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Renewable Energy Transmission Initiative v2.0

Plenary Group Report

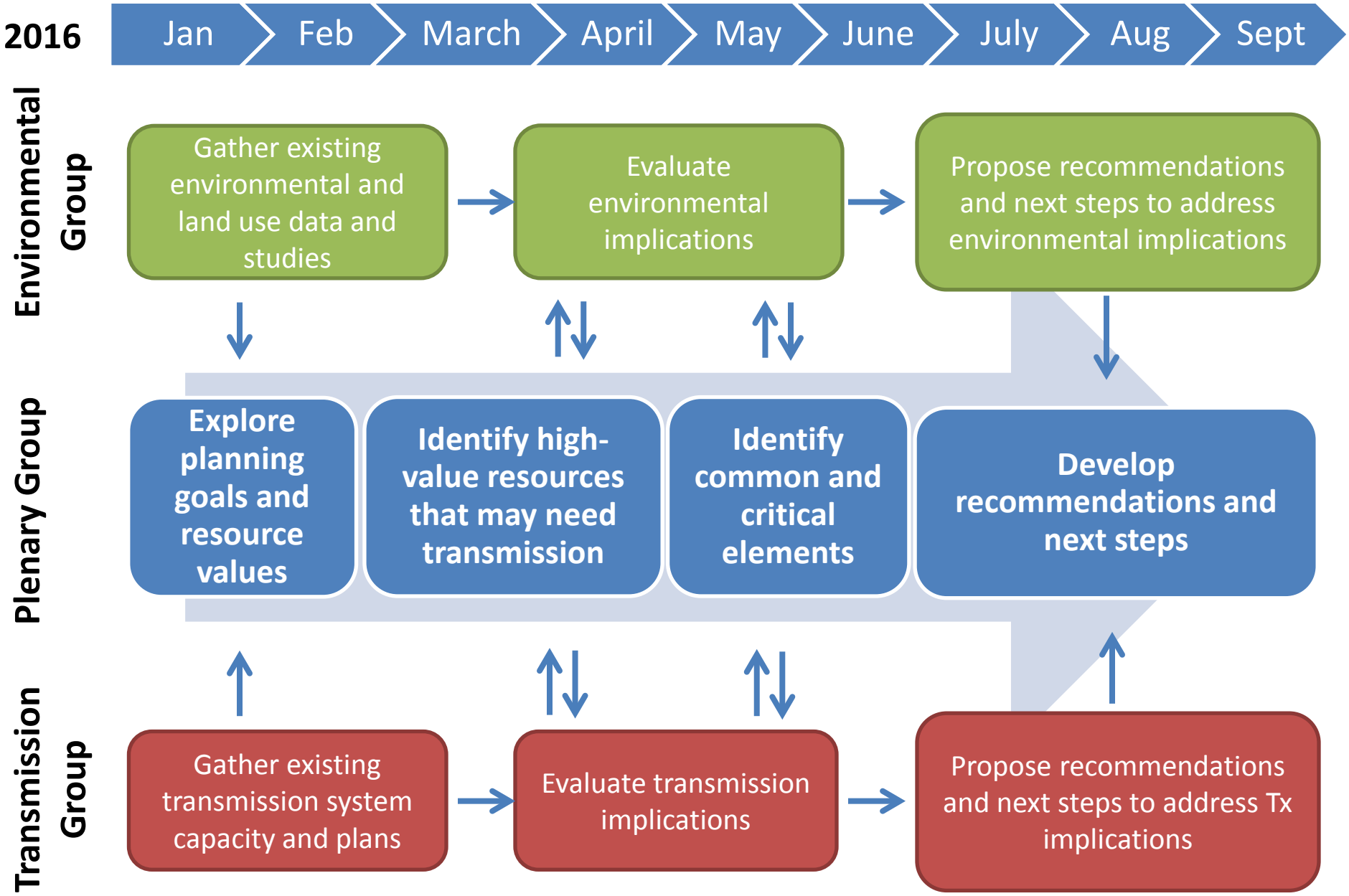
Resource Values Summary

Brian Turner
RETI 2.0 Plenary Group

Joint Agency Workshop
2 May, 2016

Background and context

RETI 2.0 Process and Timeline



Context and caveats

- RETI 2.0 is examining large-scale renewable resource potential for transmission implications
  - At least roughly 500 MW in an area
- Not examining:
  - Distributed energy resources (DER); community-scale renewables; rooftop PV
  - Most biomass, new hydro, solar thermal, and grid storage
  - Offshore wind and other emerging technologies

Process

RETI 2.0 Plenary Group Meeting on Renewable Resource Areas

March 16, 2016

1. What renewable energy zones in California and across the West may be of most interest to California utilities and developers by the 2030 timeframe?
2. Costs: What is the latest data regarding the costs of various renewable technologies in different resources zones?
3. Values: What is the latest data or analysis regarding the value(s) that various renewable technologies in different resources zones can provide to the utility or markets?
4. Utility interest: How do utility resource planners plan to supply electricity in 2030 that is at least 50% renewable, at least 40% lower in GHG? What types of renewable resources do they expect will be needed by their company to meet their mandates?
5. Commercial interest: Where do commercial renewable interests see the greatest opportunity for responsible development? Where are they most interested in offering projects?

RETI 2.0 Plenary Group Meeting on Long-Term Renewable Scenarios

April 18, 2016

1. What conclusions can be drawn from long-term renewable resource portfolios about the kinds of resources that may be important for California utilities to procure by 2030?
2. What lessons about the role of transmission can we learn from the studies?
3. Based on these studies and prior information, where should RETI 2.0 focus in examining transmission options and implications?
4. Is the proposed Transmission Assessment Focus Area approach appropriate for guiding the next phase of the RETI 2.0 project?

Contributors

- State and local government agencies
  - California Energy Commission
  - Public Utilities Commission
  - Department of Water Resources – State Water Project
  - County of Imperial
- Regional agencies
  - National Renewable Energy Laboratory
  - Western Electricity Coordinating Council
  - Western Interstate Energy Board
- Utilities
  - Pacific Gas and Electric
  - Southern California Edison
  - San Diego Gas and Electric
  - Sacramento Municipal Utility District
  - Los Angeles Department of Water and Power
  - Imperial Irrigation District
  - Modesto Irrigation District
  - Bay Area Municipal Transmission Group
- Project developers and associations
  - Large-Scale Solar Association
  - California Wind Energy Association
  - Geothermal Energy Association
  - Center for Energy Efficiency and Renewable Technologies
  - Sunpower
  - First Solar
  - 8minutenergy
  - EnergySource
  - Ormat Technologies
  - Westlands Solar Park
  - Power Company of Wyoming
  - Transwest Express
  - Pathfinder Wind
  - Southwest Power Group
- Other stakeholders
  - The Nature Conservancy

2030 studies

California Low Carbon Grid Study

Low Carbon Grid Study
Principal Conclusions

I. Climate & Clean Energy Goals are Technically Feasible without significant rate impacts

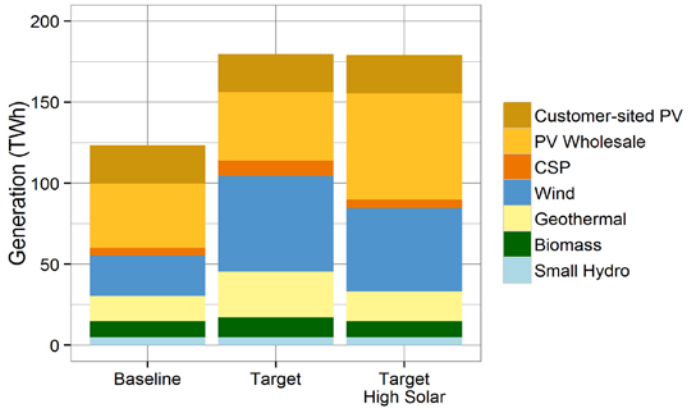
- The California electric sector can reduce 40-50MM Tons/CO2 annually by 2030, a significant contribution to executive order B-30-15, for 40% below 1990 GHG levels. On the trajectory to meet long term goal of 80% reduction.
- Meets or exceeds a 50-60% RPS
- Accommodates a 50% reduction in commercial and industrial energy use in buildings
- Absorbs the increased energy load from a projected 3.3 MM electric vehicles

II. Multiple Paths with Significantly Different Costs

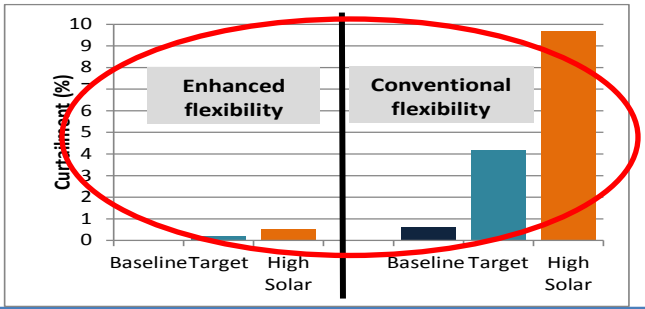
- Conventional Flexibility measures present significant cost barriers to effective GHG reduction
- Enhanced Flexibility measures present low cost means to 2030 GHG reduction target as well as pathway to deeper reductions

III. Critical Components of Enhanced Flexibility

1) Real-time carbon accounting for dispatch, unit commitment as well as procurement and planning
2) Technologically and geographically diverse renewable energy portfolio including: grid-scale PV solar, rooftop solar, regional wind, geothermal, biomass, and concentrating solar power with thermal storage
3) Bulk storage benefits shared across multiple balancing authorities and utilities, including both new projects and an optimized, statewide use of existing non-IOU pumped hydro
4) Essential reliability services provided by non-thermal resources including CSP w/ TES and the entire state hydro fleet
5) Strategic dispatch of natural gas resources, staggered quick starts to prevent idling, ramping
6) Increased flexibility in unbundled REC accounting, enabling optimal sub-hourly dispatch



Case	Net Cost (% of RevReq)	CA Carbon (MMT/yr)	RE Curtailment (%)
Diverse/Enhanced	0.6%	41.1	0.2%
High Solar/Enhanced	2.2%	42.2	0.5%
Diverse/Conventional	2.3%	45.0	4.2%
High Solar/Conventional	4.1%	46.8	9.7%



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CPUC RPS Calculator v6.2

2016 Portfolio Sensitivity Analyses

- March 2016 CPUC Staff Paper studied LTPP scenarios and additional "sensitivities" to 2030
- Not "optimized" portfolios, but do yield insights into potential trade-offs

Portfolio Balance:
Declining capacity value of solar PV + increasing curtailment of solar PV drives selection of complementary resources, especially wind, starting in mid 2020s

Land Use:
More restrictive land use assumptions may increase curtailment by eliminating high quality in-state wind

In-State Wind:
In-state wind connecting as energy-only resources may reduce overall portfolio costs if prioritized for available transmission capacity

Geothermal:
Assuming a significantly lower geothermal costs, including in the Salton Sea area, reduces the amount of PV on the system by 2026

Electric Vehicles:
Battery electric vehicle adoption tends to increase solar PV selection and reduce curtailment

Exports:
Exports can greatly reduce solar PV curtailment

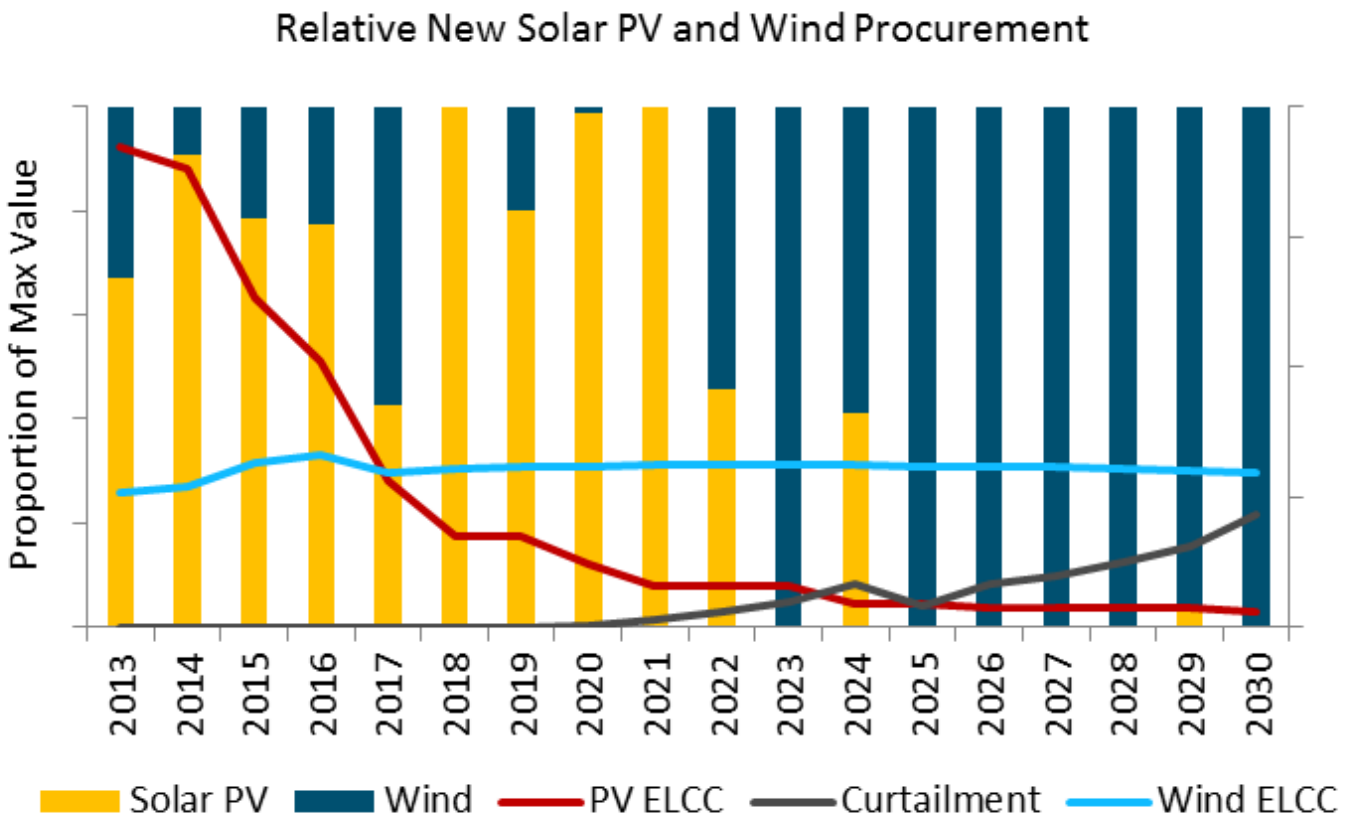
Storage:
Storage can greatly reduce solar PV curtailment, but at a higher cost than exports

Sensitivity	Total Generic Buildout (MW)	Total DNU (MW)	PV Ratio (PV GWh/ RN GWh)	Curtailmt (% RPS energy)	Rev Reqmt ($MM)	Avg Rate (¢/kWh)
Default	5,495	3,260	0.49	7.9%	37,530	30.8
Env Baseline	5,689	4,000	0.50	8.9%	37,686	30.9
DRECP/SJVP	5,580	4,500	0.49	8.2%	37,745	31.0
Energy Only	5,054	0	0.44	5.6%	37,410	30.7
EO & WECC	4,284	0	0.44	5.4%	37,242	30.5
In-State Wind	4,348	1,500	0.47	6.1%	37,469*	30.6*
Geotherm. 2	2,785	7,500	0.40	5.4%	37,303*†	30.7*†
High BEV	6,952	4,260	0.52	5.9%	37,693	28.7
Exports	3,521	1,500	0.48	0.5%	37,402	30.7
Storage	4,151	2,500	0.48	2.6%	38,788	31.8

*costs are not comparable with other portfolios because of forced-in resources
†without assuming lower geothermal capital costs, rev. req. is $37,632 MM, avg. rate is 30.9¢/kWh

2016 Portfolio Sensitivity Conclusions

WECC-wide, energy-only portfolio

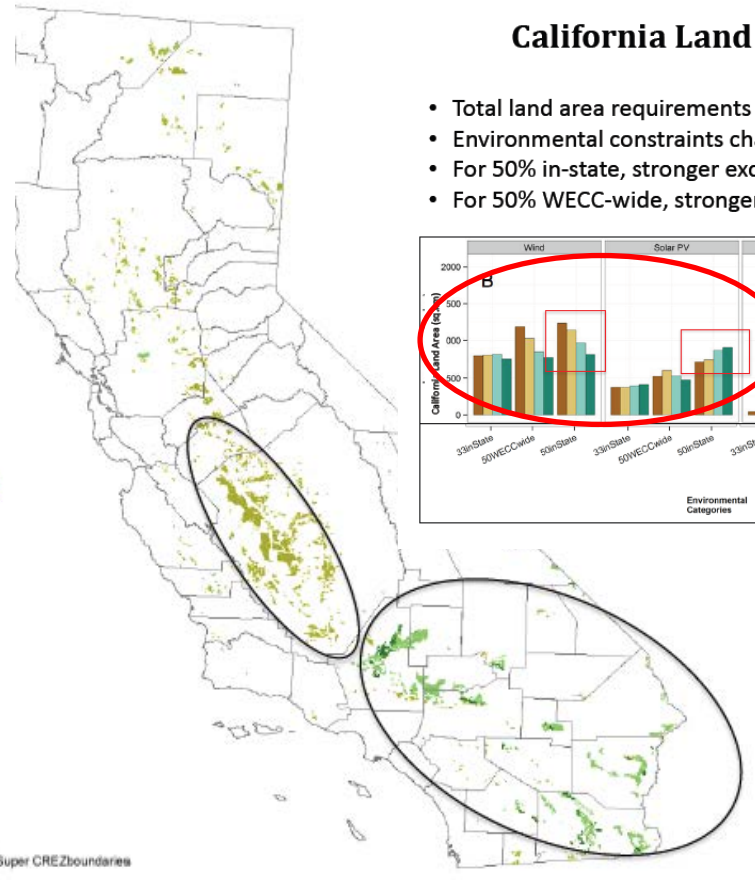


The Nature Conservancy
Renewable Energy Build-Out Model

Integrating Land Conservation and Renewable Energy Goals in California:

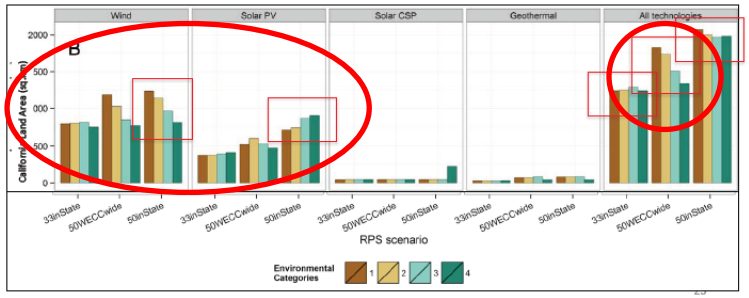
A Study of Costs and Impacts Using the Optimal Renewable Energy Build-Out (ORB) Model

The Nature Conservancy California



California Land Area Requirements

- Total land area requirements increase with level of RPS (%)
- Environmental constraints change generation mix
- For 50% in-state, stronger exclusions reduce wind, increase solar
- For 50% WECC-wide, stronger exclusions reduce CA land area



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Technical Resource Potential

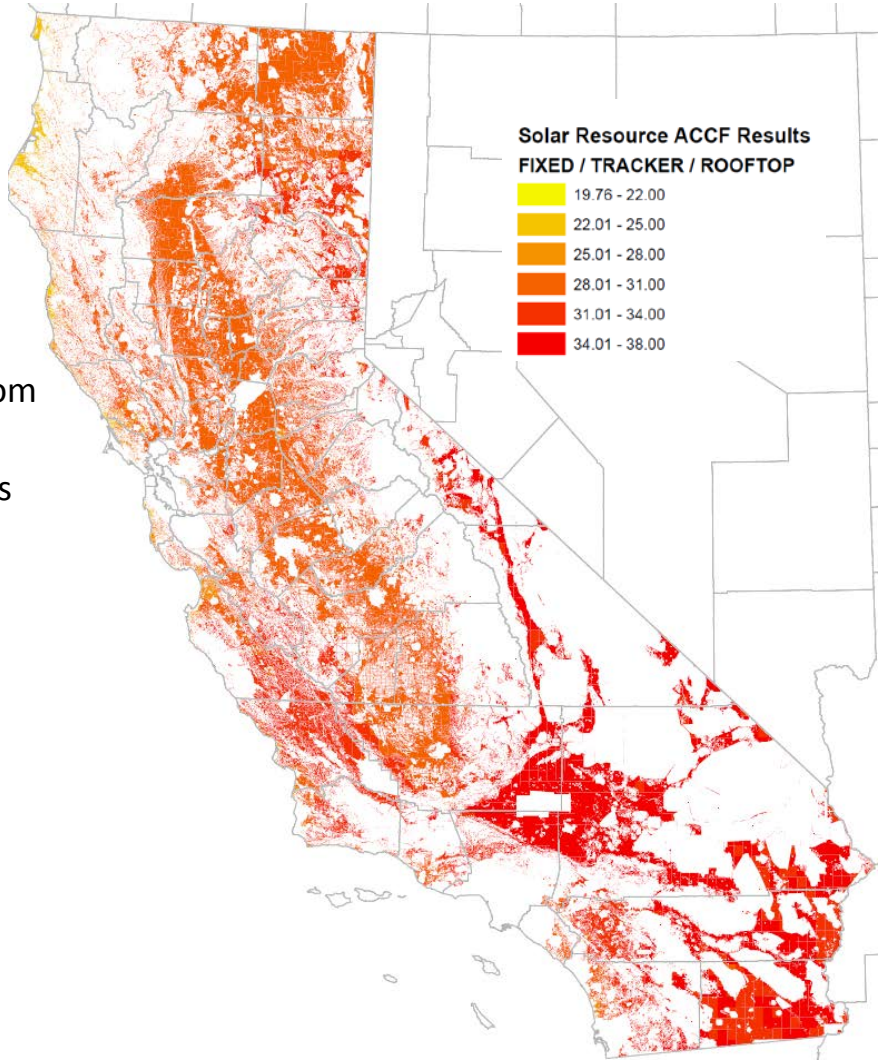
In-state Solar Resources

Solar Photovoltaic

- Widespread and generally good quality throughout California
- Cost reduction of 82% in last six years ; LCOE range from $35/MWh to $57/MWh (*Lazard's 2015)
- The worst current RPS Calculator PV resource now less expensive than the best RETI 1.0
- Substantial improvement in PV capabilities, barriers appear more institutional than technological
  - Voltage / VAR control and/or Power Factor regulation
  - Fault ride-through
  - Real power control, ramping, and curtailment
  - Primary frequency regulation
  - Frequency droop response
  - With storage, potential for black start capability

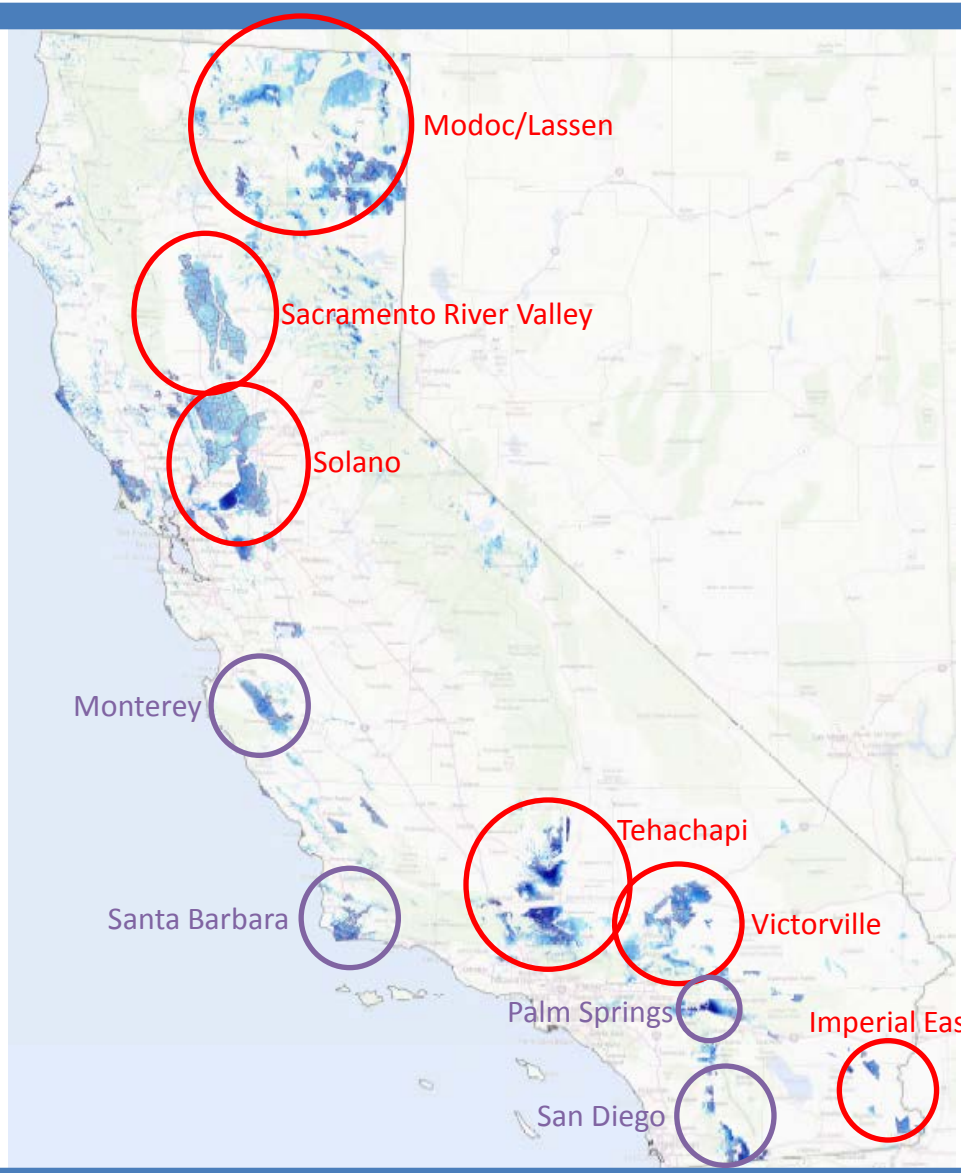
Solar Thermal technologies

- Stakeholders advised not competitive



In-state Wind Resources

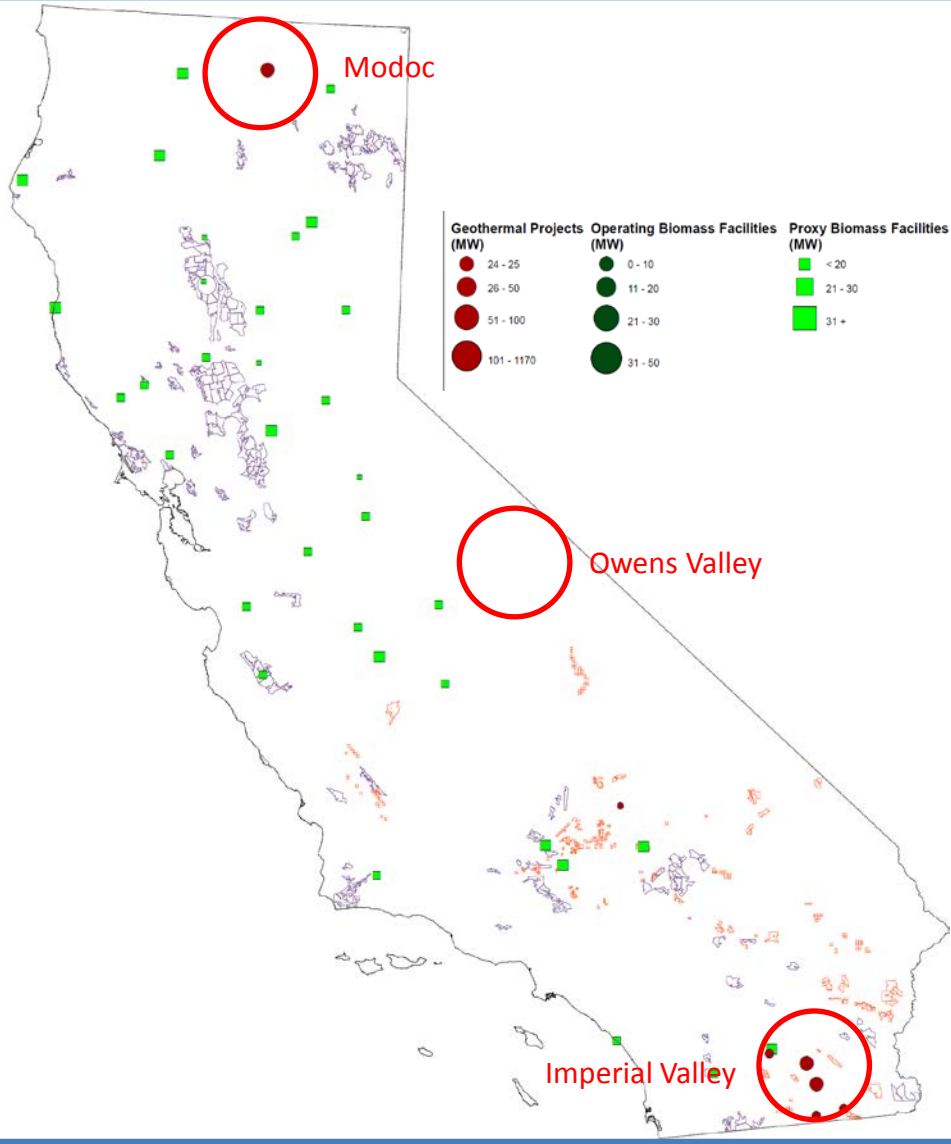
- High technical potential wind resources concentrated in a few areas
- Most highest potential sites already developed
  - Repowering existing sites
- Skepticism about many remaining undeveloped areas



In-State Geothermal and Biomass

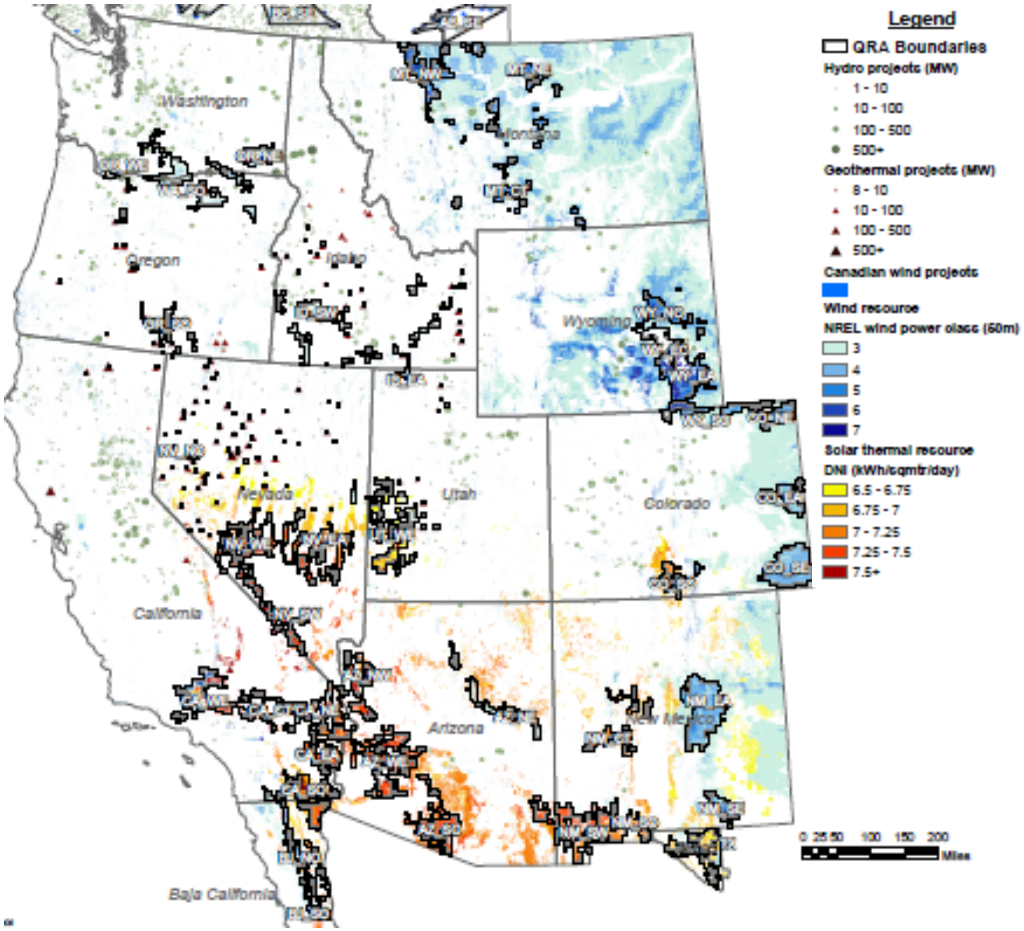
- Geothermal concentrated in very few areas
- Costs are very site-specific, and subject to considerable dispute
- High capacity factor and potential flexibility

- Biomass very dispersed across state
- Current tree mortality planning does not suggest new large facilities



Western renewable energy potential

- Solar
  - Active development in AZ and NV
  - Advance solar land use planning, including BLM
- Wind
  - Best resources for CA in Wyoming, New Mexico
  - Colorado and Montana also good resource, but more remote
- Geothermal
  - Northern Nevada
  - SE Oregon



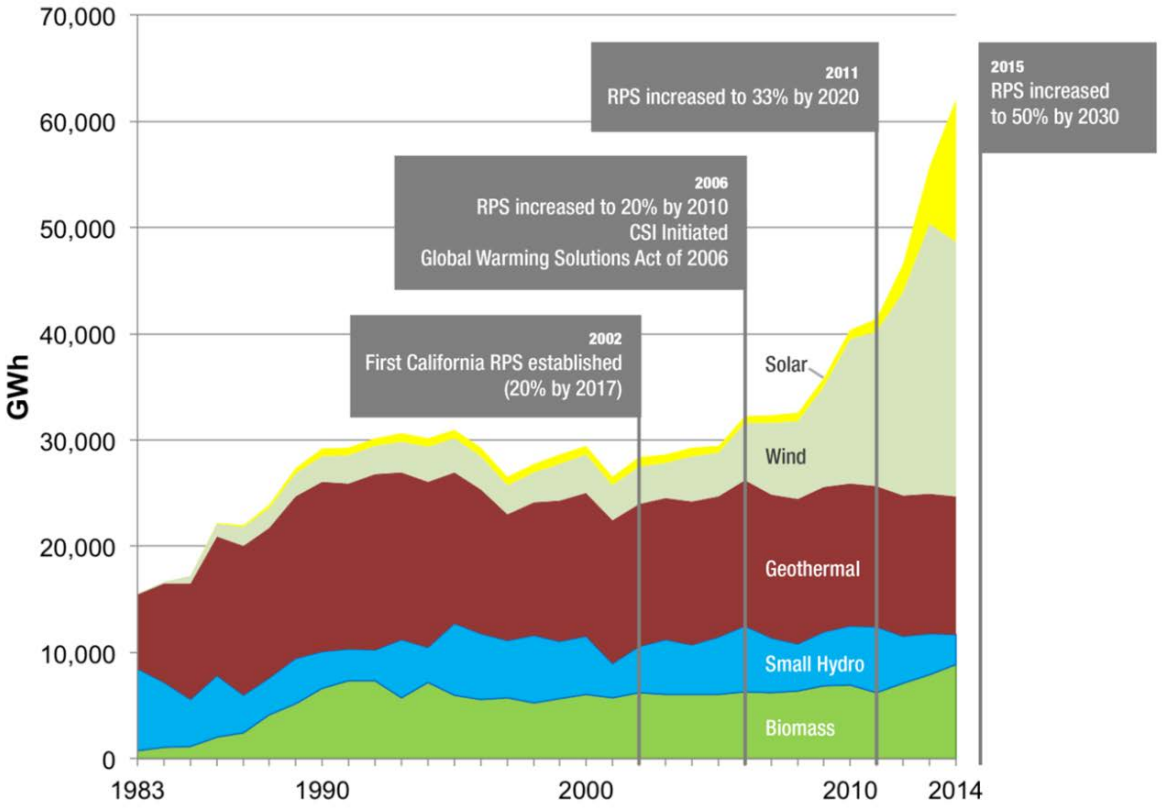
Commercial Interest

Current CA portfolio

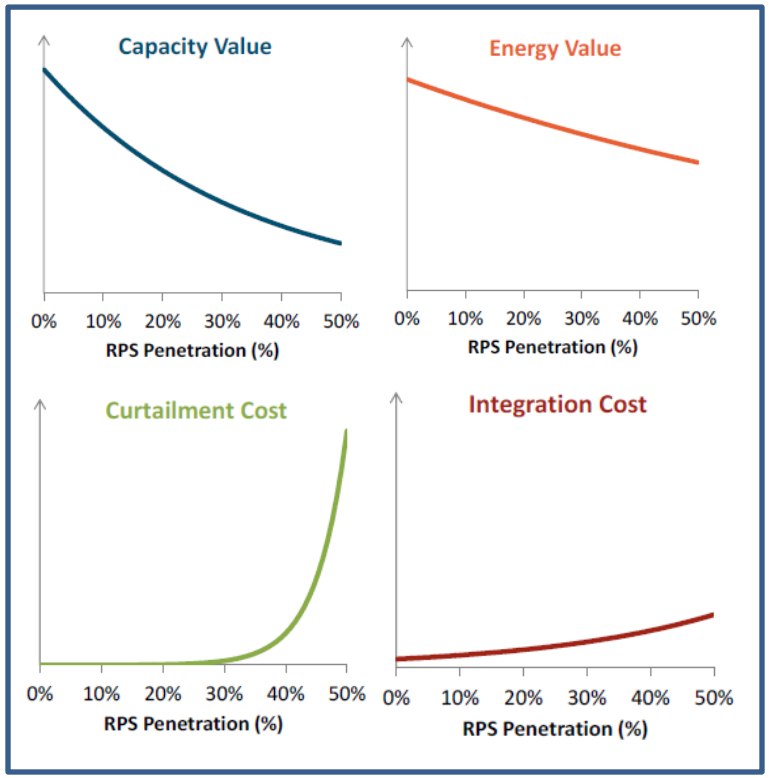
- Current projects with contracts, and under development will surpass the 33 % RPS mandate for 2020

- Installed Renewable Generation Capacity:
  - 21,700 MW (as of 10/2015)
  - Includes 3,700 MW of self-generation capacity

- Retail Sales Served by Renewable Energy, 2014: 25 %



Utility resource valuation



Leading the Way in Electricity℠

RPS Valuation and Selection: LCBF Methodology Overview

- **"Least-Cost"** – Proposals are evaluated and ranked by Net Market Value ($/MWh)

Costs	Benefits
Contract Payments	***Energy Value***
• Based on the capacity prices, expected generation and contract term	• Captures market value of the energy including a forecast for GHG while taking into account generation profile of offers
Transmission Cost	***Capacity Value***
• Cost adders for required network upgrades based on the best information	• The value of the countable Resource Adequacy capacity. (zero for energy only projects)
Debt Equivalence Cost	***Ancillary Services and Real Time Flexibility Value*** (if applicable)
• Cost of contract commitments on SCE's balance sheet	• Attributed to dispatchable, supply-side projects offering AS capability
GHG Cost (if applicable)	
• There is usually no GHG cost to the majority of renewable offers	
Renewable Integration Cost Adder (RICA)	
• Adopted Interim methodology	
Congestion	
• This can be a negative or a positive number for projects based on the location	
Energy Only Cost Adder	

All costs and benefits are valued using SCE's latest forecasts

- **"Best-Fit"** – After the quantitative valuation process, SCE evaluates each proposal's qualitative characteristics
  - Contribution to other SCE programs and goals (e.g. Energy Storage, portfolio diversity, LCR, WMDVBE, TRTP, viability, safety, environmental impacts, etc.)

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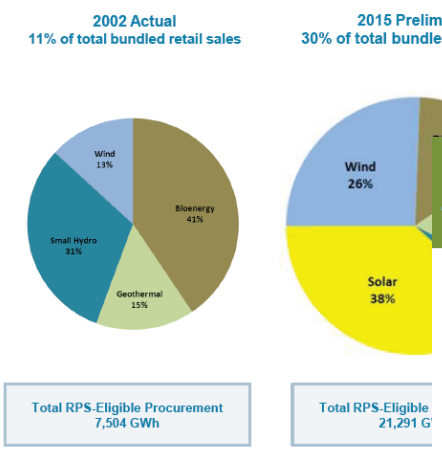
Utility portfolios

Renewable Portfolio Progress

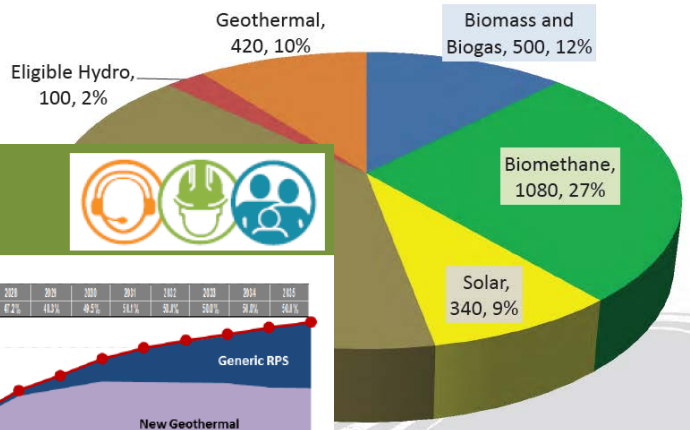
PG&E has a diverse portfolio of RPS resources



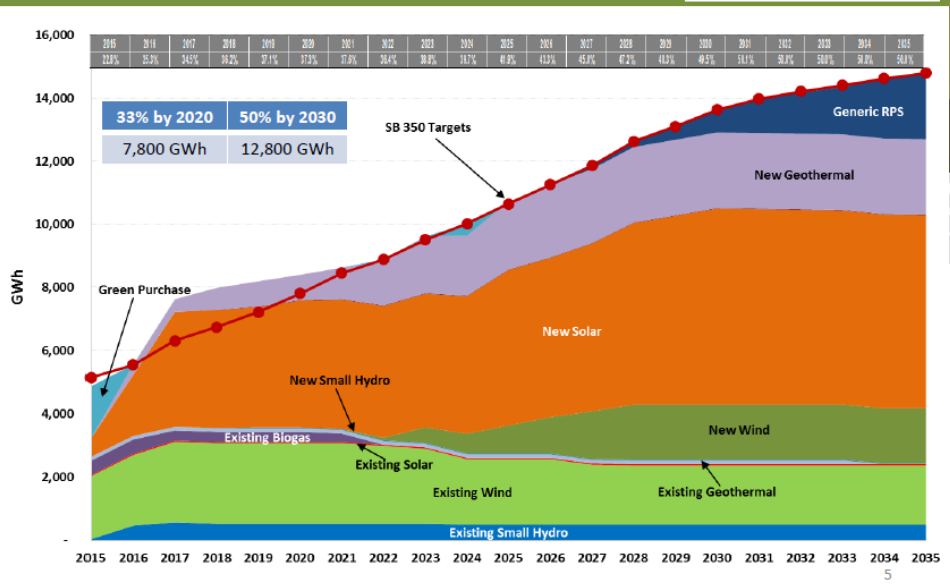
Data Sources: PG&E's 2002 Corporate Environmental Report, and PG&E's 2015

SMUD's Expected Renewable Portfolio: 2020

~ 4070 GWH total, 39%



Achieving 50% RPS by 2030



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Utility Resource Interest

LADWP Power Resources

- **Address the key renewable energy and transmission issues that have emerged in other relevant proceedings:**
  - **Out-of-state renewables**
  - **Potential CAISO expansion**
  - **Energy-only RPS resources**

PG&E

Which Wind Locations are Promising?

SDGE — A Sempra Energy utility

- Wyoming wind + Transmission; New Mexico wind + Transmission
  - Annual capacity factors 45%-50%
  - By comparison, solar PV at 30%
  - Long-Term focus
    - Banked renewable credits affects timing
    - GHG goals
    - 10+ years for major transmission development
- Permitting progress
  - Some large-scale wind projects have major permits
  - Some large-scale interstate transmission projects substantially permitted
- CHALLENGE: Securing a critical mass of PPA's
  - Recent near-term extension of federal tax credits may create an opportunity

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Renewable Energy Action Team (REAT) Project Database and ISO Interconnection Queue

- Projects in Development
  - 321 projects @ 21,945 MW
- Projects in Review
  - 110 projects @ 10,145 MW
- Projects with Permits to Build
  - 211 projects @ 11,800 MW
- Projects with Contracts
  - 2,000 MW
- Projects Under Construction
  - 32 projects @ 2,454 MW
- Expected to come on-line 2016
  - 1,080 MW
- CAISO Interconnection Queue
  - 257 requests @ 19,538 MW

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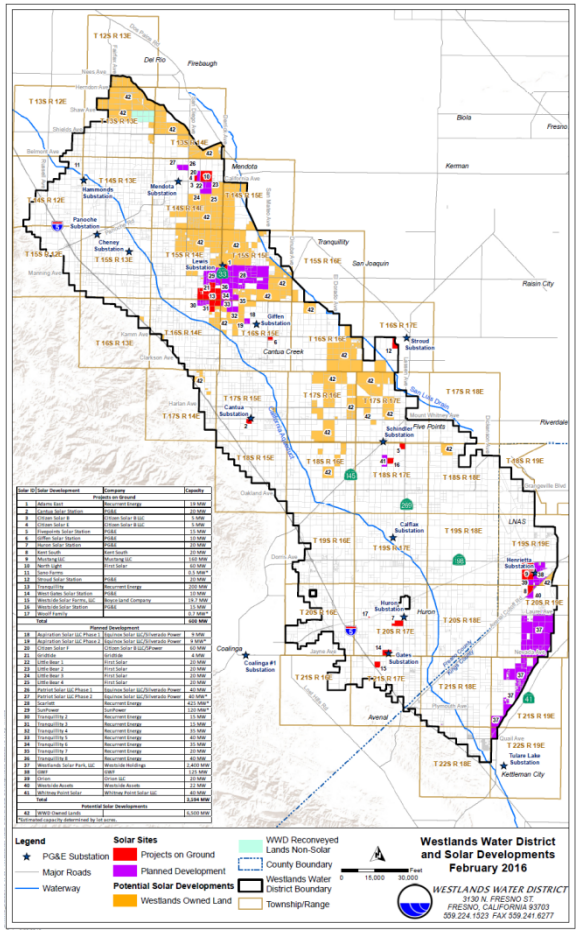
Solar interest

- Multiple parties commented that the ISO Queue Cluster 9 would be very instructive of commercial interest
- Likely show substantial activity statewide
- Cluster 9 request window closes 5/2/16; data should be available in a few weeks



SCE North of Lugo Area Requires More Infrastructure

- The North of Lugo Area has approximately 1,700 MW of projects in the CAISO generation queue
- This area is ideal for solar: it has high insolation, low quality habitat and low quality farmland
- Interconnection substations include Kramer, Jasper, and Coolwater

The Coolwater - Lugo project would help deliver clean renewable power, while supporting system reliability and meeting the region's increased demand for electricity.

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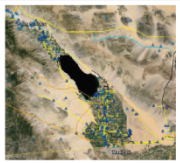
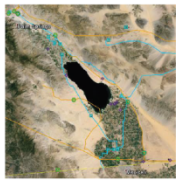
Salton Sea Area Has Huge Potential





Positive Attributes for Solar

- Solar resource is very high
- Thousands of acres of vacant, sub-prime land

Limited Transmission

- Existing infrastructure is inadequate for large projects with highest efficiencies and lowest cost
- 230/500 kV new transmission enhancements are needed between Salton Sea and Devers and IV Sub to deliver geothermal and solar projects
- High voltage infrastructure reinforcing IID BA connection with CAISO would provide much needed reliability and stability in CAISO southeast region
- RA allocation from IID BA needs to be designed in a way to remove the risk, enhance reliability and reduce cost to consumers

Need for higher voltage infrastructure and strengthened IID-CAISO path

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In-state wind interest

- Wind industry activity has decreased substantially
- Reality and perception of land use and environmental restrictions
- Further work necessary on remaining areas

The (Limited) Wind Energy Potential in California

Nancy Rader, Executive Director
California Wind Energy Association

RETI 2.0 Workshop
March 16, 2016

CalWEA

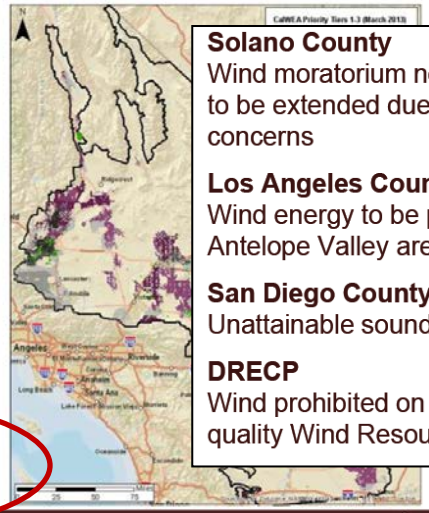
DRECP: BLM Wind Exclusions

The best wind resources within the DRECP region are shown in shades of gray.

BLM wind prohibition areas are shown in purple-overlay

Wind permitted in Development Focus Areas – green-overlay areas

CalWEA estimated max new wind potential: DRECP = 1,000 MW. All CA = 2,000 MW



Solano County
Wind moratorium north of Hwy 12 likely to be extended due to Travis AFB concerns

Los Angeles County
Wind energy to be prohibited in Antelope Valley area (So. of Tehachapi)

San Diego County
Unattainable sound standard

DRECP
Wind prohibited on 80% of BLM high-quality Wind Resource Areas

3

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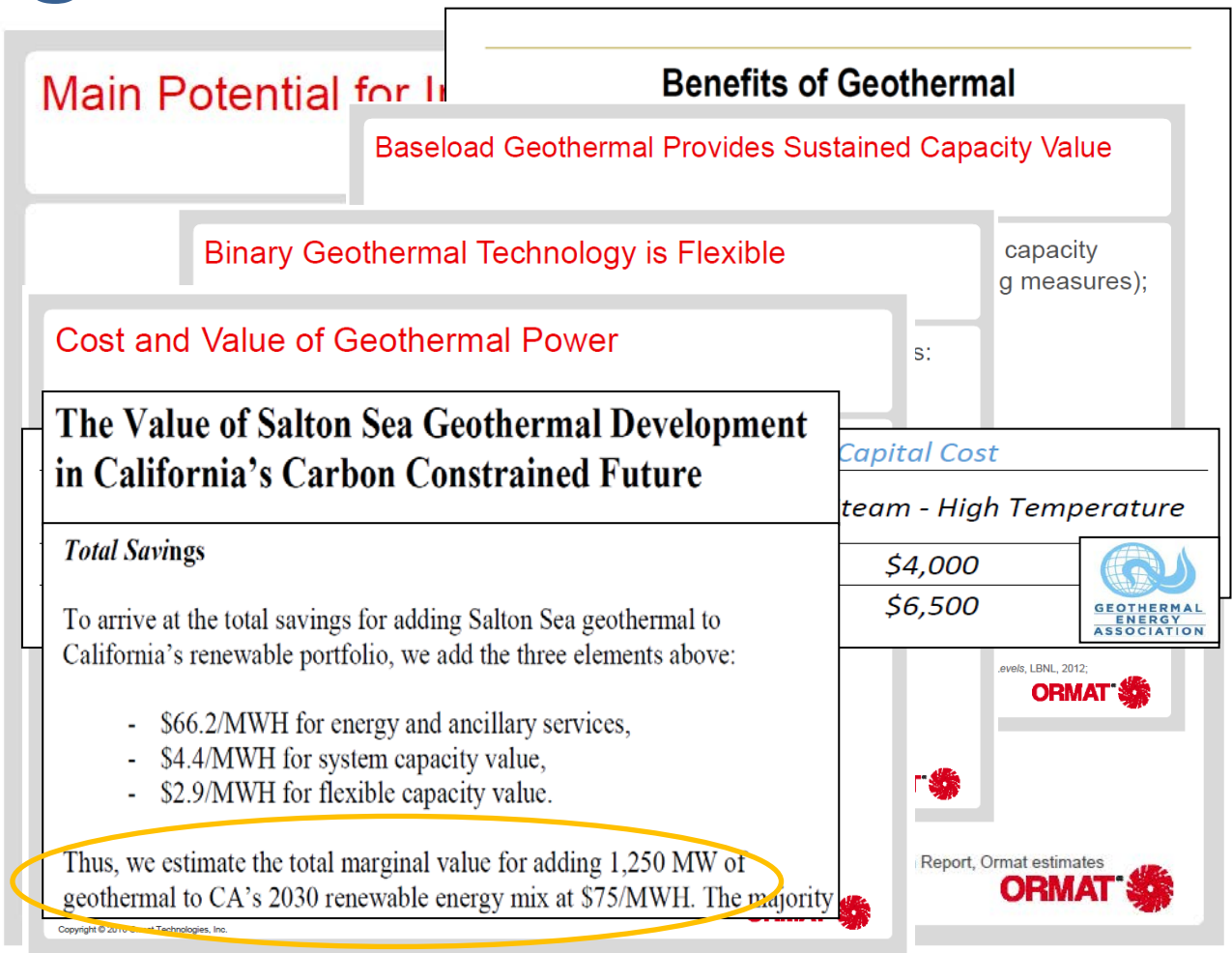
In-state geothermal interest

- Interest in several significant resource areas
  - Each site requires in-depth technical analysis
- Transmission seen as one challenge among several
- Most challenges are economic and institutional: refining cost and benefits



Out-of-state interest

need to consider some level of full-deliverable procurement. DATC encourages procurement from multiple geographic regions that have thus far been eliminated from California's energy planning processes, including the San Joaquin Valley, the Lassen North area and other states, like Wyoming and northern Nevada. A flexible transmission plan that provides early signals

rstanding
rces that can
he **existing**

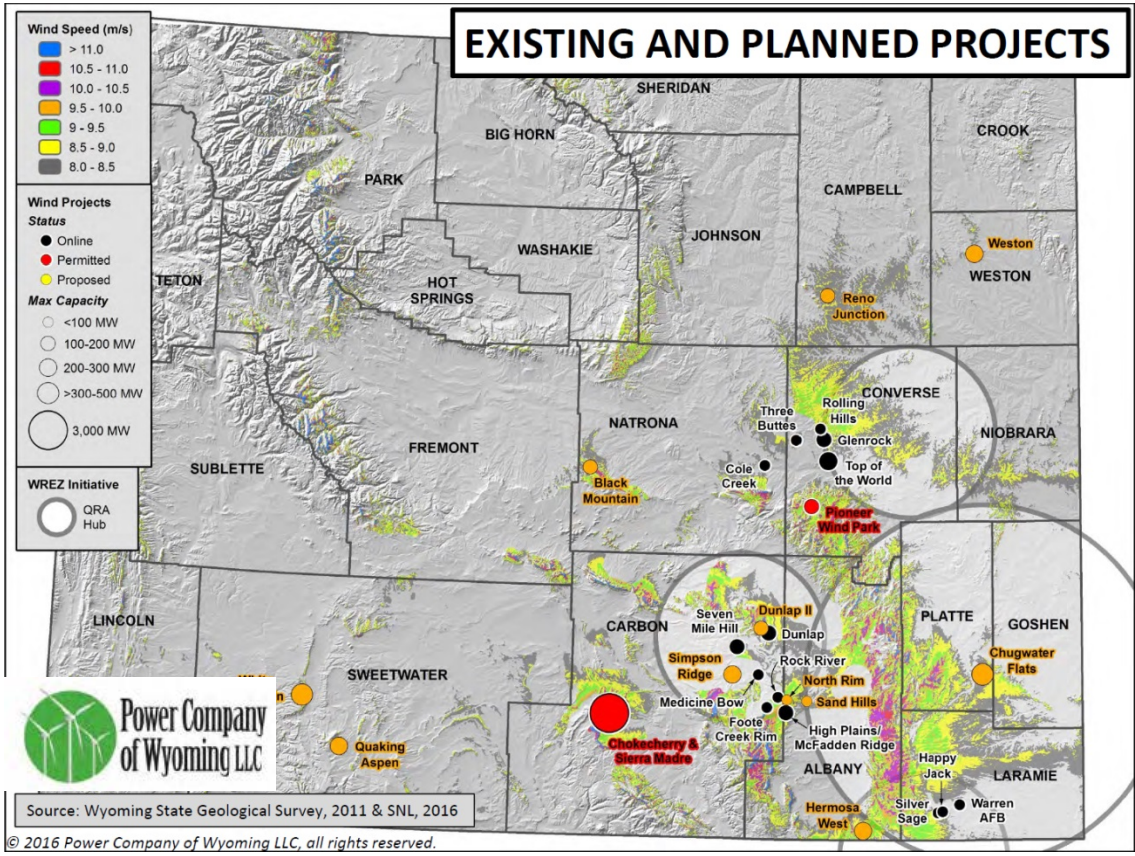
transmission infrastructure. Such an assessment would involve potentially "repurposing" the existing transmission. One such example would be the Intermountain DC Intertie, an HVDC line owned and operated by the Los Angeles Department of Water and Power (LADWP), which can potentially be used to import OOS renewable resources once the Intermountain coal-fired power plant retires. This same concept could also apply to other retiring coal plants elsewhere in the Western Interconnect. CPUC Commissioner Florio has indicated identifying such reuse or repurpose of the existing transmission as one of the major priorities for the RETI 2.0 efforts.[2]

ETI 2.0 in considering
ıt-of-state alternatives.

ıering and sharing may
despite our collective
e agencies on regional
ed in joining with the CAISO. Getting ahead of planning with regional opportunities outside of California will require that the RETI 2.0 group put extra effort into continuing its focus on equally-informed choices both inside and outside of California. SWPG is not suggesting that the

Out-of-state interest

- CA utilities signing contracts with AZ and NV solar, NM wind
- Multiple projects in advanced permitting in WY and NM
- Proposals evolving to phase development, access multiple markets, utilize existing transmission
- Less current data regarding development interest in other states
- Further outreach necessary



Conclusions

- Low cost solar is ubiquitous, but does raise long-term integration challenges
  - Many integration options, but resource and technology diversity and exports are among the cheapest
- Determining environmental feasibility and transmission access for remaining in-state wind may be a priority
- Geothermal may offer important benefits by 2030 but costs and benefits need further work
  - Transmission access one important component
- Environmental and land use constraints tend to favor in-state solar and out-of-state wind
- Broad support for further assessment of Out-of-state resources
  - High-quality, low-cost resources with complementary profiles
  - Quality and timeliness of data does not match in-state
  - Options for access by existing transmission largely un-assessed
  - Export options very important