Intermittency Analysis Project:

Achieving 33% Renewables in CA by 2020

Project Highlights

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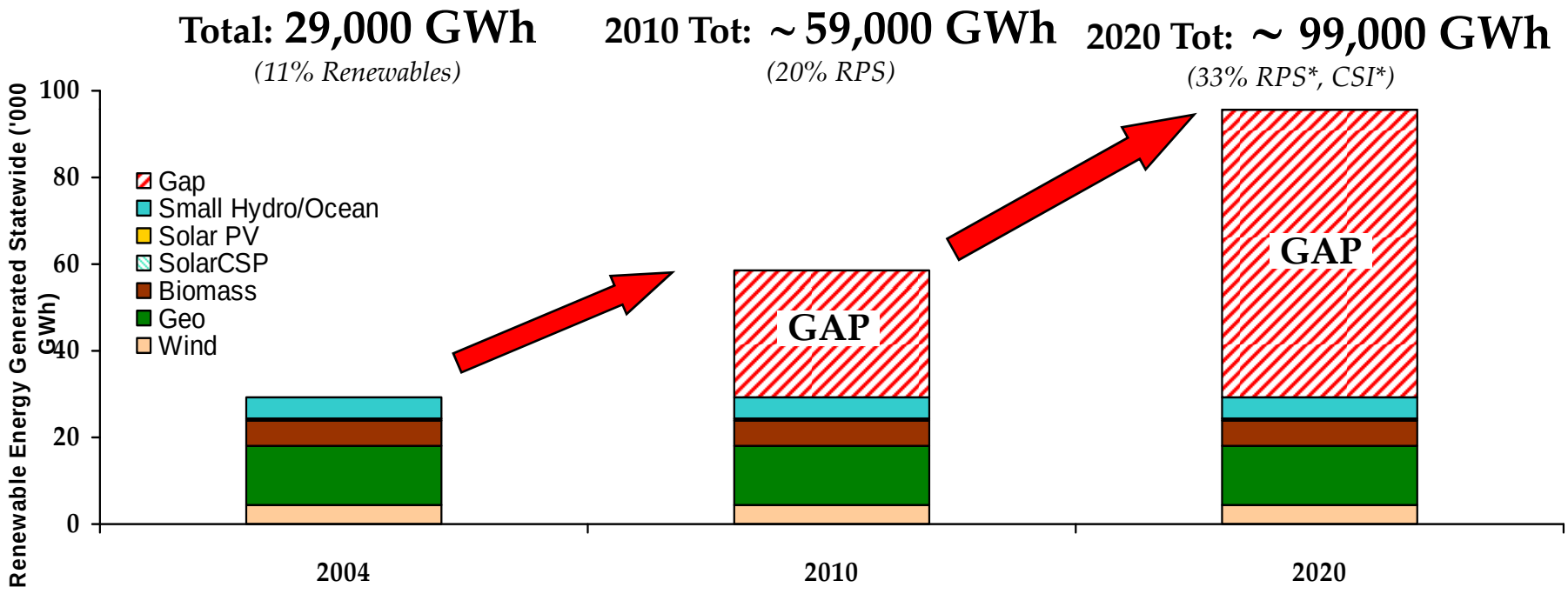
Projections to Meeting RPS

Projected Renewables to Meet California Policy Goals



Data Sources: 2004, CEC Electricity Report which includes all renewables in the State, not just IOUs; 2010 and 2020, PIER Renewables Projections.

*RPS: Renewable Portfolio Standard
*CSI: California Solar Initiative

Renewable Integration Questions

- What will the future electricity system look like and where are in-state resources likely to come from?
- What is needed for the grid to accommodate renewables (infrastructure, market, regulation, technologies) ?
- What are the impacts of increasing renewable energy penetration on system reliability and dispatchability?

IAP Focus

Define Attribute Requirements

- Renewable generation performance curves
- Renewable resource potential & locations
- New technology attributes

Reduce Uncertainty

- Consistent statewide datasets
- Generation & load for multi-years
- Transmission datasets

Resource Policies

- Mix including renewables and conventional
- Perspective on generation to load centers
- Mitigation/storage options
- Lessons learned (world-wide experience)

Improve Planning and Modeling

- Quantified impacts
- Confidence in modeled options
- Expanded options and contingencies

IAP Objectives

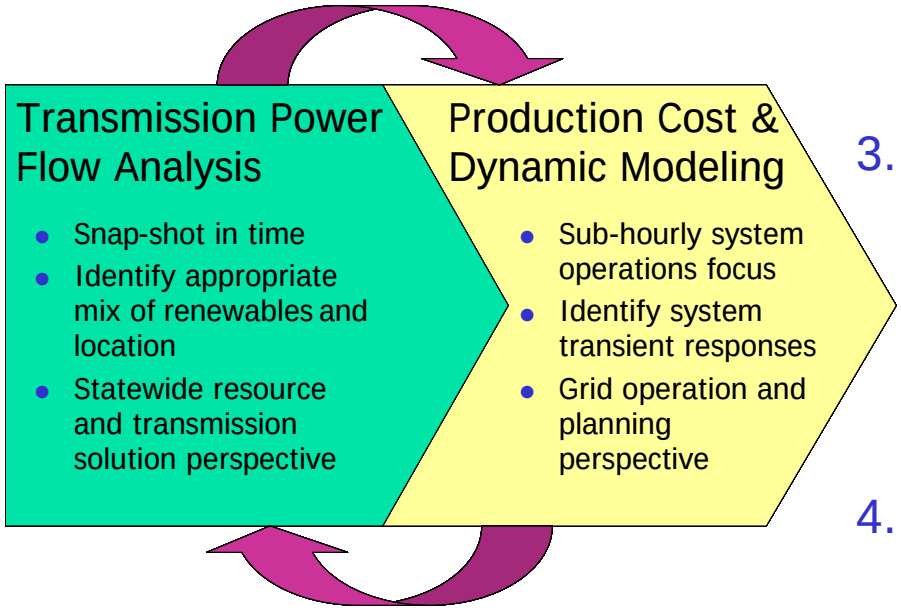
- Focus on statewide transmission *planning options* to achieve policy goals
- Focus on providing *quantitative impacts* (pros & cons) of various options on transmission reliability, congestions and mix of renewable technologies
- Develop *tools and analysis methods* to evaluate renewables along with conventional generation
- Provide a *common perspective* for evaluating different technologies competing for limited system resources
- Provide a *common forum* for Commissions, utilities and developers to examine the location and timing of new generation/transmission projects and public benefits of these resources

IAP = "a piece of the puzzle"

Four IAP study scenarios

Scenarios of Increasing Wind Penetration

1. **2006 Baseline**
   Existing system with existing mix of generation resources



End-to-End Approach

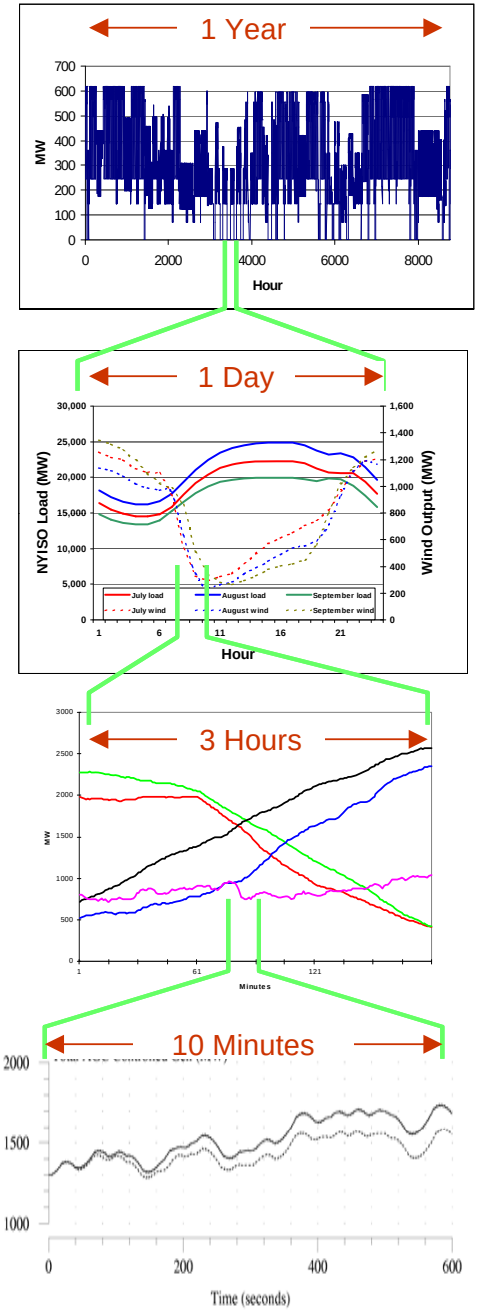
2. **2010 Tehachapi (2010T)**
   20% renewable energy with approximately 6 GW wind generation statewide, assuming 3000 MW concentrated at Tehachapi

3. **2010 Accelerated (2010 X)**
   Sensitivity study cases to assess system buildout needs toward a 33% renewables electricity infrastructure

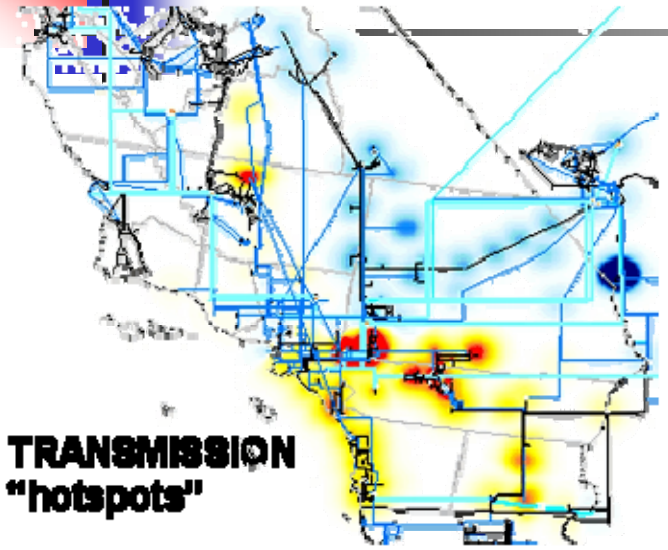
4. **2020 33%**
   Blend of renewables designed to meet policy targets with high wind penetration

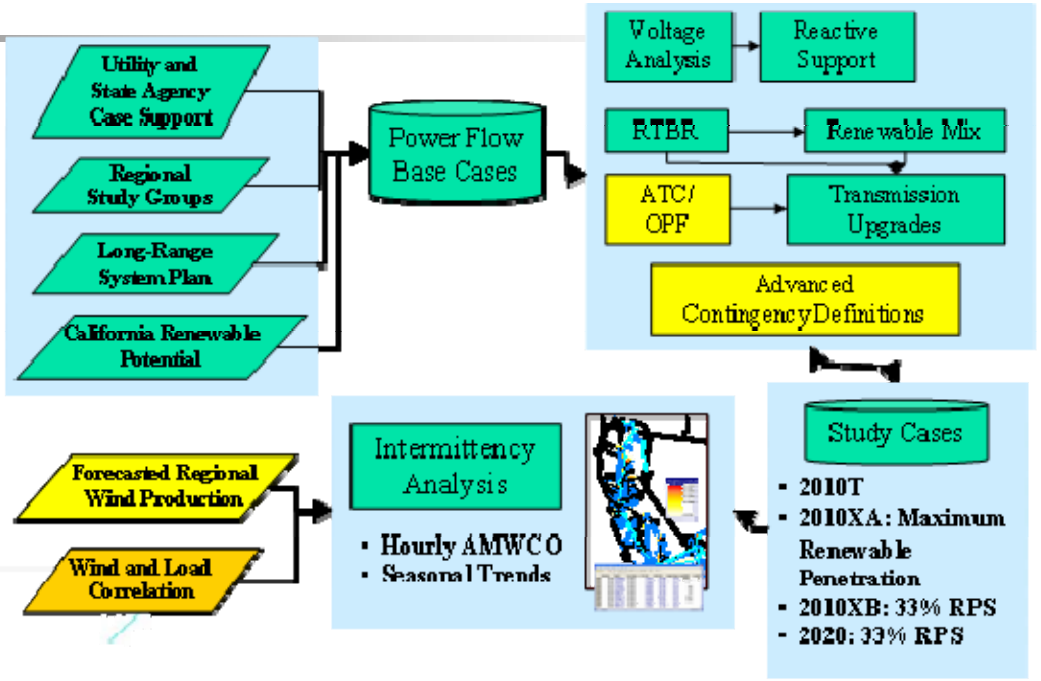
Production Cost Model addresses time scales necessary for System Reliability and Operation

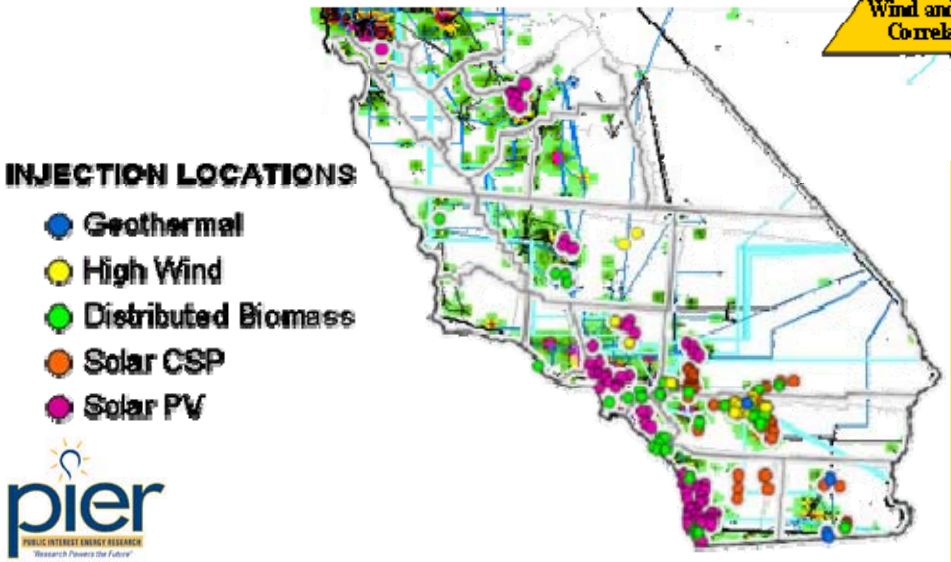
	Planning and Operation Process	*Technology Issues*
Slower (Years)	**Resource and Capacity Planning** **(Reliability)**	**Capacity Valuation (UCAP, ICAP) and Long-Term Load Growth Forecasting**
Time Frame	**Unit Commitment and Day-Ahead Scheduling**	**Day-ahead and Multi-Day Forecasting**
	Load Following (5 Minute Dispatch)	**Hour-Ahead Forecasting and Plant Active Power Maneuvering and Management**
Faster (seconds)	**Frequency and Tie-Line Regulation (AGC)**	**Real-Time and Autonomous Protection and Control Functions (AGC, LVRT, PSS, Governor, V-Reg, etc.)**



Transmission Analysis Approach







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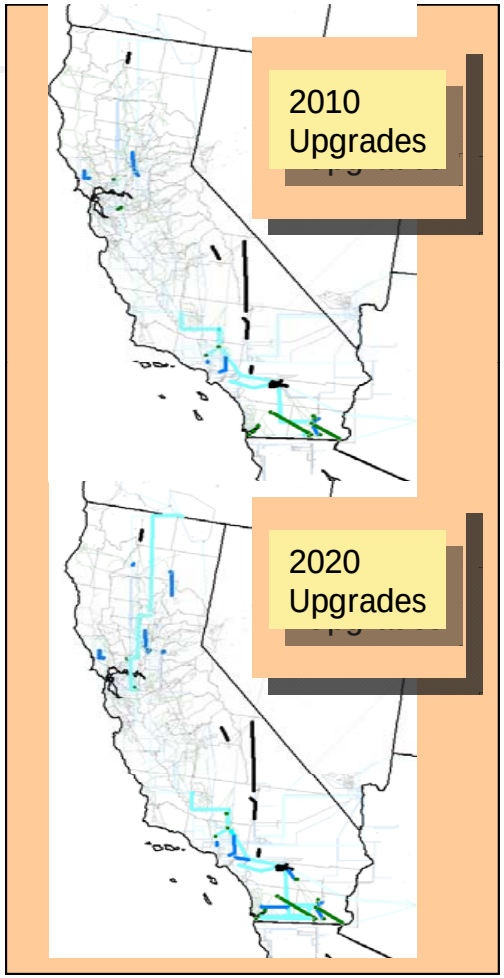
Approach to optimally place generating resources to reduce transmission constraints and meet demand in a sustainable fashion

2010 & 2020 Transmission Expansions

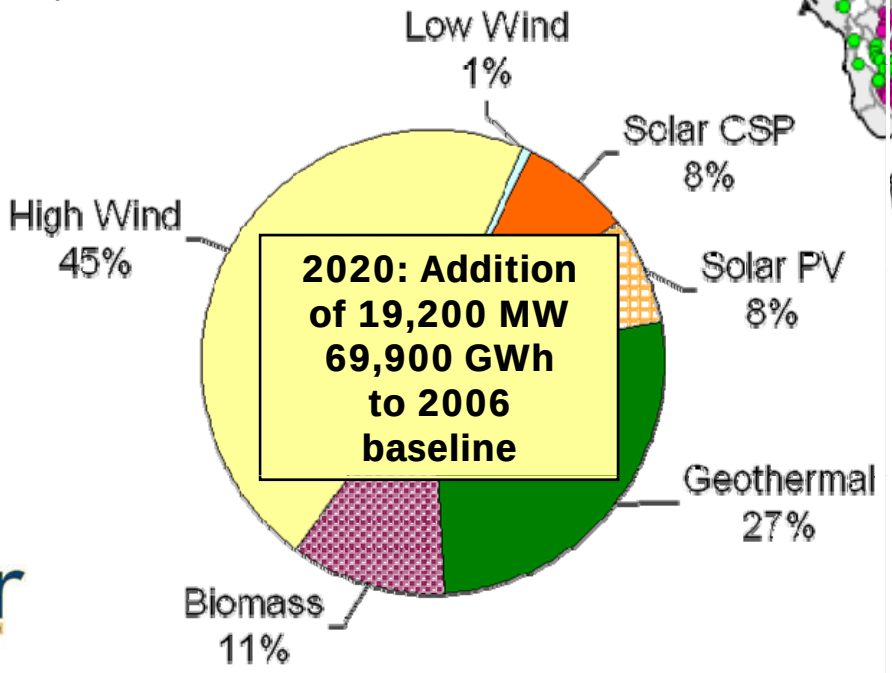
Line Voltage	2010 Line Segments	2020 Line Segments	2010 Transformers	2020 Transformers
500	8	22	2	9
230	8	38	6	18
161/138	0	2	1	0
115	49	49	9	5
Below 110	13	17	14	8
Total #	**78**	**128**	**32**	**40**
Estimated Cost*	**$1.3 Bil**	**$5.7 Bil**	**$161 Mil**	**$655 Mil**

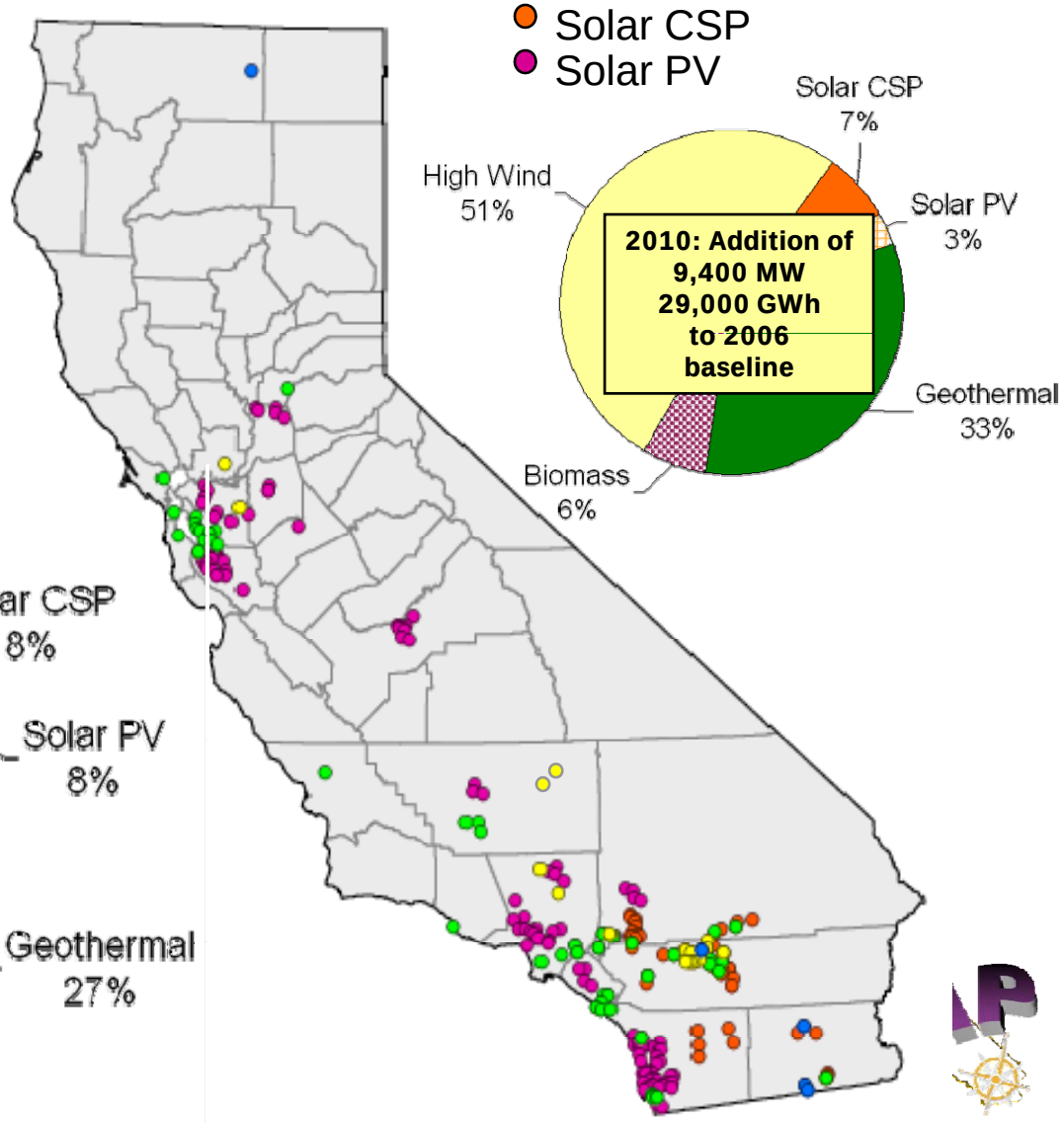


* Order of magnitude estimates based on N-1 contingency, lines greater than 230kV
* Transmission plans and additions based on combination of utility projects and IAP team assessed needs

2010 & 2020 Scenario

- Up to 33% renewable generation penetration
- Portfolio mix of statewide resources
- 3,000 MW of wind at Tehachapi and nearly 3,000 MW of PV





IAP Portfolio Mixes

	2006	2010T	2010X	2020
Peak California Load, MW	58,900	62,600	62,600	74,300
Peak CAISO Load, MW	48,900	51,900	51,900	61,200
Total Geothermal, MW	2,400	4,100	3,700	5,100
Total Biomass, MW	760	1,200	1,000	2,000
Total Solar, MW	330	1,900	2,600	6,000
Total Wind, MW	2,100	7,500	12,500	12,700
Wind at Tehachapi, MW	760	4,200	5,800	5,800
CA Intermittent Capacity Penetration	4%	15%	24%	25%
CAISO Intermittent Capacity Penetration	5%	18%	29%	31%

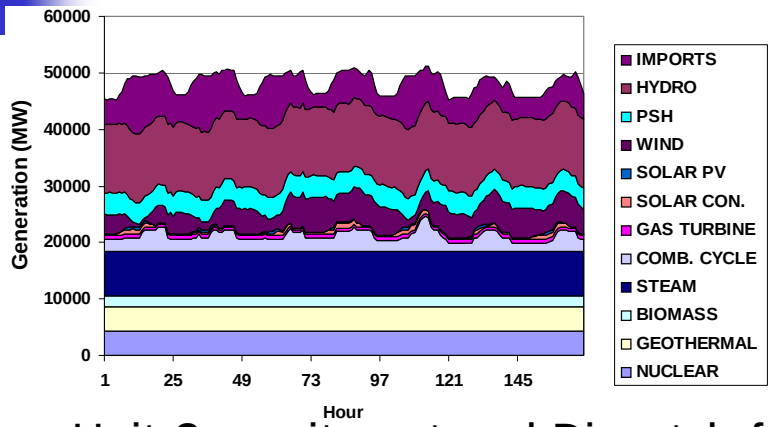
*values rounded for presentation purposes

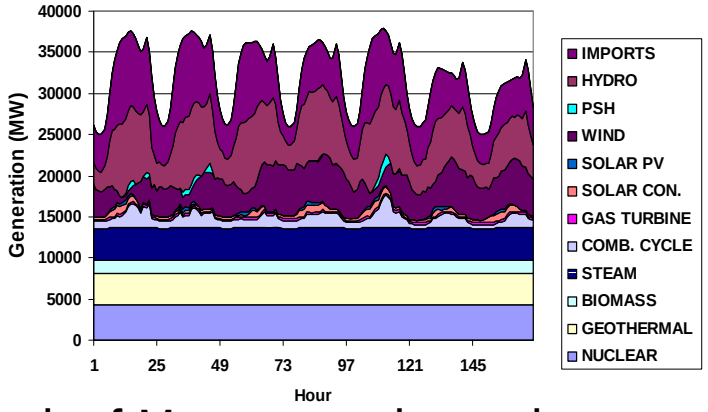
Findings/Observations Highlights

- **System operation at 33% with 12,500 MW of wind and nearly 3,000 MW of solar PV is feasible in the 2020 scenario**
- **Some operating conditions will require intermittency management strategies**
  - Periods of high load rise (summer morning or winter evening)
  - Periods of light load will increase in frequency and when combined with extremely high winds, may require mitigation
- **Value added by appropriate forecasting increase value of intermittent resources by $4.37/MWh**
- **Possible additional cost for increased regulation and load following ranging 0 to 69¢/MWh**
  - Analysis shows increased requirement of about 20MW
  - Present range of procured regulation (300-800MW up and 300-500MW down) sufficient to meet increases in need
  - If no additional regulation provided, CPS2 violations would be expected to increase about 1-2%

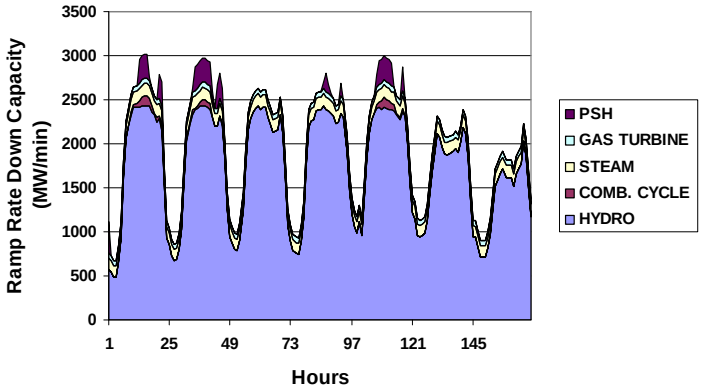
Ramping Capability

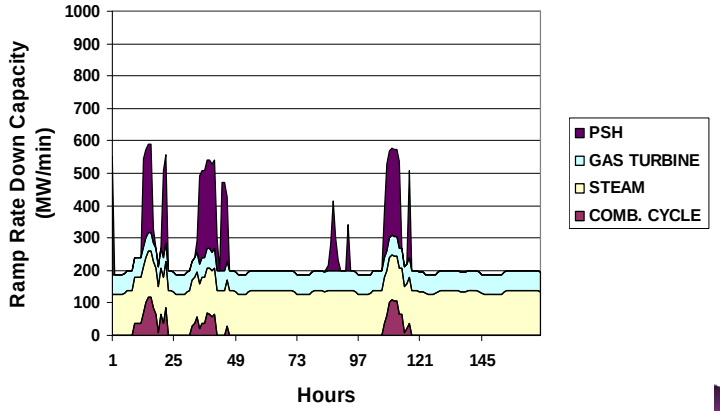
EX: May light load conditions





Unit Commitment and Dispatch for week of May – sample week



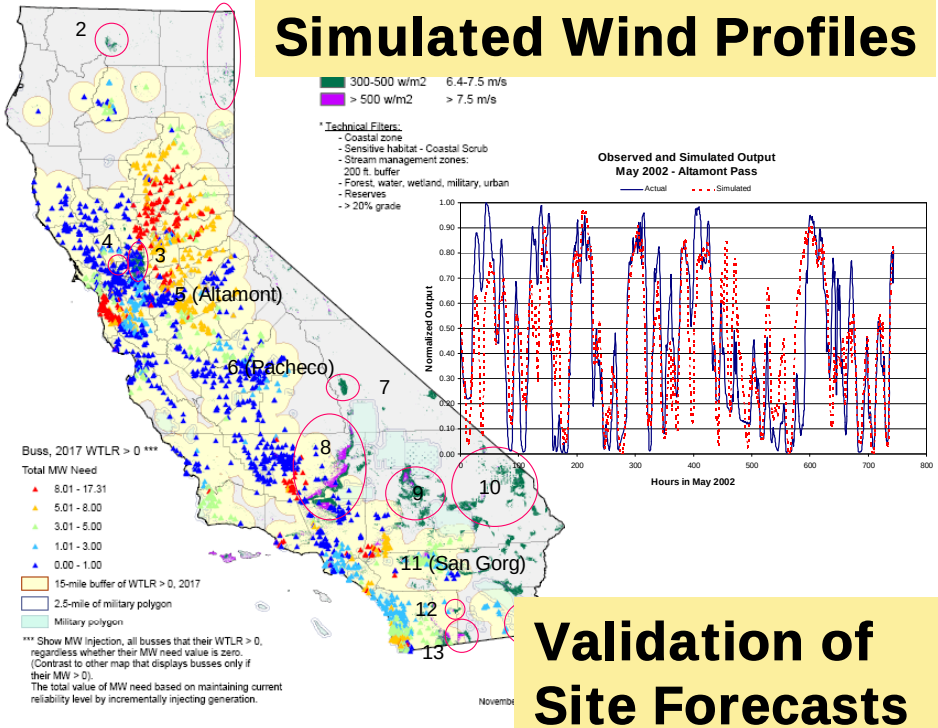


Analysis showed that even without hydro resources, the system has 200MW/min capability with a few hours outside of this capability

Considers New Sites, Technologies & Forecasts

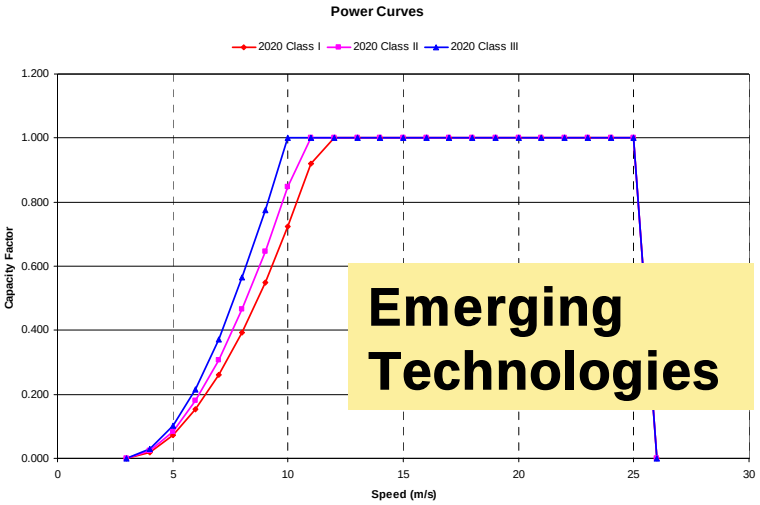
Wind output & forecast for 3 years with over 22GW of new capacity

New Locations with Simulated Wind Profiles



Validation of Site Forecasts

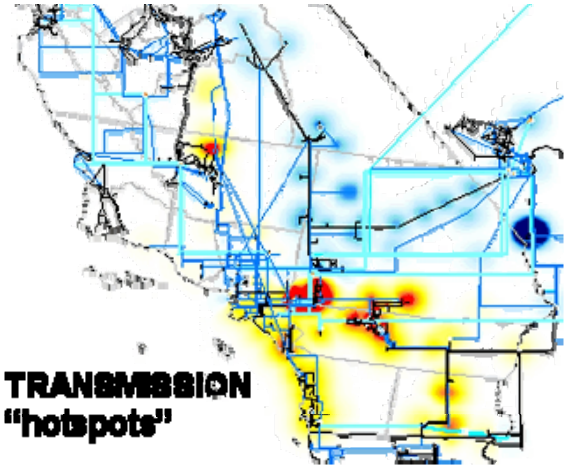
Region	Four-Hour Forecasts			Next-Day Forecasts		
	Existing	2010	2020	Existing	2010	2020
Tehachapi	9.4%	7.8%	7.5%	14.6%	12.2%	11.5%
San Gorgonio	8.9%	8.6%	NA	14.9%	14.6%	NA
Altamont	7.3%	8.1%	NA	11.3%	12.0%	NA
All	5.5%	6.3%	4.3%	8.7%	10.3%	6.5%



Emerging Technologies

- Incorporate emerging technologies & opportunities (low-speed)
- Forecasts validated using CaISO generation data from each wind region
- Addition of resources results in larger geographic diversity resulting in reductions of forecast errors

Seasonal and Geographic Diversity of Renewables



Region	Resource	Spring	Summer	Fall
Medicine Lake	**Geothermal**	X	Neutral	X
Imperial Valley	**Geothermal**	X	Neutral	
Sulfur Bank	**Geothermal**			Neutral
LADWP	**Wind**		X	X
Altamont Pass	**Wind**	X		
Solano	**Wind**	X		X
Tehachapi	**Wind**		Neutral	X
Central Valley	**Biomass**			X
SDG&E	**CSP**		Neutral	Neutral
SCE	**CSP**			Neutral
Residential	**PV**			Neutral

For Further Information

See the following links for details of IAP project, presentations and reports.

- August 15, 2006: 1st workshop
  http://www.energy.ca.gov/pier/conferences+seminars/2006-08-15_RPS_workshop/index.html
- February 13, 2007: 2nd and final workshop
  http://www.energy.ca.gov/pier/notices/ look at the Feb 13th presentations
- Three IAP reports providing methodology and the identification process for locating resource potential.
  - Intermittency Analysis Project: Characterizing New Wind Resource in California
  www.energy.ca.gov/2007publications/CEC-500-2007-014/CEC-500-2007-014.PDF
  - Intermittency Analysis Project: Summary of Preliminary Results for the 2006 Base and 2010 Tehachapi Cases - Interim Project Report
  www.energy.ca.gov/2007publications/CEC-500-2007-009/CEC-500-2007-009.PDF
  - Review of International Experience Integrating Renewable Energy Generation
  www.energy.ca.gov/2007publications/CEC-500-2007-029/CEC-500-2007-029.PDF
- Background documents supporting Commission IEPR process and renewable resource assessments can be found on the Commission websites
  http://www.energy.ca.gov/pier
  http://www.energy.ca.gov/2005_energypolicy/documents/2005_index.html#070105