# The Importance of Regional Collaboration and Distributed Solar Resources to Support the Grid

Yucca Valley, California, January  2019

Angelina Galiteva

Founder Renewables 100 Policy Institute,
Vice Chair Board of Governors California Independent System Operator,

Renewables 100 Policy Institute

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Renewables 100
Policy Institute

Founded in 2007

To study and accelerate the global transition to **100% renewable energy** in all sectors – electricity transportation, heating cooling, water treatment and fuels .

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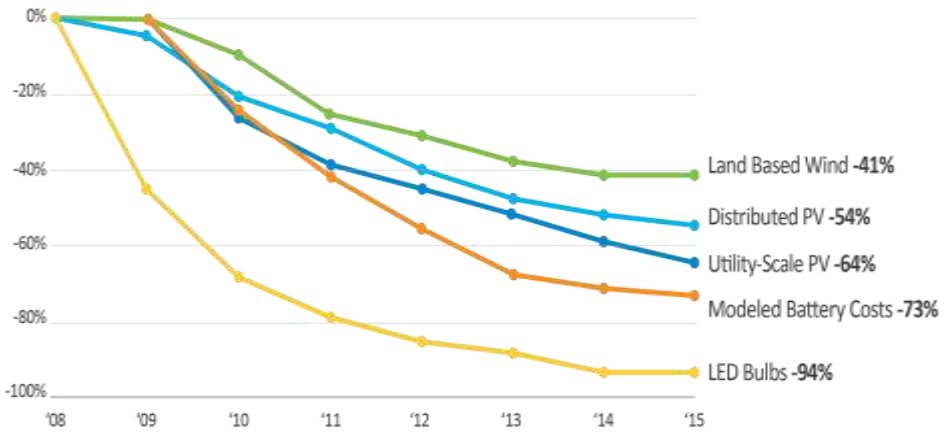
# Highlights

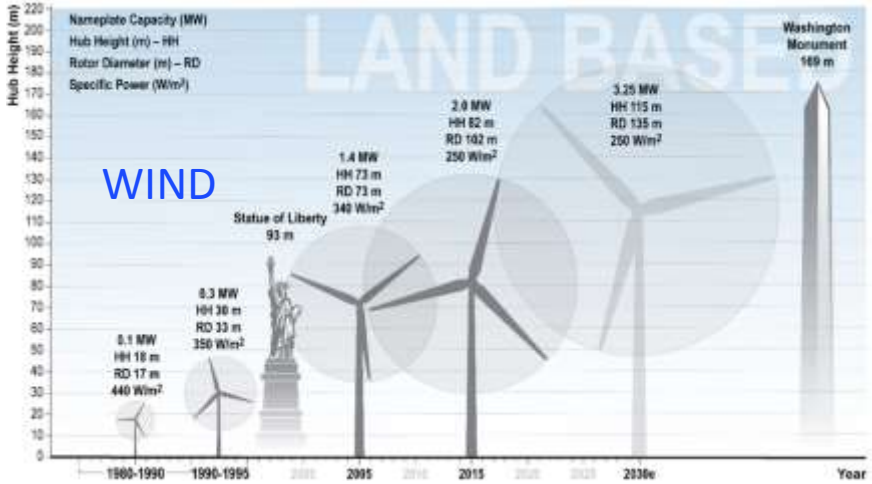
## International Learning & Collaboration, Accelerating Change

Under 2 MOU - Subnational Global Climate Leadership Memorandum of Understanding

UNDER 2°

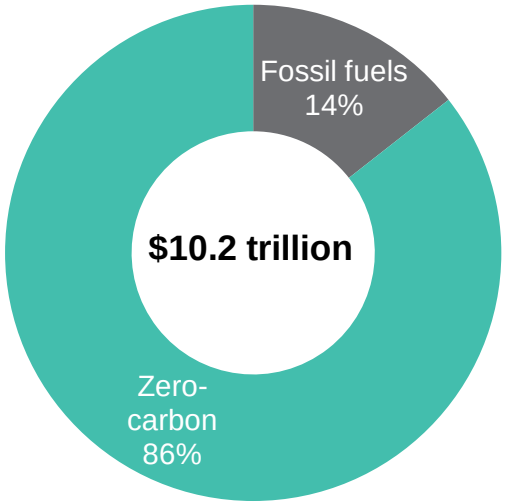
# Price of renewables continue to decrease

# Solar and wind attract 60% of new investment in power generating capacity

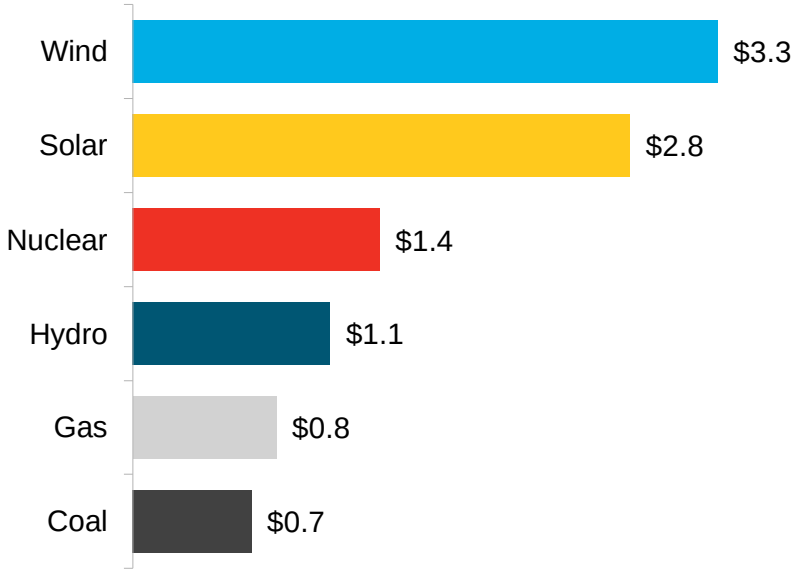
## Investment, by technology, 2017-2040




*Source: Bloomberg New Energy Finance, NEO 2017*

## Investment, by technology, 2017-2040

($ trillion - 2016 real)




*Source: Bloomberg New Energy Finance*

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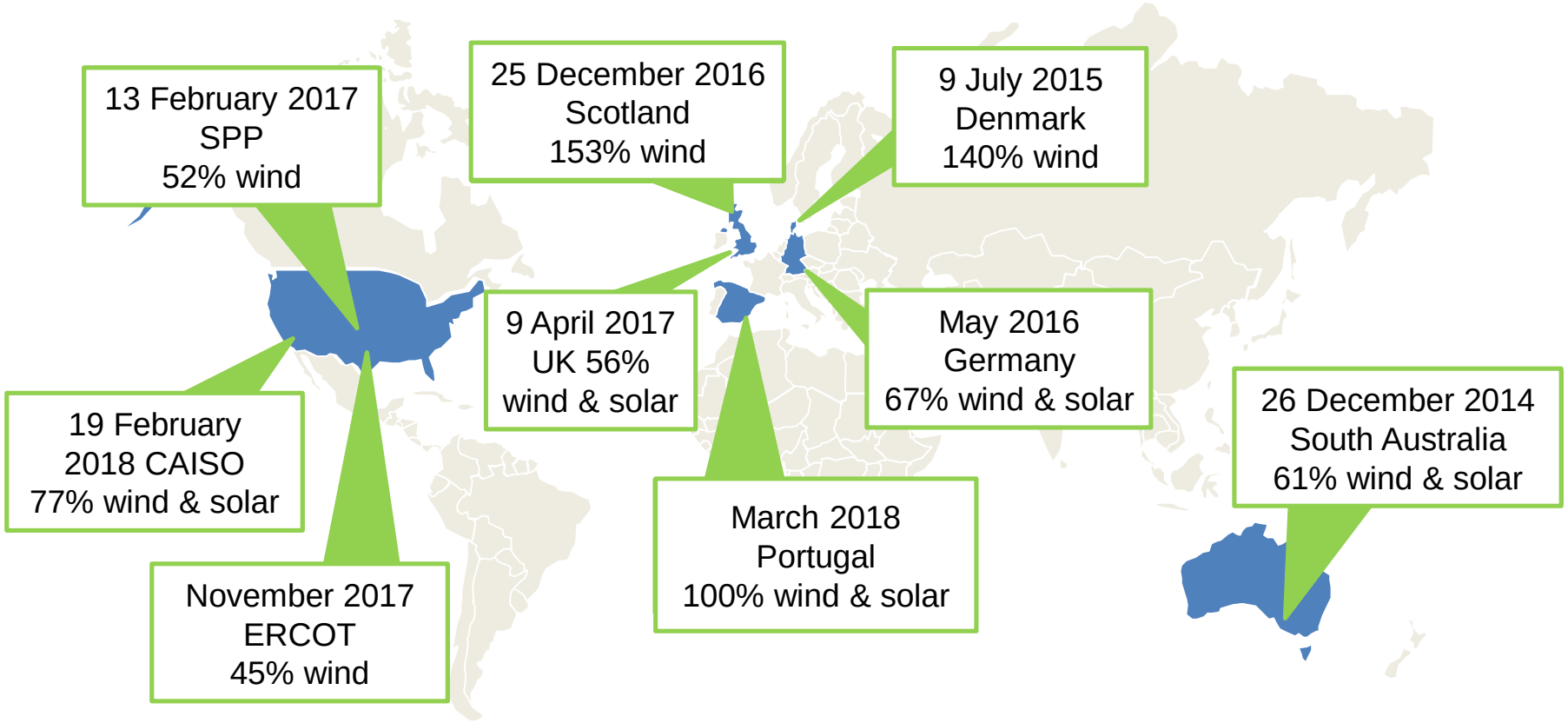
# High Levels of Renewable Penetration – the New Normal




*Source: Bloomberg New Energy Finance, various*

# U.S. Renewable Resources

Achieving 100% Renewables include:

- *Grid modernization*
- *Storage options*
- *Transmission*
- *Behaviors/education*
- *Resources*
- *Cooperation*

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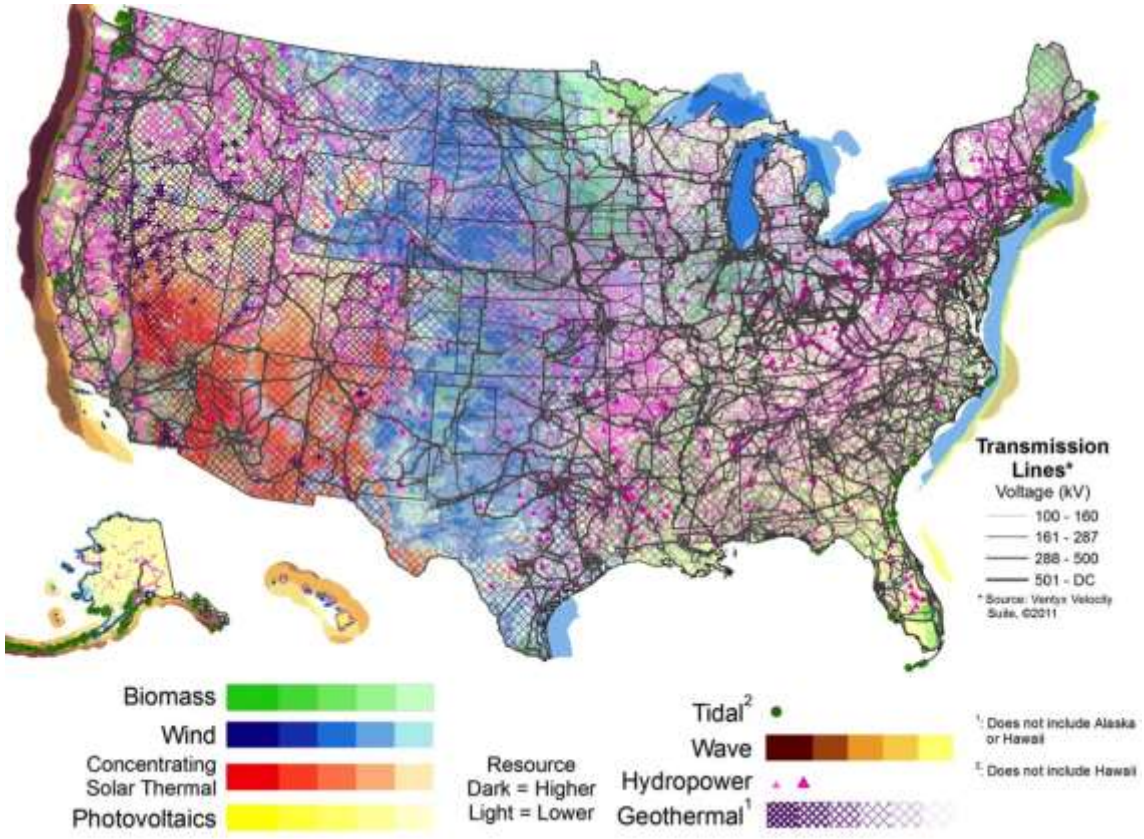
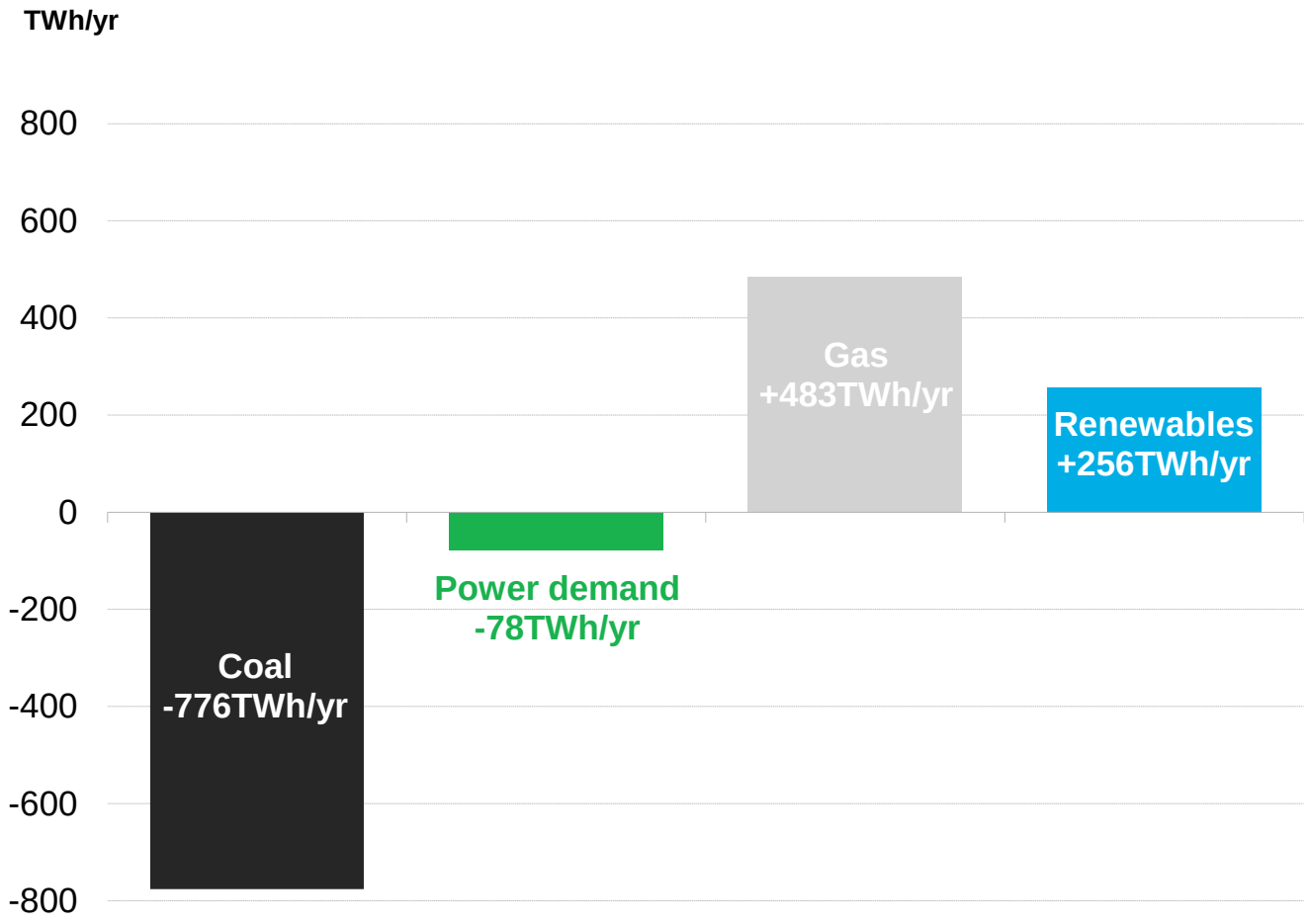



| Resource | Solar PV/CSP) | Wind | Geothermal | Water Power | Biopower |
|---|---|---|---|---|---|
| **Theoretical Potential** | 155,000 GW (PV)<br>38,000GW (CSP) | 11,000 GW (onshore)<br>4,200 GW (offshore to 50 nm) | 38 GW (conventional)<br>4,000 GW (EGS) | 68 GW | 62 GW |

# US power sector fuel mix

- Change in generation 2007-16




- Source: EIA

# Electric industry in the midst of unprecedented change - *Driven by fast-growing mix of interrelated issues*

Existing 50% goal

Federal Election Impacts

Gas Storage Challenges

NEW 100% goal

Community or Retail Choice

Grid Modernization

Regional Collaboration

Consumer-owned Power

Fossil Plant Retirements

Transmission & Distribution Systems Interface

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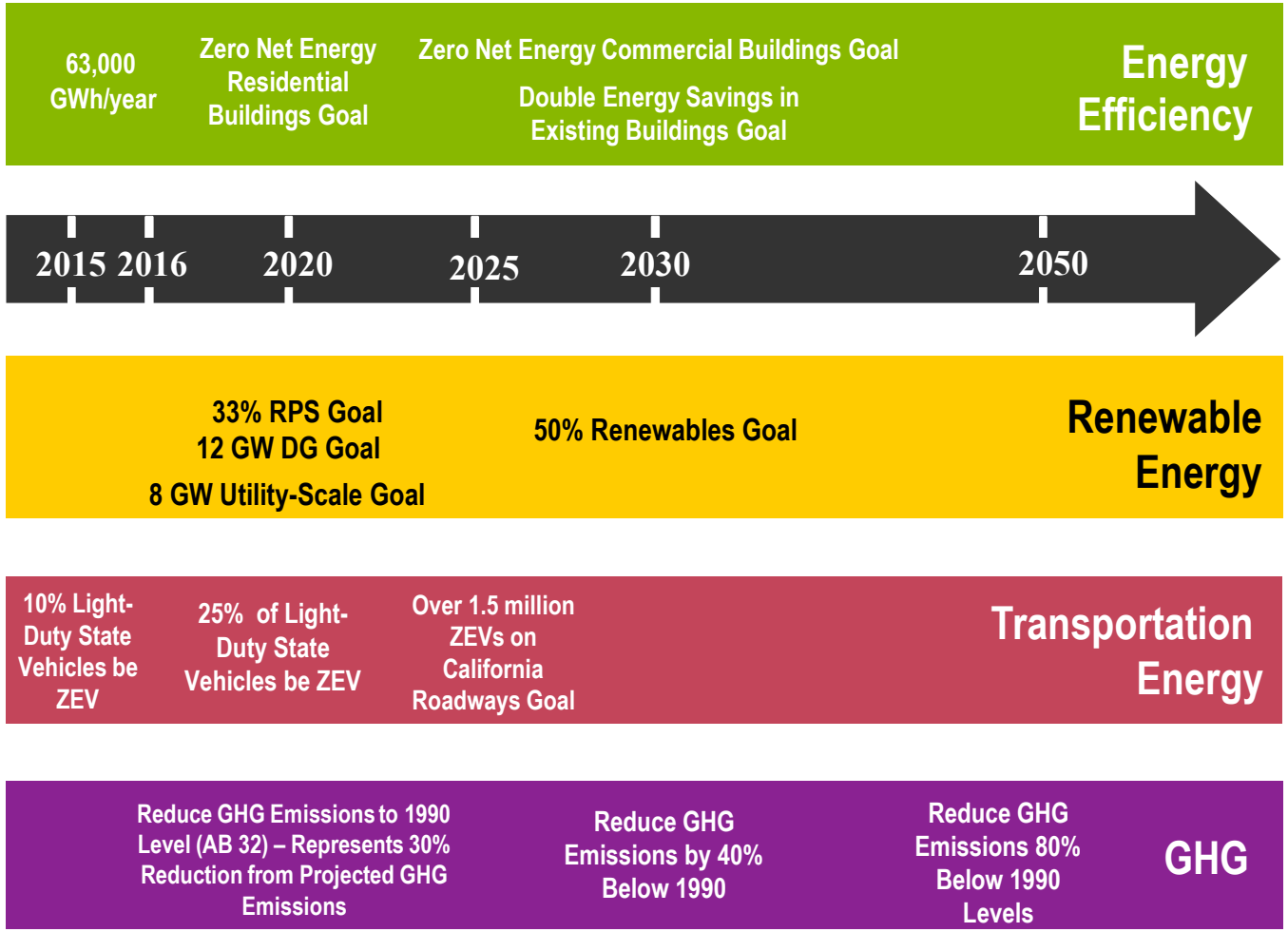
# State Energy Policy Drives Energy RD&D Investments



# Growth of solar PV and wind on the California ISO system

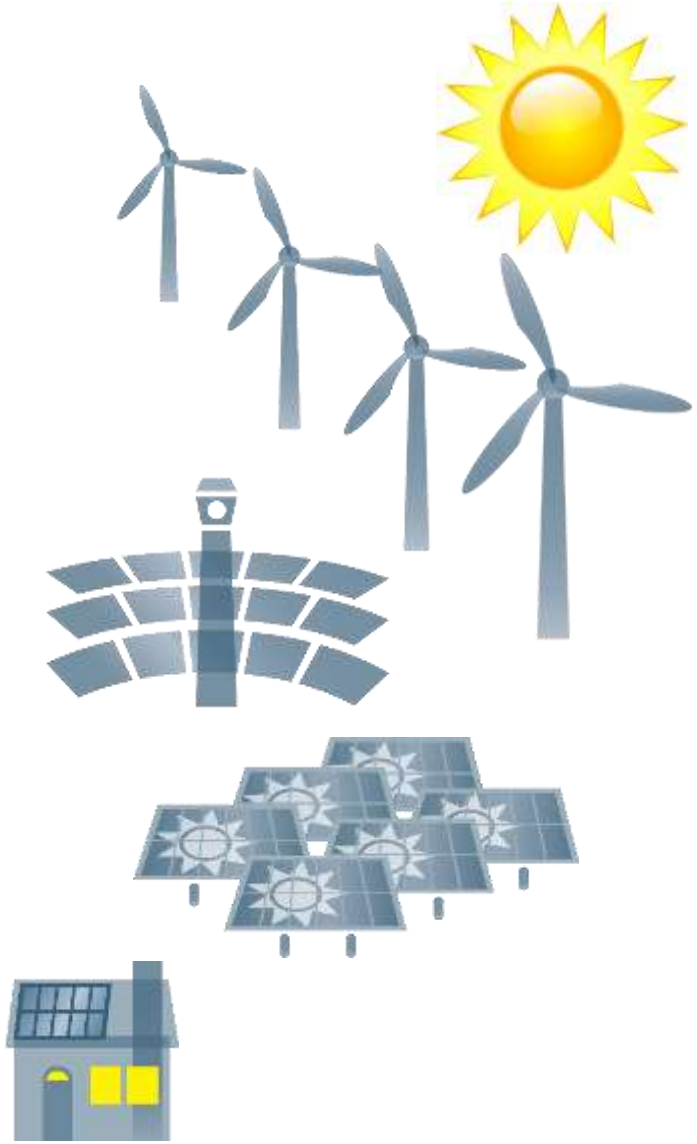
| | 2010 | 2018 |
|---|---|---|
| Solar | 85 MW | 9,952 MW PV<br>1,237 MW Thermal<br>6,569 MW BTM[1] |
| Wind | 3,309 MW | 6,295 MW |



[1] *See GoSolarCalifronia.gov - BTM number includes both investor owned utility and publicly owned utility installations.*

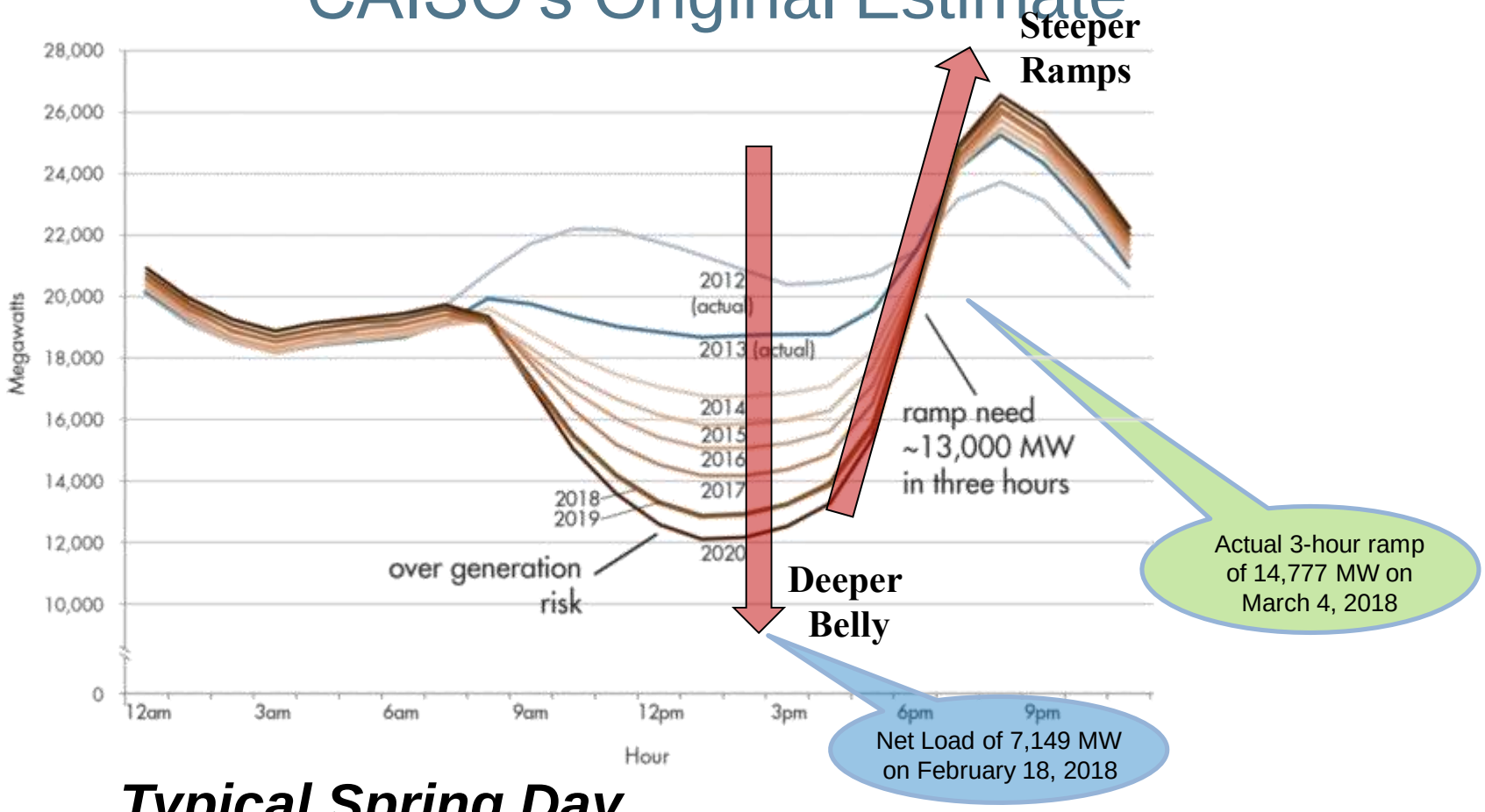
# Major progress on meeting California's renewable goals

- Currently Installed:
  - 21,000 MW of large-scale renewables
  - 6,000 MW of rooftop solar
- Additional renewables:
  - 3,300 MW for 50% RPS by 2030*
  - 11,400 MW of consumer rooftop solar by 2030**



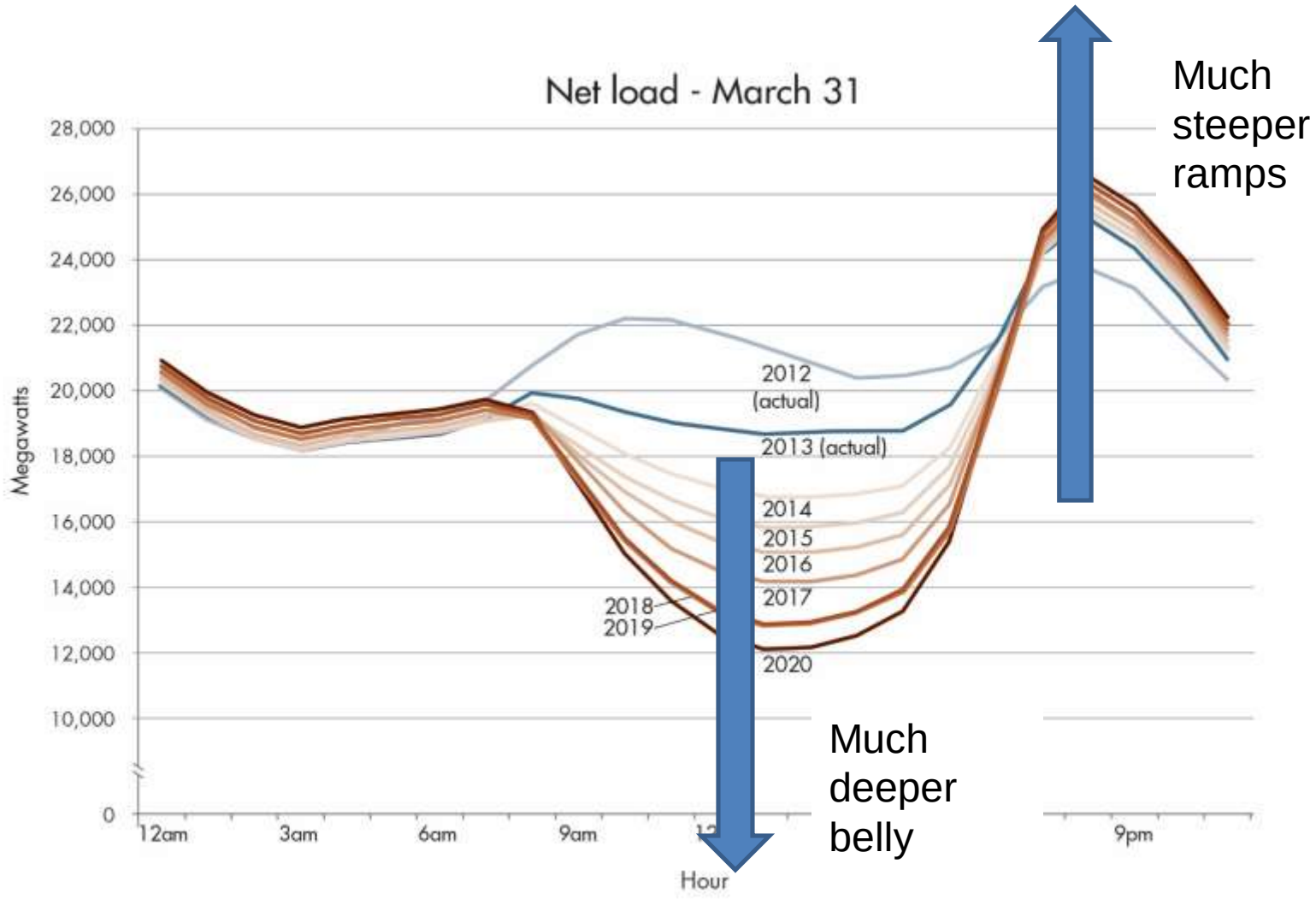
* 2018 CPUC IRP
**2017 CEC IEPR

# The “Duck” turns 10 years old: Actual Net-load & 3-hour Ramps are about Four Years ahead of the CAISO’s Original Estimate




***Typical Spring Day***

# ISO working on a 50% duck curve



# Transparency Real-Time Emissions (17:35, January 24, 2018)

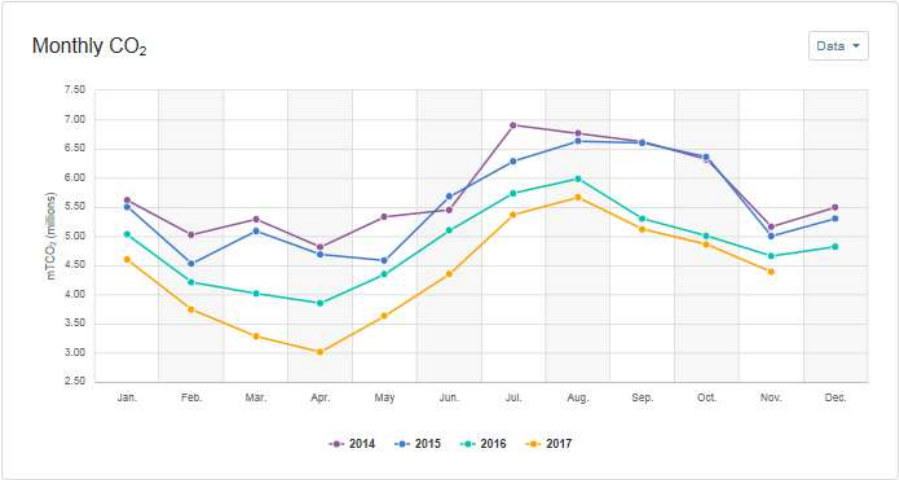
## Current $CO_2$ emissions (serving ISO load) AS OF 17:35

| 28,402 MW | 8,828 $mTCO_2/h$ | 0.311 $mTCO_2/MWh$ | 24% |
|---|---|---|---|
| Current demand | Current $CO_2$ emissions | Current $CO_2$ emissions rate | Reduction in $CO_2$ emissions |

The California ISO supports the state's clean air policies by integrating clean, zero carbon resources such as wind and solar. This page shows the success in reducing power plant emissions. $CO_2$ emissions data is an approximation. View how $CO_2$ is calculated.

### Historical $CO_2$ emissions (serving ISO load)

The addition of zero or very low carbon renewable resources to the grid is reducing $CO_2$ emissions over time.

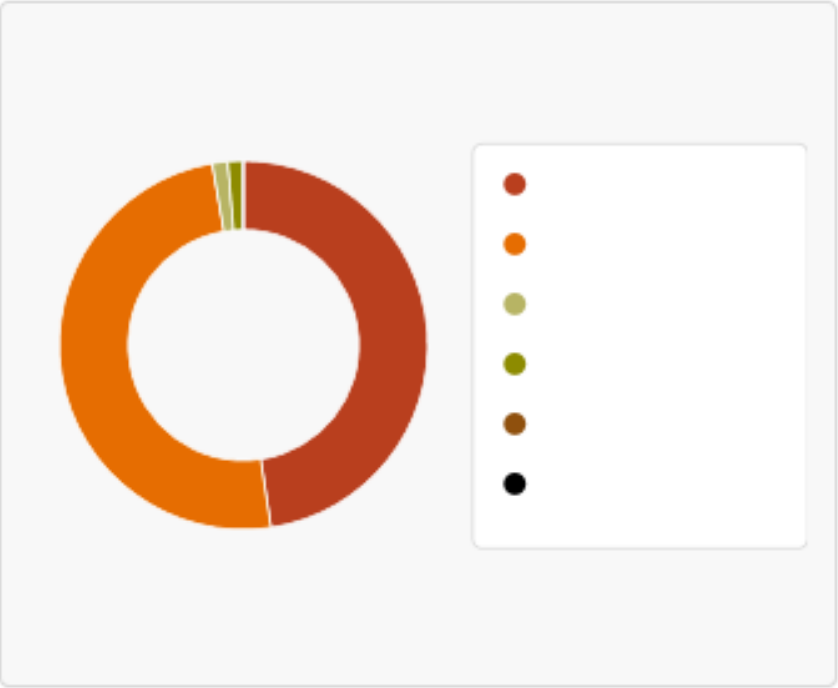



Today's Outlook is provided for informational purposes ONLY and should not be relied upon by any party for the actual billing values or operational planning.
For official data, visit OASIS. For official emissions data, visit CARB.

# Transparency: Real-Time Emissions Source and Daily Outlook

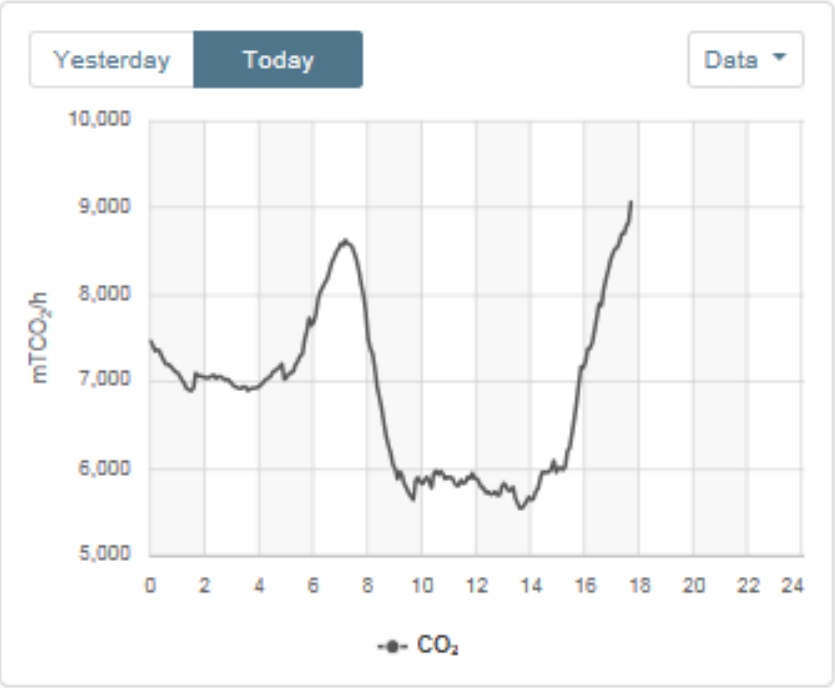
## Current $CO_2$ per resource

$CO_2$ is produced when a fuel is combusted to turn generator turbines. Wind, solar, batteries, hydro and nuclear operate without emissions.



## Today's $CO_2$

Emissions typically rise when traditional resources are needed, such as during periods of reduced production of solar and wind resources.



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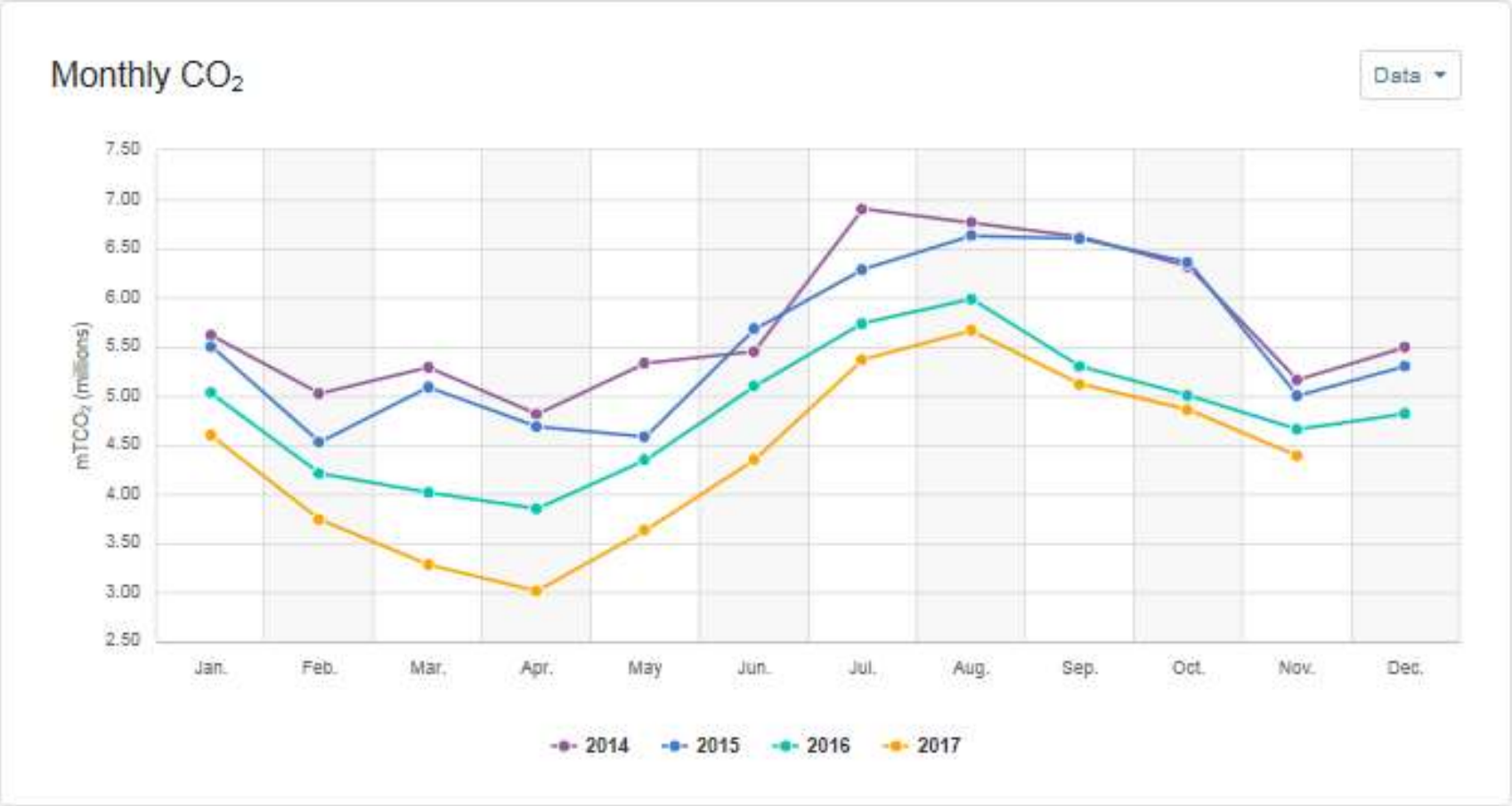


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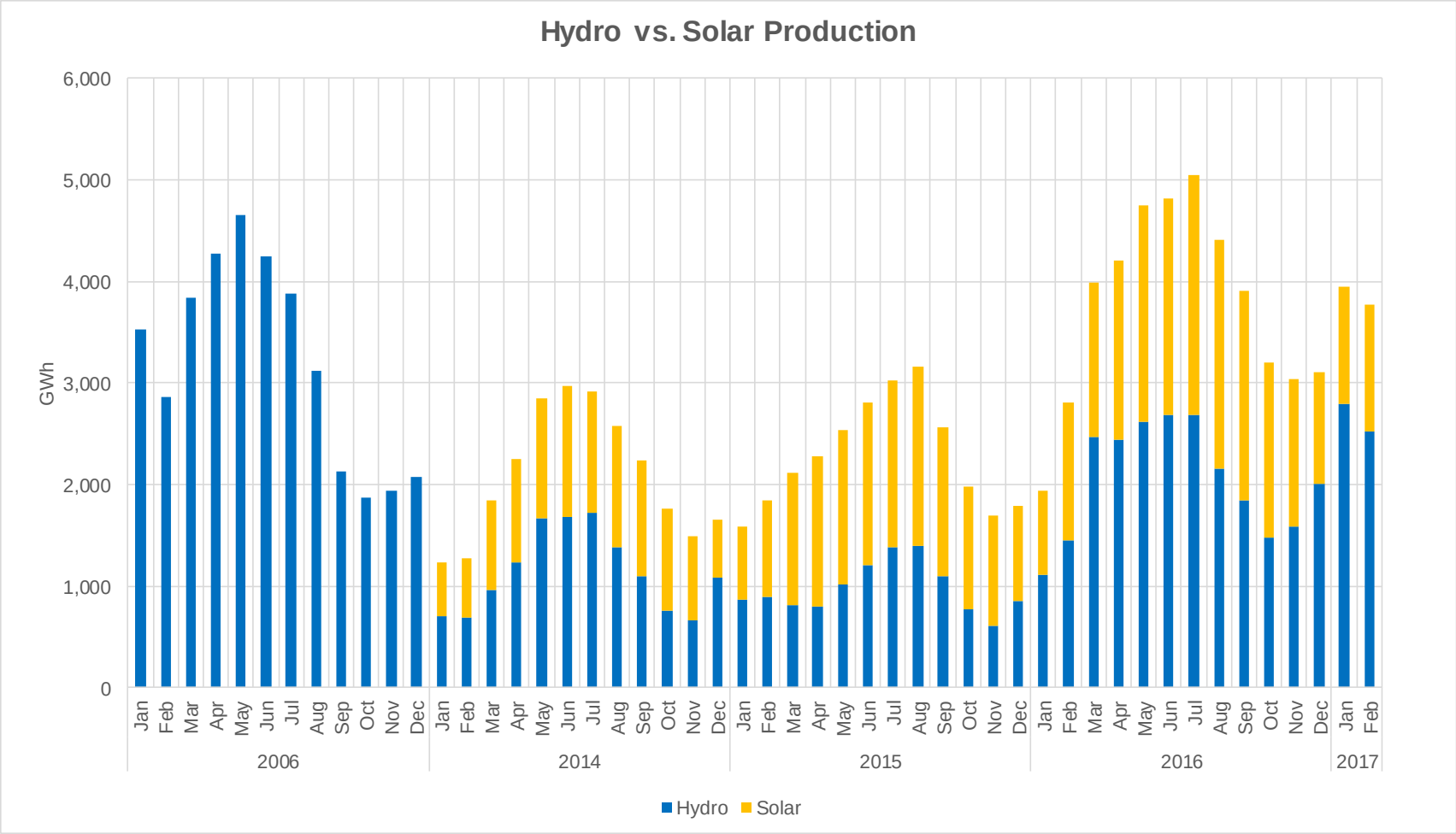
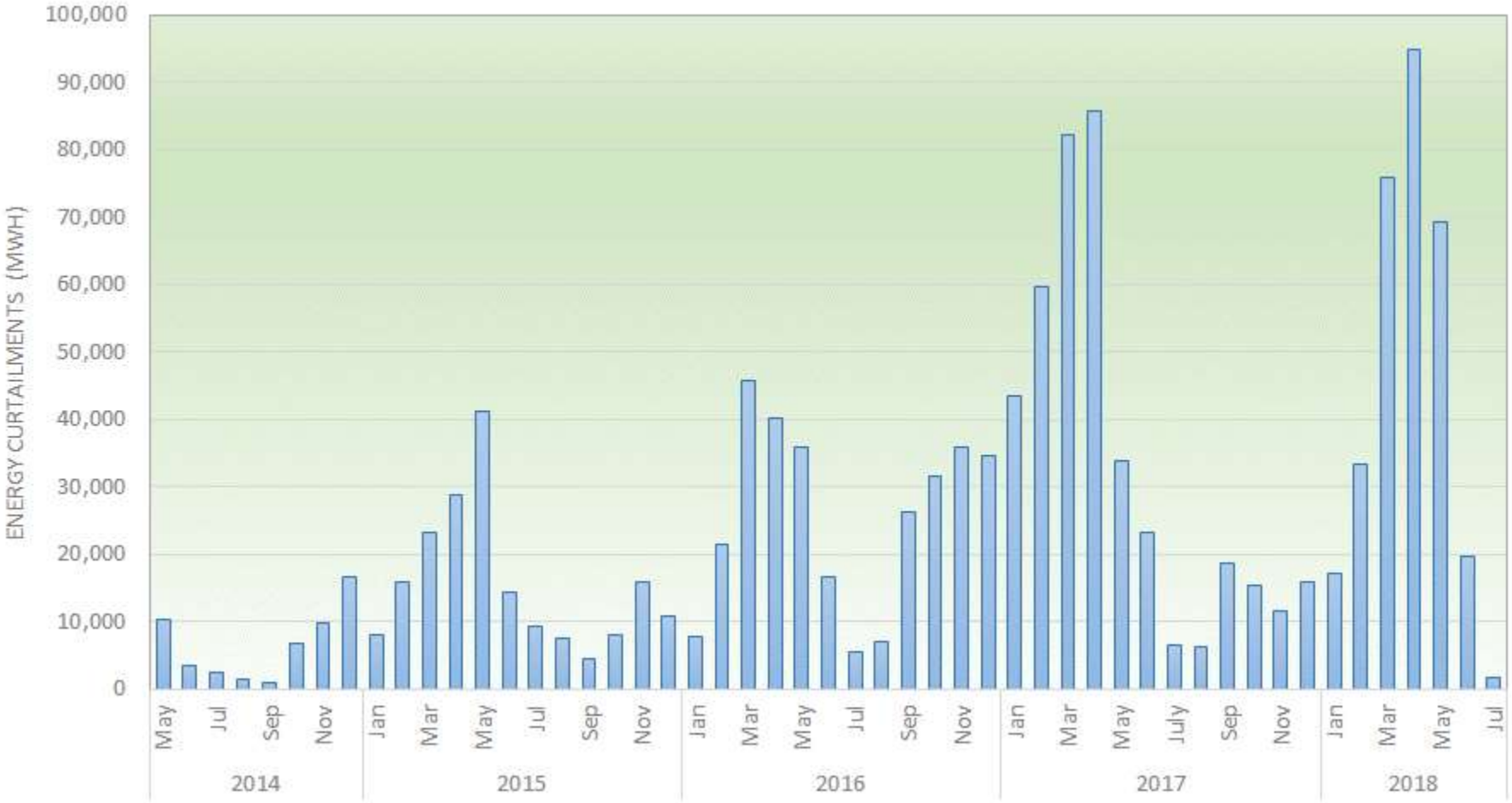
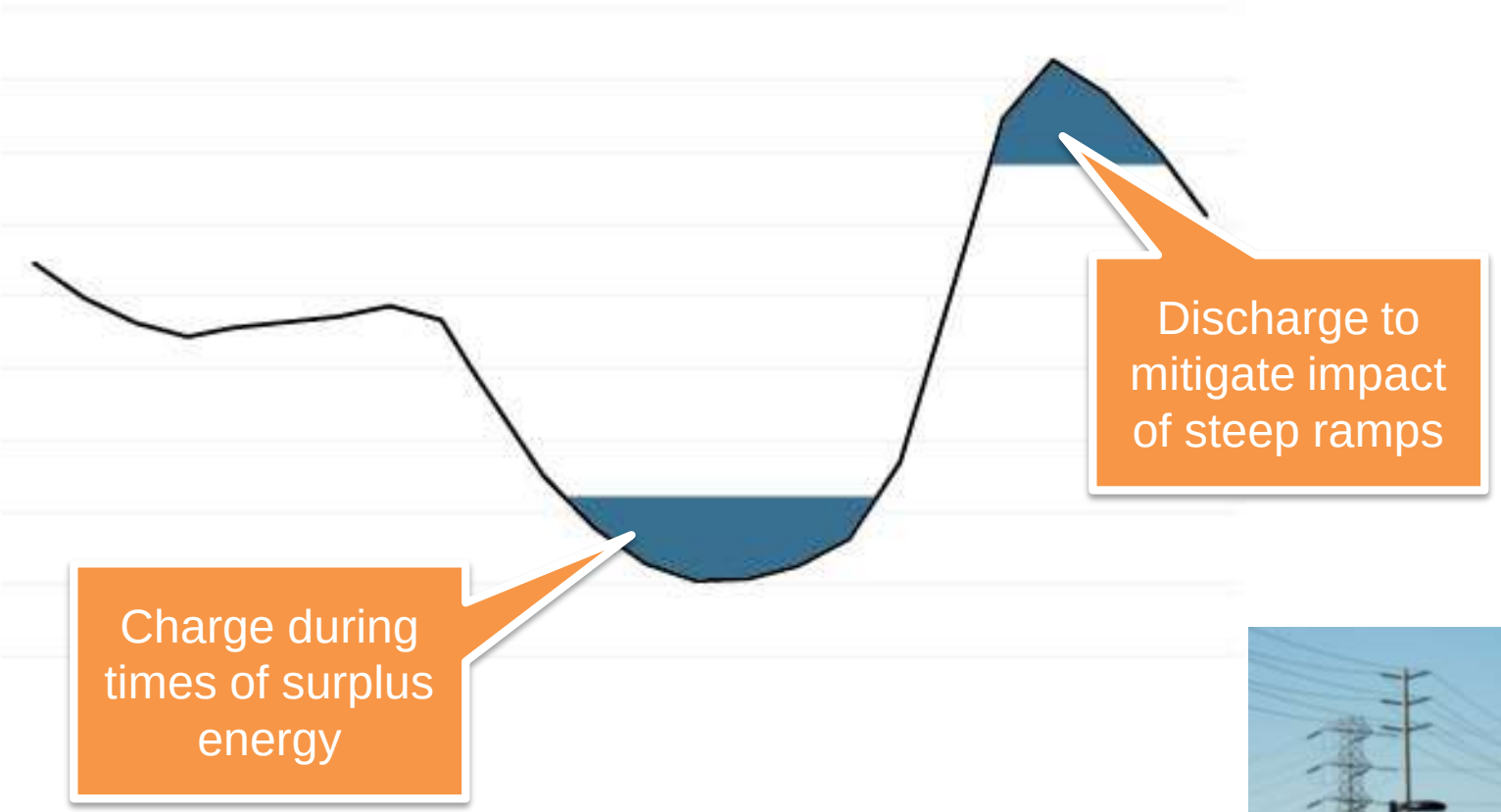
# Solar production complemented the hydro production during the drought years as compared to 2006, which was a high hydro year



# Increasing Trend of Renewable Curtailment Varies with Seasonal and Hydro Conditions

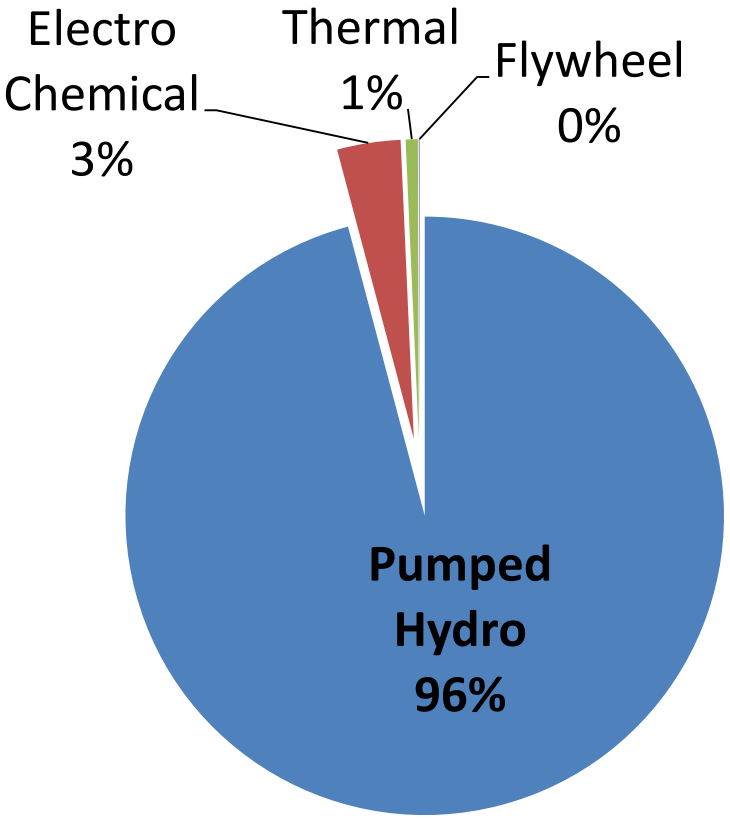


# Storage uniquely qualified to help mitigate operational issues



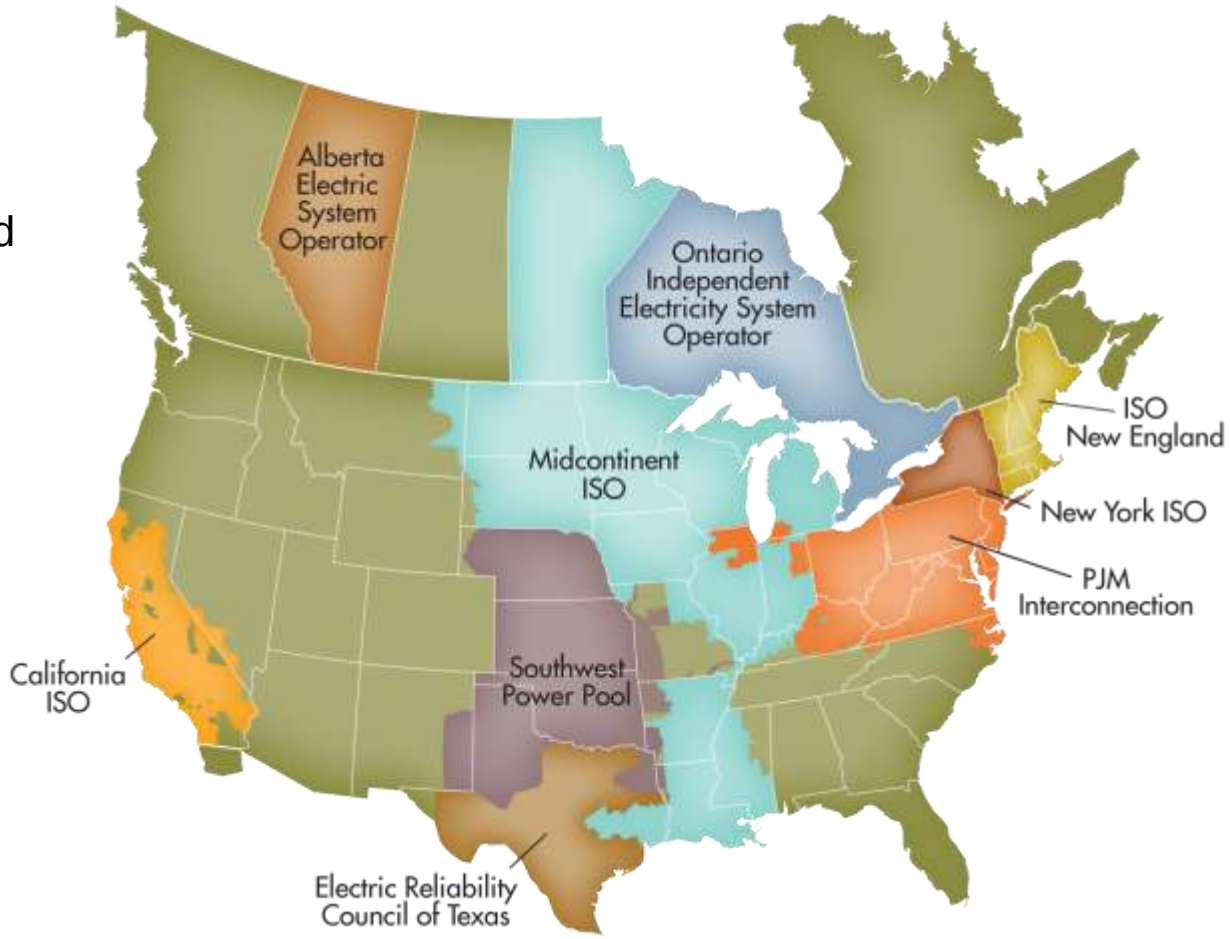

# Existing Storage in California

Pumped Hydro: 4087 MW
Electro-chemical: 146 MW
Thermal: 28 MW
Flywheel: 2 MW



# One of nine Grid Operators in the U.S.

- 2/3 of the U.S. is supported by an ISO
- ISO is one of 38 balancing authorities in the western interconnection

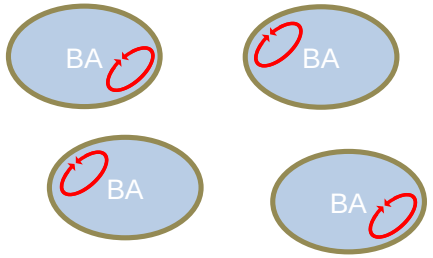


# The California ISO

- Balance supply and demand…every 4 seconds
- Operate markets for wholesale electricity and reserves
- Manage new resource interconnections
- Plan grid expansions

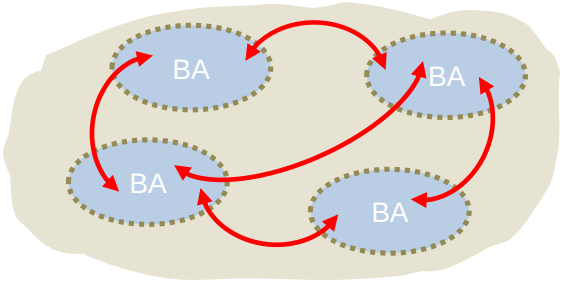
# EIM Efficiencies

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

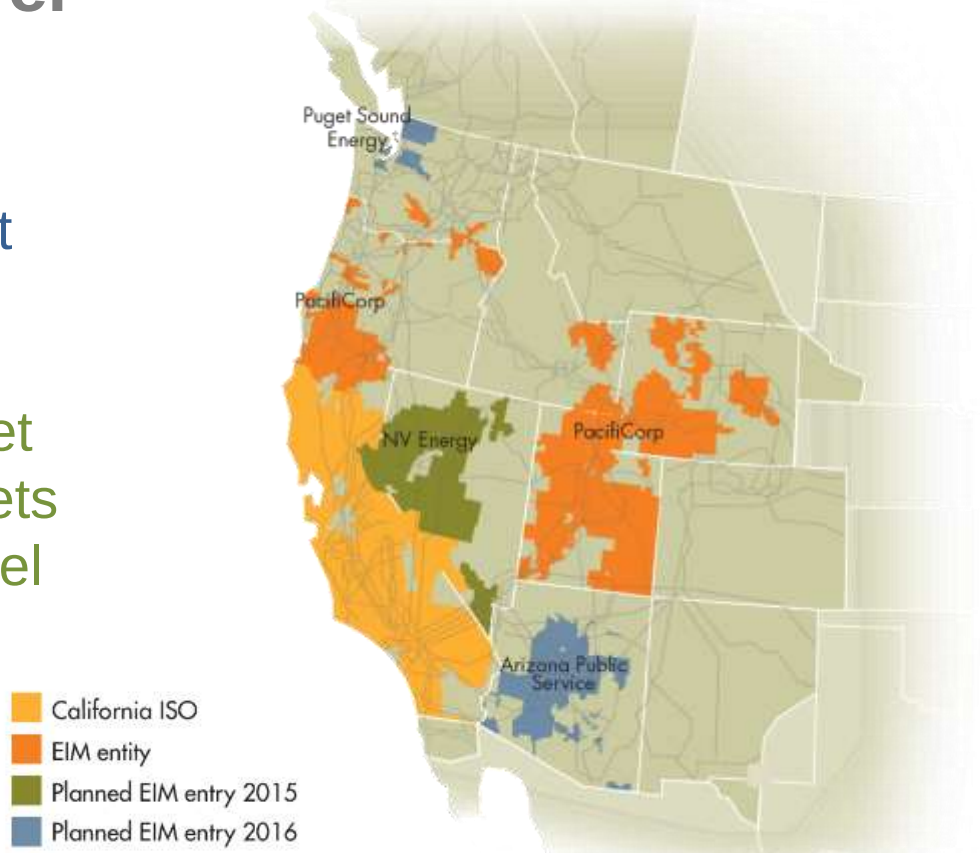



- Diversity of balancing resources
- Increased flexibility
- Decreased flexible reserves
- More economically efficient
- Decreased integration costs

# Regional Collaboration helps to manage surplus power

## Energy Imbalance Market

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



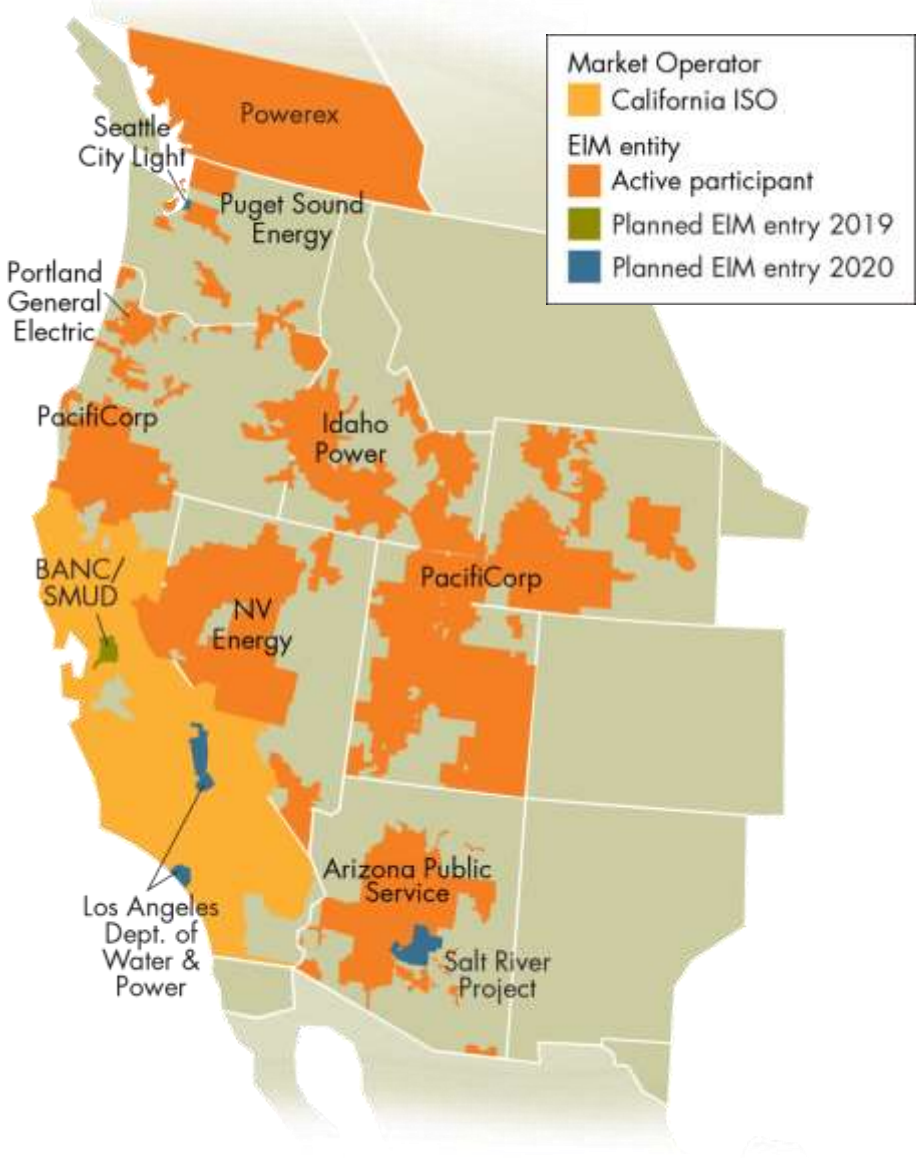
# The Modernization of the Western grid

Western Energy Imbalance Market (EIM):

- Savings of $330.52 million since 11/14
- 586,277 MWh curtailment avoided, displacing an estimated 250,845 metric tons of CO2
- Balancing authorities maintain control and reliability responsibilities

Regional Grid Collaboration

- Integration of renewables across a larger geographical area
- Enhances reliability with improved situational awareness
- Reduces costs through automatic economic dispatch
- Comprehensive transmission planning
- More diverse renewables on the system
- Advanced dispatch enables innovation



# An integrated regional grid will increase benefits across the West

**No change in governance needed**

## EIM

- Saved $145 million in 2017
- About 5% of overall energy services

**Current governance makes participation highly uncertain**

## Extending day-ahead services

- **Creates significantly more benefits than** EIM
- Co-optimizes **energy and critical grid services** increasing EIM benefits
- **Improves balancing** of supply and demand

**Governance change necessary**

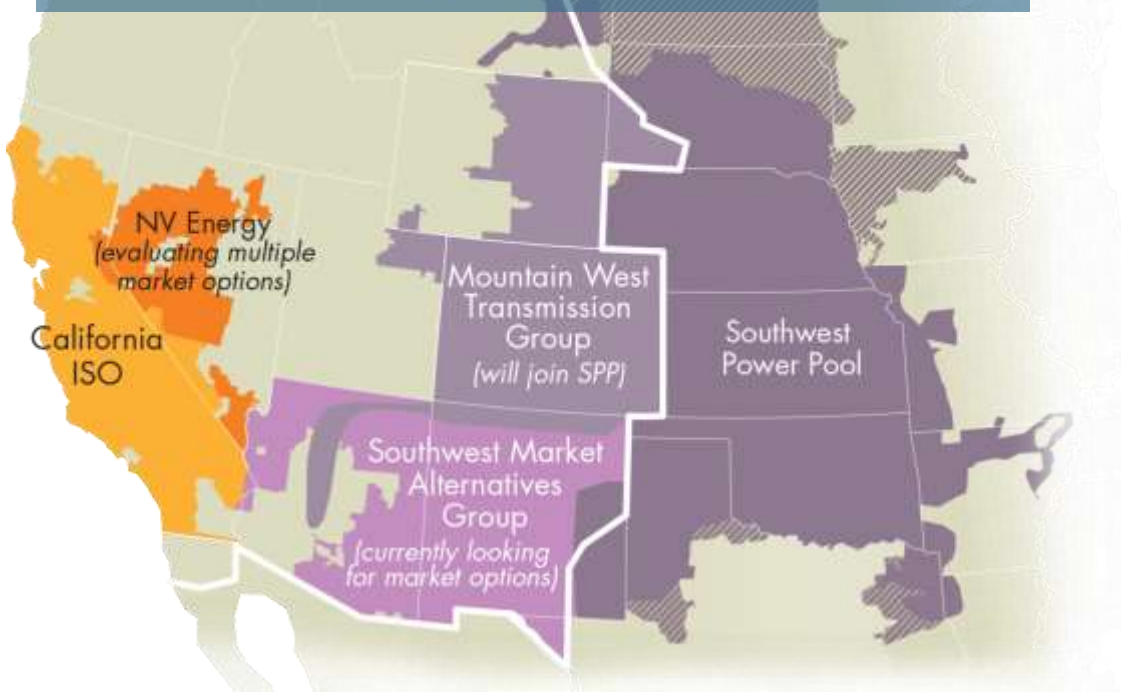
## Regional grid – annual savings could exceed $1.5B

- Captures benefits of EIM and extending day-ahead services
- Enhances reliability across a broader footprint
- Significant savings from coordinated planning & resource sharing
- Reduces overall need for capacity

# Risks of California not moving to a regional grid

- Developing clean energy resources becomes more difficult thereby impacting job growth
- Misses opportunity to enhance regional reliability
- Requires continued operation of unnecessary fossil fuel power plants
- Creates risk of not achieving California GHG reduction goals

***Other grid operators are vying for control of the western grid. California leaders must act to avoid slowing transition to clean energy***




*Mountain West Transmission and Southwest Market Alternatives represent groups of utilities looking to pool their balancing areas for market services. SPP and PJM/Peak Reliability have both offered to provide market services in the West.*

# Consumers (Prosumers) as New Energy Supply Participants

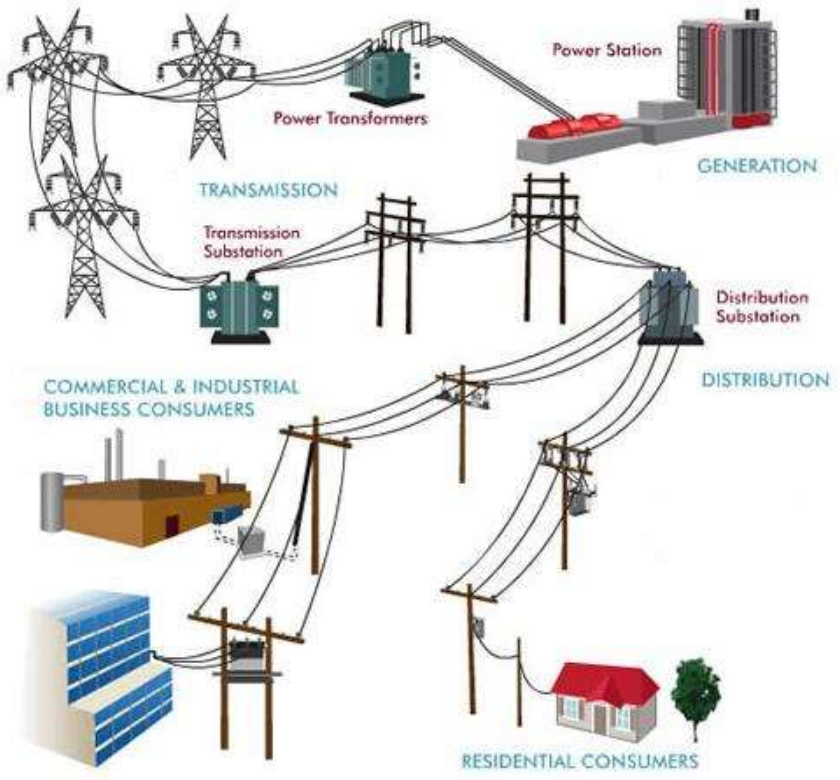
Rooftop Solar and storage

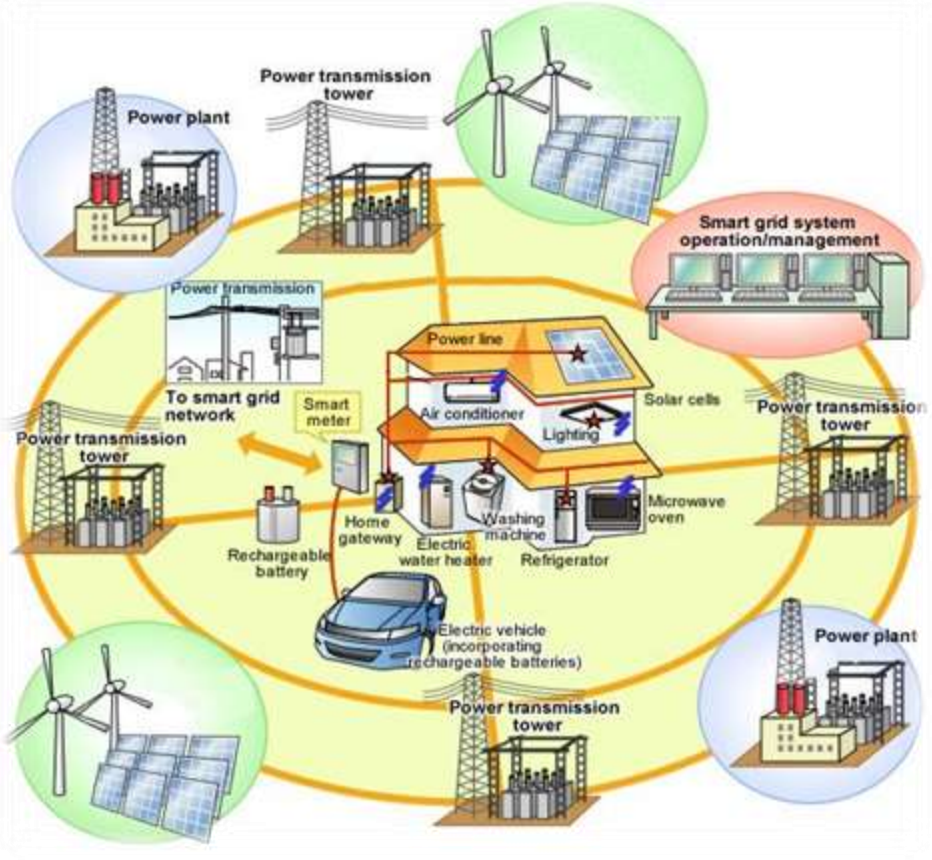
Electric Vehicles

Consumer control

Rates and grid signals help them participate

# Supporting Evolution of the Electricity Grid

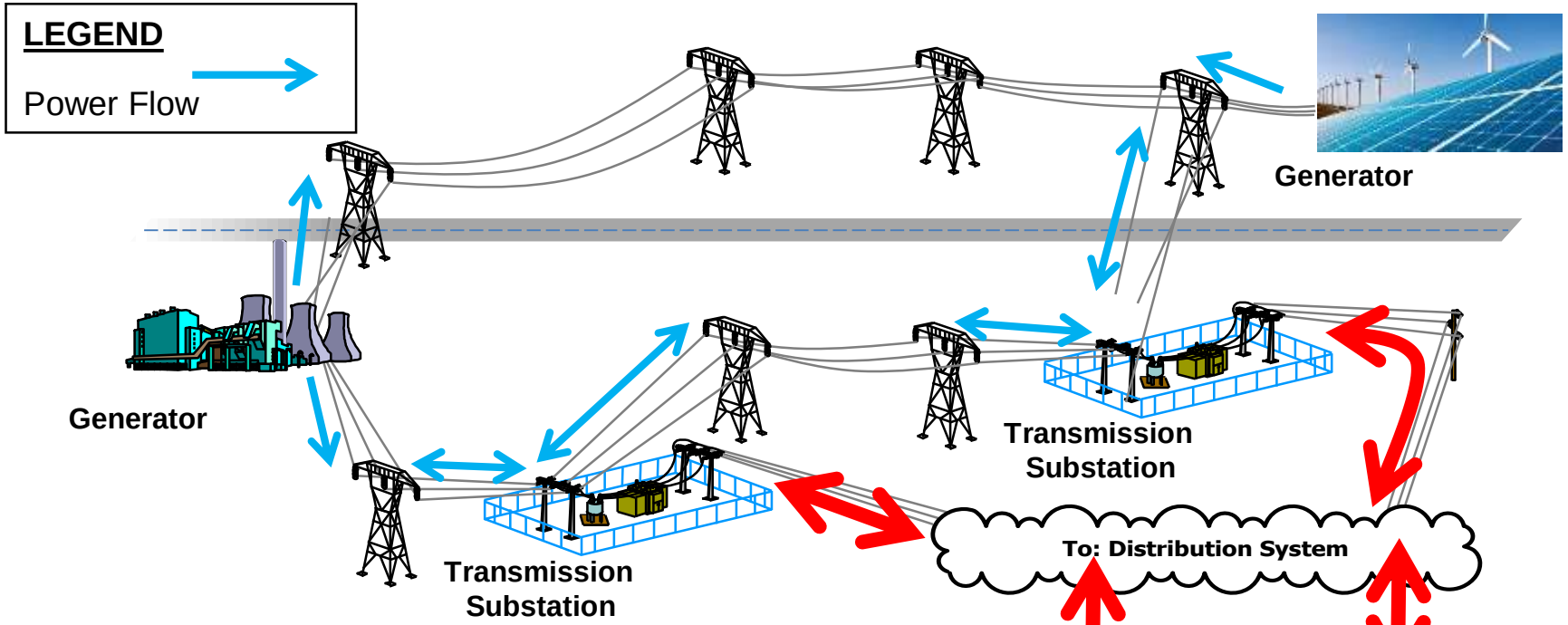



Historical Grid → “Smart” Grid

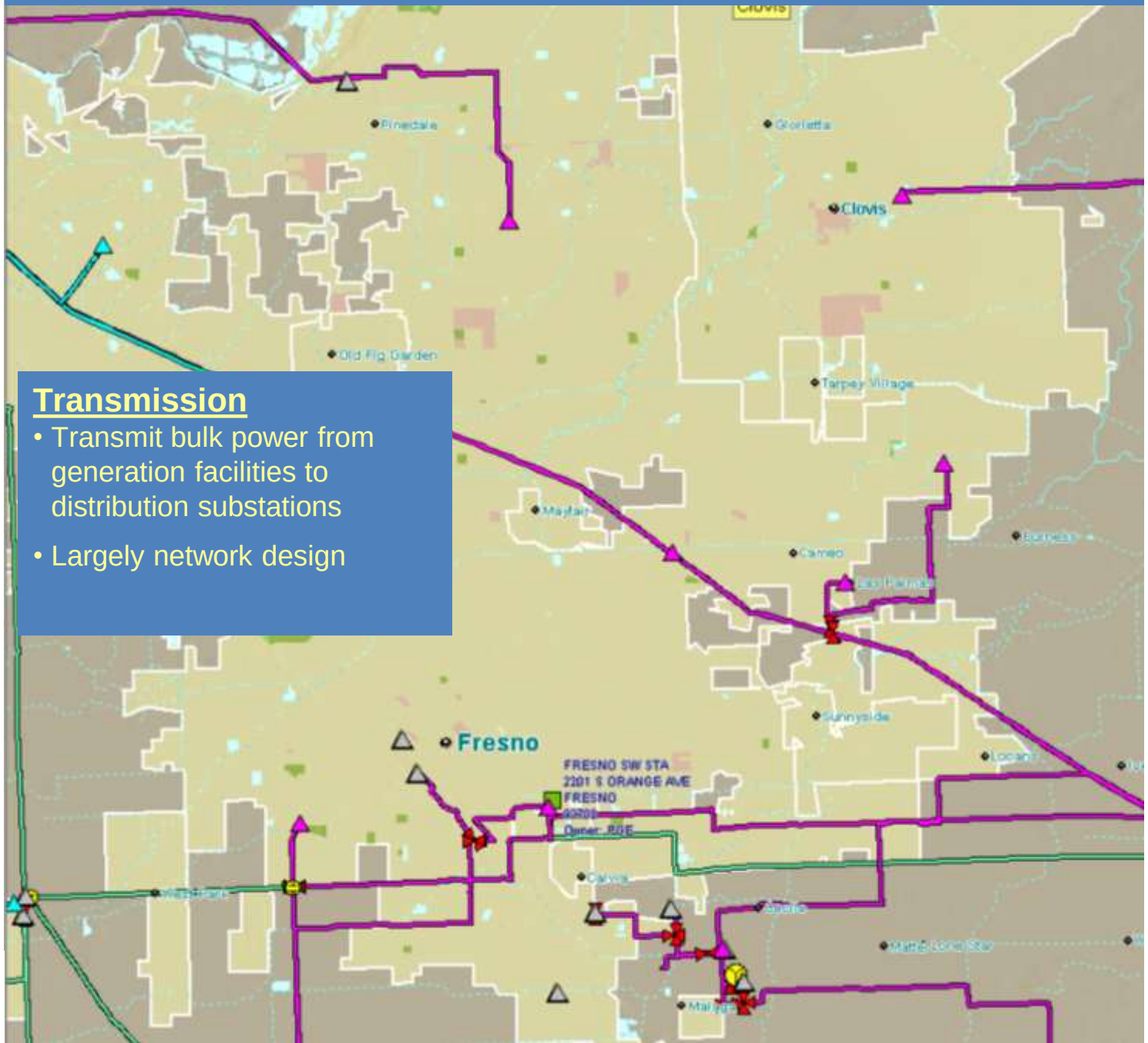
# Potential Transmission Power Flow With High Penetration of DER

- Potential for power to flow  bi-directional at the Transmission and Distribution Interface
- The current system is not designed or modeled to accommodate this potential  bi-directional power flow which may move the system t into unstudied conditions




Potentially hundreds of thousands of injection points from rooftop solar, battery, and other distributed generation resources

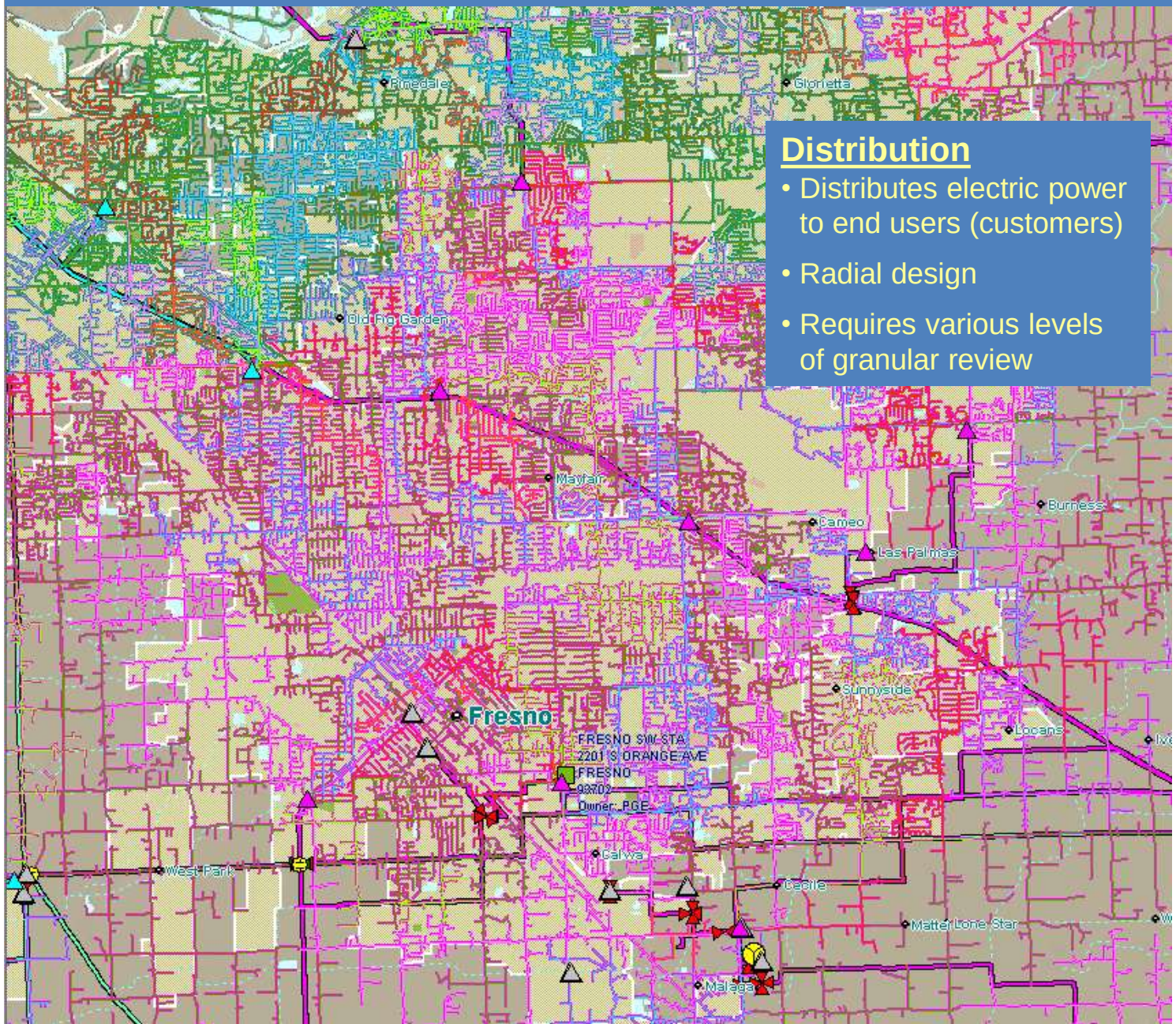
# Central Fresno Transmission System




**Transmission**

- Transmit bulk power from generation facilities to distribution substations
- Largely network design

# Central Fresno Transmission and Distribution Systems




## Distribution

- Distributes electric power to end users (customers)
- Radial design
- Requires various levels of granular review

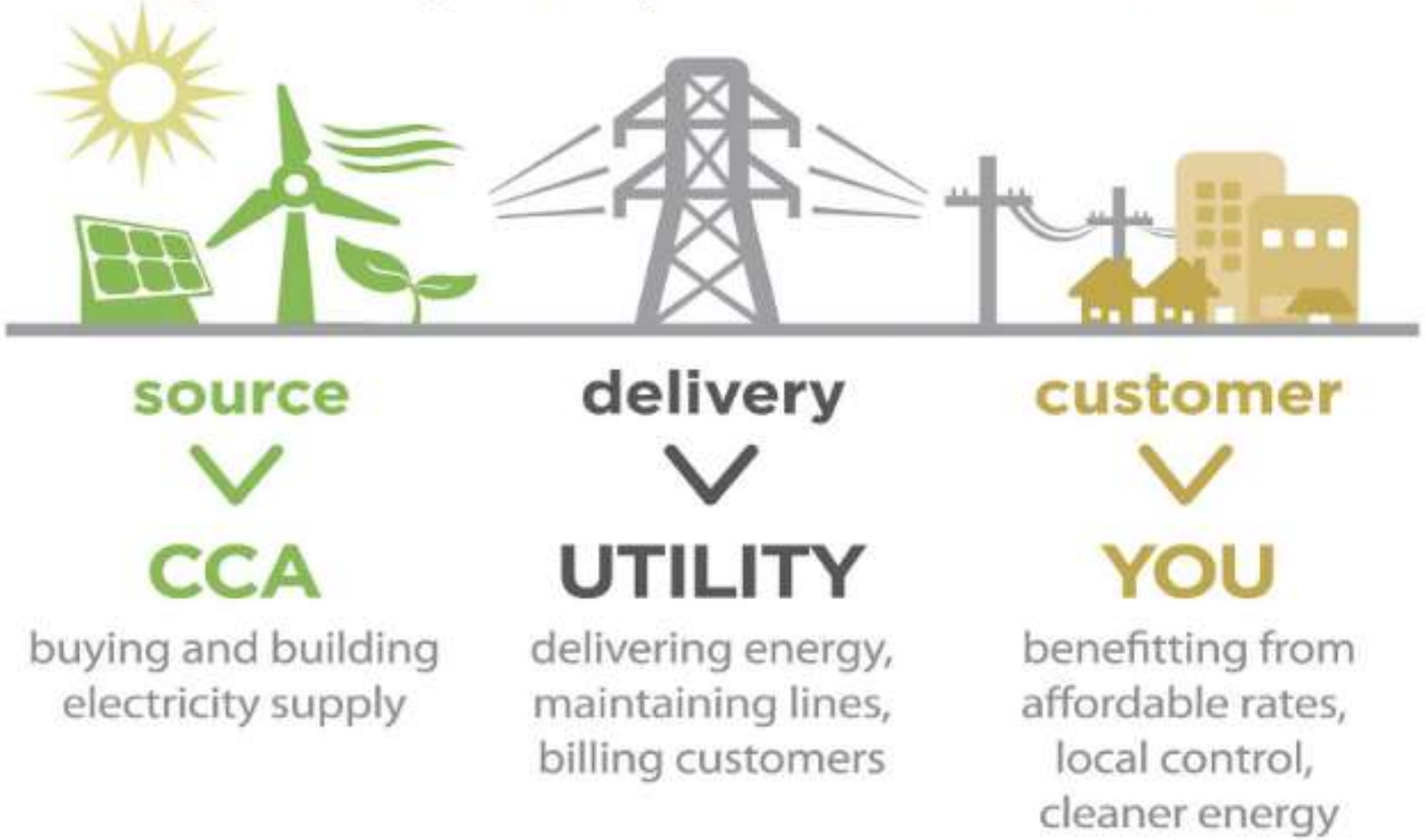
# PG&E – System Architecture

There is a significant scale difference between Transmission and Distribution

| Transmission System | Distribution System |
|---|---|
| **18,165** miles of transmission lines | **142,000** circuit miles of distribution lines |
| **~2,800** subst. transformers | **~1MM** dist. line transformers |
| **173** unplanned t-line outages<br>**24** planned t-line outages | **28k** unplanned dist. outages<br>**19k** planned dist. outages |
| Built not to break -- Resilient<br>If it does break -- Contingency | Less resilient<br>Built for rapid repair response |
| Consolidated from 15 control centers to 1 with a hot backup | Consolidated from 16 control centers to 3 |

While there are challenges, PG&E's distribution system is well positioned To meet the rapidly growing distributed energy resource model.

**Figure 3:** Cooperative System between IOUs and CCAs




**Source:** Nicholas Armour et al (2014). "Community Choice Aggregation in Torrance, a Pre-Feasibility Study." The University of Southern California Price School of Public Policy.

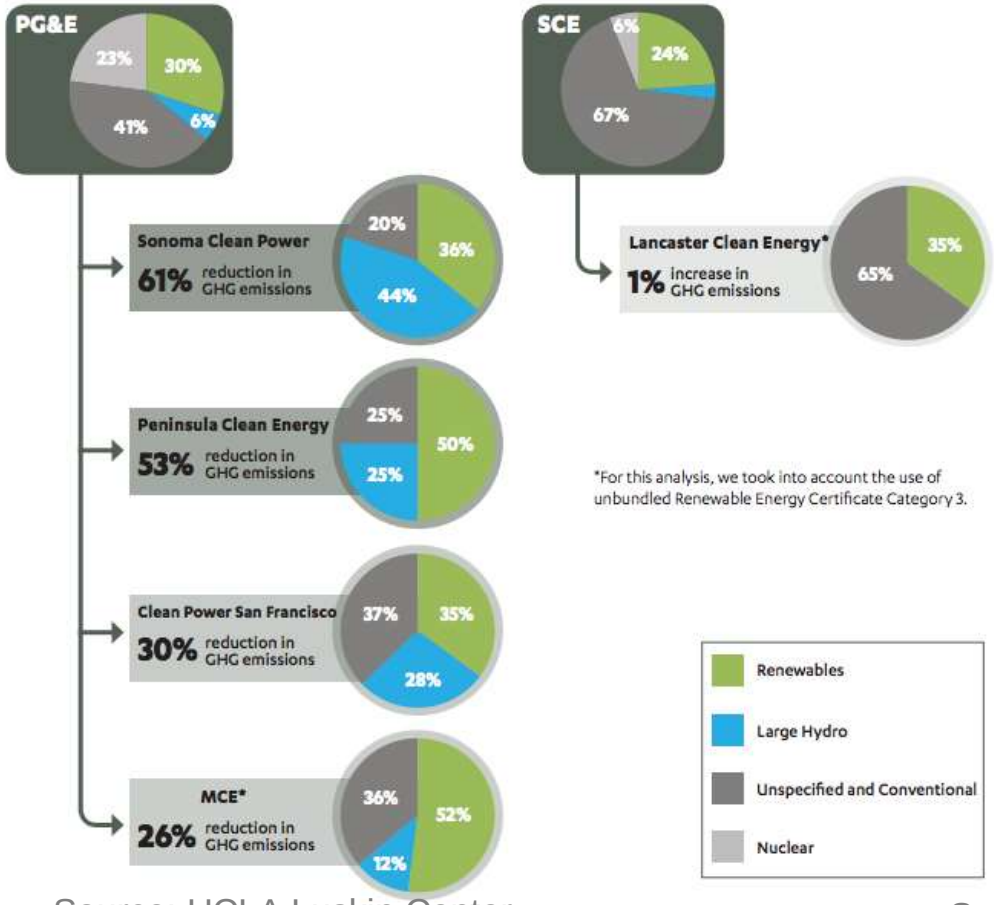
# Existing Programs

- Clean Power SF
- MCE
- Peninsula Clean Energy
- Sonoma Clean Power
- Monterey Bay Community Power
- Valley Clean Energy
- Pioneer Community Energy
- Rancho Mirage Energy Authority
- San Jacinto Power
- Lancaster Choice Energy
- Apple Valley Choice Energy
- Redwood Coast Energy Authority
- Silicon Valley Clean Energy
- Pico Rivera Innovative Municipal Power
- East Bay Clean Energy
- Clean Power Alliance
- King City Community Power
- Solana Energy Alliance

## Existing CCE Program Success

- Over 2.5 Million Customer Accounts
- Over $90 Million Estimated Customer Savings in 2018
- Over 940,000 Metric Tons of GHG Avoided as of 2016

# Success across California



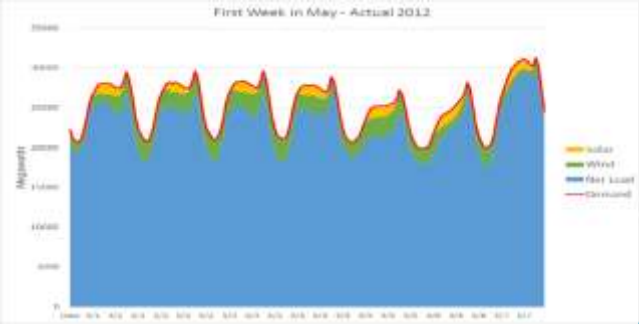

Source: UCLA Luskin Center, 2017


Source: Clean Power Exchange

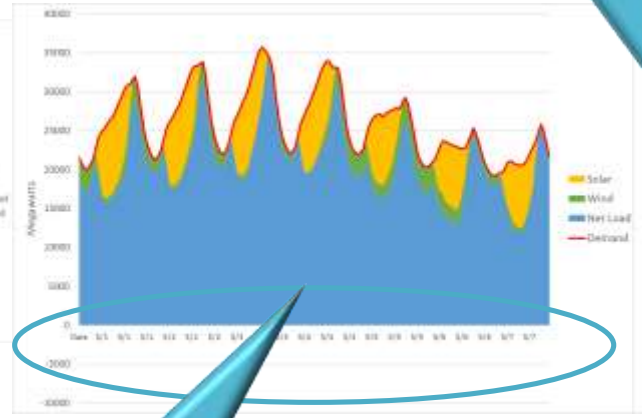
# Evolving structure of power supply - California

Huge ramp rates up and down

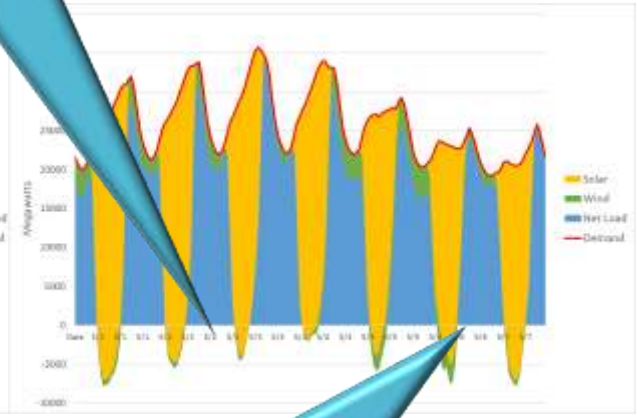
**First week of May 2012 (actual)**




**First week of May 2017 (actual)**



**First week of May 2030 (modelled)**



No more “baseload”

Lots of DR, storage and export - or curtailment

Source: CAISO OASIS; CEC proposed IRP; LM Power; CESA; Bloomberg New Energy Finance

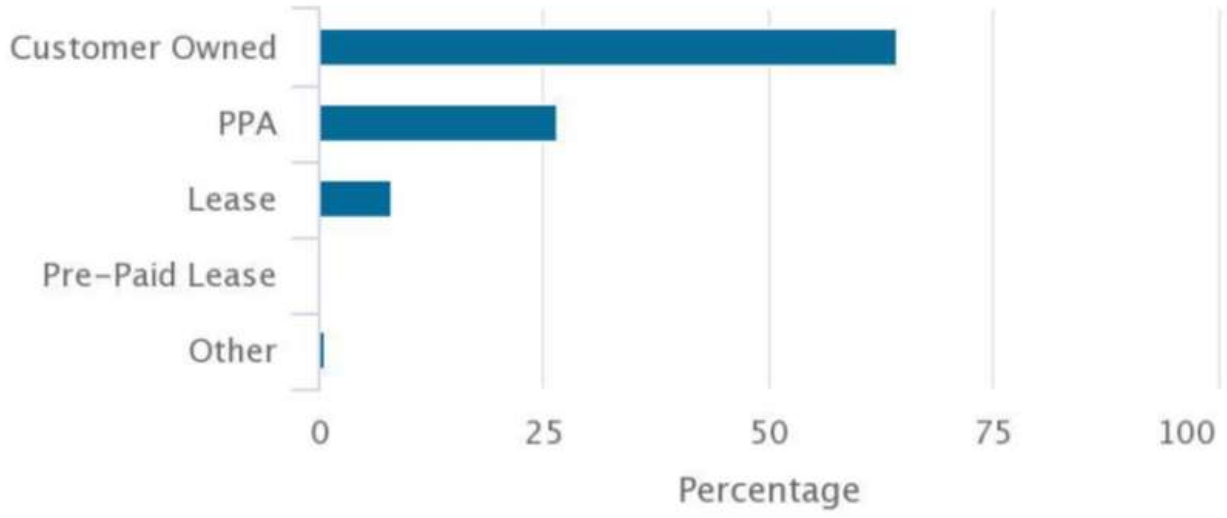
# IOUs' NEM Solar Capacity by Territory and Location (As of March 31, 2018) All DER Technologies are in Play

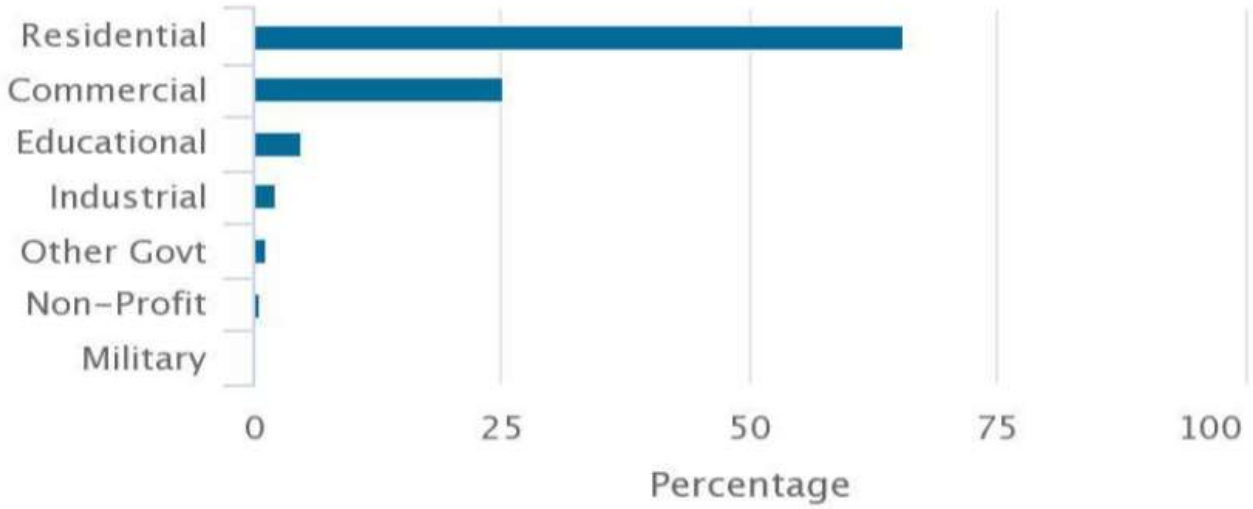

| | 2013 | 2016/17 | Percent Change |
|---|---|---|---|
| Energy Efficiency (GWh) | 1,693 | 3,197 | 89% |
| Demand Response (MW) | 2,187 | 1,997 | -9% |
| Behind-the-Meter PV (MW) | 2,102 | 5,900 | 180% |
| Plug-in Electric Vehicle (PEV) (number of registrations) | 69,999 | 266,866 | 281% |
| Distributed Advanced Energy Storage (MW) | 54 | 350 | 548% |
| Microgrids (MW) | 122 | 390 | 220% |

California Distributed Generation Statistics; accessed June 5, 2018. https://www.californiadgstats.ca.gov/charts/nem

# BIPV Products will become competive

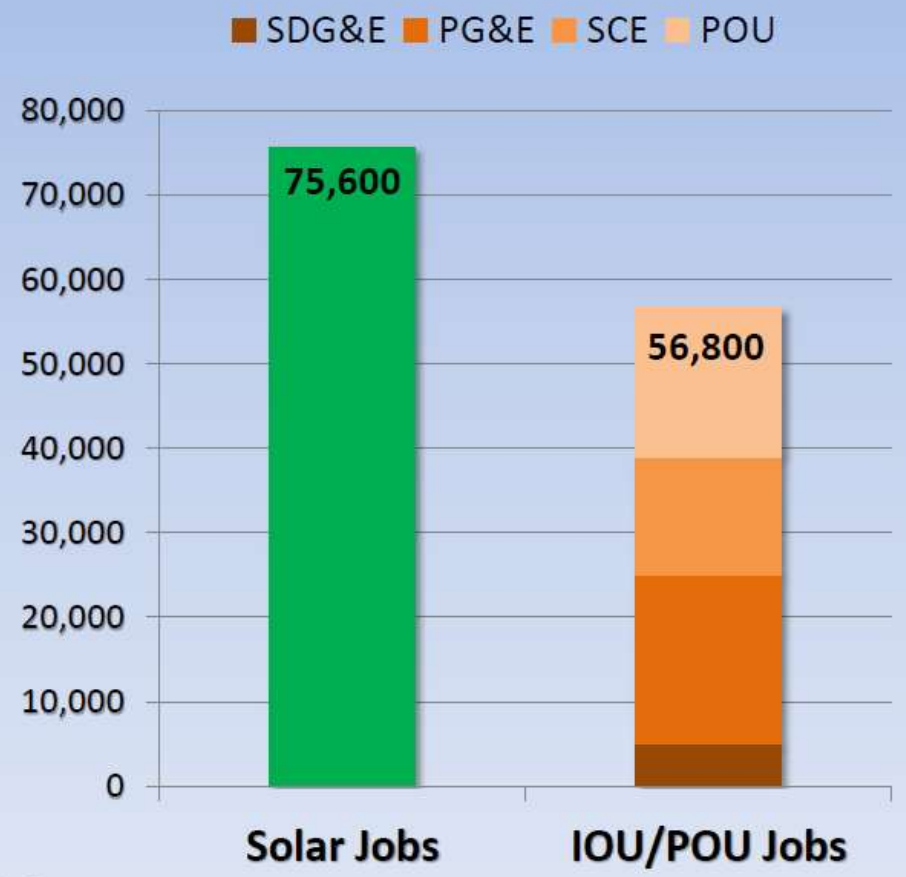
# Solar PV BTM Ownership 2015-2018




California Distributed Generation Statistics; accessed June 5, 2018. https://www.californiadgstats.ca.gov/charts/nem

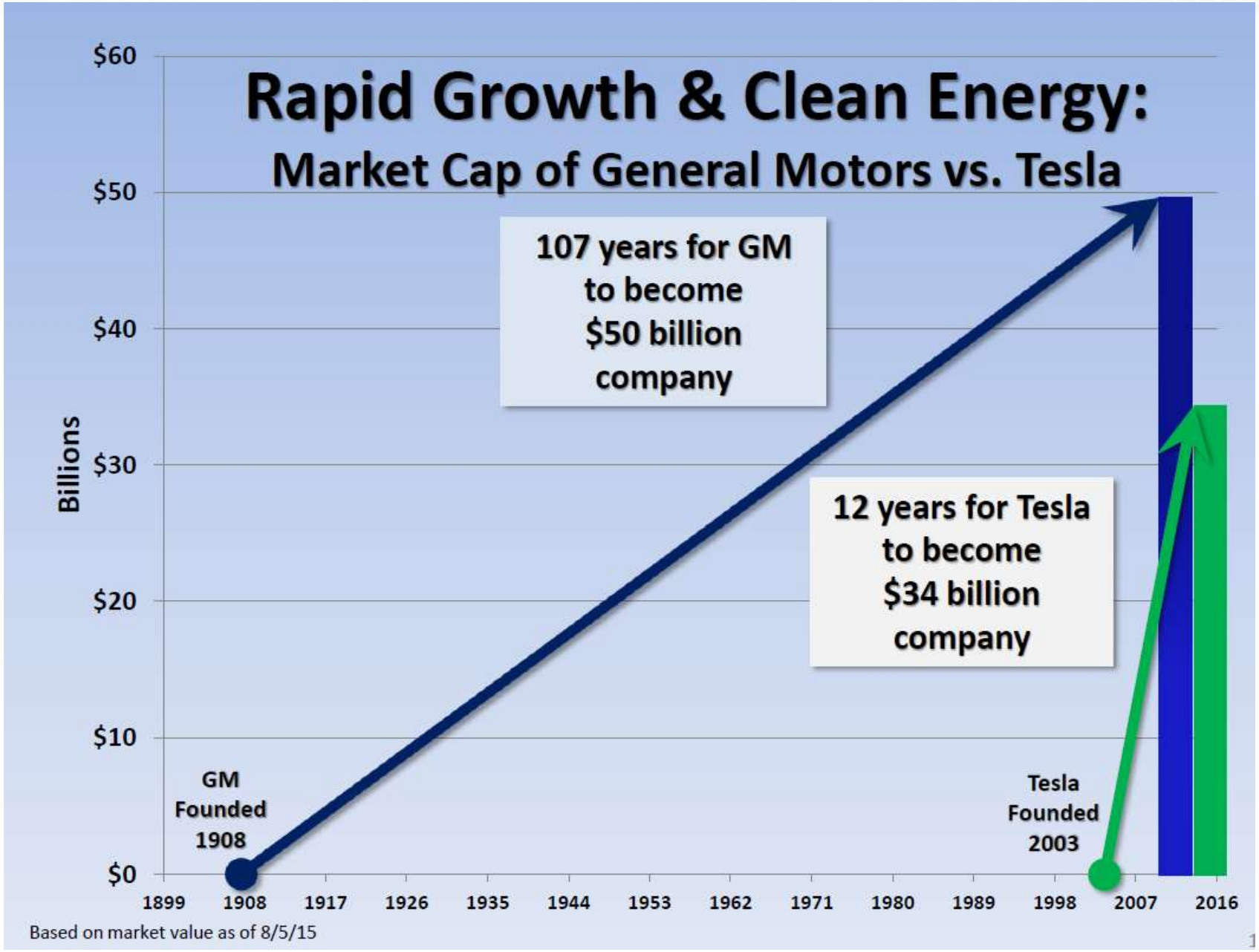
# More Californians Work in the Solar Industry Than for All Utilities Combined

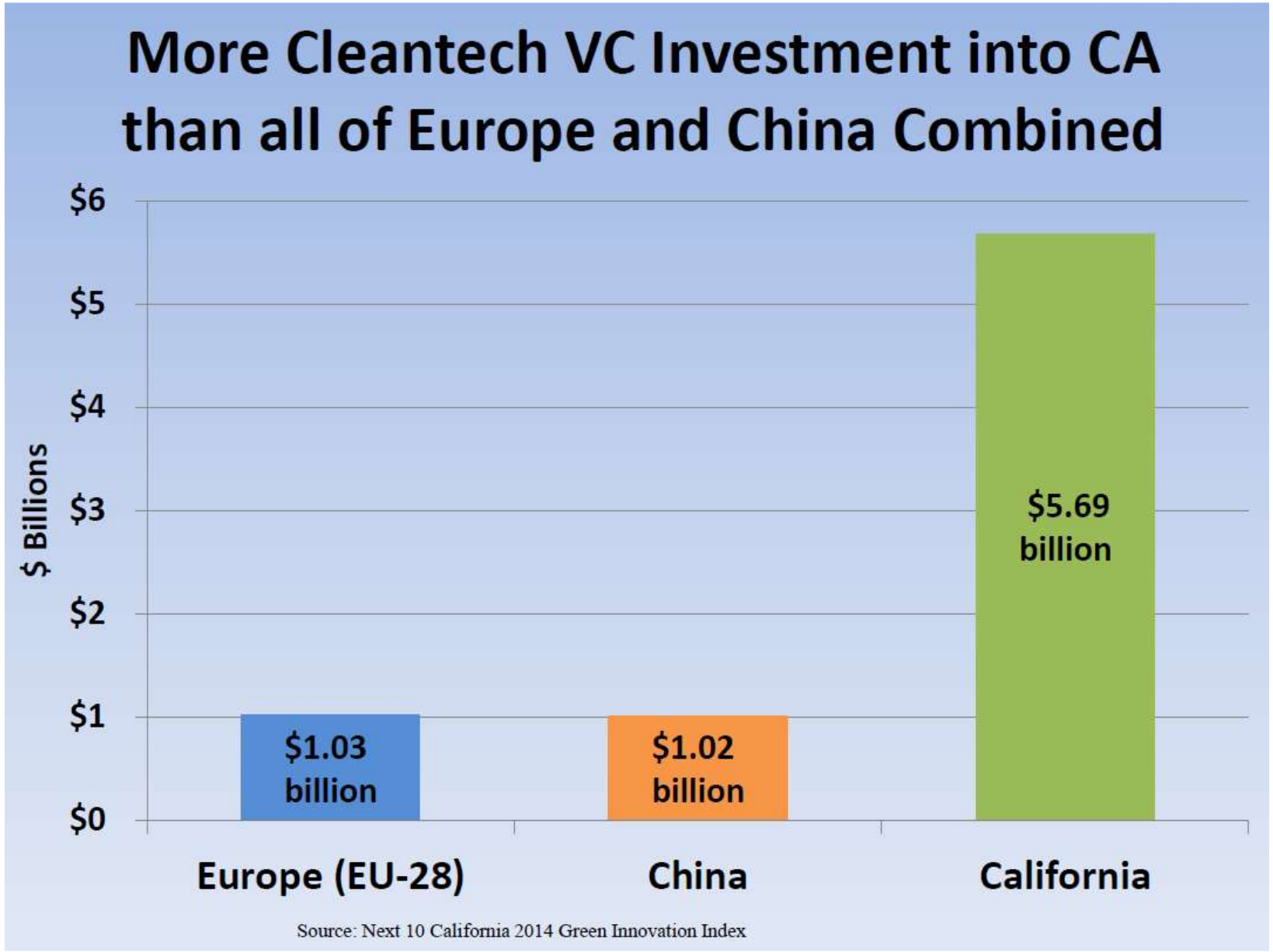



Sources:

Solar Foundation, 2015 Solar Jobs Census

U.S. Securities and Exchange Commission, Form 10-K, 2014
http://www.sec.gov/edgar/searchedgar/companysearch.html


Rapid Growth & Clean Energy:
Market Cap of General Motors vs. Tesla
Billions
$60
$50
$40
$30
$20
$10
$0
107 years for GM to become $50 billion company
12 years for Tesla to become $34 billion company
GM Founded 1908
Tesla Founded 2003
1899
1908
1917
1926
1935
1944
1953
1962
1971
1980
1989
1998
2007
2016
Based on market value as of 8/5/15


More Cleantech VC Investment into CA than all of Europe and China Combined
$6
$5
$4
$3
$2
$1
$0
$ Billions
$1.03 billion
$1.02 billion
$5.69 billion
Europe (EU-28)
China
California
Source: Next 10 California 2014 Green Innovation Index

# A suite of solutions are necessary

**Storage** – increase the effective participation by energy storage resources.

**Western EIM expansion** – expand the western Energy Imbalance Market.

**Demand response** – enable adjustments in consumer demand, both up and down, when warranted by grid conditions.

**Regional coordination** – offers more diversified set of clean energy resources through a cost effective and reliable regional market.

**Time-of-use rates** – implement time-of-use rates that match consumption with efficient use of clean energy supplies.

**Electric vehicles** – incorporate electric vehicle charging systems that are responsive to changing grid conditions.

**Renewable portfolio diversity** – explore procurement strategies to achieve a more diverse renewable portfolio.

**Flexible resources** – invest in fast-responding resources that can follow sudden increases and decreases in demand.

# Thank you

Renewables100 Policy Institute

## *Questions?*


***Angelina Galiteva***

***+1/310/ 735 3981***

***a.galiteva@renewables100.org***