Making More from Less: Environmental Constraints and California's Future Electricity Investments

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Motivation for Talk

- California policy--Provide more energy services using less fossil fuels
  - Ambitious greenhouse gas reduction goals
- Two primary mechanisms to achieve these goals create special challenges
  - Renewable energy
  - Energy efficiency
- Renewable energy
  - Intermittent—Energy can be produced only when wind, sunlight, and water exists
  - Non-dispatchable—Can only obtain energy that is available
  - Location specific—Resource only exists at specific locations

Motivation for Talk

- Energy efficiency
  - Reduce amount of fossil fuel or electricity necessary to produce given energy service
    - Heating, lighting, appliances
  - More efficient utilization of existing energy resources
    - Price-responsive final demand
- What must California's future energy infrastructure look like to support these goals?
  - Transmission expansion
  - Hourly meters for all final consumers
  - Investments in energy storage technologies
- What can Californians do to achieve this infrastructure?

California's RPS

SB 1078 established the State's Renewable Portfolio Standard (RPS).

- By the year 2010, 20% of electricity consumed in California must come from renewable resources
  - Investor-owned utilities (IOUs), community choice aggregators, and energy service providers (ESPs)
  - Publicly owned utilities not subject to 20 percent goal but must implement their own RPS
- By 2020, 33% of the energy should come from renewables
- Renewable Resources include:
  - Wind
  - Solar
  - Geothermal
  - Biomass
  - Small hydro (less than 30 MW)

Progress Toward Goal

Since implementation of SB 1078 in 2002 there has been little progress towards goal

Table 1. Comparison of Renewable Generation, 2002–2005

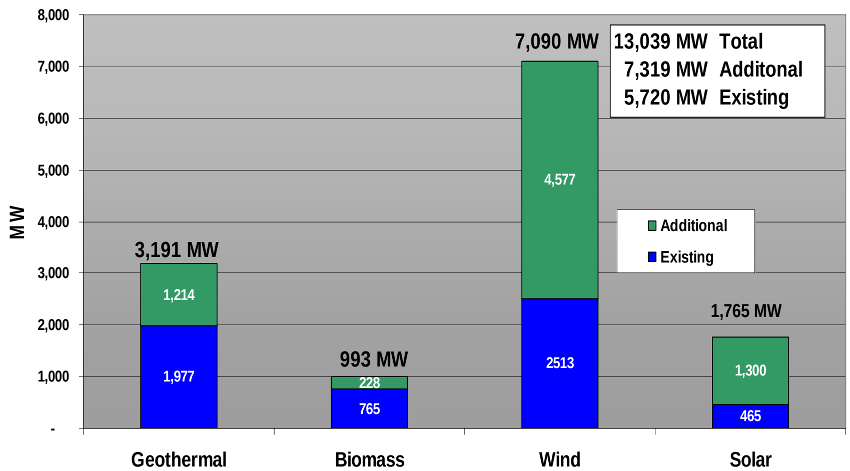
	PG&E	SCE	SDG&E	Total
2002 Retail Sales (GWh)	70,797	68,462	14,301	153,560
2002 Generated/Sold RPS Renewable (GWh)	7,392	11,658	141	19,191
BASELINE: 2002 IOU RPS Renewable Generation as % of IOU Retail Sales	10.4%	17.0%	1.0%	12.5%
2005 Retail Sales (GWh)	72,727	75,302	16,002	164,030
2005 RPS Renewable Generation (GWh)	8,650	12,930	825	22,405
IOU RPS Renewable GWh as % of IOU Retail Sales	11.9%	17.2%	5.2%	13.6%

Sources: 2002 data from 2004 Annual Procurement Target filings of PG&E, SCE, and SDG&E to the CPUC, as required in Rulemaking 01-10-024; 2005 data from August 1, 2006 Renewables Portfolio Standard Compliance Filing to CPUC of PG&E, SCE, and SDG&E.

Progress Toward Goal

- IOUs have made more progress in contracting for future deliveries of renewable energy
  - As of end of 2006 IOUs have signed 69 contracts for approximately 3,500 MW of renewable generation capacity
    - CPUC estimates approximately 4,500 MW is necessary to meet RPS goal
  - Several contracts have been cancelled, at least 10 are not expected to deliver until 2010, and at least 13 have been delayed
  - Many contracts are from facilities that were in process before RPS was implemented
- ESPs had 0.25 percent renewable share in 2005
- All publicly-owned utilities are below IOU aggregate share
  - In 2005 LADWP at 2.4 percent, SMUD at 11 percent, IID 7.6 percent

Existing California Renewable Generation and Possible Additions to meet the 20% RPS Goal by 2010*



* Data on additional renewable resource is based on a current CEC studies on renewables.
Potential retirements of existing resources and repowering projects are not included.

Wind Generation Regions in CA

Barriers to Meeting Goals

- Transmission lines needed to access major renewable regions
  - Tehachapi region has close to 4,500 MW wind potential
    - Transmission capacity from region inadequate for resource potential
  - Imperial Valley region has significant geothermal and solar resource potential
    - Transmission capacity from region inadequate for resource potential

Barriers to Meeting Goals

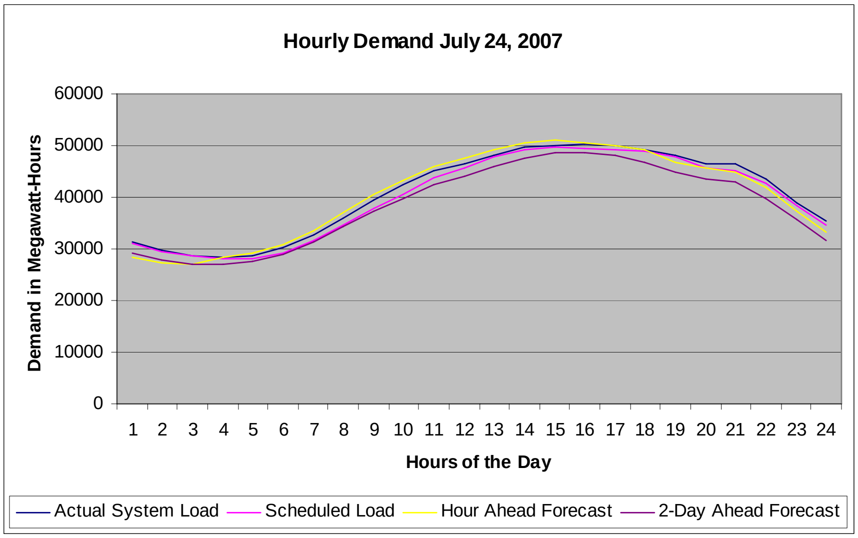
- Extremely difficult to obtain permit and cost recovery for transmission expansions in California
  - Transmission expansion process subject to unnecessary delays
    - Many due to NIMBY concerns
  - California process for transmission expansion assessment ill-suited to current wholesale market regime
    - Ignores state-wide and regional benefits of expansion
  - Embedded cost of California’s transmission network is less 10 percent of delivered price of electricity
    - Cost of expansions should not be a major factor in decisions
    - Transmission expansions increase competitiveness of wholesale market
      - Wolak, F.A., “The Benefits of an Electron Superhighway” see web-site

Managing Intermittency

- Electricity supply must equal demand at every instant in time at all locations in transmission network
  - Requires some units to follows second-to-second instructions from system operator—Automatic Generation Control (AGC)
    - AGC only provided by fossil-fuel units in California
  - Requires units to turn on and off and ramp up and down to meet load increases and decreases through day
    - Wind and solar units cannot provide this service
- Similar to operating automobile, starting and accelerating very costly in terms of fuel efficiency, greenhouse gases and other pollutants

Managing Intermittency

- Wind and other renewables often unavailable during peak periods
  - July 2006 heat storm, July 24 demand in California ISO control area hit a 1 in 50 year peak of 50,200 MW
    - Less than 5 percent of installed wind capacity was operating at the time
  - Tehachapi wind energy comes primarily at night
  - Solar photovoltaic panels less efficient during very hot portion of day



Managing Intermittency

- Renewable energy can disappear extremely rapidly
  - Sun can go behind cloud
  - Wind can suddenly shift or stop blowing
- Significant system operation challenges associated with large renewable energy share
  - With 20 percent renewable share, significant fraction of energy can disappear with little warning
  - Operators need to hold more operating reserves
    - Fossil fuel units running with unloaded capacity
    - Quick start combustion turbine generation units
  - Energy storage technologies required
    - Transfer off-peak power to peak

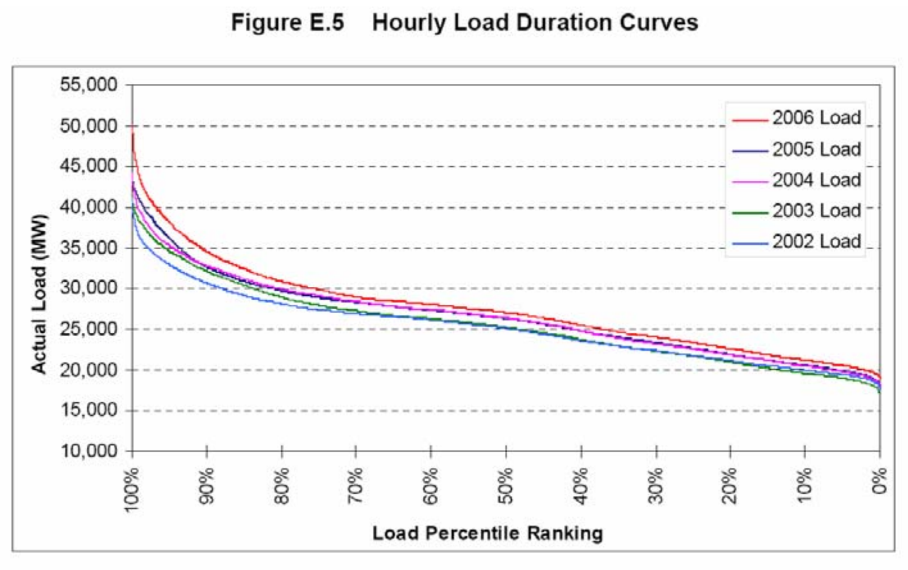
Managing Intermittency

- Example from Spanish market
  - Spain has approximately 12,000 MW of wind resources
    - It has two system operators
      - Regulator system operator
      - Wind system operator
    - Roughly 700 MW of wind counted as reserves by system operator
  - Hydroelectric energy can complement wind and solar power
    - Fast response
    - Reservoir for storage

Economics of Energy Efficiency

- Variation in electricity demand throughout day and year
  - On 7/24/07 demand ranged from 28,300 MW to 50,200 MW
- Average MW consumption per hour during 2006
  - Approximately 31,000 MW
  - Peak demand for 2006 is 50,200 MW
- Reducing peak demand
  - Eliminate need to construct new generation capacity
  - Can retire old inefficient units located close to large cities
- Significant fraction of generation capacity used very infrequently
  - In California approximately 5,000 MW (10 percent of peak demand) used less than 2 percent of hours of the year
  - With global climate change larger fraction is likely to be used even less frequently

California ISO Control Area



Economics of Energy Efficiency

- Ways to smooth demand peaks
  - Technologies for storing electricity
  - Price-responsive final demand
- Necessary infrastructure for price-responsive demand
  - Meters capable of recording hourly consumption
    - Conventional meters are read once per month
      - Monthly bill is difference between meter readings
- The role of prices in smoothing demand peaks
  - Value of energy storage technology is energy cost savings from buying cheap energy and selling it as expensive energy

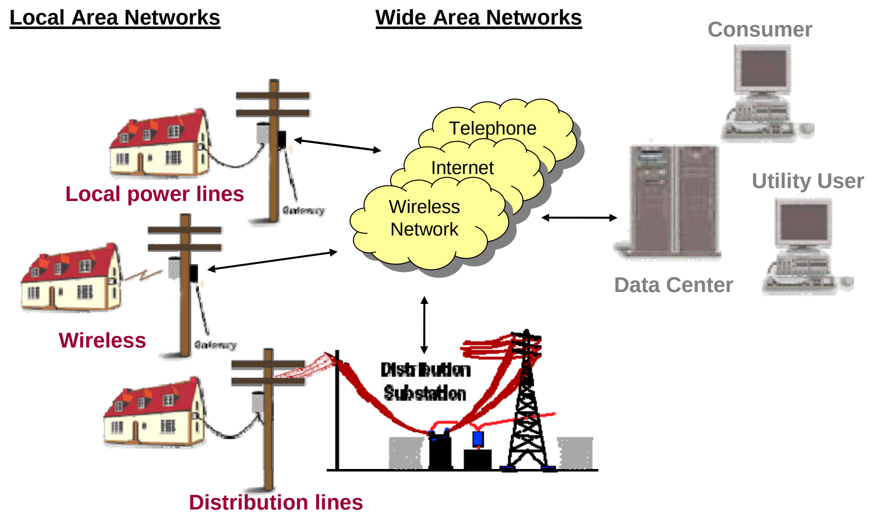
Economics of Energy Storage

- Suppose it costs 2 MWh to store 1 MWh in off-peak period to sell in peak period of day
  - If price during peak period more than twice price in off-peak there are revenues to pay for investments in energy storage technology
- If average peak price is $30/MWh and average off-peak price is $10/MWh
  - Total revenues for 1 MWh energy storage per day to sell during peak hour each day of the year is $3,650
- Larger the price differences between peak and off-peak hours make more energy storage technology investments profitable

Price-Responsive Demand

- Lack of hourly metering of final demand makes it impossible to set hourly retail prices that pass-through hourly wholesale price
  - Customer reduces monthly bill by same amount by reducing consumption by 1 KWh during hour when wholesale price is $5000/MWh as he does when price is $0/MWh
- Economics of hourly meters is rapidly changing because of technological change
  - Major cost of monthly reading for conventional meters is labor cost
  - Modern hourly meters are read remotely by wireless or wireline technology

Advanced Metering Communication Networks



Price-Responsive Demand

- Substantial state-level regulatory barriers to active demand-side participation
  - "Consumers must be protected from short-term price risk"
  - "Electricity is an essential commodity consumers shouldn't be protected from volatile wholesale prices"
  - Wolak, Frank (2007) "Managing Demand-Side Economic and Political Constraints on Electricity Industry Re-structuring Processes," on web-site.

Price-Responsive Demand

- Interval meters have up-front installation costs and communications network cost
  - Variable cost per meter per month is less than $0.50 per meter
  - Economic case for hourly meters can almost be made based on metering cost saving alone
  - Estimated wholesale energy purchase costs savings improves economics
- A number of large retailers in the United States, Canada, Australia, Italy have or are installing universal hourly metering
  - Metering is a regulated distribution network service

Price-Responsive Demand

- Important point--Fixed-retail price does not imply customers do not pay real-time hourly wholesale price in retail prices
  - Retailers will go bankrupt if this outcome does not hold on annual basis
  - Customers just cannot benefit from lower annual bill from reducing consumption during high-priced hours

Price-Responsive Demand

- All California investor-owned utilities are installing hourly meters for all customers
  - Major barrier to active demand-side participation in California will soon be eliminated
- Remaining challenge is regulatory barrier
  - Recent empirical evidence on "politically acceptable real-time pricing" is promising
    - Methods to share risk of responding short-term prices between consumers and retailers

Politically Acceptable Real-Time Pricing

- Major complaints with implementing real-time retail pricing is that customers cannot respond to hourly wholesale prices
  - Difficult to determine when is best time to take action
- If action is costly and price increase is one hour in duration, a very large price spike is needed to cause most customers to respond
  - For residential customer with (2.5 KW) flat load shape, a large price spike is needed to overcome $5 cost of taking action to reduce demand by 20 percent
    - $100,000/MWh for a 0.5 KWh demand reduction for 1 hour
  - Longer duration of high prices requires smaller increase in prices
    - $50,000/MWh average price for 0.5 KWh demand reduction for 2 hours
- For residential customers, mechanisms that share risk of high wholesale price with retailer can result in more customers taking on real-time price risk
  - Critical Peak Pricing (CPP) is a very popular way to do this

Politically Acceptable Real-Time Pricing

- Critical Peak Pricing—Customer consumes according to usual fixed-price tariff or increasing block fixed-price tariff during all hours of each day
- Customers face risk of Critical Peak Pricing (CPP) day
  - Retailer commits to no more than X CPP days in a give time interval
    - For example 12 CPP days during summer months
  - During peak-period of a CPP day, customer pays a much higher price for electricity
    - Strong incentive reduce demand during this time period
    - Peak period is typically 4 to 6 hours during day, say noon to 6 pm
  - Retailer faces risk that after CPP events is called wholesale price make falls below wholesale price implicit in CPP retail price

Politically Acceptable Real-Time Pricing

- CPP with rebate mechanism is even more popular with consumers
  - Consumption during peak hours of CPP days receives a rebate relative to household's reference consumption, if its actual consumption is less than reference consumption
  - Rebate implies that customers *guaranteed not to pay more* than they would have under baseline tariff
    - "You can't lose from rebate mechanism"
    - Reward customers with rebate for reductions during stressed system conditions
    - Politically palatable form of real-time pricing
  - Retailer faces risk that total rebates paid will be more than wholesale energy procurement cost savings
    - If CPP day wholesale price is $300/MWh then if wholesale price is below $300/MWh, by calling a CPP days the retailer loses money

Benefits of Real-Time Pricing

- Wolak (2006) "Residential Customer Response to Real-Time Pricing: The Anaheim Critical-Peak Pricing Experiment" on web-site
    - 13% average demand reduction on CPP days
- Suppose regulators set CPP with rebate mechanism as default rate for all California consumers
    - On CPP days demand is reduced by 13%
- Declaring a maximum of 12 CPP days per summer
    - Could eliminate the need for approximately 5,000 MW of generation capacity
- Demand response has potential to reduce system peaks and need for construction and operation of peaking units
    - CPUC must require customers and retailers to manage jointly short-term wholesale price risk

What Can Californians Do?

- Allow transmission upgrades necessary for deliverability of renewable energy
- Do not suppress true price volatility in wholesale market
    - Makes both energy storage and price responsive demand economic
- Default retail price in California should be hourly pass-through of real-time wholesale price
    - Provides customers with an incentive to manage wholesale price risk, rather than simply pay for it in higher average fixed-price over the entire year

Questions/Comments

For more information

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