ENERGYGPS LLC

Comparing Bilateral and RTO Markets

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The Arc of PNW Market

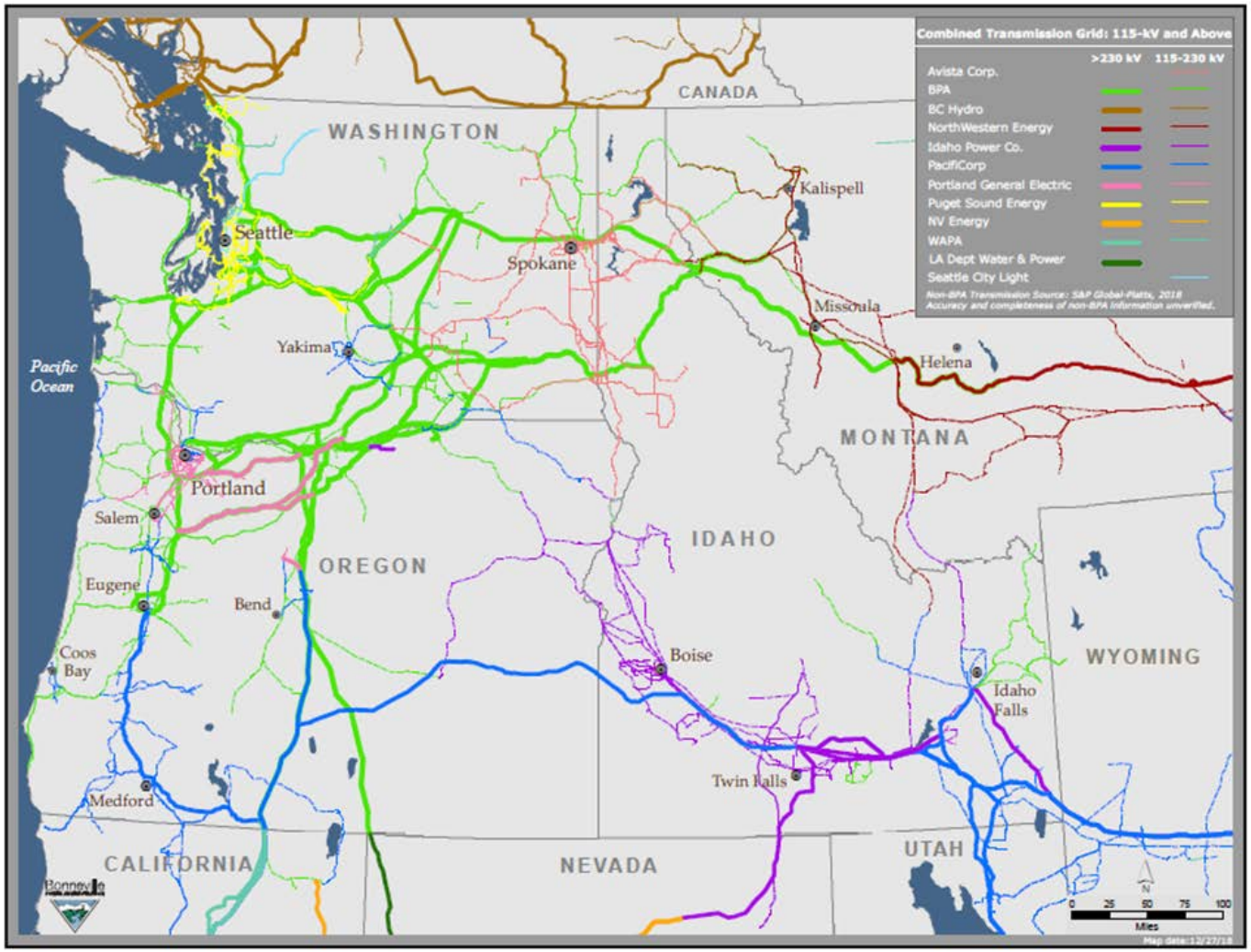
- The build out of the hydro fleet.
  - BPA, Aluminum Smelters, and Public Power.
  - Mid Columbia and IOU contracts
- Low cost and excess supply from 1930's to 1970's
- 1970's High Demand Projections – Regional Deficiency, WPPS
- 1970's Transmission to California
- 1980 Northwest Power Act cuts the deal for the future.
  - Carves up BPA power into DSI's, Preference Customers, Residential Exchange.
- 1990's – Open access to wholesale markets.
- 2000-2001 Western Energy Crisis
- 2001 to 2010 – Aluminum Smelters close down.
- 2000's combined cycle fleet build out.
- 2010's renewable fleet build out.
- 2014 to Present: CAISO Expansion via Energy Imbalance Market
- Future: De-Carbonize Electricity Grid and Electrify More Things

Bilateral Markets Have Served Us Well

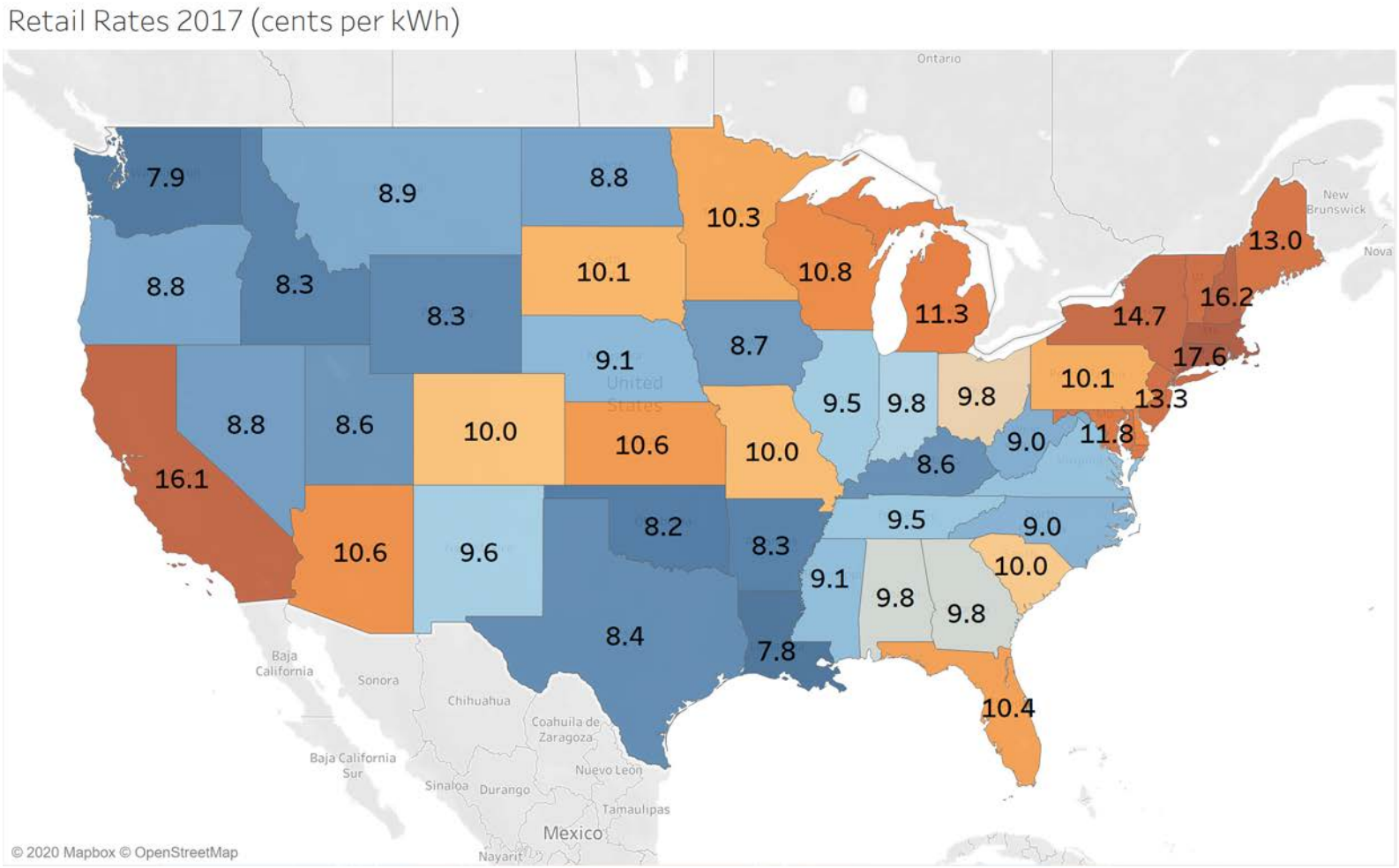
Bilateral markets have been excellent at:

- Movement of low-cost energy to load.
- Sorting out the dispatch priority of a relatively simple system: hydro/nuke/coal/gas.
- Enabling market participants to “buy rather than generate” and “sell any excess if the price is right.”

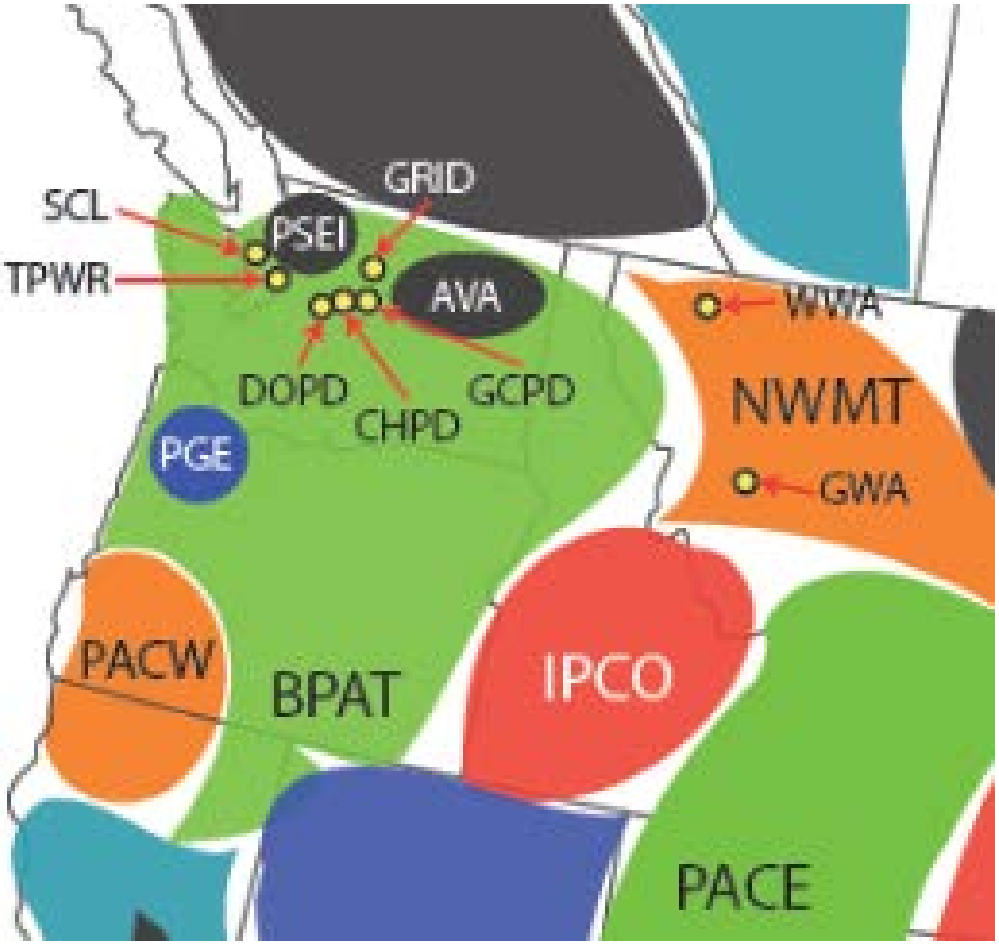
Robust Transmission System Moves Load Cost Energy to Load



Low Cost Generation Begets Low Rates



Bilateral Markets Have Served Region Well for Many Years



- A system that relies on many individual balancing authorities.
- Trading large blocks of energy.
- Performing unit commitment, dispatch, and balancing independently.
- Track record of meeting needs and reasonable cost.

The Question

Does a bilateral market structure meet changing needs?
Does it enable the grid of the future?

- Optimize flexibility on the system?
- Maximize transmission utilization.
- Enable massive changes to generation fleet?
- Enable massive electrification: (e.g., transport)
- Enable rapid technology innovation like the industry hasn't seen before: storage, demand response?

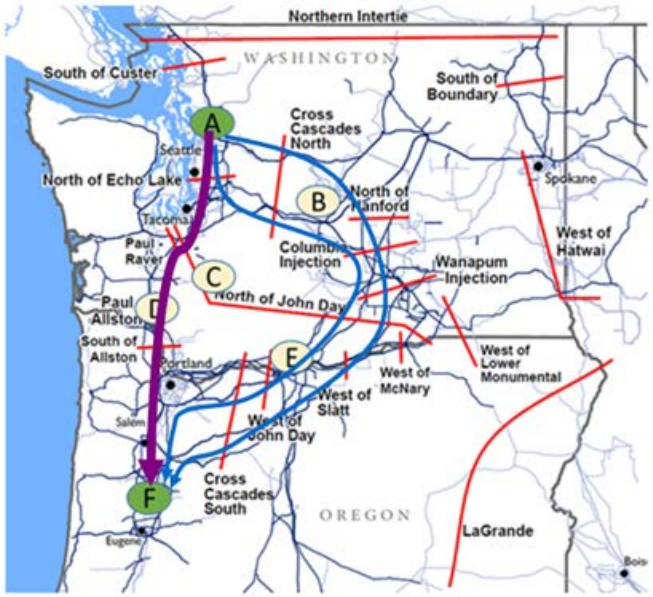
Historically – Every Load Serving Entity Had Flexible Hydro

Question: Is this flexibility sufficient for the future?

Avangrid and WindWatch balancing authorities are expensive ways to balance wind (but obviously cheaper than the available alternative).

Bilateral Market Uses Transmission Contract Path: Typically scheduled for the hour before the hour starts. Is this efficient enough to maximize utilization of transmission grid?

Contracts vs. Physics of Energy Moving on the Grid



- In a *contract path* system, a seller near Seattle wants to sell generation to a buyer with load near Eugene
- They enter a transmission service contract for the right to move power from a point of receipt (A) to a point of delivery (F)
- In a *physical flow* system, actual energy movement is more complicated. It automatically splits across multiple paths

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Source: Sarah Edmonds Presentation

Renewables Have Unique Impact

- Volatile supply.
- Require sub-hourly flexibility.
- Require multi-hour ramping capability.
- Most cost effective balancing occurs when flexibility can be accessed across broad geographic region.
- Need for new capacity and flexibility products.

Criteria for Evaluating Market Structure

Short Term:

- **Lowest cost dispatch.**
- **Lowest emission dispatch.**
- **Achieve reliability objectives**
- **Efficient allocation of transmission resources to achieve above.**

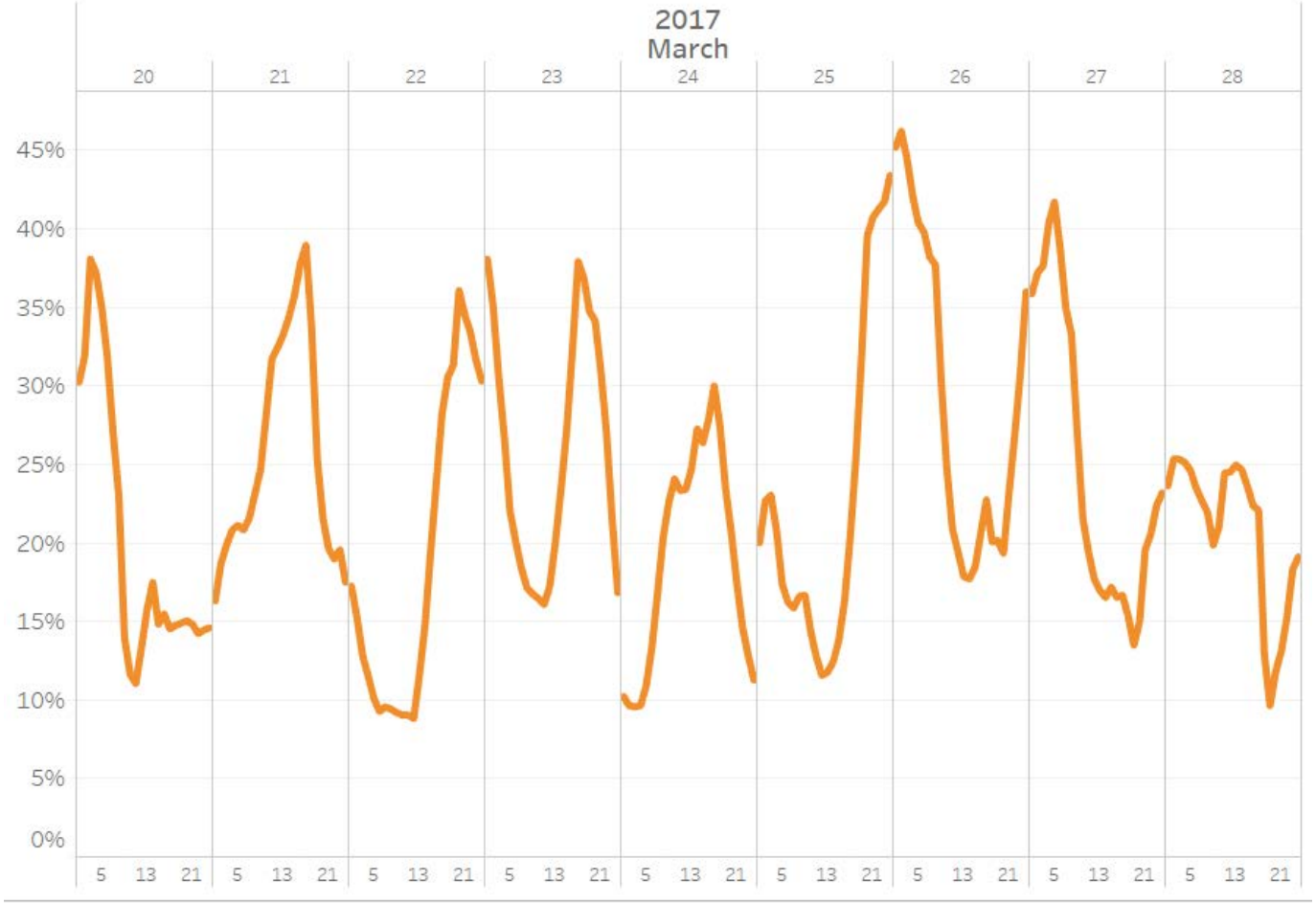
Long Term

- **Incent investments in resources which meet policy and economic goals.**
- **Enable investment from a broad array of capital providers (beyond just ratepayers).**
- **Enable participation from a broad array of asset owners.**
- **Provide a set of rules and policies which provide clear price signals for energy and reliability products that accomplish the above goals.**

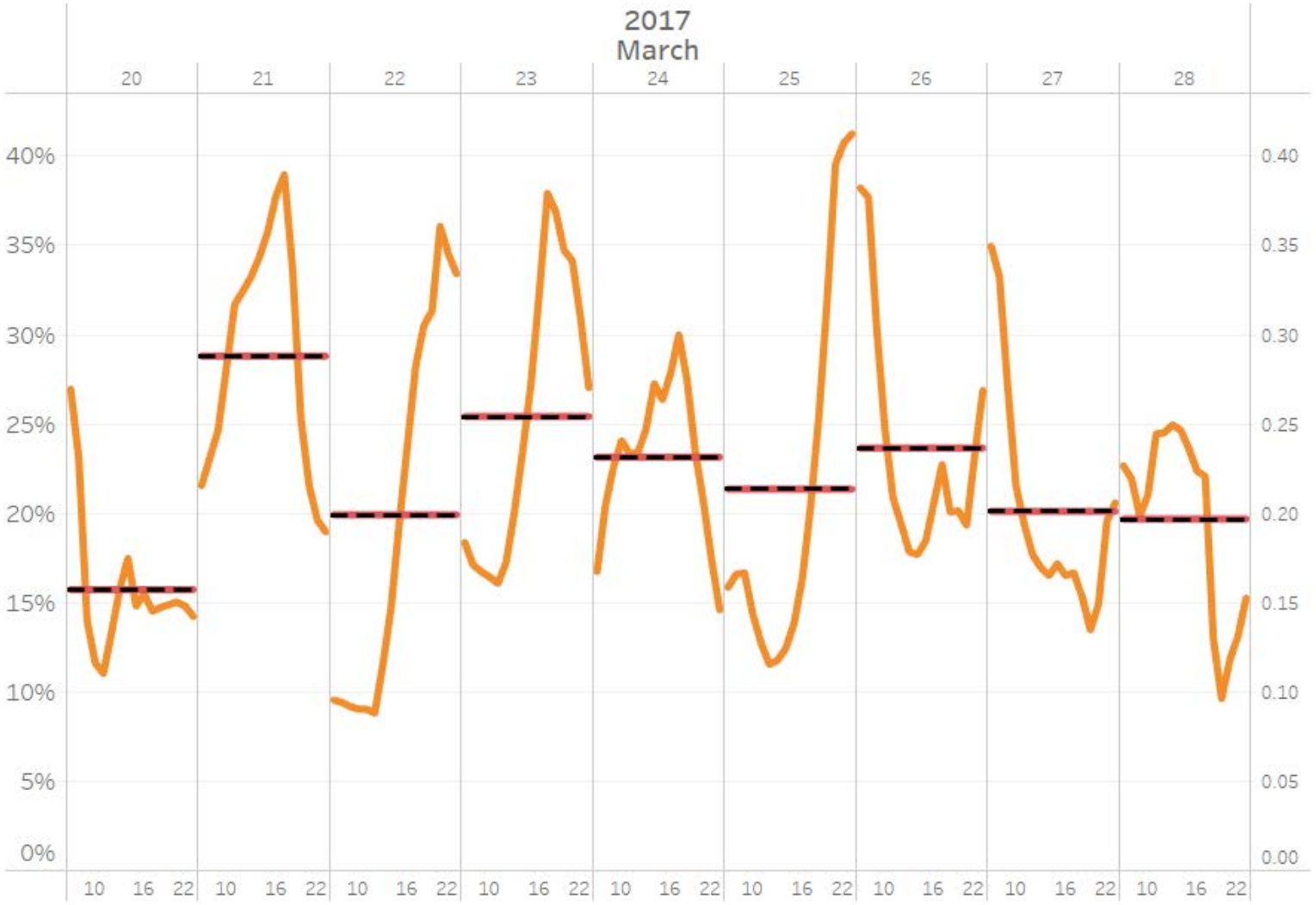
Day Ahead Market Activities

Function	Benefit	PNW	Centralized
Day Ahead Block Hub Trades	Allows market participants to balance position and transfer risk using standard products.	Yes. Mid C Hub. Bilateral.	Yes in every market. Bilateral.
Day Ahead Hourly Market	Allows load and intermittent resources to more precisely balance position.	None	Yes in every market. Computer optimized.
Day Ahead Ancillary Service Market	Allows balancing authority to procure flexibility from lowest cost resource. Provides revenue to generators.	Essentially none.	Yes in every market. Computer optimized.
Day Ahead Unit Commitment	Ensures that there are sufficient generators that will be available during operating hour to meet energy and flexibility requirements. Provides time for long-start generators to turn on.	Performed by each individual balancing authority with no collaboration or optimization.	Centrally executed by market operator taking into consideration needs of large geographic footprint.

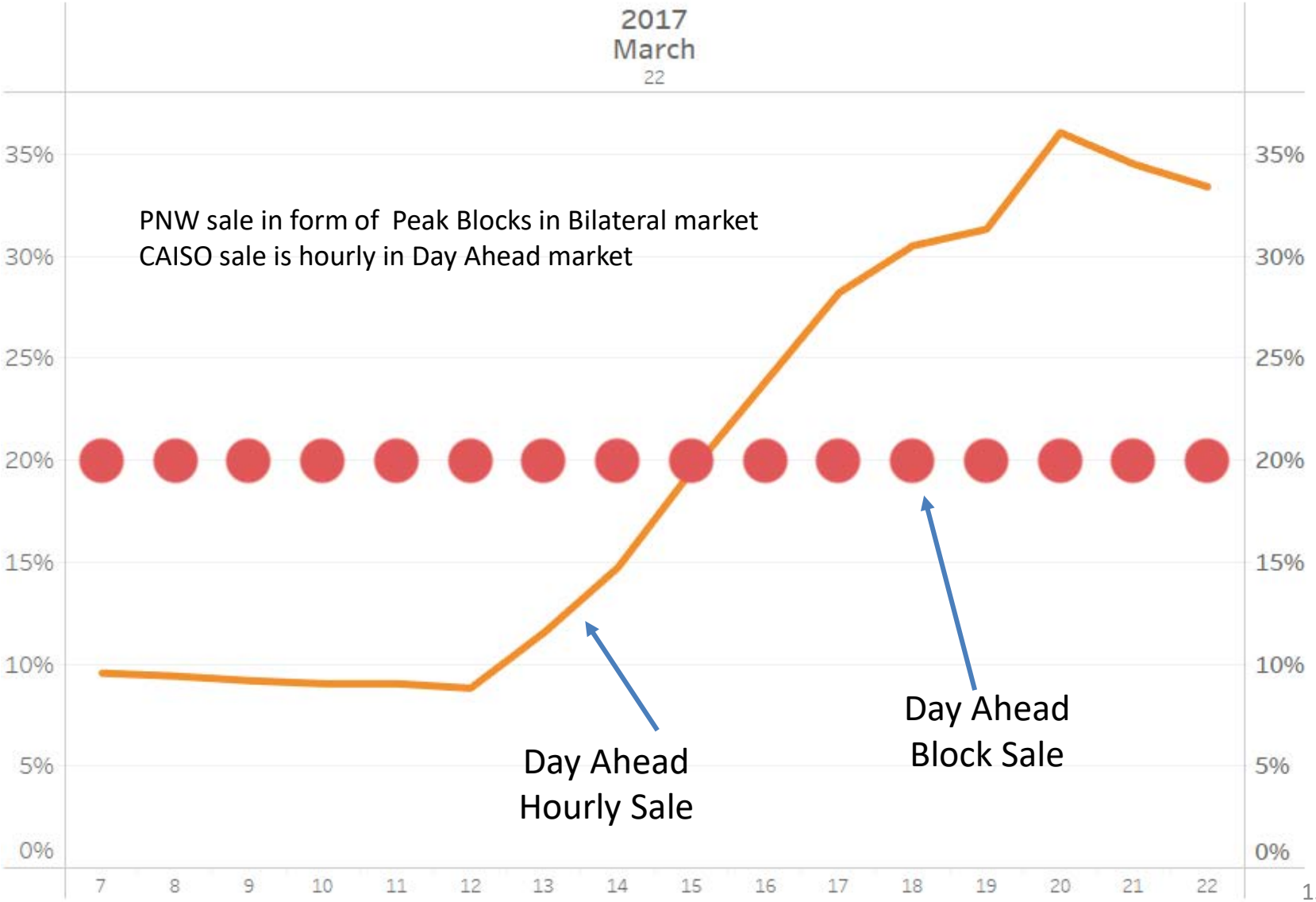
Hourly Wind Variability Requires Hourly Energy and Flexibility Products



Forecast On Peak Wind Production Compared to Daily Blocks



Day Ahead Sale



Day Ahead Market Activities (Continued)

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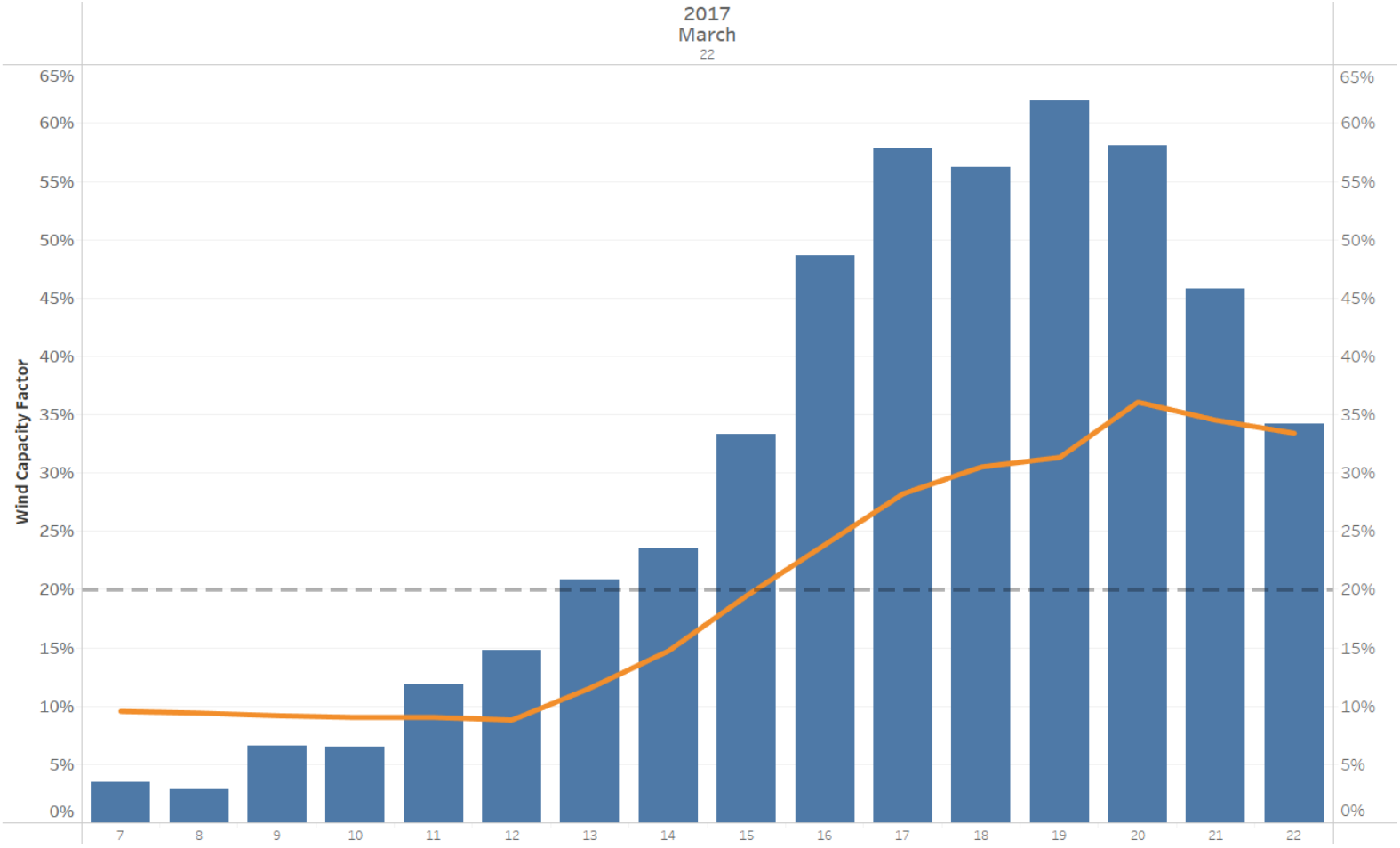
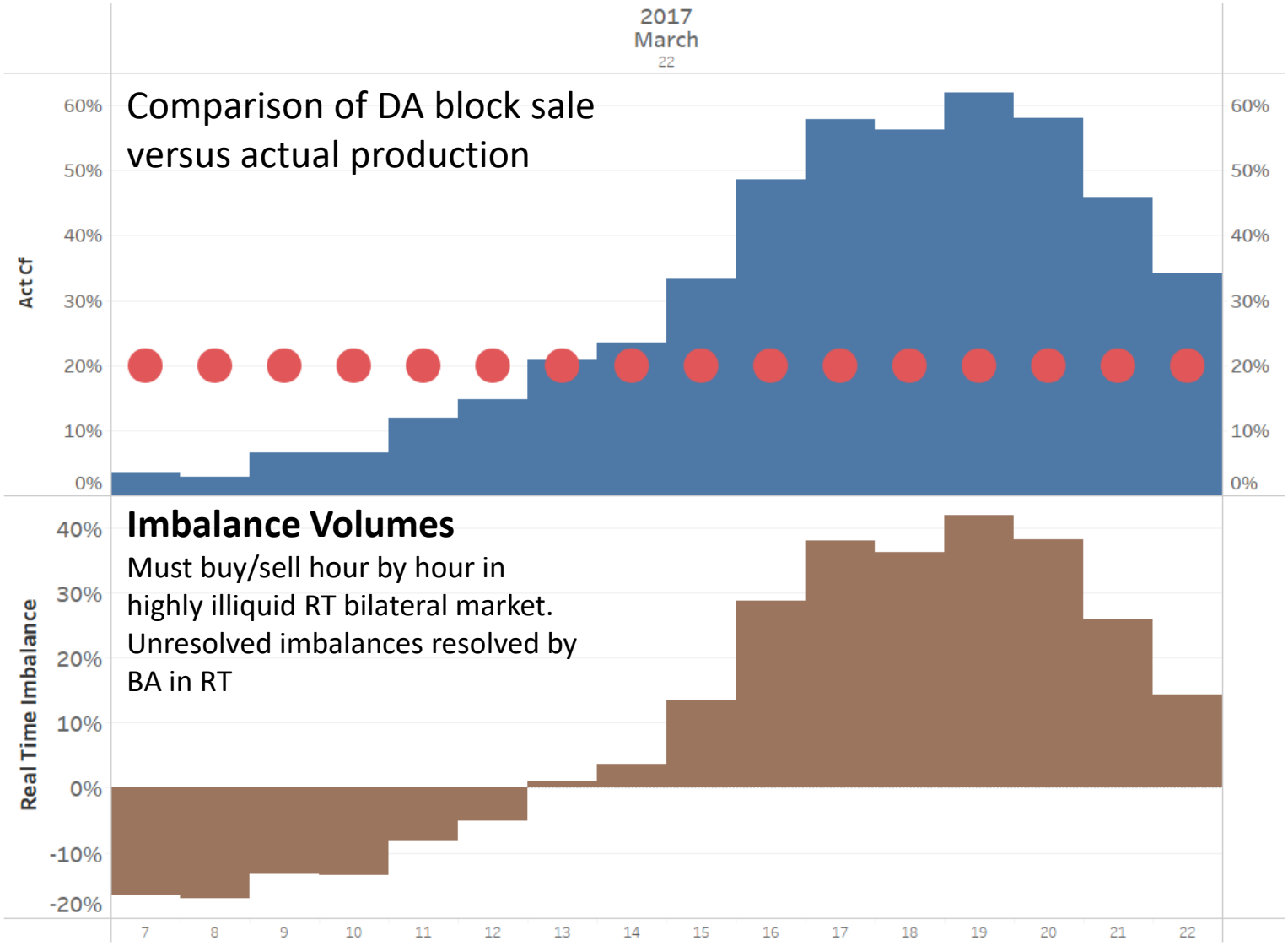
Real Time Market Activities

Function	Benefit	PNW	Centralized
Real Time Unit Commitment	Ensures that there are sufficient generators that will be available during operating hour to meet energy and flexibility requirements. Limited to fast start units.	Performed by each individual balancing authority with no collaboration or optimization.	Centrally executed by market operator taking into consideration needs of large geographic footprint.
Real Time (Before the Hour Starts) Hourly Market	Allows market participants to re-balance position within the day before the hour.	Yes. Extremely illiquid. Bilateral.	Yes. Extremely illiquid. Bilateral.
Transmission Optimization	Is the transmission grid fully utilized to enable efficient dispatch of generation and movement of energy.	Contract path transmission scheduled before the hour. Limited options to change within hour.	Sub-hourly dispatch and transmission allocation. Enables market to re-optimize every five minutes.
Sub-Hourly Balancing Market	Provides BA with access to wide array of generation. Provides generation and load to balance positions.	No. Each balancing authority (BA) manages its own sub-hourly imbalances. **EIM is exception.**	Yes in every market. SCED

Actual Wind is Different in Real Time



Resolve Block Imbalances in Real Time



Long Term Time Horizon
Capital Deployment

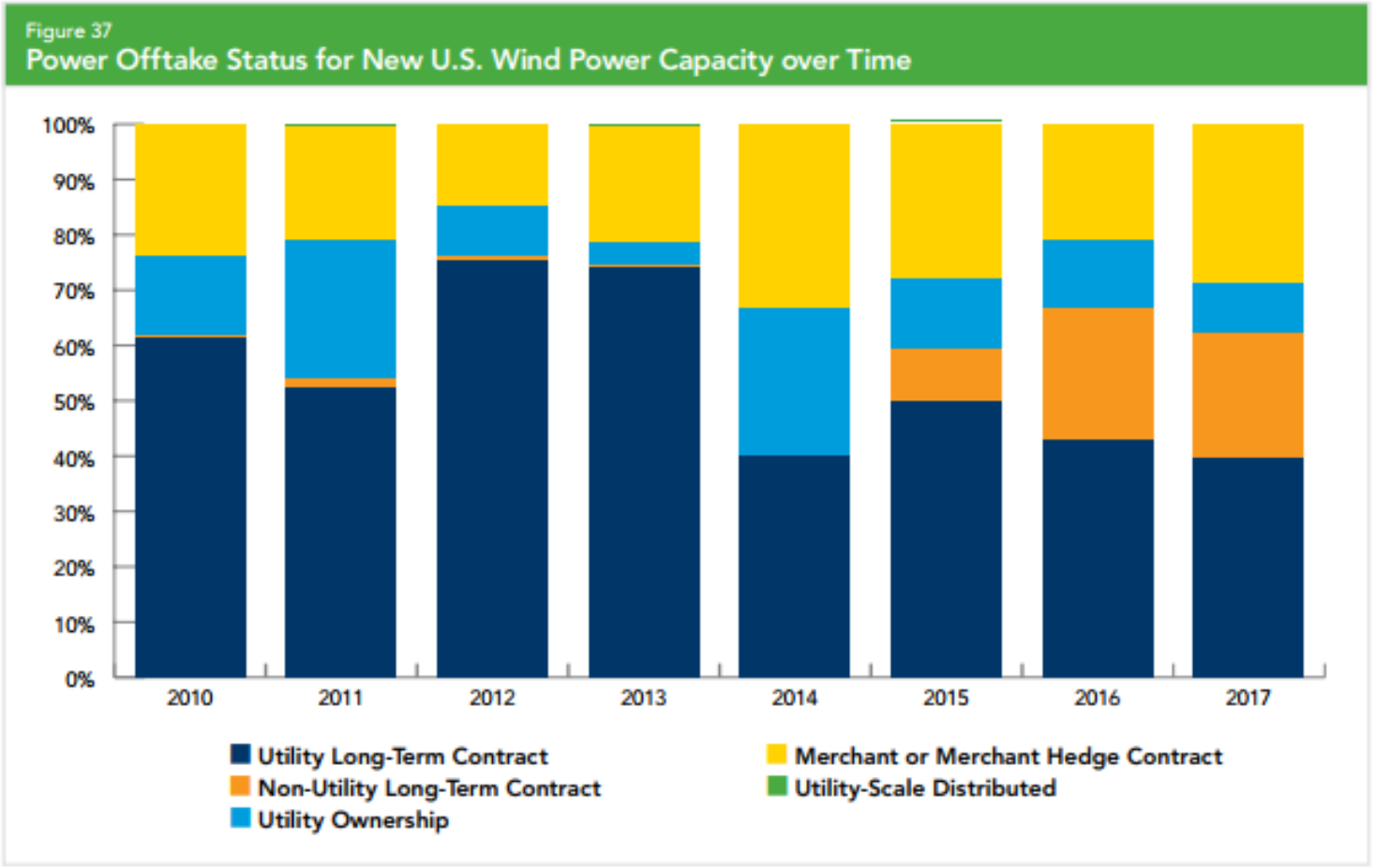
Function	Benefit	PNW	Centralized
Long Term Capacity	Ensure sufficient resources to meet future demand. Send price signal / provide revenue for generators.	Market: None	ERCOT: None CAISO: 1 Year PJM: 4 years
Resource Procurement	Want to buy the right amount of generation in the right location.	Utility procurement via IRP or bilateral contracts.	Utility procurement via bilateral contracts.
Resource Ownership and Financial Risk	Who is ultimately responsible for the capital deployed?	Ratepayer shoulders almost 100% of financial risk. Little new merchant generation since early 2000s.	Mix of ratepayer risk and other providers of capital such as European pension funds. Large deployment of capital not backed by ratepayers.

Renewable Dispatch and Tracking

Function	Description	PNW	Centralized
Economic Dispatch	Load serving entity purchases renewables and must meet load.	Utility schedules to load. If not needed, use phone to sell excess. Pay for transmission to move to alternate point of delivery.	Market operator automatically moves renewables from generation to load, charging for any difference in price. Any excess generation automatically sold at node.
Managing Curtailment	Efforts to minimize curtailment and maximize renewable generation.	Manual process to find a home for any excess power. Manual process to find excess transmission. Phone calls and transmission schedules. Curtail if efforts fail.	Dispatch occurs based on economics and transmission constraints. Computer optimizes use of transmission grid based on economics. Curtailment occurs only when there is no transmission available to move power to a place where needed.
Transaction and Balancing Costs	How large are transaction and balancing costs?	High. Can be in the range of $5 to $7 per MWh or higher.	Low. In the range of $1 to $3 per MWh.
RECs	How are REC's treated?	Based on metered generation.	Based on metered generation.

Comparison of Wind Economics for Illustrative Corporate Power Purchase Agreement PNW versus PJM

Who Is Buying Wind?



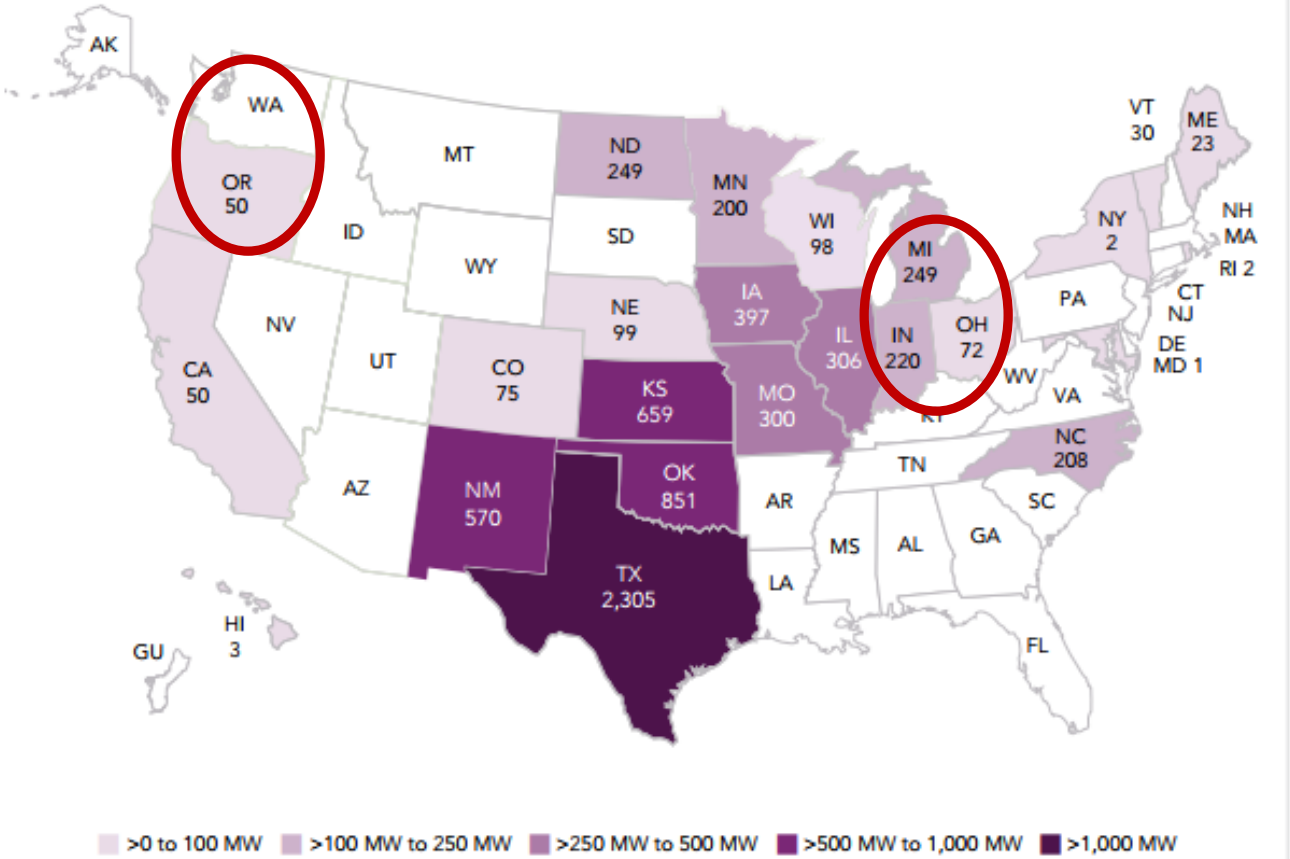
More than half of new wind being purchased by non-utility entities.

PJM Versus PNW New Wind Math

	PJM	PNW	Comment
Approximate Cap. Factor	35%	35%	
Levelized Cost of Energy	**$40.00**	**$40.00**	Total amount needed for 15-years.
Capacity Revenue	-$5.21	$0.00	$ paid by PJM per EGPS capacity market wind modeling.
Basis	$0.50	$0.00	Typical price difference from node to hub in PJM. NA in PNW.
Transmission and Integration	$1.00	$12.00	Various PJM costs. BPA transmission and integration charges.
Other Costs/Revenue	**-$3.71**	**$12.00**	
Required PPA Price	**$36.29**	**$52.00**	Price required for intermittent power at market hub.
		-$15.71	Cost premium required for PNW deal.

PJM vs PNW

Figure 3
U.S. Wind Power Capacity Installations in 2017



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