

Power Market Challenges in the US: Today's Responses, Tomorrow's Needs

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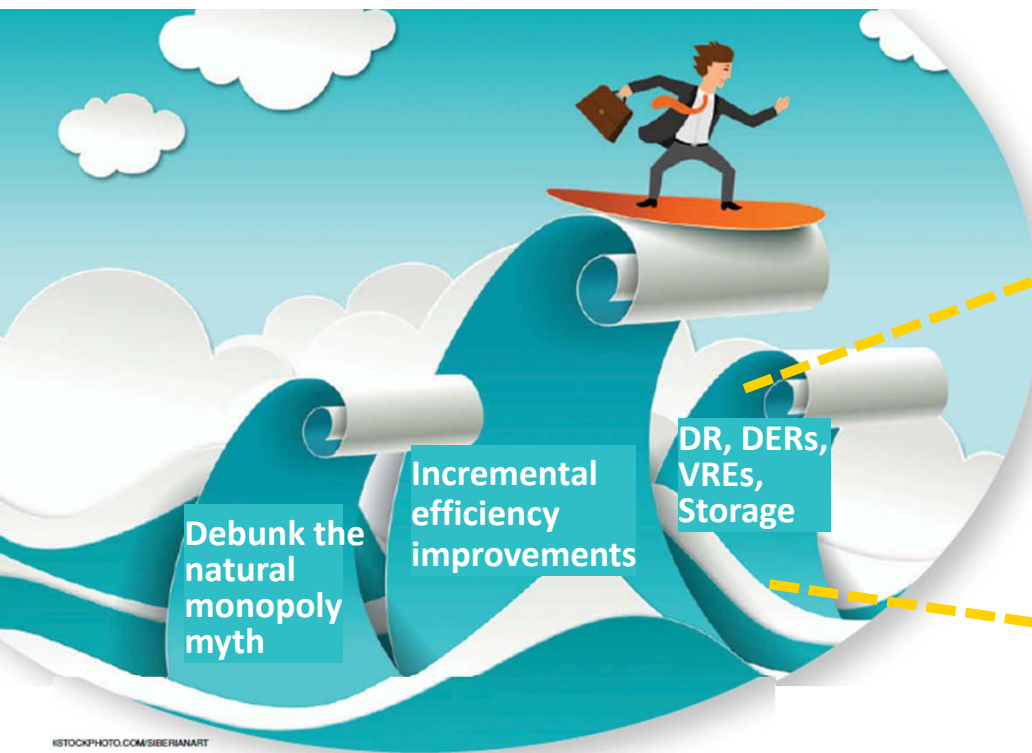
Chair, California ISO Market Surveillance Committee

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EPRG Winter Meeting, 8-9 Dec. 2023

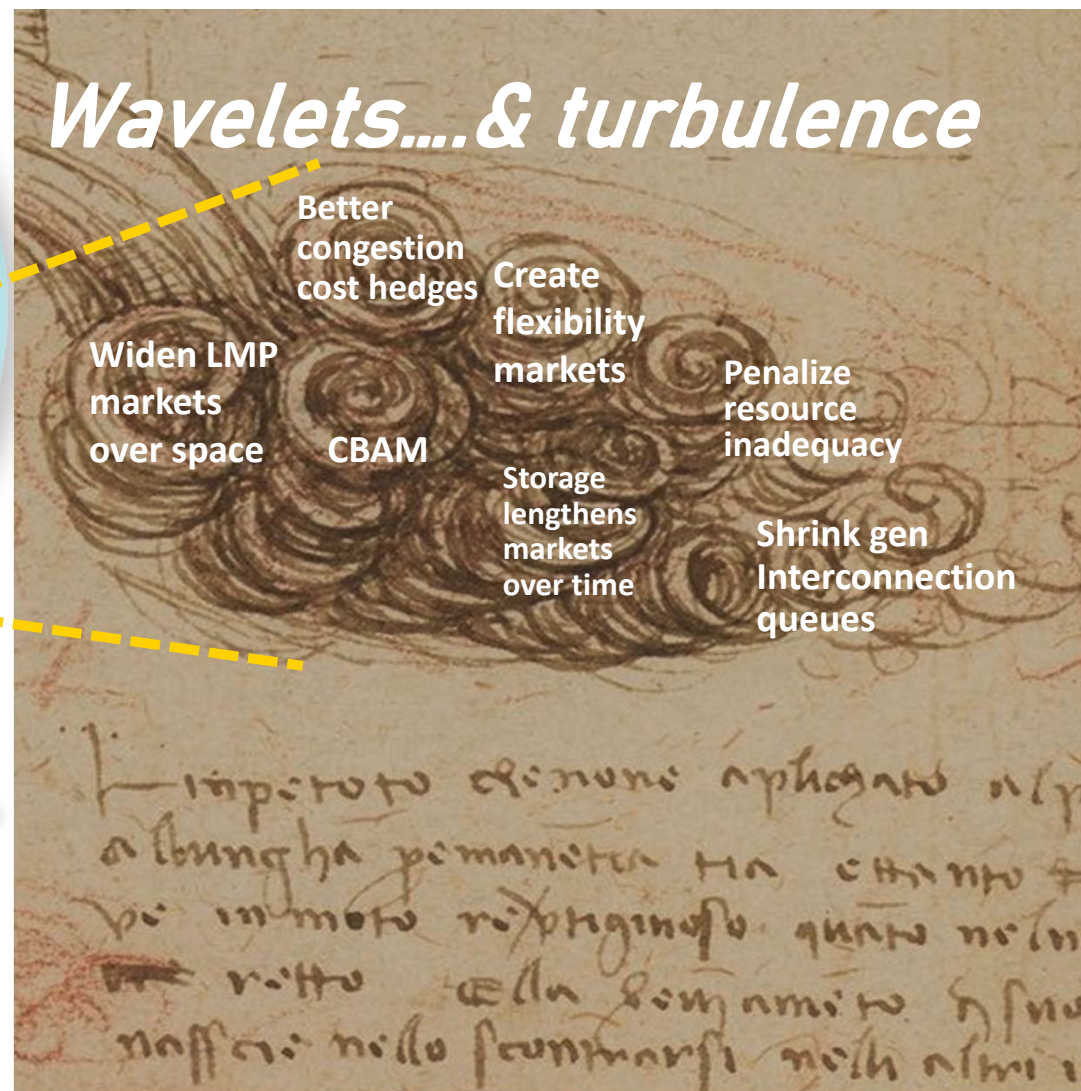
Outline

- I. Waves & wavelets
- II. Are our problems your problems? ([menti.com](https://www.menti.com) poll)
- III. Some California responses to those problems



Three Waves of U.S. Reforms

Hobbs & Oren, Power & Energy Magazine, 2019



da Vinci, Studies of water (c.1510-12) www.rct.uk/collection/912662/studies-of-water .
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Features of US Markets

- Arbitraged day-ahead & balancing markets
- Co-optimized energy, ancillary services, transmission
- Detailed offers reflect internal constraints & costs
- Ex ante mitigation of market power
- Detailed resource & network modeling
- Settle energy using LMPs
- States lead resource adequacy





Wavelets & Turbulence

Sun, Levin, Kwon, Xu, Singhal, Ela, Zhou, Crespo-Montanes, Frew, Hytowitz, Mills, Heidarifar, de Mello, Botterud, Hobbs, "Research Priorities and Opportunities in United States Wholesale Electricity Markets", NREL/TP-6A20-77521, doi.org/10.2172/1785331

Wavelet	Challenge	Today's Response	Future Need
1. Energy pricing over space (LMP)	Exploit resource diversity over large regions	Expand energy-only markets	
2. CBAM	Distortions from subregional C pricing	Carbon border adjustments	
3. CRR reform	Hedge LMP risks fairly	Give away & auction CRRs	
4. Energy pricing over time	Optimize storage, given uncertainty (price, degradation, & market power mitigation)	Storage offers & bids, but weak mitigation	
5. Flexibility reserves	Flexibility undervalued by markets	Flexiramp product	
6. Long-run resource adequacy	Provide right investment incentives as markets expand spatially	Short run restrictions on leaners' market participation	
7. Transmission planning	2 TW of wind/solar in the US queue	First in/first out, with FERC encouragement of coordination	

AUDIENCE POLL: What is the relevance to the UK market of the challenges faced by the US today?

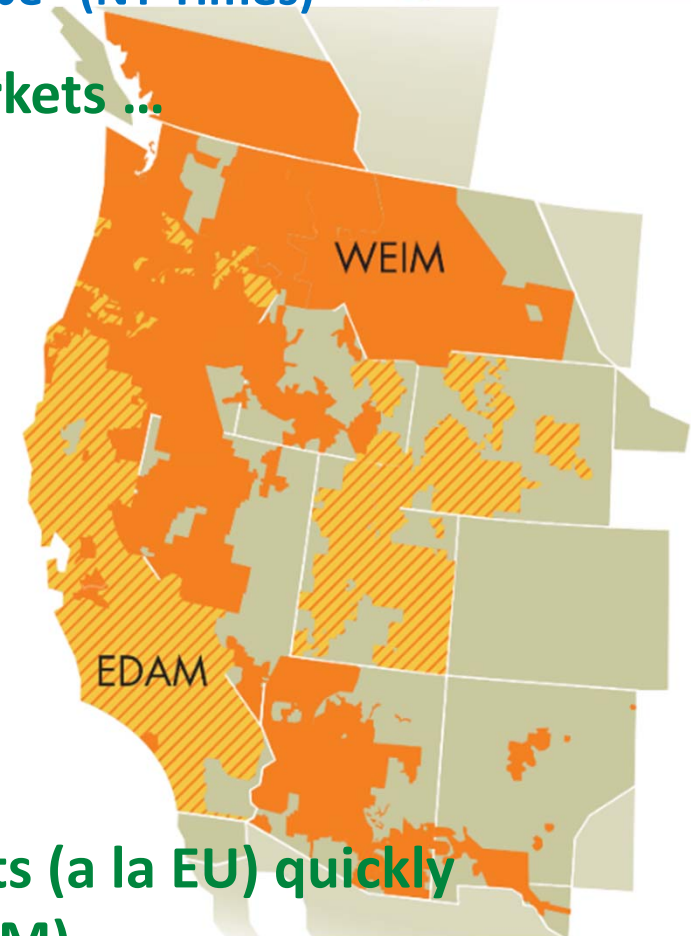
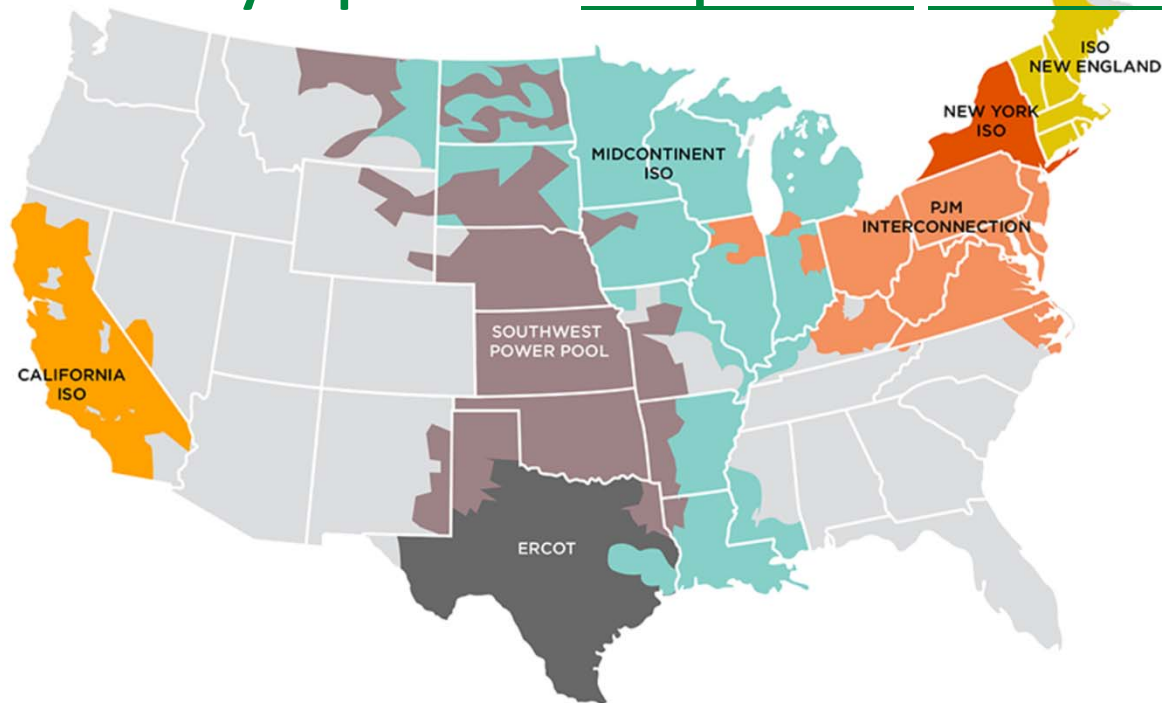
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1. Market enlargement

“To call US power markets ‘Balkanized’ insults southeast Europe” (NY Times)

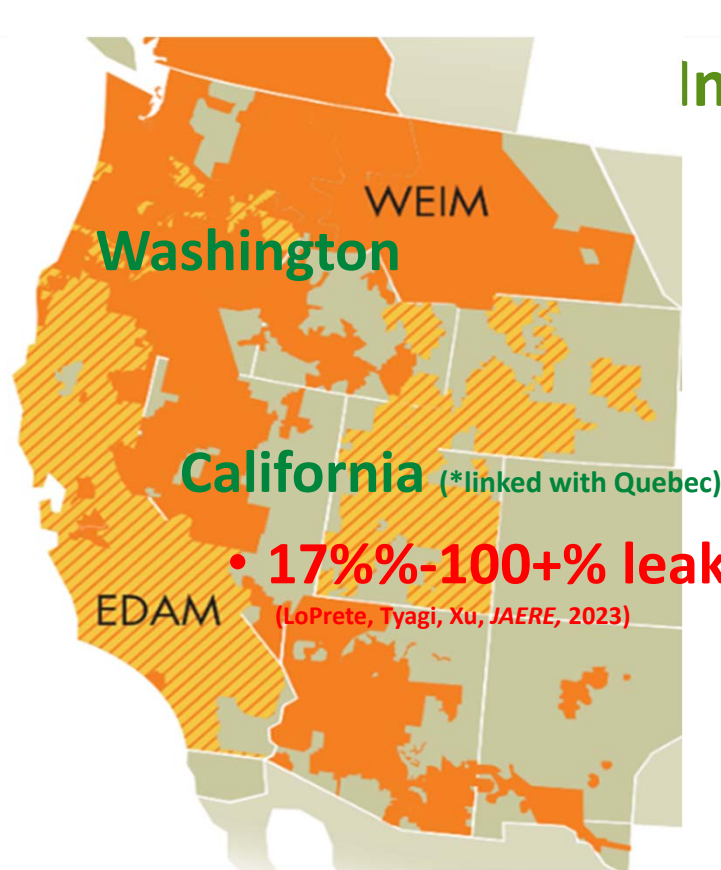
We slowly expand ISO co-optimized LMP-based markets ...



..While expanding regional energy-only markets (a la EU) quickly
..While competing for participants (SPP vs EDAM)

2. Correcting inefficient subregional C prices: CBAM

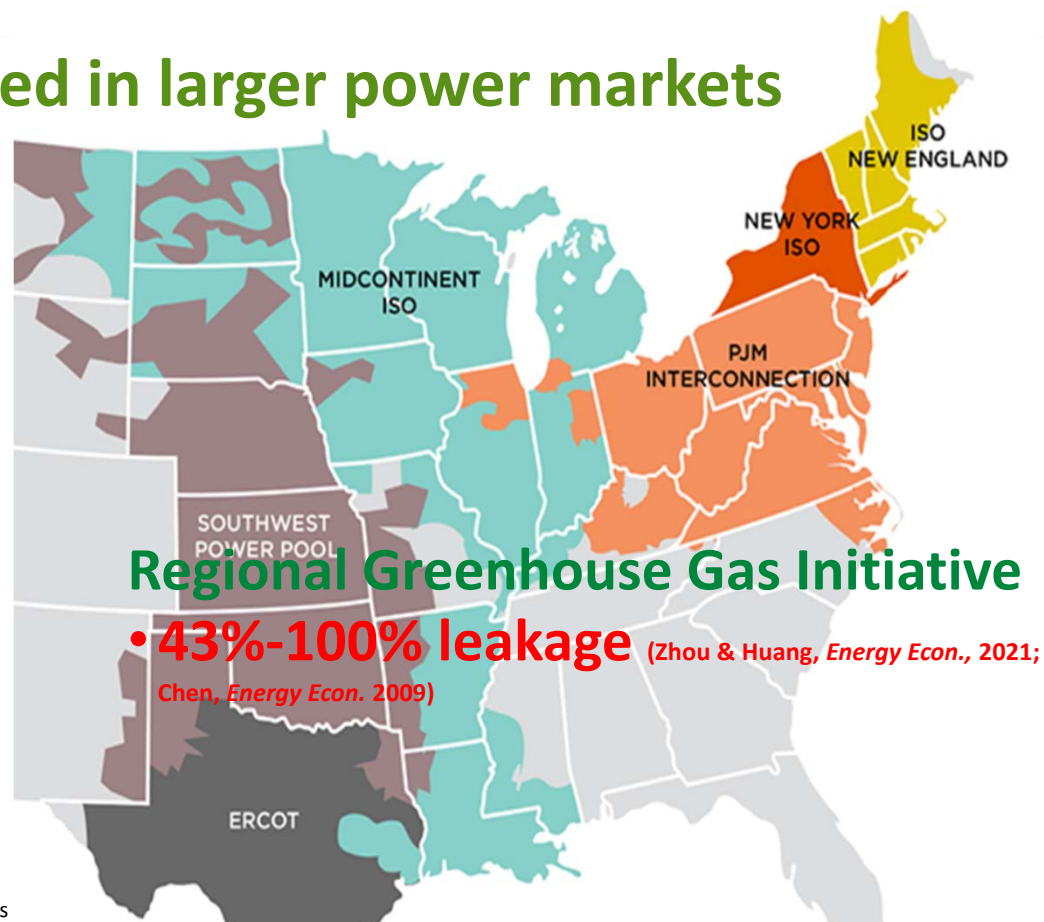
US Carbon Trading Regions ...



• 17%%-100+% leakage

(LoPrete, Tyagi, Xu, *JAERE*, 2023)

Imbedded in larger power markets



Regional Greenhouse Gas Initiative

• 43%-100% leakage

(Zhou & Huang, *Energy Econ.*, 2021;
Chen, *Energy Econ.* 2009)

Case Study: Western North American Markets 2034

Using JHSMINE (van der Weijde & Hobbs *En.Econ.*, 2012, Xu & Hobbs, *Energy Policy*, 2021)



• Questions:

1. Can Carbon Border Adjustment Mechanisms cost-effectively reduce emissions?
2. Can CBAMs be counter productive?
3. How do answers depend on the precise design & parameterization?

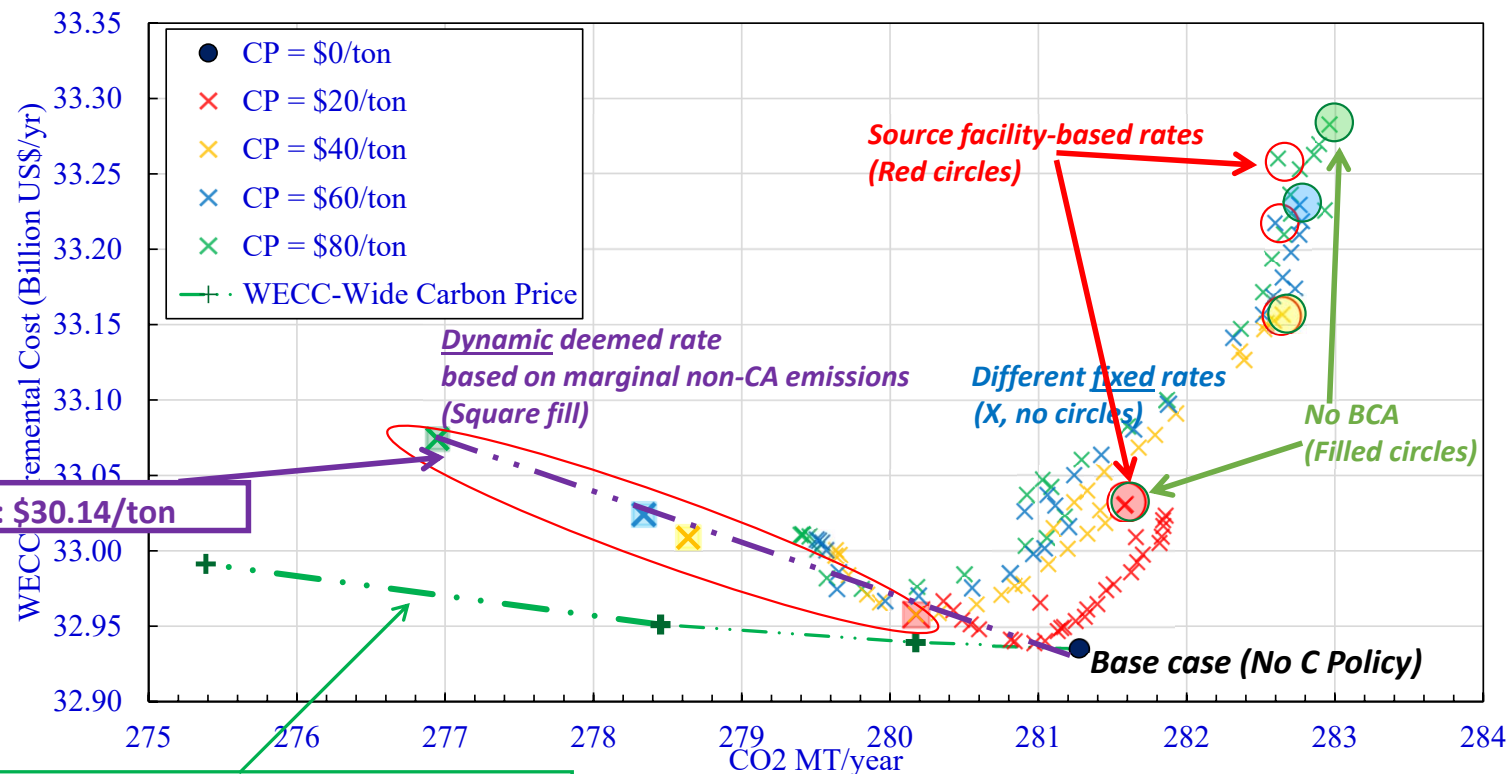
• CBAM: Evaluate choices for design:

- ▶ “Trace” & penalize dirty imports by source **OR:**
- ▶ All imports pay same \$/MWh
= deemed marginal non-CA emissions (ton/MWh)
* price of AB32 CO₂ [\$ /ton]
- ▶ Various “Deemed rates”; can be static or dynamic



Tinkering with a CBAM policy: Effect of “deemed CO₂ emission rates” for CA imported power (Xu, Hobbs, *Energy Policy*, 2022)

2034 West-wide cost & emissions resulting from California’s AB32 + 60% RPS,
under various CBAM systems and deemed CO₂ rates for imports





3. Hedging LMP risks with Congestion Revenue Rights

1. *Vanilla CRR: ISO pays MW quantity * ($P_{sink} - P_{source}$)*

Big design questions:

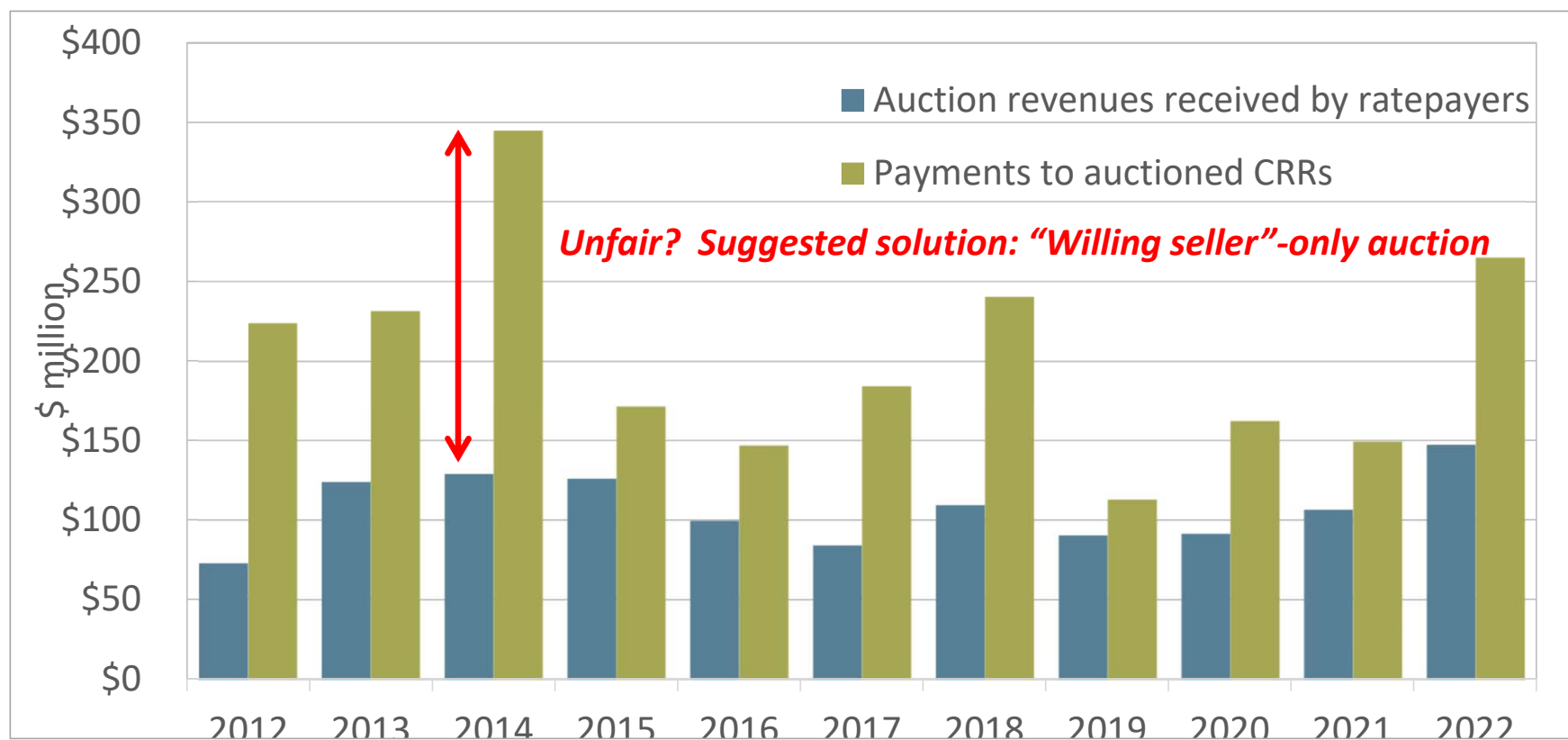
- How many rights?
- Who gets the rent? (who is given the rights?)
- What if payments owed \ll congestion revenue? (if too many rights allocated)

2. *California:*

- Give some rights to consumers, auction to reconfigure
 - Sell rest of rights in same auction (revenues to consumers)
- **Problem:** Auction revenues \ll Payments

Ratepayer Auction Revenues vs. Congestion Payments for Auctioned CRRs

Source: CAISO Market Monitor 2022 Annual Report (Fig. 6.10),
www.caiso.com/market/Pages/MarketMonitoring/AnnualQuarterlyReports/Default.aspx

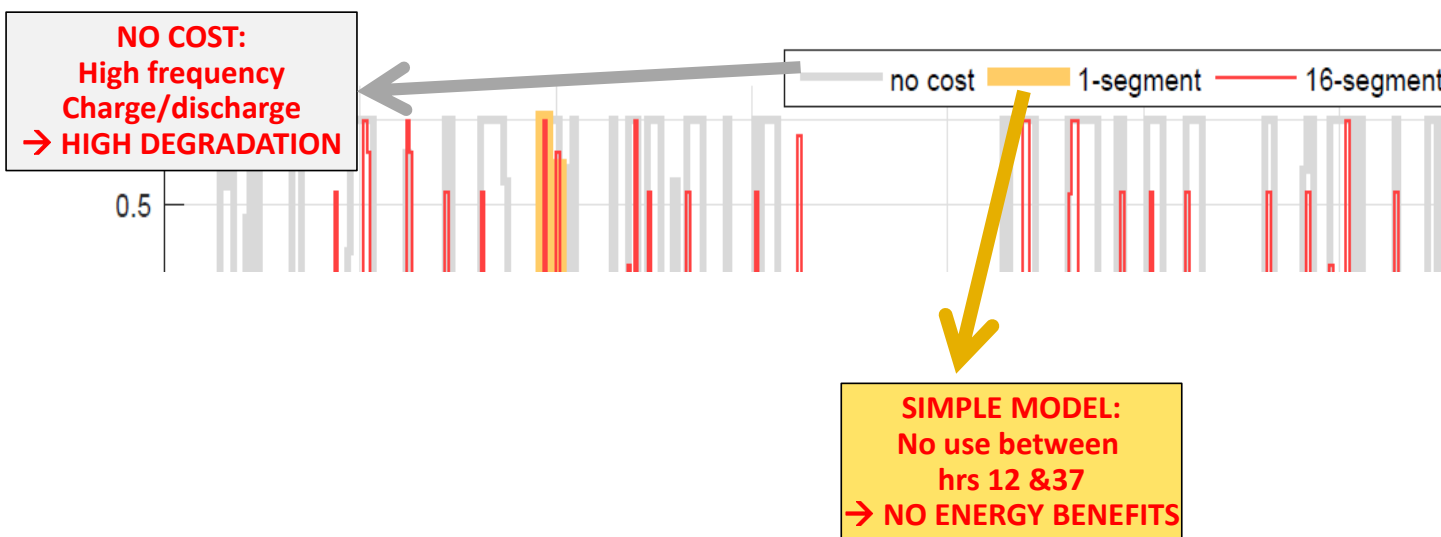


4. Intertemporal pricing: Storage optimization

CAISO has 7 GW of battery storage in a 45 GW peak system

- Market software can't model all physics of storage (marginal value depends on state-of-charge, long run degradation)
 - so CAISO allows storage to make its own bids to charge & offers to discharge
 - But offers are not SOC dependent, so can't model degradation costs
- Batteries may be the only resource available in 5 minute intervals, and can be large (Moss Landing: 750 MW).
 - Problem: How to do market power mitigation when “cost” is based on opportunity cost, not fuel?

Ignoring or oversimplifying degradation costs → gross over / under use of batteries in ISO-NE



Xu, Kirschen et al., *IEEE Tran. Power Sys*, 2017

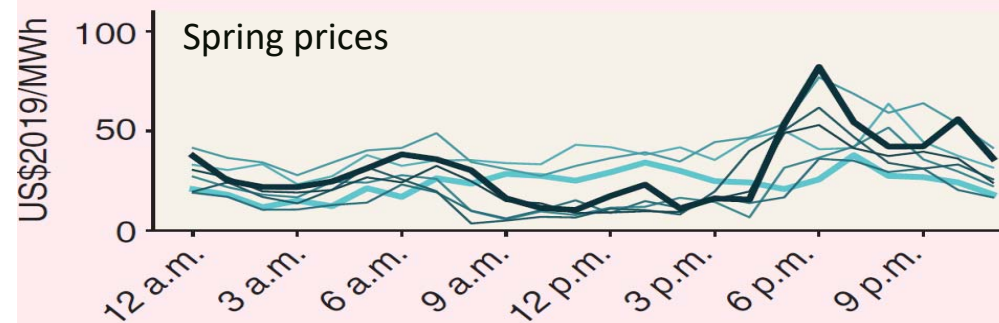
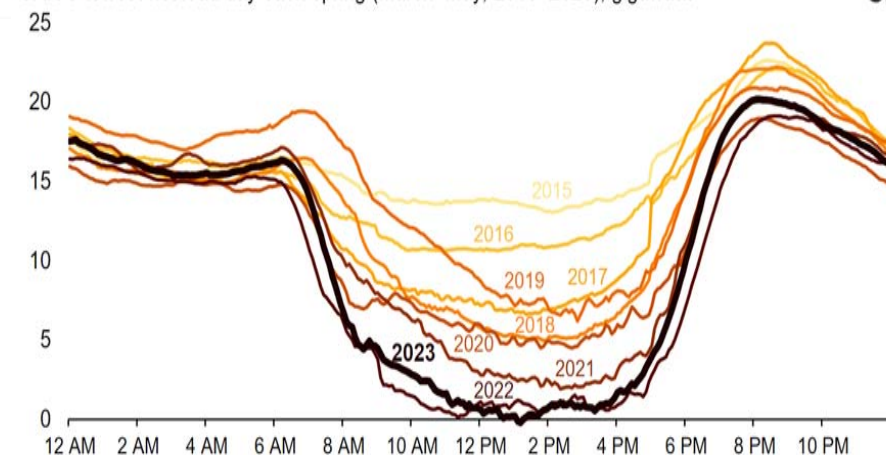
In the face of difficult or impossible to estimate costs, should we give up on *ex ante* market power mitigation?

5. Intertemporal pricing: Flexibility is undervalued

- Flexibility/options undervalued: price volatility suppressed by loooooong intervals & lack of uncertainty in models (Lund et al. 2015)
- Several ISOs created “flexible ramp product” (procure gen “head room” up & down, to accommodate unexpected net load ramps)
 - Procured zonally
- Flexiramp’s problem: ~zero procurement price & underdeployed
 - We procure it at buses where energy has low value due to congestion– so turns out useless!
- Solution? Network-constrained ramp (a flexibility LMP!)

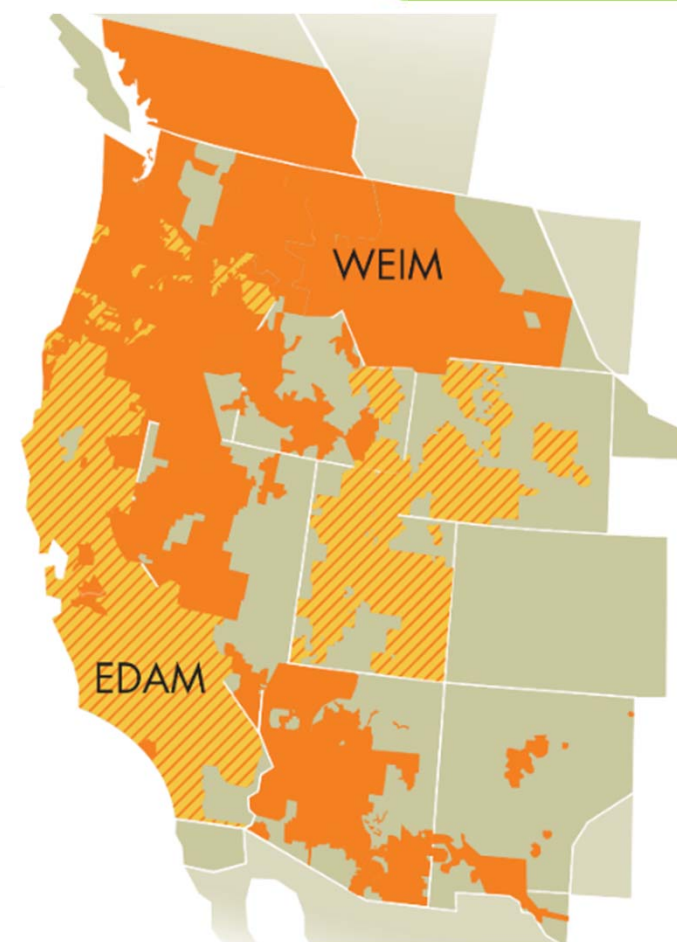
California's duck curve is getting deeper

CAISO lowest net load day each spring (March–May, 2015–2023), gigawatts



6. Resource adequacy: Texas shows it can be a matter of life & death

- ▶ **CAISO once hoped for a west-wide ISO (energy, ancillary services, RA)**
 - But its DA/RT west-wide markets (EDAM/WEIM) are now settling for just energy
 - Question: how do you prevent member subsystems from leaning on each other's capacity?
- ▶ **Approach:** Incent subsystems with short-run penalties to provide long-run RA.
 - In each market interval, if subsystem doesn't have on-line (and flexible) capacity to meet 97.5th percentile of net load/ramp risk, then:
 - Restrict MW interchange
 - Financially penalize interchange



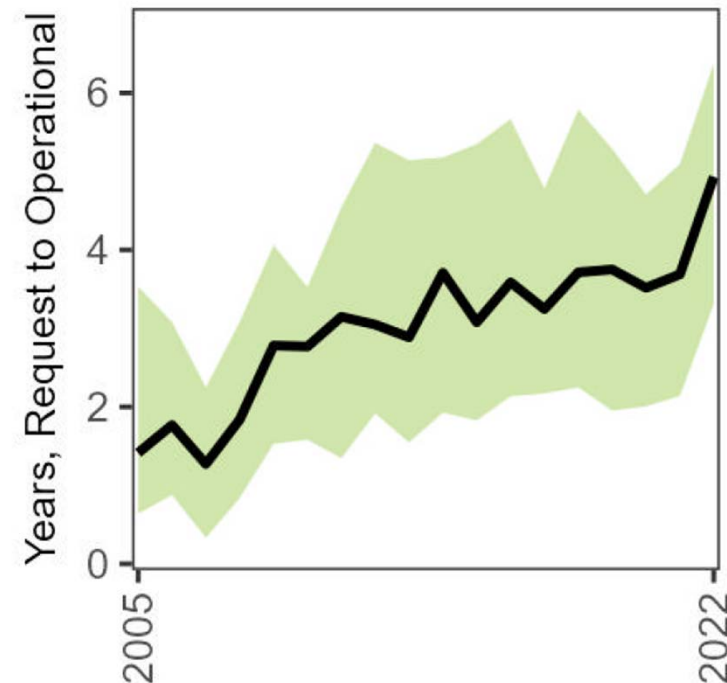
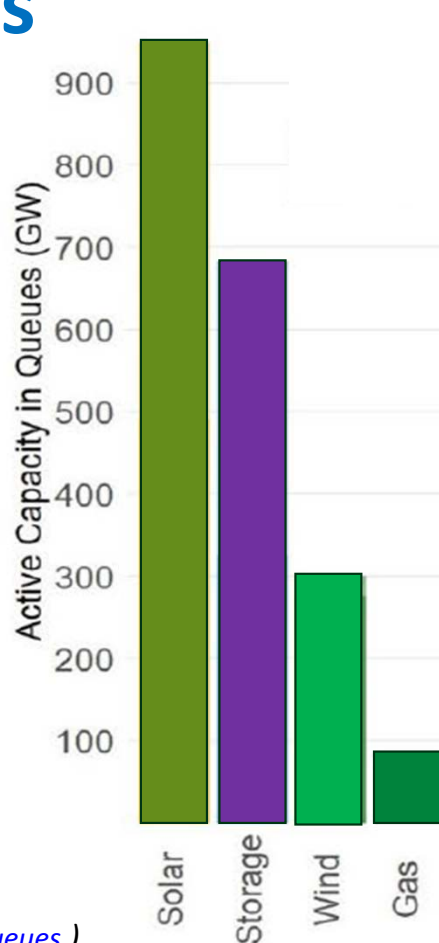
7. Transmission traffic jam: new gen connection process

➤ Power plants seeking transmission connection by type:

- 2 TW in queue (45% solar)
- Cf. 1.2 TW installed capacity (44% gas)

➤ Approaches (FERC/MISO/...):

- Change first-in/first-out to first-ready/first-out
- Proactive transmission planning and either choose winners or auction capacity
- Connect-and-manage



Median/interquartile range of years from generator interconnection request to operation for projects dating back to 2005

Conclusion: What's Needed in Long Run

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1. Energy pricing over space (LMP)	Exploit resource diversity over large regions	Expand energy-only markets	Expand co-optimized energy/reserve/RA markets
2. CBAM	Distortions from subregional C pricing	Carbon border adjustments	Systemic C pricing
3. CRR reform	Hedge LMP risks fairly	Give away & auction CRRs	Consumers keep rents, maintain CRR hedging value
4. Energy pricing over time	Optimize storage, given uncertainty (price, degradation, & market power mitigation)	ISO models SOC & rolling horizons; Storage offers & bids but weak mitigation	Multiple intraday markets and settlements
5. Flexibility reserves	Flexibility undervalued by markets	Flexiramp product	Deliverability
6. Long-run resource adequacy	Provide right investment incentives as markets expand spatially	Short run restrictions on market participation upon "leaners"	Consistent RA markets that allow inter-market trading
7. Transmission planning	2 TW of wind/solar in the US queue	First in/first out, with FERC encouragement of coordination	Proactive transmission planning under uncertainty