Overview of California Renewable Energy and Grid Infrastructure Policies, National and Global Trends

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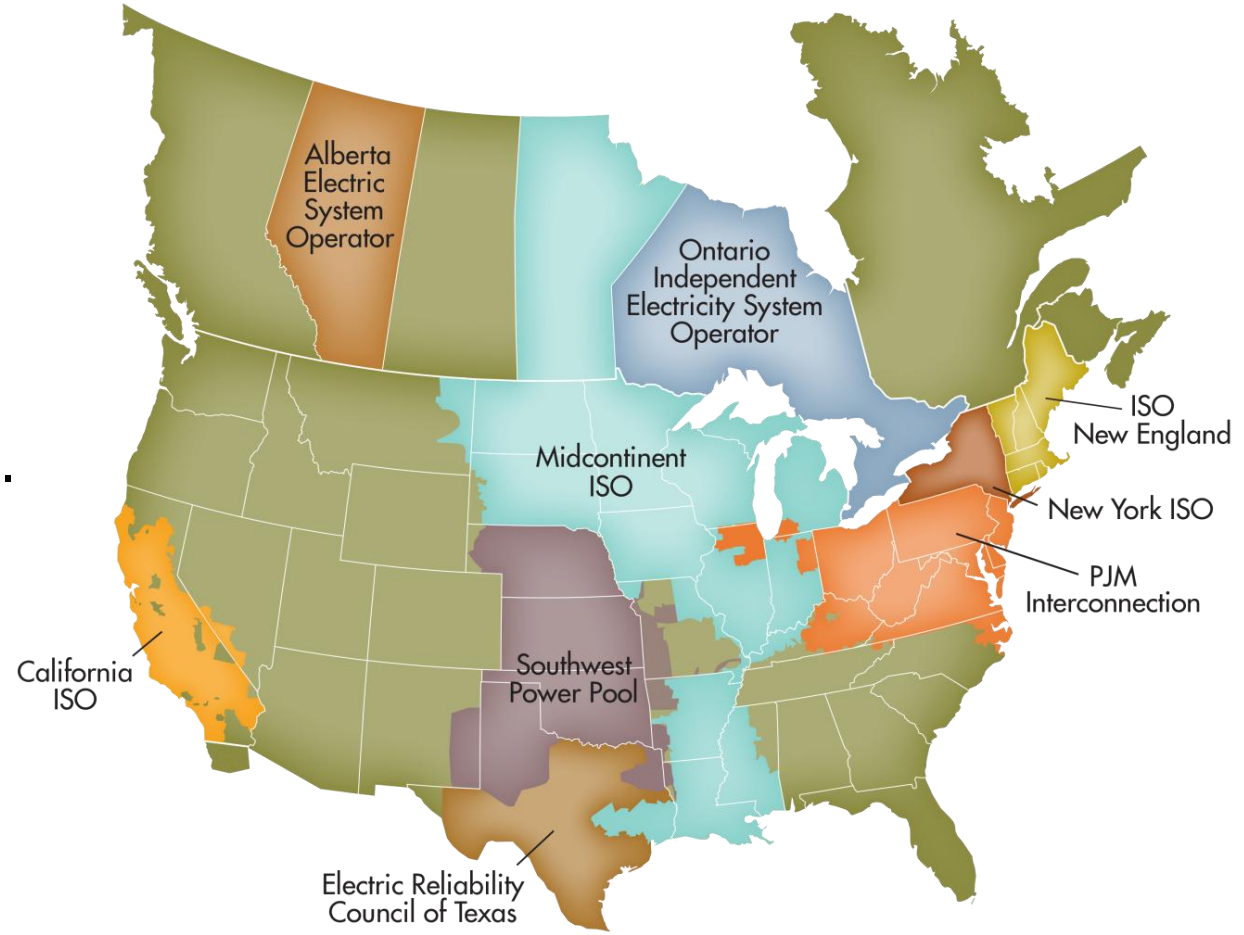
Governor, California ISO, Founder Renewables 100 Policy Institute

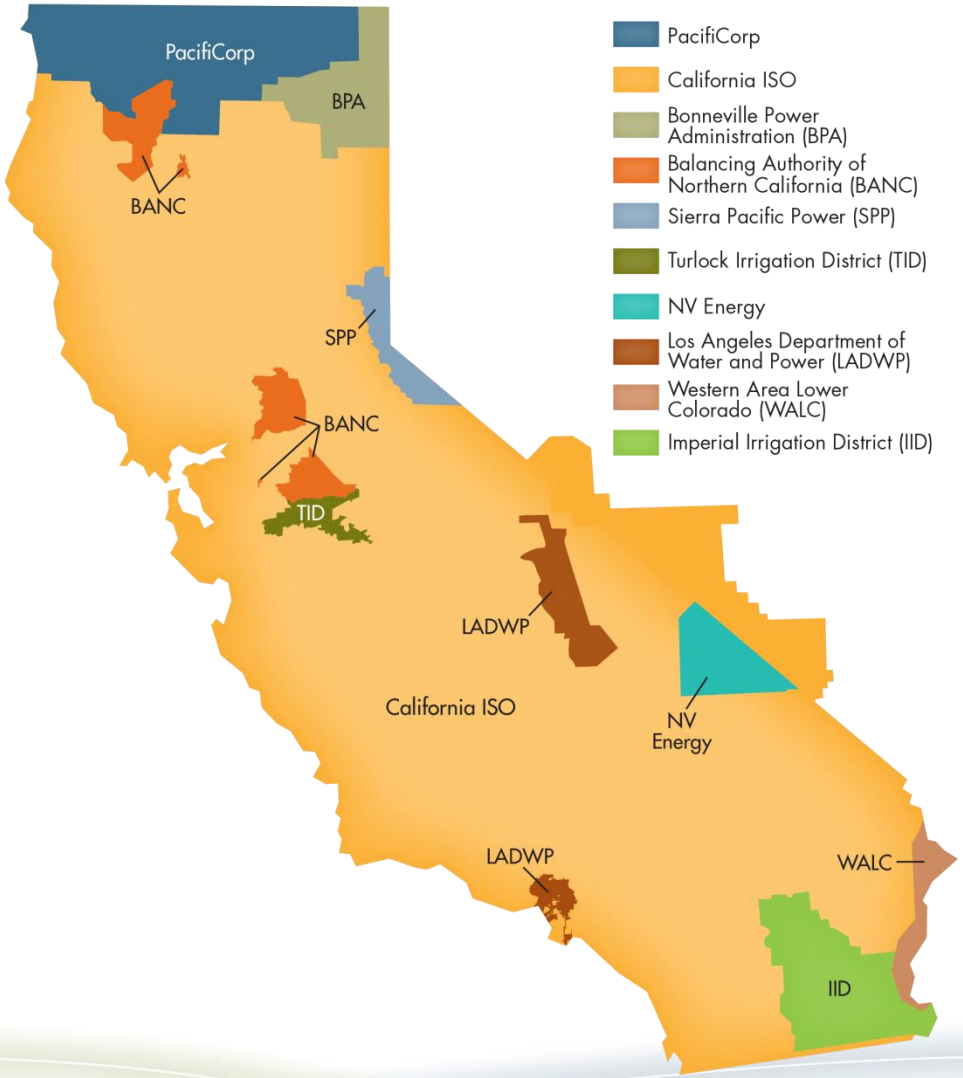
Paris, December 2015

The California ISO

One of nine grid operators in North America.



ISO by the Numbers



- **Serves 30,000,000 Californians**
- **80% of state**
- **26,000 wire-miles**
- **65,000 MW system**

Our Role

- Maintain reliability
- Implement State policy
- Operate wholesale market

- Plan for system expansion
- Interconnect resources

Coordinate with Many Masters

- Governor's Office
- CEC
- CPUC
- ARB
- FERC
- WECC Compliant

Striking a critical balance

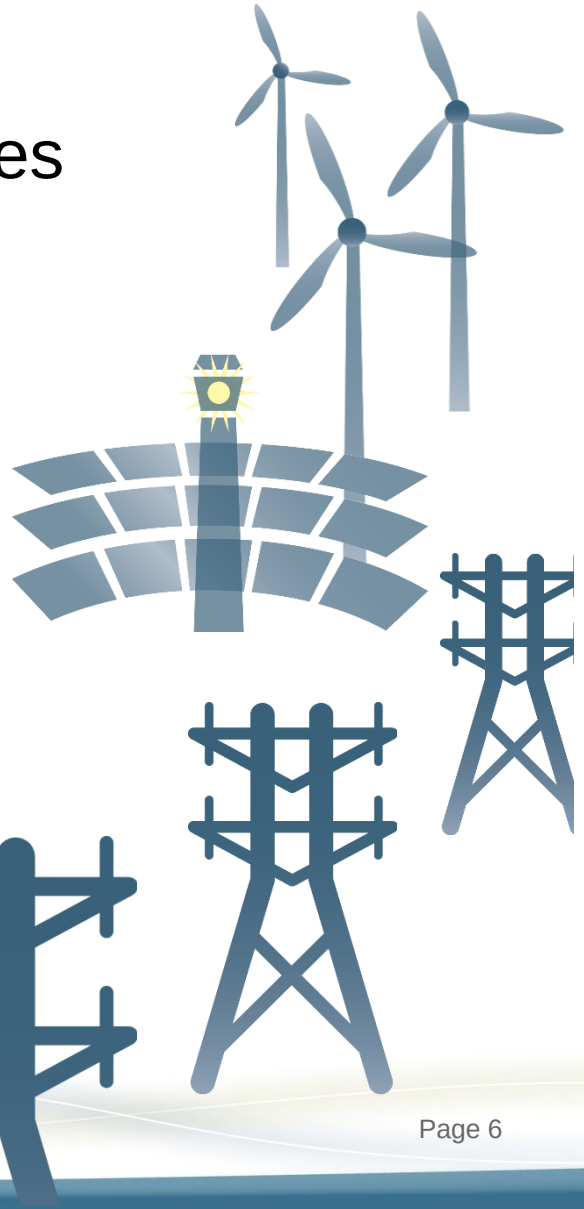
Deploy Renewable Energy Sources

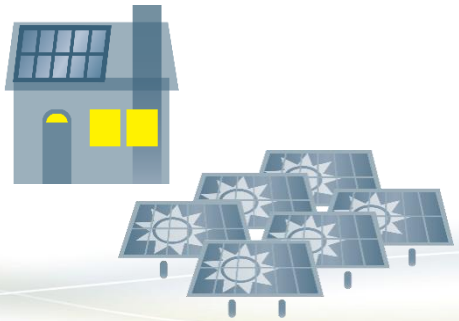
Maintain reliability

Mitigate upward pressure on costs

The Resource Mix is Transforming
- Components of New Grid Model

1. Rapid growth in utility-grade renewables
2. California RPS 20% by 2013, 33% by 2020, 50% by 2030
3. The rise of consumer-owned solar
4. Governor's 50% Goal…now Law
5. Challenges and opportunities for CA and the western U.S.





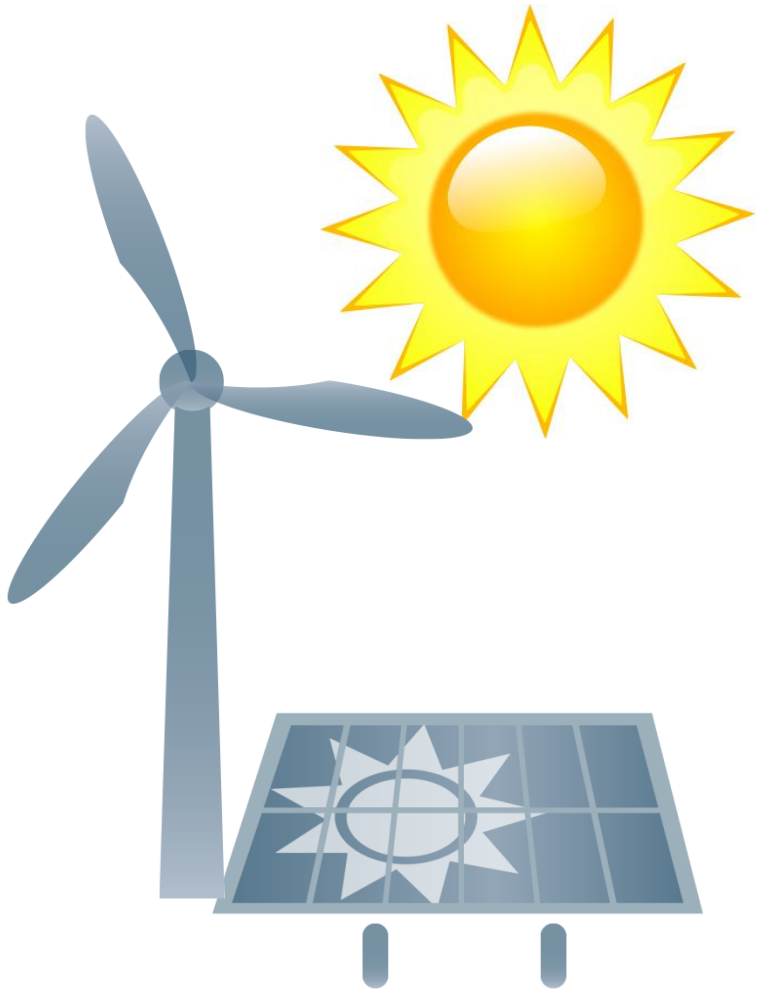
Utility-Grade and Consumer-Owned Renewables

<u>Utility renewables online</u>

- 14,000 MW wind and solar
- On track for 33% by 2020

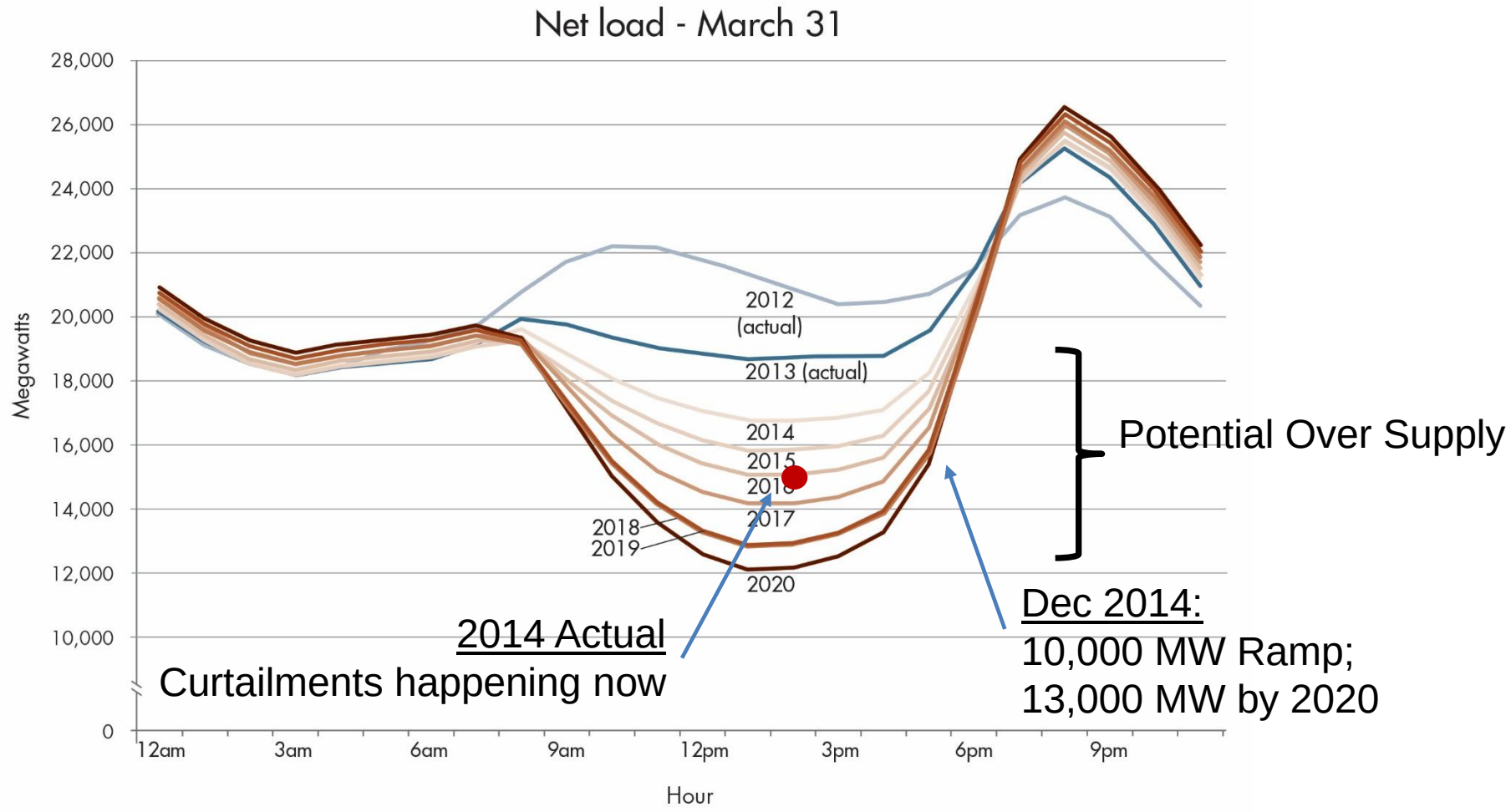
<u>3,000 MW of Consumer Solar</u>

- 7,000 new rooftops per month
- “Invisible” to ISO



Over Supply and Ramping

Significant Challenge for Grid Operators

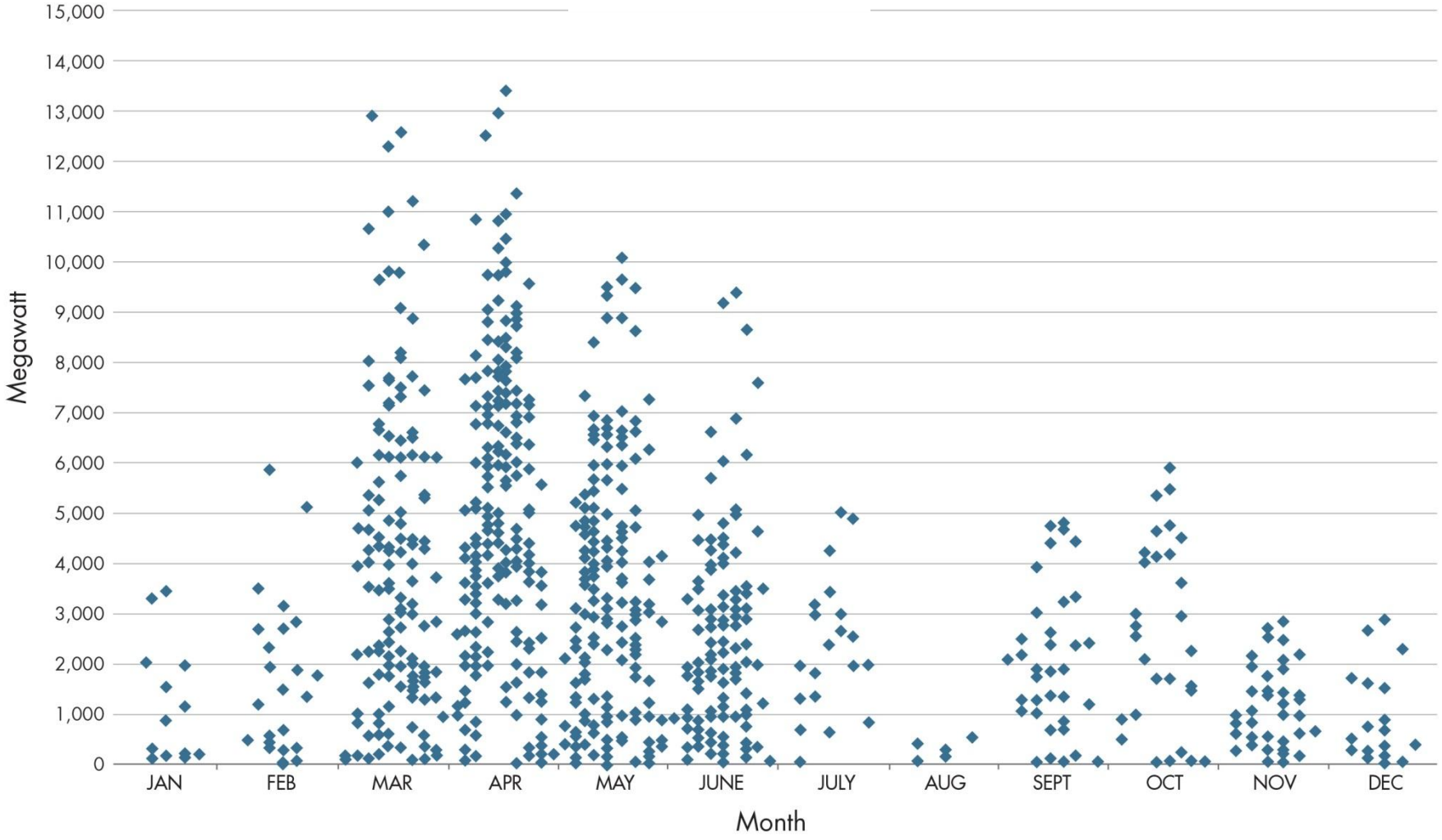


Implications of "Duck" Chart

- Net load = hourly demand minus wind and solar
- Midday net load drops 22,000 MW ➔ 12,000 MW
  - Solar pushes gas off the system in the middle of the day
  - Impact on over-generation? Prices?
- Peak power not 2-5 pm but 6-8 pm; solar at zero
- Presents operational challenges
- Underscores need for flexible generation solutions, gas, customer and utility scale storage solutions that can respond quickly to system needs
  - Steep ramps – as much as 13,000 MW in 3 hours by 2020
  - Multiple ramps per day

Challenge grows over the next decade

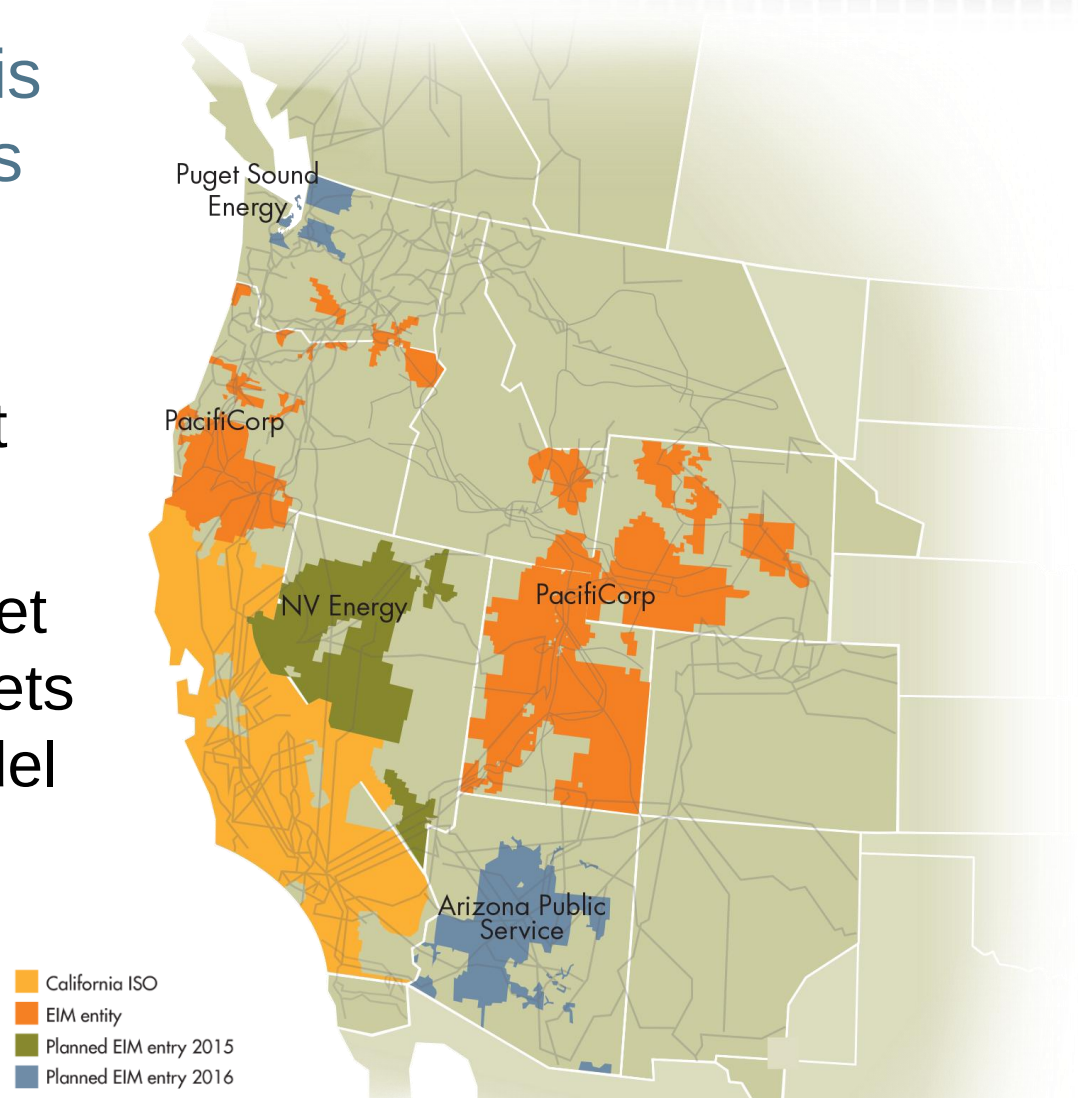
800 +curtailments in 2024, under 40% RPS Scenario



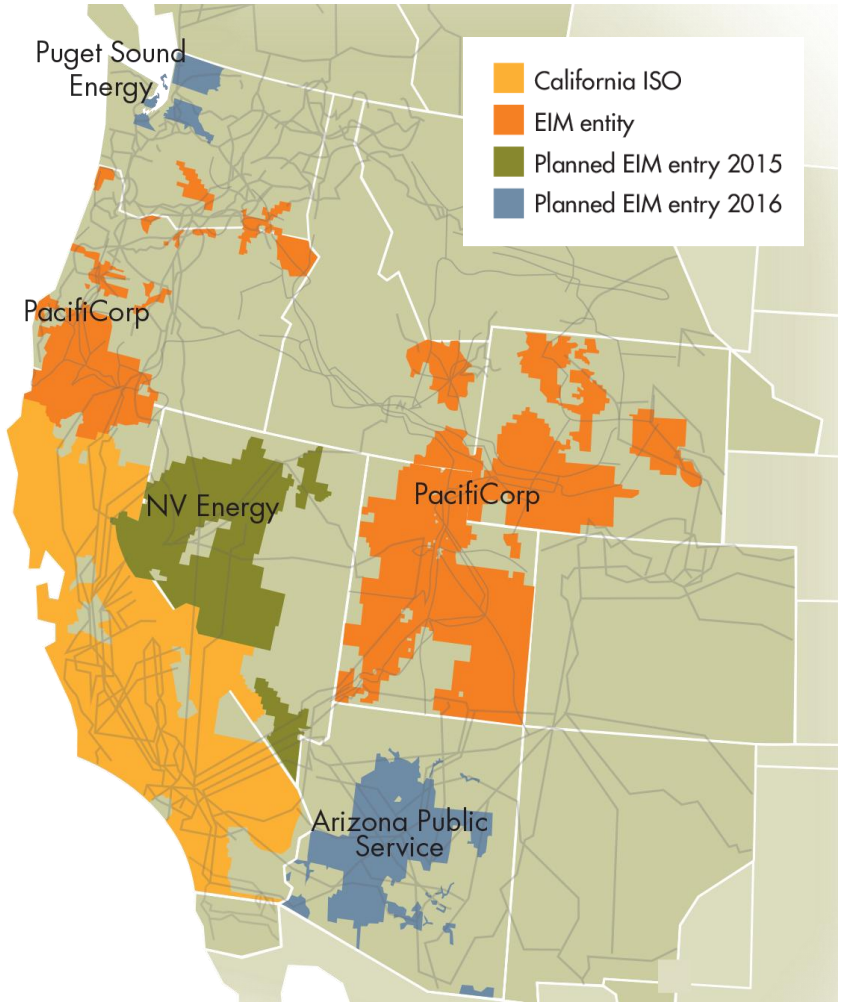
Regional Collaboration is key to managing surplus power

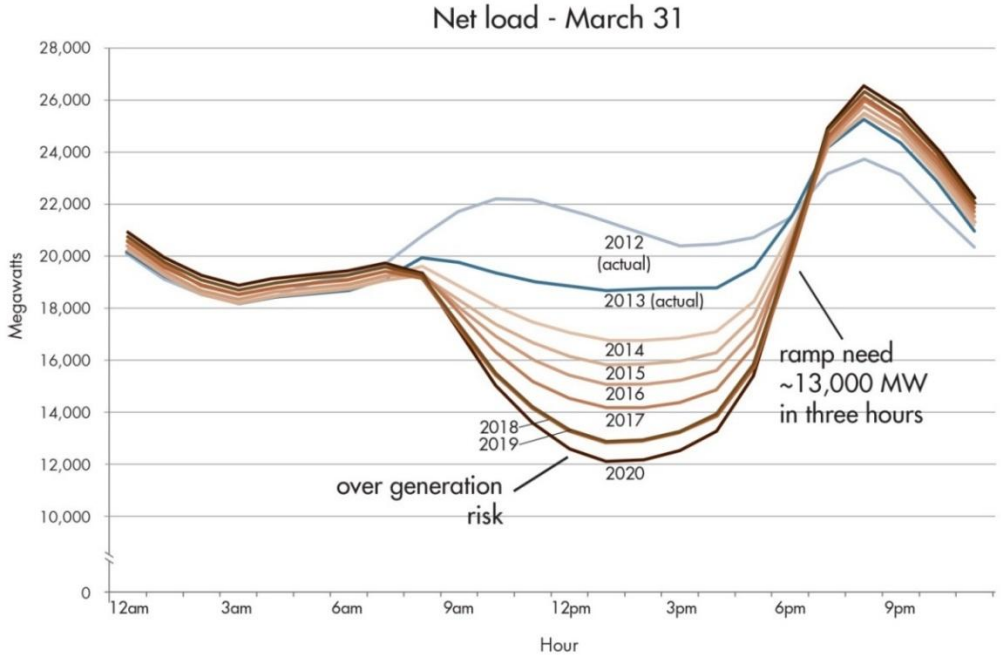
Energy Imbalance Market

- ✓ 5 minute market
- ✓ Regionally diverse fleet
- ✓ Optimize existing assets
- ✓ New governance model



California ISO is the largest of ten BAs in CA – Energy Imbalance Market operates in seven western states

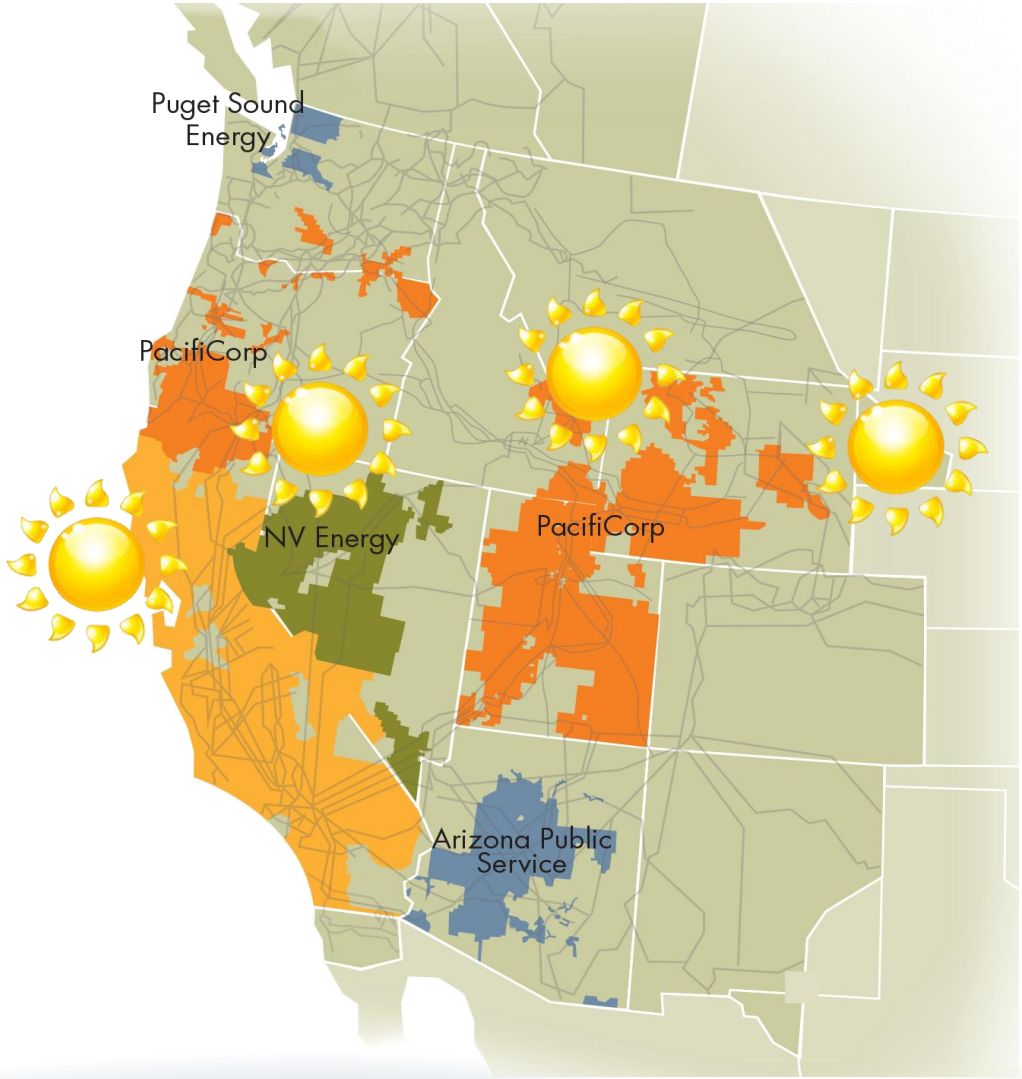




- **65,226 MW** of power plant capacity (net dependable capacity)
- **50,270 MW** record peak demand (July 24, 2006)
- **30 million** people served
- **80%** of the load served in California

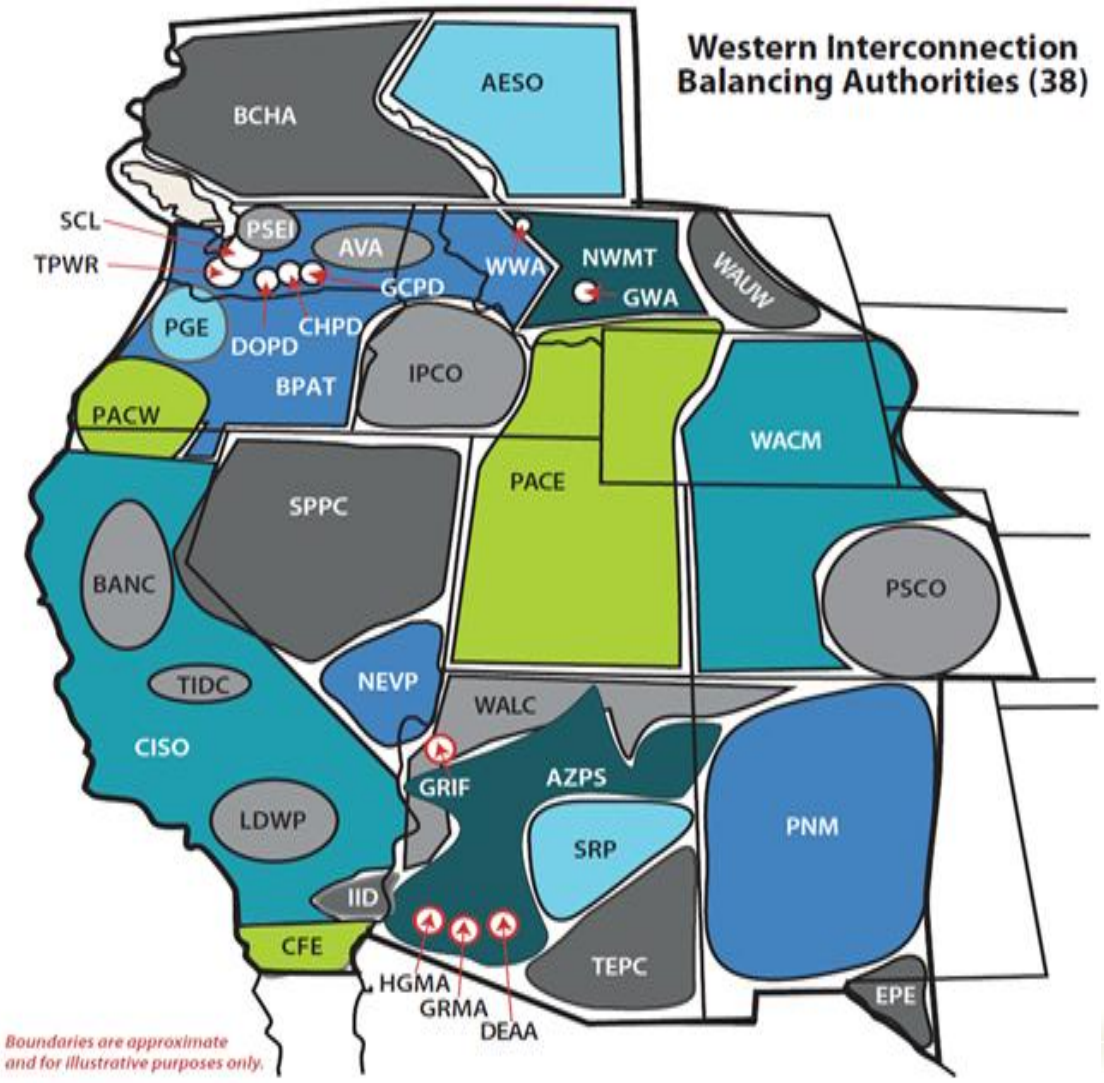
Energy Imbalance Market is an important tool for effective use of resources around the west

- Builds on existing market
- Automated dispatch resolves imbalance & avoids congestion
- Provides situational awareness, enhances reliability
- Voluntary and no exit fees
- Preserves autonomy, including compliance, balancing, and reserve obligations



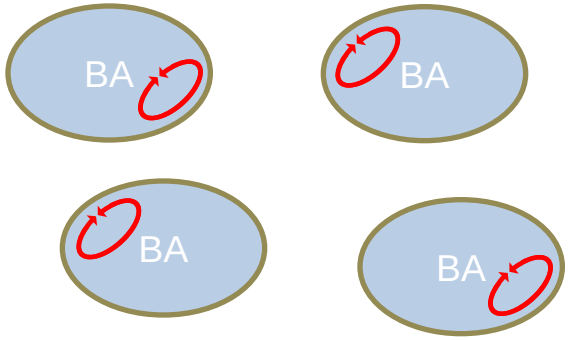
A balancing authority (BA) is responsible for operating a transmission control area.

- Each matches generation with load and maintains electric frequency of the grid
- 38 balancing authorities in the western interconnection
- Today, each BA balances load and generation separately from other BAs



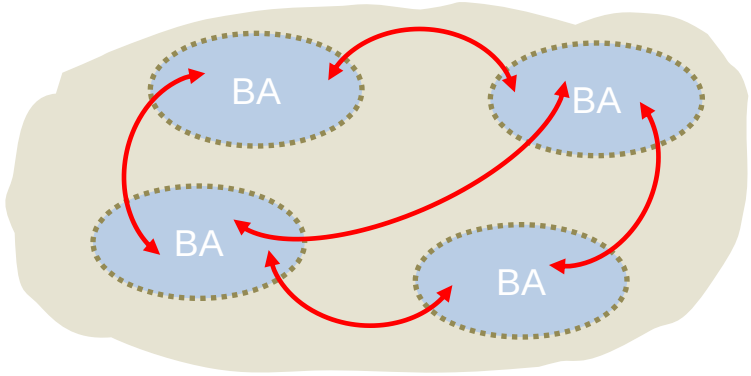
Today vs. EIM

Today:
Each BA must balance loads and resources w/in its borders.



- Limited pool of balancing resources
- Inflexibility
- High levels of reserves
- Economic inefficiencies
- Increased costs to integrate wind/solar

In an EIM:
The market dispatches resources across BAs to balance energy

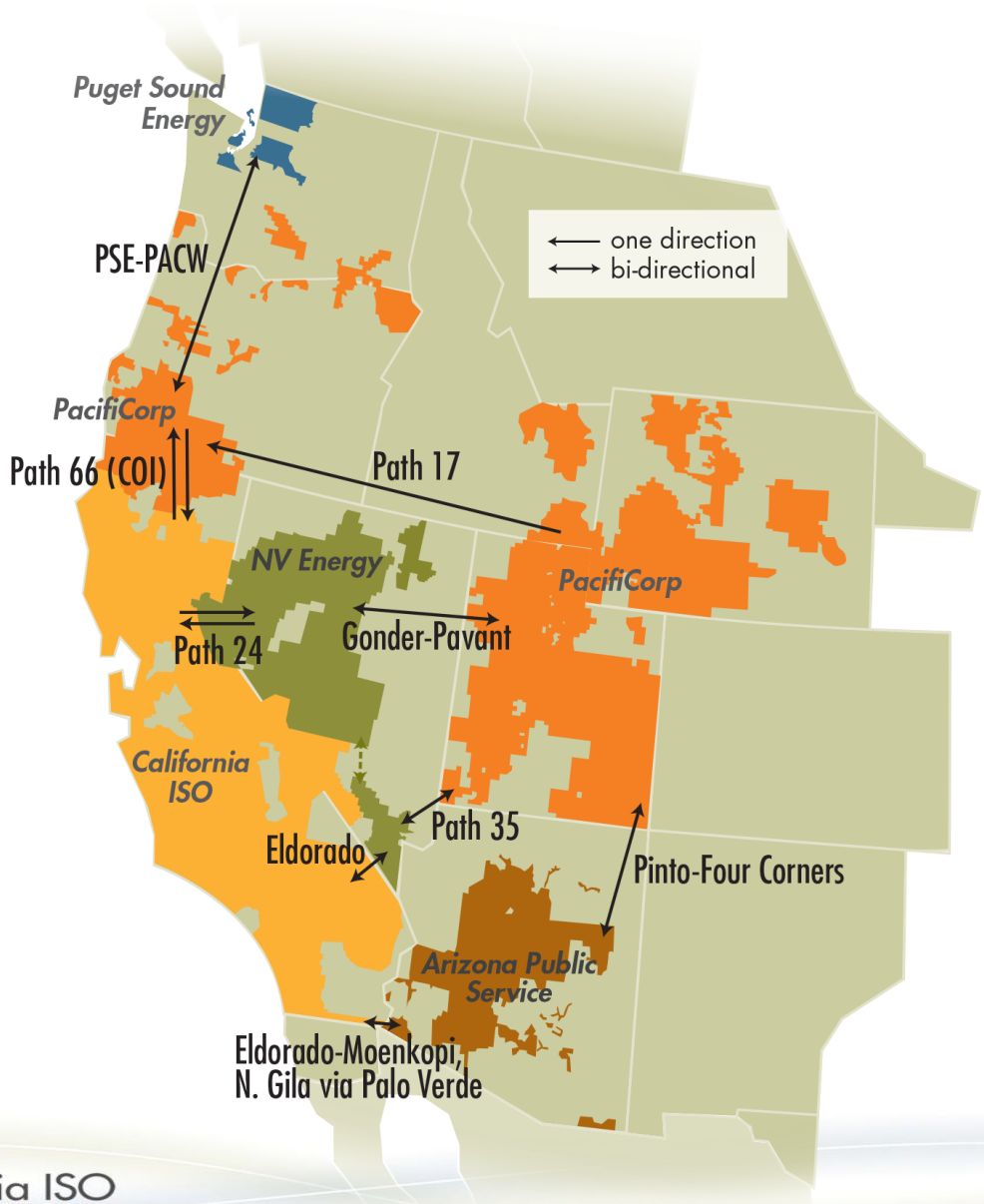


- Diversity of balancing resources
- Increased flexibility
- Decreased flexible reserves
- More economically efficient
- Decreased integration costs

Expanded participation will increase the benefits

	PacifiCorp	NV Energy	Puget Sound Energy	Arizona Public Service
Activation	Nov 2014	Oct 2015	Oct 2016	Oct 2016
Peak demand	9,500 MW	8,150 MW	4,900 MW	6,500 MW
Annual benefits	$21-129 M	$9-29 M	$18–30 M	$11 M
Start-up costs	$20 M	$11.2 M	$14.2 M	$13.5 M
Annual on-going costs	$3 M	$2.6 M	$3.5 M	$4 M

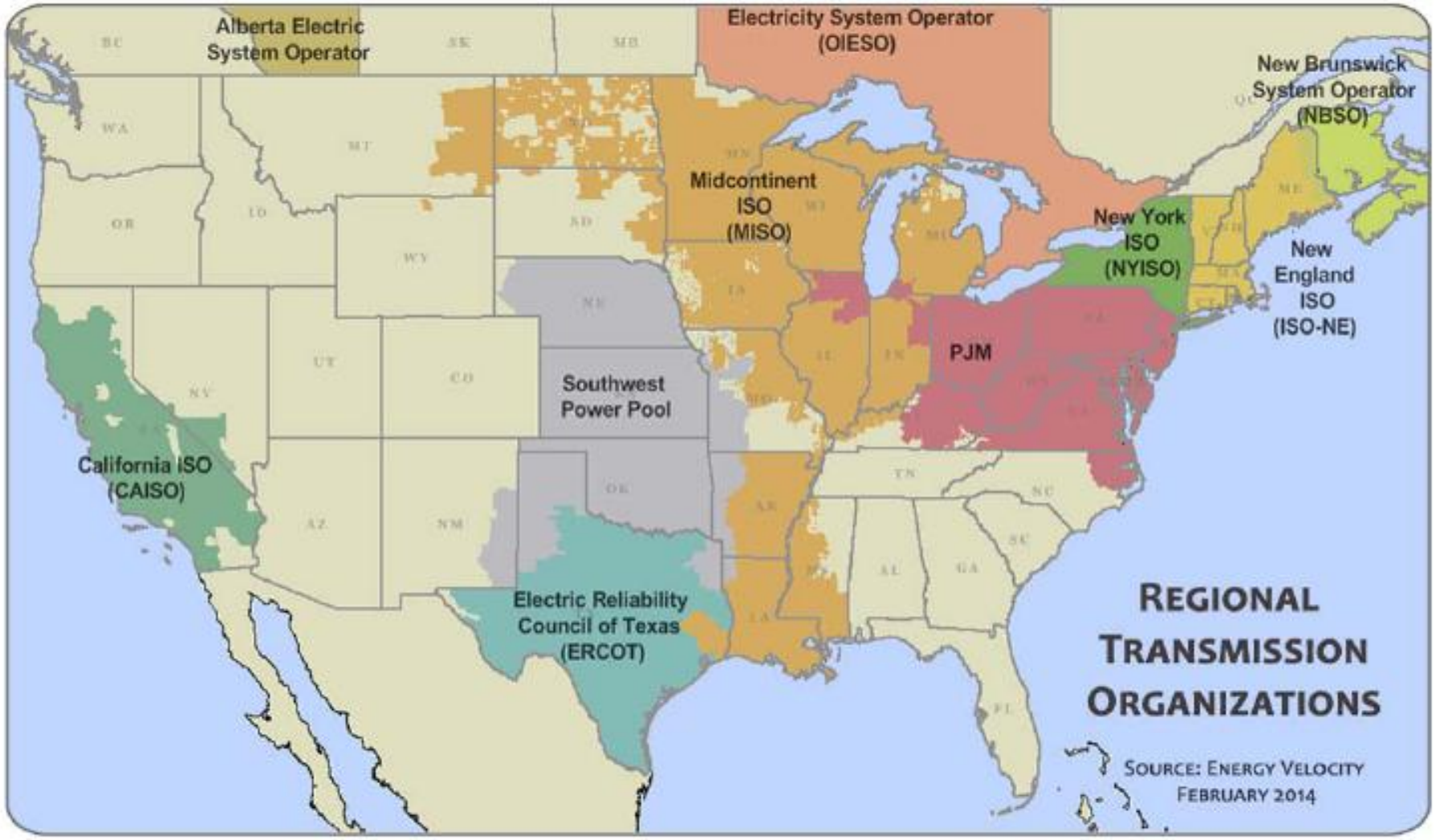
EIM Interties



Path	Estimated Max Capacity (MW)*
Path 24 *(west to east)*	100
Path 24 *(east to west)*	35-90
Eldorado	1,500
Path 35	580
Gonder-Pavant	130
Path 66 (COI) *(south to north)*	331
Path 66 (COI) *(north to south)*	432
Path 17	200
PSE-PACW	300
Eldorado, Moenkopi, N. Gila, Palo Verde	2,500
Pinto-Four Corners	600

**Current as of September 2015*

Regional Transmission Organizations



2000 Proposed FERC Wholesale Independent Electric Market Regions

G7 JUNE 2015 – SCHLOSS ELMAU

"Emissions must be cut 40-70% by mid-century and phased out entirely by 2100"

Picture: Wikimedia

“There is an urgent need to develop sources of renewable energy.”

Pope Francis

Picture: Wikimedia

100% RE: Global Call to Action RENFORUS

2014 El Hiero Declaration:

Call To Action for 100% Renewable Energy

RENFORUS Forum in Madrid November 19, 2015

Thank you

Renewables 100 Policy Institute

Questions?

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