Hybrid configuration with rapidly changing market prices

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Electricity Markets and Policy Department @ LBNL

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- Electricity Markets & Policy (EMP) informs public and private decision making within the U.S. electricity sector
- We use independent, interdisciplinary analysis of critical electricity policy and market issues.
- We envision a clean, efficient, reliable, and affordable electricity system that meets the United States' diverse and growing energy needs.

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Package of complementary research performed on Hybrid (Energy Storage + Renewables) over last 3 years by EMP @ Berkeley National Lab

The top ten findings

GROWTH
Developer interest in hybrid power plants is strong and growing

PRICE VS. VALUE
PV+storage hybrids have low PPA prices and high value in some regions

MARKET DRIVERS
Solar hybridization is driven by tax credits and other benefits

CONFIGURATION CHOICES
Market prices have incentivized shorter duration batteries with PV

CAPACITY VALUE
The capacity contribution of a hybrid is less than the sum of its parts

ANCILLARY SERVICES
Ancillary service markets are a valuable yet fleeting option for hybrids

MARKET PARTICIPATION
Hybrids can more flexibly engage with electricity markets

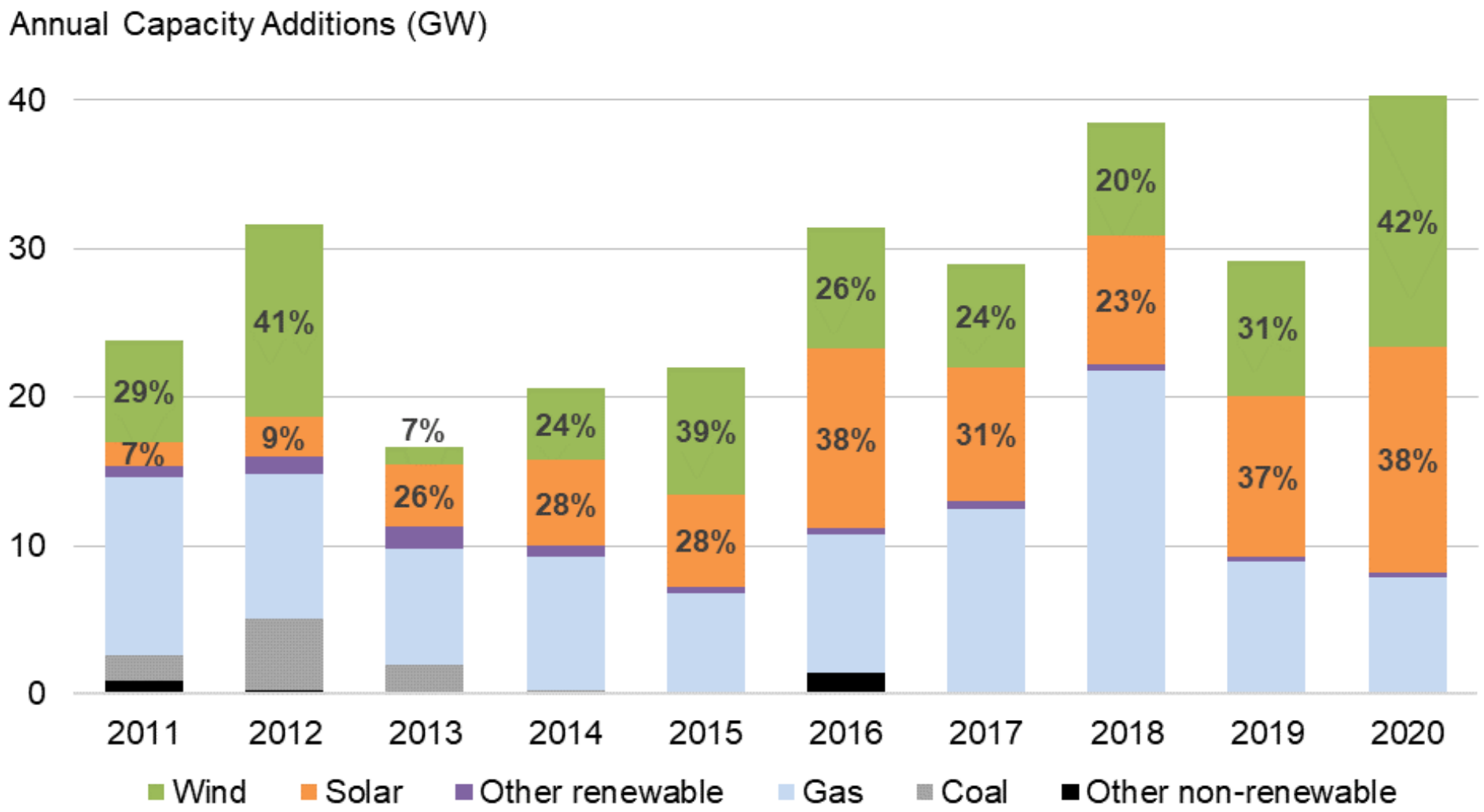
OPERATIONS
The power system value of hybrids depends on how they are operated

DISTRIBUTED HYBRIDS
Growth of customer-sited PV+storage hybrids offers new opportunities

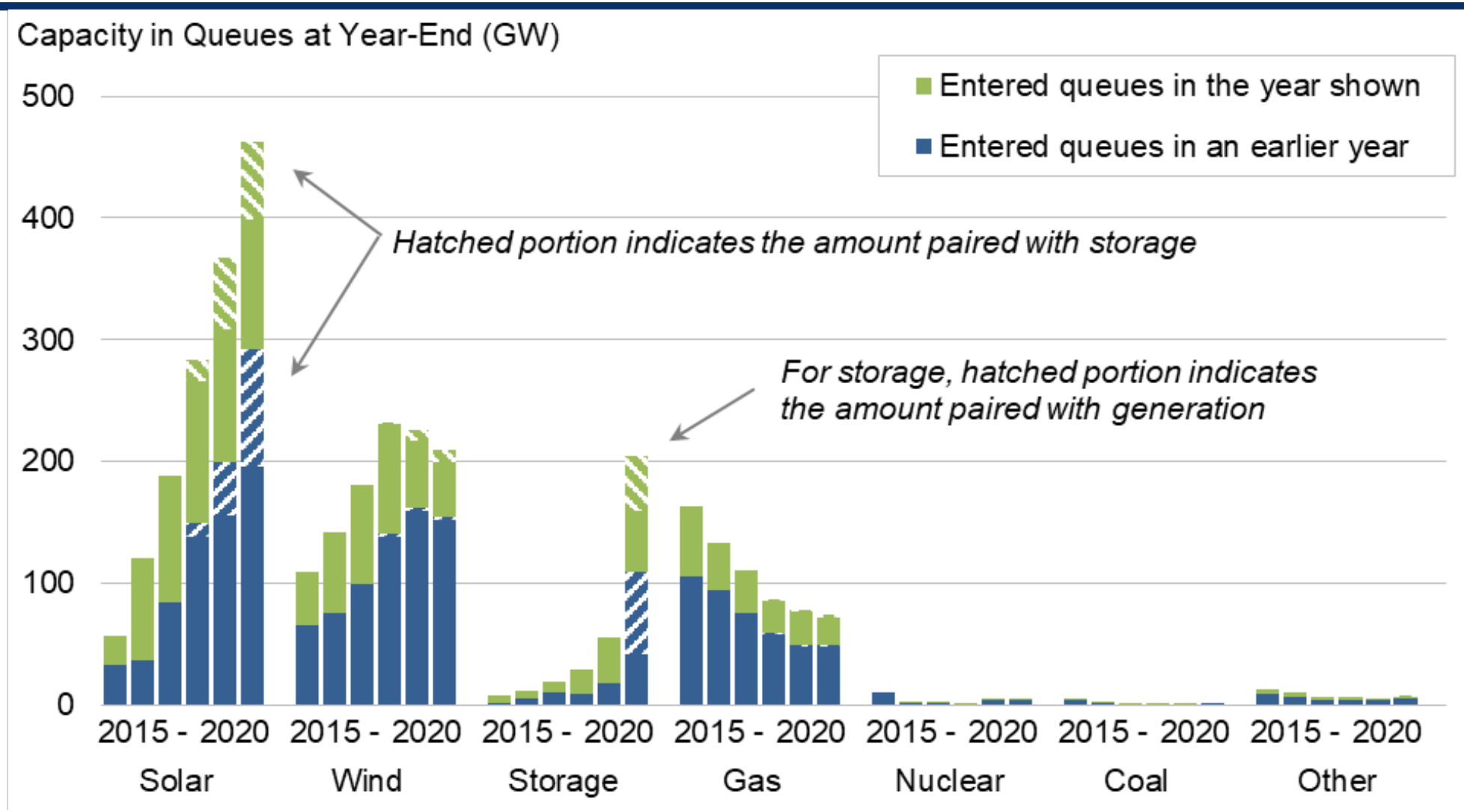
FUTURE RESEARCH
Where next? Priority areas for hybrid power research

Electricity Market with Rapidly Growing Renewables (Solar, Wind) and Energy Storage

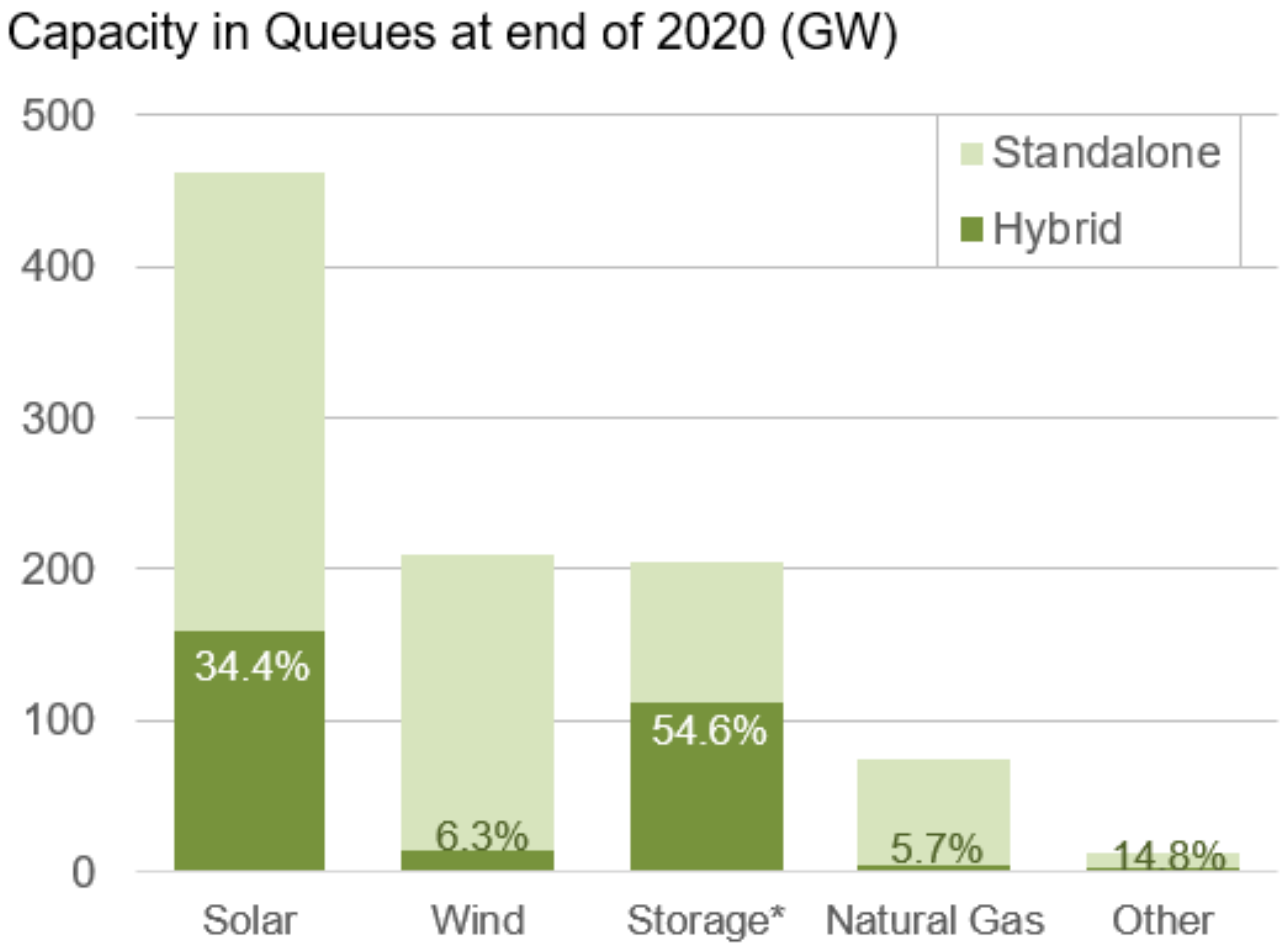
Wind and solar have begun to dominate new generation capacity additions in the United States



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

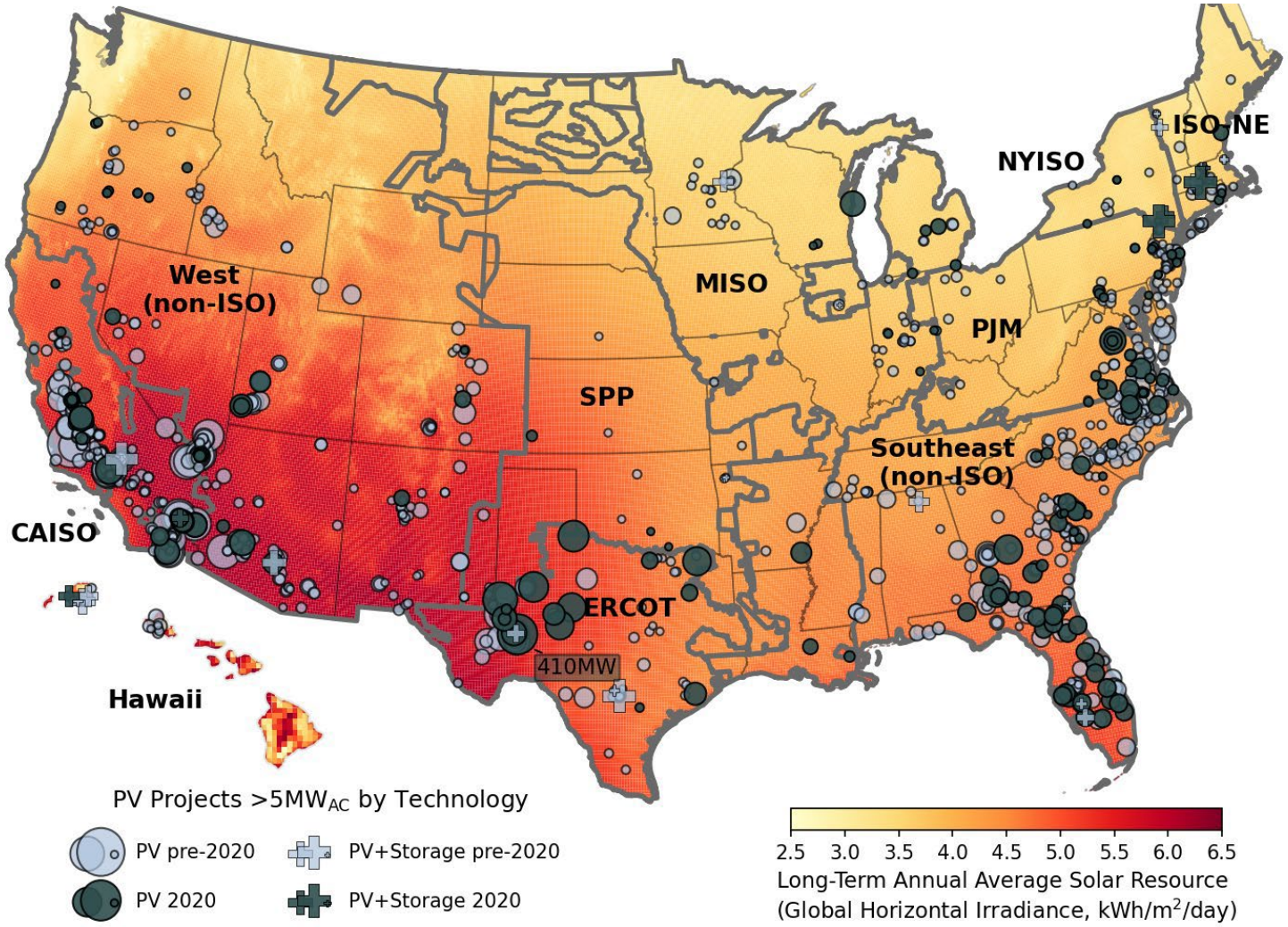


High proportion of capacity in queues in a hybrid configuration as of the end of 2020

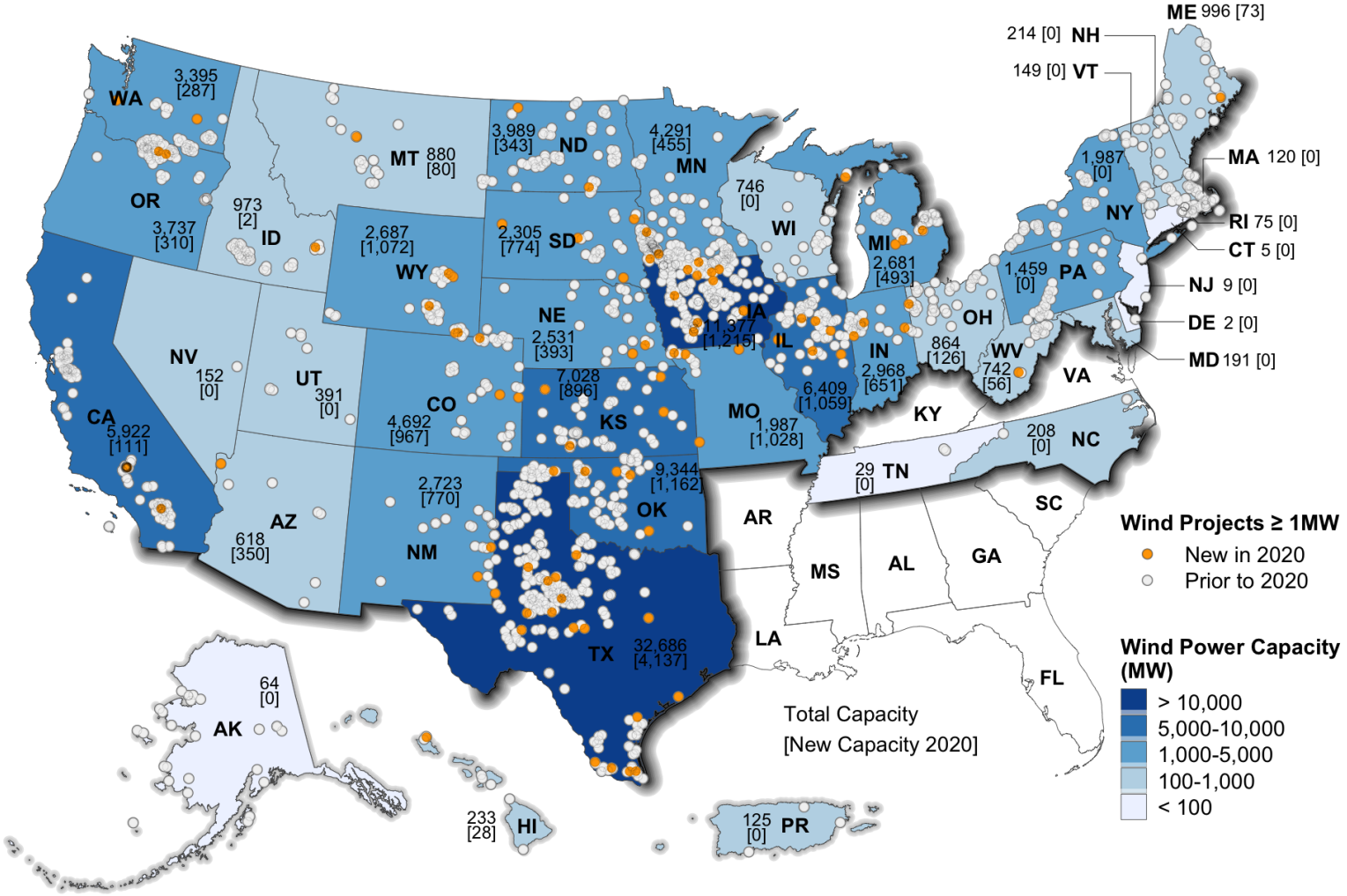


Rapidly Changing Electricity Market Price

Utility-scale PV are concentrated in the sunny Southwest and the declining installed costs enabled it to expand across the country

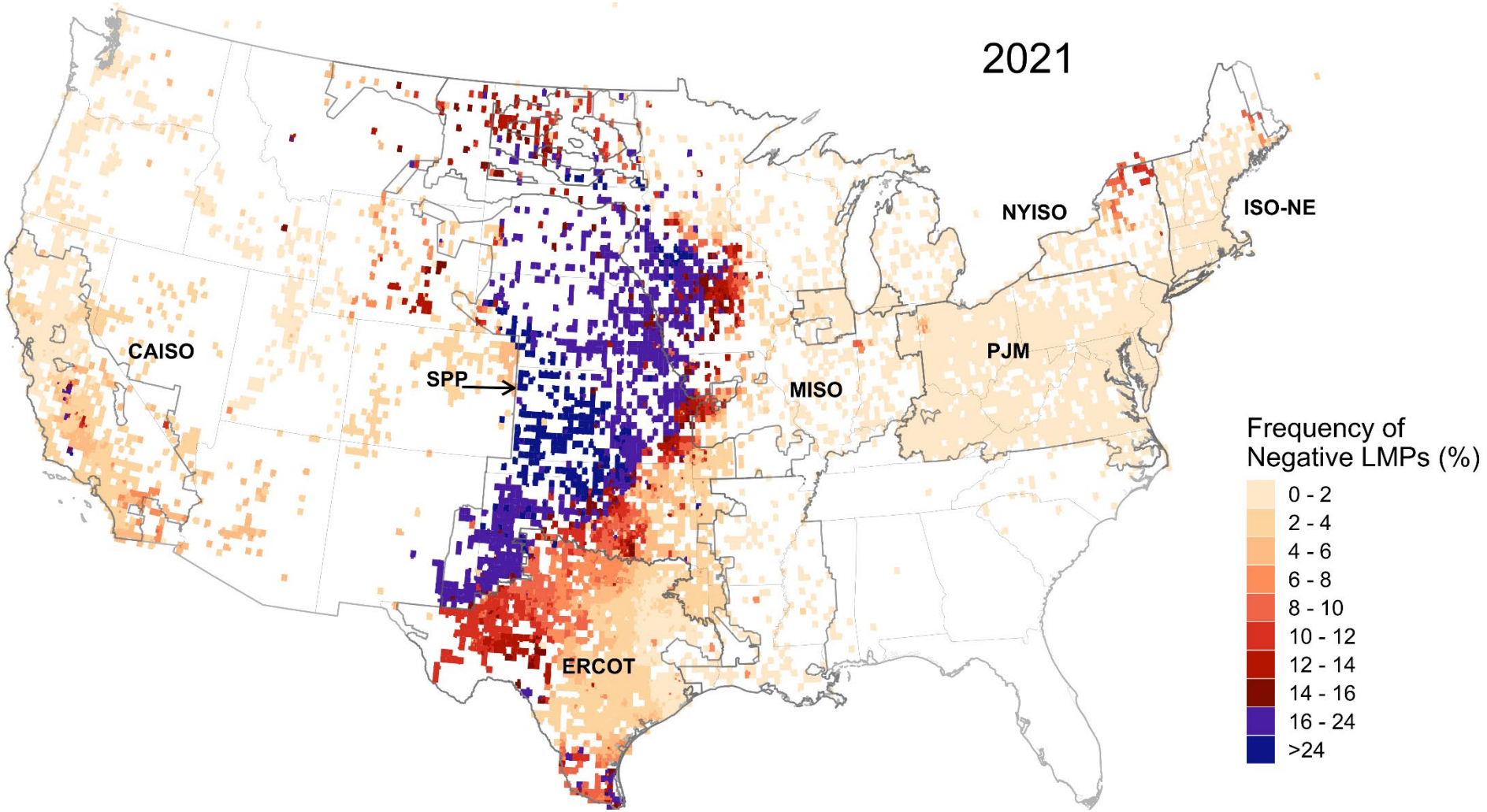


Utility-Scale Wind power installations are dispersed, but concentrated in the U.S. interior, including ERCOT, SPP, and MISO



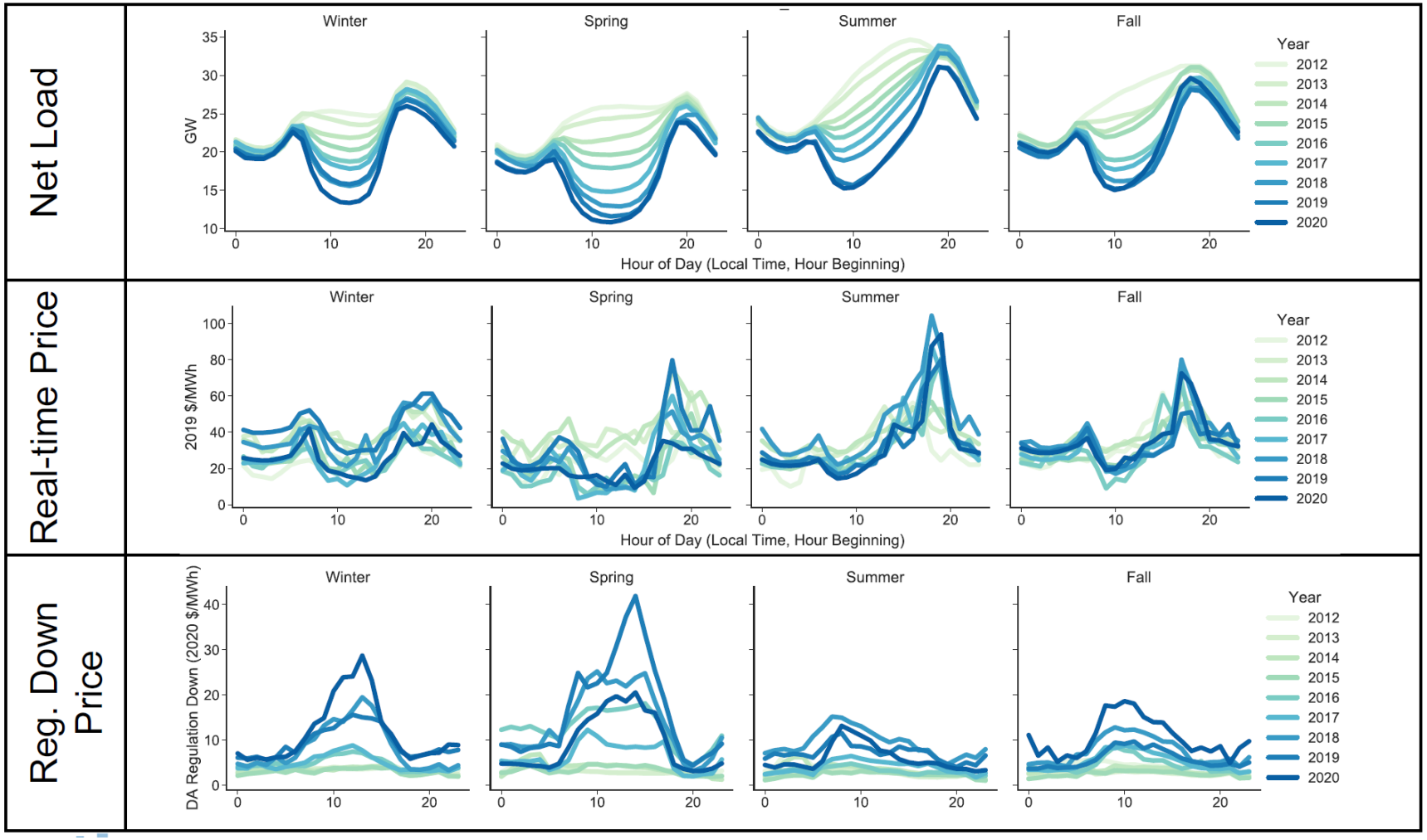
Note: Numbers within states represent megawatts of cumulative installed wind capacity and, in brackets, annual additions in 2020.

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

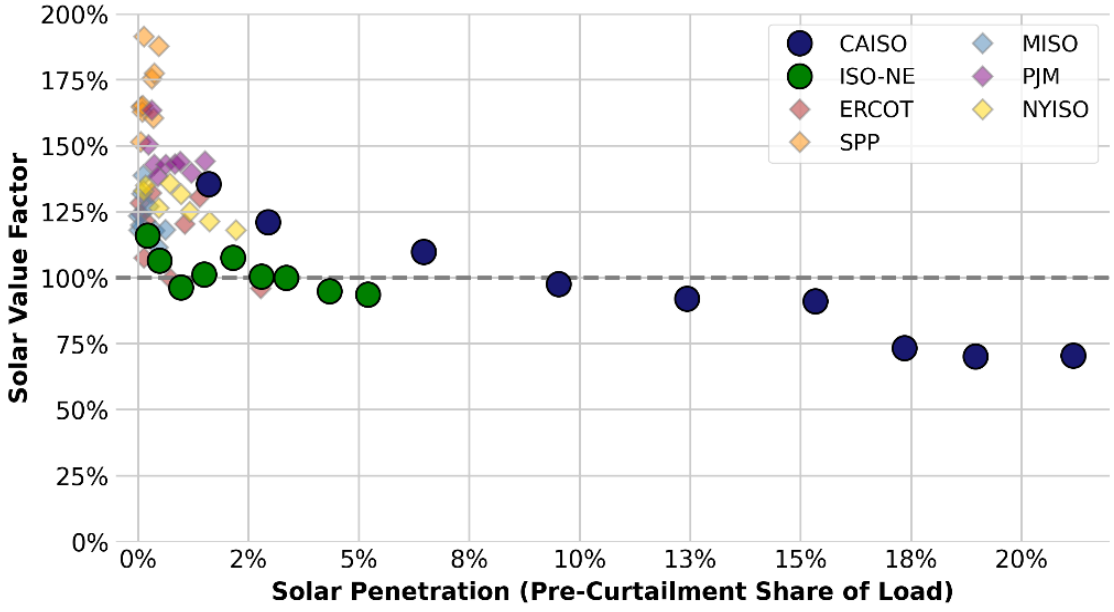
Obvious impacts of solar on CAISO, California ISO, net load and wholesale market prices



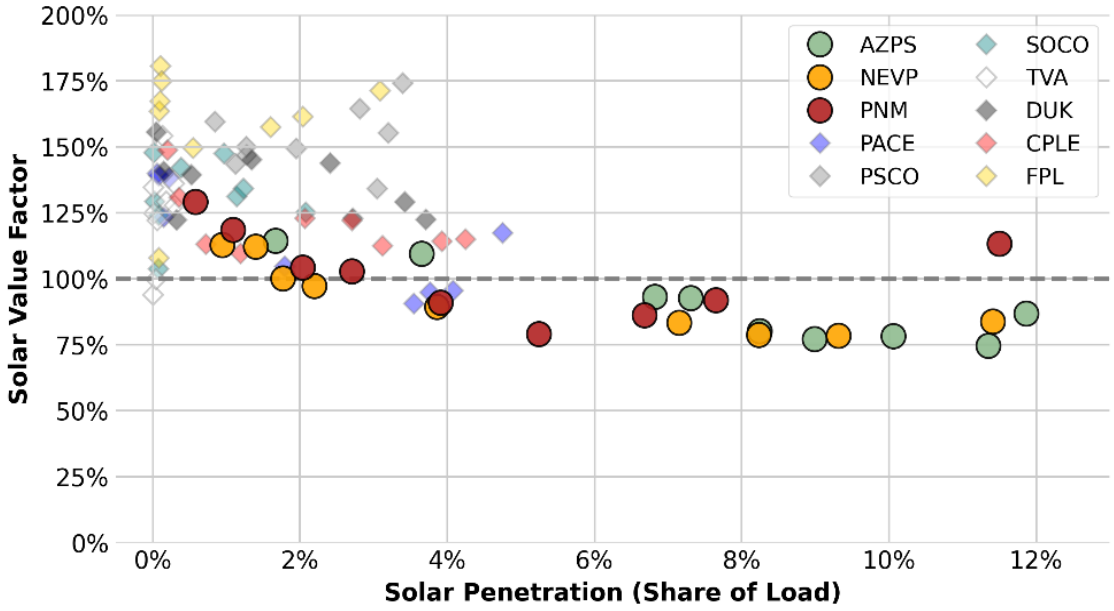
Hybrid configuration choices with rapidly changing market prices

Market value of solar declines with higher solar penetration relative to average prices

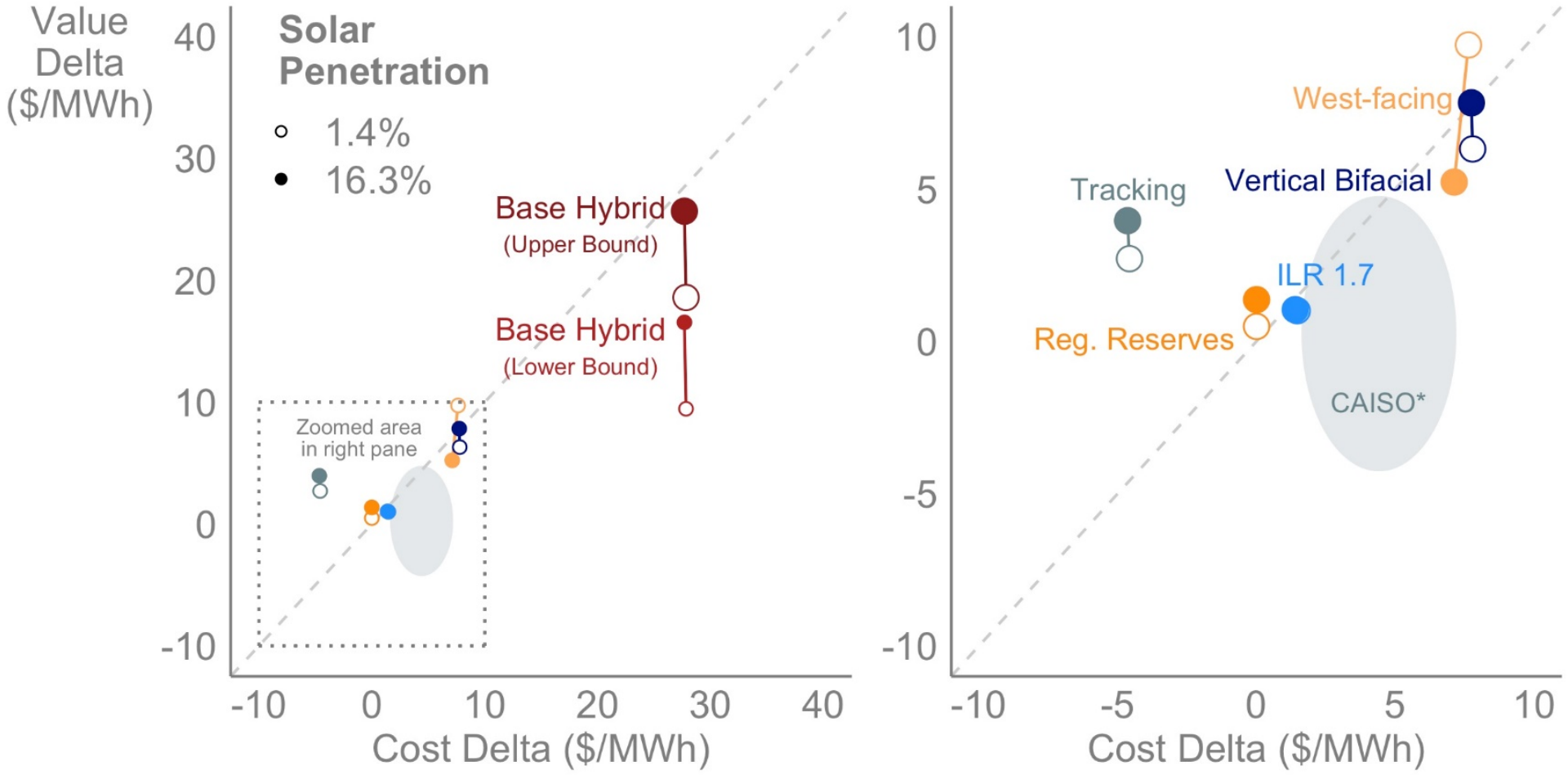
ISO/RTOs



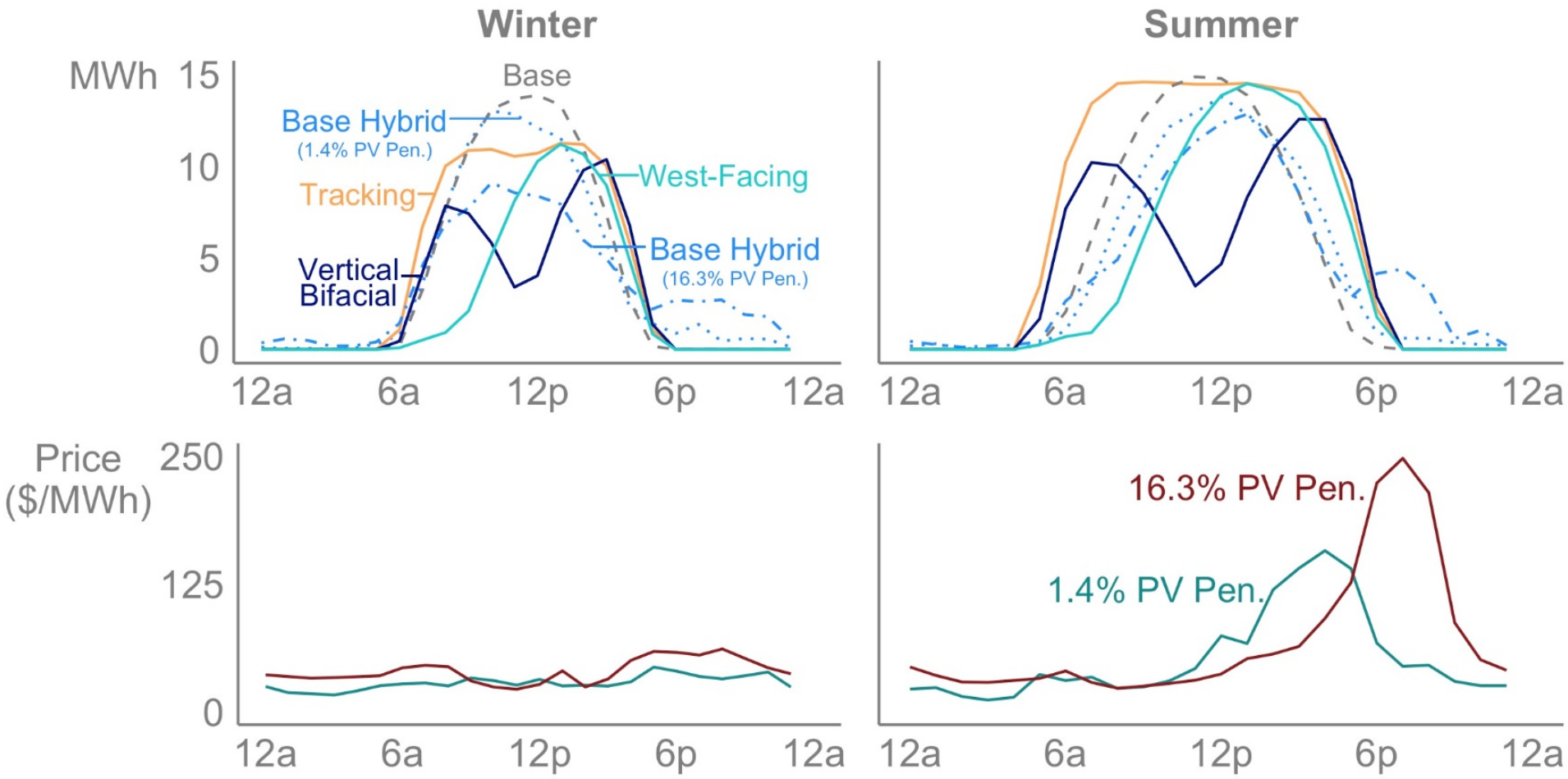
Utilities



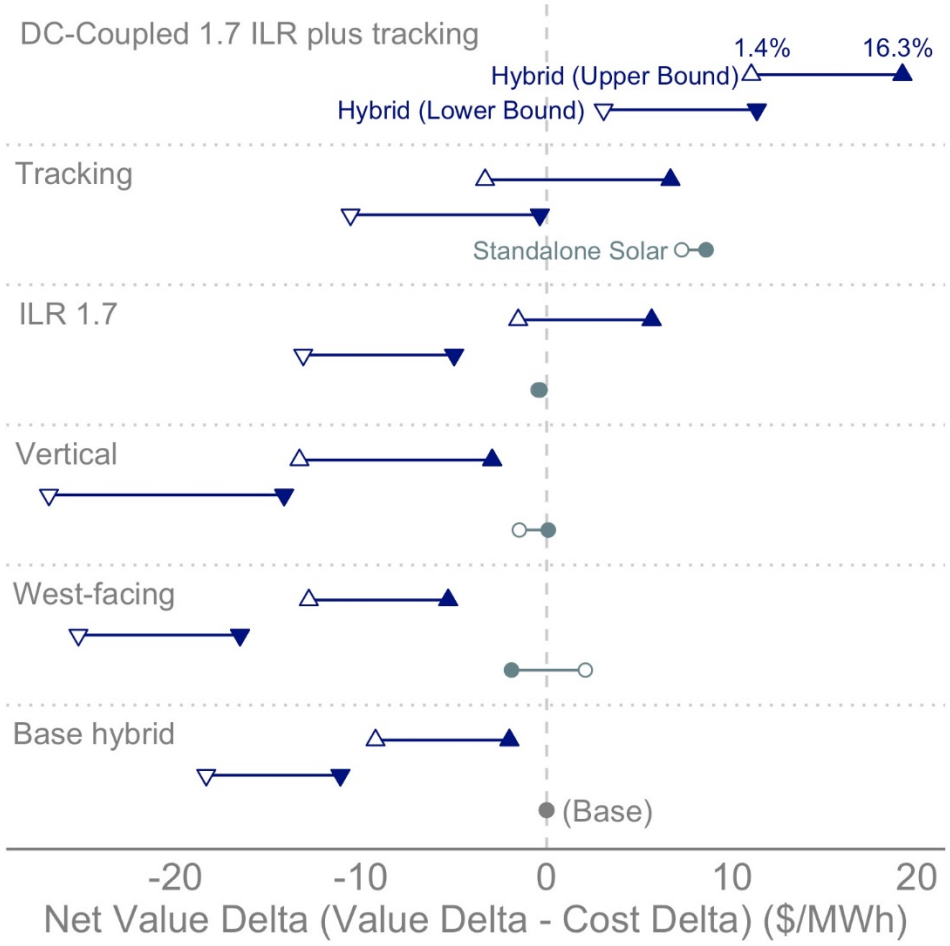
Value increase comes from changing the timing of production to better align with peak system needs, when the prices are higher



The impact of higher solar penetration on value added by a grid-friendly option depends on the way production is shifted by the option



Generation-maximizing strategies with energy-shifting capabilities of hybrids yield the most net-value benefits at higher solar penetration



- Upper bound: Perfect foresight of real-time prices and solar production
- Lower bound: Imperfect foresight

- Net value rankings of options with storage differ from the ranking of standalone PV options
- PV subsystems that sacrifice overall production to better align solar production is less attractive
  - West-Facing, Vertical Bifacial
- Options that increase annual production are more attractive
  - 1.7 ILR, Tracking
  - Best: DC 1.7 ILR + Tracking

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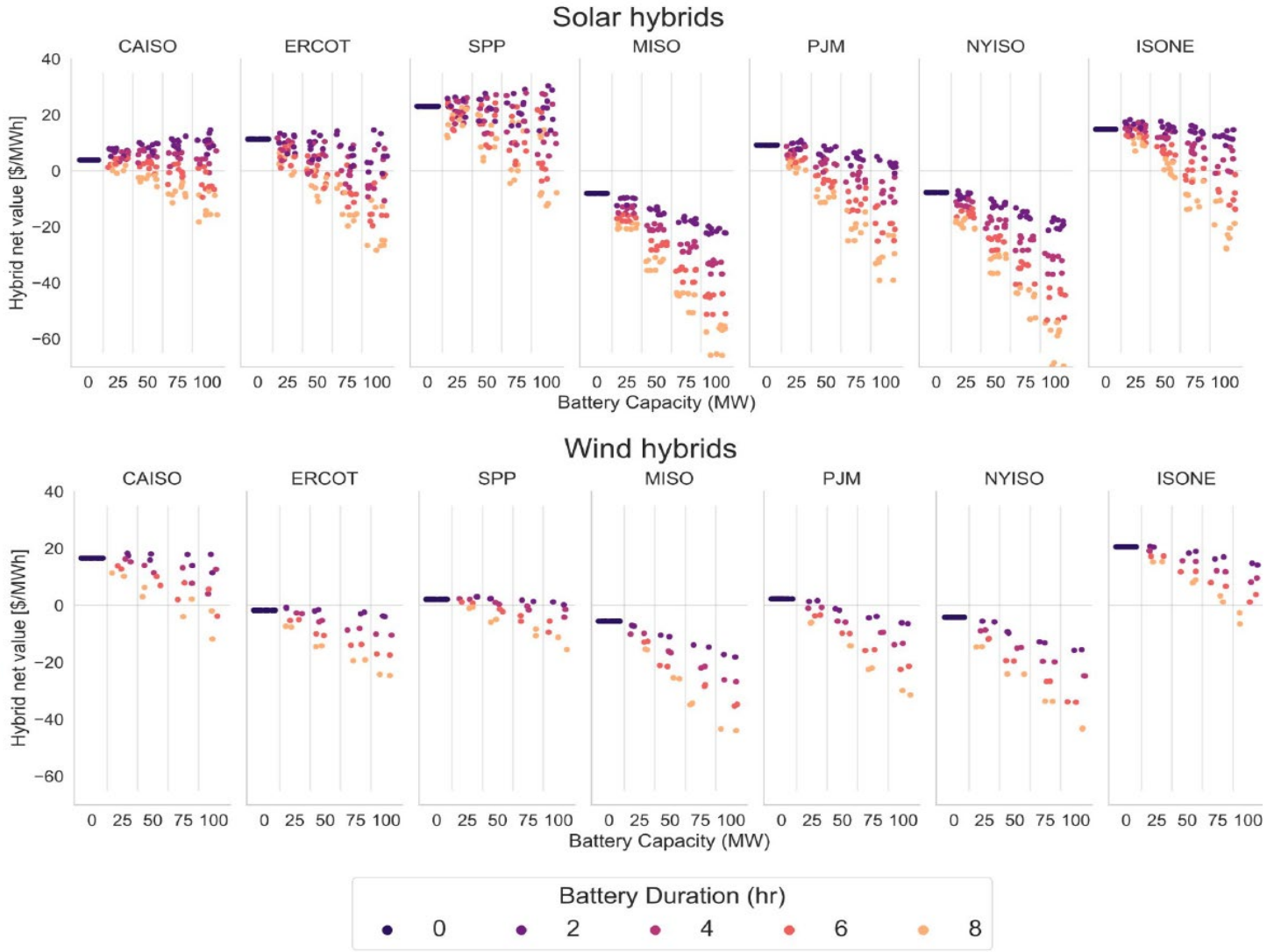
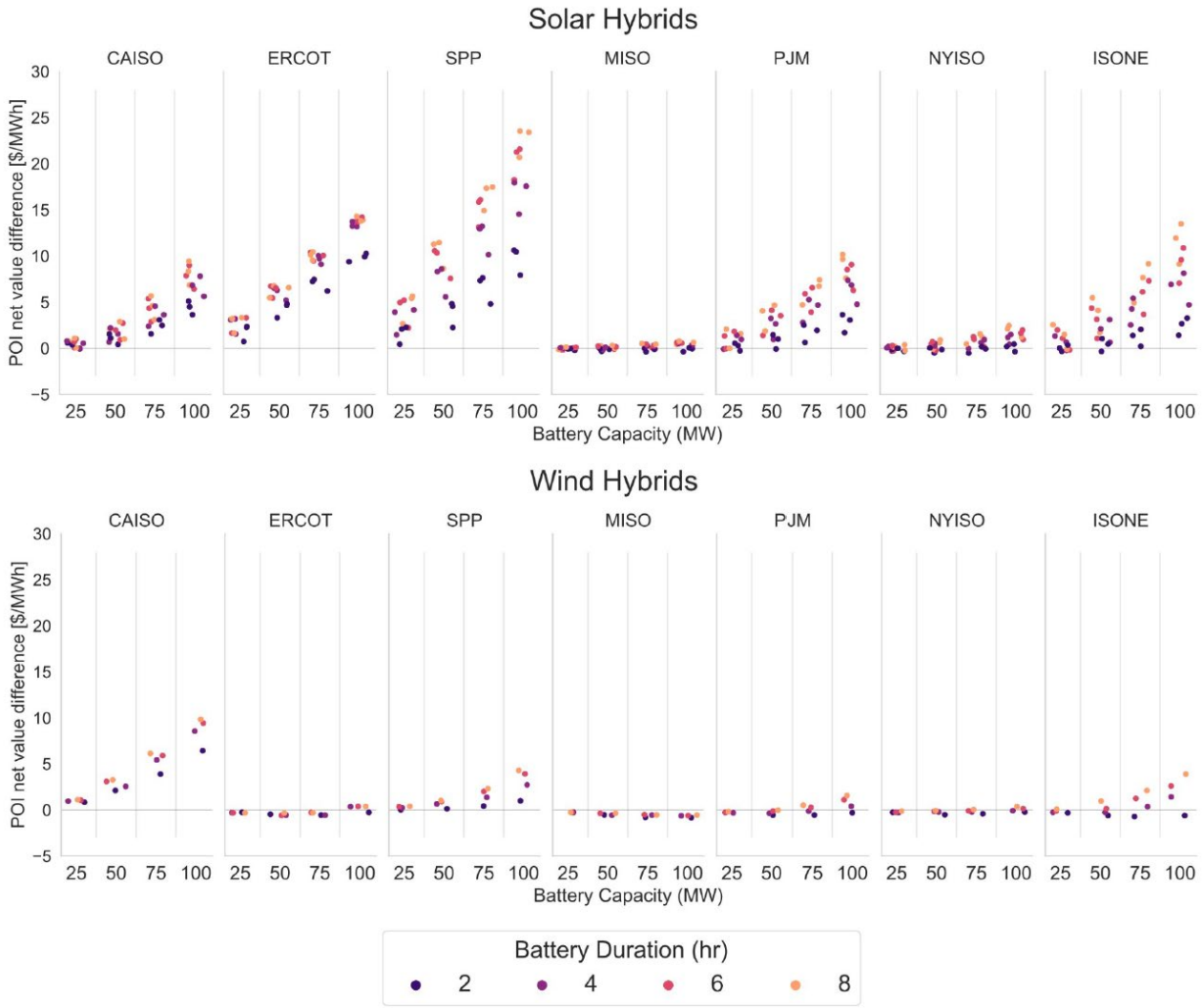
Hybrid configuration to retaining more value as market price changes with increasing renewables

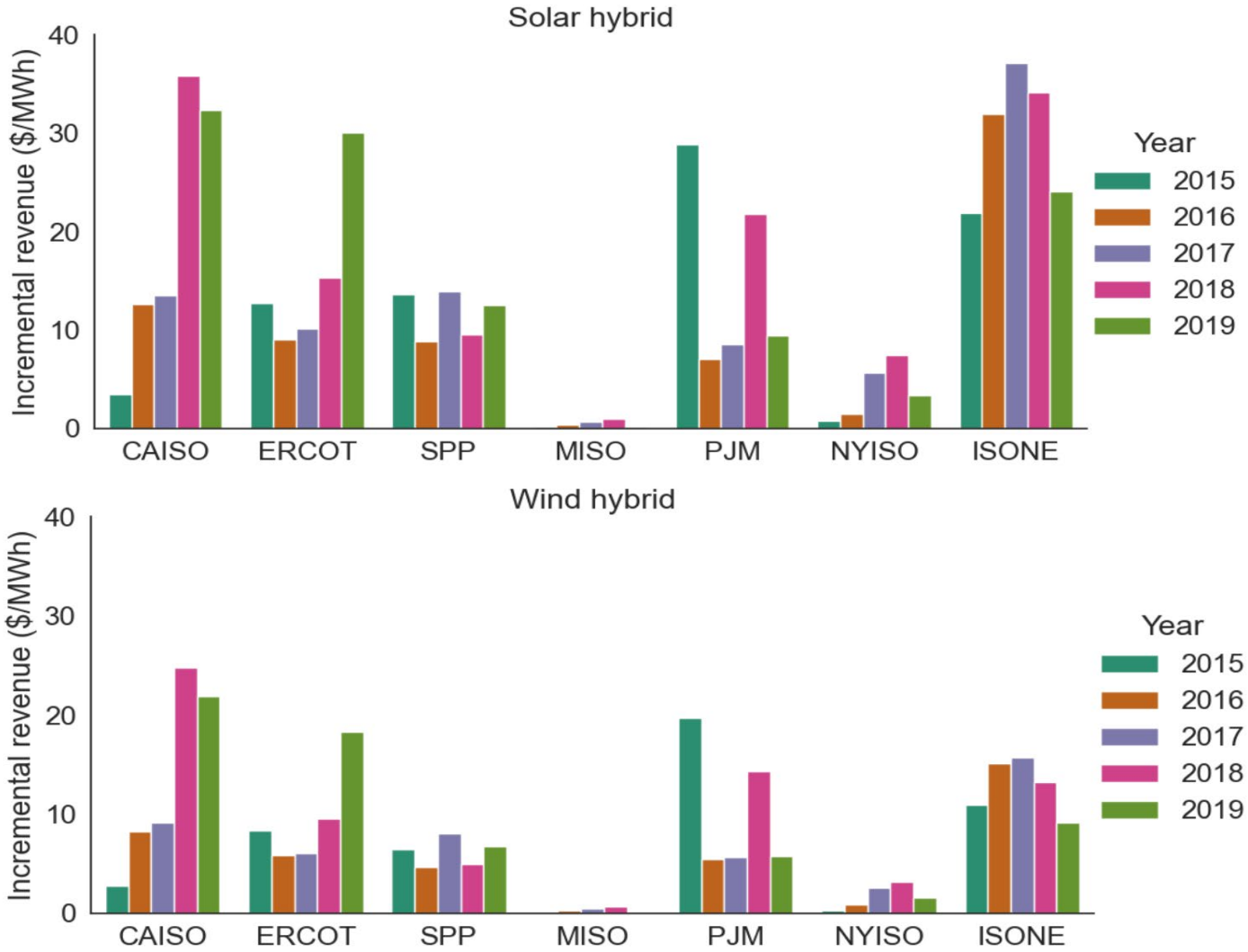
Storage duration and capacity have the largest impact on the net value of hybrids where highest net value have 2-hour duration storage



Net value often increases with sufficient interconnection capacity to discharge generator and storage; POI effect increase with larger storage capacity with longer storage duration



AS market participation to hybrid VRE resource owners secures additional value ($/MWh)



Science and technology policy to support value boosting hybrid configuration choices

Energy Earthshots Initiative aims to accelerate breakthroughs of more affordable and reliable clean energy solutions within the decade to quickly reach the goal of net-zero carbon emissions by 2050

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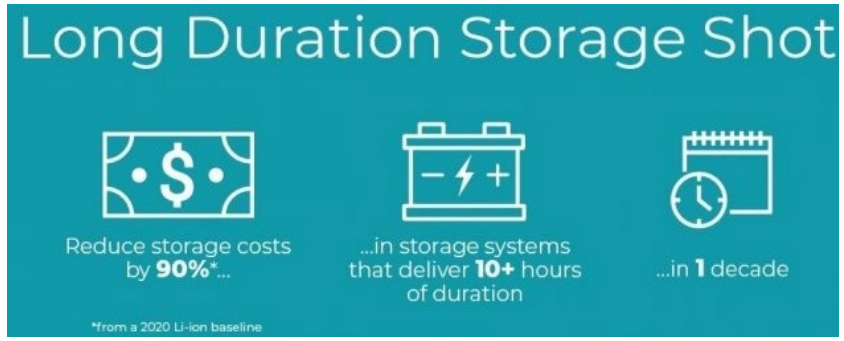

- Reduce the cost of grid-scale energy storage by 90% for systems that deliver 10+ hours of duration within the decade

ENERGY earthshots U.S. DEPARTMENT OF ENERGY

- Hydrogen Shot - reducing the cost by 80% by 2035
- Carbon Negative Shot - less than $100/net metric ton of CO2-equivalent.
- Enhanced Geothermal Shot - reduce the cost by 90%, to $45 per megawatt hour by 2035.
- Floating Offshore Wind Shot - driving down costs to $45 per megawatt hour by 2035
- Industrial Heat Shot - 85% lower greenhouse gas emissions by 2035

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