



ELECTRICITY MARKET OVERVIEW

Silicon Valley Clean Energy Authority, Board Workshop

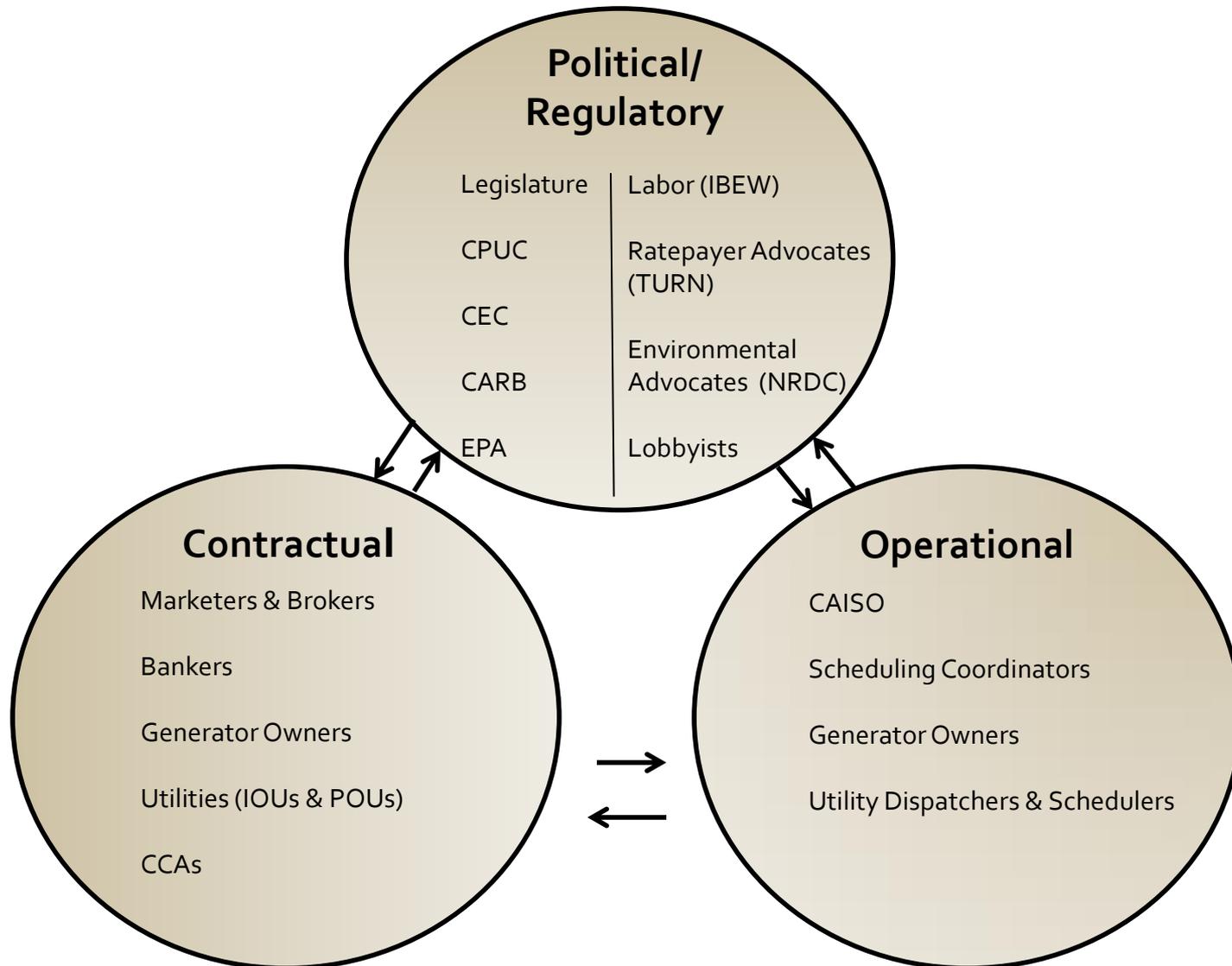
August 27, 2016



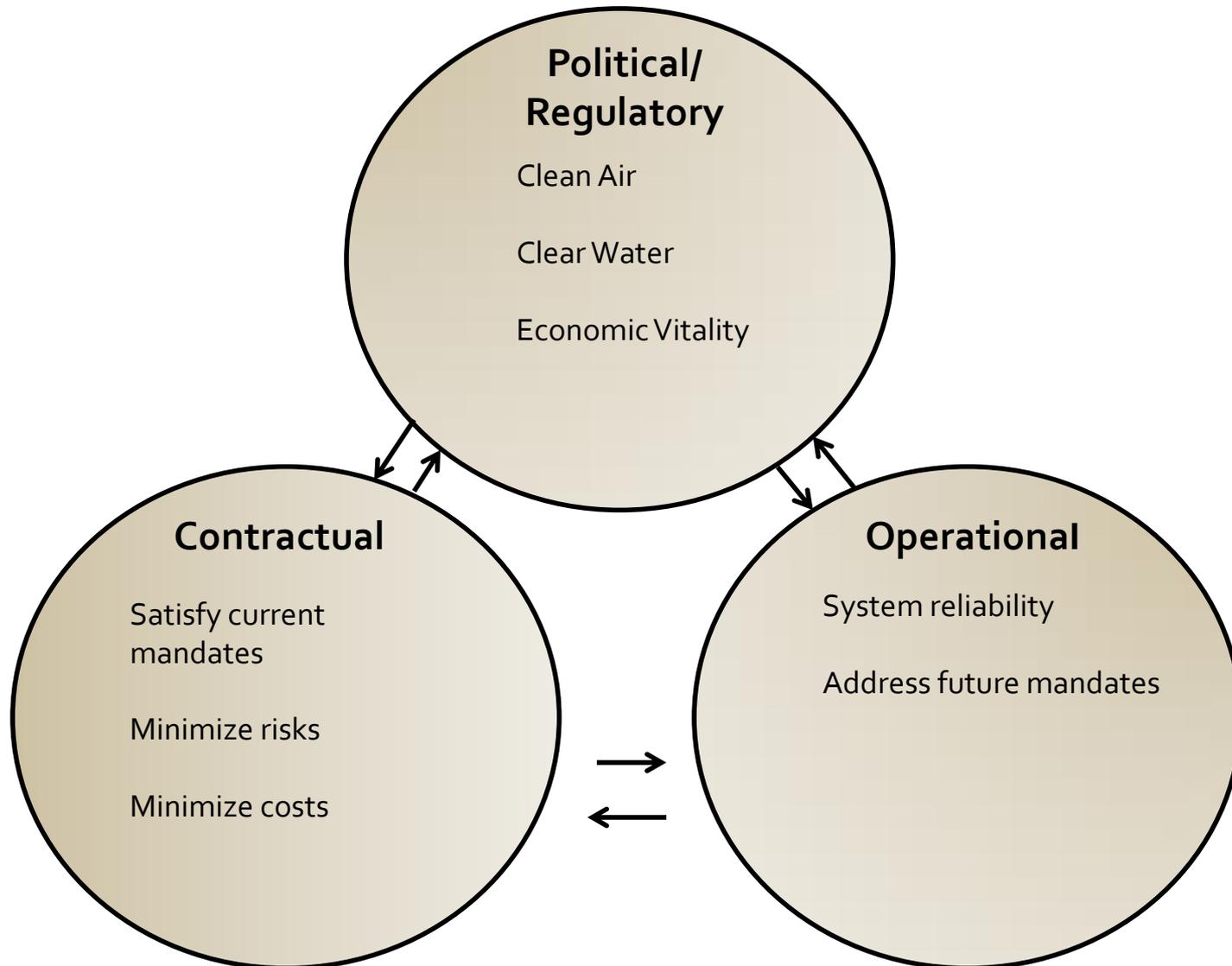
Workshop Overview – Key Topics

- Introduction: The World of Electricity – Participants, Ends and Means
- How The Grid Works: Overview
- Who's In Charge: Generation, HV Transmission and Distribution
- Generation Power Content: State and Local
- Independent System Operator (ISO): Functions and Oversight
- Energy Procurement: Products and Processes
- Clean Energy: Available Technologies and Key Considerations
- What Comes Next?

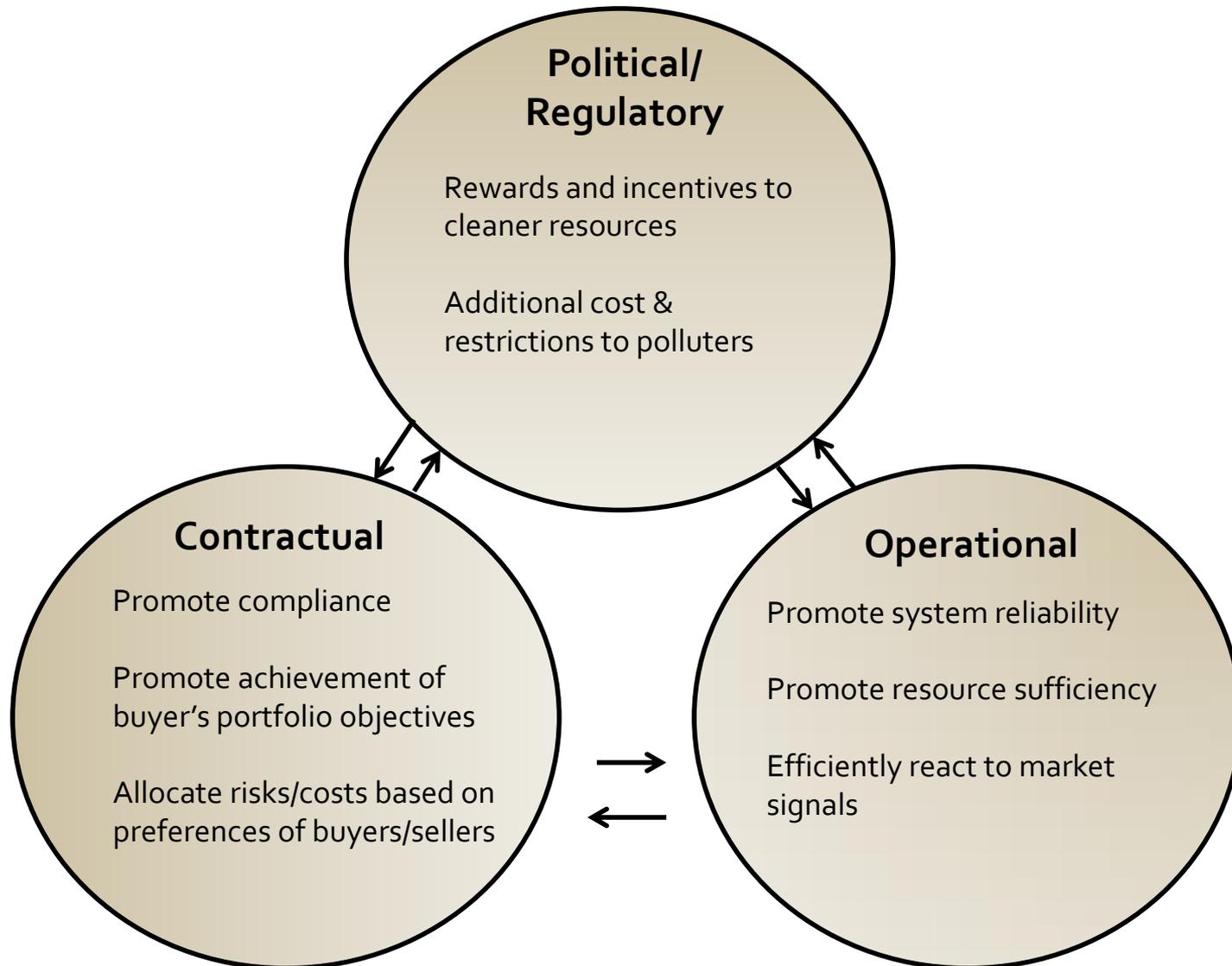
The World Of Electricity: Key Functions



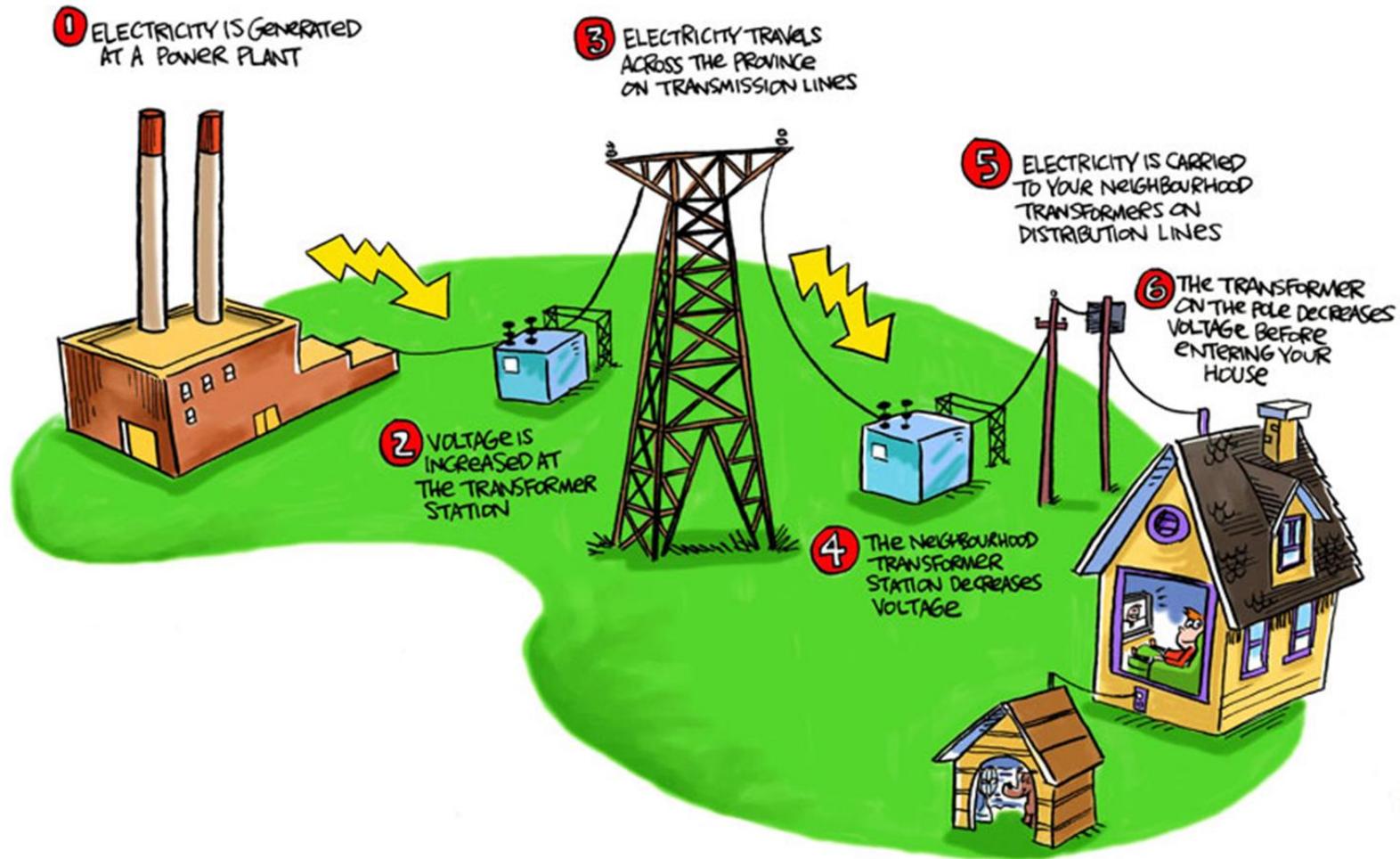
The World Of Electricity: Goals



The World Of Electricity

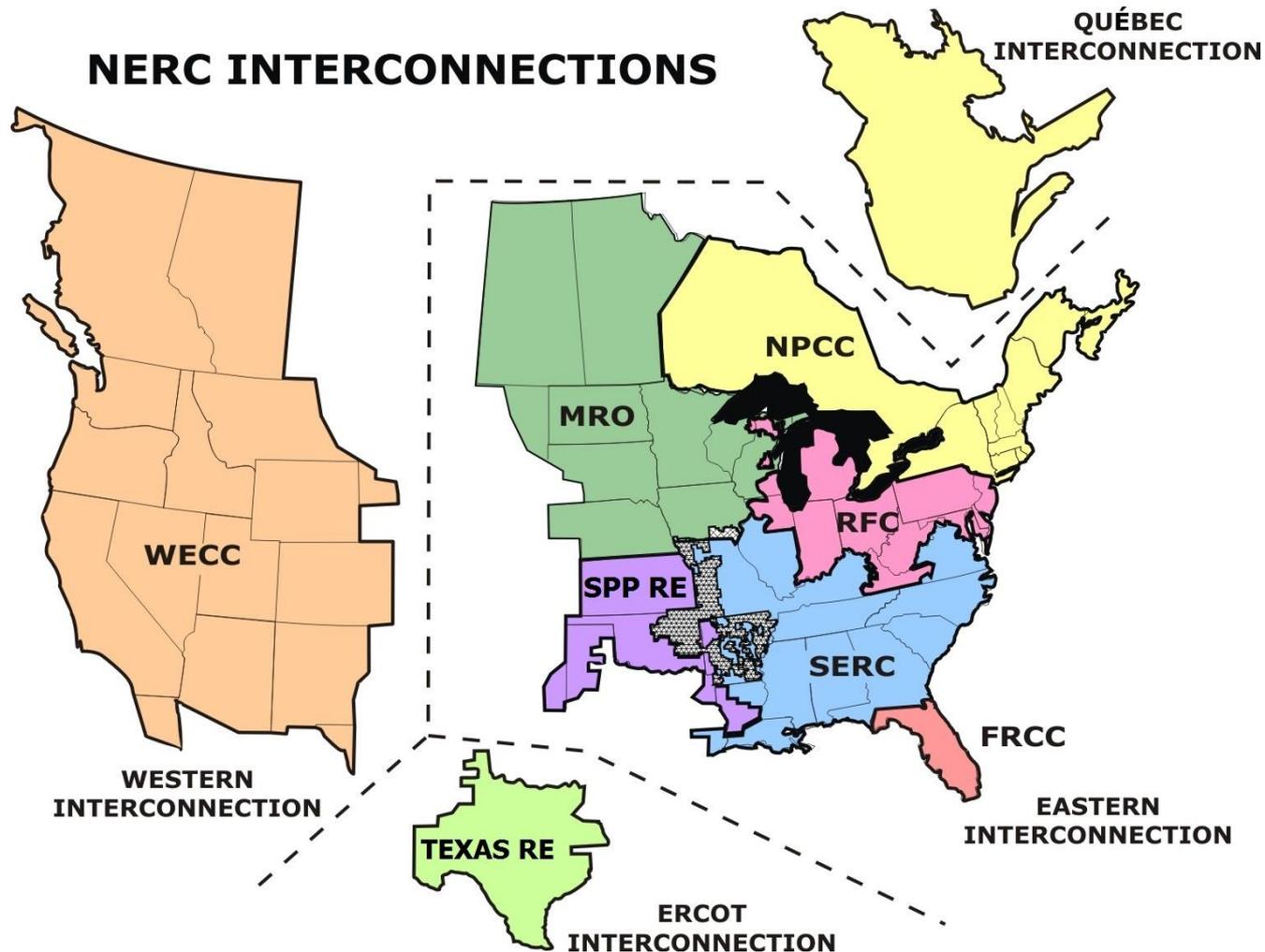


How "The Grid" Works: Utility Infrastructure



How “The Grid” Works: National Oversight

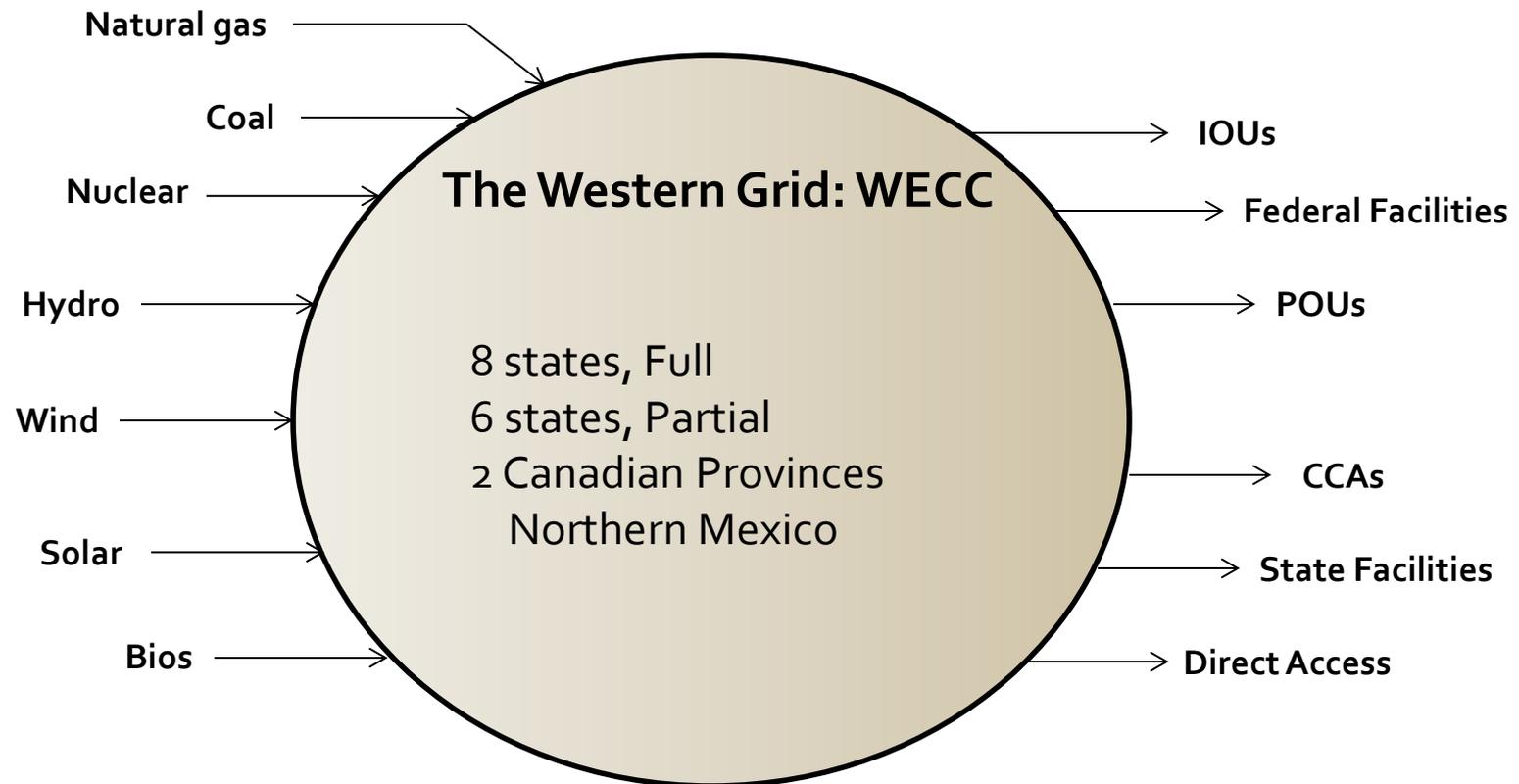
NERC = North American Electric Reliability Corporation



How “The Grid” Works: Sources & Sinks

Sources = Generation/Supply

Sinks = Electric Loads/Energy Users



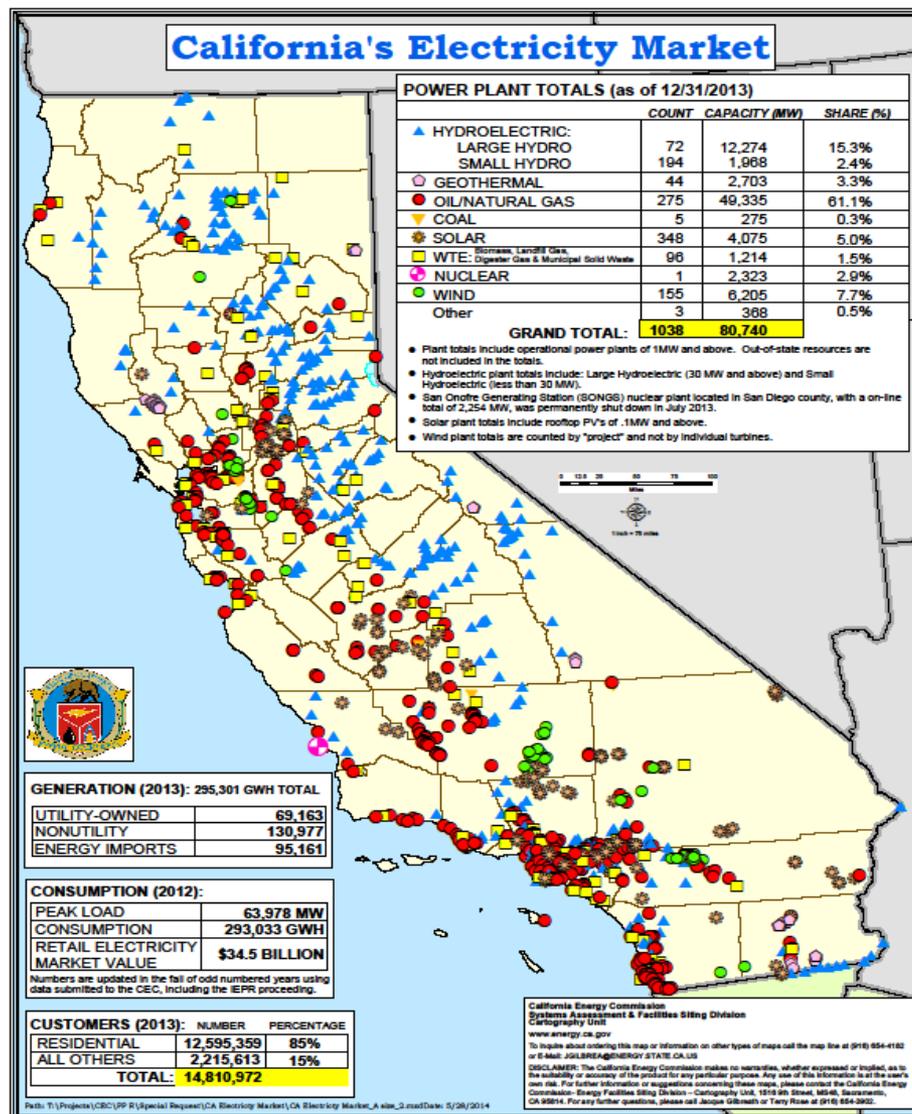
Who Manages the Grid?

- Balancing Authorities are responsible for real-time balancing of supply (generating resources) and demand (load) to ensure grid reliability.
- Eight Balancing Authorities in California, with the largest being the California Independent System Operator (CAISO).
- CAISO imbalance market extends beyond CA – movement toward regionalization.



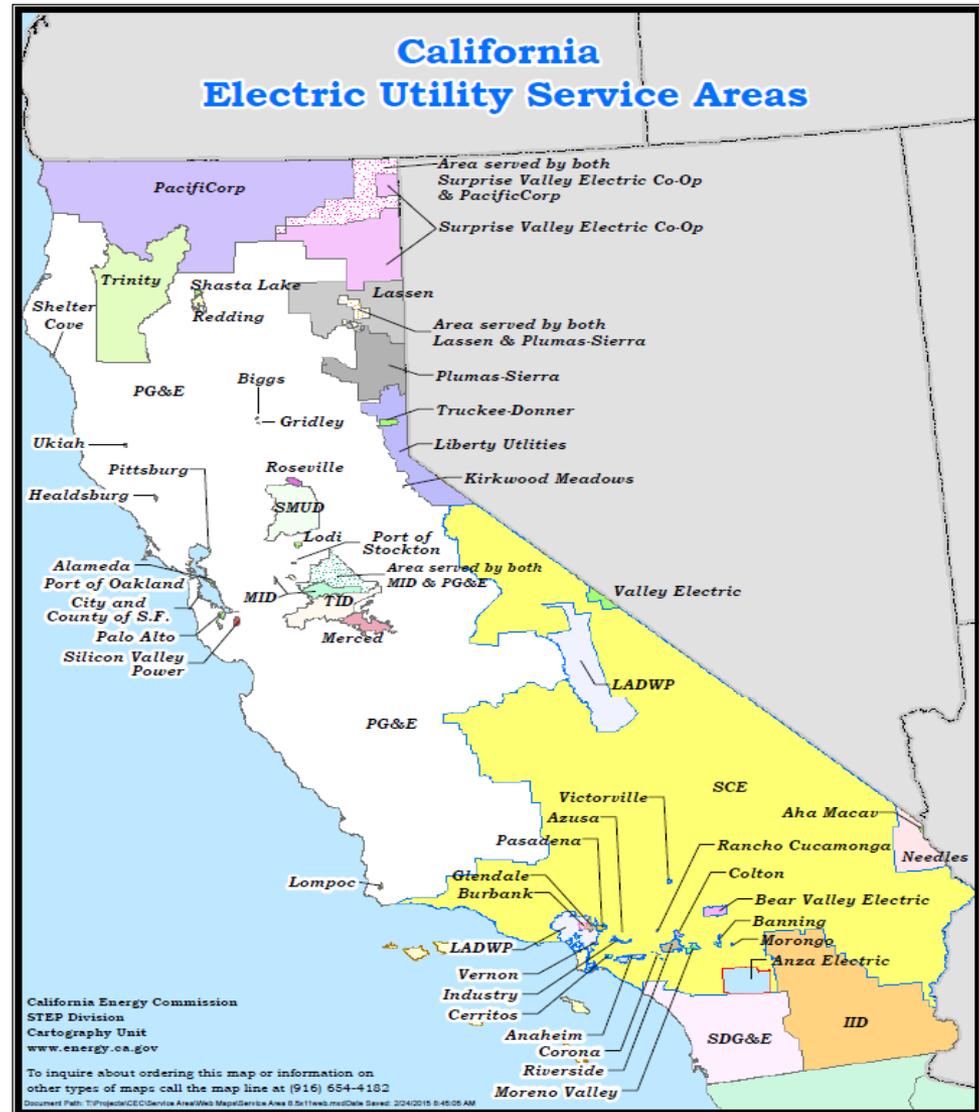
Who Generates Power?

- Over 1,000 electric generating units > 1 MW.
- Over 79,000 MW of generating capacity.
- ≈57% of capacity is natural gas.
- ≈66% of CA's energy is produced in-state.
- ≈ 12% is imported from NW.
- ≈ 21% is imported from SW.
- Approximately 24% of CA's generating capacity uses renewable fuel sources.
- 1,000 MW increase in solar PV capacity from 2014 to 2015.



Who Delivers Power?

- Distribution Utilities connect end-user to the transmission grid via distribution systems.
- 75% of electricity used in CA is delivered by investor owned utilities: PG&E, SCE and SDG&E.
- Public sector utilities deliver remaining 25%.



Power Content Accounting

- Once delivered to the grid, electrons are indistinguishable from one another.
- There is no way to physically track “green” vs. “brown” electrons.
- Accounting for electric power is “attribute based”.
- Power supply contracts specify ownership of product attributes (examples: electric energy volumes and RECs/emissions reductions).
- Owners of product attributes can make claims with regard to renewable energy content and environmental impacts.
- RECs, e-tags and contract documents are typically referenced to substantiate such claims.

California Power Content (2015)

“Contractual”

Fuel Type	California In-State Generation (GWh)	Percent of California In-State Generation	Northwest Imports (GWh)	Southwest Imports (GWh)	California Power Mix (GWh)	Percent California Power Mix
Coal	538	0.30%	0	16,903	17,735	6.00%
Large Hydro	11,569	5.90%	2,235	2,144	15,948	5.40%
Natural Gas	117,490	59.90%	49	12,211	129,750	44.00%
Nuclear	18,525	9.40%	0	8,726	27,251	9.20%
Oil	54	0.00%	0	0	54	0.00%
Other	14	0.00%	0	0	14	0.00%
Renewables	48,005	24.50%	12,321	4,455	64,781	21.90%
Biomass	6,362	3.20%	1,143	42	7,546	2.60%
Geothermal	11,994	6.10%	132	757	12,883	4.40%
Small Hydro	2,423	1.20%	191	2	2,616	0.90%
Solar	15,046	7.70%	0	2,583	17,629	6.00%
Wind	12,180	6.20%	10,855	1,072	24,107	8.20%
Unspecified Sources of Power	N/A	N/A	20,901	18,972	39,873	13.50%
Total	196,195	100.00%	35,800	63,410	295,405	100

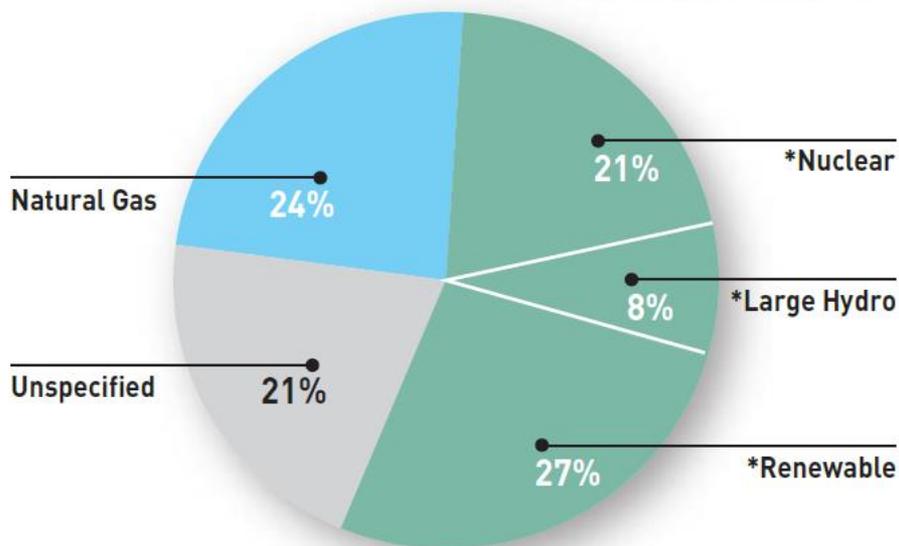
Source: California Energy Commission

PG&E Power Content – 2014

“Contractual”

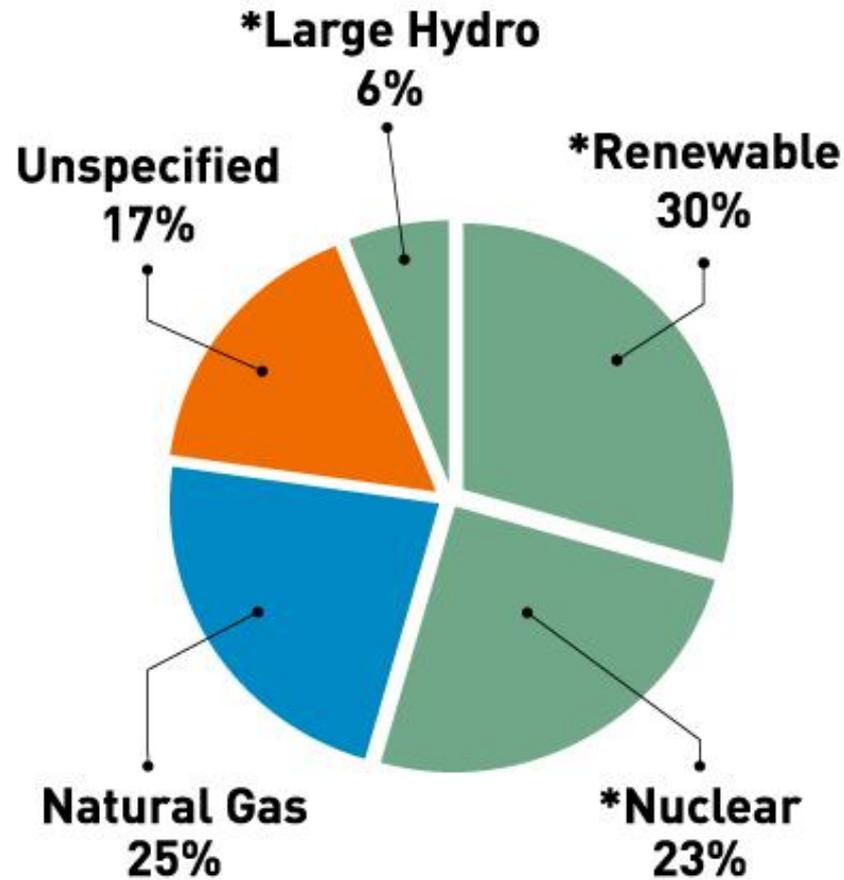
PG&E 2014 POWER MIX

*These resources are greenhouse gas-free and/or renewable



ENERGY RESOURCES	PG&E 2014 POWER MIX (Actual)	2014 CA POWER MIX* (For Comparison)
Eligible Renewable:	27%	20%
• Biomass and waste	5%	3%
• Geothermal	5%	4%
• Small hydroelectric	1%	1%
• Solar	9%	4%
• Wind	7%	8%
Coal	0%	6%
Large Hydroelectric¹	8%	6%
Natural Gas	24%	45%
Nuclear	21%	9%
Other	0%	0%
Unspecified**	21%	15%
TOTAL	100%	100%

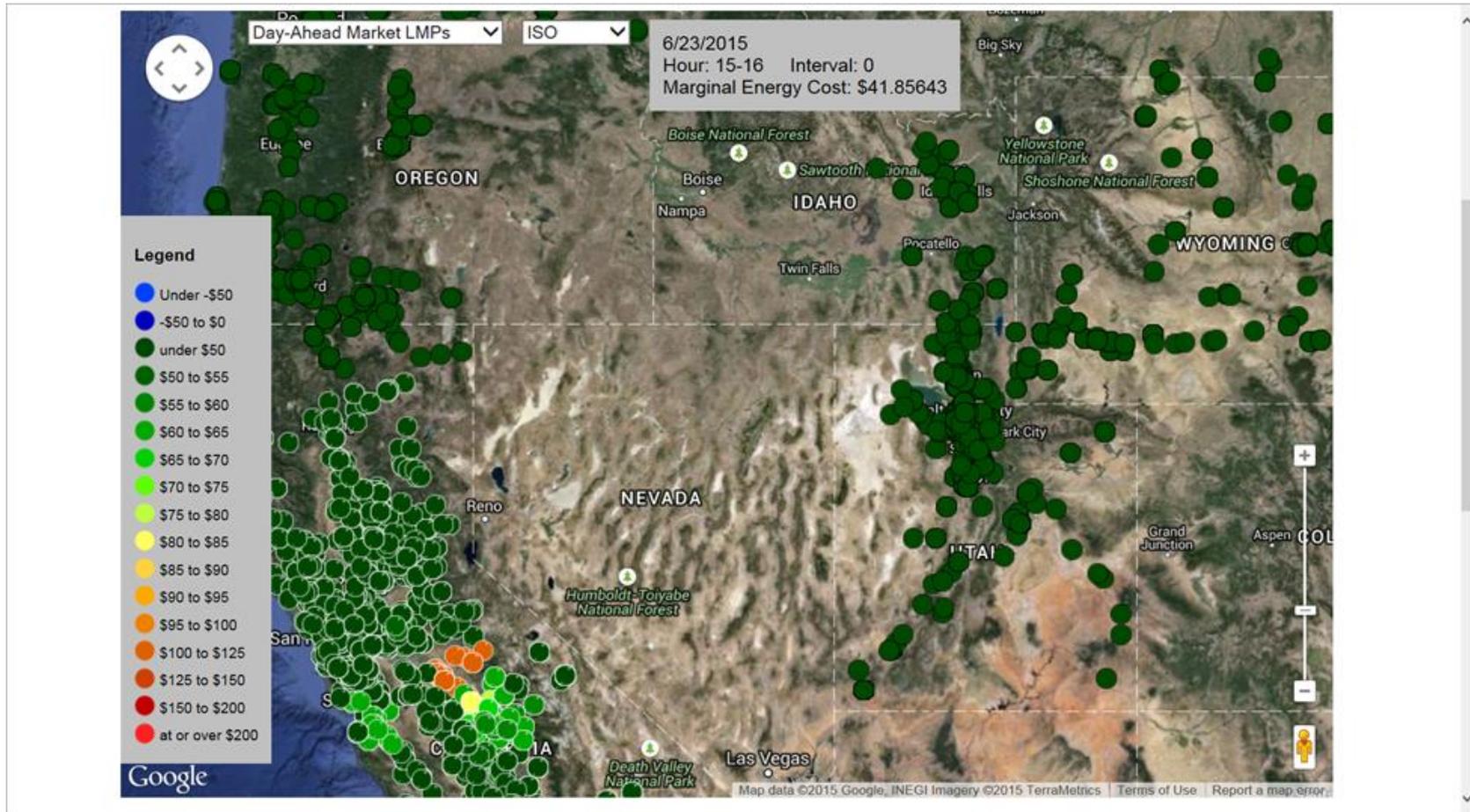
PG&E Power Content - 2015



Source: Pacific Gas & Electric Company

*Carbon-free resources; 58.2% total carbon-free (PG&E's 2015 PSDP annual report)

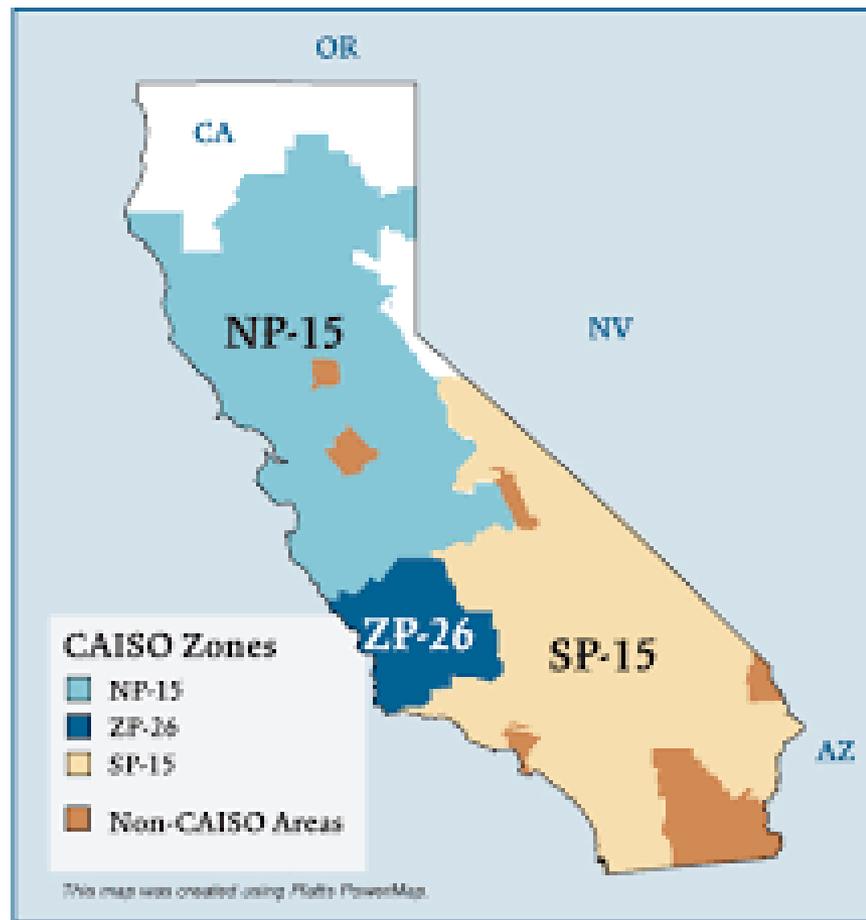
CAISO Electricity Market – Nodal Pricing



Source: California Independent System Operator

CAISO Trading Hubs

- Trading hubs: aggregated pricing nodes corresponding to CAISO transmission zones.
- NP-15 and SP-15 are actively traded delivery points in the wholesale power market.
- Trading hub vs. DLAP.



CAISO Centralized Energy Market

Load = 100 MW
P_Load = \$27.50



\$2,750



\$2,250

Gen1 = 75 MW
P_Gen1 = \$30



\$500



Gen2 = 25 MW
P_Gen2 = \$20

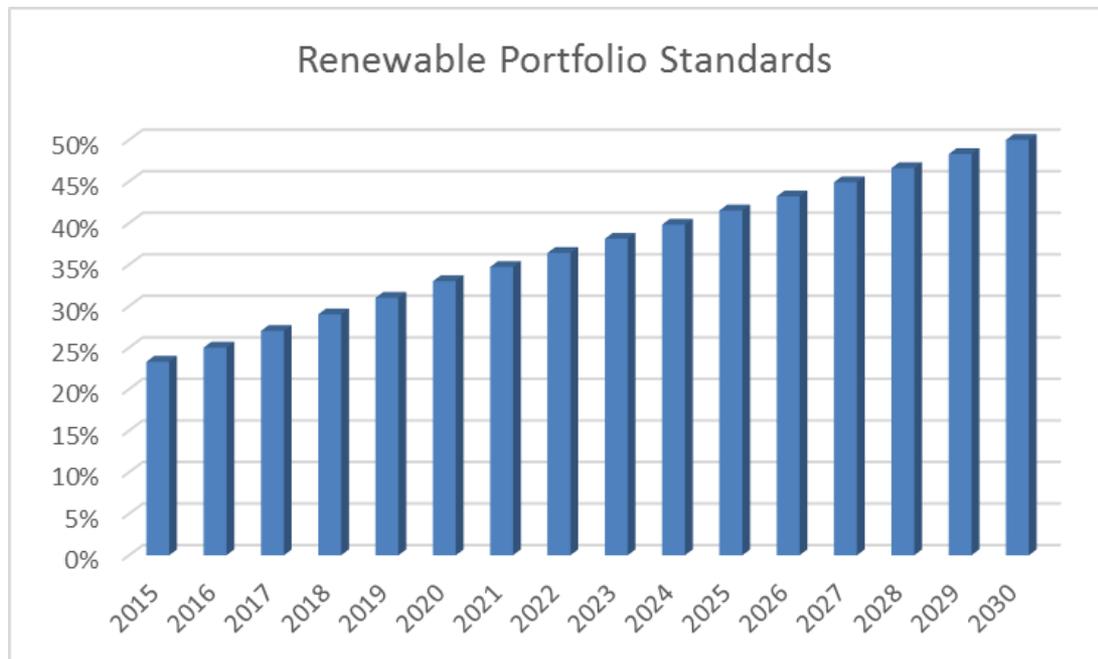
Energy Products & Services for CCAs

- **Electric Energy:** procured through term energy contracts (which mitigate price risk) or market purchases (which may reduce near-term costs but also expose CCAs to market volatility).
- **Renewable Energy:** procured to meet RPS mandates, support voluntary targets and supply specific retail product offerings.
- **Other Specified Energy Products:** GHG-free energy (typically hydro) and non-RPS-eligible renewable energy; generally procured to meet internally defined policy objectives.
- **Resource Adequacy Capacity:** procured to meet reserve capacity requirements.
- **Scheduling Coordinator Services (“SC” services):** SCs schedule forecasted hourly load, report usage, and settle transactions with the CAISO.
- **Contracting Options:** Variety of contracting options are available in regards to term (short-, mid-, long-), pricing structure (fixed or index+), and development status (new or existing).

Acquisition of Electric Power

- Buyers and sellers can transact for future electricity deliveries through bilateral contracts.
- Forward contracts provide price certainty for duration of contract term, reducing exposure to CAISO price volatility.
- Contracts are also used to obtain certain attributes such as renewable energy certificates or carbon claims.
- Without owning product attributes, claims cannot be made with regard to renewable energy content or carbon intensity.
- Forward contracts often specify electricity delivery during defined time periods (i.e., peak, off-peak or around the clock) or based on generator availability, which may be intermittent.

Renewable Energy Procurement



- California's Renewables Portfolio Standard (RPS) specifies renewable energy procurement obligations through 2030 (SB 350, 50%).
- Load Serving Entities, including CCAs, must demonstrate that specified proportions of annual electricity sales were procured from qualifying renewable energy technologies.
- Compliance is demonstrated annually by ownership of renewable energy certificates or "RECs".

Renewable Energy Procurement (Cont'd)

- ALL renewable energy production is substantiated via REC ownership.
- In the western U.S., RECs are tracked through a centralized accounting system, known as WREGIS (Western Renewable Energy Generation Information System), to ensure that renewable energy purchases are not double counted.
- Compliance is measured over multi-year periods with interim progress reported and tracked annually.

Renewable Energy Procurement (Cont'd)

- Various contracting mechanisms/products are permissible under RPS rules, subject to specified minimums/maximums:
 - Bucket 1 – Located in-state or dynamically scheduled into CA (RECs delivered contemporaneously with electric energy)
 - Bucket 2 – Firmmed/shaped imports into CA (REC and energy quantities are balanced annually)
 - Bucket 3 – Unbundled RECs (RECs are sold separately from energy)
- Detailed compliance obligations for 2021-2030 are currently under development (SB 350).

Resource Adequacy Capacity

- LSEs must secure/procure capacity for projected monthly peak loads plus 15% reserve margin.
- Reserve capacity is also referred to as “Resource Adequacy” or “RA” – a separate product from energy.
- Procuring capacity reserves helps ensure that sufficient generation is available to maintain grid reliability.
- Additional requirements apply to RA procurement: geographic and operating flexibility specifications.
- RA capacity is transacted bilaterally (i.e., no organized market).

Specifying Source in Energy Contracts

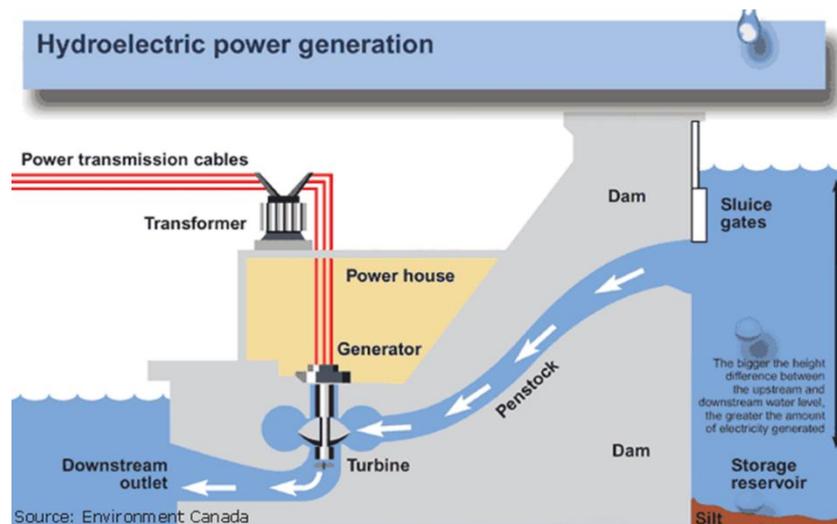
- Specified source purchases are reported on Power Content Label under appropriate fuel category:
 - Renewable energy purchases by generating technology/fuel source
 - Unit specific purchases by fuel source
- Purchases from CAISO market and contract purchases of system power are reported as “Unspecified”.
- Specified source contracts are typically sold at a premium (relative to unspecified) due to reduced supplier flexibility.
- Specified source contracts from out-of-state generators may require additional documentation (e-tags) to demonstrate CA delivery.

Greenhouse Gas Reporting

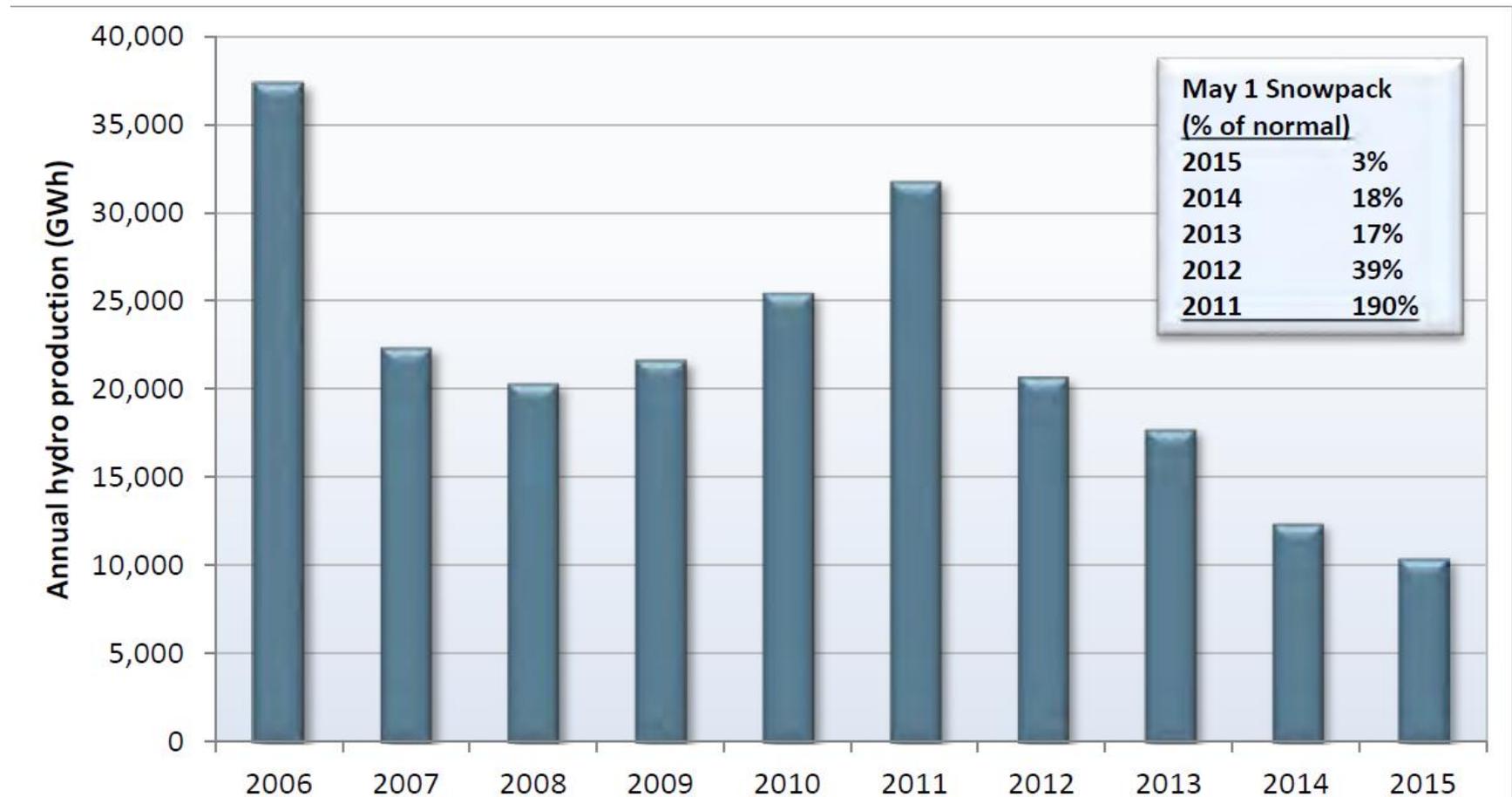
- Many load serving entities voluntarily report GHG portfolio emissions to their retail customers.
- Voluntary standards such as The Climate Registry's protocol are commonly used, but no single methodology is universally adopted or required.
- Renewable energy, hydro-electric energy and nuclear energy are generally considered carbon-free (or nearly carbon free).
- Unbundled RECs are commonly used to reduce reported portfolio GHG emissions, but some entities disregard unbundled RECs in GHG reporting.
- Potential legislative/regulatory changes may clarify treatment of unbundled RECs in GHG emissions reporting (AB 1110, Ting).

Sources of Power Generation – Hydro

- In California, dams smaller than 30 MW are considered RPS-eligible.
- Generators above 30 MW are considered “large hydro” (GHG-free).
- California’s drought has reduced hydropower production and increased natural gas generation:
 - During the first half of 2014 ~ 10% of California’s total electricity generation
 - Average 2004 – 2013 ~ 20%

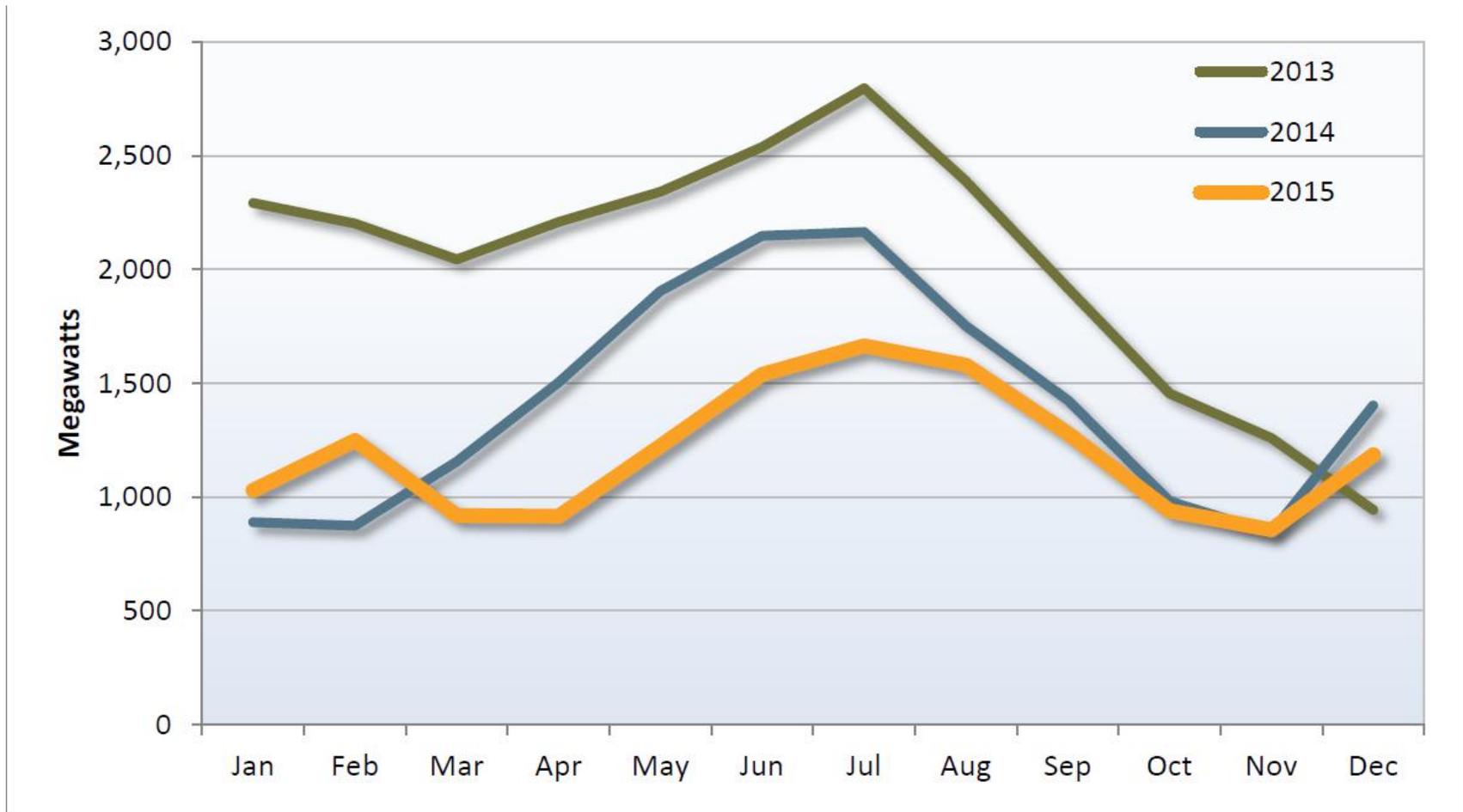


California Hydroelectric Production



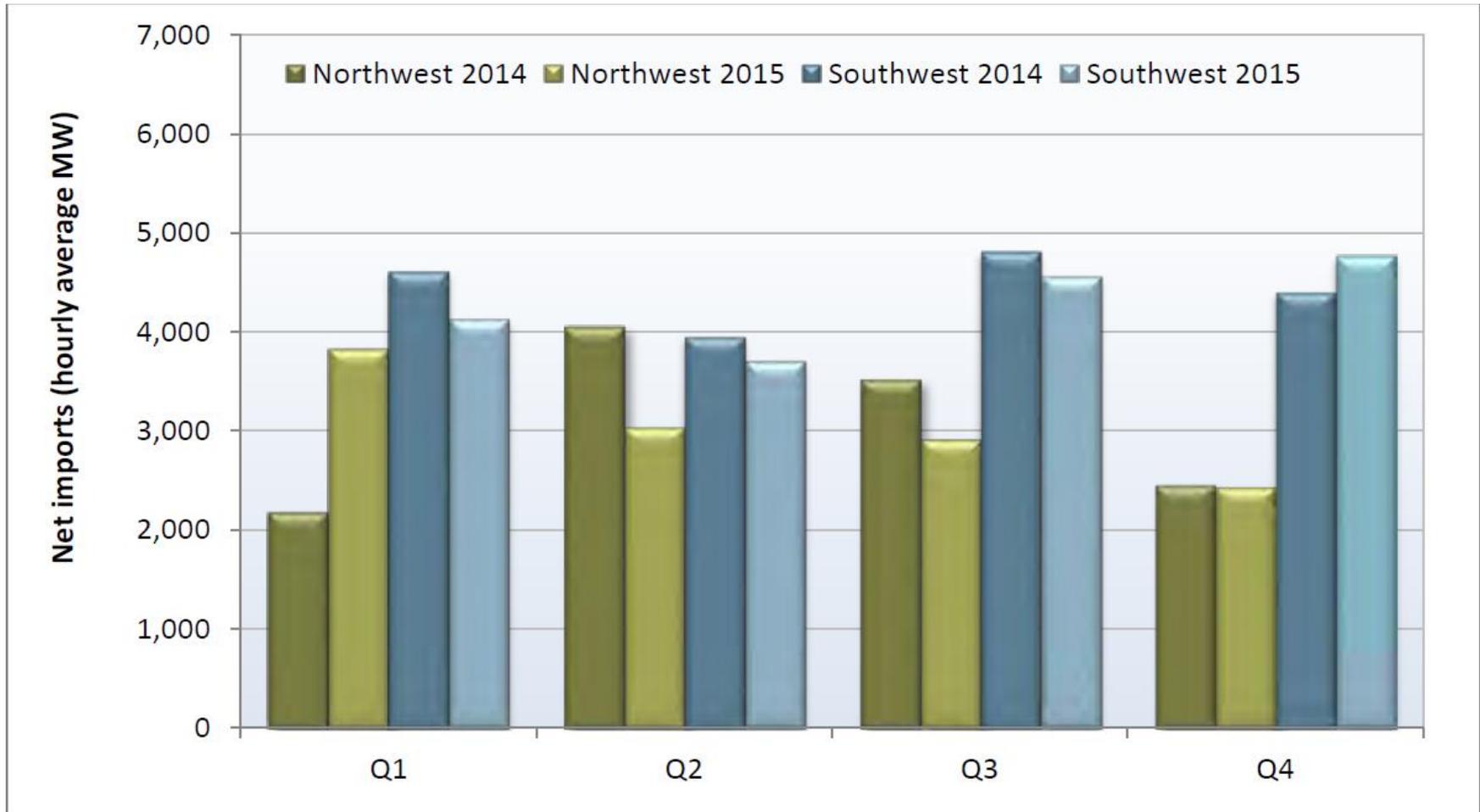
Source: California Independent System Operator

Seasonal Hydroelectric Production



Source: California Independent System Operator

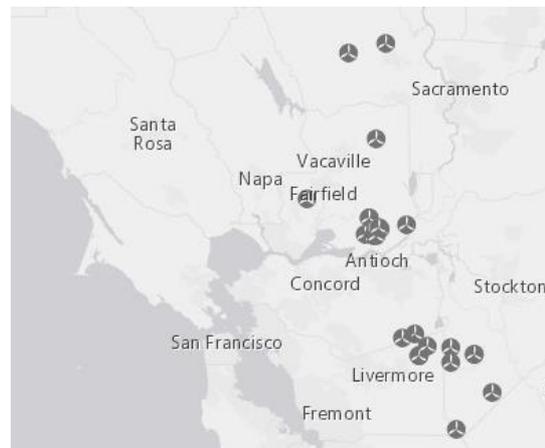
California's Imported Electricity



Source: California Independent System Operator

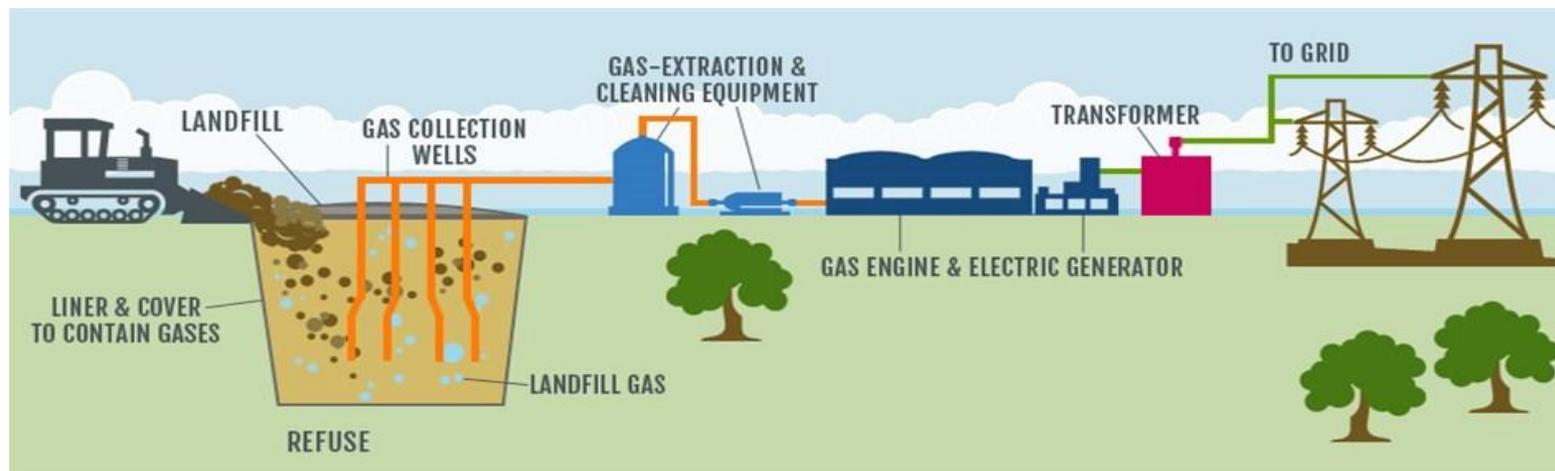
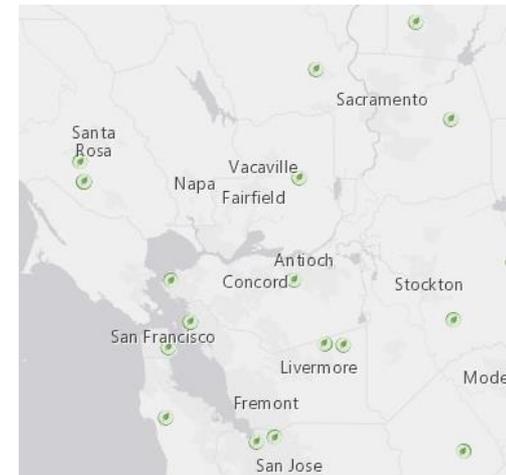
Sources of Power Generation – Wind

- One of the largest renewable resources.
- Relatively inexpensive – sometimes cheaper than gas.
- Power supply is intermittent.
- Aesthetic concerns – turbines on ridgelines.
- Avian fatalities – turbines responsible for 0.01% of human-caused bird fatalities.



Sources of Power Generation – Biogas

- Produced through the anaerobic digestion of biodegradable materials such as manure, sewage, waste and plant material.
- Uses material that is already part of the carbon-cycle.
- Carbon-emitting, but an overall decrease in emissions through complete process.



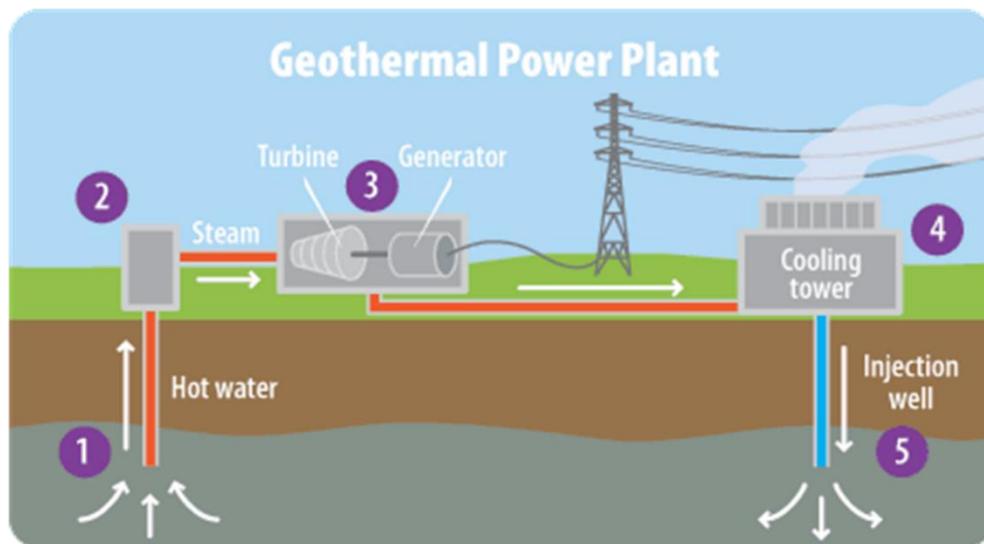
Sources of Power Generation – Solar

- A rapidly growing and “preferred” renewable resource.
- Different technologies available, though photovoltaic is dominant.
- Power supply is intermittent but near-term delivery profile is predictable.
- Potential for wildlife disturbance, agricultural land conversion.

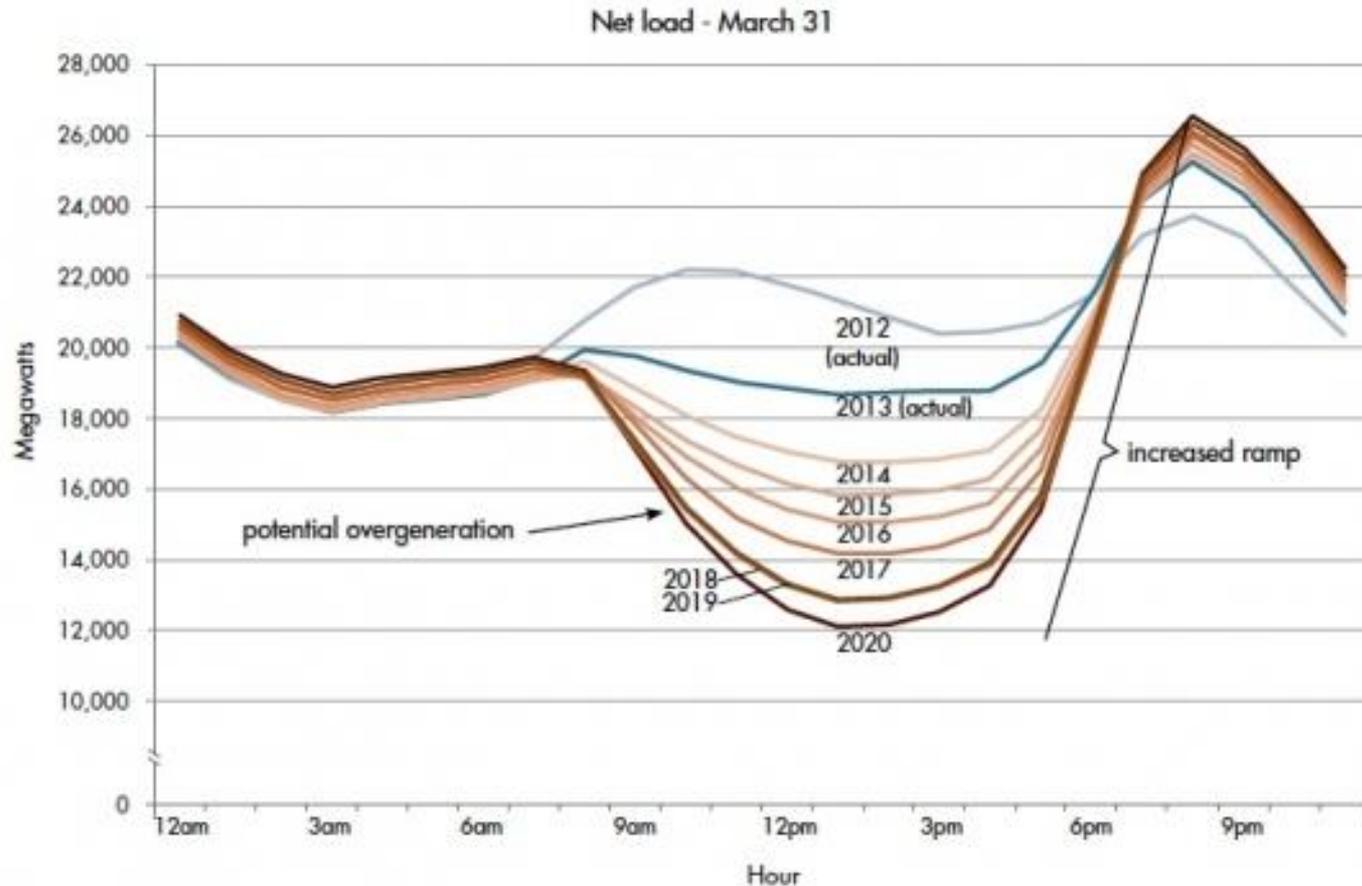


Sources of Power Generation – Geothermal

- Very low-carbon emitting generation process.
- Generates electricity using heat from the earth's core.
- Generating potential is regionally isolated.
- Requires large amounts of water.
- Large facilities create potential for wildlife disturbance.
- Causes minor (only) local earthquakes.



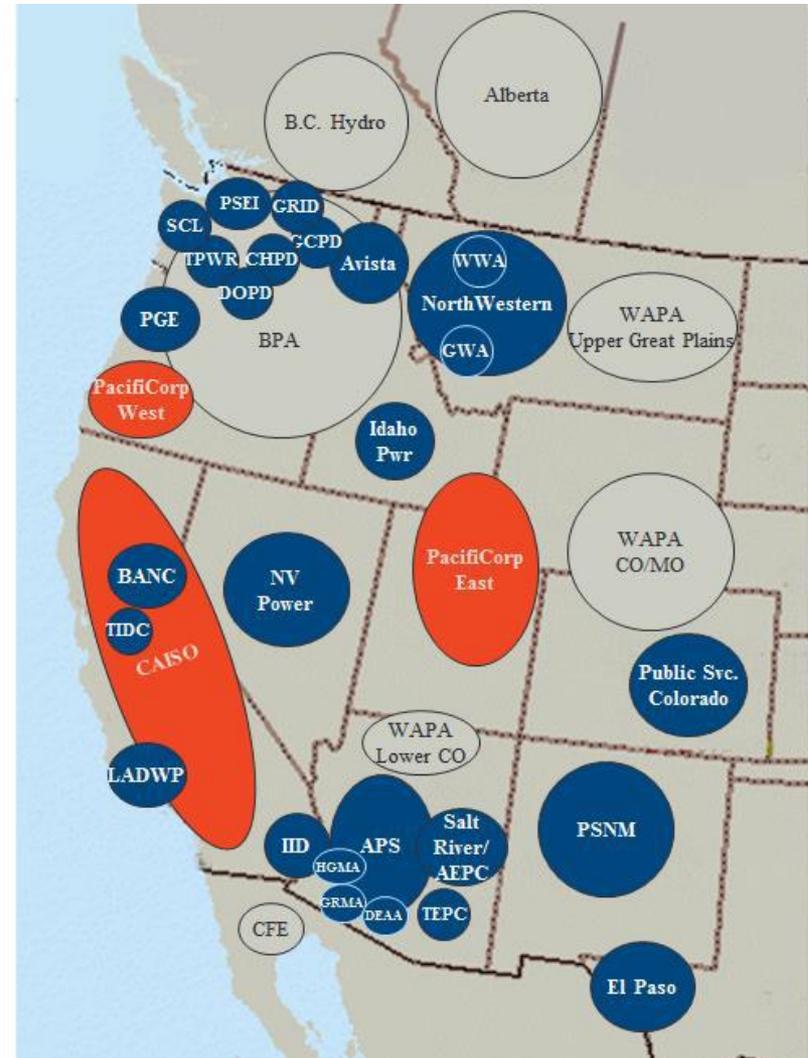
Evolving Grid Patterns



Source: California Independent System Operator

Regionalization

- SB 350: Transform CAISO into regional organization (if determined to be in CA's best interest)
- Recent studies indicate variety of benefits:
 - Reduced costs
 - Renewable integration
 - Reduced emissions



Source: CAISO/Brattle Group

California Regulatory Agencies – Electric

- California Public Utilities Commission (CPUC): Regulates the investor owned utilities (i.e., PG&E, SCE, and SDG&E), but also regulates capacity reserve and RPS compliance of CCA's.
- California Energy Commission (CEC): Primary energy policy and planning agency in California – areas of focus include long-term forecasting, planning for energy emergencies, generator permitting and certification as well as promoting energy efficiency and renewable technologies.
- California Air Resources Board (ARB): Objectives are to maintain healthy air quality and to promote approaches for compliance with air pollution rules and regulations.



California Air Resources Board

- CARB, through its Mandatory Reporting Requirement and cap and trade program, regulates sources of GHG emissions:
 - Electricity Generators within CA
 - Importers of electricity to CA
- Point source emitters (generators or importers) must obtain GHG allowances under the cap and trade program and report emissions to CARB.
- CARB does not regulate load serving entities, and retail portfolio emissions disclosure is outside of CARB's purview.
- Unbundled RECs cannot be used to offset a reporting entity's GHG emissions to CARB.

The Road Ahead

- **Regionalization**

Support renewable resources to all regions and service territories throughout the Western Interconnect

- **Local Renewables**

Use set aside funds to expand local renewable and energy storage facilities

- **Electrification and Fuel Switching**

Support actions that will shift demand from Fossil Fuels to renewable resources

- **Energy Efficiency**

Prepare to absorb funding and consolidate energy efficiency programs implementation