Power Markets Structure and Design for Low-Cost De-Carbonization

HEPG
October 1, 2019

Rob Gramlich

Grid Strategies LLC

ENERGY INNOVATION
POLICY & TECHNOLOGY LLC

AMERICA'S POWER PLAN

Grid Strategies LLC

RAP®

www.energyinnovation.org
98 Battery Street, Suite 202
San Francisco, CA 94111
power@energyinnovation.org

WHOLESALE ELECTRICITY MARKET DESIGN FOR RAPID DECARBONIZATION: A DECENTRALIZED MARKETS APPROACH

BY ROB GRAMLICH[1] AND MICHAEL HOGAN[2] ● JUNE 2019

"What wholesale market design would provide the best framework for integrating reliably and at least cost the new, clean resources that will be needed to de-carbonize the power system?"

This common question includes what model best provides clean sources with fair access, what model best drives timely retirement of the fossil

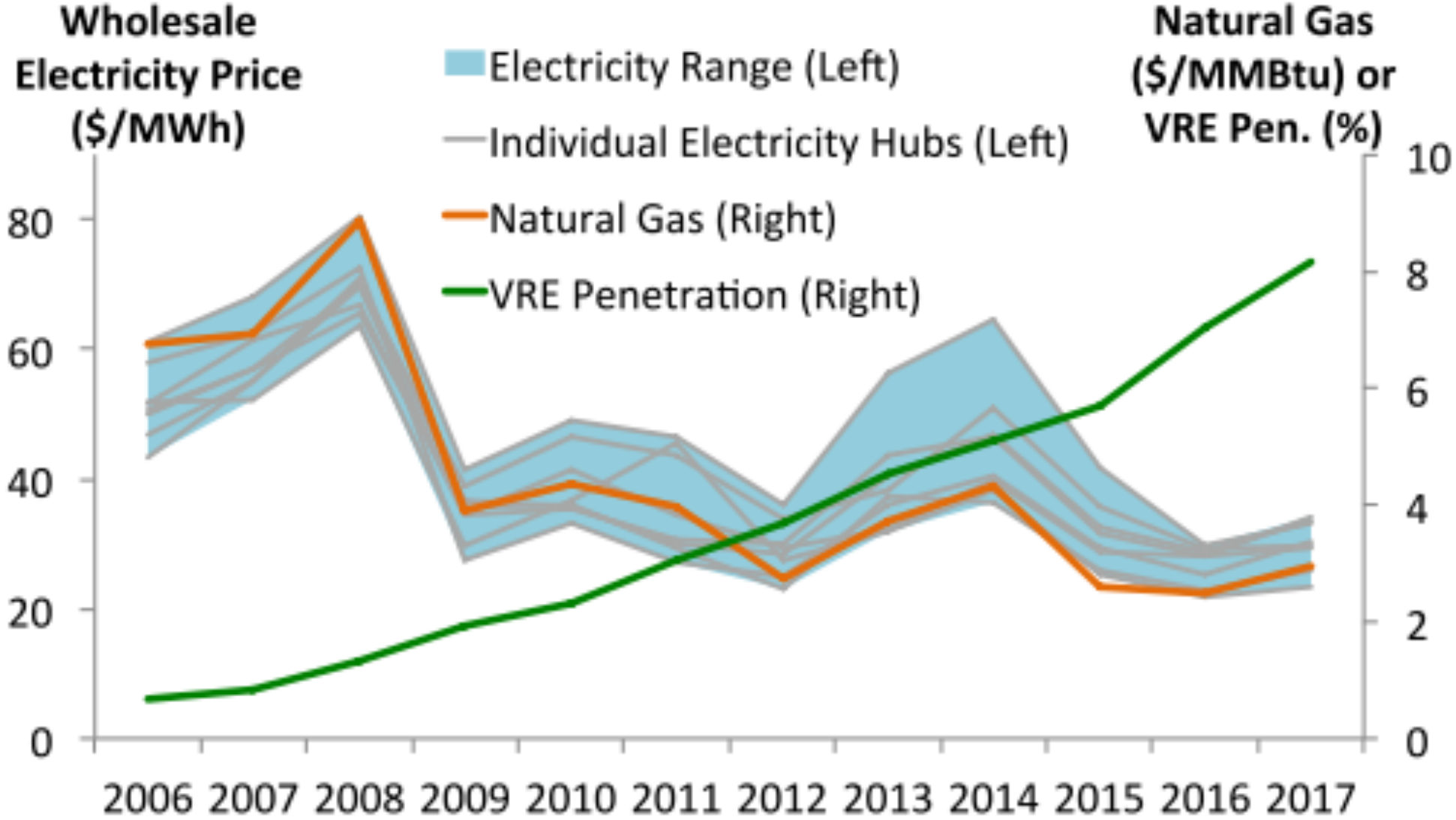
TABLE OF CONTENTS

www.gridstrategiesllc.com

https://windsolaralliance.org

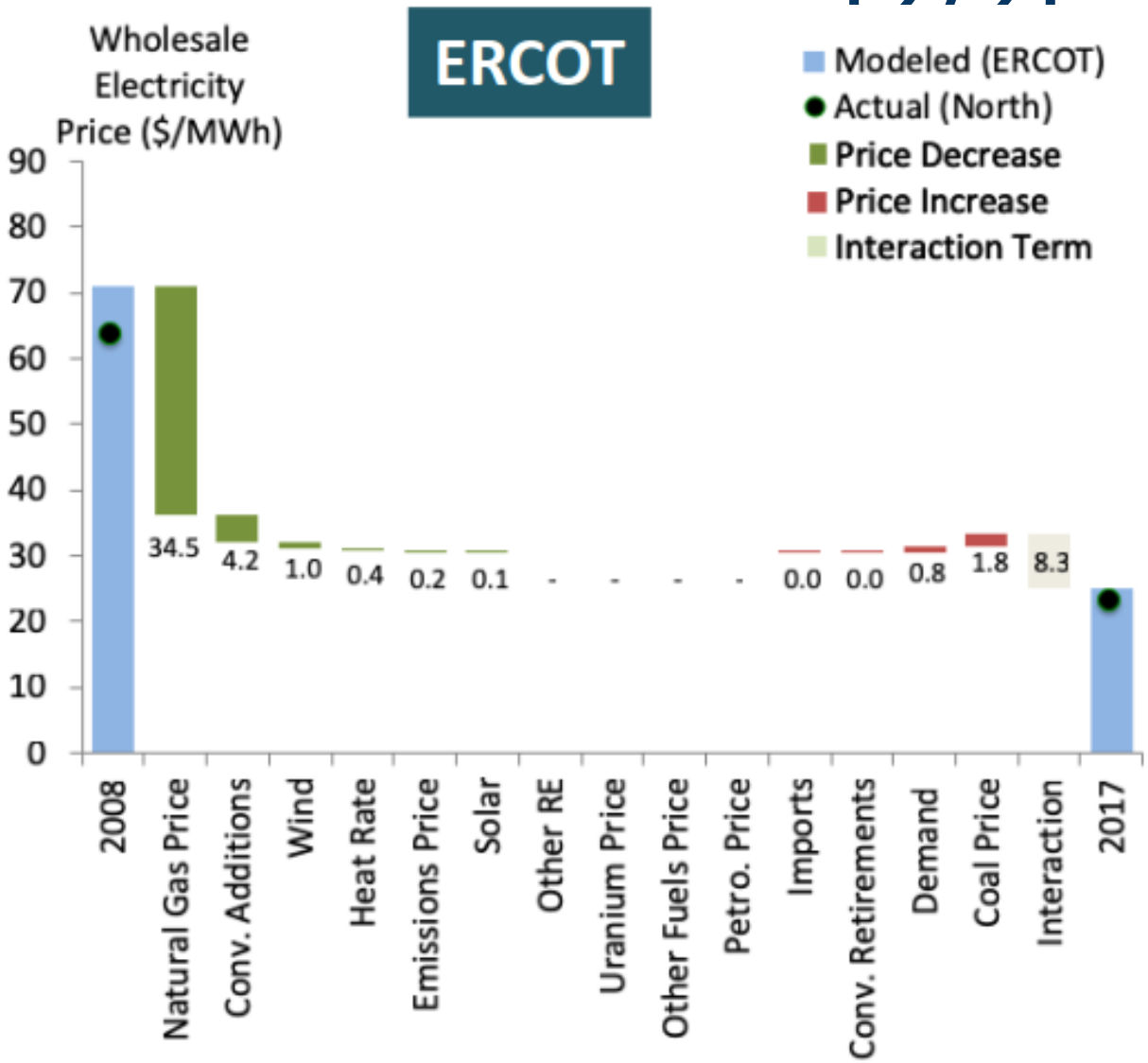
Q: What is Causing Low Power Prices Now?

A: Mainly low gas prices



Source: LBNL

What is Causing Low Power Prices Now? (2/2)



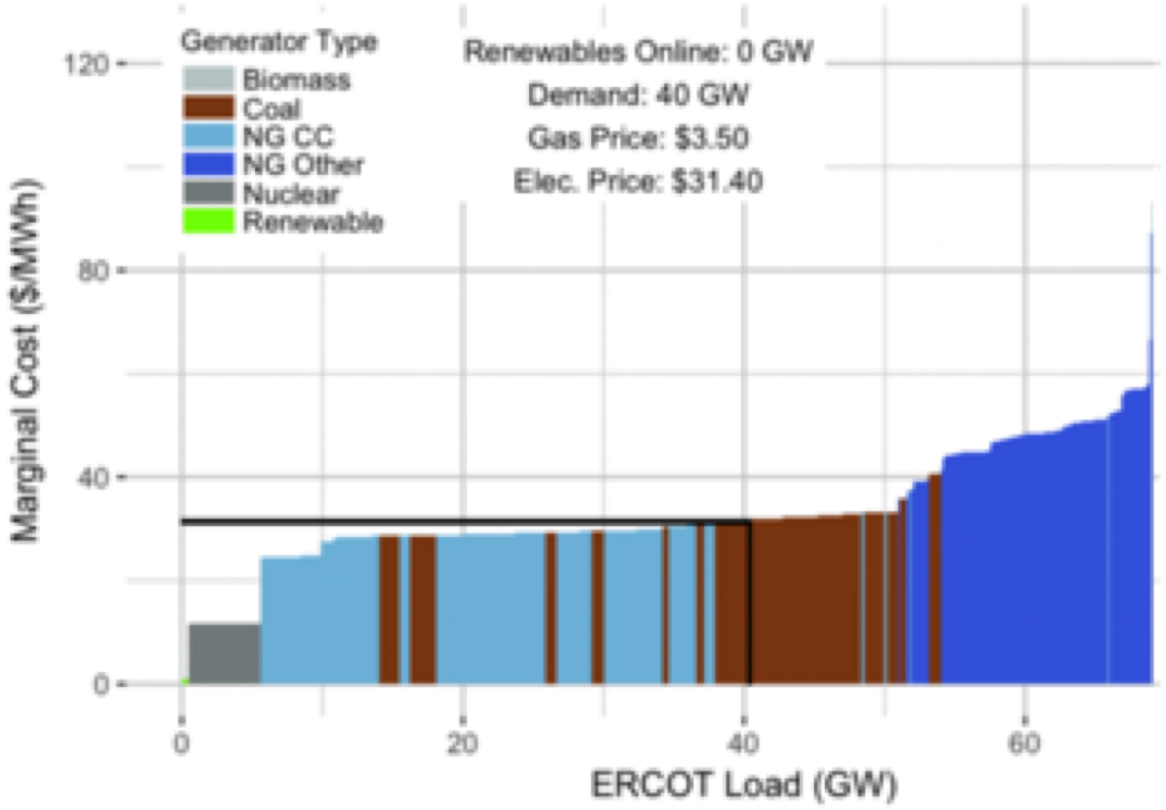
Source:

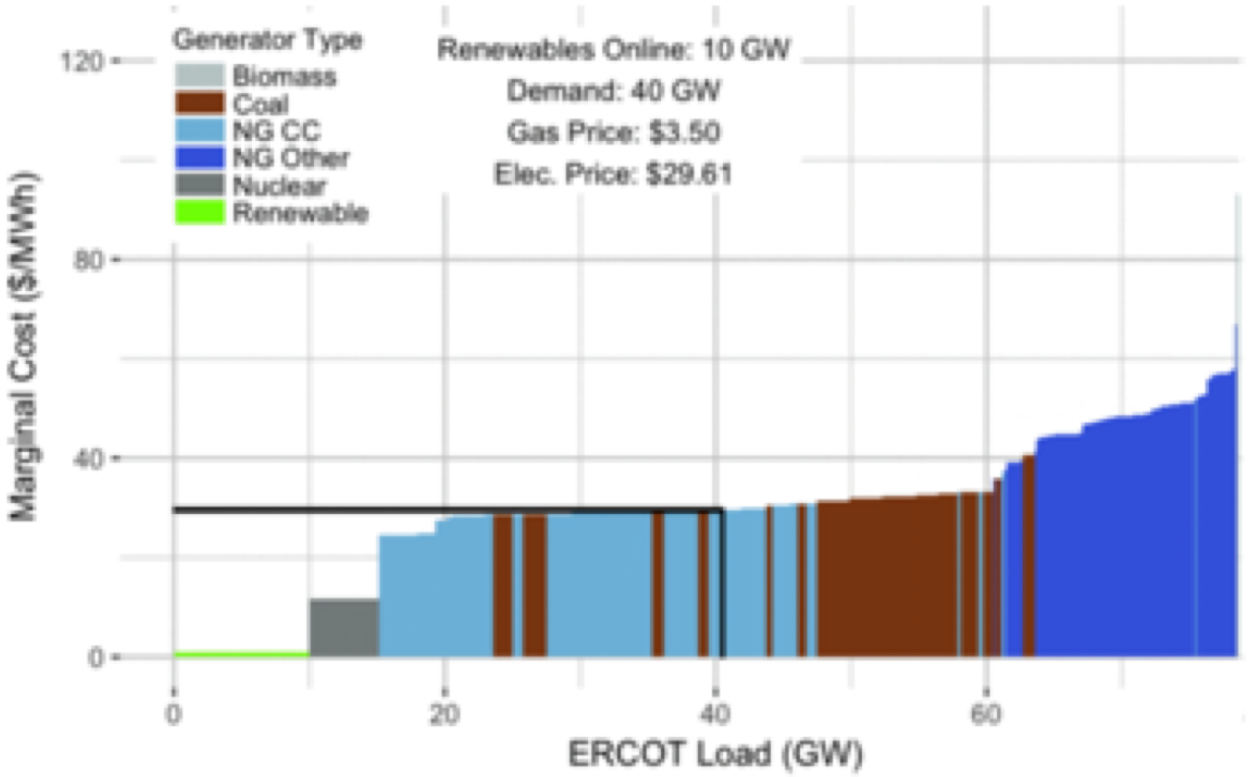
LBNL

https://emp.lbl.gov/publications/impacts-high-variable-renewable

See also Jenkins http://ceepr.mit.edu/files/papers/2018-001.pdf

Impact of adding zero-fuel-cost renewables



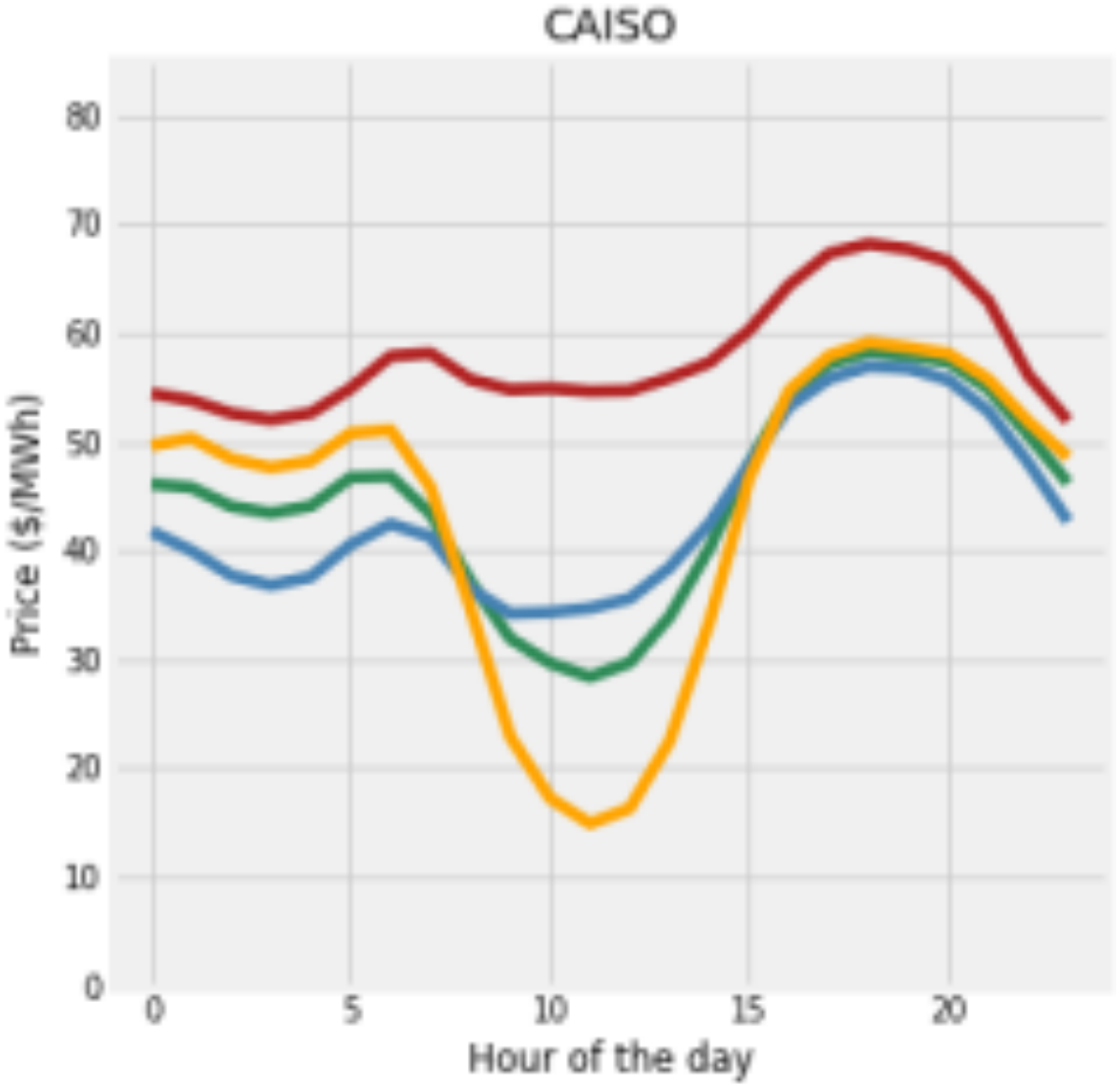


Source: UT Austin http://theconversation.com/are-solar-and-wind-really-killing-coal-nuclear-and-grid-reliability-76741

What about in the 2030s?

Power prices w/40% renewables by hour of day

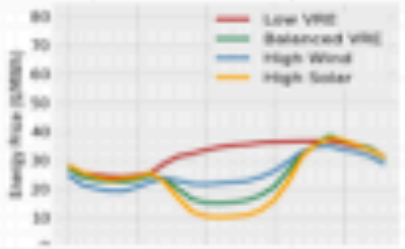
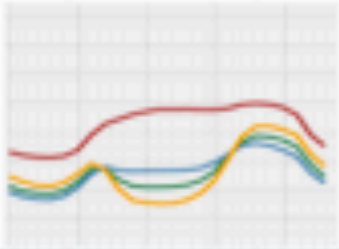
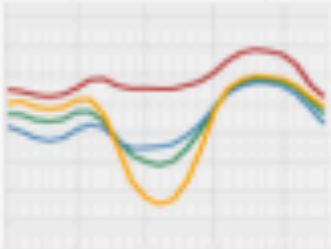
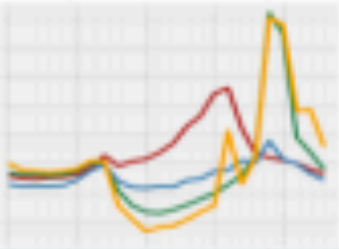
- 2016 portfolio
- Balanced: 20% wind, 20% solar
- High wind: 30% wind, 10% solar
- High solar: 30% solar, 10% wind



Source: LBNL

Wholesale Price Effects of 40-50% Wind & Solar

(Wind: 30% wind & 10+% solar | Balanced: 20% wind & 20% solar | Solar: 30% solar & 10+% wind)

Impacts in 2030 relative to baseline with 2016 wind & solar shares	Southwest Power Pool 2016: 18% wind & 0% solar			NYISO (New York) 2016: 8% wind & 1% solar			CAISO (California) 2016: 7% wind & 14% solar			ERCOT (Texas) 2016: 16% wind & 1% solar		
	Wind	Balanced	Solar	Wind	Balanced	Solar	Wind	Balanced	Solar	Wind	Balanced	Solar
Lower Average Prices [$/MWh]	-19%	-21%	-27%	-37%	-38%	-39%	-25%	-23%	-27%	-25%	-17%	-15%
More Hours <$5/MWh In baseline: 0% of all hours	6%	8%	13%	2%	7%	11%	6%	7%	11%	6%	11%	19%
Changes in Diurnal Price Profile red baseline shows 2016 wind & solar shares												
More Price Variability	1.8x	2.1x	2.5x	2.1x	2.3x	2.5x	3.0x	2.9x	3.4x	1x	4.7x	6.6x
Higher AS Prices Regulation Down	5x	6x	9x	2x	2x	3x	3x	3x	3x	2x	3x	4x
Change in Timing of Top Net-Load Hours	Shift from 4pm to 7pm			Shift from 3pm to 5-7pm			No further shift 7pm			Shift from 3pm to 6-8pm		

Source: LBNL

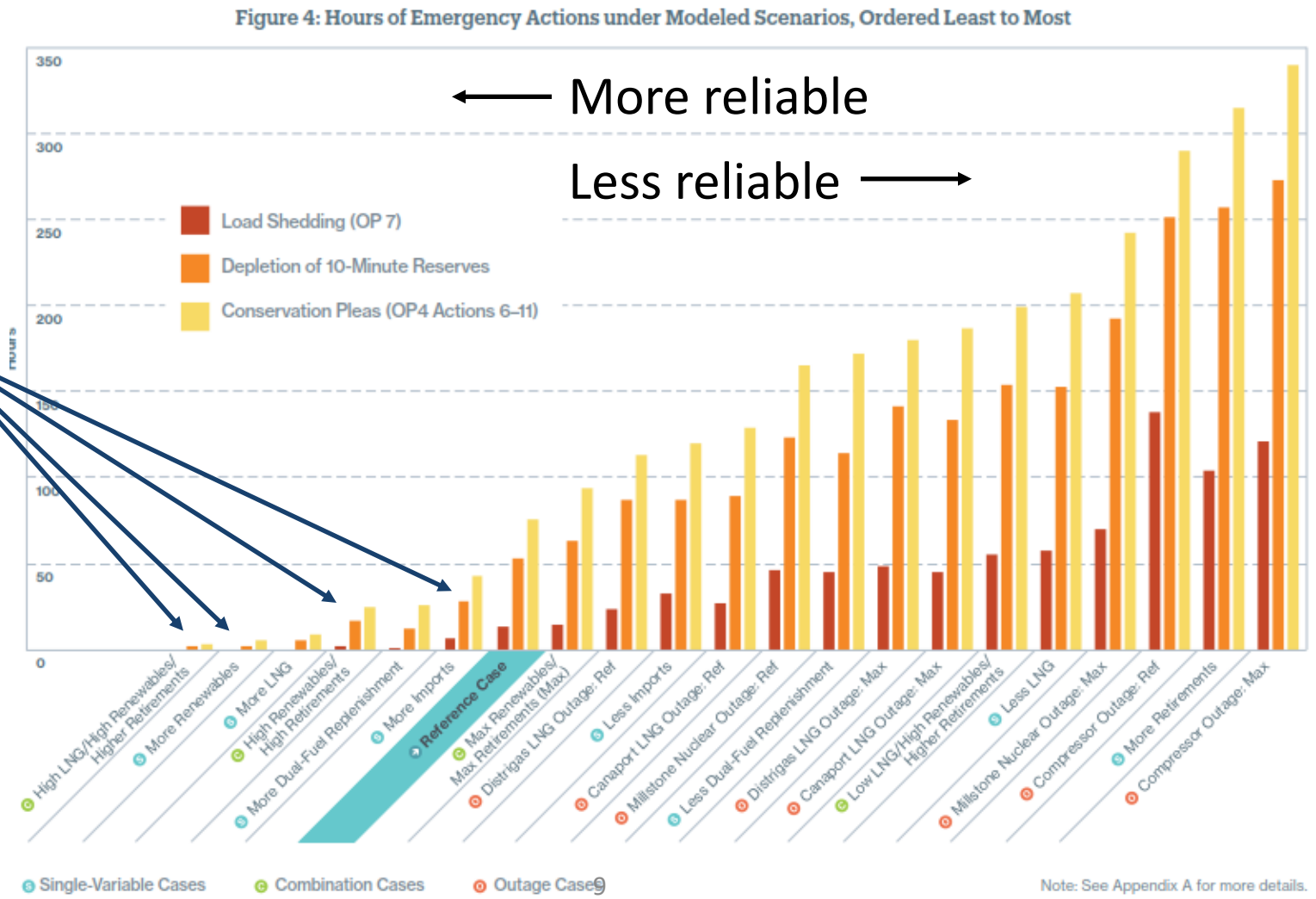
Economic and reliability policy questions for a de-carbonized grid

1. **Whether long run efficiency can be achieved, given:**
   - high penetration of zero marginal cost resources, frequently setting prices of $0/MWh
   - Energy and other services are needed at times and places that renewables alone won't provide, and
   - Long run efficiency requires that capital costs be recoverable.
2. *Whether physical balancing can be achieved with highly variable supply mix*
3. *Whether frequency support will be adequate after the loss of inertia from synchronous unit retirements*

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

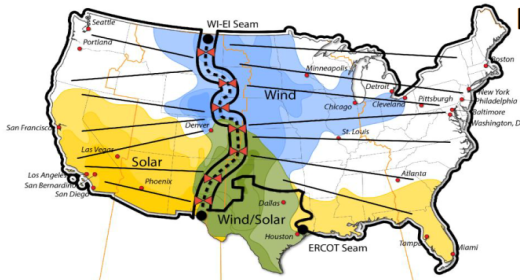
Physical Balancing With High Renewables:
Fuel Security in ISO-NE

High Renewable Scenarios



Accepted Physical System Requirements

- FAST
  - Short dispatch intervals handling fast ramps
- FAR
  - Large regional central dispatch netting out variability and managing congestion, operating on an expanded grid

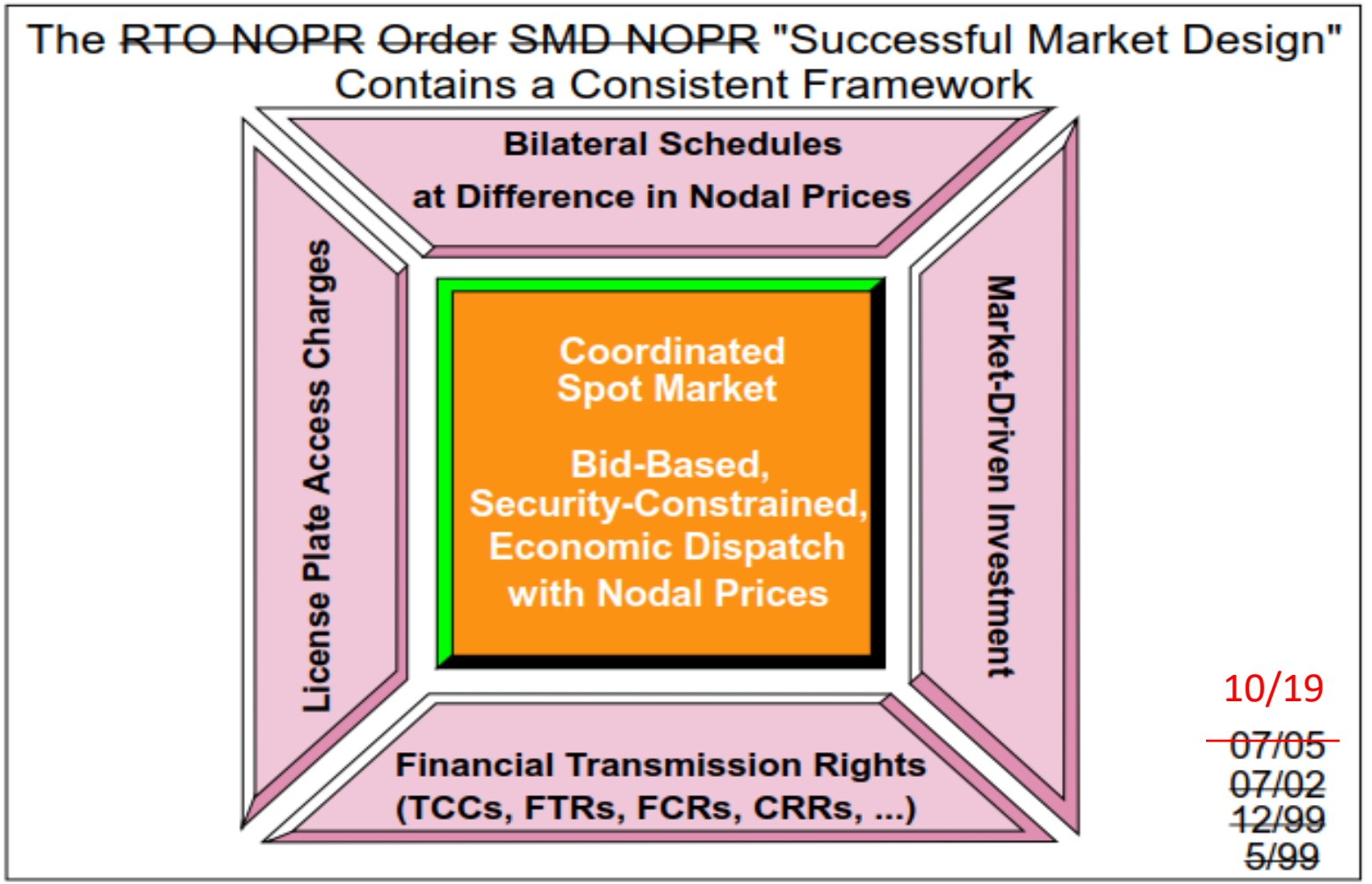


- FULL
  - Short-term energy, flexibility, frequency and voltage support (ERSs)
    - Includes times and places when renewable output is low or rapidly changing

Best Market Structure for Low Cost De-Carbonization (what isn't happening now highlighted)

- Environmental regulators internalize externalities
- RTO/ISO balances power system and administers short term spot markets
  - Procures energy and reliability services based on engineering definitions
  - Also plans transmission infrastructure for reliability and efficiency given future resource mix, recovers cost in regional tariff
- Retail suppliers competitively procure power (hedge) with PPAs to serve load
- State PUCs oversee hedging for some or all customers
  - ensure retail suppliers are credit-worthy buyers of wholesale power
- Utilities build, own, and operate monopoly T&D (not G) with regulated rates
- Independent Power Producers build and own generation to sell electricity products to retail suppliers/wholesale buyers
- Financial participants provide risk management products

Best Market Design for Low-Cost De-Carbonization

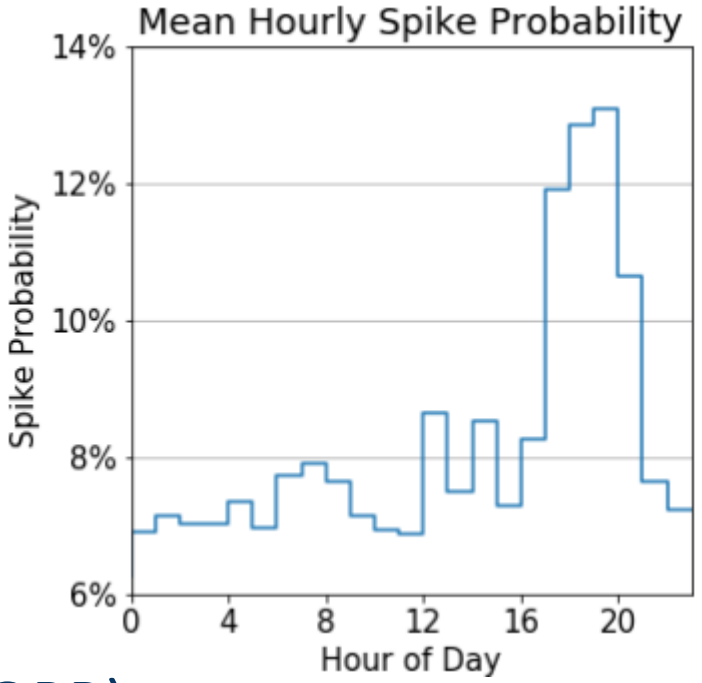


W. Hogan, On an "energy only" electricity market design for resource adequacy" (2005)

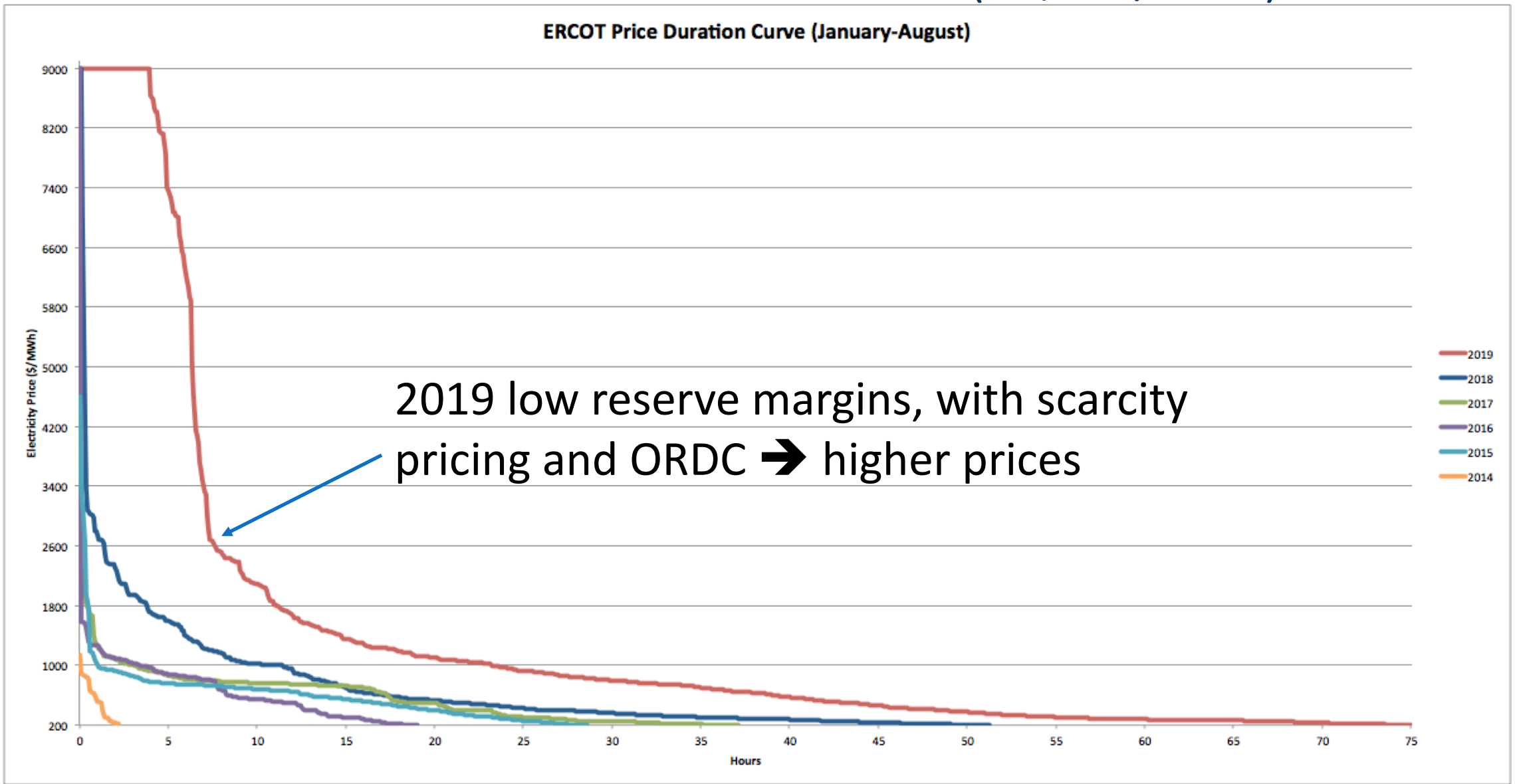
Best Market Design, cont'd

- Spot market with bilateral contracts
  - Expect most payments and revenue in long term PPAs, priced at average cost of competitive new unit
  - Spot market for residuals and re-balancing
- Energy at each time and location
  - Hourly locational marginal pricing (LMP)
- Reliability Services--technology-neutral
  - Operating reserves, exact needs vary by region
  - Reactive support—non-market compensation
- Scarcity pricing
  - prevents free-riding, encourages contracting, attracts flexible resources
- No mitigation of state environmental policies (broad MOPR)

Ascend Analytics CA model:

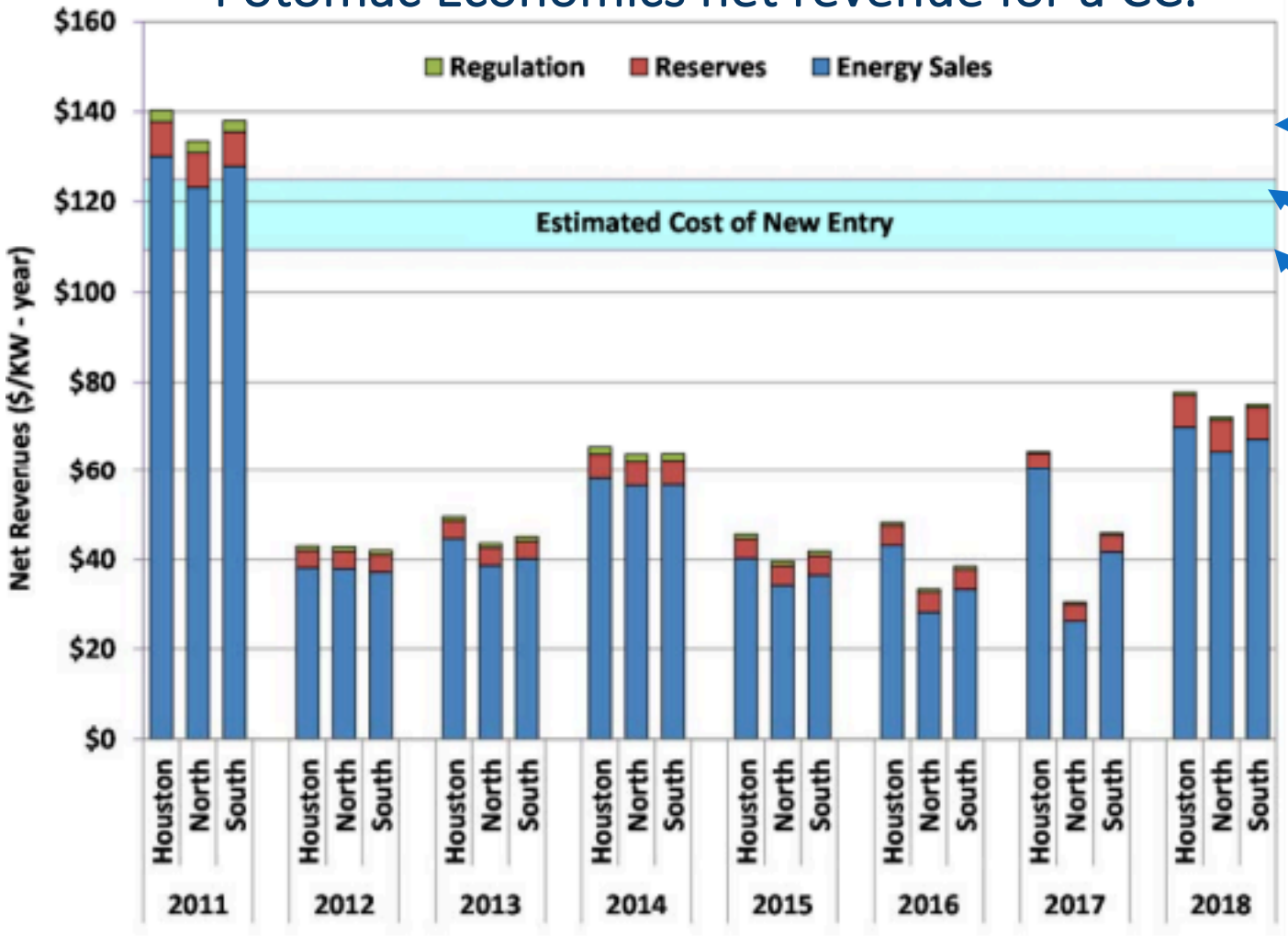


Is It Working?:
ERCOT Price Duration Curve (P>$200/MWh)



ERCOT Net Revenue

Potomac Economics net revenue for a CC:



2019 est. peaker net rev. $137/kw-yr

2019 YTD peaker net rev. $123/kw-yr

Peaker CONE of $105/kw-yr

Source: Grid Strategies estimates

Market Prospects in ERCOT

- “We think prospects remain altogether quite constructive through the medium term with the continued rally in power boding particularly well for '20 ERCOT curves. We stress the further 0.25 std-dev improvement in ORDC parameters should drive yet higher probabilities of achieving ORDC pricing next year as well as suggesting prospects for yet another meaningful outcome on pricing (the percent of hours with ORDC & total value delivered from ORDC curves through the summer despite comparable weather earlier in the summer speaks to the benefits YoY of pricing uplift). We maintain Buy on [redacted] and perceive clear positive trends”

-Julien Dumoulin-Smith, B of A 9/29/19

Spot Prices Don’t Finance 40 Year Assets
Making Generation Financeable

- **Revenue risk reduction through:**
  - Physical bilateral (PPA)
  - Synthetic PPA
  - Swaps
- **Buyers need capability and clear responsibility**
  - Municipals, coops, IOU LSE buyers, or competitive retail suppliers
  - Sufficient financial wherewithal as creditworthy counter-parties
    - PUC credit requirements to serve load
    - Avoid free rider problem

Typical Generator Finance in ERCOT

"The Project entered into a hedge arrangement for the output of the project simultaneously with financial close, providing certainty of revenue for the majority of the Project's output for a 12 year period from the commencement of commercial operations ("COD"), with settlement at the [redacted] trading hub. The Project also entered into a basis hedge for a period of 3 years post-COD, mitigating exposure to transmission congestion risk through to the completion of approved transmission upgrades in [year redacted]."

-Actual investor prospectus for a wind farm in Texas

Consumer Perspective on ERCOT Revenue Sources

"Bilateral hedging activity and premium forward pricing provides a considerable revenue stream for generators beyond realized real-time pricing and the Operating Reserve Demand Curve (ORDC). This is an efficient market solution for entities wanting to avoid price risk… futures markets capture the risk that things may not go according to plan and very high prices may materialize. The market is exceptionally good at rationalizing these types of risks and pricing them appropriately, as the reaction to lower planning reserve margins demonstrates."

Texas Industrial Energy Consumers (TIEC)
http://interchange.puc.texas.gov/Documents/48551_25_993729.PDF p. 4.


DIRECTV