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

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Thanks to my colleagues & students, especially Qingyu Xu (Tsinghua U), Yinong Sun (Sequoia) and USDOE, NSF, CAISO for support. All opinions are my responsibility

EPRG Winter Meeting, 8-9 Dec. 2023

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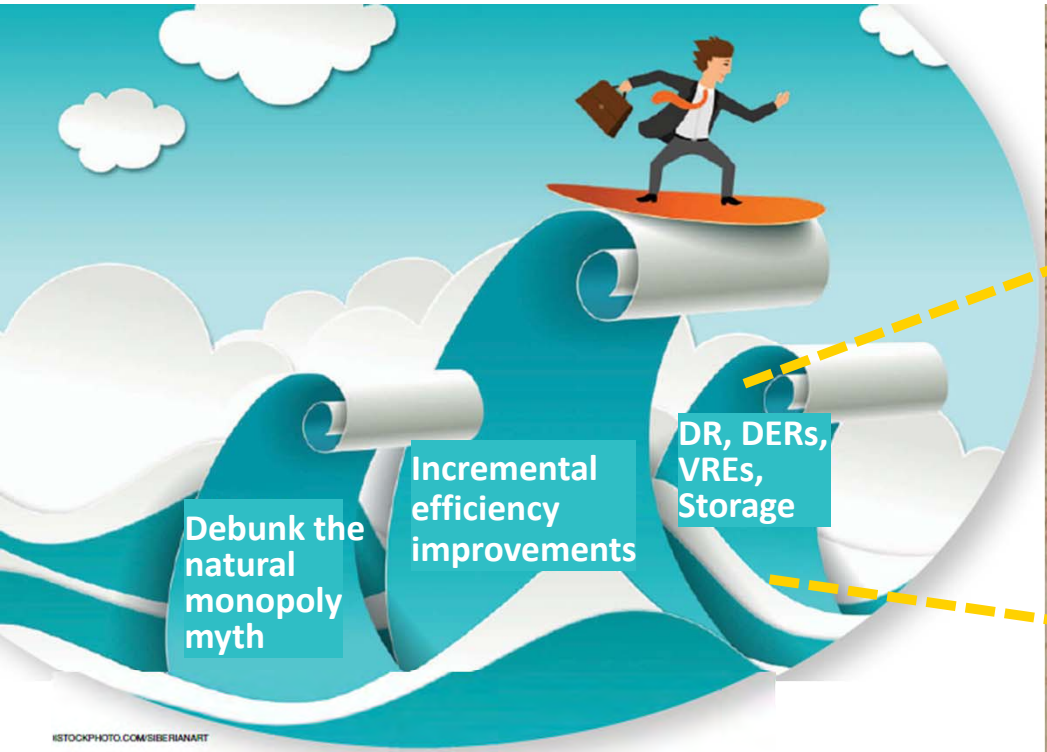
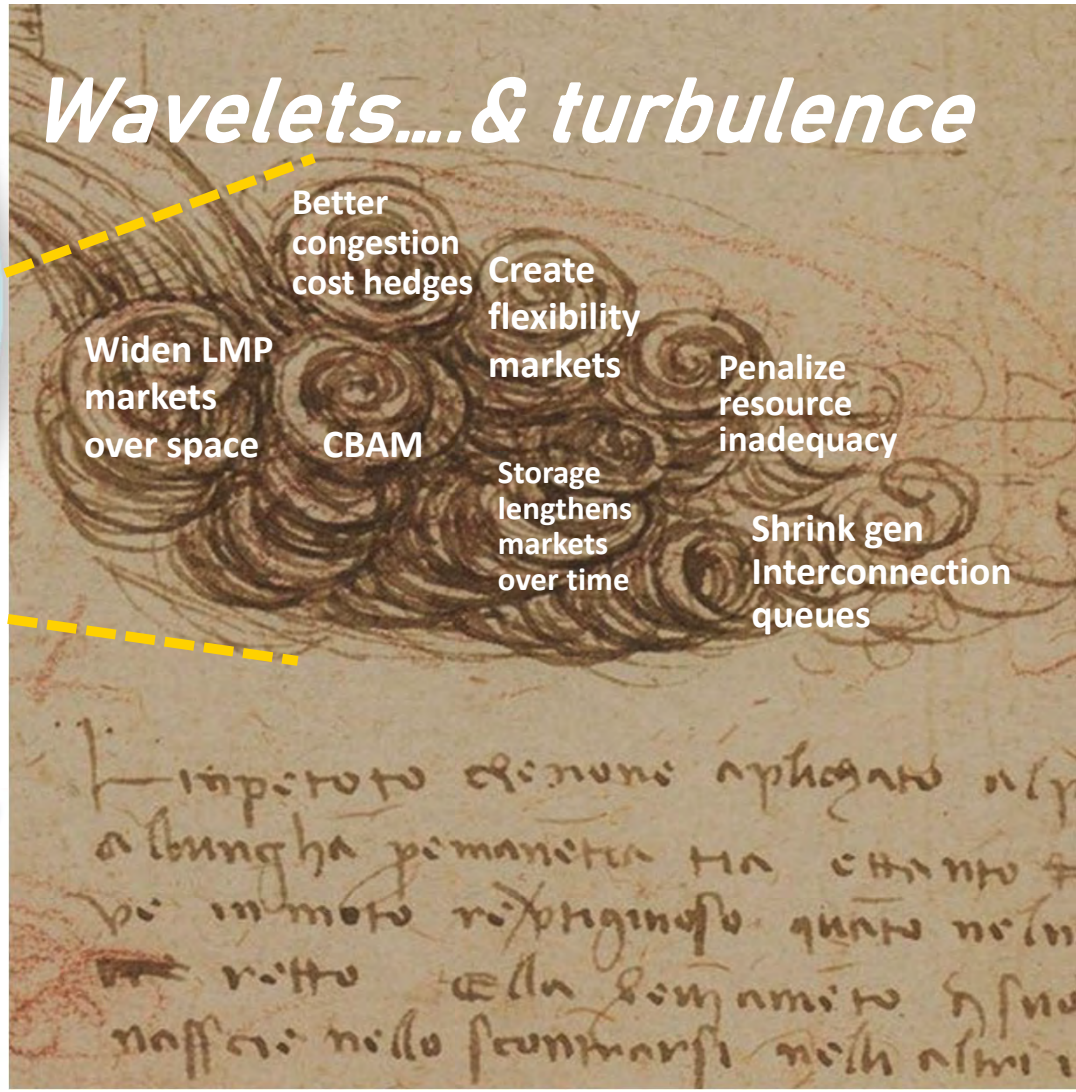
Outline

I. Waves & wavelets
II. Are our problems your problems? (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 .

Features of US Markets

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- 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

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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)

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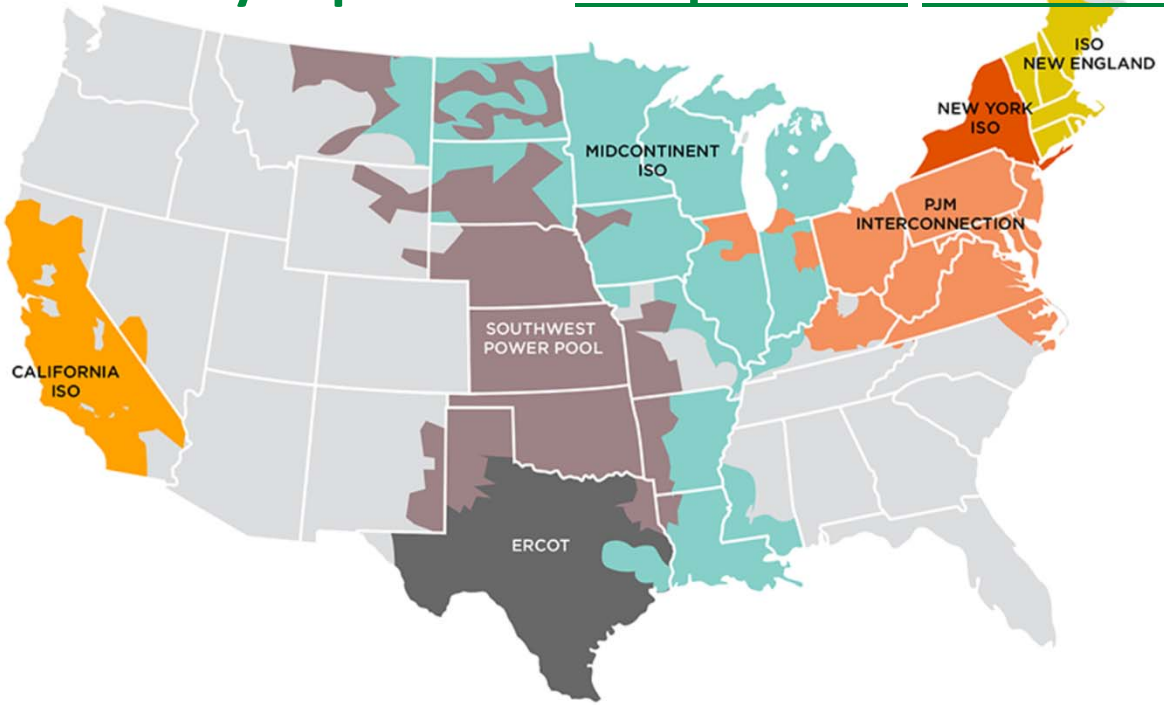
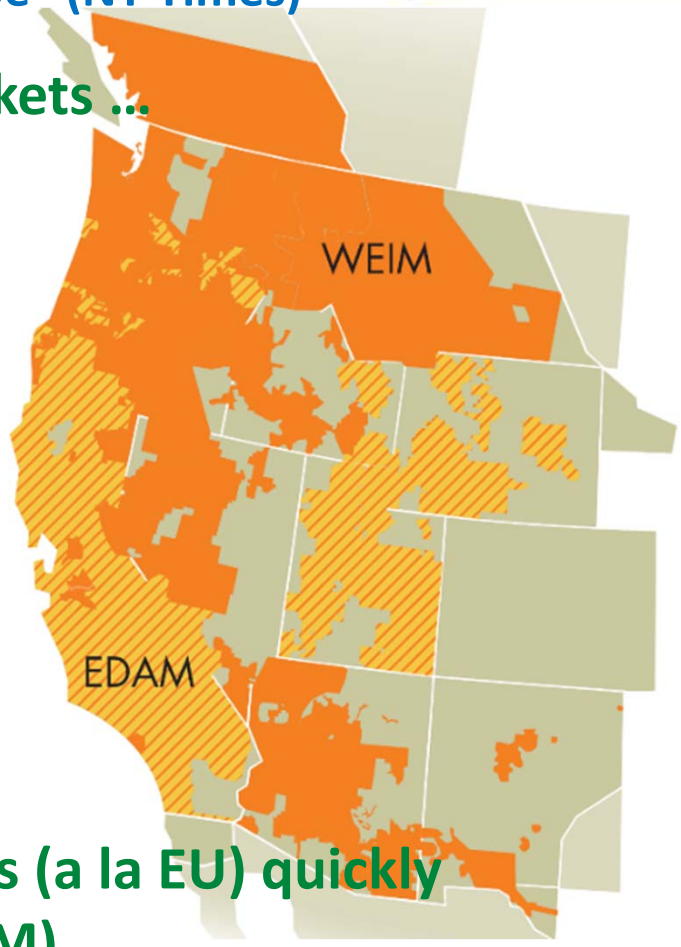
We slowly expand ISO co-optimized LMP-based markets …





..While expanding regional energy-only markets (a la EU) quickly

..While competing for participants (SPP vs EDAM)

2. Correcting inefficient subregional C prices: CBAM

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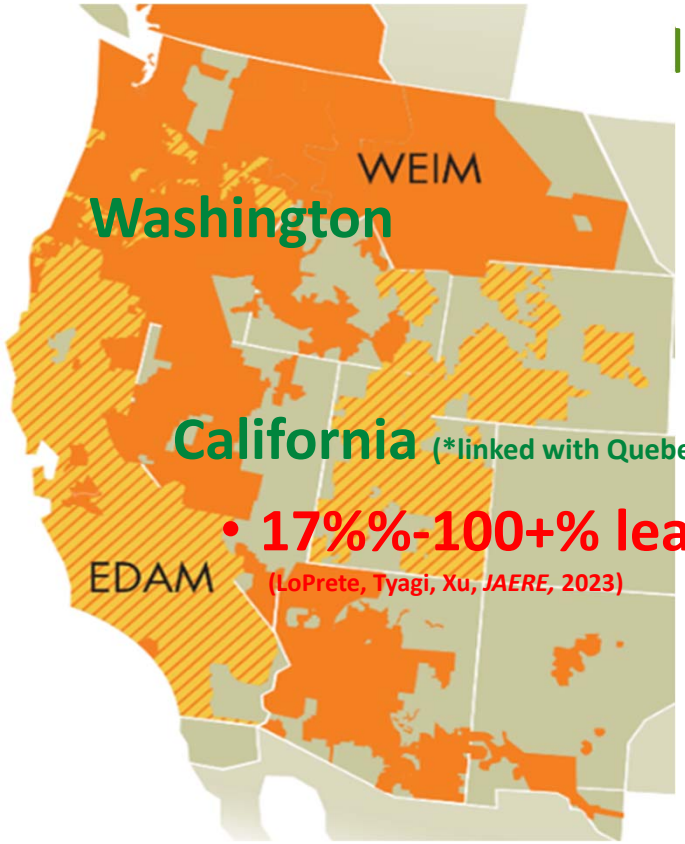
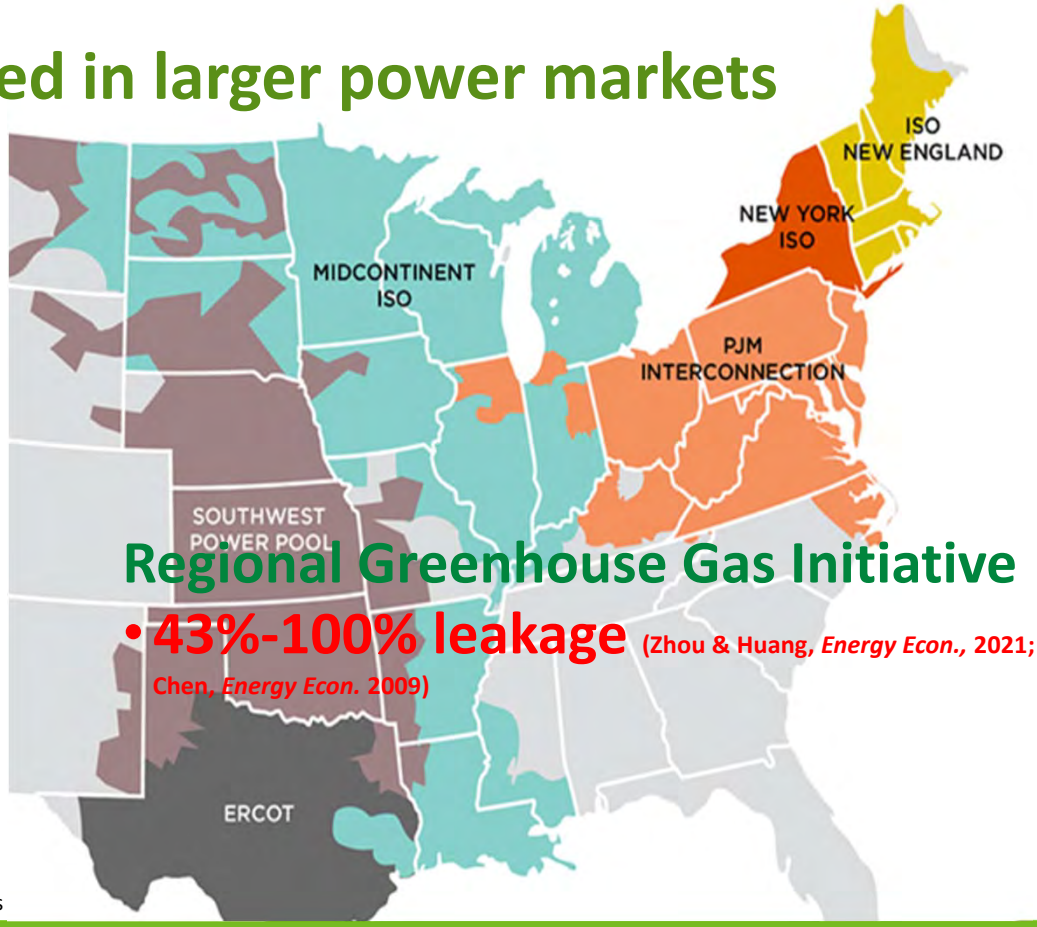
US Carbon Trading Regions …



- **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)

https://www.ncsl.org/energy/greenhouse-gas-emissions-reduction-targets-and-market-based-policies

Case Study: Western North American Markets 2034 Using JHSMINE (van der Weijde & Hobbs *En.Econ.*, 2012, Xu & Hobbs, *Energy Policy*, 2021)

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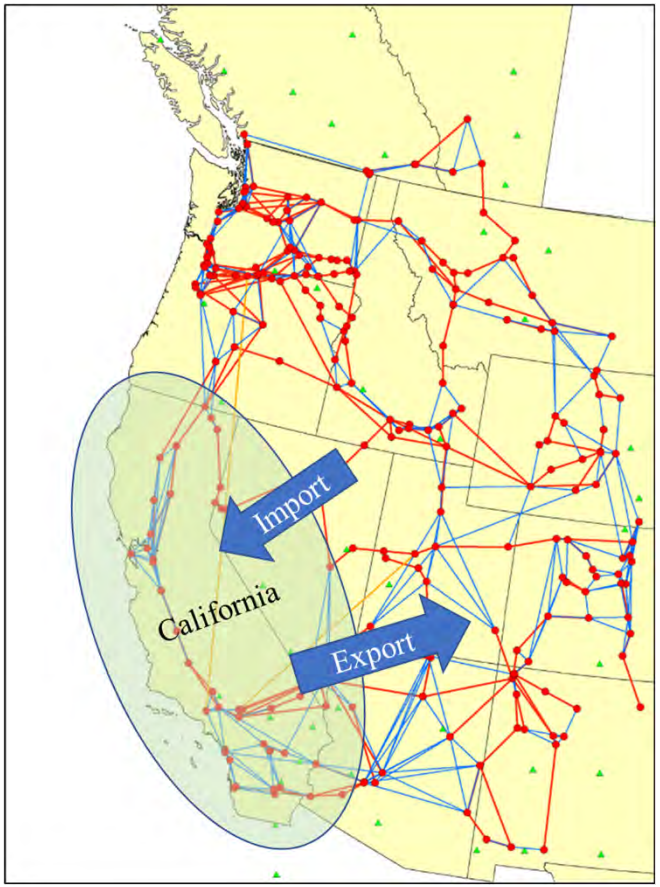

- **Questions:**
  1. Can Carbon Border Adjustment Mechanisms cost-effectively reduce emissions?
  2. Can CBAMs be counter productive?
  3. How do answers depend on the precise design & parameterization?

- **CBAM: Evaluate choices for design:**
  - "Trace" & penalize dirty imports by source *OR:*
  - All imports pay same $/MWh
    = deemed marginal non-CA emissions (ton/MWh)
    * price of AB32 CO_2 [$/ton]
  - Various "Deemed rates"; can be static or dynamic

Tinkering with a CBAM policy:
Effect of "deemed CO_2 emission rates" for CA imported power *(Xu, Hobbs, Energy Policy, 2022)*

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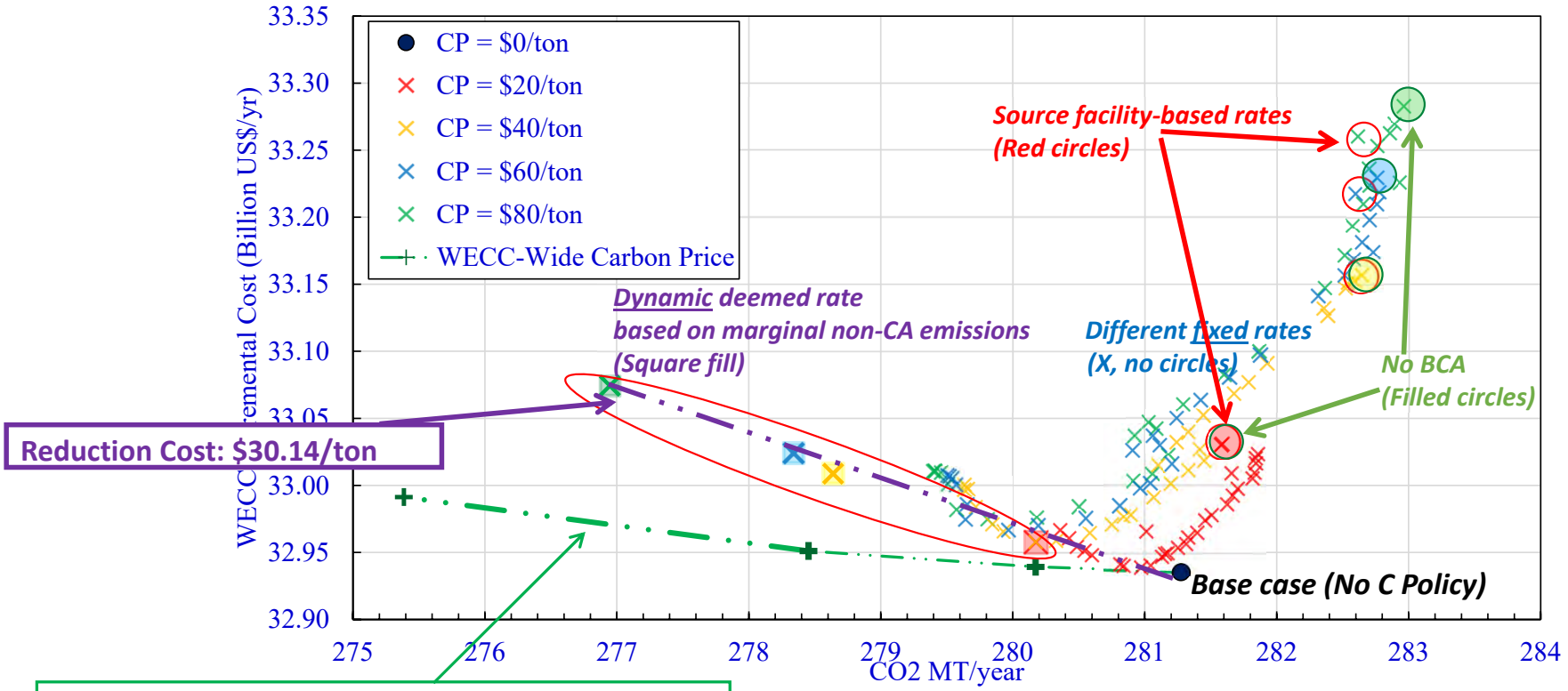
2034 West-wide cost & emissions resulting from California's AB32 + 60% RPS, *under various CBAM systems and deemed CO_2 rates for imports*



3. Hedging LMP risks with Congestion Revenue Rights

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

Big design questions:

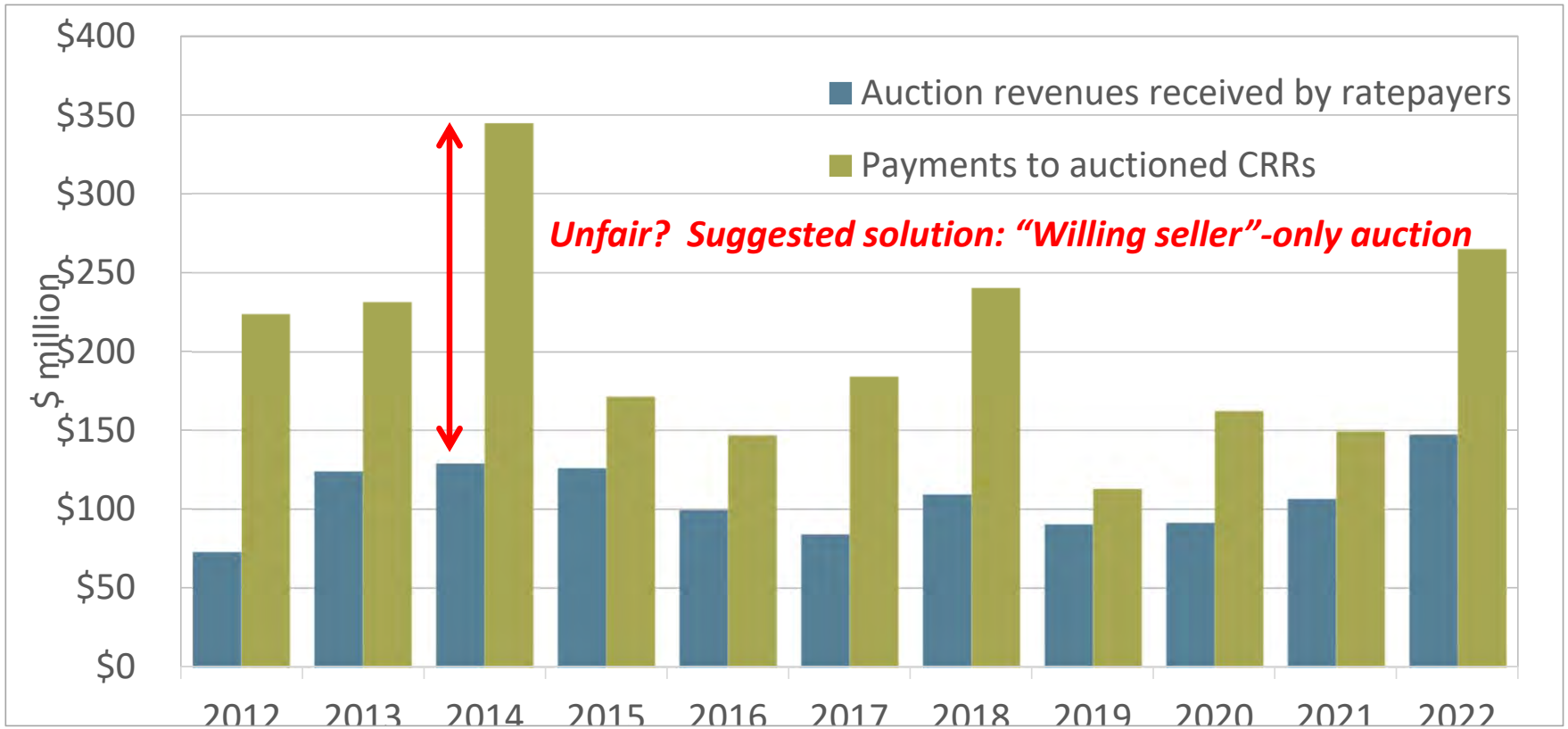
- How many rights?
- Who gets the rent? (who is given the rights?)
- What if payments owed << congestion revenue? (if too many rights allocated)

2. California:

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

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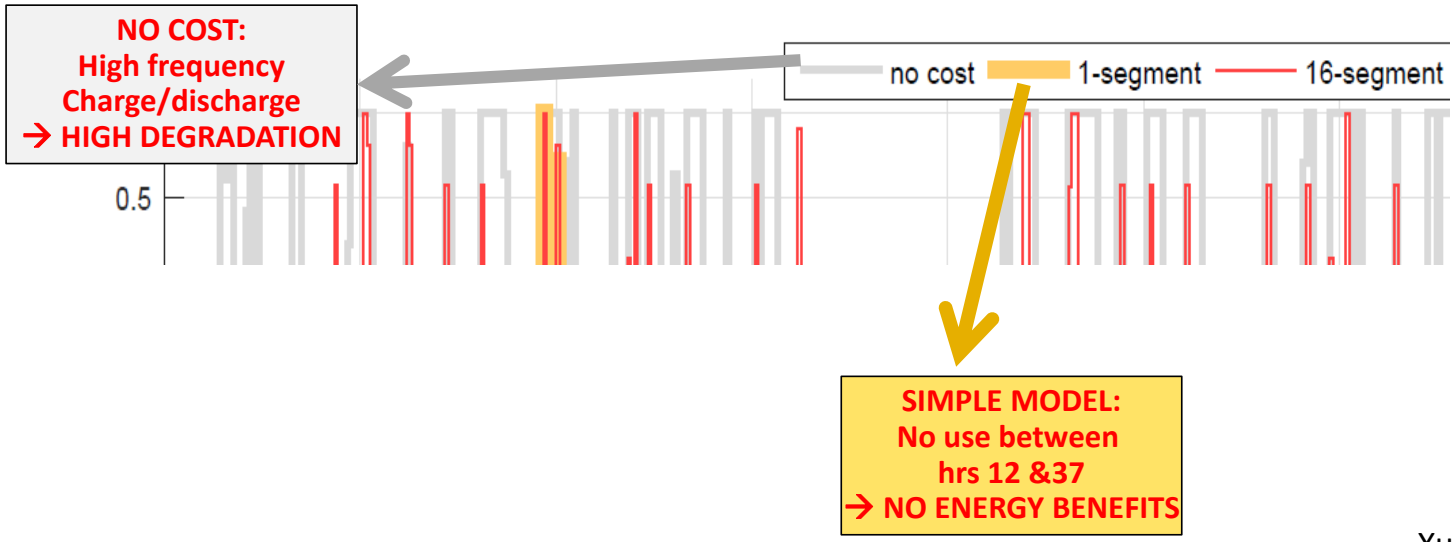
CAISO has 7 GW of battery storage in a 45 GW peak system

- 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

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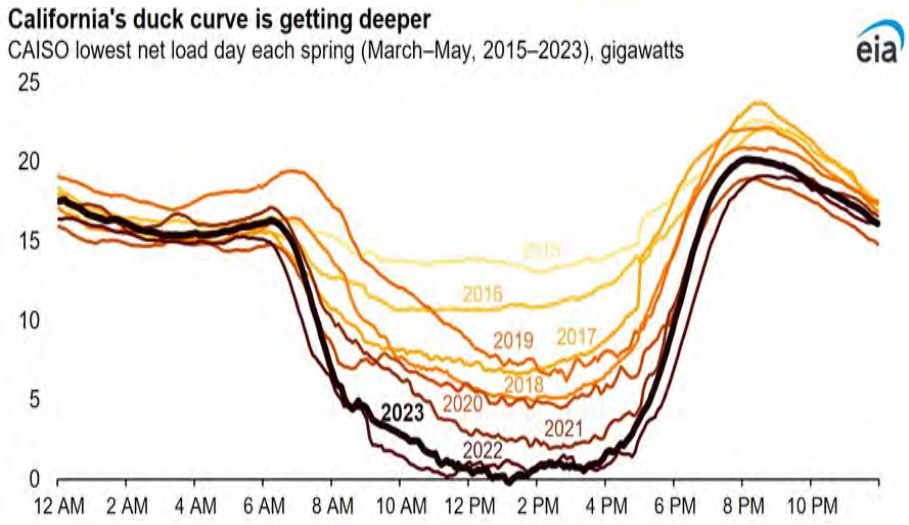
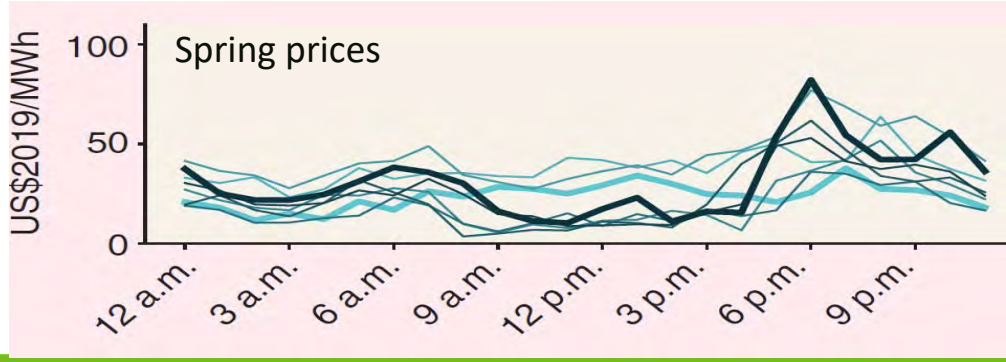
- **Flexibility/options undervalued: price volatility suppressed by looooong intervals & lack of uncertainty in models (Lund et al. 2015)**
- **Several ISOs created "flexible ramp product" (procure gen "head room" up & down, to accommodate unexpected net load ramps)**
  - **Procured zonally**
- **Flexiramp's 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!)**





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

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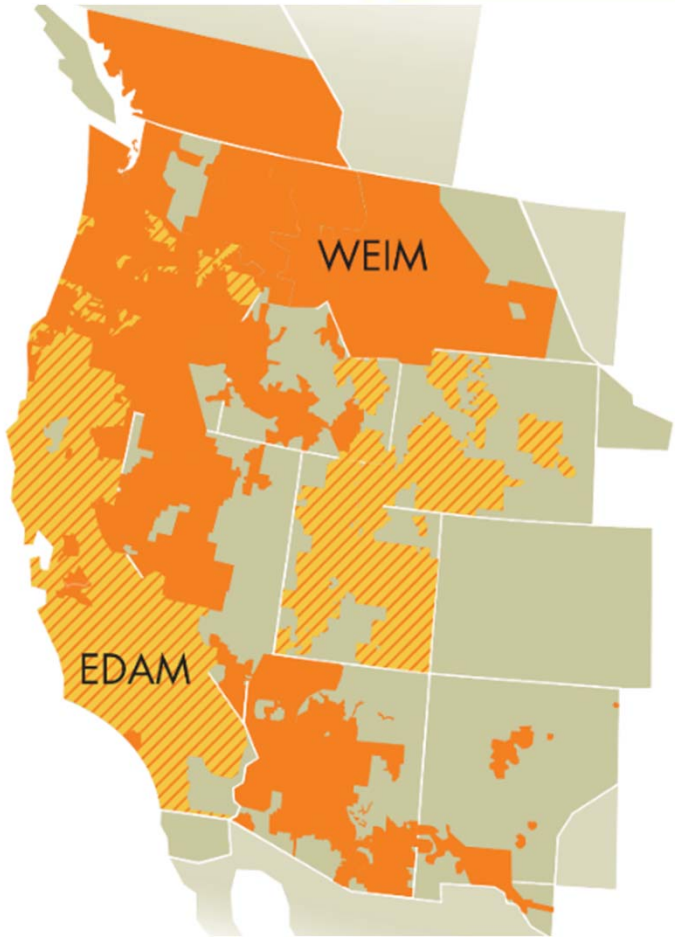
- **CAISO once hoped for a west-wide ISO (energy, ancillary services, RA)**
  - But its DA/RT west-wide markets (EDAM/WEIM) are now settling for just energy
  - Question: how do you prevent member subsystems from leaning on each other's capacity?

- **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

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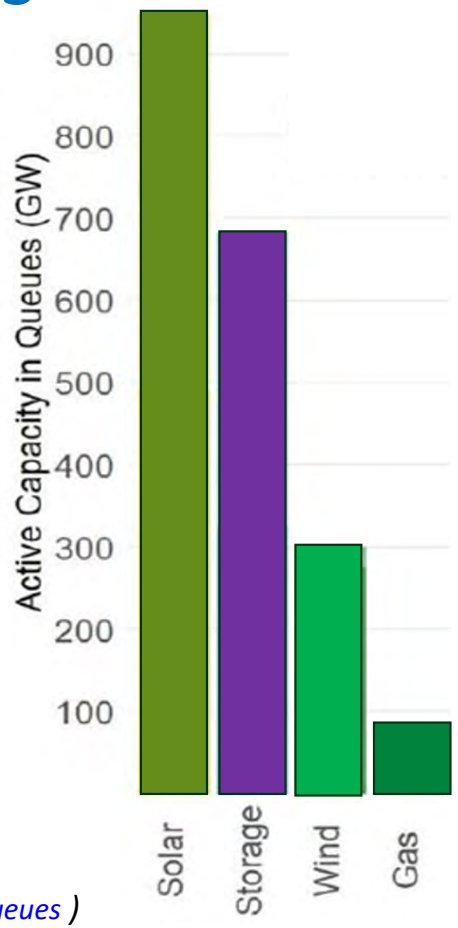
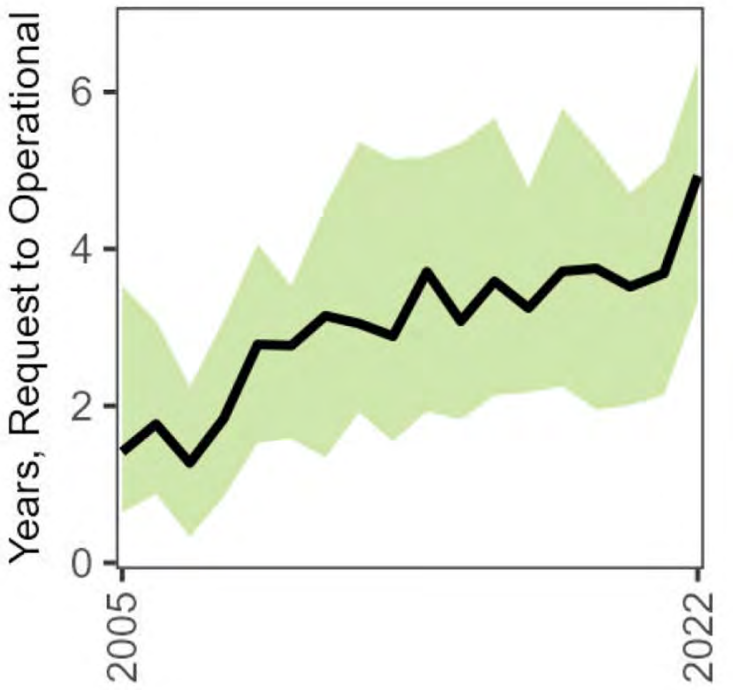
- ***Power plants seeking transmission connection by type:***
  - **2 TW in queue (45% solar)**
  - **Cf. 1.2 TW installed capacity (44% gas)**
- ***Approaches (FERC/MISO/…):***
  - **Change first-in/first-out to first-ready/first-out**
  - **Proactive transmission planning and either choose winners or auction capacity**
  - **Connect-and-manage**



USDOE National Transmission Needs Study, Oct. 31, 2023
(Data from Lawrence Berkeley Natl. Lab.; https://emp.lbl.gov/queues)



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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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

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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