Resource and transmission planning to achieve a 33% RPS in California – ISO Modeling tools and planning framework

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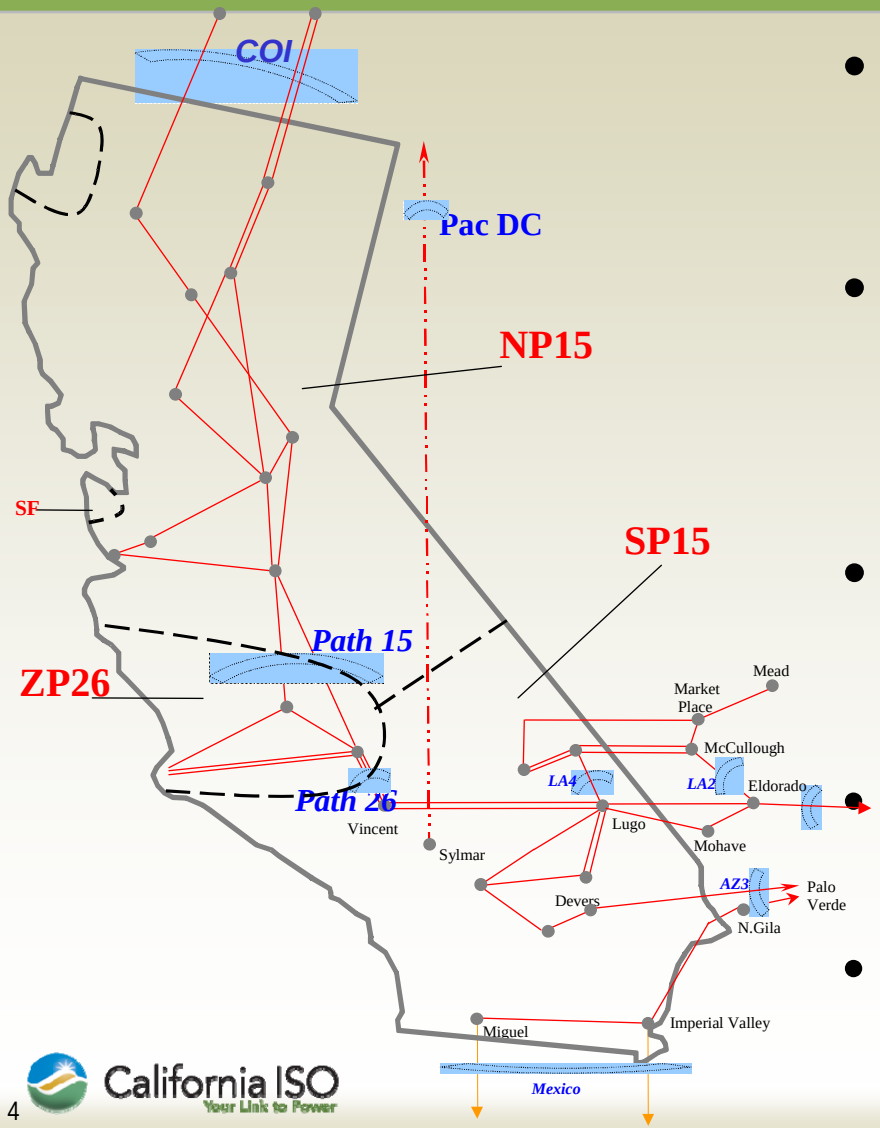
Overview of presentation

- Background
- CAISO modeling and analysis tools for transmission and operational planning
- Some proposed revisions to the CAISO Transmission Planning Process to support 33% RPS by 2020
- Inputs to CAISO Transmission Planning Process

California is planning towards multiple power sector environmental policy objectives by 2020

- State law AB32 – Reduction of greenhouse gas emissions to 1990 levels by 2020
- 20% Renewable Portfolio Standard (RPS) by 2012-13
- 33% RPS by 2020 (Executive Order)
- Repowering, replacement, or retirement of once-through cooling power plants (~38% of in-state gas and nuclear capacity)

California ISO by the numbers



- Approximately 80% of California's electricity load is managed by the ISO
- Encompasses 30 million consumers in PG&E, SCE, and SDG&E and many municipal utilities
- Heat storm in 2006 with historical peak load of 50,270 MW on July 24,2006
- **55,027** MW of power plant capacity + 10 GW import capacity
- **25,526** circuit-miles of transmission lines

CAISO Transmission Planning Functions and Available Software Tools

NERC/WECC Reliability Assessment and Mitigation	
▪ Conduct transient stability, small signal analysis, voltage stability and steady-state studies on an annual basis ▪ Identify NERC/WECC reliability criteria violations and mitigation measures	▪ GE Positive Sequence Load Flow (PSFL) ▪ Siemens PTI PSSE ▪ Powertech Labs, Inc., DSA Tools
Economic Planning Studies	
▪ Perform congestion analysis on annual basis using production simulation ▪ Identify transmission solutions with positive economic benefits	▪ Ventyx, Inc., PROMOD ▪ ABB Gridview

CAISO Transmission Planning Functions and Available Software Tools (cont.)

Probabilistic Reliability Studies	
▪ Perform Planning Reserve Margin (PRM) studies ▪ Perform transmission reliability assessment	▪ GE Multi-Area Reliability Simulation (MARS) ▪ EPRI Probabilistic Reliability Assessment (PRA) ▪ Siemens PTI PSS TPLAN ▪ V&R Physical Operational Margin (POM) Probabilistic Reliability Indices (PRI)

CAISO Transmission Planning Functions and Available Software Tools (cont.)

Generation Interconnection Studies	
▪ Perform reliability assessment ▪ Perform generation deliverability studies	▪ GE Positive Sequence Load Flow (PSFL) ▪ Siemens PTI PSS MUST

CAISO Operational/Market Planning for Renewable Integration and Available Software Tools

Sub-hourly operational/market requirements analysis	
▪ Estimates of potential intra-hour capacity and ramp rate require-ments for load-following and Regulation, up and down	▪ Monte Carlo simulation tool developed by Pacific Northwest National Labs and CAISO
• Quantify changes in system frequency deviation and area control error (ACE) due to wind and solar variability at 20% - 33% RPS • Calculate the Regulation/ frequency response require-ments and value of additional capabilities, such as storage	▪ KEMA KERMIT tool; evaluation using CAISO data under California Energy Commission grant; final CEC report pending

CAISO Operational/Market Planning for Renewable Integration and Available Software Tools (cont.)

Hourly and Sub-hourly operational/market production simulations	
▪ Production simulation with unit commitment and dispatch, co-optimization of energy and ancillary services, zonal or DC load flow network models ▪ Applications with stochastic day-ahead/hour-ahead forecasts and real-time 5-10 min. dispatch	▪ Ventyx, Inc., PROMOD ▪ ABB Gridview ▪ PLEXOS
▪ Detailed simulations utilizing actual day-ahead to real-time market data and full network model ▪ Initially used to benchmark 20% RPS production simulations; later will examine “stress days”	▪ CAISO/Siemens Market Simulation tools developed for ISO and market participants to test market design changes

CAISO has proposed significant revisions to its Transmission Planning Process to support 33% RPS (filed at FERC, June 5)

- Phase 1 – Formulate statewide conceptual 33% RPS transmission plan with CTPG, including joint projects
- Phase 2 – Refine conceptual plan to arrive at comprehensive plan for the ISO BAA, including renewable access as well as reliability and other transmission needs
  - Stakeholder process will allow comments and suggestions for improving CTPG plan
  - Plan will identify transmission needed for renewable access as Category 1 (unconditional approval) or Category 2 (pending generation development)
- Phase 3 – Receive & review concrete project proposals
  - Participating Transmission Owners (PTOs) and non-PTOs may propose to build Category 1 elements
  - ISO will assess 2008-9 request window economic projects against the final renewable build-out represented in the Phase 2 plan

In Phase 2, CAISO has proposed to identify two categories of transmission elements to reflect uncertainty

- "Category 1" policy-driven transmission elements will get recommendation of unconditional approval from CAISO Board of Governors
  - In the 2010 cycle, the ISO will exempt the identified network upgrades for ARRA projects from assessment in the TPP so that the project developers can complete their interconnection agreements in a timely manner
- "Category 2" transmission elements are potentially needed for achieving the 33% RPS, but are not yet recommended for approval pending further information on resource development
- A methodology will be established to distinguish elements in these categories using environmental, commercial and economic criteria

Criteria for revising the conceptual plan

- Models utilizing stated criteria will support both refinement of Phase 1 conceptual plan and Phase 2 Category 1 or 2 designations
- Transmission elements within ISO BAA may be ranked based on:
  - Commercial interest in the zone(s) accessed by the transmission element
  - Environmental assessment of zone(s) and transmission elements
  - Capacity (MW) and expected energy (MWh) to be accessed
  - Supply cost function of renewable resources in each zone
  - Cost of the transmission element

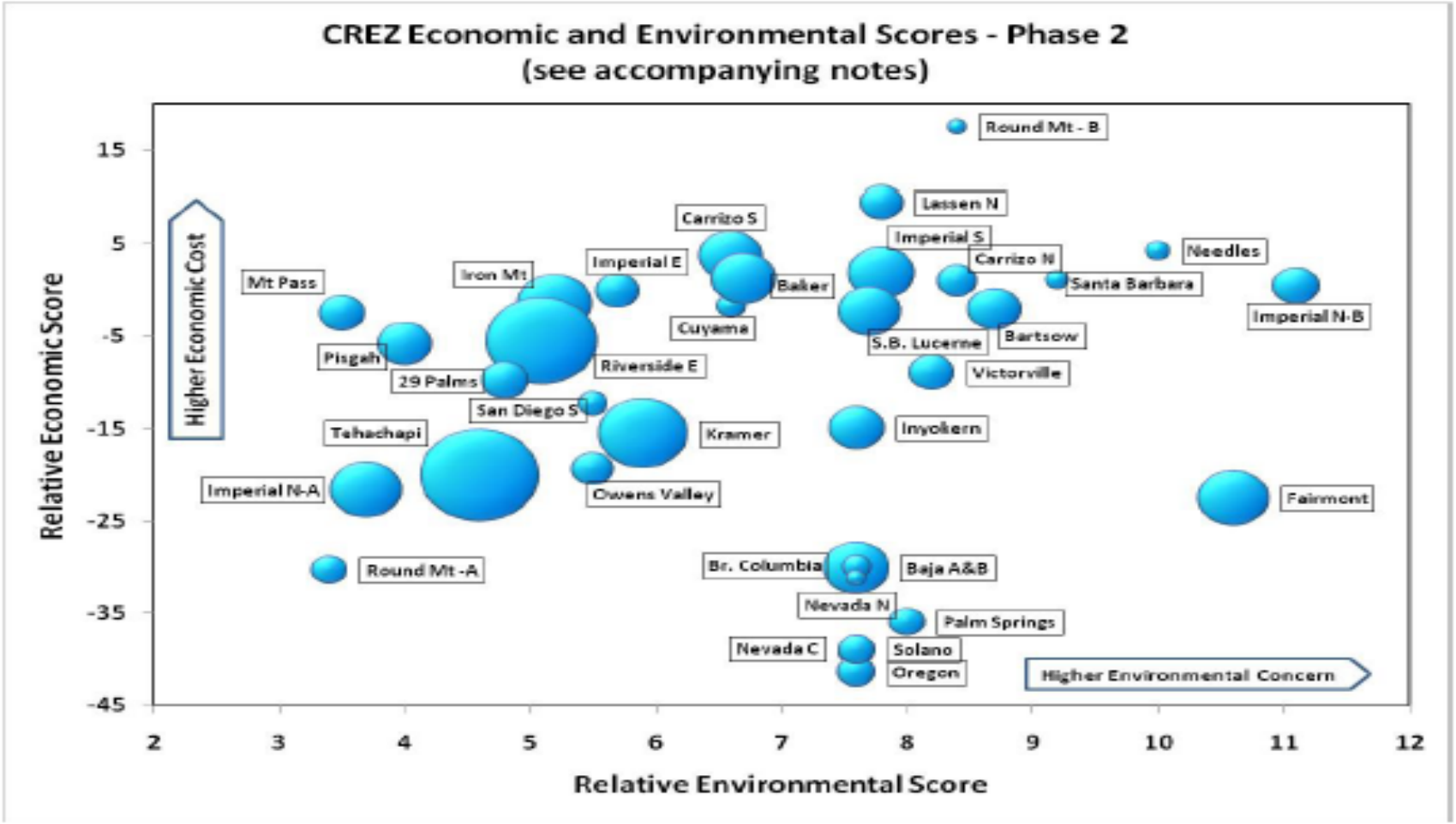
Criteria for revising the conceptual plan (*cont*.)

- (*cont.*) Transmission elements within the ISO BAA may be compared based on:
  - Additional reliability or economic benefits to the ISO grid provided by the transmission element
  - Potential future connections to other renewable resource areas and transmission elements
  - Renewable integration impacts and costs associated with the resources in particular zones
  - Potential for a particular transmission element to provide access to generation and non-generation resources needed to support renewable integration (e.g., pumped storage)
  - Risk of stranded investment due to uncertainty associated with the above criteria or other considerations

Identification and Ranking of Competitive Renewable Energy Zones (CREZs) in California

- Environmental Criteria
- Economic Criteria
  - By location and technology; capital costs and market benefits of renewable resources; renewable integration requirements; transmission costs
- Commercial Interest Criteria
  - Power Purchase Agreements
  - Generation interconnection queue status
  - "Shortlisted" LSE projects
  - CPUC evaluation to identify high ranked, or "core" projects

Renewable Energy Transmission Initiative (RETI) identification of "Best CREZs" in California and out-of-state



Source: RETI Phase 2A Final Report, pg. 2-39.

Evolution of 33% RPS statewide conceptual transmission planning initiatives and methodologies

- Renewable Energy Transmission Initiative (RETI) (2009)
  - Conceptual transmission planning to examine impact of interconnecting 31 CREZs; limited to shift factor analysis
- CAISO 33% RPS conceptual plan based on generation interconnection queue (2009)
  - Power flow/stability studies; 1 scenario with 14 CREZs
  - ISO made assumptions about resources in other California BAAs
- California Transmission Planning Group (CTPG) (2009-10)
  - Power flow/stability studies; multiple stakeholder driven scenarios
- CAISO proposed Phase 2 of revised TPP would be the next step

CTPG renewable portfolios by percentage of renewable energy (GWh) needed to get to 33% RPS ("net short")

Percent of Net Short By Scenario						
Scenario	Bio	Geo	Solar	Wind	In State	Out of State
LSE Procurement Interest (Phase 1)	2	11	49	38	79	21
Gen Queue Development Interest	1	21	44	34	92	8
RETI Heavy In-State	5	14	45	36	70	30
North/Northwest	<1	14	21	65	58	42
Desert Southwest	1	19	51	29	76	24
Owens Valley	1	18	55	26	92	8
RETI Best CREZ	4	17	43	36	70	30

California ISO
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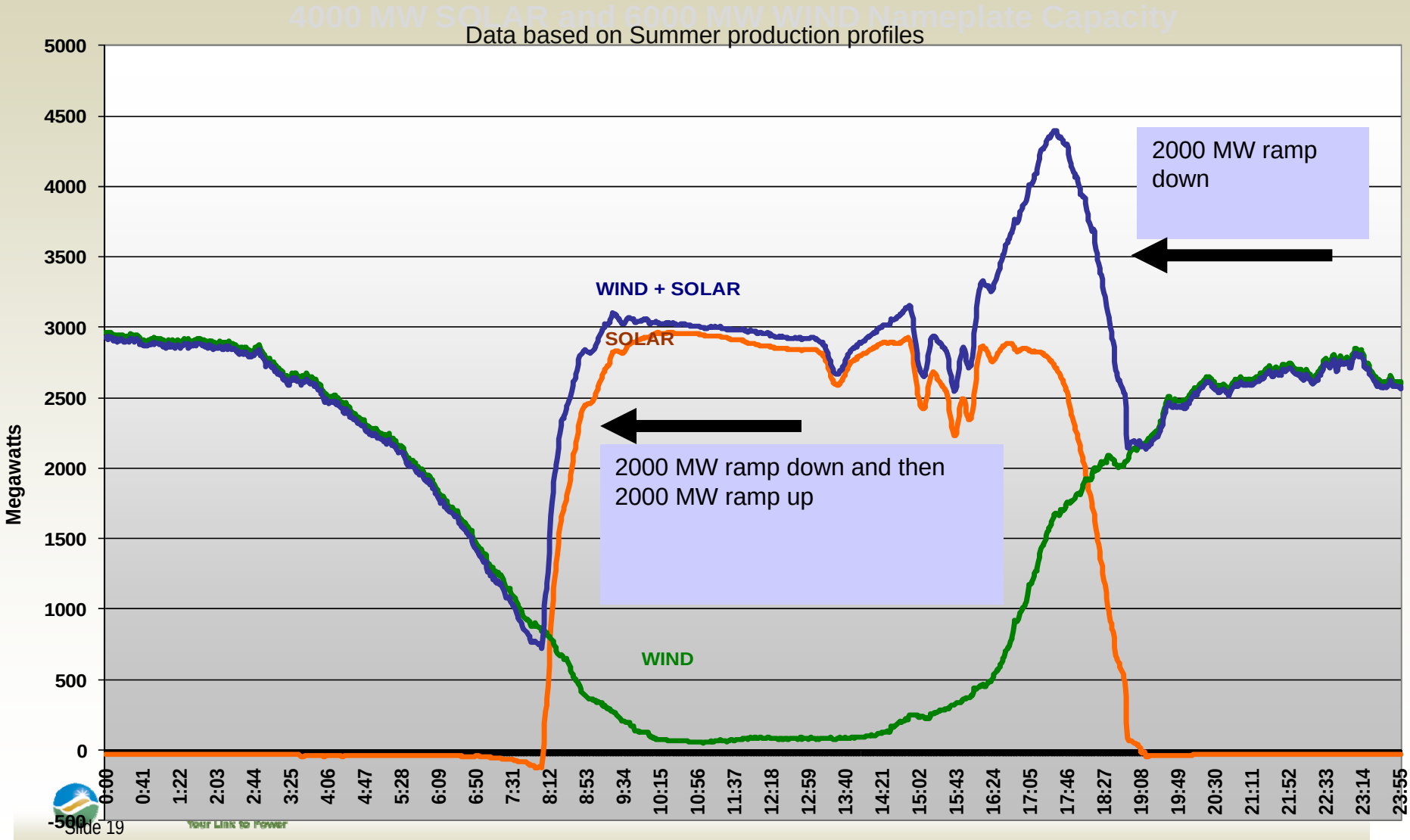
Source: CTPG stakeholder presentation, available at http://www.ctpg.us/public/images/stories/pdfs/CTPGApril20StakeholderPresentation.pdf

Incorporating the costs and operational requirements of renewable integration: 33% RPS operational simulation studies using CPUC proposed renewable scenarios for 2020

	Biogas	Biomass	Geo-thermal	Solar Thermal	Solar PV	Wind
33% Reference	279	429	1,497	6,513	3,165	8,338
High Out-of-State	279	339	2,532	1,753 (534 OOS)	890	10,870 (6,290 OOS)
High Distributed Generation	234	328	1,298	1,095	15,959 (15,098 DG)	5,067
27.5% RPS	30	328	1,298	4,868	2,864	5,977
Low Load	30	328	1,299	4,907	2,867	7,091

Based on CPUC analysis conducted in mid 2009

Example of ramping challenges at ~20% RPS

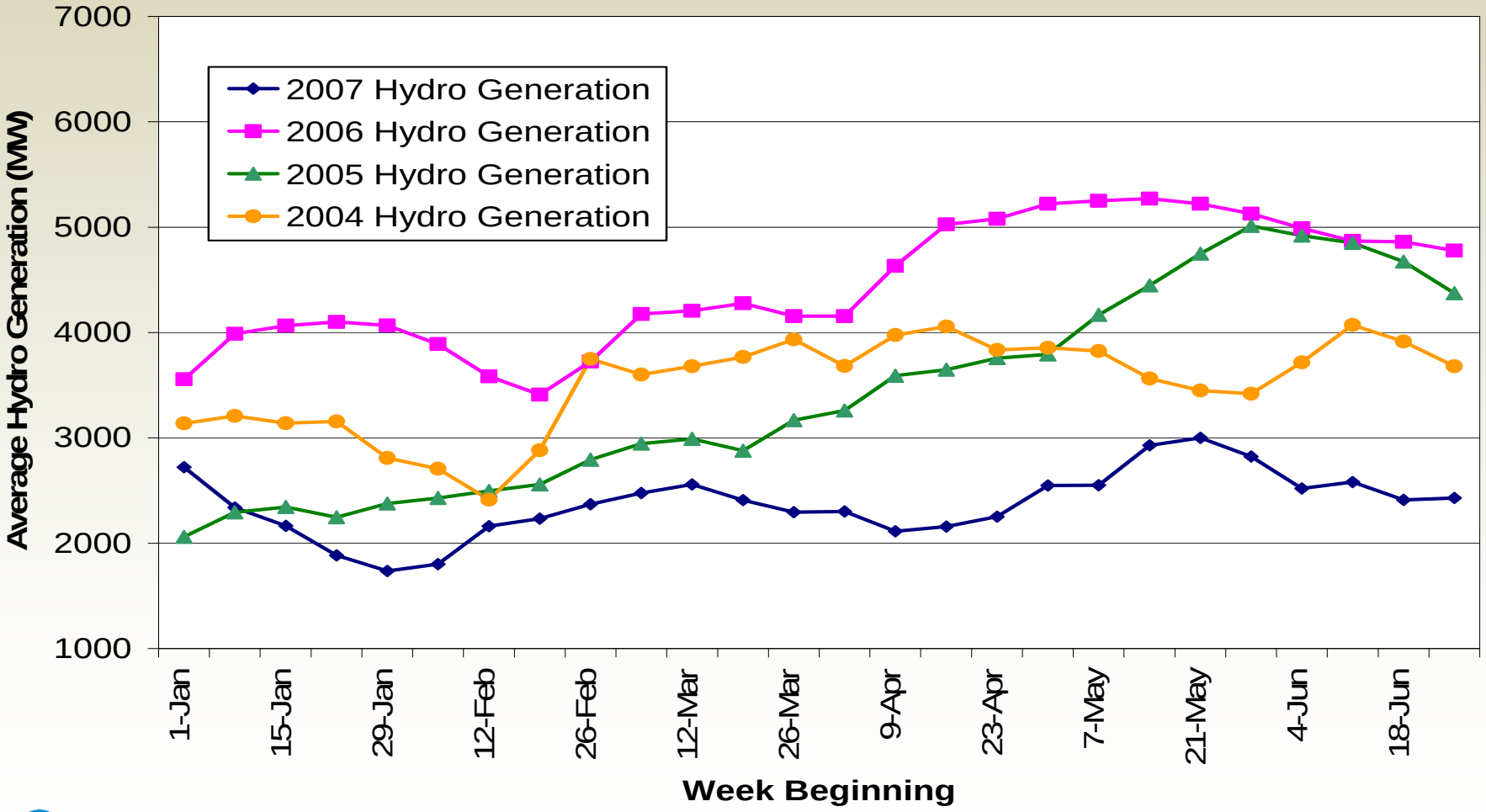


From operational simulation modeling: Expected increase in Regulation and load-following capacity (MW) requirements

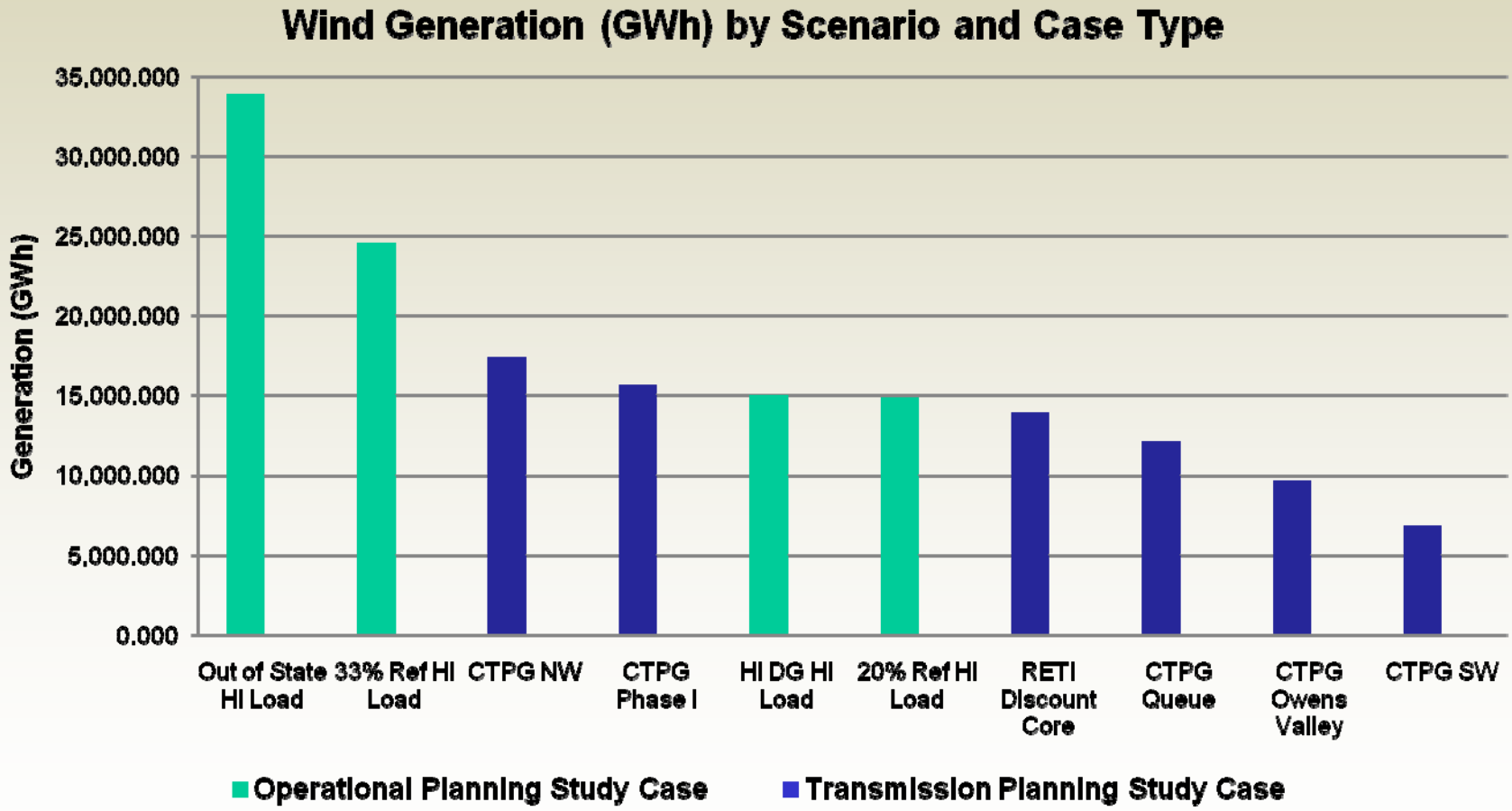
	Spring			*Summer*			*Fall*			*Winter*		
	2006	**2012**	**2020**	**2006**	**2012**	**2020**	**2006**	**2012**	**2020**	**2006**	**2012**	**2020**
Maximum Regulation Up Requirement (MW)	277	502	1,135	278	455	1,144	275	428	1,308	274	474	1,286
Maximum Regulation Down Requirement (MW)	-382	-569	-1,097	-434	-763	-1,034	-440	-515	-1,264	-353	-442	-1,076
Maximum Load Following Up Requirement (MW)	2,292	3,207	4,423	3,140	3,737	4,841	2,680	3,326	4,565	2,624	3,063	4,880
Maximum Load Following Down Requirement (MW)	-2,246	-3,275	-5,283	-3,365	-3,962	-5,235	-2,509	-3,247	-5,579	-2,424	-3,094	-5,176

2012 Case = 20% RPS with additional 1,800 MW solar and 4,100 MW wind
2020 Case = 33% RPS with additional 9,700 MW solar and 8,350 MW wind

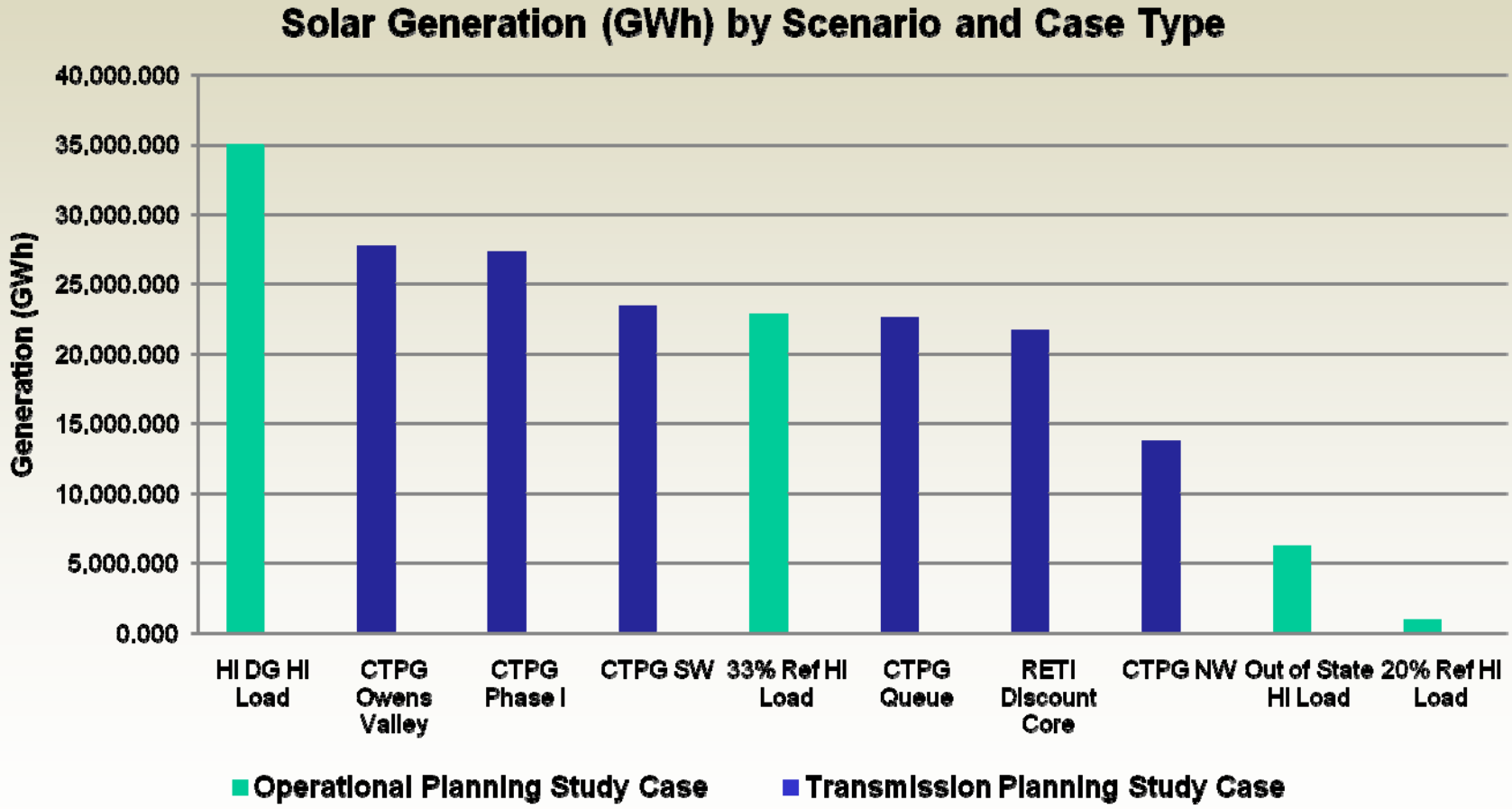
Production simulation of 20%-33% RPS:
High Hydro (2006) vs. Low Hydro (2007) Years for Overgeneration Sensitivity



Comparison of total wind production (in-state + out-of-state) modeled in different 33% RPS operational and transmission planning scenarios



Comparison of total solar production (in-state + out-of-state) modeled in different 33% RPS operational and transmission planning scenarios



Some intersections of “planning” and “operational/ market” models in high renewables scenario analysis

- Impact of renewable production profiles, hourly and sub-hourly ramp and ancillary service requirements on power flows and transmission needs
  - What to assume about “overgeneration” by renewable resources given policy goals
- Representation of storage and demand response
  - Typically represented as load modifiers in production simulation, but that is not sufficient for their potential uses in high renewables scenarios
- Assumptions about other load modifiers (e.g., State energy efficiency goals) and distributed resources (CHP, distributed PV, etc.)

Conclusions

- Development and adaptation of modified resource and transmission planning models to reflect high renewables scenarios is underway
- In California, process is underway to review initial large number of stakeholder driven scenarios and develop a transmission plan staged to reflect resource development and policy uncertainties
- Further simulation model development will assist in refining these plans in 2010 and subsequent years