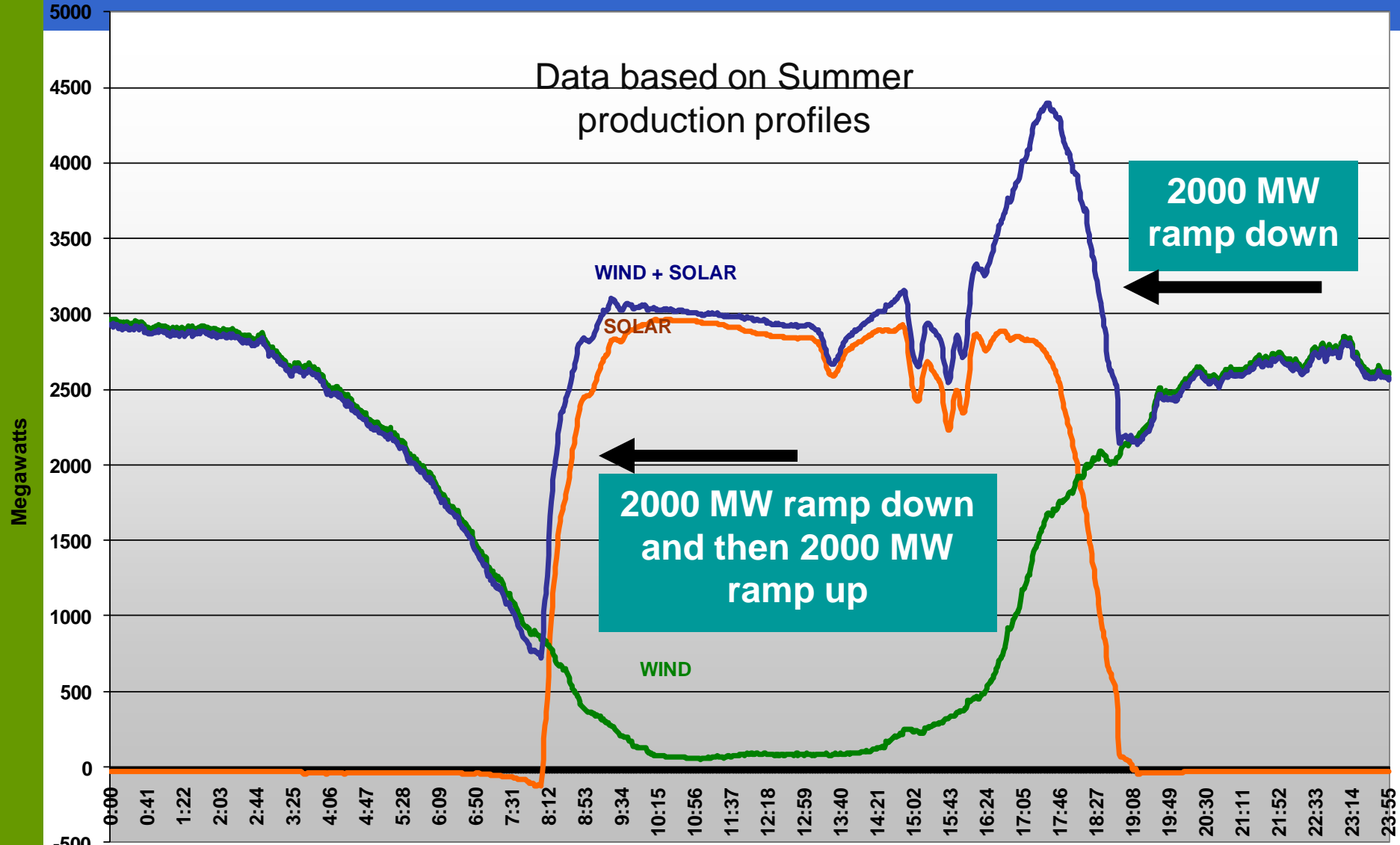
Year	Plant Capacity in Megawatts			
	2009 (Existing)	2012 Forecast	2020 low	2020 high
PV	400	830	3,234	3,234
Conc. Solar	400	996	7,297	10,000
Wind	3,000	5,917	10,972	13,000
Geothermal	900	1,039	2,400	2,400
Small Hydro	844	844	844	844
Biomass/Biogas	900	950	1000	1000

Implications for traditional generation

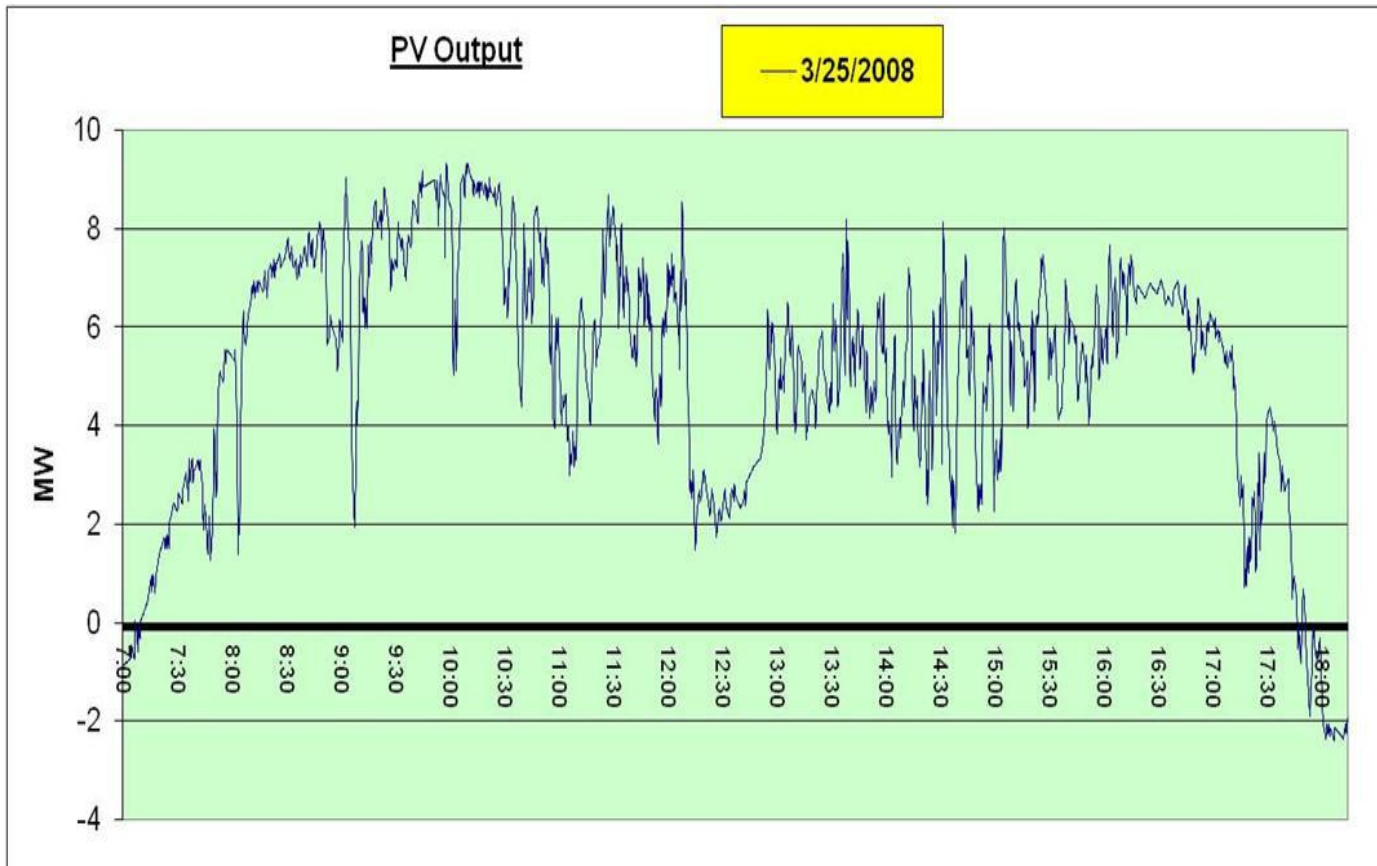
1. More frequent starts and stops
2. Demand for faster ramping – Up and Down
3. Increase wear & tear – more maintenance
4. Increased demand for regulation service
 - ◆ Potential increase in \$\$ revenue for regulation
5. Loss of revenue due to displacement of gas fired plants by wind and solar generation



4000 MW SOLAR and 6000 MW WIND Nameplate Capacity



Solar PV plant output variability (partly-cloudy day, 10-second time-step)



**Potential
voltage
control and
power
quality
issues due
to PV
variability**

**Energy
storage on
distribution
circuits may
be essential**

Key Energy Storage Questions

1. What Type of Storage?
 2. How Much?
 3. Where?
-

■ Major Drivers:

- ◆ Increase in the amount of variable generation (renewables)
 - Helpful for 20% RPS
 - Essential for 33% RPS
- ◆ Regulation and ramp energy requirements will significantly increase
- ◆ Need for load-shifting to match diurnal wind pattern
- ◆ Green house gas (GHG) limitations under California law will limit thermal generation usage
- ◆ Shut down of power plants using once-through cooling potentially eliminates as many as 45 power plants that supply ancillary services

Energy Storage Applications

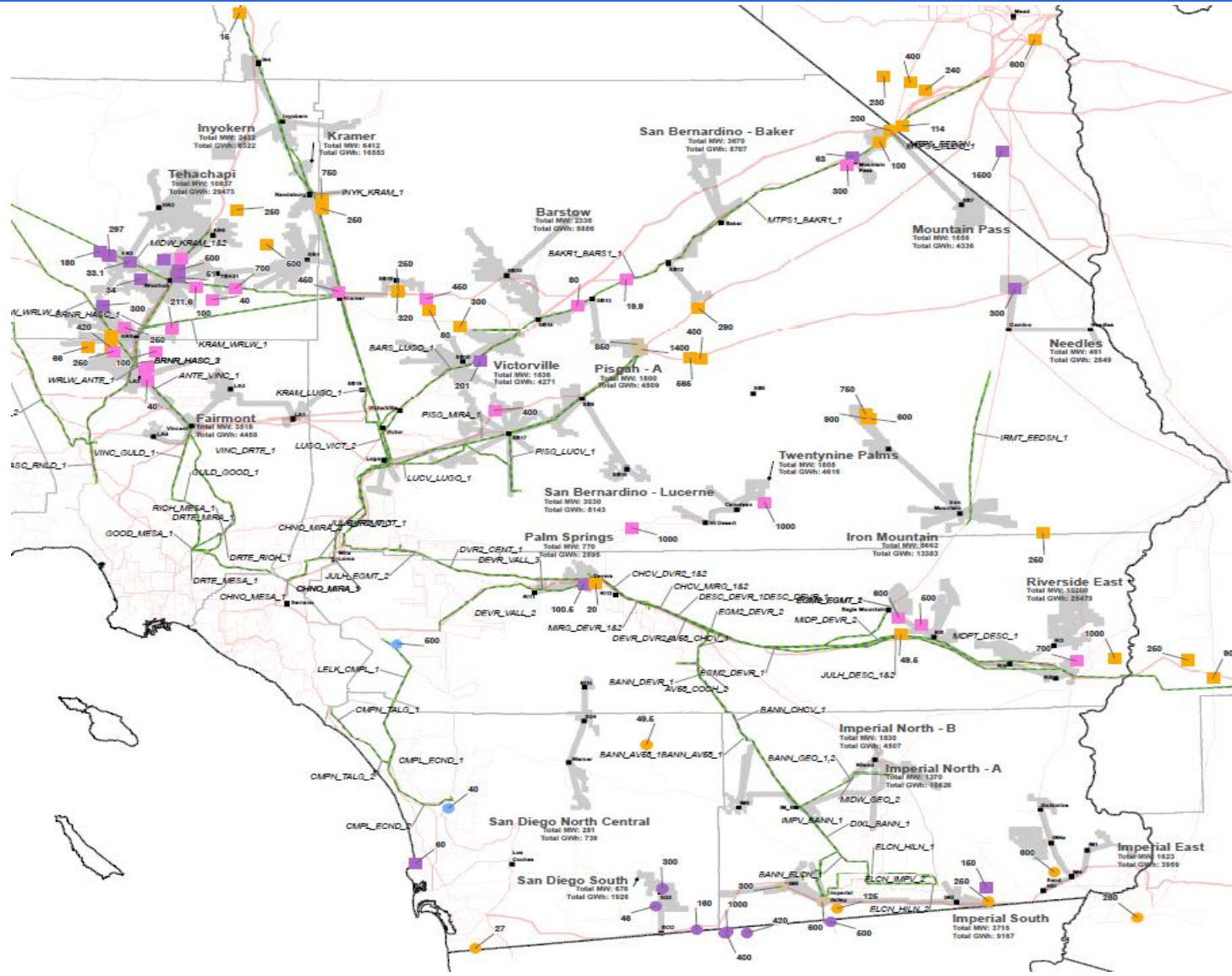
Utility scale storage – 1 MW to 1000 MW

		Market Based Services					
		←				→	
		Seconds to 1 Minute	1 Minute to 15 Minutes	15 Minutes to 60 Minutes	1 hour to 4 Hours	4 hours to 24 Hours	Multiple Days
Technology	Super Caps	Flywheels	Batteries	Batteries	Batteries	CAES	CAES
	Flywheels Batteries	Batteries	Flywheels (15 Min.)	Compressed Air Energy Storage (CAES)	Pump Storage	Pump Storage	Pump Storage
Service	Distribution Power Quality mitigation due to solar PV	Distribution PQ Grid Frequency	AS Regulation & Contingency Reserves	Supplemental Energy Dispatch	Supplemental energy and energy shifting	Supplemental energy and energy shifting	Supplemental energy and energy shifting
	Value	Potential source for energy injection for grid stabilization	Voltage control and system frequency control	Meet BA control performance standards	Intra-hour energy change needs Transmission congestion	Load following & energy scheduling	Load following & energy scheduling

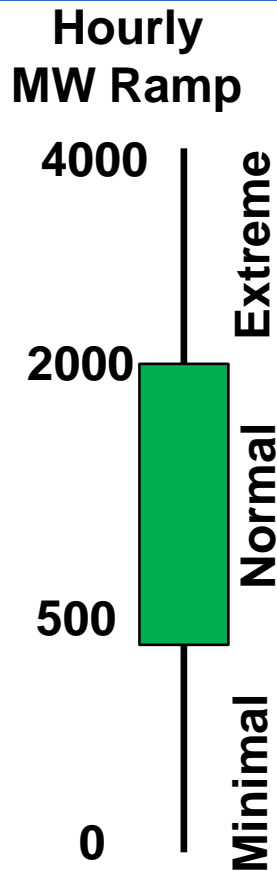
Storage should be located in areas with lots of renewables

Location of
Potential
Renewable
Energy sites

Southern
California



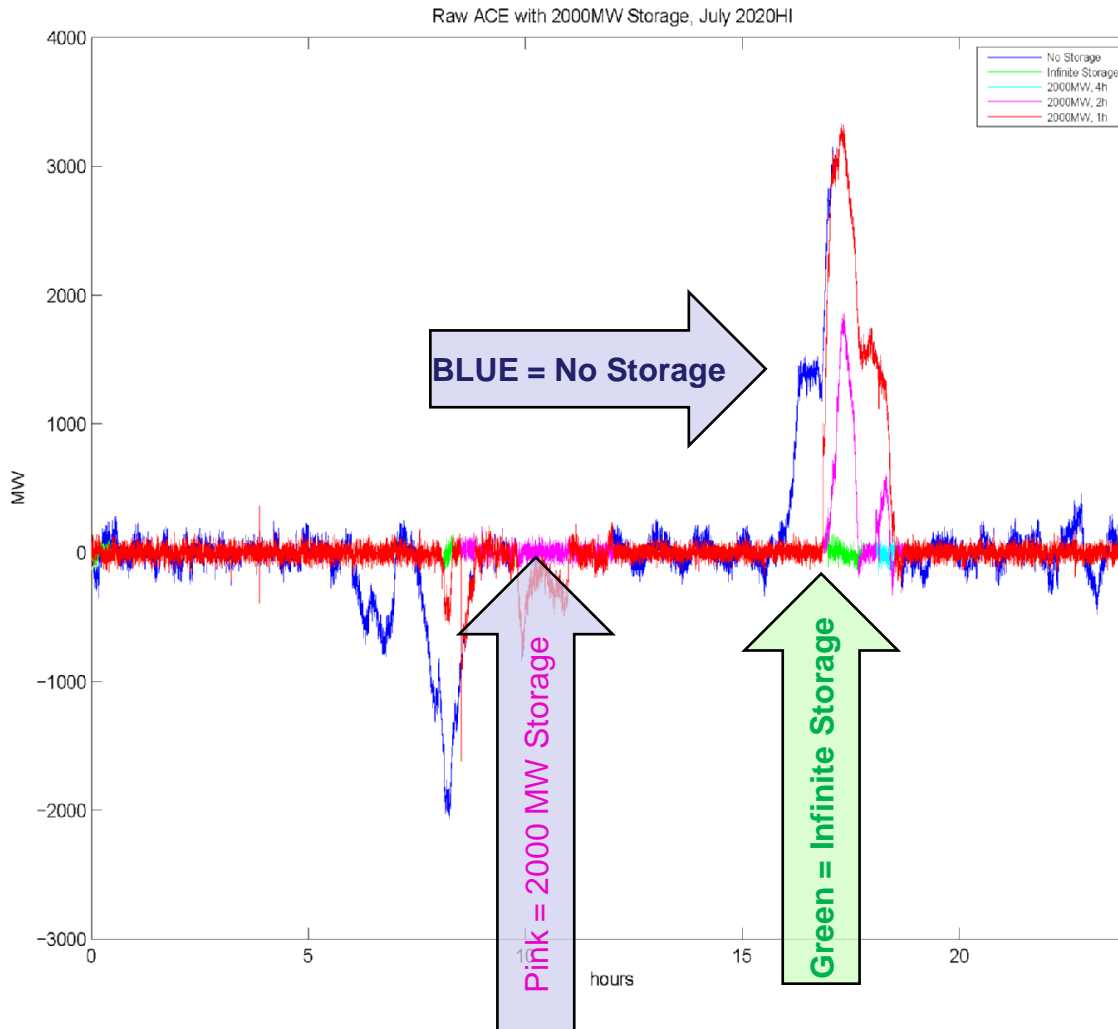
Large Ramp Strategies



- **Active control of wind & solar required to limit ramps**
- Increase amount of regulation and number of resources providing regulation (MW/Min criteria as well as \$/MW)
- Peaker Generators, Large Storage, Demand Response
- Fast Ramping Energy Storage and Hydro Generation For Regulation and Supplemental Energy Dispatches
- Existing generation fleet for Supplement Energy and Regulation and Operating Reserves
- Existing Generation fleet – normal operation

**Large Ramps will challenge BA's ability to meet
NERC Control Performance Standards
for frequency, ACE and Transmission Congestion**

Energy Storage will play a key role at the 33% renewables level

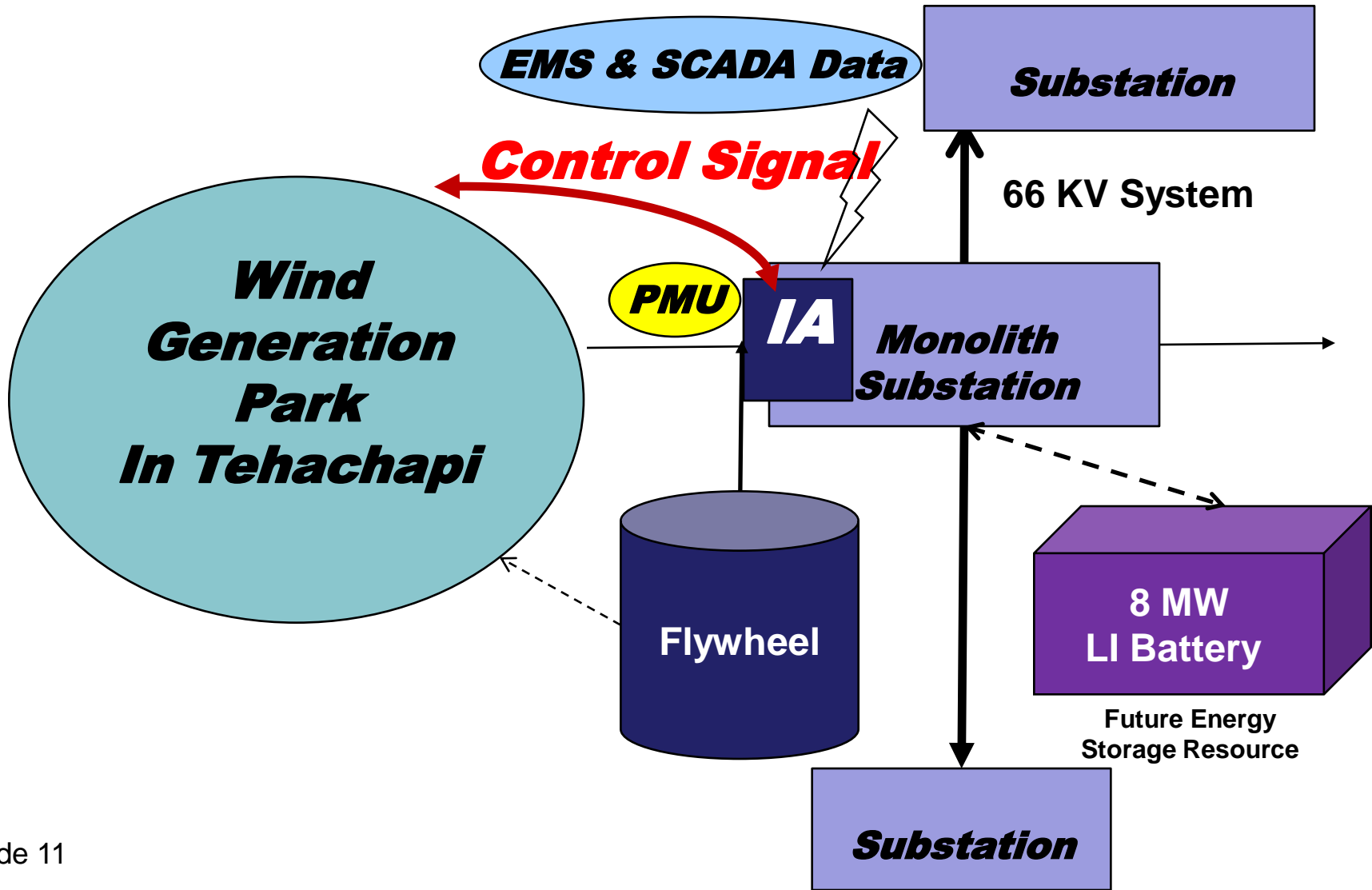


2009 Study with KEMA's Simulation Tools indicate 2000 MW of energy storage with 2 hours to 4 Hours of capacity works to control ACE and Freq.

1 Hour of energy storage or less does not provide enough capacity to mitigate large ACE problems due to high ramps

These are early results and more studies are needed.

Application of Intelligent Agent Technology



Summary:

- Energy storage technology is rapidly advancing and cost should decline
- Much more work is needed to:
 - ◆ Improve study tools for both transmission and distribution energy storage.
 - ◆ Add new energy storage models into markets.
 - ◆ Explore optimum use of storage for ramp mitigation, regulation and transmission congestion relief.



Backup Slides

Current Projects in California

- SANO Battery test for Regulation services
- AGC/Regulation signal improvements to provide an energy neutral reg. signal
 - ◆ EPRI project
- Non-Generation Resources in AS Markets
- Intelligent Agent Project – 100 KVA flywheel
- Development of intra-hour simulation tool
 - ◆ CEC-KEMA project
- SCE 8 MW – 36 MW-Hr battery project
- PG&E CAES project & NaS Battery project

SCE 8 MW Battery Project

Smart Grid Demonstration Project Targeted Uses

Transmission-Related Uses	<ul style="list-style-type: none"> • Voltage Support & Grid Stabilization • Decreased Transmission Losses • Diminished Congestion • Increased System Reliability (Load Shed Deferral) • Deferred Transmission Investment • Optimize Size and Cost of Renewable Energy-Related Transmission
System-Related Uses	<ul style="list-style-type: none"> • Provide System Capacity & Resources Adequacy • Renewable Energy Integration (Smoothing) • Wind Generation Output-Shifting
ISO Market-Related Uses	<ul style="list-style-type: none"> • Frequency Regulation • Spin/Non-Spin Replacement Reserves • Deliver Ramp Rate • Energy Price Arbitrage

Installation in the Tehachapi-Antelope 66 KV system

SANO Battery - Regulation

2 MW – 500 KW-Hr Lithium Ion Battery

Installed in Southern California

**Pilot Test for Regulation Services
scheduled to start in February 2010**

Series of 8 hour tests over a 2 week period

- **Test of market system to accept a battery storage resource for regulation**
- **Test of EMS / AGC signal**
- **Verification unit ramp rate**
- **Test of settlements system and financial consequences**

