Introduction to Power Markets

March 11, 2022
Webinar Logistics

Join audio:
• Choose Mic & Speakers to use VoIP
• Choose Telephone and dial using the information provided

Use the orange arrow to open and close your control panel

Submit questions and comments via the Questions panel

This webinar is being recorded. We will email you a webinar recording within 48 hours. This webinar will be posted on CESA’s website at www.cesa.org/webinars
CESA.org/100
100% Clean Resources

Regions that have adopted official zero-GHG or 100% renewable energy goals for their power sector or whole economy.

For more information visit https://www.csea.org/projects/100-clean-energy-collaborative/
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
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

Brokers

Power flows

Short-term markets

Bilateral transactions

Self-supply

Brokers
Market mechanisms

In PJM last year

59% Self-supply

16% Bilateral transactions

25% Short-term markets

Day ahead, 15 minute, right NOW

Long term commitments, in advance
Market products

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

Constraints

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>Water</td>
</tr>
<tr>
<td>Congestion</td>
<td>Etc.</td>
</tr>
</tbody>
</table>
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
“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
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

Warren Leon
Executive Director
Clean Energy States Alliance
wleon@cleanegroup.org

Learn more about the 100% Clean Energy Collaborative at
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)

Read more and register at: www.cesa.org/webinars