Rethinking the Role of Financial Transmission Rights in Wind-Rich Electricity Markets in the Central U.S.

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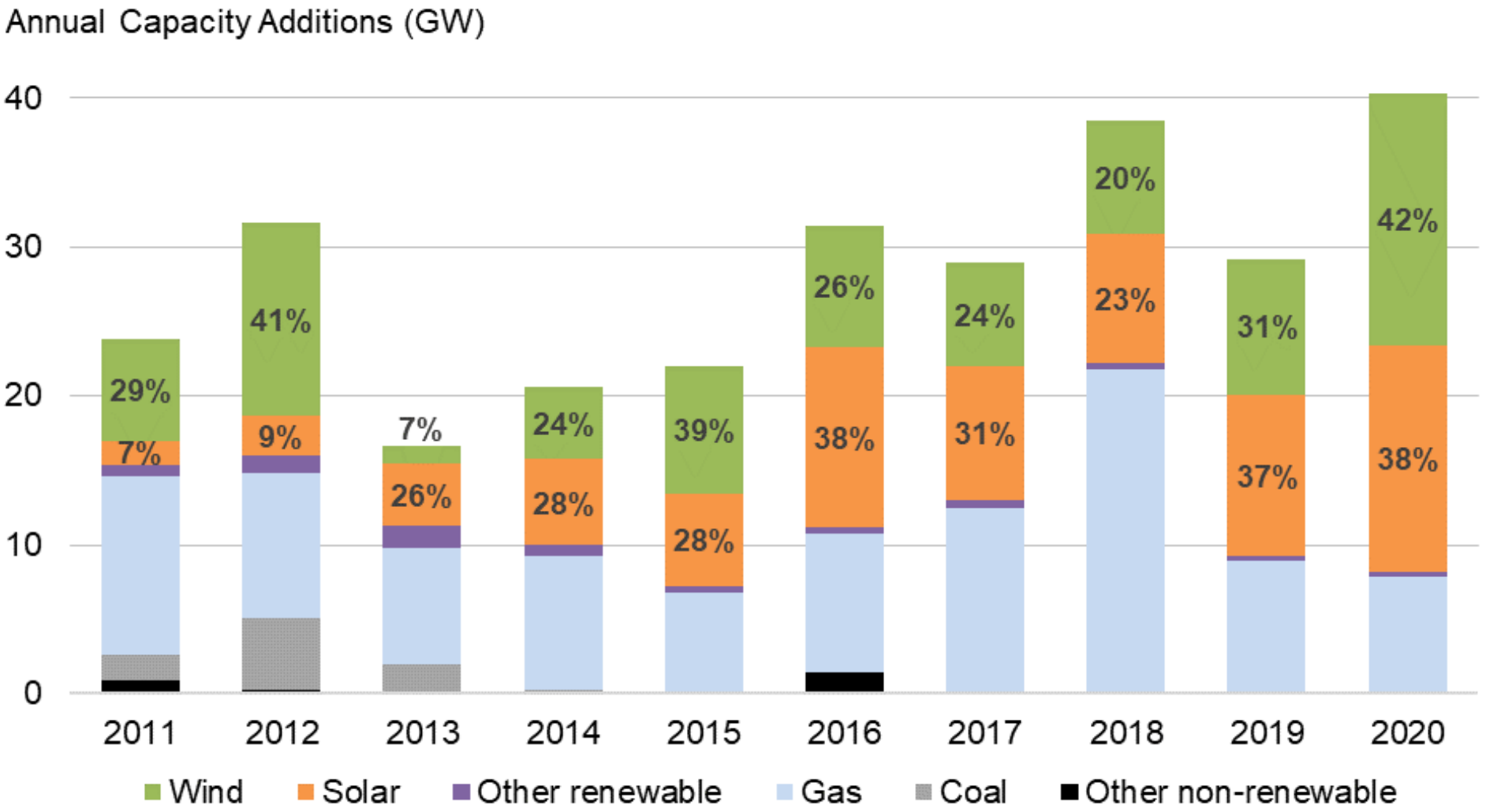
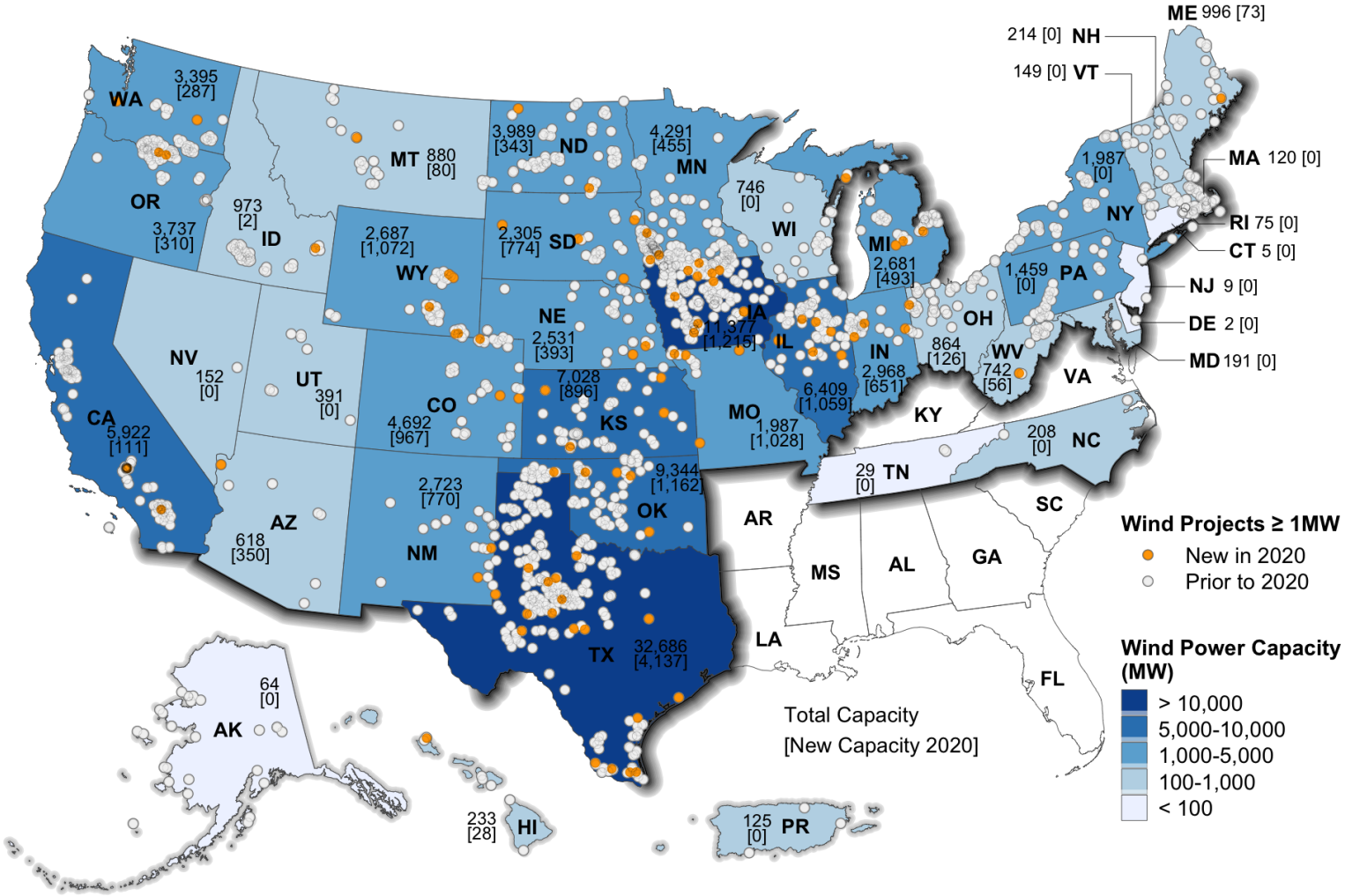
Wind and solar have begun to dominate new generation capacity additions in the United States

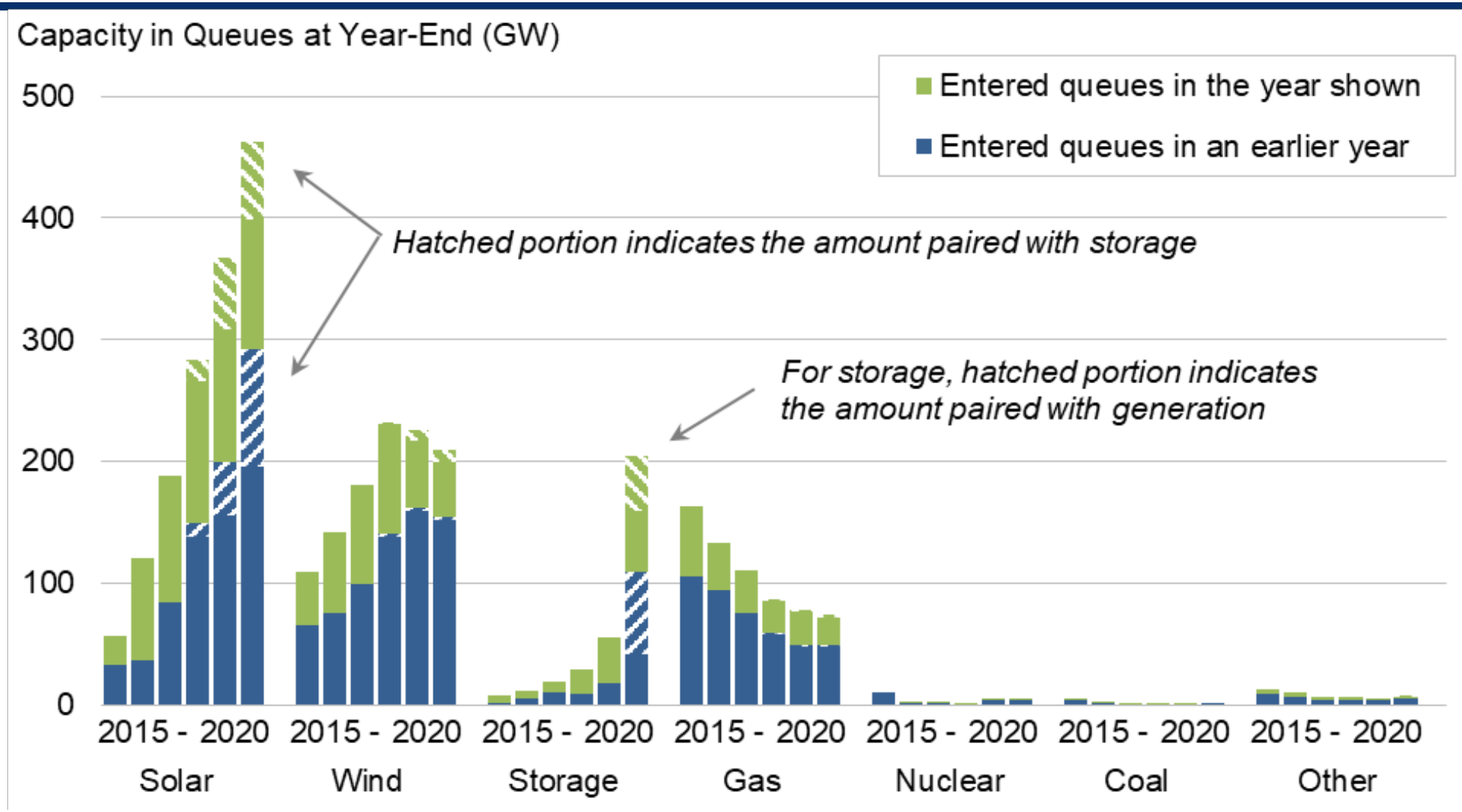


Wind power installations are dispersed, but concentrated in the U.S. interior, including ERCOT, SPP, and MISO



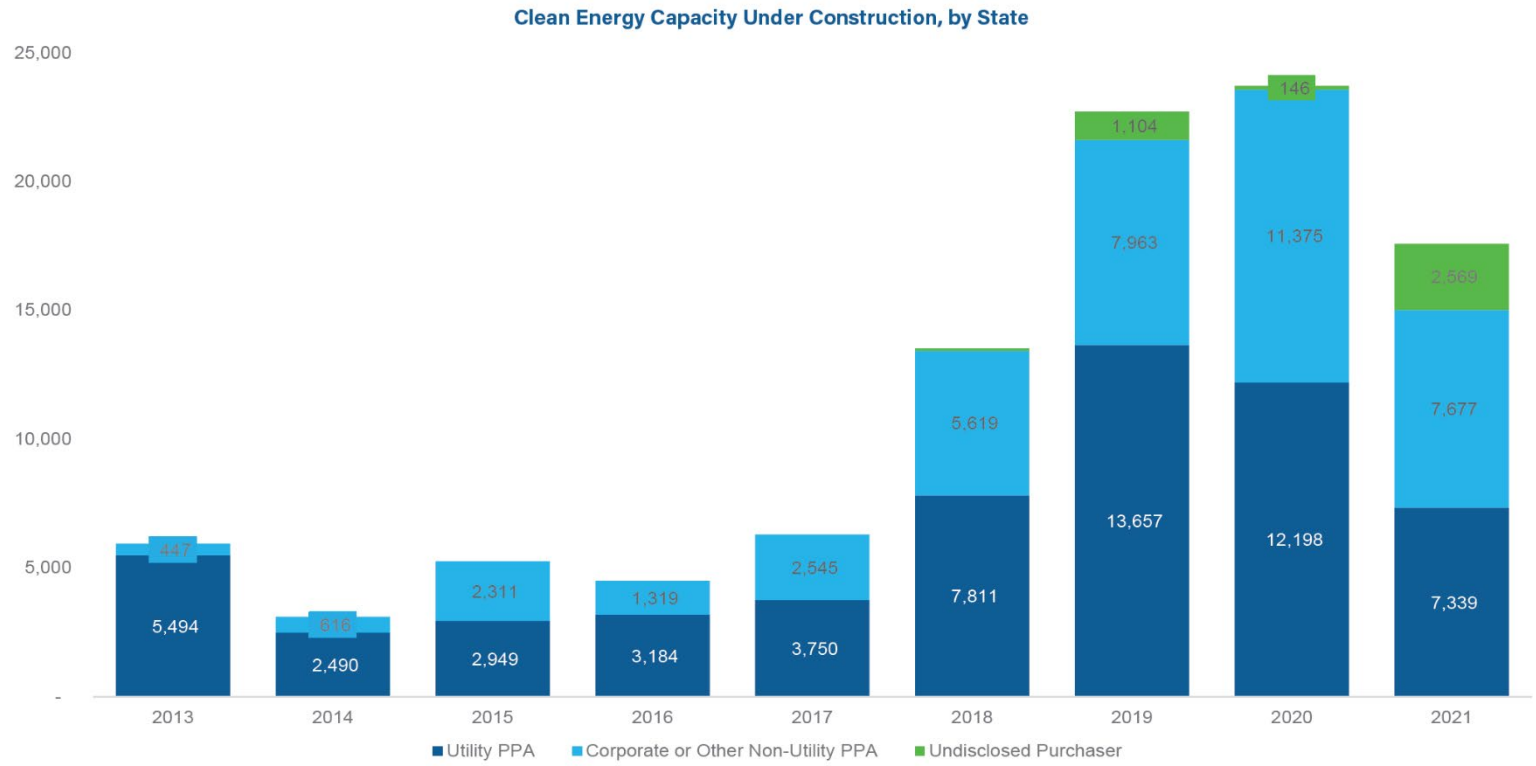
Note: Numbers within states represent megawatts of cumulative installed wind capacity and, in brackets, annual additions in 2020.

More wind and solar are on the way based on data on projects in the transmission interconnection queues; new coal and now gas are declining



Power sales to corporate customers have increased, exposing project developers / owners to new wholesale price risks

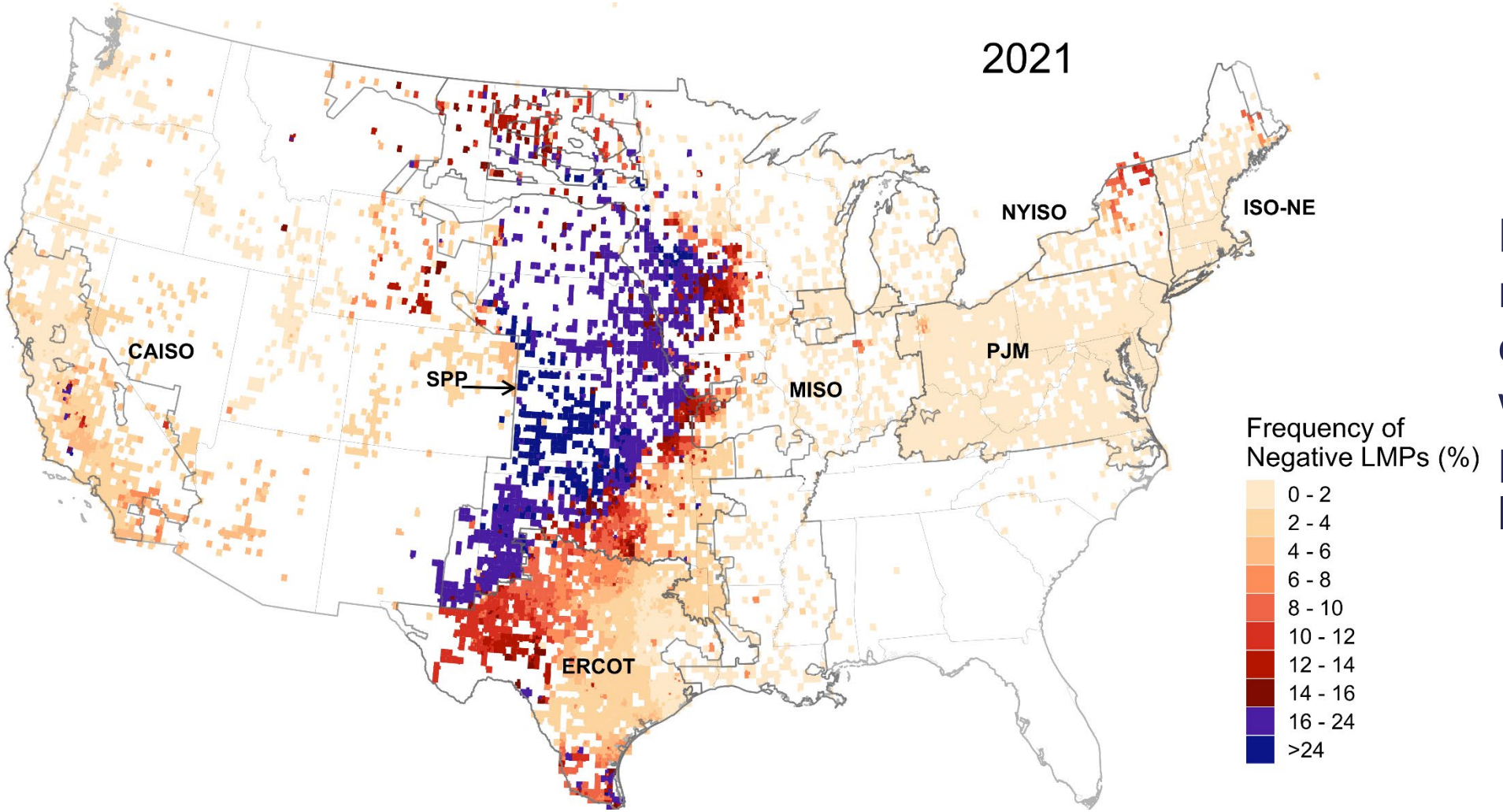
Wind and Solar Purchasers: Growth of Corporate Buyers



- PPAs with utilities are often settled at the local wholesale pricing node—shielding developers/ owners from basis risks
- In contrast, corporate PPAs are often settled at liquid trading hubs, with developers / owners facing basis risk (increasing revenue uncertainty)
- Generally, greater exposure to wholesale market risk

Source – America Clean Power Quarterly Report Q3 2021

Growing wind and solar have been impacting wholesale electricity market price levels and uncertainty: example below of negative wholesale prices



Negative prices more frequently occur when wind and solar production levels are high

Many of the electricity market design discussions around VRE have been focused on energy, capacity, and AS markets: less focus on FTRs

Energy Markets	• Move towards faster markets, use of wind/solar forecasts, large geographic scope
Capacity Markets	• Move towards better quantification of capacity contributions under uncertainty
Ancillary Services	• Move towards new services and service definitions, broader participation
Financial Transmission Rights	• Not much design evolution in recent years

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Introduction and motivation

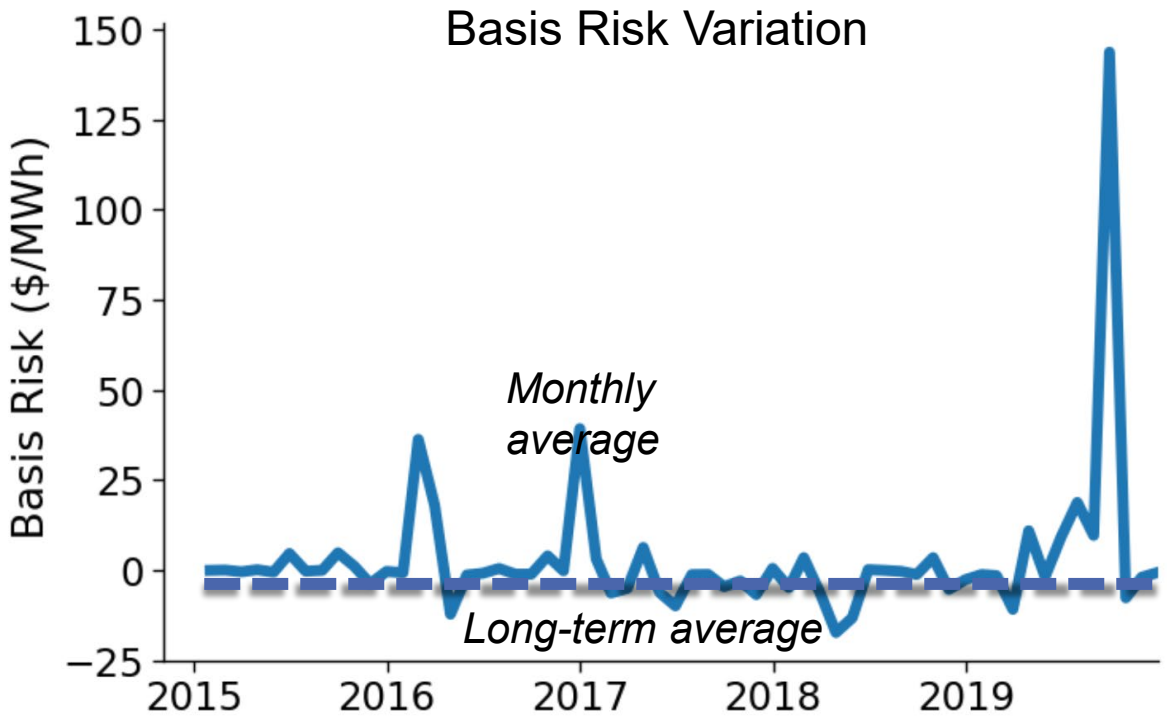
Power plants with contracts settled at a trading hub are exposed to basis risk due to price differences between the plant node and the trading hub

- Market prices vary across locations
  - Limited transmission line capacity
  - Varying patterns of weather, load, and generation
- 'Basis' is the price difference between the contracted trading hub and power plant node

- 'Basis Risk' accounts for the weighting of the basis by generator output:
  *Basis Risk = Σ(Basis*Generation)*
- Basis risk can be more significant for wind power due to its remote location
  - Resulting in greater transmission constraints
  - No issue when selling at wind node

Source: Reducing Risk in Merchant Wind and Solar Projects through Financial Hedges (RFF)

Basis risk introduces additional uncertainty in contract revenues



- Keechi Wind plant in ERCOT (110MW, Trading Hub: HB_NORTH)

- Basis risk can be hard to predict due to the nature of electricity market topology
  - Transmission constraint
  - New (retire) power plant
  - Weather event, etc.
- The high variation of basis risk makes it hard to use fixed price offset into the PPA to make up for expected basis risk
- Unlike traditional Utility PPA settles at the local pricing node, Corporate PPA frequently settles at the trading hub
  - Corporate PPA is growing
  - New market participants are facing this growing issue

Financial Transmission Rights are financial instruments to hedge basis risk by fixed volume

Example

Buyer purchases 10 MW from the trading hub at 10*$25 = $250
Power Plant sells 10 MW of power at the plant node at 10*$20 = $200
10 MW FTR from node to hub would payout 10*($25 - $20) = $50

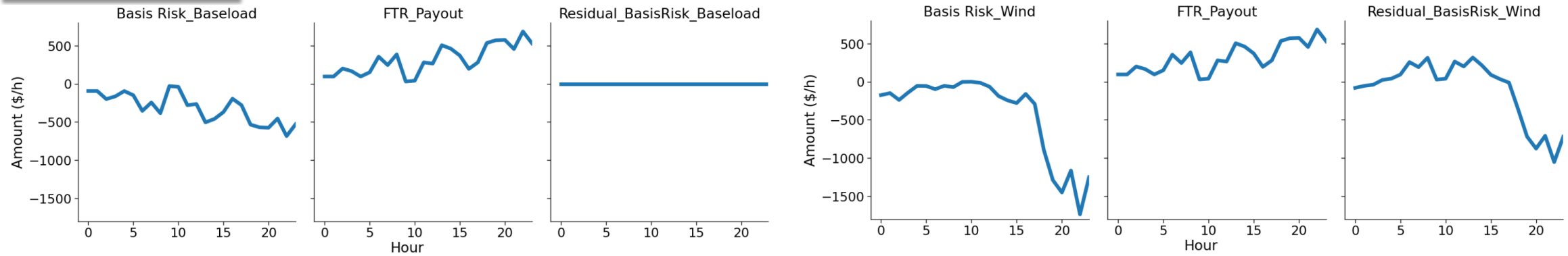
- FTRs are a financial tool to hedge the congestion component of the LMP across two different locations
- FTRs were designed by ISO/RTOs when conventional generators dominated the generation mix
- Selling its output at the plant node plus the payout of the FTR is equivalent to selling its output at the trading hub
- FTR is purchased in the auction at the clearing price; the payout in this study does not consider the cost to purchase

A fixed volume FTR does not perfectly hedge a transaction involving variable output, leading to a residual basis risk even with an FTR

Baseload

Basis Risk and Residual Basis Risk: Baseload vs Wind

Wind



Type: Baseload, Capacity: 50 MW, FTR: 50MW

Type: Wind, Capacity: 50 MW, FTR: 50MW

- The current FTR designs specify a fixed volume over a time horizon, independent of the plant output
- Fixed volume FTRs can effectively hedge the basis risk for energy resources with a constant generation profile, such as a baseload plant
- Resources whose output changes over time, including both variable resources like wind and dispatchable resources like a combustion turbine, are poorly hedged with the existing fixed volume FTRs

Scope: For different generation types, compare historical basis risk in the wind-rich Midwest US along with residual basis risk with FTRs

Hypothesis

- Basis risk is larger for wind than for other technologies, making FTRs potentially more important for wind
- Fixed volume nature of FTRs make them imperfect hedging instruments for resources with variable output, leading to a residual basis risk
- Alternative FTR designs can be more effective

Approach

- Use historical generation and wholesale price data to measure basis risk and residual basis risk with FTRs
- Focus on the Midwest US (MISO, SPP, and ERCOT)
- Use wholesale prices from 2015-2019
- Use two key metrics to measure the effectiveness: basis risk level and uncertainty

Contributions

- Quantification of the basis risk and residual basis risk for different technology types
- Evaluation of an alternative Wind FTR, which dynamically adjusts the volume based on the ISO-wide wind generation level

Key Findings

- Wind energy faces the largest basis risk and it is growing with further wind deployment
- Basis risk can lead to losses for contracts that settle at a trading hub; the magnitude of the losses varies from month-to-month
- Fixed-volume Annual FTRs can eliminate basis risk and reduce uncertainty for baseload generators, but are much less effective for wind
- ISO/RTOs are responsible for designing FTR products, and may need to adjust the design to address resources that are most impacted by congestion
- Alternative FTRs, such as a “Wind FTR” (will be explained soon), may be a more useful hedging mechanism for wind-rich markets in the Midwest.

Literature

A few alternative flexible FTR designs were proposed to better hedge the basis risk of the variable generators

Varying Volume FTR

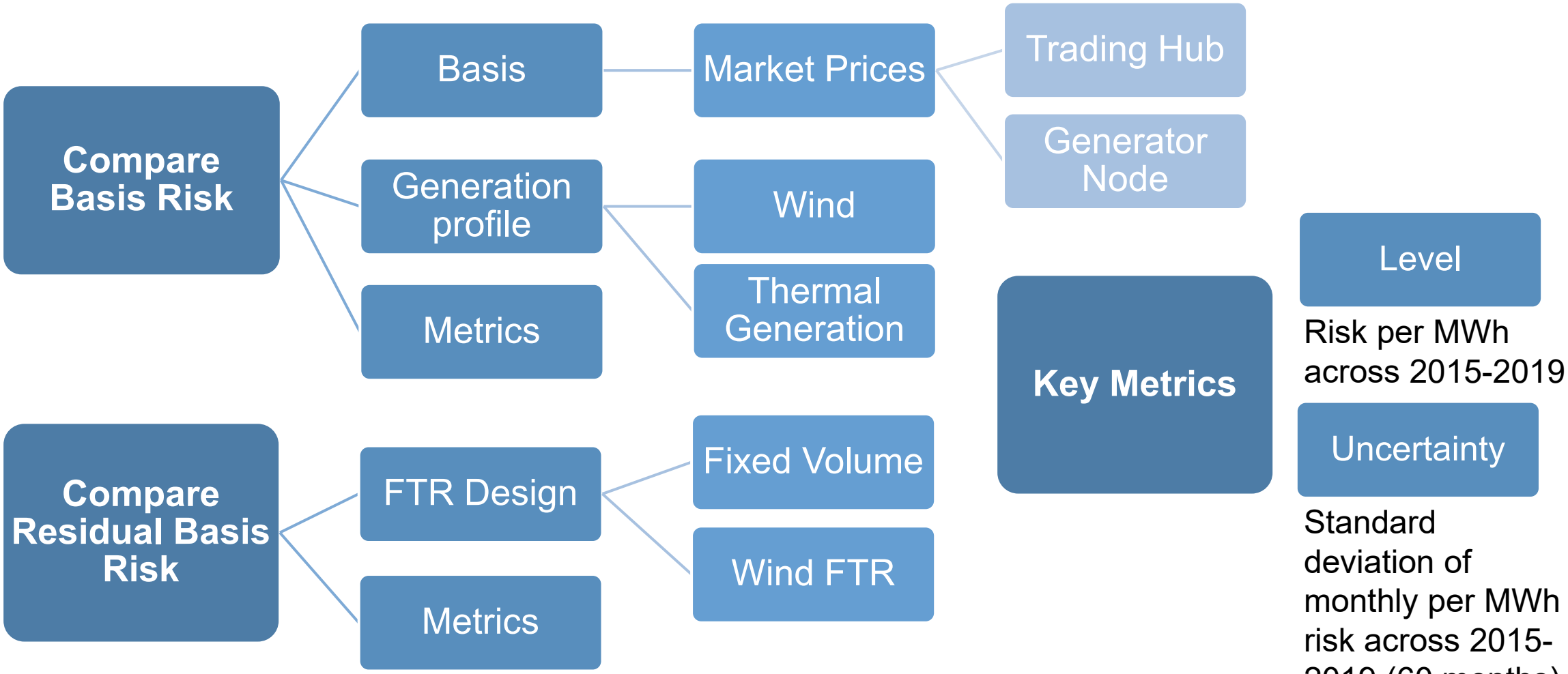
- Biggar and Hesamzadeh (2013) proposes a type of flexible FTR
  - Varying volume with prices to exercise the FTR that can help to hedge the varying volume price-taking generator
- Extending the idea of the flexible FTR, the ISO/RTOs can develop auctions for varying volume FTR products (variable FTRs)

Dispatchable FTR

- Nimmagadda et al. (2013) proposes a dispatchable FTR
  - Overcome the fixed-volume nature of the existing FTR and provide better hedge for the intermittent generation asset such as wind
- In their study, the part of FTRs equal to the actual MWs committed in the DAM are called as dispatchable FTRs and the remainings as residual FTRs

Methods

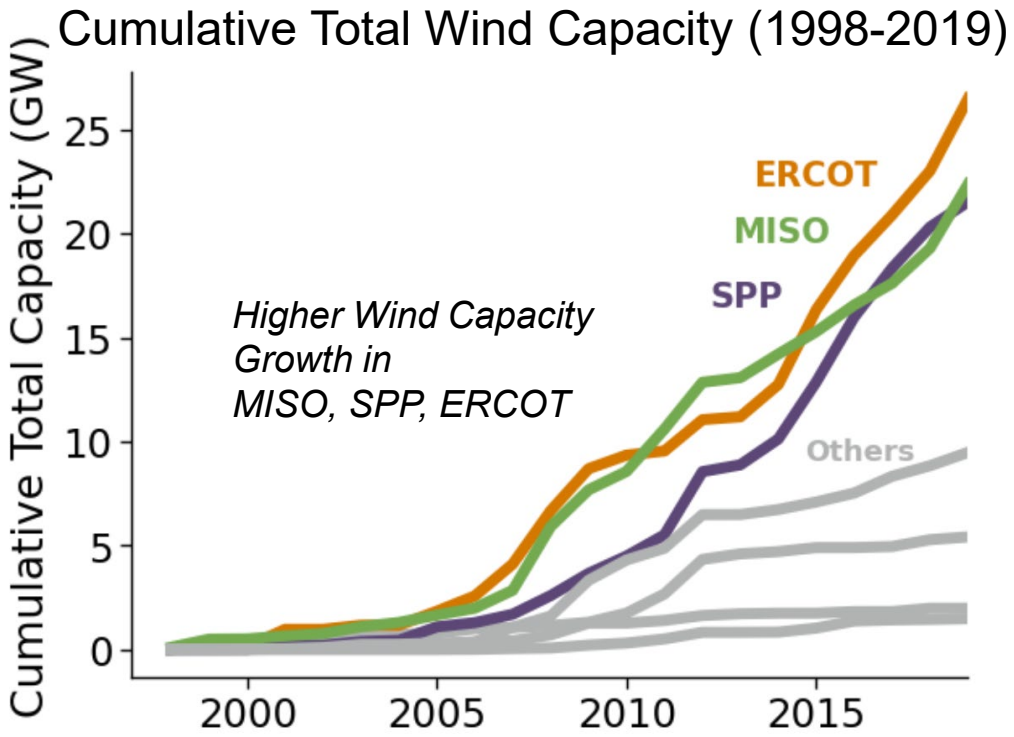
Quantify and compare basis risk and residual basis risk across generation technologies



Assumptions and Data

- Basis
  - Generators are paired with a nearest price node (Reported in Velocity Suite or calculated when missing from Velocity Suite)
  - Basis is calculated between the generator node and the nearest major trading hub
  - Major trading hubs are:
    'HB_NORTH', 'HB_SOUTH', 'HB_HOUSTON' (ERCOT), 'SPPNORTH_HUB', 'SPPSOUTH_HUB', 'EDE_EDE' (SPP), 'ILLINOIS.HUB', 'MICHIGAN.HUB', 'MINN.HUB' (MISO)
- Generation Profiles
  - Plant-level Wind Profiles
    - Historical hourly wind generation profiles using weather data from ECMWF, then debiased using the technique developed for the 2019 Wind Technology Market Report
  - Plant-level Thermal Profiles
    - Profiles for plants tracked by the EPA's Continuous Emissions Monitoring System and reported in Velocity Suite
    - Nuclear plant profiles from the Nuclear Regulatory Commission and reported in Velocity Suite
- FTR Design
  - Standard Fixed Volume
  - Each plant's FTRs size is equivalent to the annual average plant production
- Wind FTR
  - The volume changes with the aggregate wind profile for the market region. Aggregate wind profiles from the ISO/RTOs and reported in Velocity Suite

Focus on the Midwest US



- This study focuses on the ISOs in the Midwest US, which has far greater wind capacity growth
  - MISO: Focus on MISO North

Source: WTMR

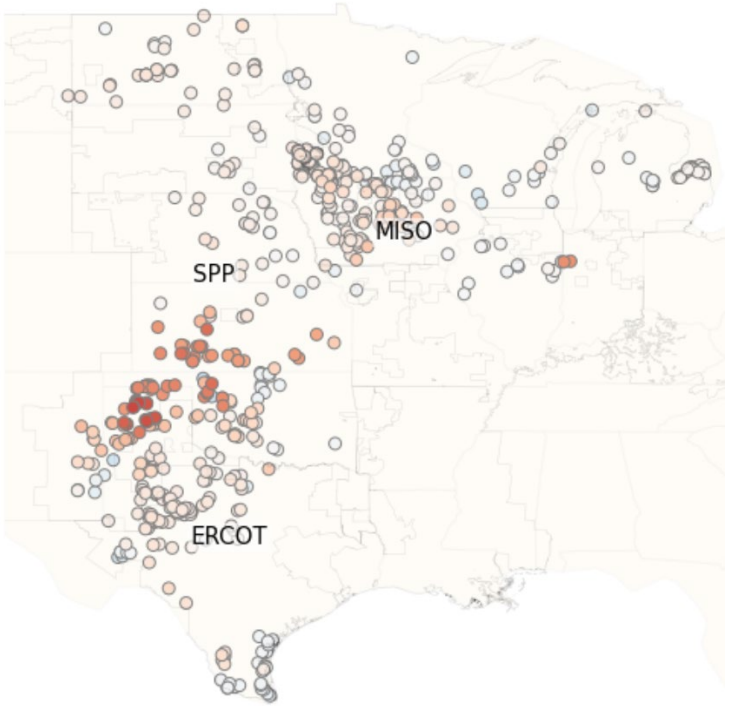
Each dot represents the selected hubs in MISO, SPP, ERCOT

- Representative and geographically distinct hubs in MISO, SPP, ERCOT are selected
  - Guided by anecdotal evidence from the domain experts
  - Sensitivity analysis showed robustness of the hub selections

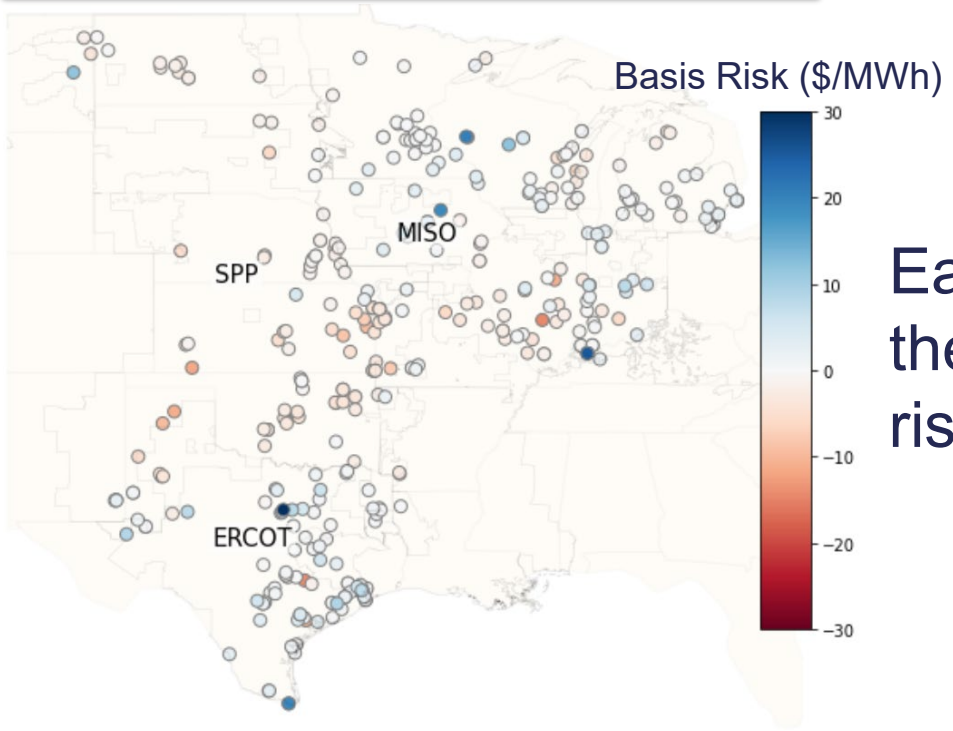
Evaluation of basis risk across technologies

Basis risk for wind plants are generally negative and clustered, while it is neutral or positive for non-wind power plants

2019 Basis Risk: Wind



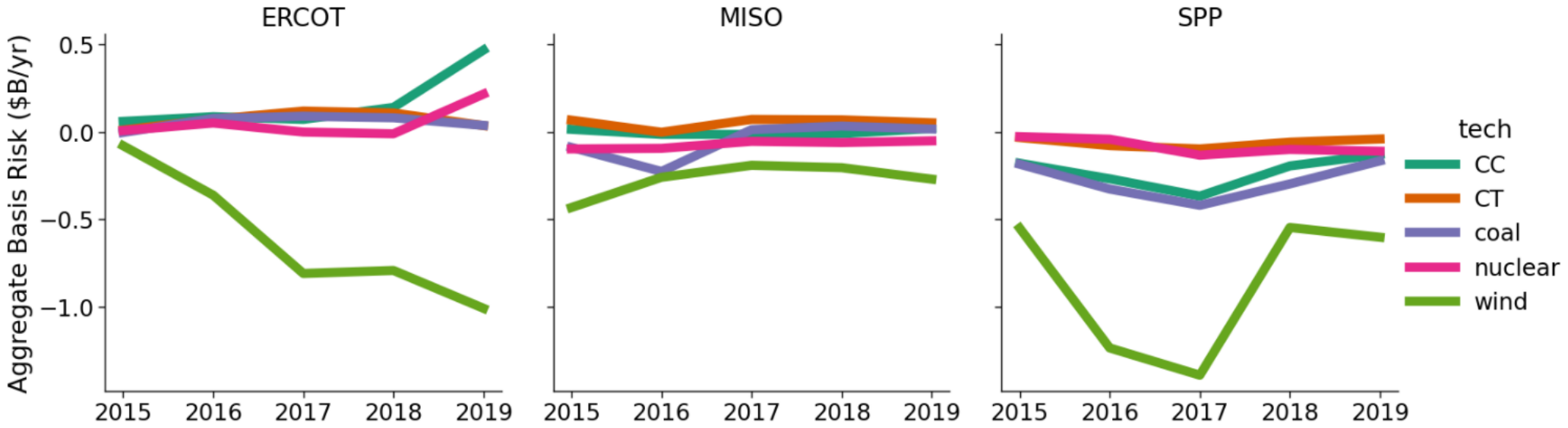
2019 Basis Risk: non-Wind



Each dot represents the plant level basis risk

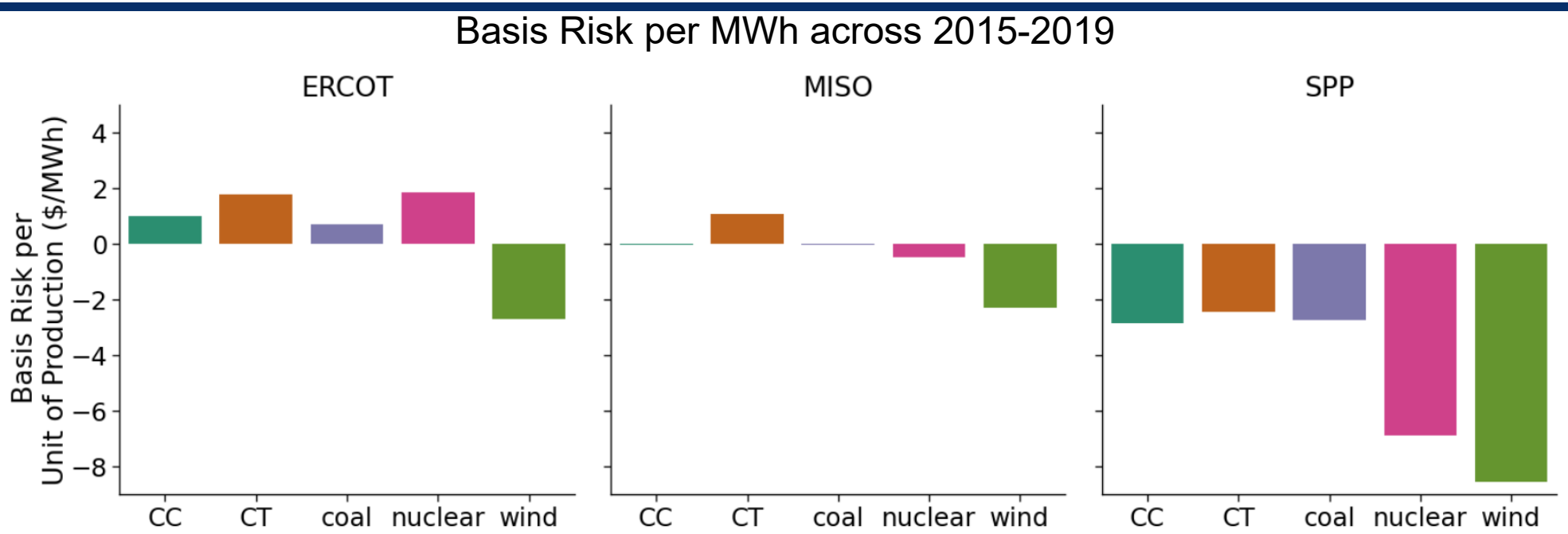
Negative basis risk indicates generation-weighted wholesale power prices are lower at the plant node than at the trading hub

Wind plants face the greatest basis risk, and its magnitude is growing with increasing wind regions



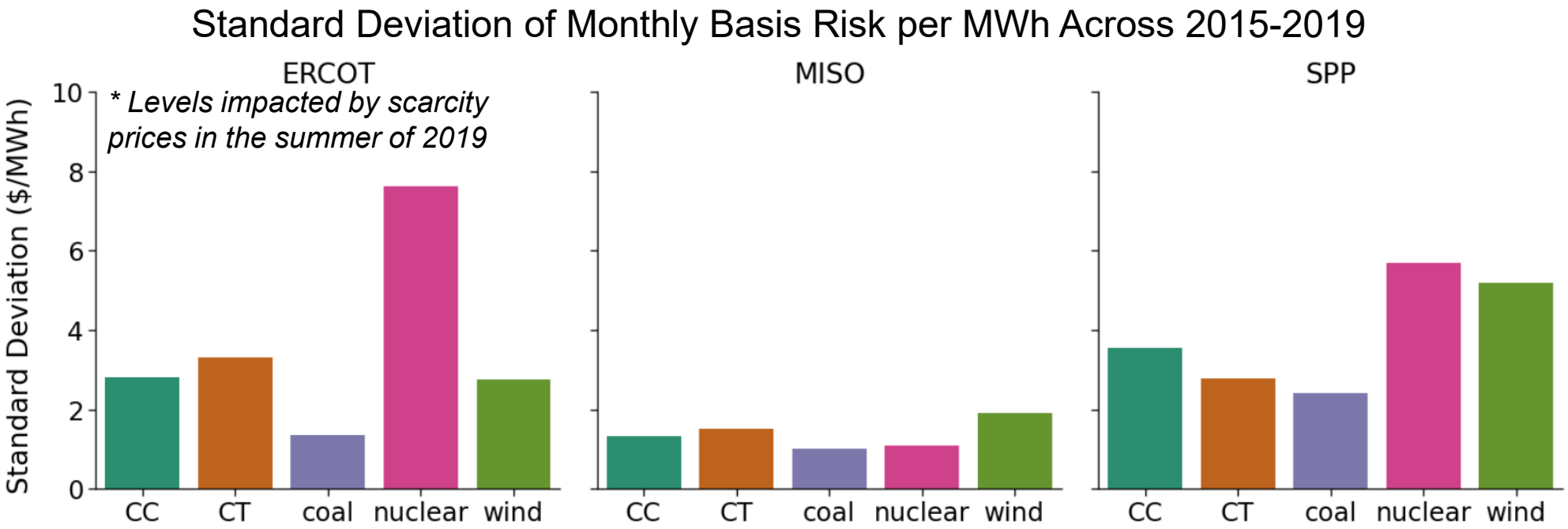
- ISO-wide total basis risk is the aggregate basis risk of the specific generation technology
- The basis risk of wind is strongly correlated to deployment of wind
- Basis risk for non-wind plants is much smaller in magnitude

Wind power is disproportionally impacted by basis risk across the three markets



- More remote location of wind, relative to trading hubs, drives greater basis risk
- A wind plant that contracted to sell power at a trading hub lost $2-6/MWh on average due to basis risk
- The magnitudes are smaller for other technologies, though as much as $4/MWh for nuclear in SPP

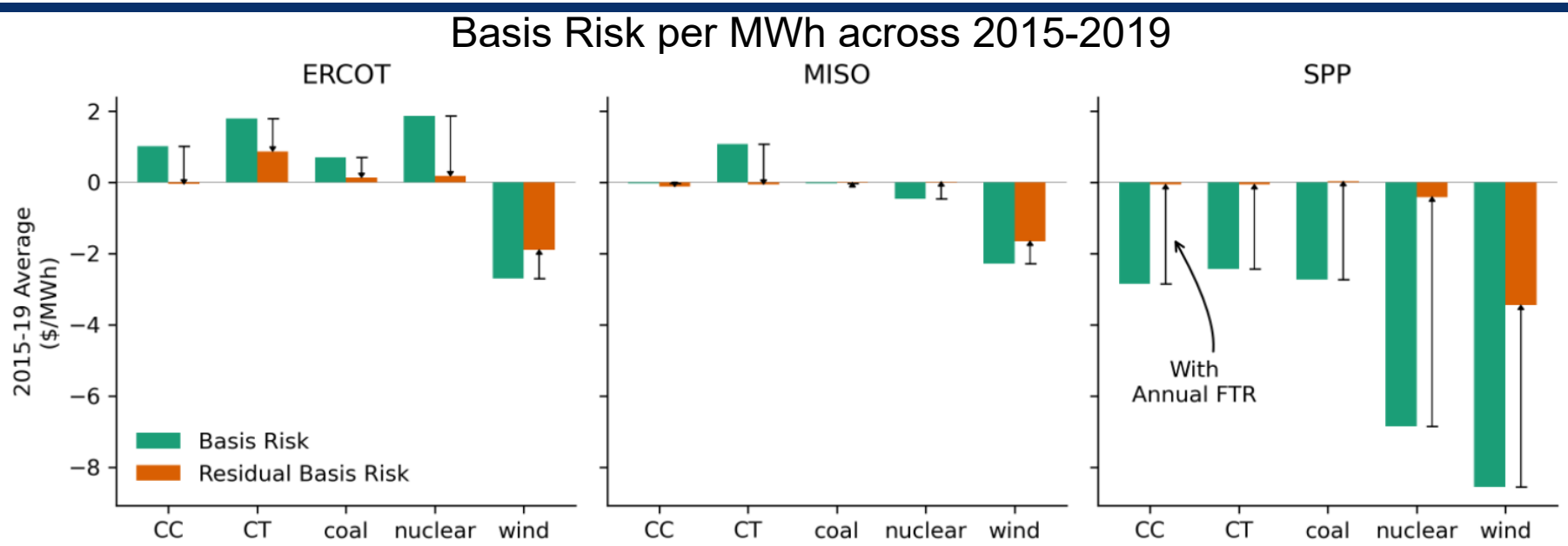
Uncertainty in the basis risk is higher for wind



- Basis risk uncertainty is the standard deviation of the monthly average basis risk.
- If the basis risk were stable and predictable, a generator could raise the contract price by an amount equal to the average basis risk.
- Considerable variation in the basis risk makes this strategy less effective and introduces uncertainty in the plant revenue.

Residual basis risk: Effectiveness of fixed-volume FTRs

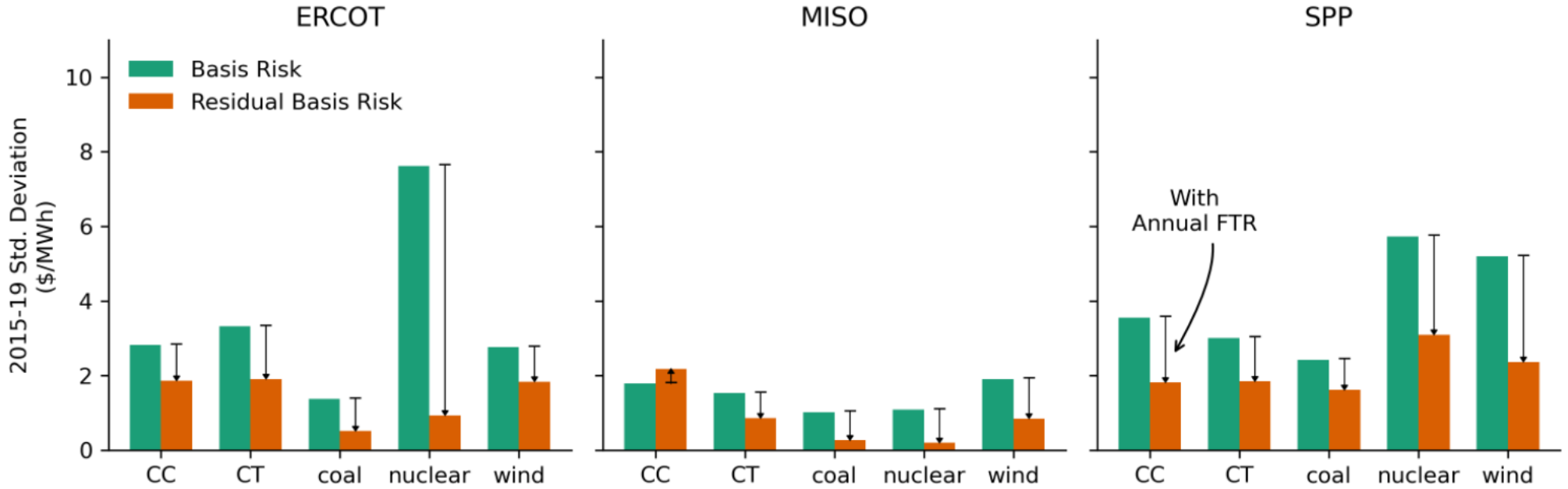
An Annual FTR that nearly eliminates the basis risk for most conventional generators, is less effective for wind



- Fixed volume FTRs are particularly effective at eliminating basis risk for nuclear and coal, traditionally baseload generators. It is not as effective for CT's in ERCOT
- Residual basis risk for wind is lower than without the FTR, but it is clearly less effective for a resource with variable output

Fixed-volume FTRs that reduce uncertainty for baseload plants, are again less effective for wind

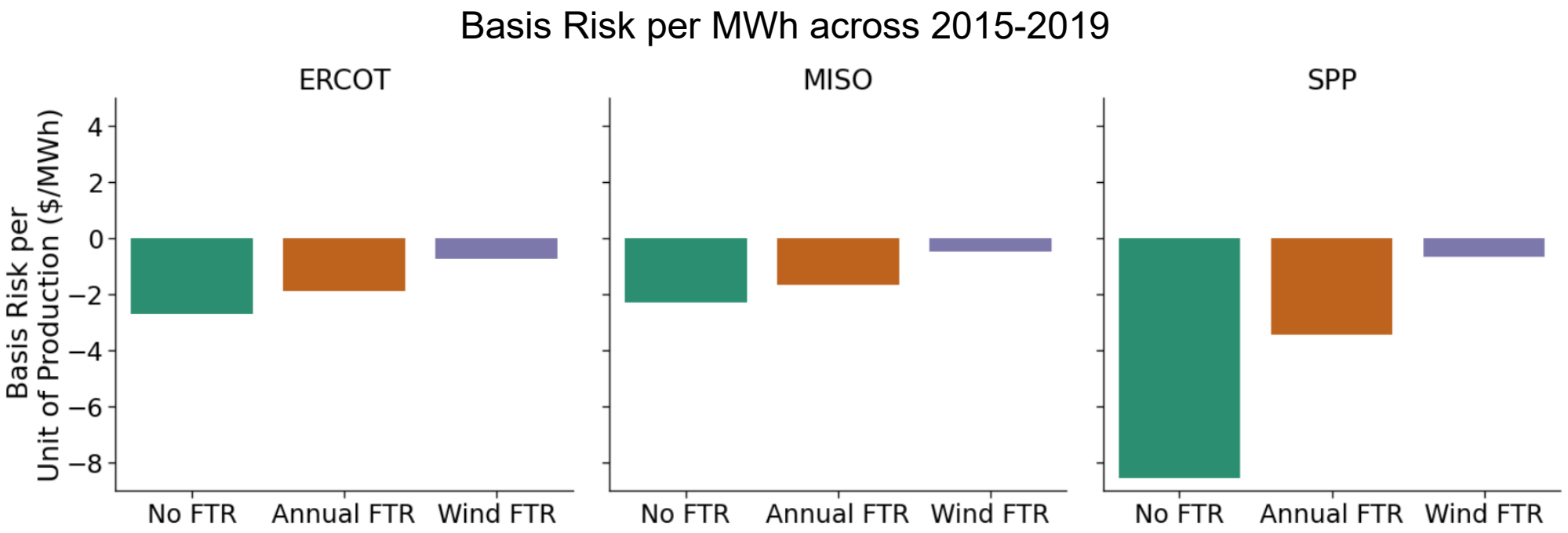
Standard Deviation of Monthly Residual Basis Risk per MWh Across 2015-2019



- Fixed-volume FTRs are much more effective at eliminating the uncertainty for baseload generators due to their stable generation pattern
- Variation in wind power, both time-of-day and month-to-month, diminish the effectiveness of an Fixed-volume FTR in reducing uncertainty in the basis risk

Wind FTR: An alternative to fixed-volume FTRs

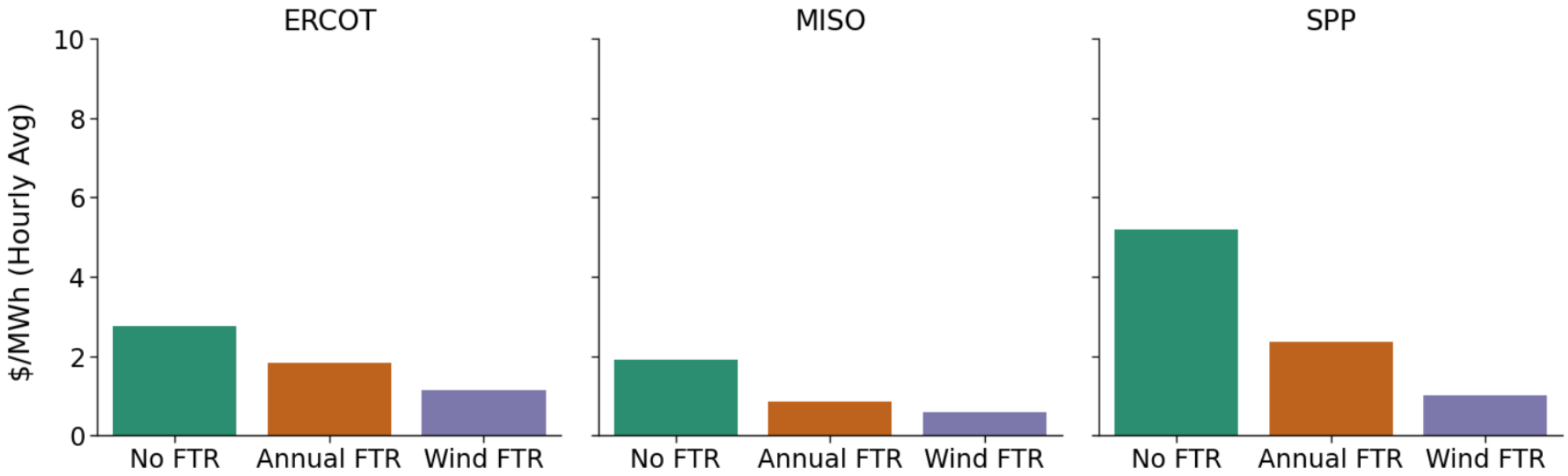
Wind FTRs reduce wind's residual basis risk more effectively



- Wind FTR is a variable-volume hourly FTR following the ISO-wide hourly wind profile for a specific year
- The wind FTR is considerably more effective than the Annual FTR in reducing wind's basis risk

Wind FTRs also reduce the uncertainty in the residual basis risk

Standard Deviation of Monthly Residual Basis Risk per MWh Across 2015-2019



- The reduction in residual basis risk *uncertainty* with a Wind FTR is relatively weaker than the reduction in the residual basis risk *level*
- The effectiveness of the wind FTR is diminished by heterogeneous plant-level wind profiles that differ from market-wide wind profiles

Conclusions

- In the Midwest U.S., wind energy faces the largest basis risk and it is growing with further wind deployment
- Basis risk can lead to losses for contracts that settle at a trading hub; the magnitude of the losses varies from month-to-month
- Fixed-volume Annual FTRs can eliminate basis risk and reduce uncertainty for baseload generators, but are much less effective for wind
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