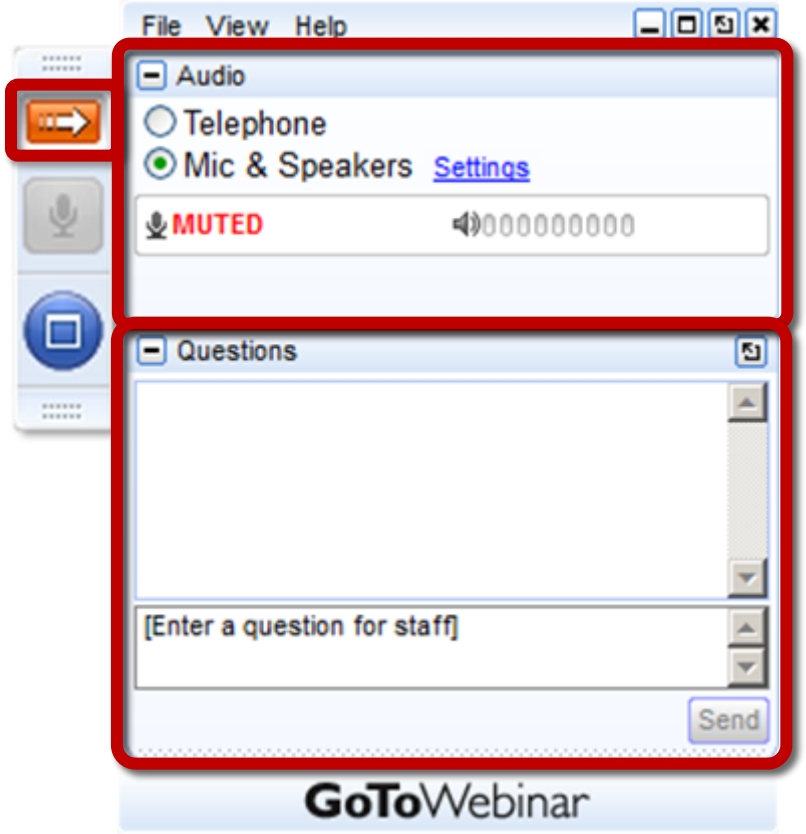
Introduction to Power Markets

March 11, 2022

CleanEnergy States Alliance

Webinar Logistics



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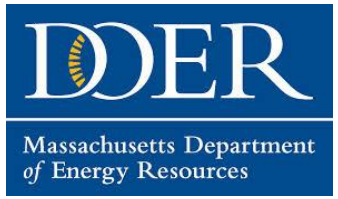
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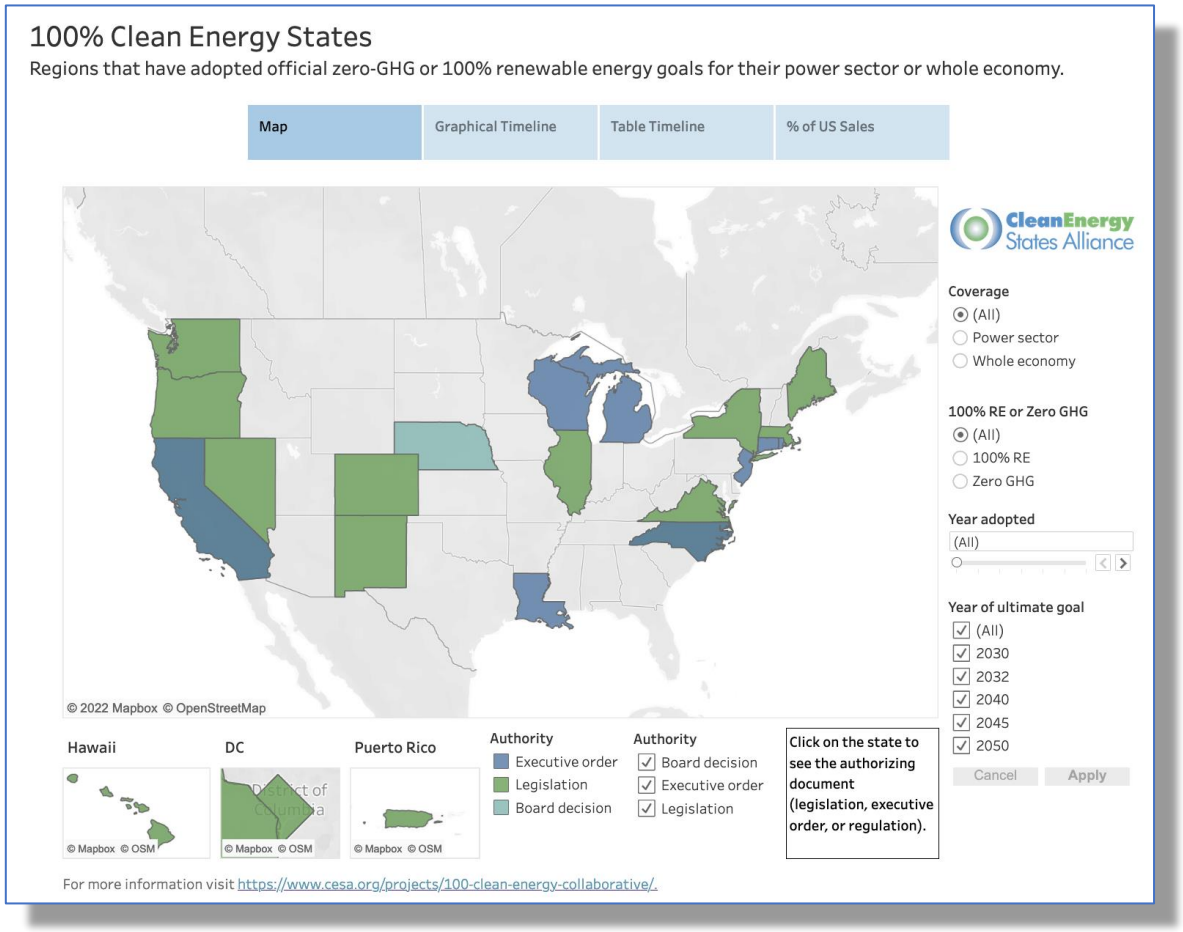

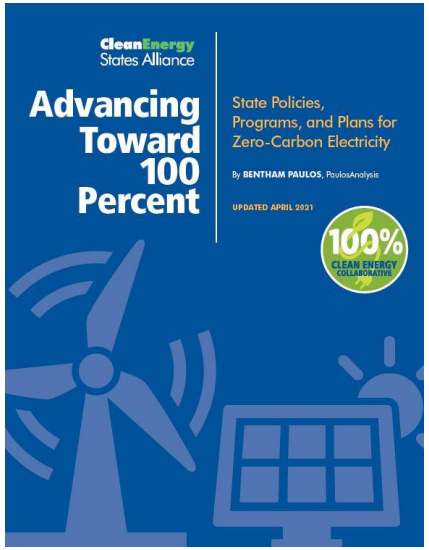

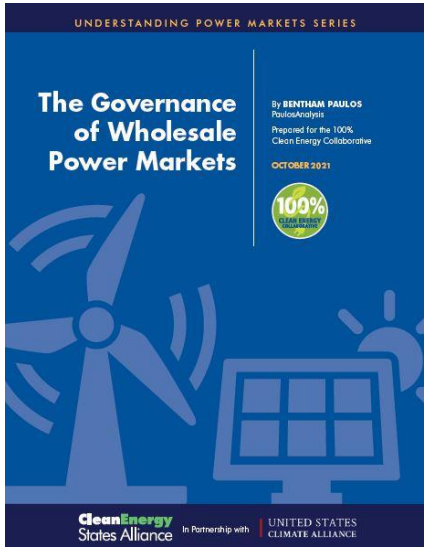

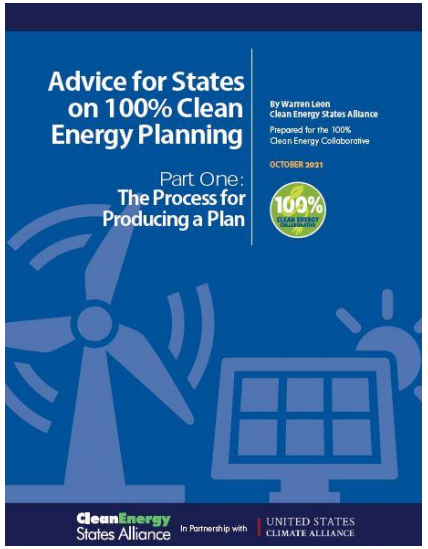

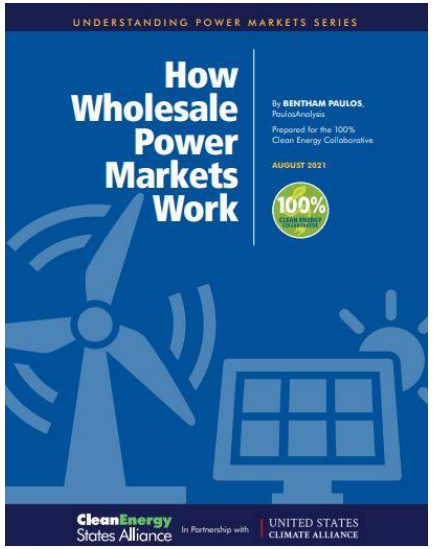

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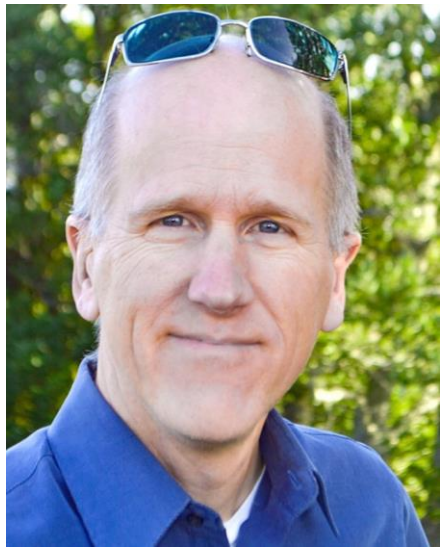
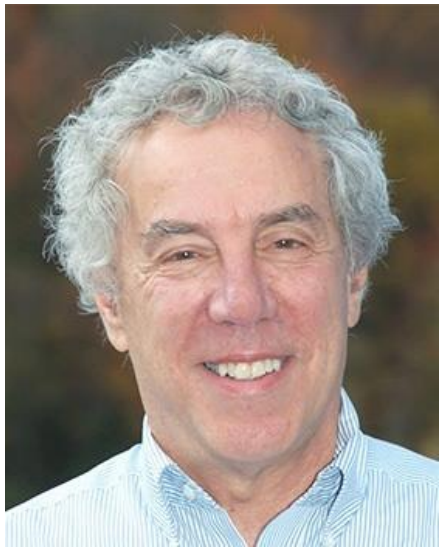
Webinar Speakers



Bentham Paulos
Senior Research Associate, Clean Energy States Alliance, and Principal, PaulosAnalysis



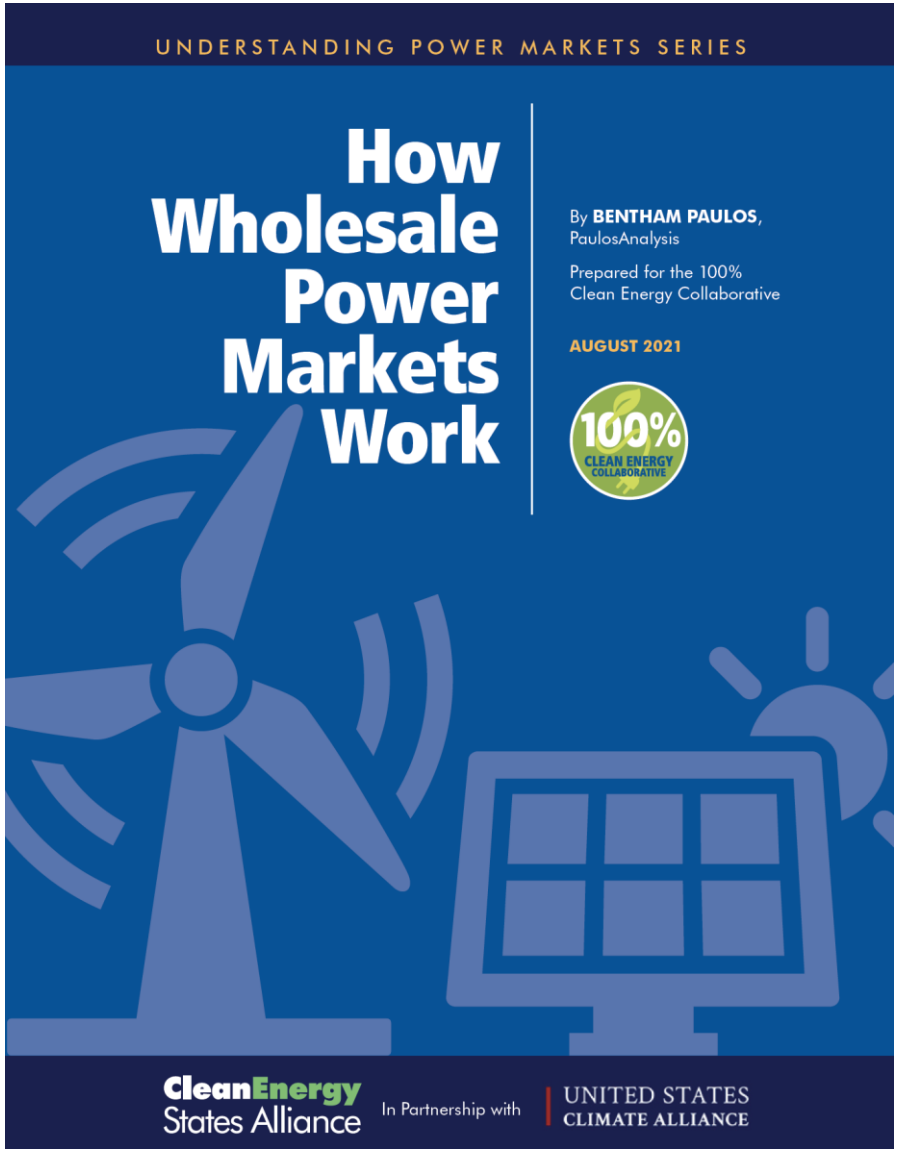
Warren Leon
Executive Director, Clean Energy States Alliance (moderator)

Introduction to Wholesale Electricity Markets

Bentham Paulos

For the Clean Energy States Alliance

March 2022



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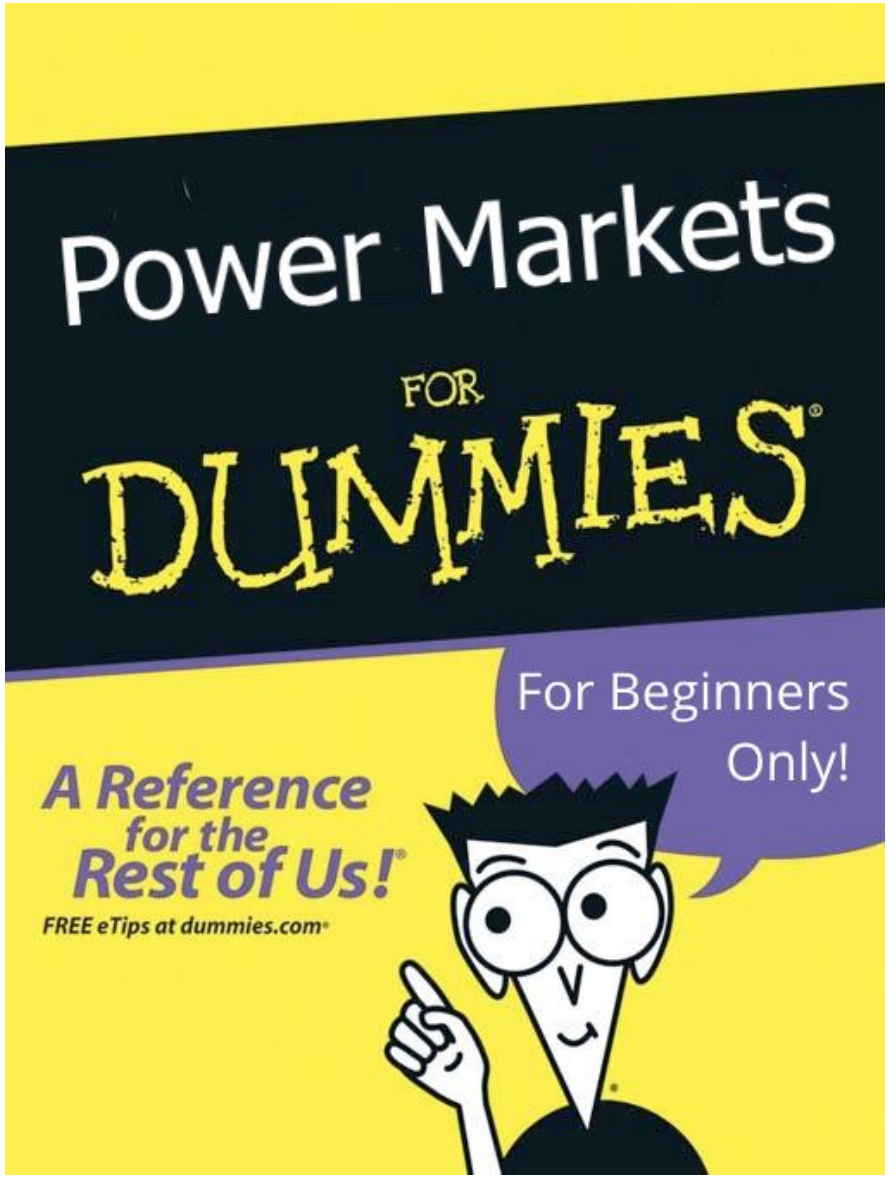
Are you in the right class?



Why worry?

- 100% clean = lots of wind and solar
- A poor fit with wholesale electricity markets premised on the marginal cost of production (i.e., mostly fuel costs)
- To understand how this might play out, you have to know how power markets work today.

Is electricity a normal product?

Yes

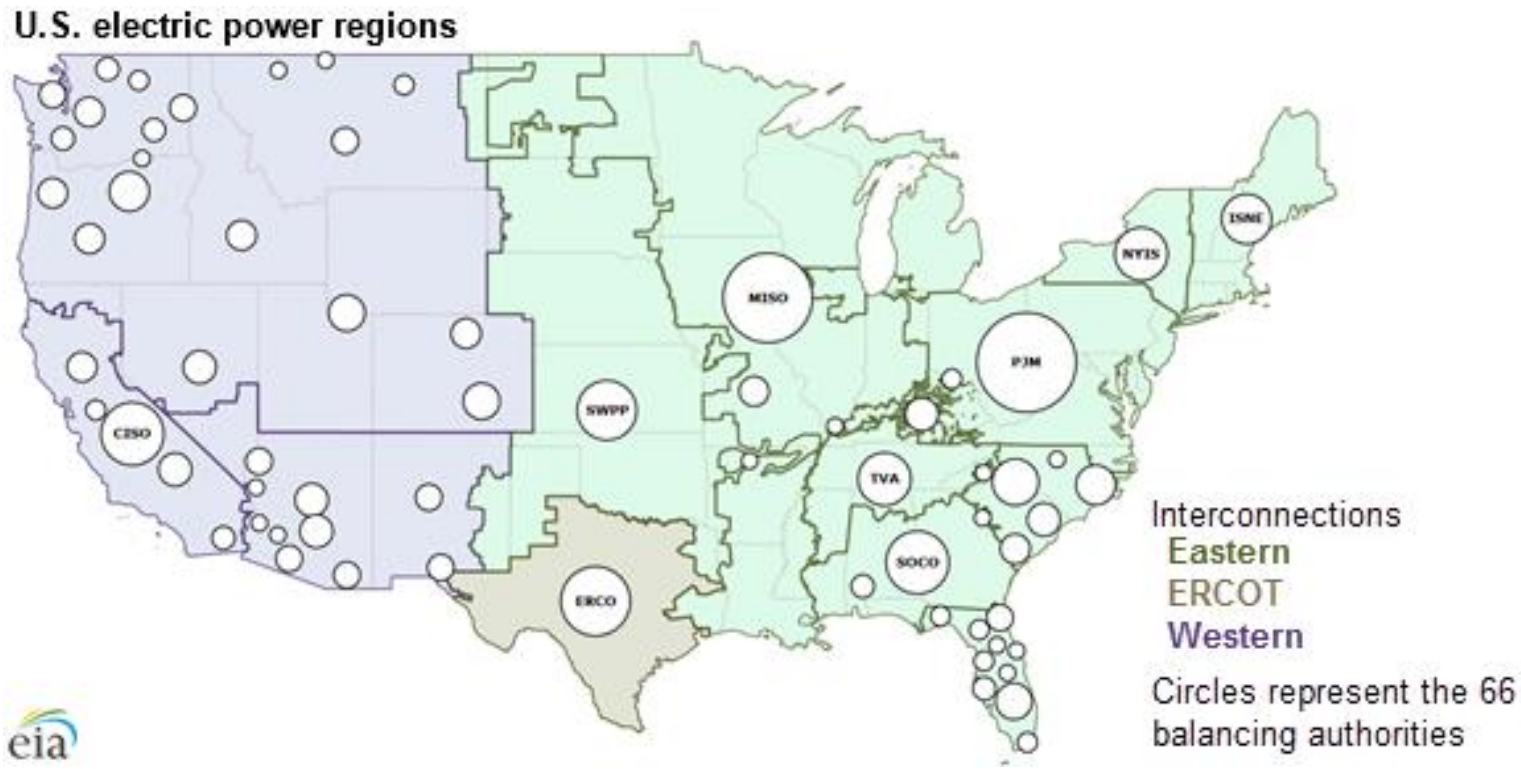
- Prices set by supply and demand (in competitive markets)
- Disruptions affect prices
- Supply chain

No

- Real time delivery
- Extreme fluctuations
- Limited elasticity

The physical grid

- “The largest machine ever made”: 7,300 power plants, 160,000 miles of high-voltage power lines, and millions of low-voltage power lines and distribution transformers, which connect 145 million customers
- Three interconnections, each a synchronized machine
- Limited connections between them
- 66 balancing authorities

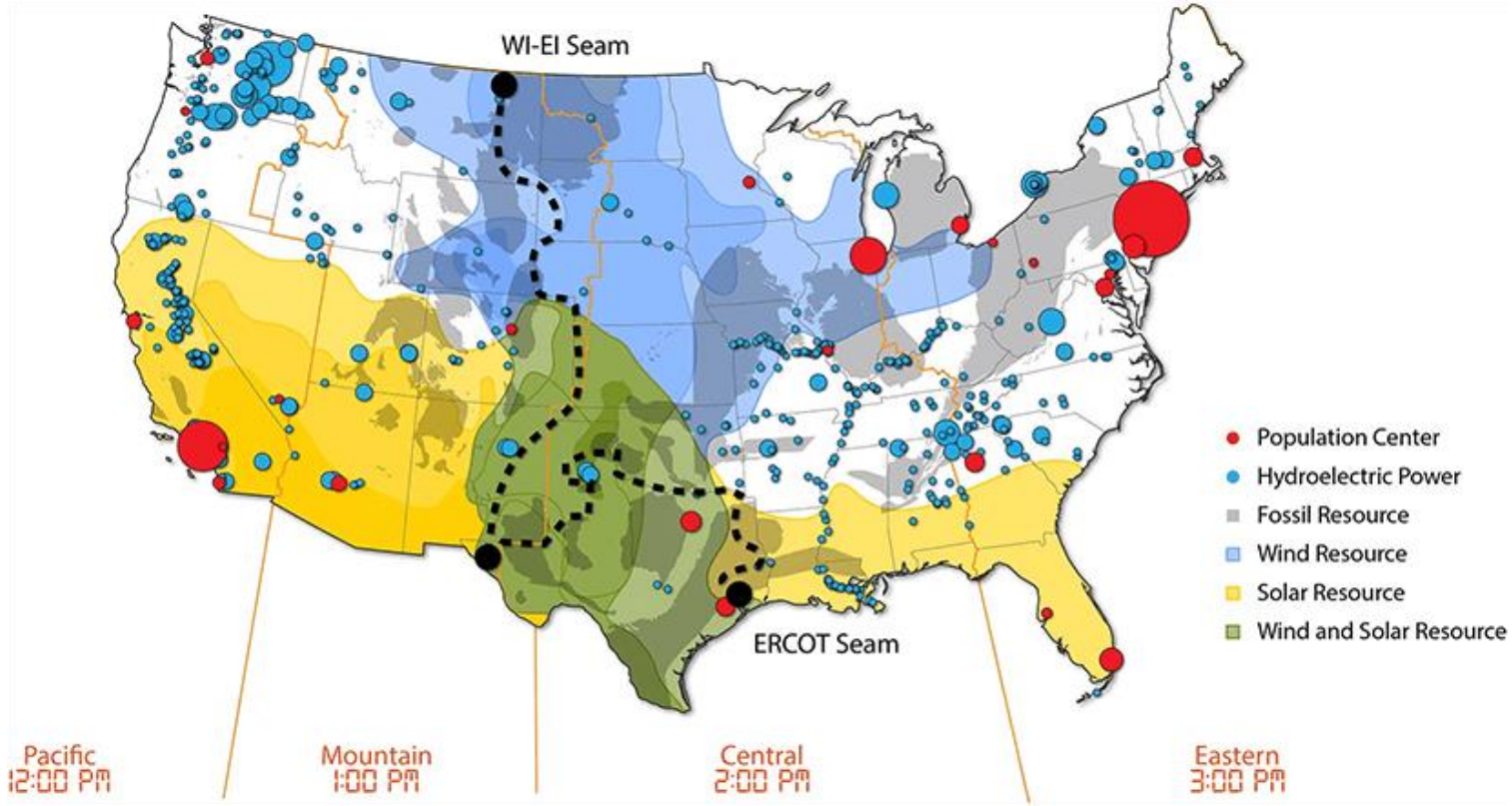


The money grid

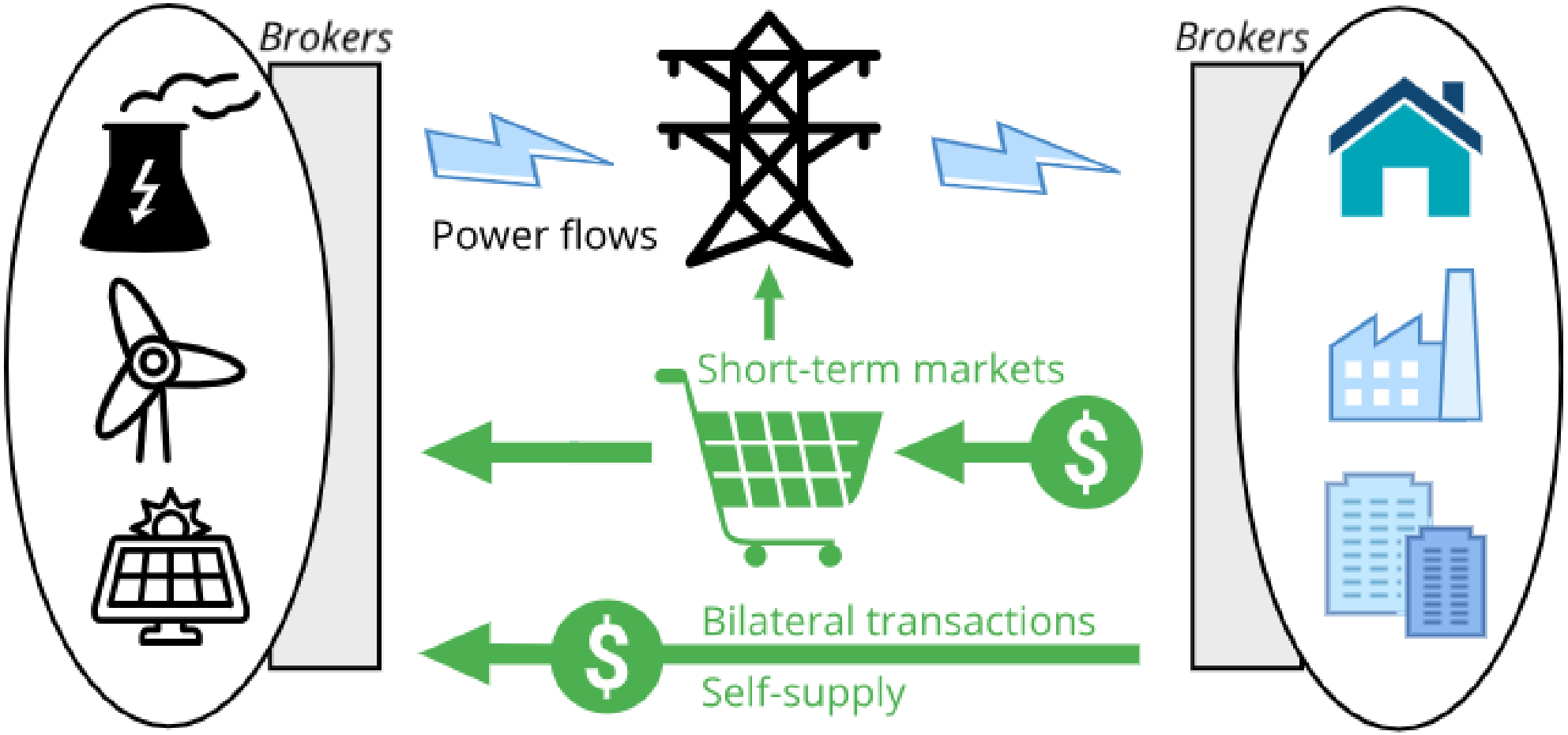
- Markets determined by politics and business
- Organized markets
  - 7 RTOs and ISOs
- Disorganized markets
  - West and Southeast
  - Each utility is independent, with informal or partial arrangements with neighbors
- Benefits of big markets: less variation, lower risk, more liquidity, more competition

The energy map of the future

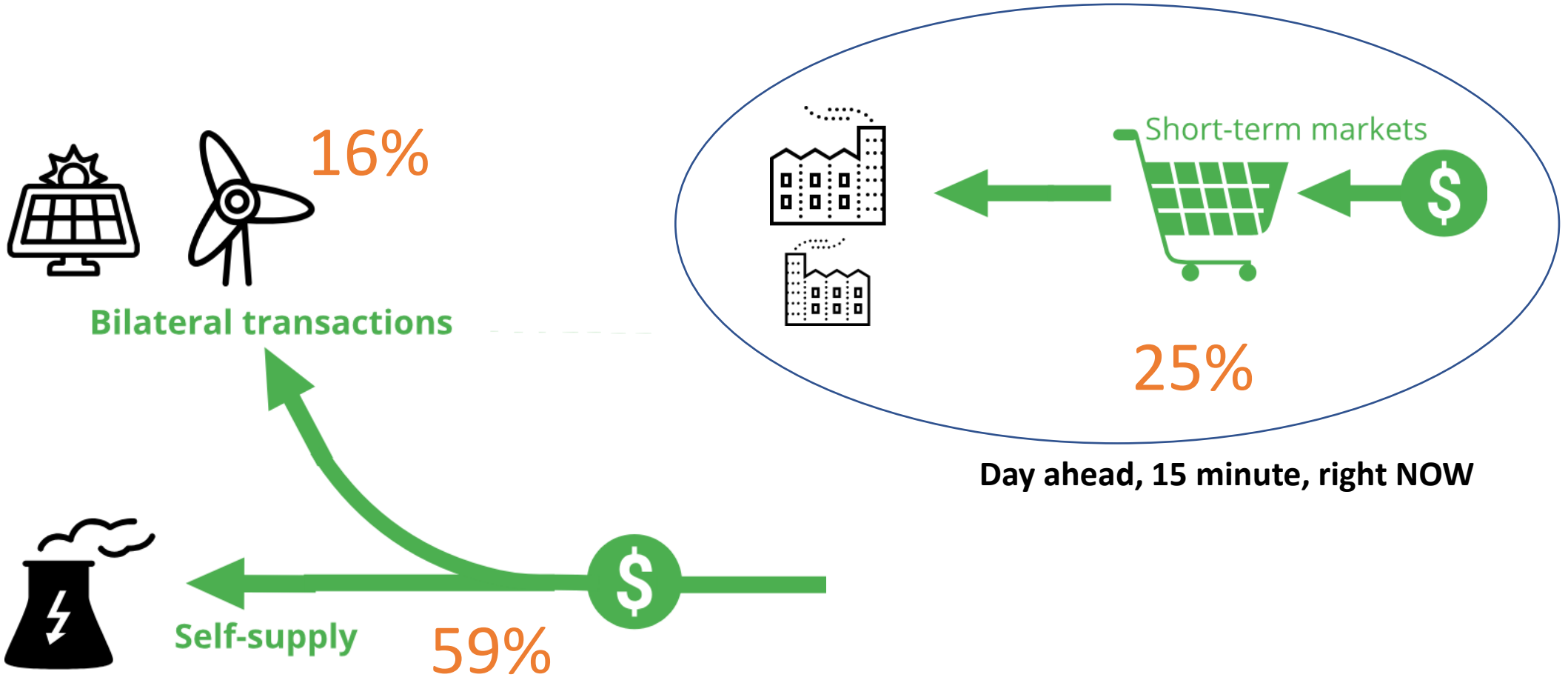
- The wind, solar, and fossil regions
- Relative to where the load is (the people)
- From the NREL “seams study”
- Illustrates the importance of transmission and seams between markets



The flows of money and power



Market mechanisms



In PJM last year

Market products

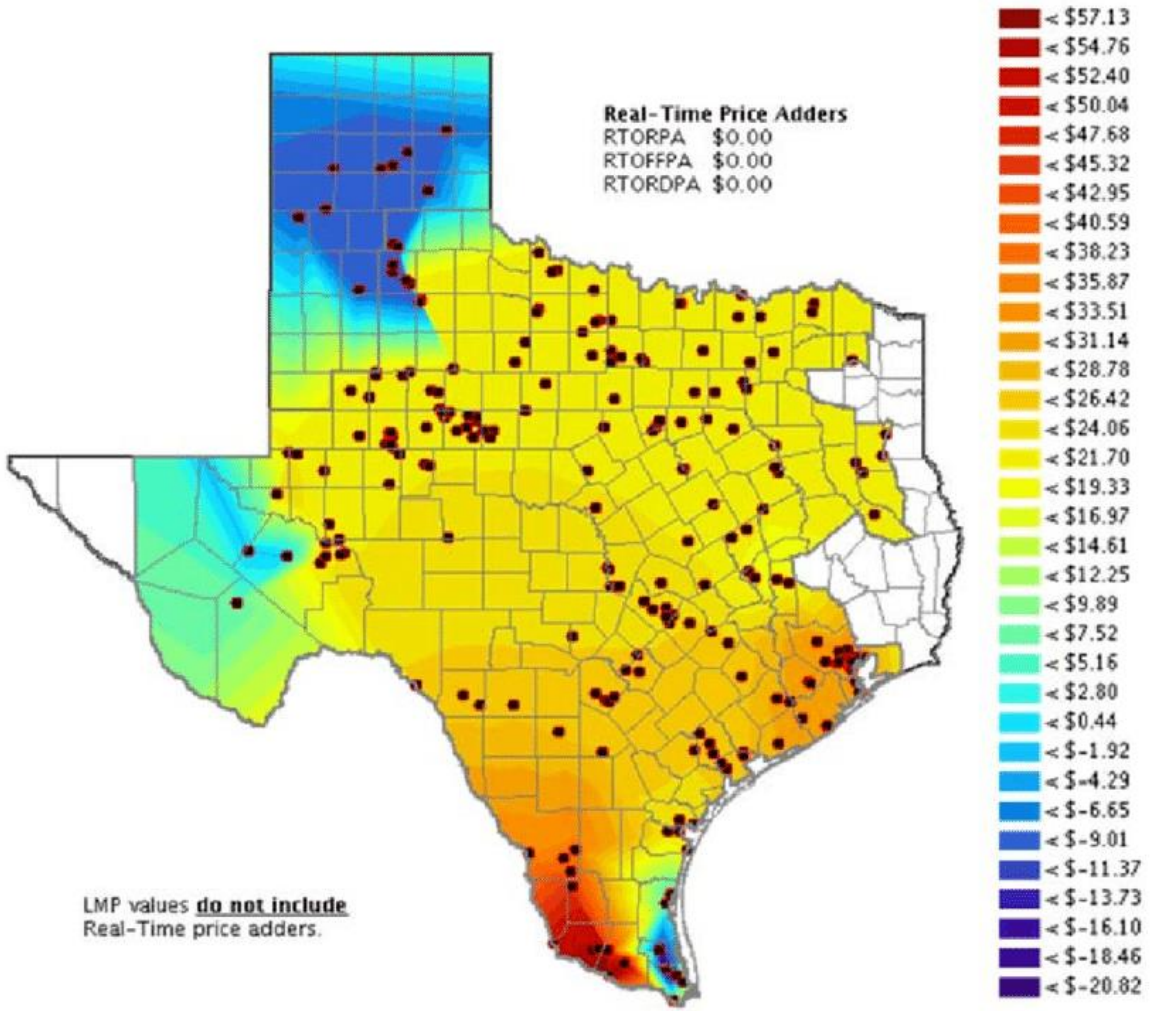
- Energy - ~50%
- Capacity - ~20%
- Transmission - ~25%
- Ancillary services - ~3%
- Renewable energy credits - $1-$40

Constraints

Capacity	Emissions
Fuel	Water
Congestion	Etc.

Local markets

- Prices vary by location – locational marginal prices (LMP)
- Illustrates the physical relation between generators and customers, and impact of congestion
- Provides detailed signals to market actors



What is marginal cost?

- Difference between **Capital and O&M**
- Capital is “sunk” cost
- Marginal = cost of next shovelful of coal
- Wind/solar have almost no marginal costs

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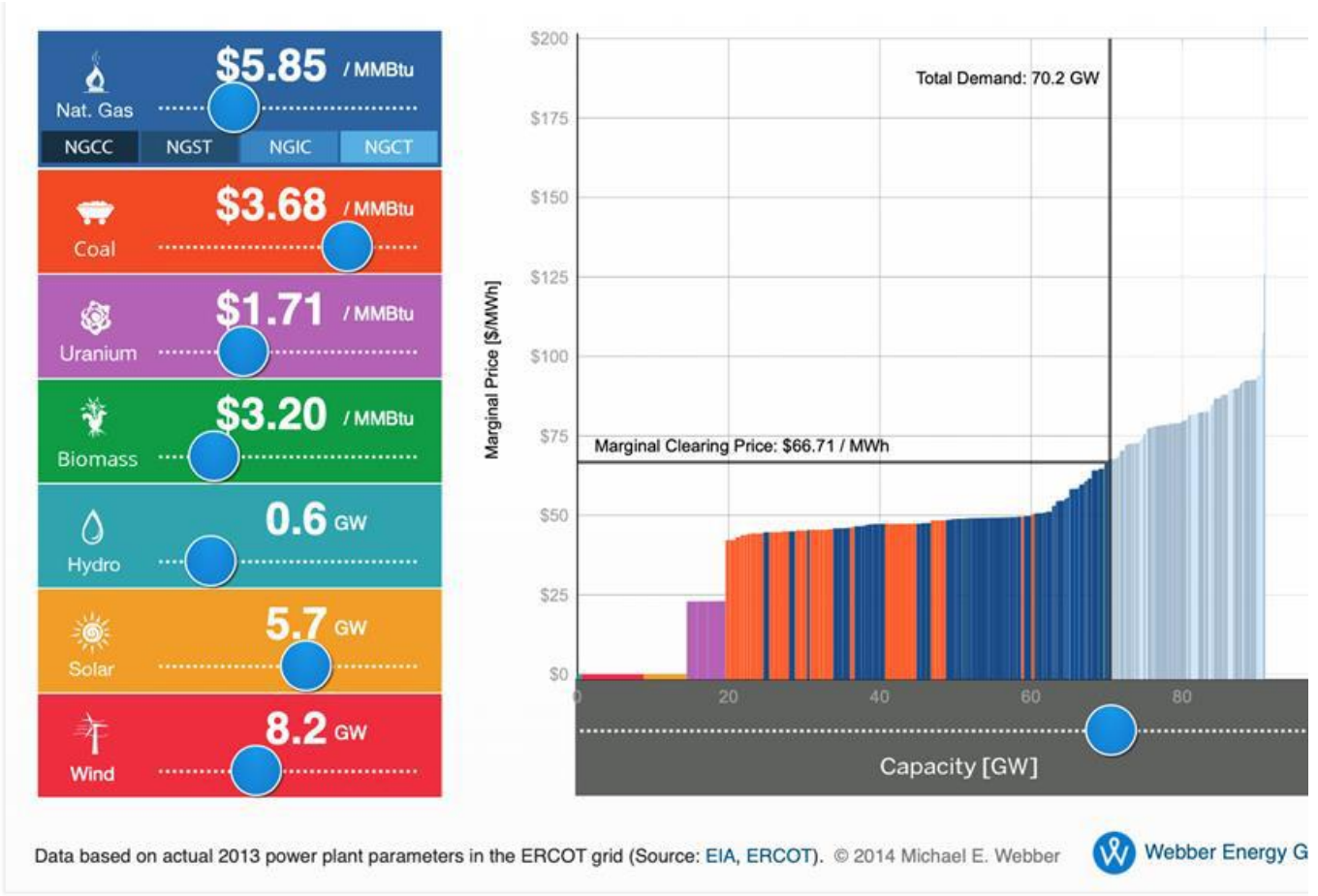
"Price discovery" -- How the short-term market works

- Bids are placed based on marginal cost, selected according to price (the **merit order**)
- Demand x marginal price = **market clearing price**
- **Price takers** always bid low
- Plants with high marginal costs bid high, and are dispatched last, if at all



www.energy101.com/calculators

What prices do customers see?

- Most customer bills are moderated through brokers, paying average prices
- Some rates can reflect peak and off-peak price bins (TOU)
- A few customers use **dynamic prices**, that reflect real-time market prices

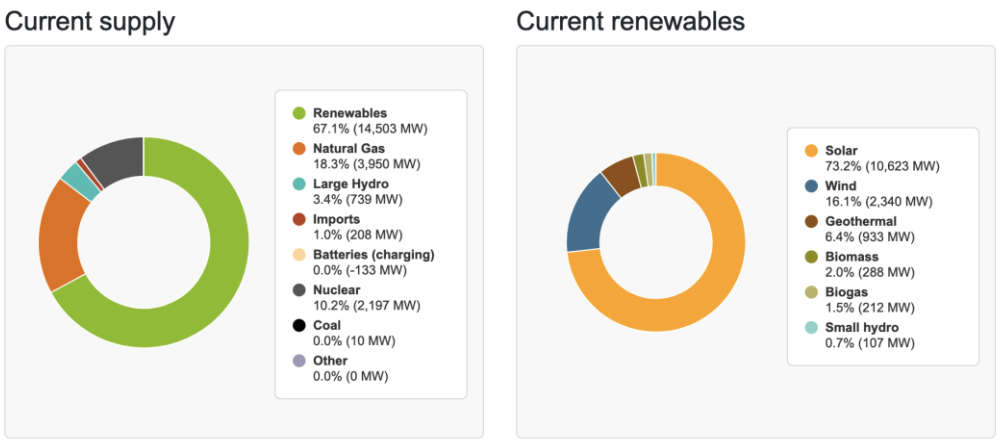
griddy
it's on.

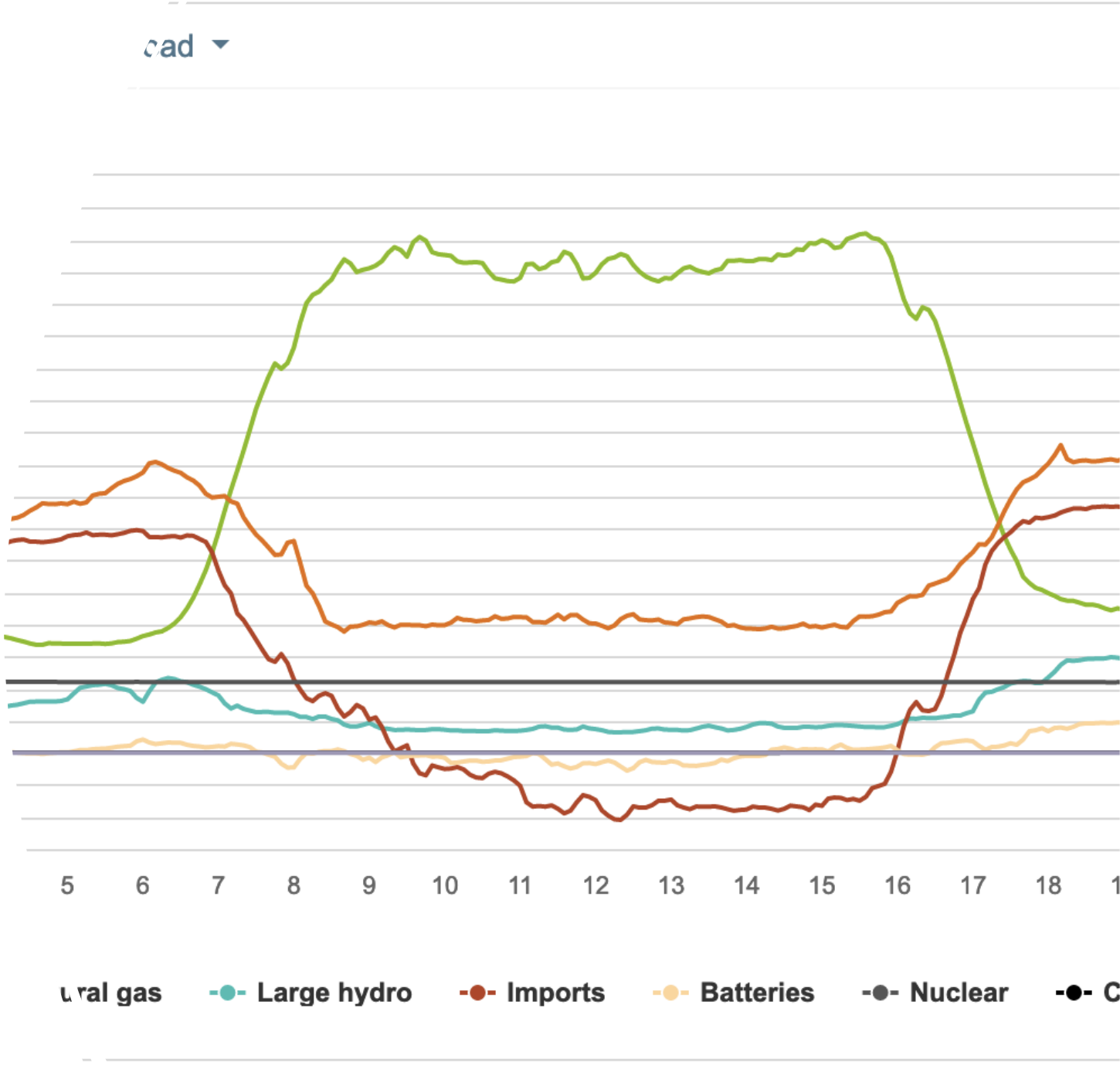
The role of the broker

- Assemble a portfolio based on predicted demand
- Seek out the **least cost / best fit / least risk** portfolio
- Mostly long-term contracts, with some flexibility to sell surplus or buy shortfalls

Impact of solar

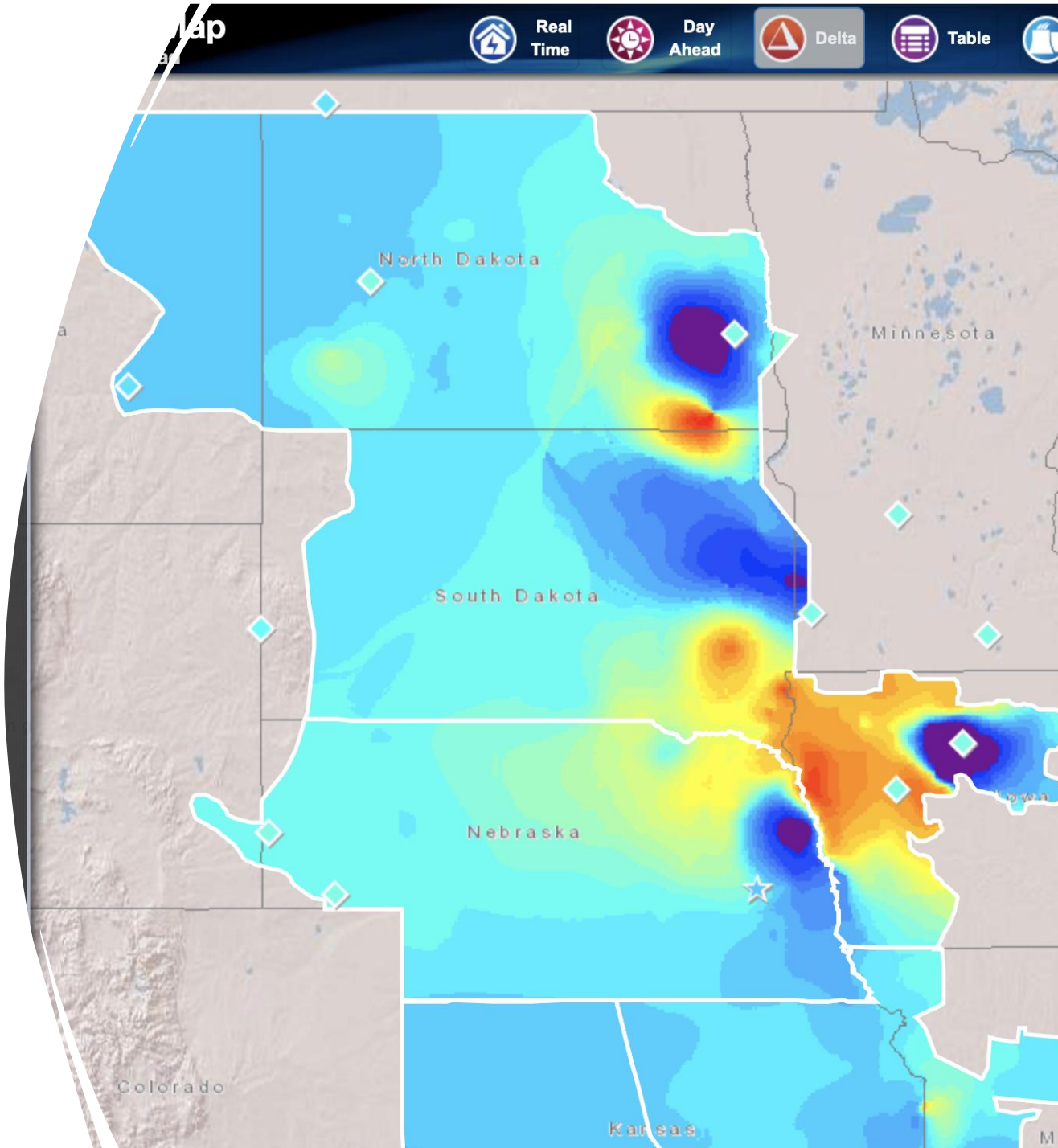
- Large amounts of wind and solar drive down the market clearing price, by pushing more expensive units out of the merit-order—known as the "merit-order effect"
- [CAISO real time]





Impact of wind

- Times of congestion and surplus create very low and even **negative prices**
- Illustrates the critical role of transmission
- [MISO real time map]



Are wind and solar free?

- Wind and solar are **not free**, despite their zero marginal costs.
- They drive down prices *just as they produce the most*.
- **But** -- they are insulated from market clearing prices in the short term, since they are sold through long-term contracts.
- **But** -- in the long run, buyers will seek those very low prices, putting downward pressure on solar/wind producers.

- The short-term merit order market is a *residual* market, not the whole market.

Do wind & solar create a problem for markets?

- Markets match buyers and sellers
- Markets discover prices
- If too much solar makes prices negative, it tells the market to produce less solar
- But it also tells the market to consume more solar
- Consumption will shift, including batteries and EV charging

Future topics

- What is the best market design for a 100% Clean future?
- How do we solve the problem of the last 10%?
- How do models work?
- What is the role of distributed energy, or nuclear power?
- How can we build more transmission?

Thank you for attending our webinar

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www.cesa.org/projects/100-clean-energy-collaborative

Upcoming Webinars

- Putting Policy into Practice: How the CT Green Bank, Eversource & Avangrid will Partner on Connecticut's Energy Storage Solutions Program (3/15)
- Use of Operating Agreements and Energy Storage to Reduce Photovoltaic Interconnection Costs (3/23)
- How CEG and CT Green Bank are Helping Connecticut Affordable Housing Facilities Install Resilient Solar+Storage (3/29)
- An Introduction to the Solar Power in Your Community Guidebook (4/14)

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