

Challenges in Designing Power Markets: *The California Experience*

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Outline



- I. Why do incentives matter?
- II. California history
- III. Today's Calif market design challenges
 1. Incenting flexibility to accommodate renewables
 2. Expanding the market geographically
 3. Capacity credit for variable renewables
 4. Harmonizing markets for bulk & distributed resources
- IV. Conclusion: Continue to Kludge?



I. Incentives matter!



www.au.sleeping-out.com/australia-map.asp



en.wikipedia.org/wiki/File:Success_prison_hulk.jpg
PRISON HULK "SUCCESS" AT HOBART. 1855. PHOTOGRAPH BY J. H. COOPER.



www.npr.org/sections/money/2010/09/09/129757852/pop_quiz-how-do-you-stop-sea-captains-from-killing-their-passengers

Getting incentives right is tricky!

(thanks to Cindy Bothwell for this example)

PNM offers two incentives that reduce your electric bill:

- **PNM REC Purchase Program:** Because you're adding renewable-fueled power to the PNM system, and that helps us meet our environmental goals, we credit your account 15 cents per kilowatt-hour for energy that your facility generates and consumes on site within a given billing period.



7/6/2010



Alamogordo Daily News

Kloepper said he set up a system to waste power in a small building at the site in order to recoup the value of his RECs from PNM, and showed the system to Teague. He explained a water heater heats 30 gallons of water to about 120 degrees, then the water is circulated through 450 feet of garden hose inside a refrigerator to cool back down and is then piped back into the water heater. The process repeats 12 times per day.

II. Market Design is About Getting the Incentives Right: *California History*

- ▶ 1996: AB 1890 passed unanimously
 - PX traded power *day-ahead*
 - Three zones, disregarded other transmission constraints
 - No forward contracting allowed
 - CAISO then ran *balancing* market to ensure feasibility (“incs” and “decs”)



<https://s-media-cache-ak0.pinimg.com/564x/79/19/3d/79193dde918fd18657e2a50198dbf667.jpg>

The 2000–2001 Crisis: Example Problems

1. No forward contracting

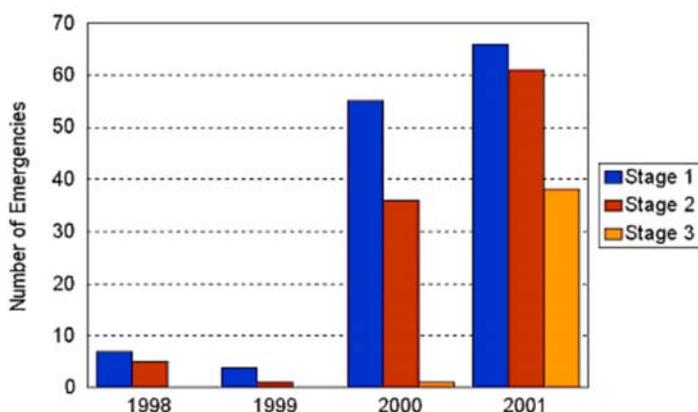
→ large incentive to take capacity off line (market power!)

- “7 Plagues of Egypt”
- Wholesale power bill → \$20B
- 38 rotating blackouts in 2001

2. Ignore constraints → incent “dec” game:

- Generators in “gen pocket” overschedule in high-price zone,
- Then they buy back power at lower price in real time

California's Declared Staged Power Emergencies, 1998--May 22, 2001



Source: California Independent System Operator



CAISO Response: ~~MD02, MD03, ...~~, 2009 MRTU (Market Redesign & Technology Upgrade)

- ▶ Features of Market Redesign:
 - Day-ahead and real-time markets with arbitrage
 - Co-optimized energy & ancillary services
 - Forward contracting requirements
 - Locational marginal pricing
 - Financial transmission rights
- ▶ Prices are competitive
- ▶ Contrast to EU markets



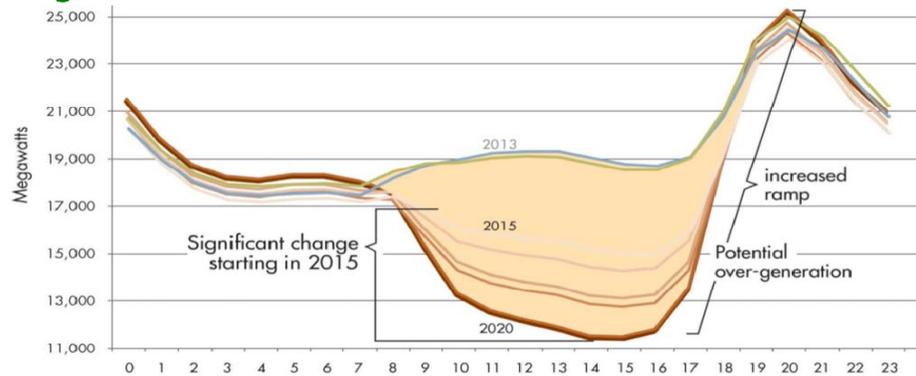
III. New Challenges in California's Power Market (1)

- ▶ California AB32 Cap & Trade:
 - Goal: Reduce CO₂ to 1990 levels
 - Allocate allowances to power plants, & trade
- ▶ Regional Integration:
 - PacifiCorp (5 states) fully joining CAISO
 - Energy Imbalance Market with 7 other utilities



New Challenges in California's Power Market (2)

- ▶ **Renewable Policy:**
 - 33% of electricity by 2020, 50% by 2030
 - But restrict imports
- ▶ **Integrating Distributed Resources:**
 - CAISO behind other markets in demand response
 - "Transmission Access Charge"
 - Avoided by behind-the-meter distributed & bulk renewables
 - But paid by front-of-meter distributed resources
 - Inflexible & high retail rates favor behind-the-meter renewables



How Can We....?

- ▶ **Expand market, & preserve "environmental integrity"?**
 - *Account for out-of-state CO₂ emissions*
 - *Facilitate development of least-cost renewable resources*
- ▶ **Oversee a multistate entity?**
- ▶ **Promote efficient transmission construction?**
 - *Planning methods*
 - *Cost allocation*
- ▶ **Support flexible "backup" capacity for renewables?**
- ▶ **Reward contributions to system reliability (capacity credits)?**
- ▶ **Incent the right mix of distributed & centralized resources?**



Stakeholder engagement opportunities

Current initiatives

Aliso Canyon gas-electric coordination

Bid cost recovery enhancements

Bidding rules enhancements

Black start and system restoration phase 2

Commitment costs

- Commitment cost enhancements phase 3

Commitment costs and default energy bid enhancements

Congestion revenue rights clawback rule modification

Contingency modeling enhancements

Demand response

- Demand response net benefits test

Energy storage and distributed energy resources

- Energy storage and distributed energy resources phase 1
- Energy storage and distributed energy resources phase 2

Expanding metering and telemetry options

Flexible resource adequacy criteria and must-offer obligations

Frequency response phase 2

Generator contingency and remedial action scheme modeling

Generator interconnection driven network upgrade cost recovery

Load serving entity definition refinement

Load serving entity definition refinement

Local market power mitigation enhancements 2015

Metering rules enhancements

Pricing enhancements

Reactive power requirements and financial compensation

Reliability services

Review transmission access charge wholesale billing determinant

Revised settlement statement and dispute timeline for T+35M

Self-schedules bid cost recovery allocation and bid floor

Stepped constraint parameters

Transmission access charge options

All regional integration stakeholder activities

Recurring stakeholder processes

2016-2017 transmission planning process

Budget and grid management charge process

Flexible capacity needs technical study process

Interregional transmission coordination

Local capacity requirements process

Participating transmission owner per unit costs

Stakeholder initiatives catalog process

Energy Imbalance Market activities

EIM Governing Body draft guidance document web conference

All active and archived EIM stakeholder activities

Regional energy market initiatives

Regional energy market

Metering rules enhancements

PacifiCorp participation study

Regional Integration and EIM Greenhouse Gas Compliance

Regional resource adequacy

Tariff clarifications filing process

Initiatives in implementation phase

Commitment cost enhancements phase 2

FERC order no 764 market changes

Frequency response

Merced Irrigation District transition

Pay for performance regulation

Payment default allocation

Reliability must-run pump load

Issue 1: Local Greenhouse Gas Regulation & Regional Markets

- ▶ AB32 covers California emissions
 - *Can't* regulate what other states do to meet their demand
 - *Can* attribute emissions to imports. How to do that? (Liu, Chen, Hobbs, *OR*, 2011)
 1. Identify particular facilities with imports? → "Contract shuffling"
 2. Average rates?
 3. Marginal rates for entire western US assuming efficient dispatch?



Issue 1: Local GHG Regulation & Regional Markets

- ▶ How do we resolve two policy objectives?
 1. *Cal. Air Resources Board*: expanding the CAISO market shouldn't worsen total emissions
 - Prefers no net increase on an *hourly* basis!
 2. *Western utilities*: econ benefits of a wider balancing market
 - Also: increase the total emissions & cost savings of renewables
- ▶ Delicate balancing: count external emissions hourly but still obtain gains from trade. **“Two step” proposal**:
 1. Calculate “counterfactual” of dispatch without Calif imports in balancing market
 2. Actual market operations
 - Then retire emissions allowances to cover increased emissions



Issue 2: Flexibility (“Ramp”)

- ▶ Should it be rewarded in the spot market?
 - In theory:
 - Let's reward ability to deliver *when needed*
 - Energy price volatility supports optimal ramp
- ▶ But averaging over 5, 15, 60 minute intervals dampens signals
 - also misses lumpy costs (start ups)



Issue 2: Flexibility (Ramp)

- ▶ **Proposal:** Belt and suspenders
 - *Spot market fixes:* If energy prices insufficient, then add new reserve products
 - “Flexiramp” (headroom up and down for next interval) (Wang and Hobbs, IEEE TPWRS 2015)
 - “Mileage payments” for frequency regulation
 - Both have fetched surprisingly low prices
 - *Capacity market fix:* Flexible “Resource Adequacy” (capacity market) requirement
 - But how do you compare the following?
 - Fully dispatchable turbines
 - Renewables that can turn down
 - 1 start/day resources
 - 4 calls/mo demand response
 - Fly wheels (15 minutes stored)

→ The problem of kludges



Issue 3: How much capacity credit to give to renewables?

- ▶ Mechanisms for “resource adequacy” (contribution of resources to system reliability) is a state responsibility, but a multistate market must have a consistent approach:
 - If a perfectly reliable, flexible resource gets \$X/MW, how much should other resources get paid?
 - **Proposal:** “Effective Load Carrying Capability”
- ▶ Devilish details. *Pay.*
 - Locationally differentiated?
 - Penalize larger thermal resource?
 - Account for operating constraints (flexibility)?
 - Change from year-to-year?
 - Average or marginal ELCC?

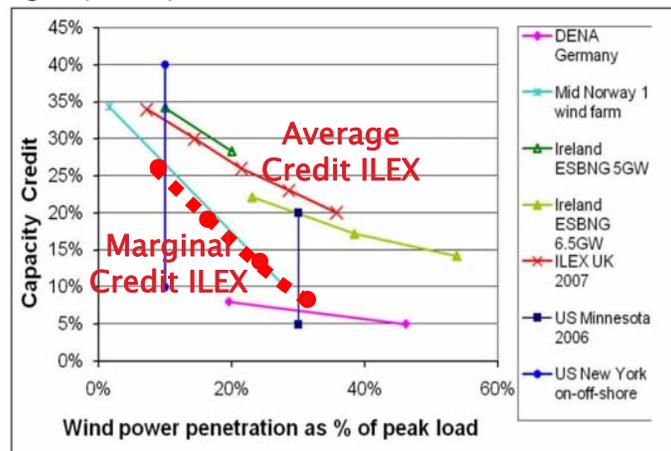
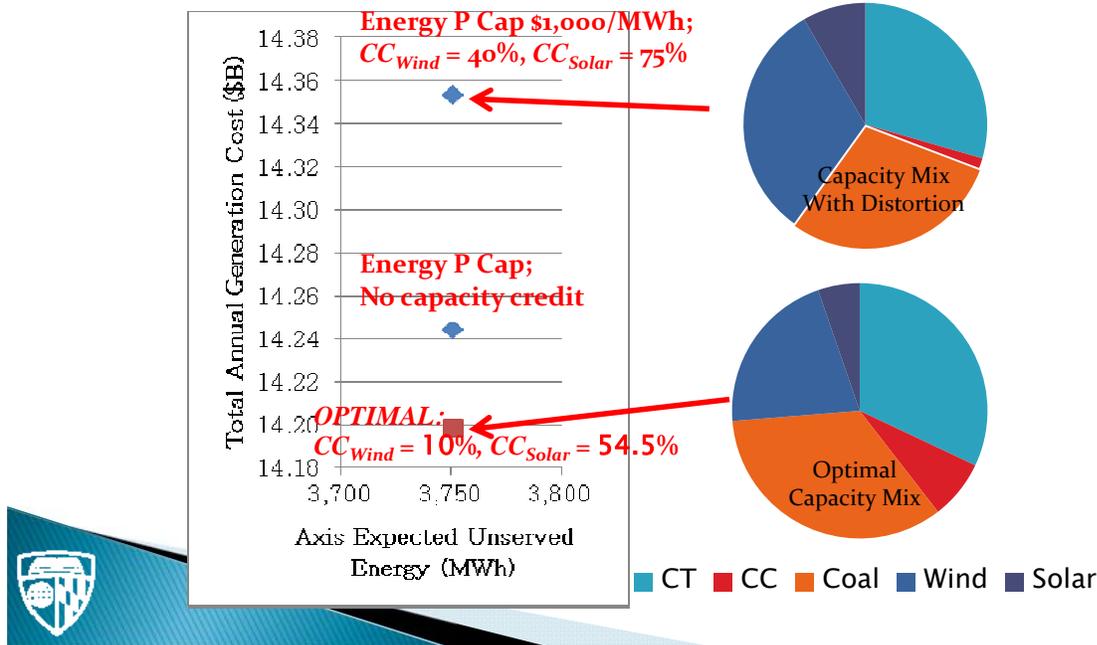


Fig. 5. Capacity Value of Wind Power with increasing wind penetration (Source: Keane et al., IEEE TPWRS, 26, 2011, 564–572)



Issue 3: How much capacity credit to give to renewables?

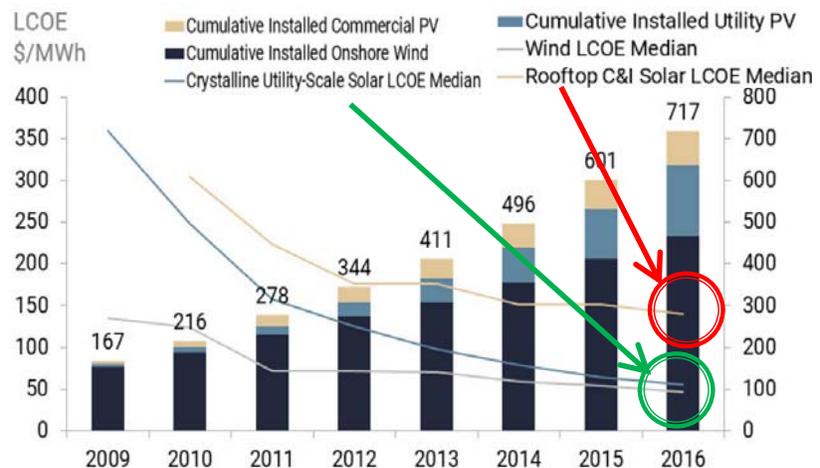
- ▶ What are welfare effects of giving the wrong credit? (Bothwell & Hobbs, *The Energy Journal*, in press)



Issue 4: Harmonizing Grid-Scale & Distributed Decisions

- ▶ Contribution to California load through Oct. 2016:
 - Bulk PV (10%); Distributed PV another 4%
- ▶ Behind-the-meter PV: costs 2–3 times utility-scale PV
 - BTM highly profitable: retail rates + netting + subsidies

- ▶ CAISO's TAC = \$10.4/MWh. *Issues:*
 - Base on MWh or peak MW?
 - Which drives transmission costs?
 - Measured at the retail meter, or at the bulk system interface?
 - **Proposal** is pending analysis of drivers



IV. Conclusion: When ought you kludge... And when start from scratch?

J. Ely, *American Economic Review* 2013 (thanks to Steve Stoft)

In July of 2004, Microsoft announced that the release of Vista, the next generation of the Windows operating system, would be delayed until late 2006. Jim Allchin famously walked into the office of Bill Gates and proclaimed, “It’s not going to work.” Development of Windows had become unmanageable and Allchin decided that Vista would have to be rewritten essentially from scratch.

Mr. Allchin’s reforms address a problem dating to Microsoft’s beginnings. PC users wanted cool and useful features quickly. They tolerated—or didn’t notice—the bugs riddling the software. Problems could always be patched over. With each patch and enhancement, it became harder to strap new features onto the software since new code could affect everything else in unpredictable ways.

