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

**Political/Regulatory**
- Legislature
- CPUC
- CEC
- CARB
- EPA

**Environmental Advocates** (NRDC)

**Labor** (IBEW)

**Ratepayer Advocates** (TURN)

**Lobbyists**

**Contractual**
- Marketers & Brokers
- Bankers
- Generator Owners
- Utilities (IOUs & POUs)
- CCAs

**Operational**
- CAISO
- Scheduling Coordinators
- Generator Owners
- Utility Dispatchers & Schedulers
The World Of Electricity: Goals

Political/Regulatory
- Clean Air
- Clear Water
- Economic Vitality

Contractual
- Satisfy current mandates
- Minimize risks
- Minimize costs

Operational
- System reliability
- Address future mandates
The World Of Electricity

Political/Regulatory
- Rewards and incentives to cleaner resources
- Additional cost & restrictions to polluters

Contractual
- Promote compliance
- Promote achievement of buyer’s portfolio objectives
- Allocate risks/costs based on preferences of buyers/sellers

Operational
- Promote system reliability
- Promote resource sufficiency
- Efficiently react to market signals
How “The Grid” Works: Utility Infrastructure

1. Electricity is generated at a power plant.
2. Voltage is increased at the transformer station.
3. Electricity travels across the province on transmission lines.
4. The neighborhood transformer station decreases voltage.
5. Electricity is carried to your neighborhood transformers on distribution lines.
6. The transformer on the pole decreases voltage before entering your house.

NERC = North American Electric Reliability Corporation
How “The Grid” Works: Sources & Sinks

Sources = Generation/Supply
Sinks = Electric Loads/Energy Users

The Western Grid: WECC

- 8 states, Full
- 6 states, Partial
- 2 Canadian Provinces
- Northern Mexico

- Natural gas
- Coal
- Nuclear
- Hydro
- Wind
- Solar
- Bios
- IOUs
- Federal Facilities
- POUs
- CCAs
- State Facilities
- Direct Access
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”

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>California In-State Generation (GWh)</th>
<th>Percent of California In-State Generation</th>
<th>Northwest Imports (GWh)</th>
<th>Southwest Imports (GWh)</th>
<th>California Power Mix (GWh)</th>
<th>Percent California Power Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>538</td>
<td>0.30%</td>
<td>0</td>
<td>16,903</td>
<td>17,735</td>
<td>6.00%</td>
</tr>
<tr>
<td>Large Hydro</td>
<td>11,569</td>
<td>5.90%</td>
<td>2.235</td>
<td>2,144</td>
<td>15,948</td>
<td>5.40%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>117,490</td>
<td>59.90%</td>
<td>49</td>
<td>12,211</td>
<td>129,750</td>
<td>44.00%</td>
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<tr>
<td>Nuclear</td>
<td>18,525</td>
<td>9.40%</td>
<td>0</td>
<td>8,726</td>
<td>27,251</td>
<td>9.20%</td>
</tr>
<tr>
<td>Oil</td>
<td>54</td>
<td>0.00%</td>
<td>0</td>
<td>0</td>
<td>54</td>
<td>0.00%</td>
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<tr>
<td>Other</td>
<td>14</td>
<td>0.00%</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>0.00%</td>
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<tr>
<td>Renewables</td>
<td>48,005</td>
<td>24.50%</td>
<td>12,321</td>
<td>4,455</td>
<td>64,781</td>
<td>21.90%</td>
</tr>
<tr>
<td>Biomass</td>
<td>6,362</td>
<td>3.20%</td>
<td>1,143</td>
<td>42</td>
<td>7,546</td>
<td>2.60%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>11,994</td>
<td>6.10%</td>
<td>132</td>
<td>757</td>
<td>12,883</td>
<td>4.40%</td>
</tr>
<tr>
<td>Small Hydro</td>
<td>2,423</td>
<td>1.20%</td>
<td>191</td>
<td>2</td>
<td>2,616</td>
<td>0.90%</td>
</tr>
<tr>
<td>Solar</td>
<td>15,046</td>
<td>7.70%</td>
<td>0</td>
<td>2,583</td>
<td>17,629</td>
<td>6.00%</td>
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<tr>
<td>Wind</td>
<td>12,180</td>
<td>6.20%</td>
<td>10,855</td>
<td>1,072</td>
<td>24,107</td>
<td>8.20%</td>
</tr>
<tr>
<td>Unspecified Sources of Power</td>
<td>N/A</td>
<td>N/A</td>
<td>20,901</td>
<td>18,972</td>
<td>39,873</td>
<td>13.50%</td>
</tr>
<tr>
<td>Total</td>
<td>196,195</td>
<td>100.00%</td>
<td>35,800</td>
<td>63,410</td>
<td>295,405</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: California Energy Commission
PG&E Power Content – 2014
“Contractual”

PG&E 2014 POWER MIX

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

- Natural Gas: 24%
- Nuclear: 21%
- Large Hydro: 8%
- Renewable: 27%
- Unspecified: 21%

ENERGY RESOURCES

<table>
<thead>
<tr>
<th></th>
<th>PG&amp;E 2014 POWER MIX (Actual)</th>
<th>2014 CA POWER MIX* (For Comparison)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible Renewable:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Biomass and waste</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>- Geothermal</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>- Small hydroelectric</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>- Solar</td>
<td>9%</td>
<td>4%</td>
</tr>
<tr>
<td>- Wind</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>Coal</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Large Hydroelectric</td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>24%</td>
<td>45%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>21%</td>
<td>9%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Unspecified**</td>
<td>21%</td>
<td>15%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Pacific Gas & Electric Company
PG&E Power Content - 2015

*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.
Load = 100 MW
P_Load = $27.50

Gen1 = 75 MW
P_Gen1 = $30

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** – Firmed/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