

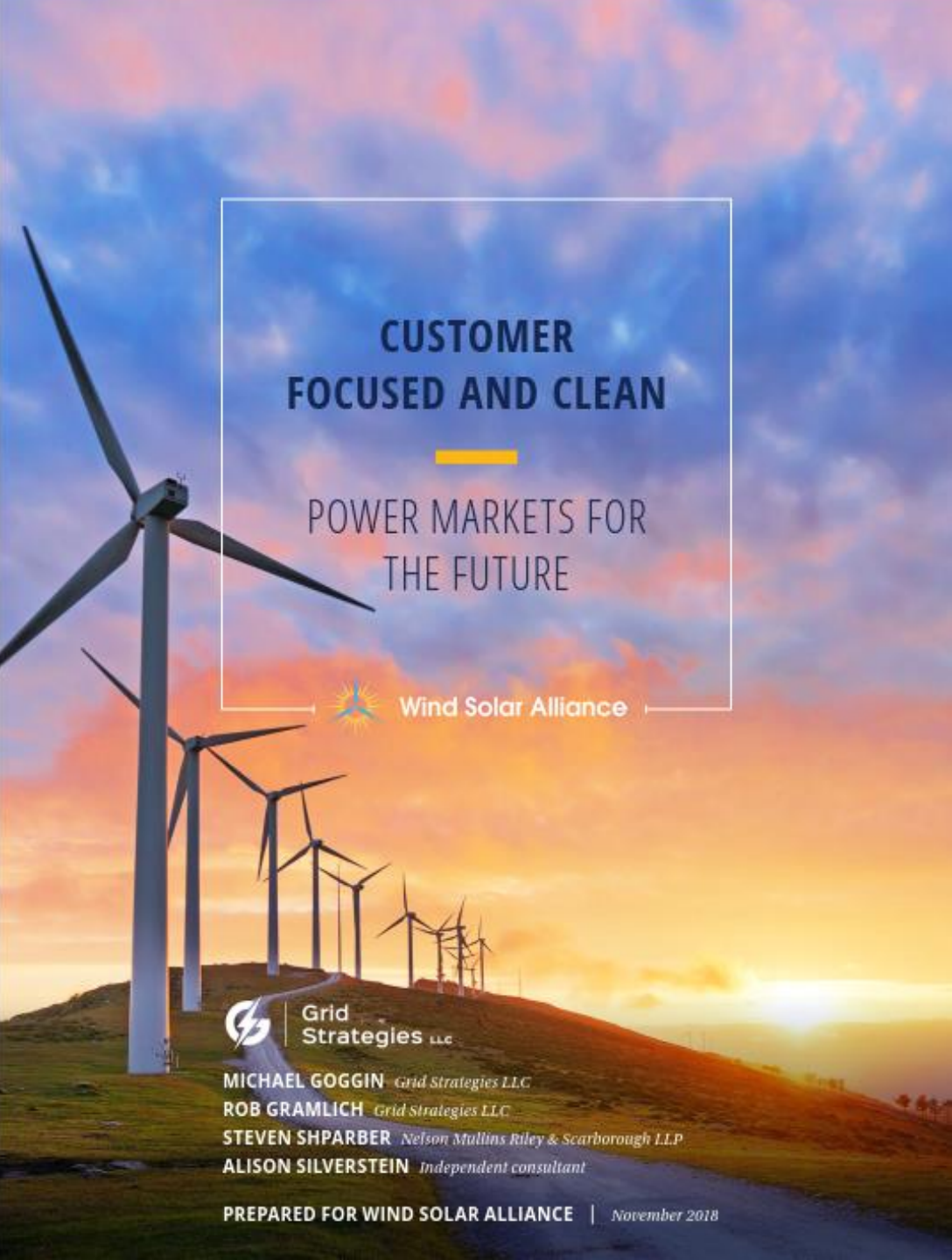
Power Market Structure and Design for Low-Cost De-Carbonization

ESIG
October 28, 2019

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Grid
Strategies LLC



CUSTOMER FOCUSED AND CLEAN

POWER MARKETS FOR THE FUTURE

 Wind Solar Alliance

 Grid Strategies LLC

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PREPARED FOR WIND SOLAR ALLIANCE | November 2018

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

BY ROB GRAMLICH¹ AND MICHAEL HOGAN² ● 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

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<https://windsolaralliance.org>



How to Finance New Generation and secure adequate resources?

- Utility ownership—the old-fashioned way
- Procurement through long-term contracts (PPAs)
 - Utilities, driven by Integrated Resource Plans
 - Retail Electric Providers and intermediaries
 - Corporate energy users
- Central capacity obligations and markets
- (Almost no one invests in 30-year assets based on estimated future hourly prices)

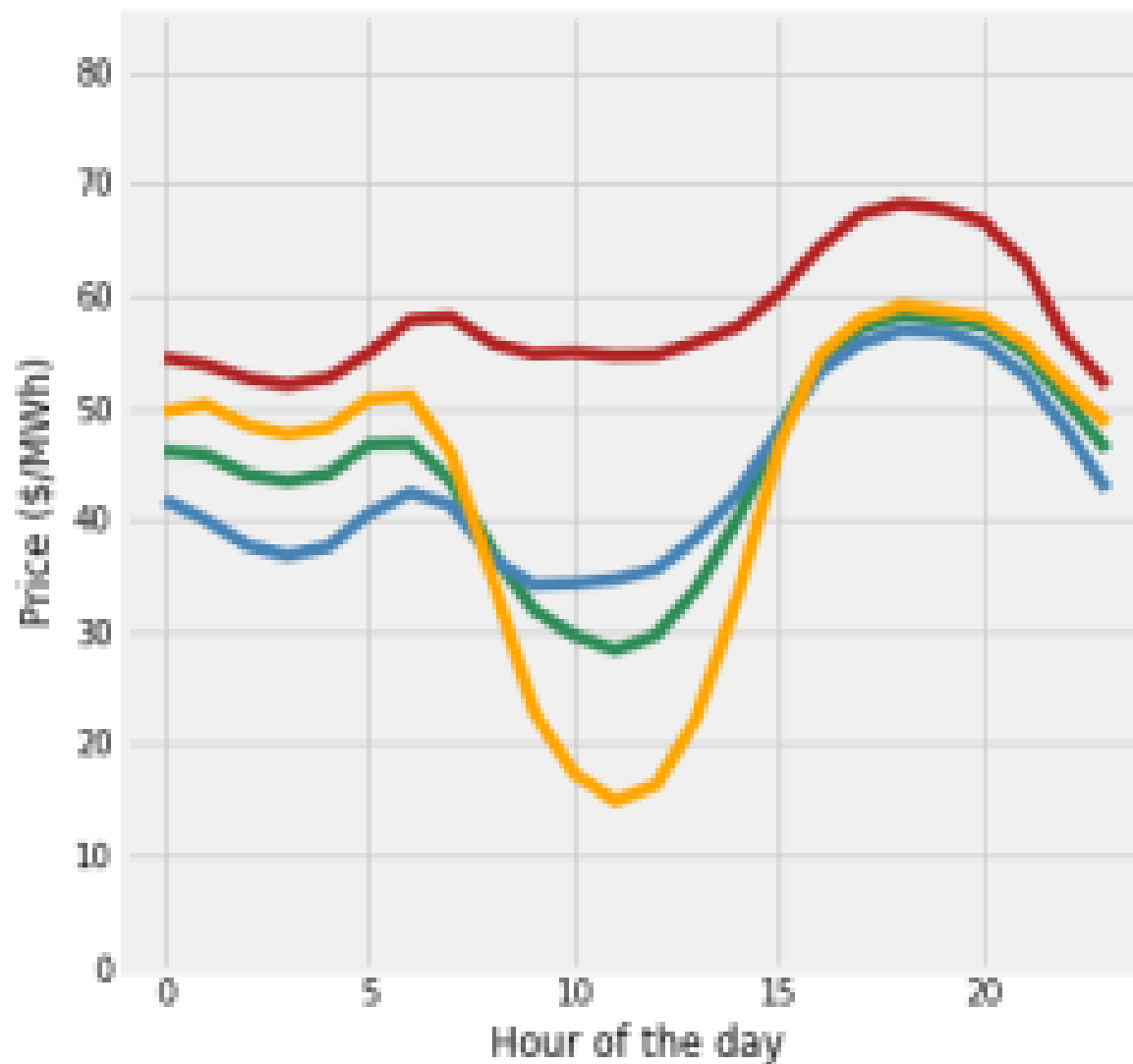


Will power prices plummet in the future?

Power prices w/40% renewables by hour of day

CAISO

- 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)

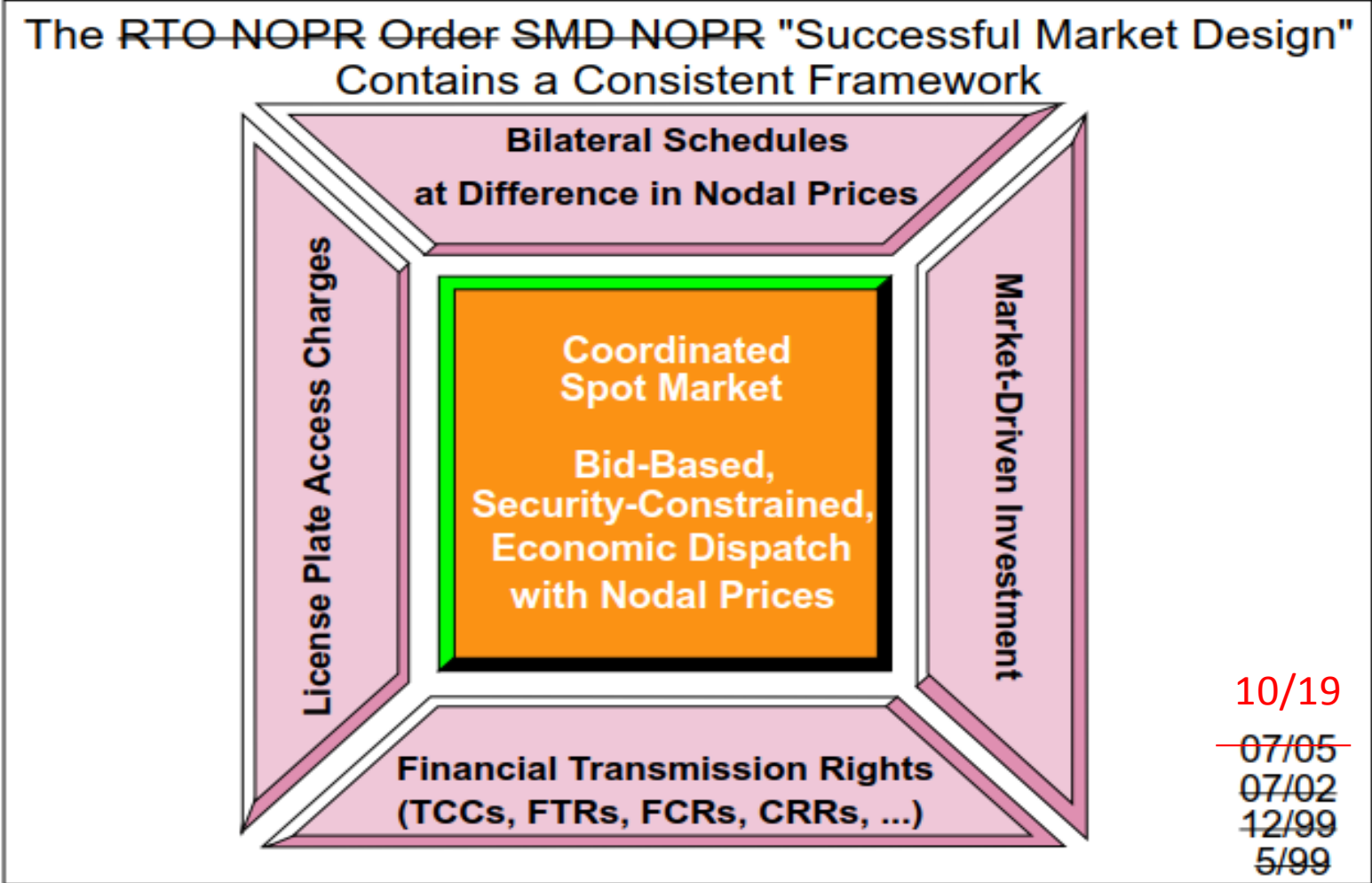
Impacts in 2030 relative to baseline with 2016 wind & solar shares	Southwest Power Pool 2016: 18% wind & 0% solar			NYISO (New York) 2016: 3% wind & 1% solar			CAISO (California) 2016: 7% wind & 14% solar			ERCOT (Texas) 2016: 16% wind & 1% solar		
	Wind	Balanced	Solar	Wind	Balanced	Solar	Wind	Balanced	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		

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)

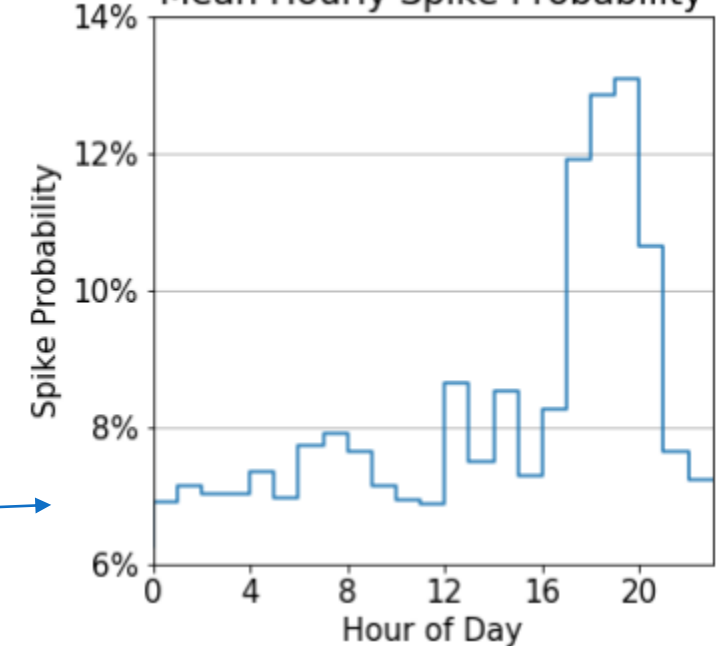


Best Market Design, cont'd

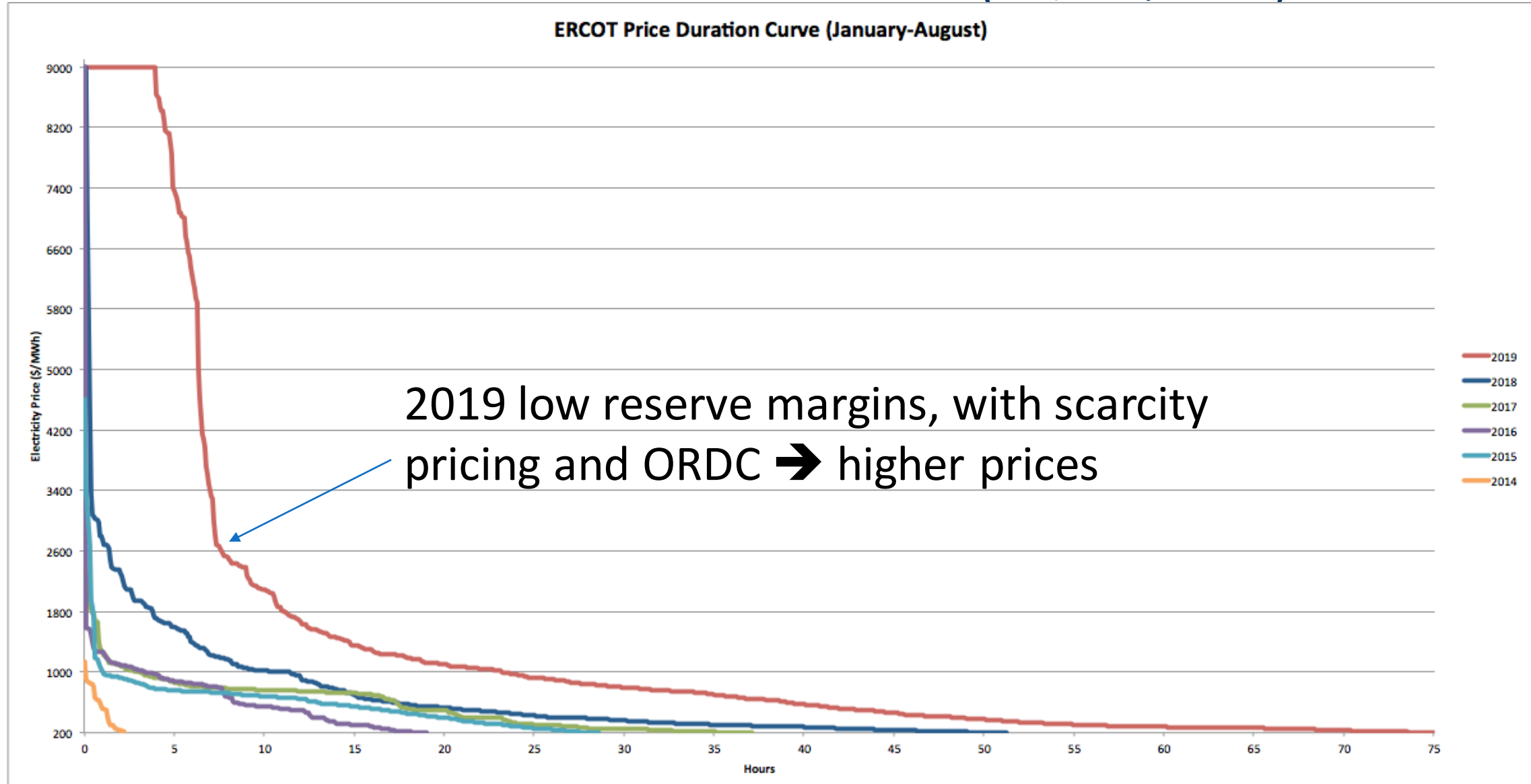
- **Spot market with bilateral contracts**
 - Expect most payments and revenue in long term PPAs, priced at average cost of competitive new unit
 - Spot market for residuals and re-balancing
- **Energy at each time and location**
 - Hourly locational marginal pricing (LMP)
- **Reliability Services--technology-neutral**
 - Operating reserves, exact needs vary by region
 - Reactive support—non-market compensation
- **Scarcity pricing**
 - prevents free-riding, encourages contracting, attracts flexible resources
 - Most load hedged, and doesn't pay it.
- **No mitigation of state environmental policies (broad MOPR)**

Ascend Analytics CA model:

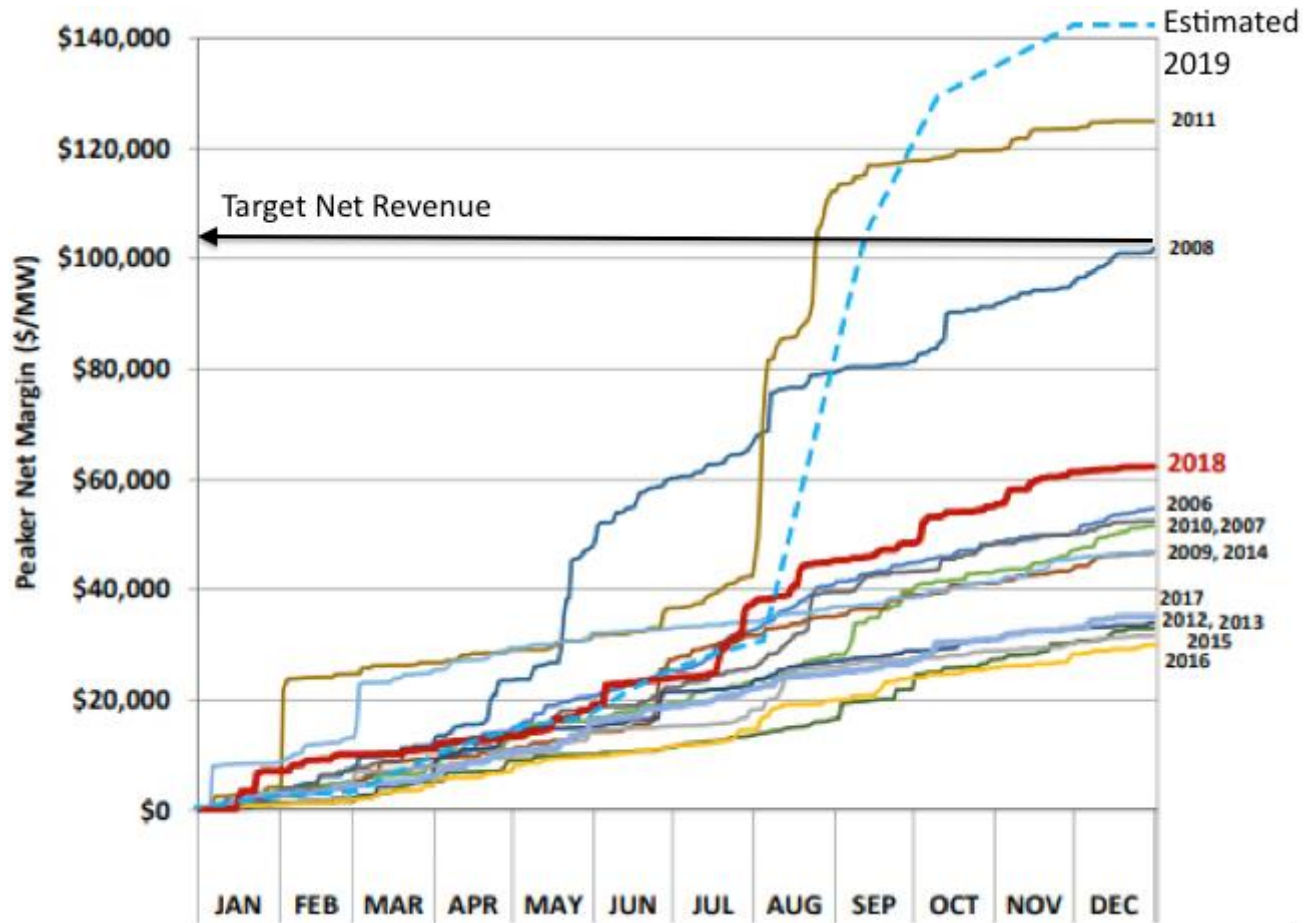
Mean Hourly Spike Probability



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



ERCOT Net Revenue Targets Exceeded in 2019



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



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.



“Issues” with capacity markets

- Subjective debates about capacity credit
- Shortages not happening at peak
- Product not well-defined in terms of value or obligations
- Attracting only one kind of new source, and more than needed
- Recent vehicle to interfere with state policy and serve as a barrier to renewable energy entry
- Dulls price signals

“Our questions should shift from ‘how many MWs do we need?’ to ‘what resources do we need to provide the full set of required system services under a wide range of possible futures?’ Frew (2018)

