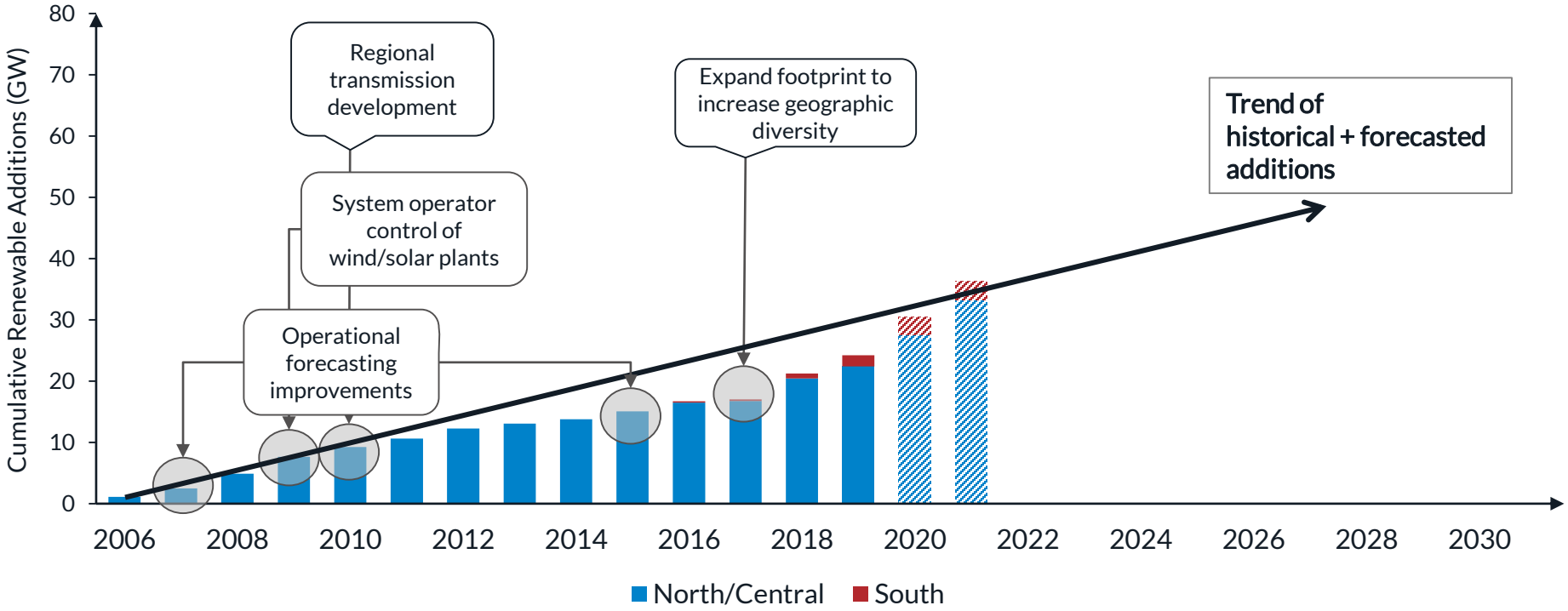
Renewable Integration Impact Assessment

Finding integration inflection points of increasing renewable energy

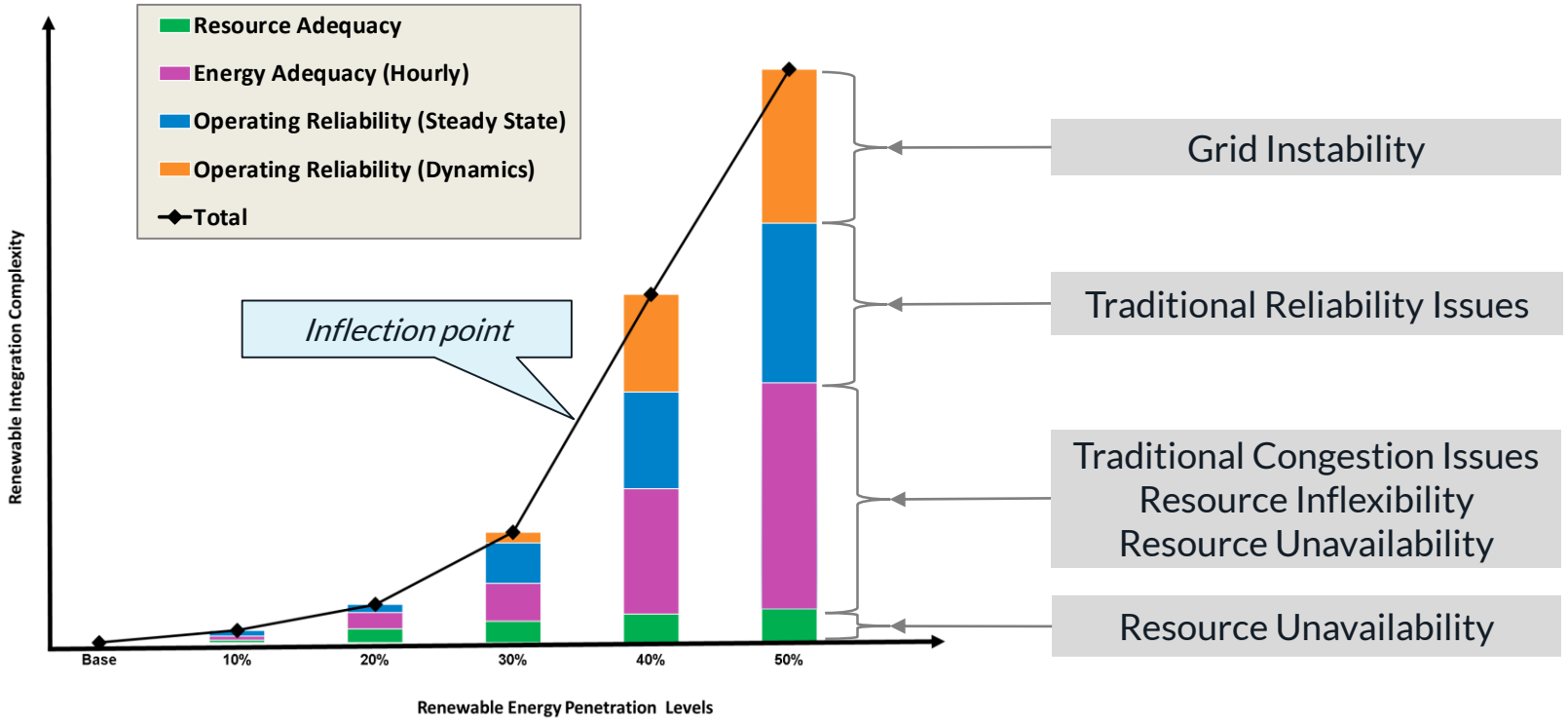
ESIG
May 21 , 2020

Renewable energy has posed challenges to the grid which the industry has successfully overcome

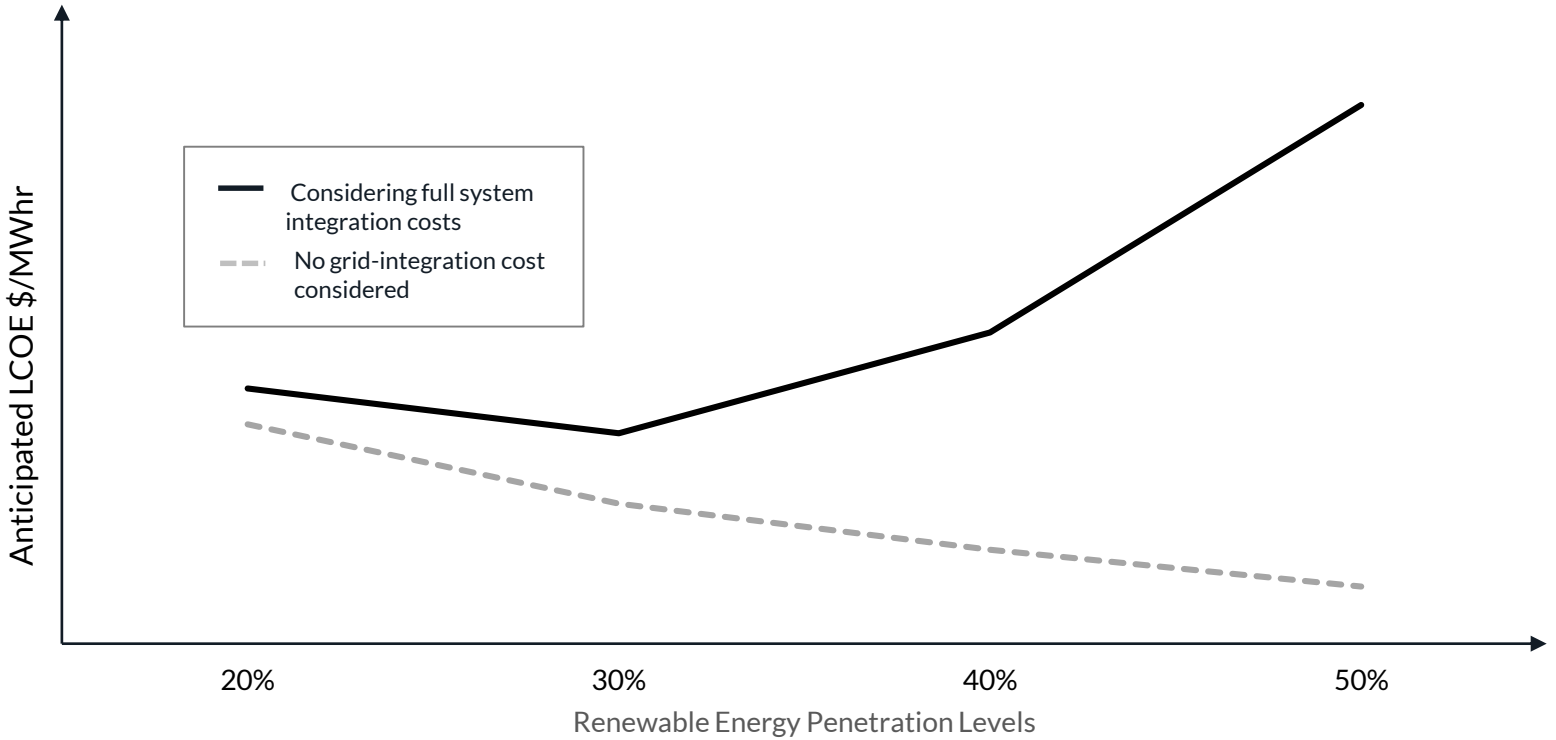


Historical queue additions + forecasted additions of 50% of DPP queue wind and solar capacity

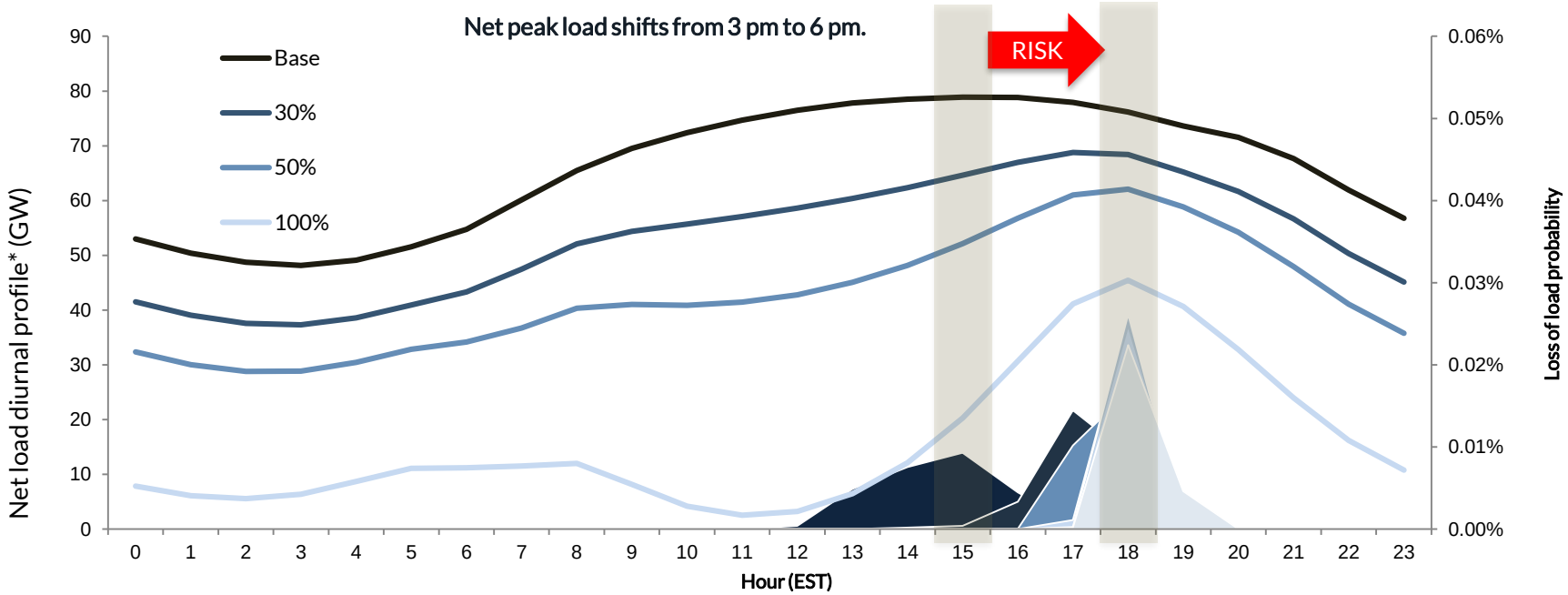
MISO's Renewable Integration Impact Assessment (RIIA) indicates system and operational complexity increase sharply beyond 30% renewable penetration



Increasing grid complexity using current technology assumptions negates the decreasing cost of renewables technology



As renewable penetration increases, the risk of losing load shifts and compresses to a smaller number of hours

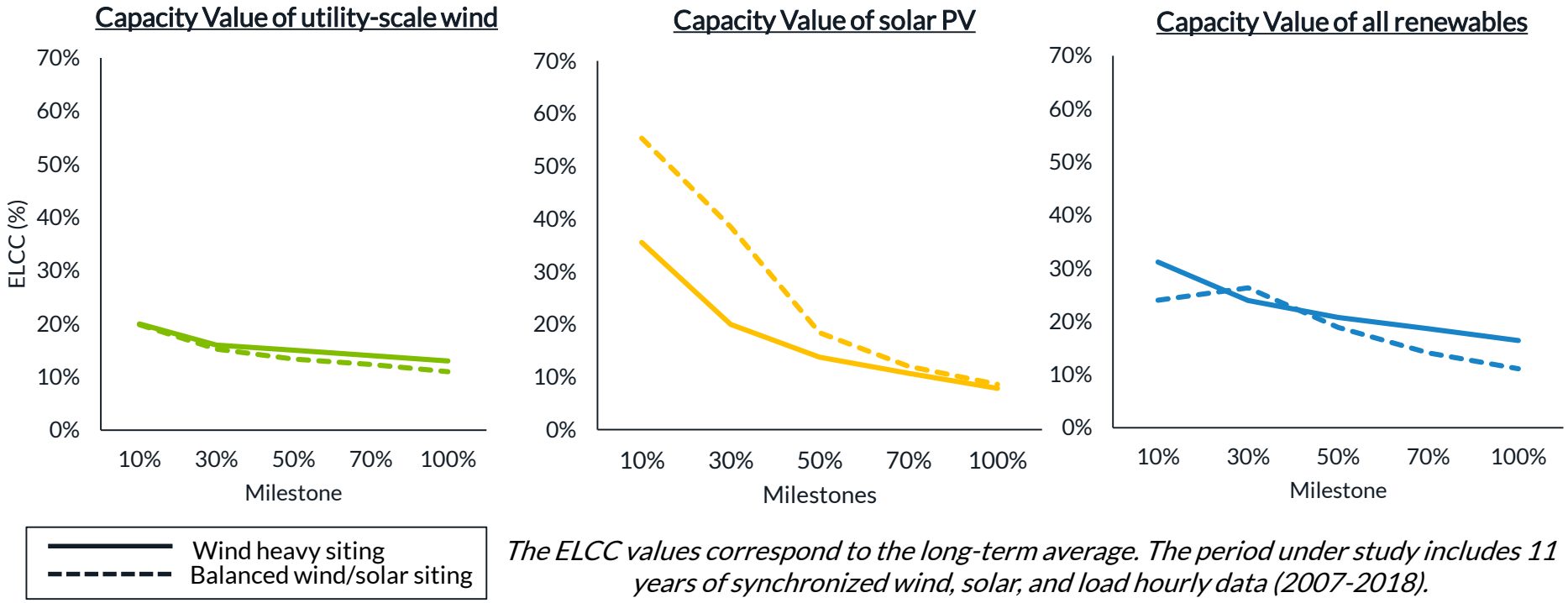


- Probability of losing load is targeted at one day in ten years over all penetration levels.
- While aggregate risk remains constant, the risk in specific hours increases.

LOLE = Loss of Load Expectation

**Profile shapes represent hourly averages across all days of the 6 study years.*

Wind and solar capacity value falls as a function of its penetration with the magnitude dependent on the siting and resource mix



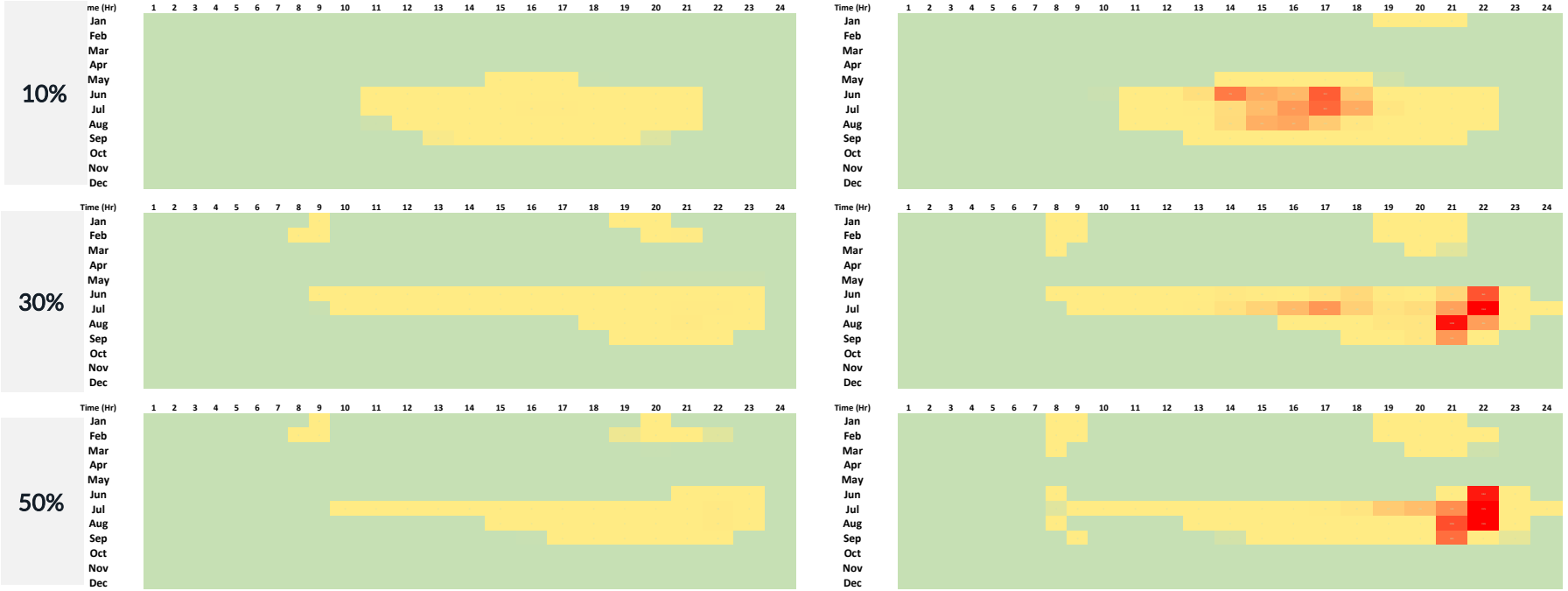
The ELCC values correspond to the long-term average. The period under study includes 11 years of synchronized wind, solar, and load hourly data (2007-2018).

*The ELCC values include both existing and new renewable generation units

The resource mix causes a seasonal shift towards winter and diurnal shift to the evening hours in the risk of serving load.

11-year Average Expected Unserved Energy

11-year Maximum Expected Unserved Energy

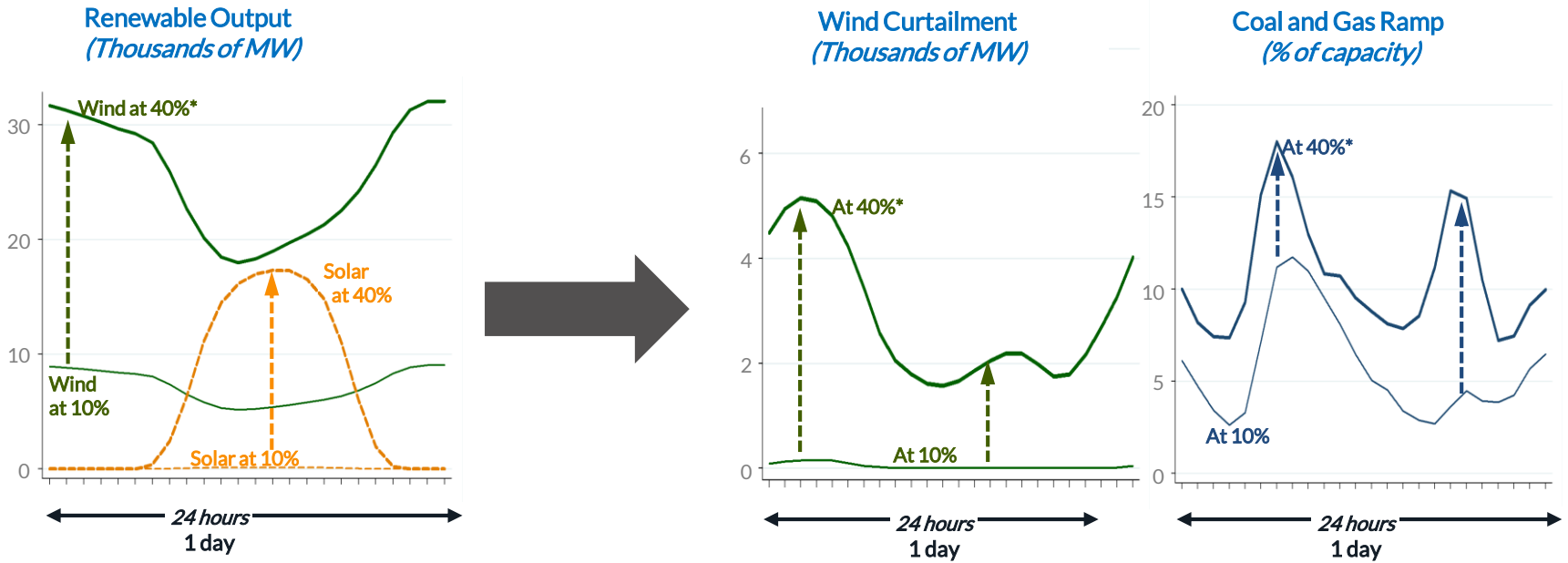


The heat maps illustrate EUE values, in MWh, from 11 years of synchronized wind, solar, and load hourly data. The period under study includes 2007-2018.

Increasing variability due to renewable generation will require generators to perform differently than today

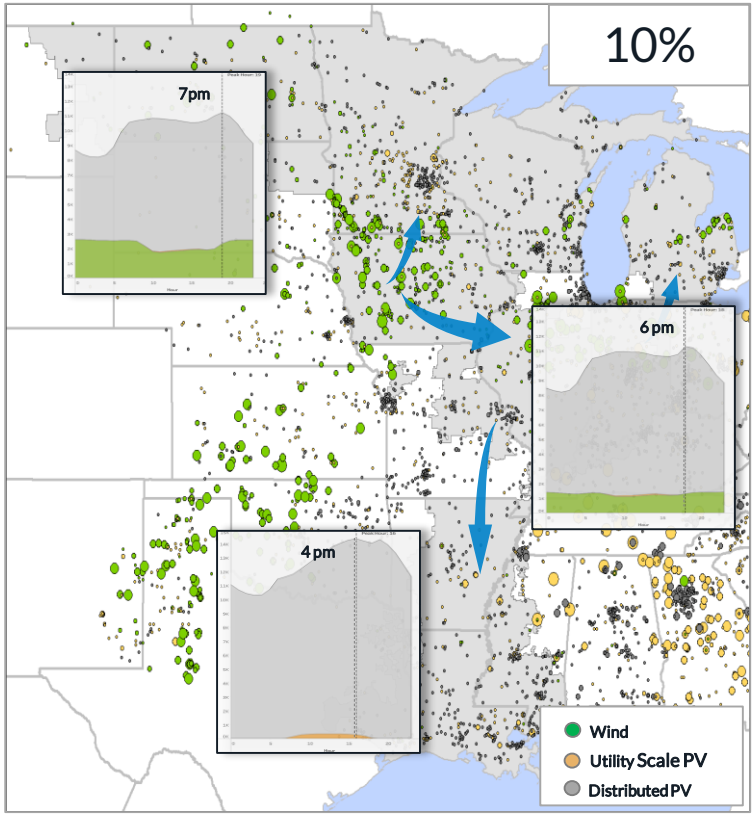
More hourly variability from renewables…

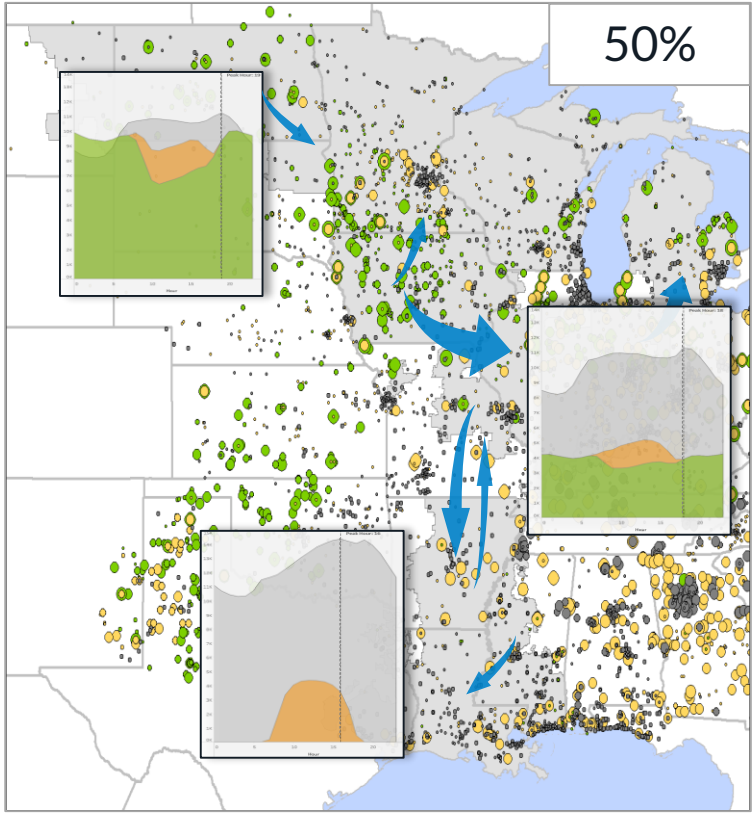
…requires increased flexibility (curtailments and ramp capability)



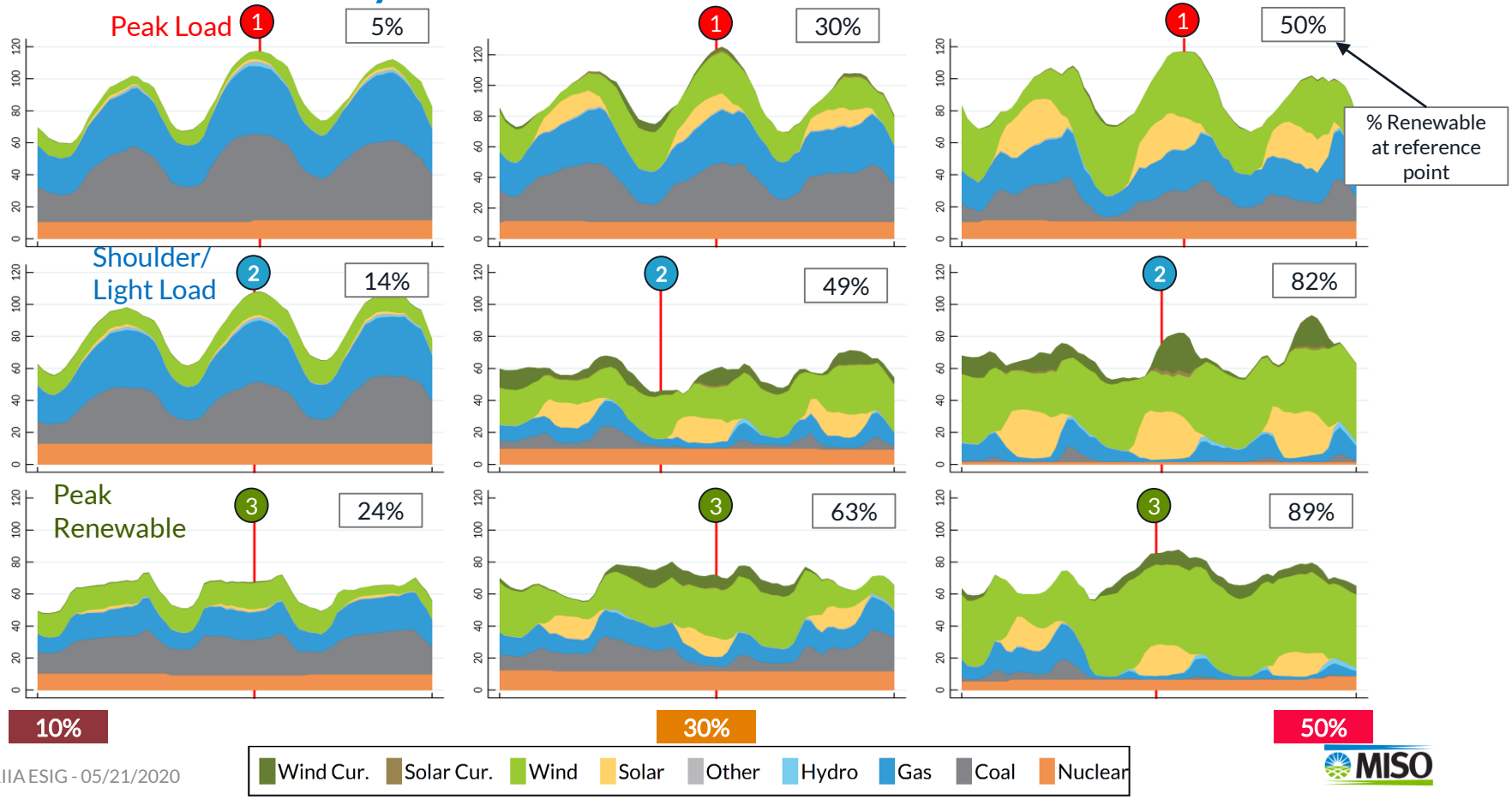
* All %'s in labels refer to MISO-wide renewable penetrations levels

An increasingly connected system is needed to balance renewable variability

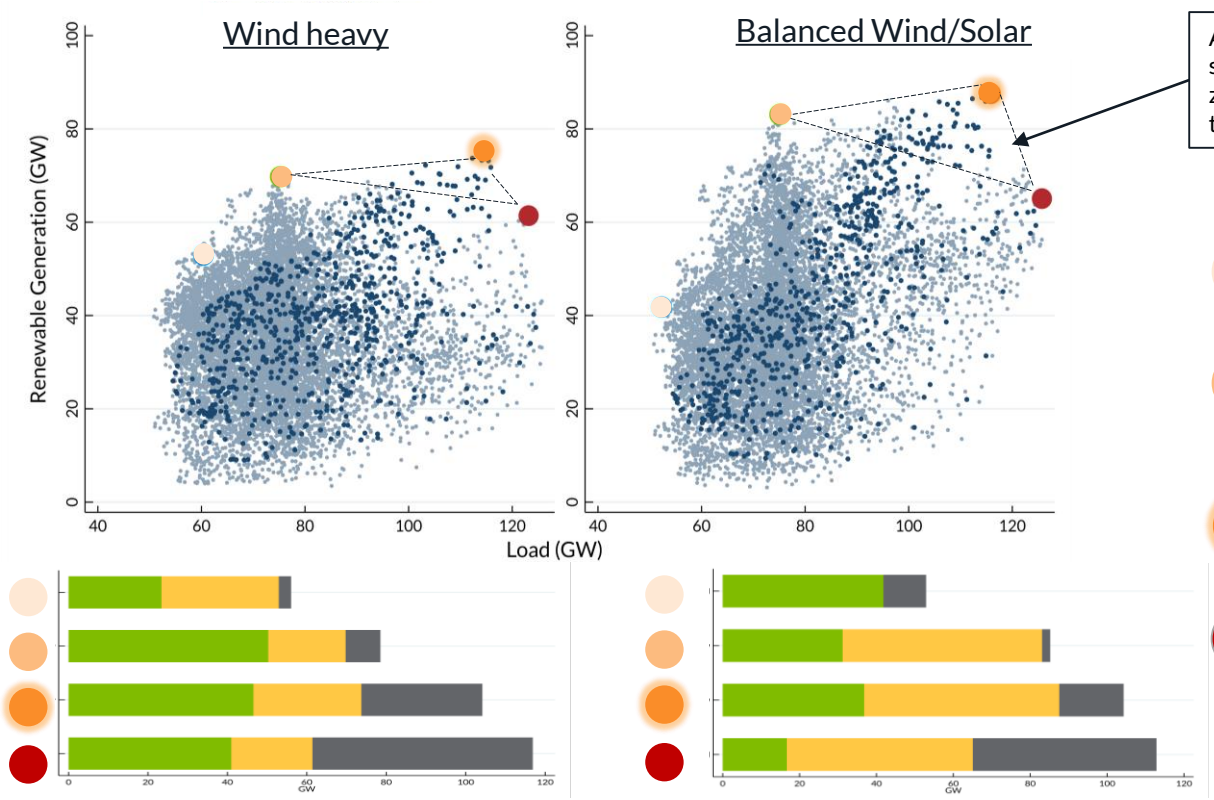




As renewable penetration increases, the change in fuel mix drives different reliability risks



Reliability risks are shifting to peak renewable conditions and low load conditions; predominantly in the spring and fall



As many more points enter the shoulder load, high renewable zone, a potential new stress point to be evaluated

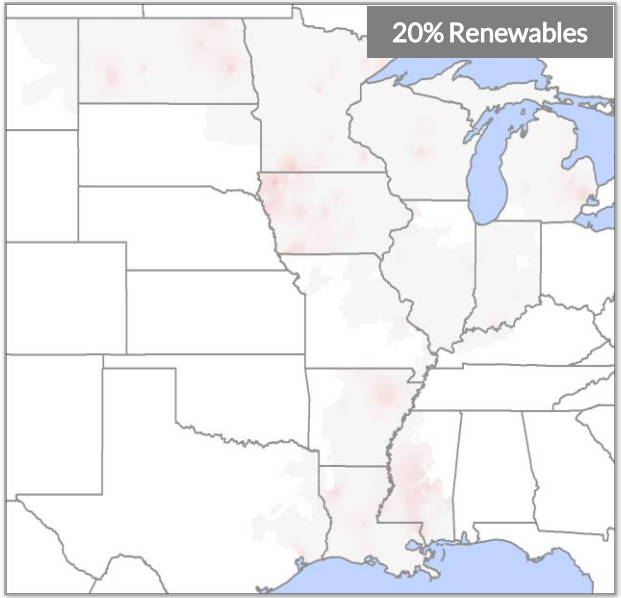
Lowest load hour in the top 20 renewable output

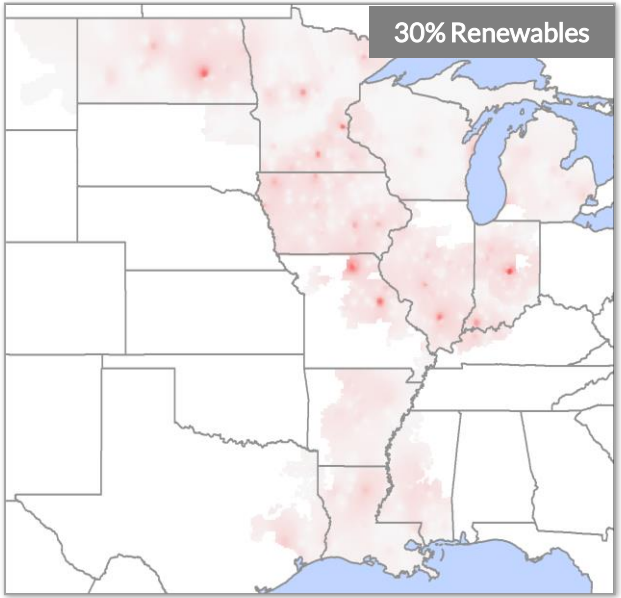
MISO highest renewable output in the lowest 20 load hours

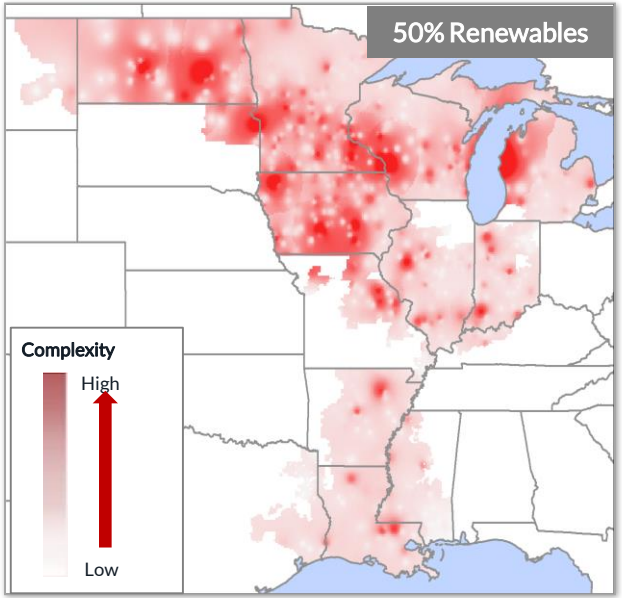
Shoulder load hour with highest renewable output

MISO Highest renewable hour in the top 20 load hours

Renewable integration complexity increases sharply beyond 30%, illustrating need for expansion of longer, higher kV, higher capacity transmission







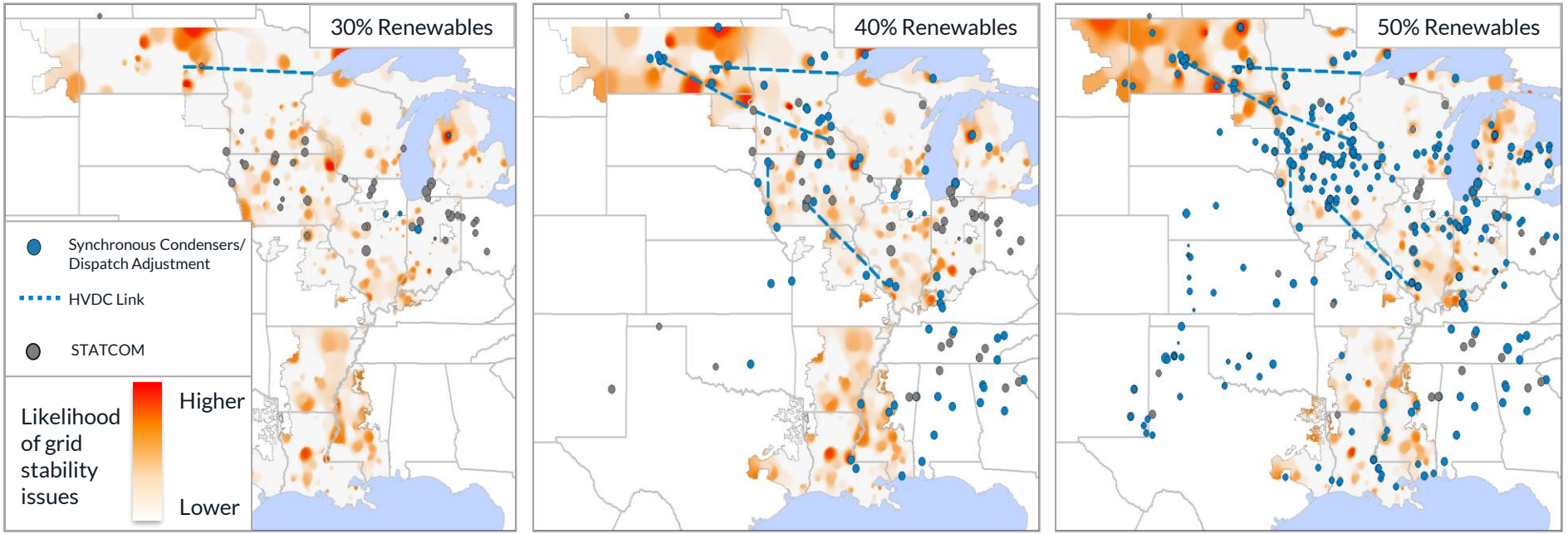
* Maps reflect cumulative indicative solutions across milestones

Incremental Transmission Mitigation at 10-20%			
kV	161 and Below	230	345 & above
Ckt*Mile	1,500	200	400

Incremental Transmission Mitigation at 30%				
kV	161 & Below	230	345 & above	HVDC
Ckt*Mile	1,600	200	500	400

Incremental Transmission Mitigation at 50%				
kV	161 & Below	230	345 & above	HVDC
Ckt*Mile	500	700	5000	600

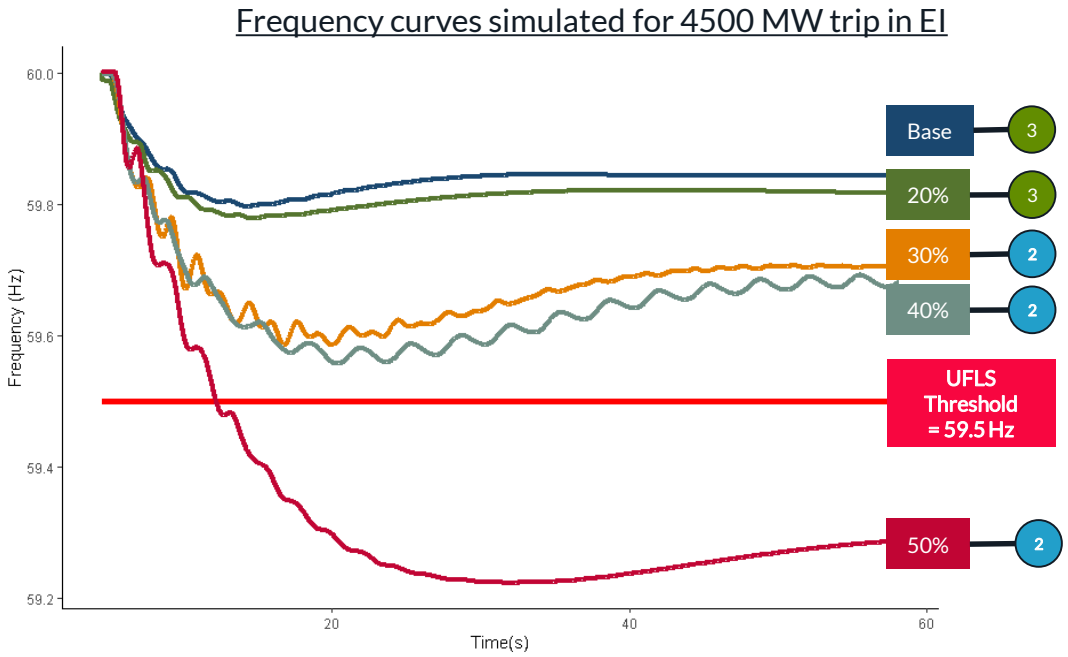
Beyond 30%, system-wide voltage stability is the main driver of dynamic complexity and requires transmission technologies equipped with dynamic-support capabilities



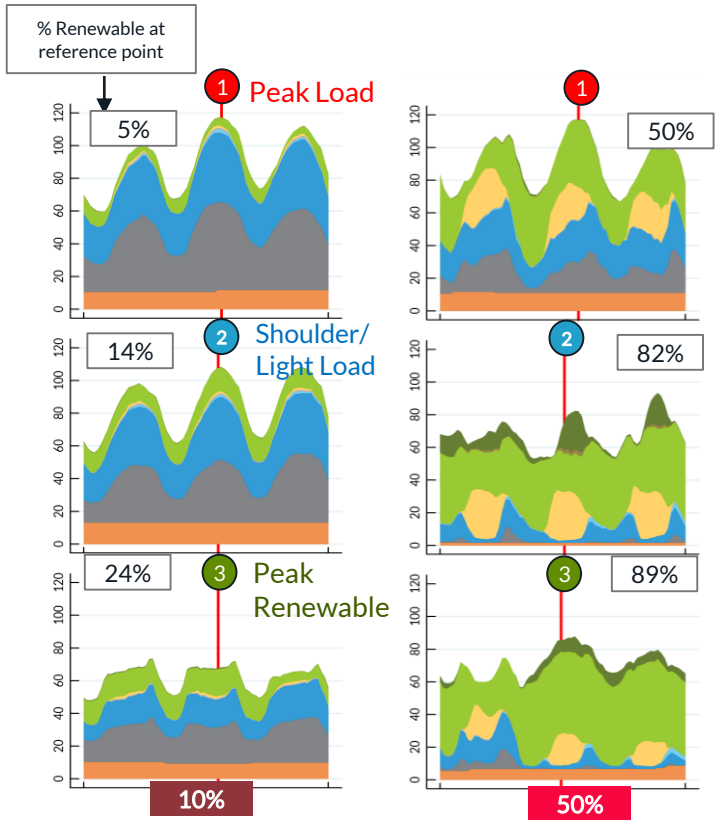
Improvement in wind and solar technologies can bring down the cost of integration

* Maps reflect cumulative indicative solutions across milestones

As renewable penetration increases, the change in fuel mix drives changing reliability risks; hours of high renewable penetration during low load become important for frequency stability



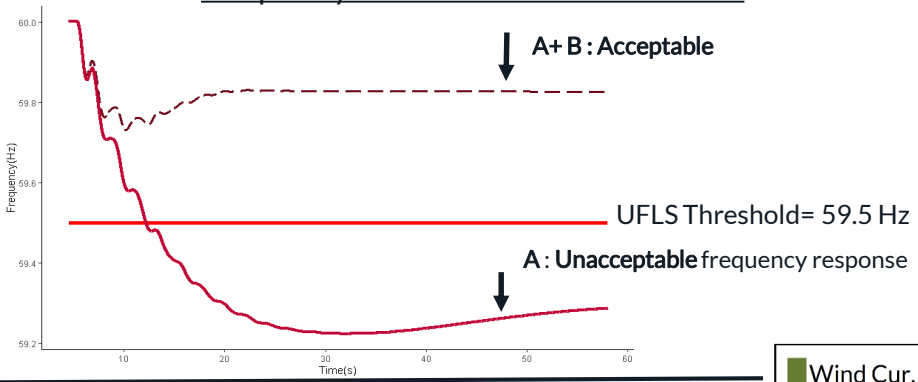
*No headroom assumed on renewable resources

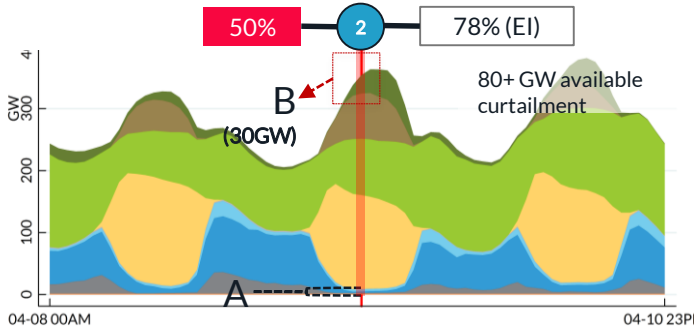


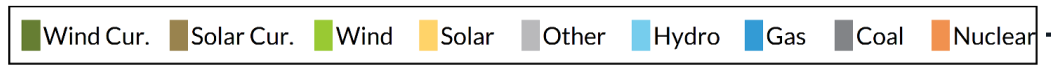
Wind Cur. Solar Cur. Wind Solar Other Hydro Gas Coal Nuclear

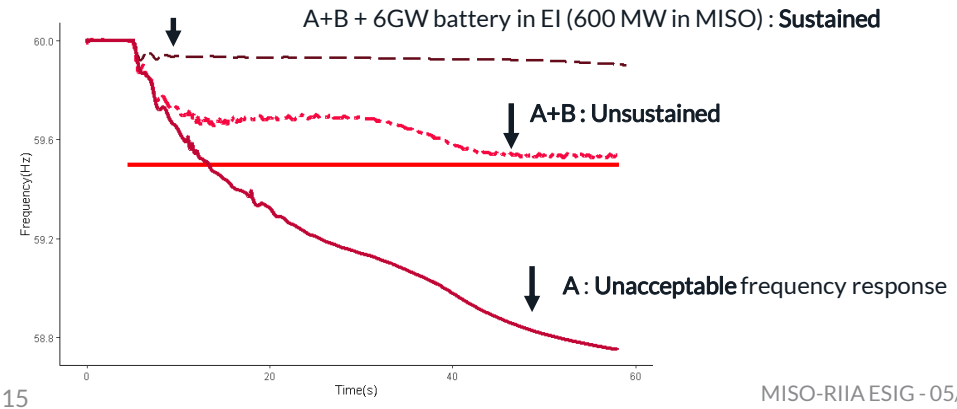
While online available curtailment may be utilized to mitigate frequency response issues at certain hours, battery storage may be needed to ensure sustained frequency response for some scenarios

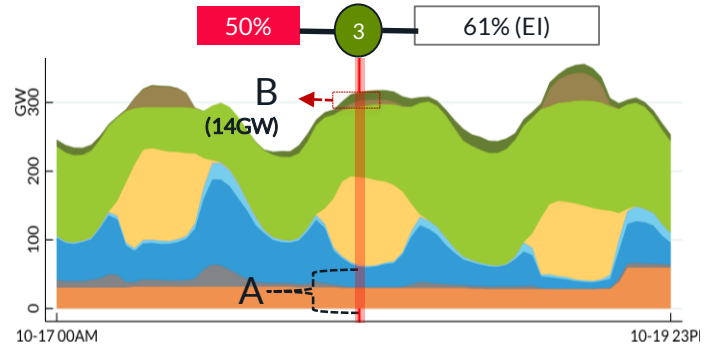
Frequency curve for loss of ~4500 MW



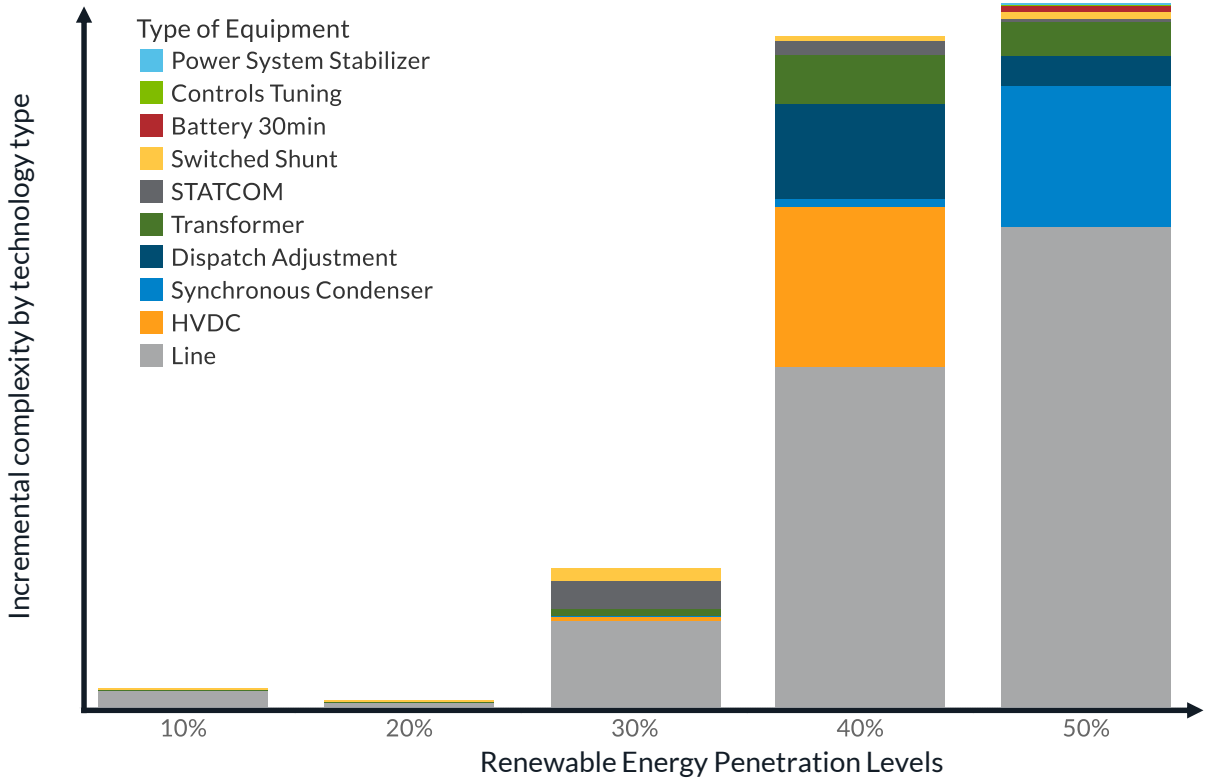








Grid-technology-needs evolve as renewable penetration increases leading to an increased need for integrated planning and a blend of transmission solution types



As an industry we can reduce the complexity needed to integrate higher levels of renewable energy

- Planning for the grid of the future needs to be more tightly integrated to account for a shifting risks throughout the system
- Target improvements to changing risks throughout the year
- Resources from a broader region need to be continually coordinated to serve load leading to a need for more visibility in all parts of the process
- Broad regional connections are needed not just for when things go wrong, but continually to balance variability and deliver energy
- New reliability metrics need to be incorporated into grid planning
- Innovation is needed to address grid stability issues

Questions?

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All RIIA-related documents can be found on MISO's web page.

Home > Planning > Policy Studies> Renewable Integration Impact Assessment