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Electricity Market Design:
A Perspective from the US & CAISO

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For further information and useful links on market design principles and applications, visit powermarkets.org

Outline

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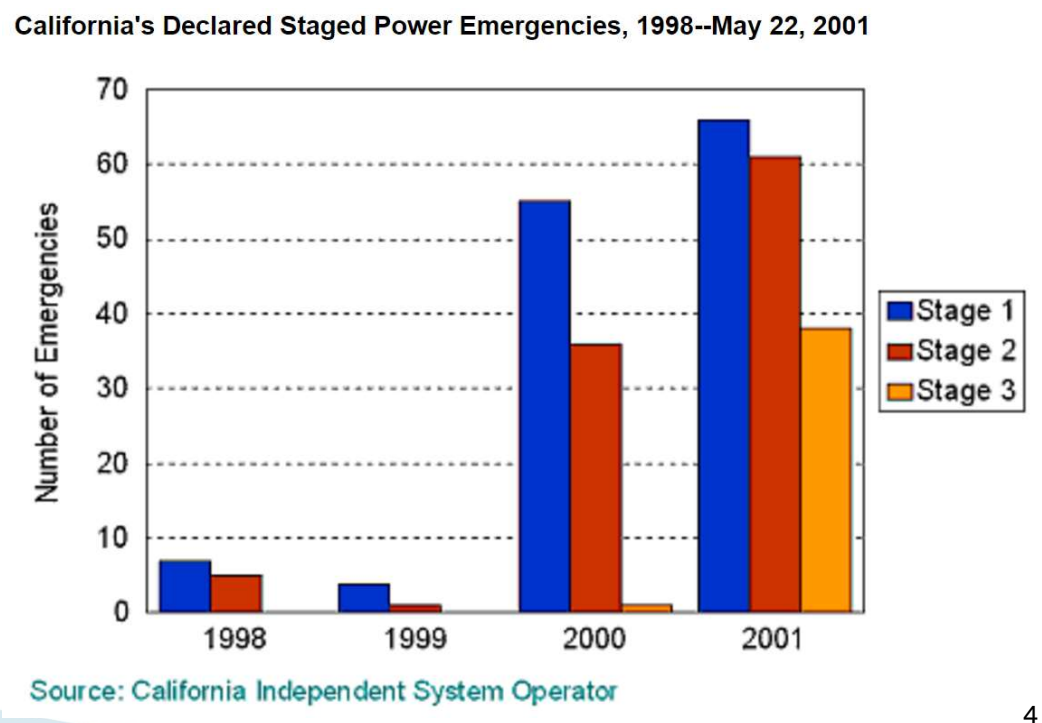
I. California's history of design challenges
II. Today's challenges
   1. Pursuing regional integration & environmental goals
   2. Long-run procurement
   3. Harmonizing markets for bulk & distributed resources
III. Conclusion: Continue to Kludge?

I. Calif's History of Market Design Challenges

- 1996: AB 1890 passed unanimously
  - Vertical unbundling
  - *Day-ahead:* PX traded power
    - Three zones
    - No forward contracting allowed
  - *Balancing:* Then CAISO inc'ed & dec'ed to attain feasibility

- The 2000-2001 crisis
  - Blackouts
  - Bulk power costs → $20B
  - Why?
    - 7 plagues of Egypt
    - No forward contracting
    - "Dec game"



CAISO response: Market redesign ~~MD02~~, ~~MD03~~, …, 2009 MRTU (Market Redesign & Technology Upgrade)

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- Features of Redesign:
  - Day-ahead and real-time markets with locational marginal prices
  - Co-optimized energy & ancillary services
  - Forward contracting requirements
  - Financial transmission rights
- Prices now competitive

Blackouts of August 2020

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Figure 4.1: August Temperatures 1985 - 2020

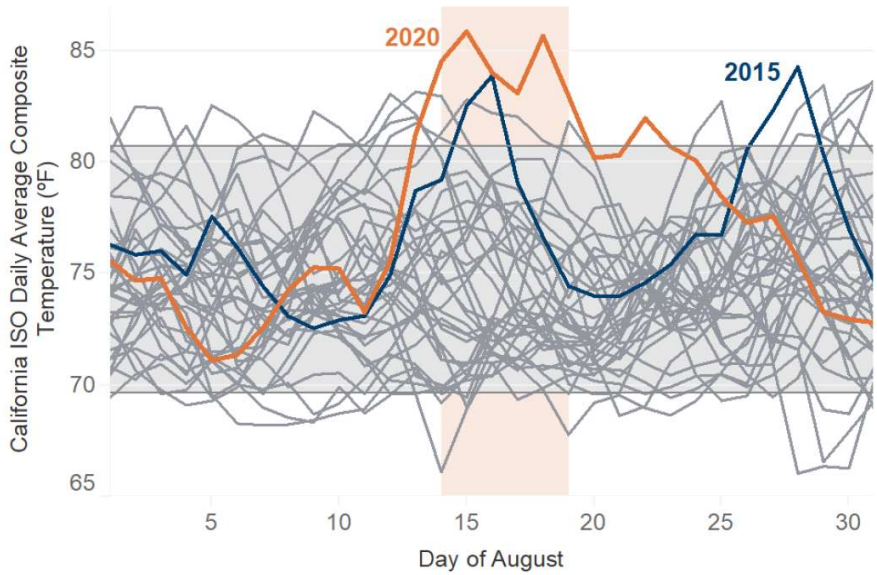
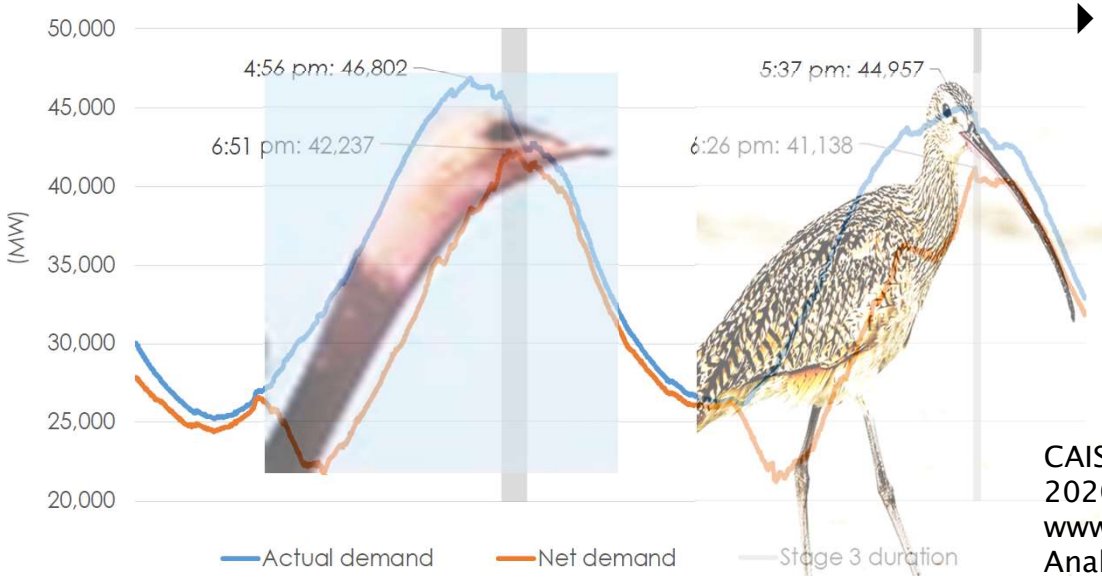


Figure ES.2: Demand and Net Demand for August 14 and 15

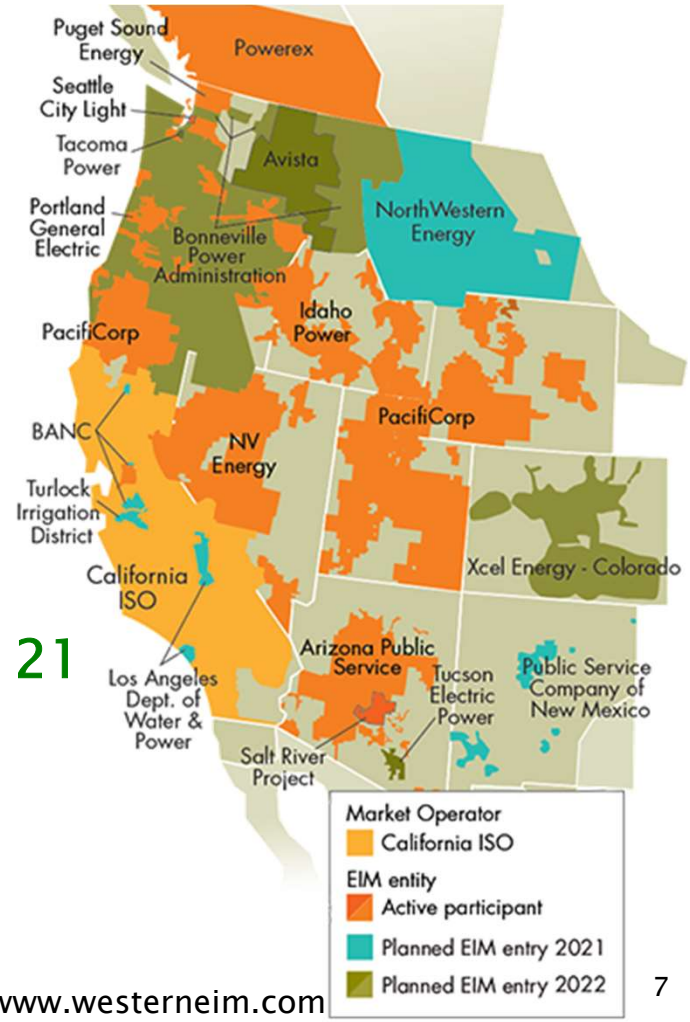


- First Rotating blackouts ("Stage 3") since 2001
- "Musical chairs" in the west…which CAISO lost due to transmission derates & mishandling of CAISO exports
- "Resource adequacy" markets:
  - Overestimated portfolio reliability
  - Overcredited certain resources

CAISO, Preliminary Root Cause Analysis, Mid-August 2020 Heat Storm, Oct. 6, 2020, www.caiso.com/Documents/Preliminary-Root-Cause-Analysis-Rotating-Outages-August-2020.pdf

III. Today's California Challenges

- California Environmental Goals:
  - AB32 CO_2 Cap&Trade: Reduce to 1990 levels
  - SB100 renewable portfolio standard: 60% by 2030, 100% carbon free by 2045
  - *Challenge:*
    - Achieve real environmental improvements
      - in spite of carbon leakage
    - Do so cost-effectively
      - but now restrict renewable import credits,
      - tilt towards costly behind-the-meter
- Regional Integration:
  - Real-time Energy Imbalance Market with 21 other utilities
  - *Challenge:* Extend to operating reserves, day-ahead, and capacity markets



www.westerneim.com

New Challenges in California's Power Market, Cont.

- Resource investment
  - Planning: largely policy driven
  - *Challenge:* Tallying reliability
    - *Old fashioned:* "add up derated capacity and compare to reserve margin"
      - Works well when many thermal units with independent and small outage rates, that are independent of load
    - *Need:* portfolio assessment that recognizes statistical dependence, diminishing returns, location dependence
- Integrating Distributed Resources
  - Huge wave of behind-the-meter PV
  - *Challenge:* Violations of "Law of One Price"
    - Inflexible & high retail rates favor behind-the-meter renewables
    - Hundreds of $M in smart meters, but little real-time pricing → Crabbed demand response
    - "Transmission Access Charge"
      - Avoided by behind-the-meter distributed & grid-scale renewables
      - Paid by front-of-meter distributed resources

How Can We….?

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1. Expand market, & preserve "environmental integrity"?
   - *Account for out-of-state CO_2 emissions*
   - *Facilitate development of least-cost renewable resources*

2. Reward contributions to system reliability (capacity credits) and support efficient long-run procurement?

3. Incent the right mix of distributed & centralized resources?

caiso.com

Home > Stay Informed > Stakeholder Processes

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 modificati

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

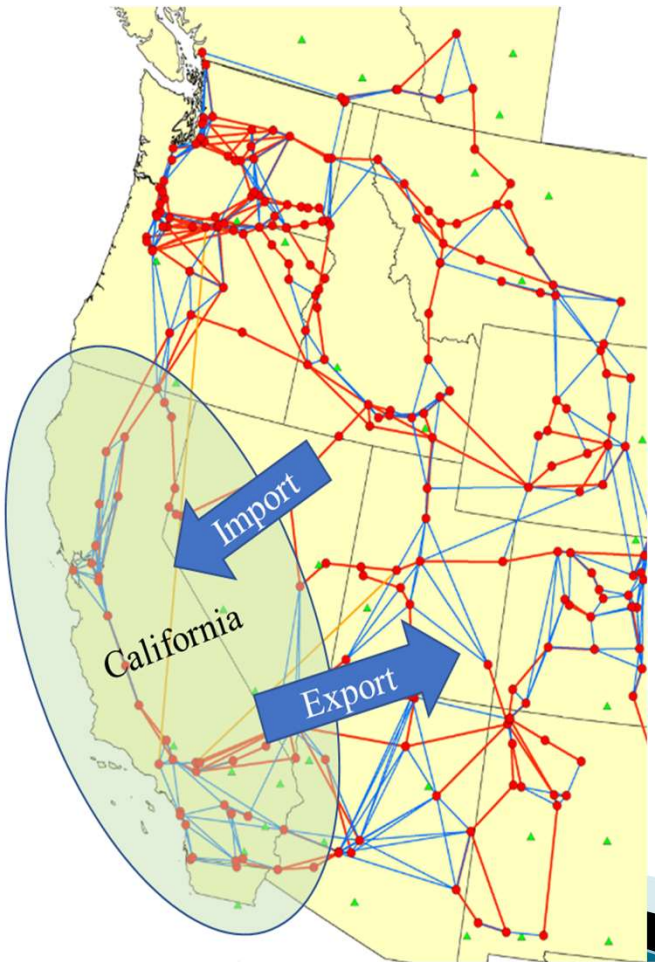
Merced Irrigation District transition

Pay for performance regulation

Payment default allocation

Reliability must-run pump load

Issue 1: Local CO_2 Regulation vs. Regional Power Markets



- AB32 covers California emissions
  - *Can't* regulate how other states meet their demand
  - *Can* attribute emissions to imports. How? (Liu, Chen, Hobbs, *OR*, 2011)
    1. Identify which particular facilities produce the imports?
       → "Contract shuffling"
    2. Average emission rates?
    3. Marginal rates for entire western US?

Effect of "deemed CO_2 emission rates" for CA imported power

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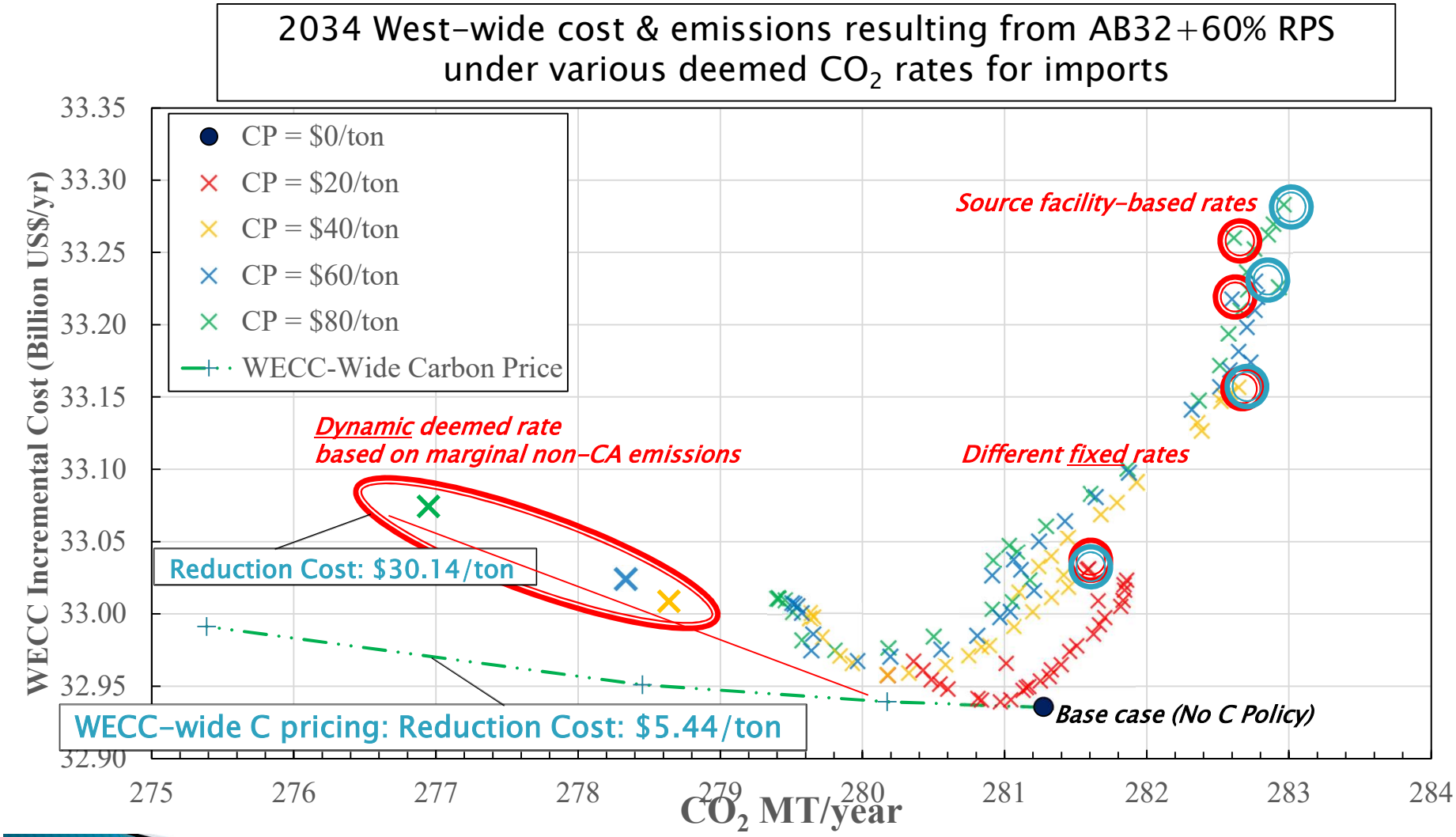
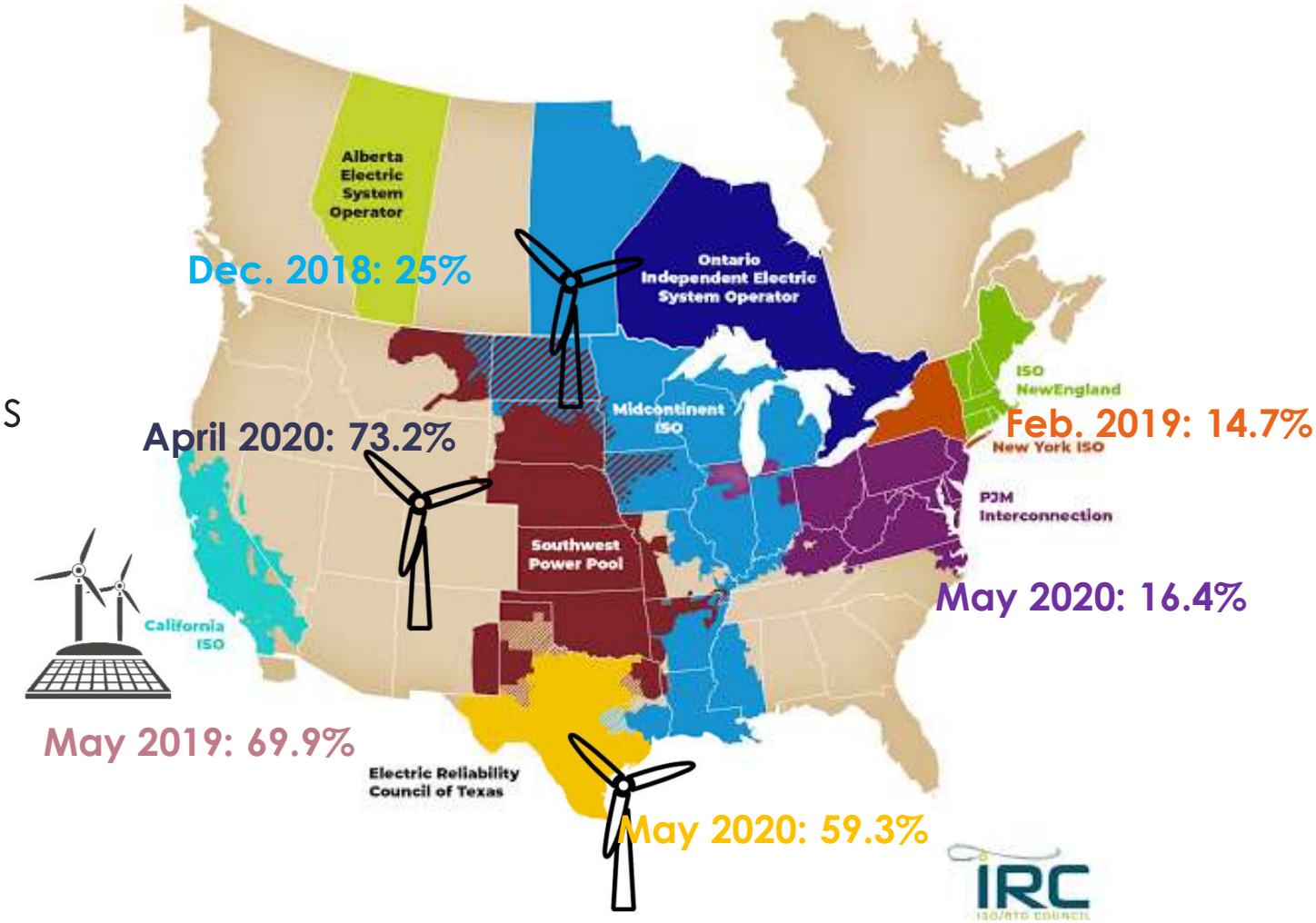


Q. Xu, B. Hobbs, Economic Efficiency of Alternative Border Carbon Adjustment Schemes: A Case Study of California Carbon Pricing and the Western North American Power Market, EPRG WP, Dec. 2020, www.eprg.group.cam.ac.uk/eprg-working-paper-2032

Issue 2: How to ensure efficient investment that meets policy goals?

Variable Renewable instantaneous penetration records



Thanks to Erik Ela, EPRI

- **Why risk of underinvestment in supply?**
  - Market power
  - Caps on energy P's (missing money) → resources don't earn full value of their production during times of scarcity
  - Absence of markets for long-term contracts → generators can't hedge long-term risks
  - Policy uncertainty

- **Policy response: Capacity markets in some ISOs**
  - CAISO: requires 1 yr ahead "capacity showing" by load-serving entities, met through bilateral contracts.
    - State tightly oversees investment; competitive procurement ("hybrid system")

- **EIM → west-wide day-ahead & capacity market?**
  - Propose: Acquire capacity that meets reliability & clean energy constraints (see, e.g., K. Spees et al., Brattle)

    → two prices in each zone

    → more flexibility & competition

How much capacity credit to give to renewables?

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- If a perfectly reliable, flexible resource gets $X/MW/yr, how much should other resources get paid?
  - **Proposal**: Marginal "Effective Load Carrying Capability"
- Difficult devilish details:
  - Locationally differentiate?
  - Account for operating constraints (flexibility)?
  - How can we predict future values?

How much capacity credit to give to renewables? (Cont.)

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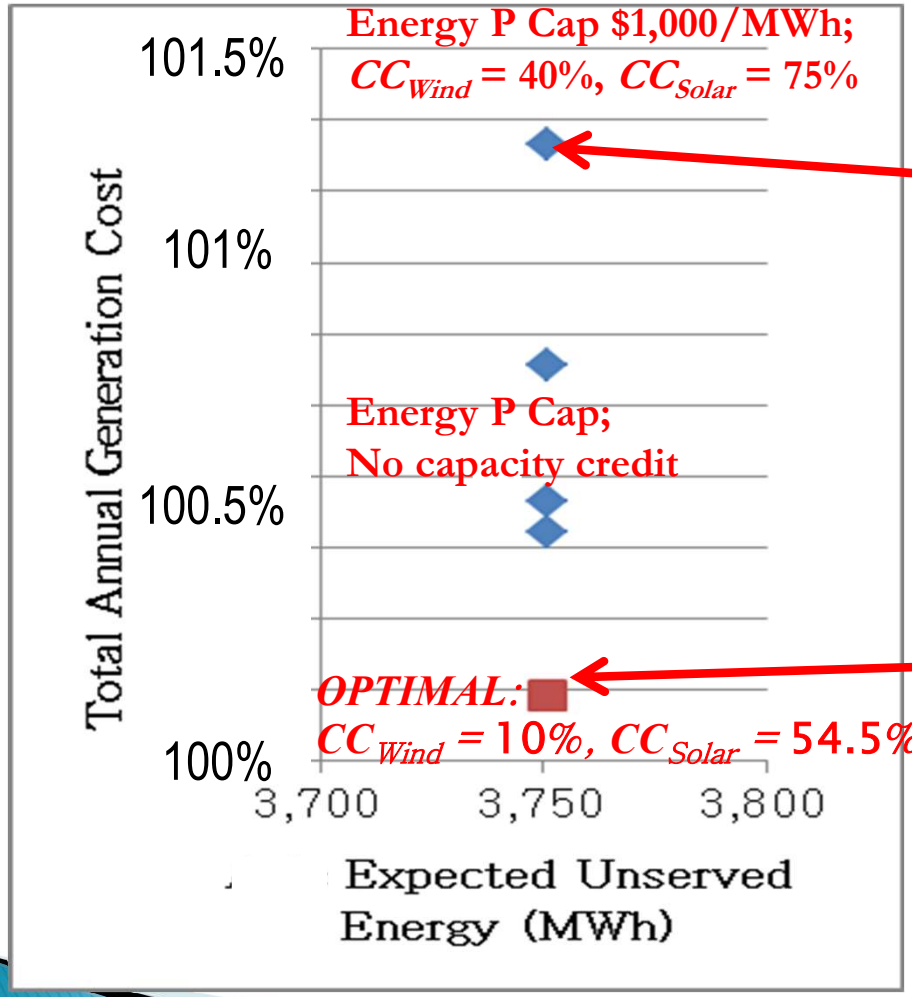
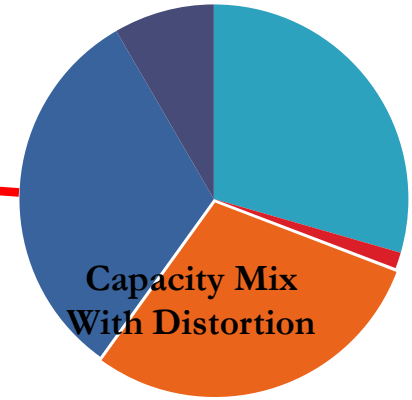
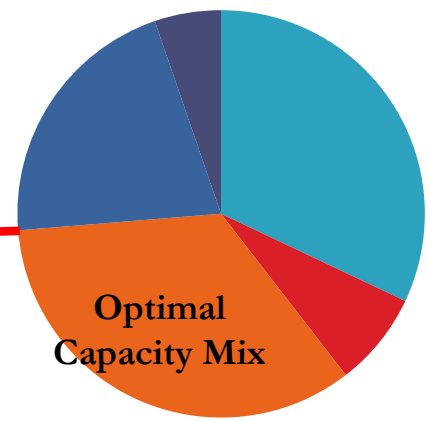
- So what are cost effects of giving the wrong credit? (In Texas)





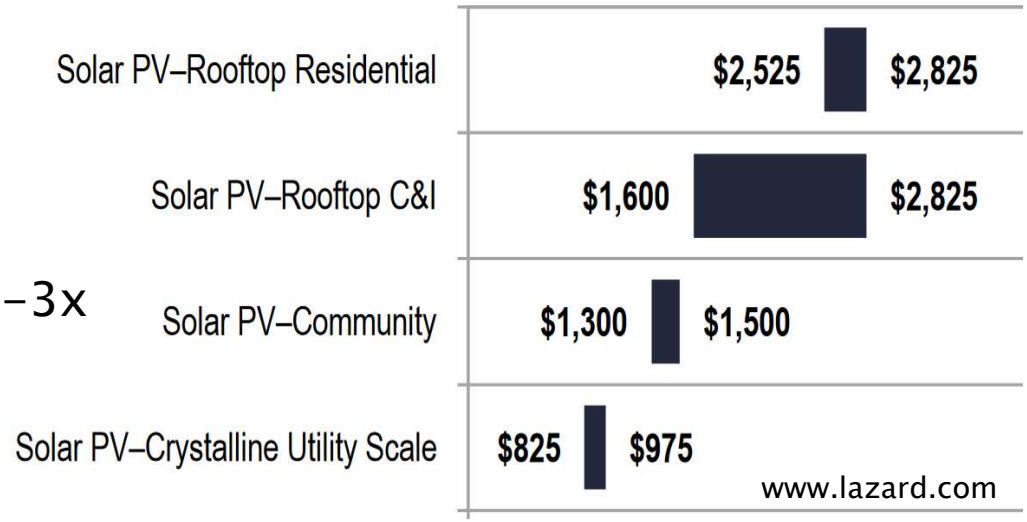


CT CC Coal Wind Solar

C.. Bothwell & B. Hobbs, Crediting wind and solar renewables in electricity capacity markets: the effects of alternative definitions upon market efficiency., 38, KAPSARC Issue, *The Energy Journal*, 2017

Issue 3: Harmonizing Grid-Scale & Distributed Decisions

- Solar Capacity in California
  - Grid Scale: 14,641 MW
  - Distributed PV: 15,579 MW
- Two issues:
  - Aggregate cost?: rooftop PV is 2-3x as expensive (2019 $/MW)
  - Who pays?: rigid retail rates + netting + subsidies



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

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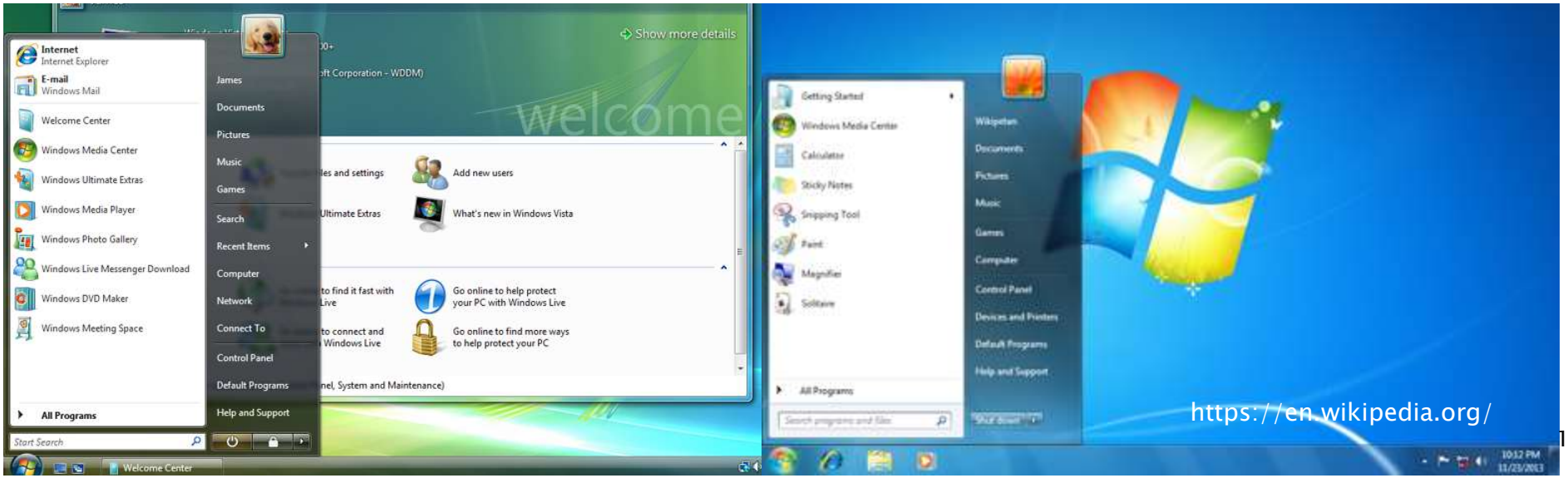
J. Ely, *American Economic Review 2013* (thanks to Steve Stoft)

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.*[1]



https://en.wikipedia.org/