

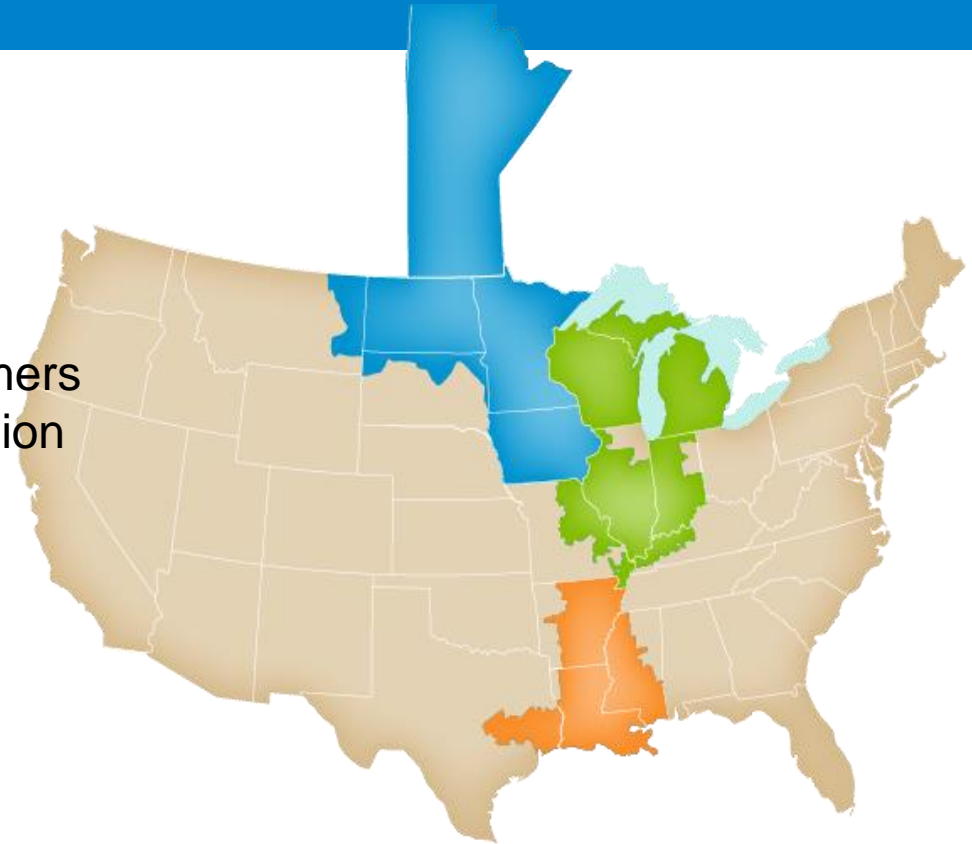


MISO, the Midwest, and Energy Storage

Midwest Energy Storage Summit
September 15, 2017

MISO's mission is to drive value creation through efficient reliability/market operations, planning and innovation

- **Footprint:**
 - 15 States
 - 1 Canadian Province
 - City of New Orleans
 - 42 million end-use customers
 - 65,800 miles of transmission
- **Generation Capacity:**
 - 175 GW (market)
 - 191 GW (reliability)
- **>170 Members**
- **>430 Market Participants**

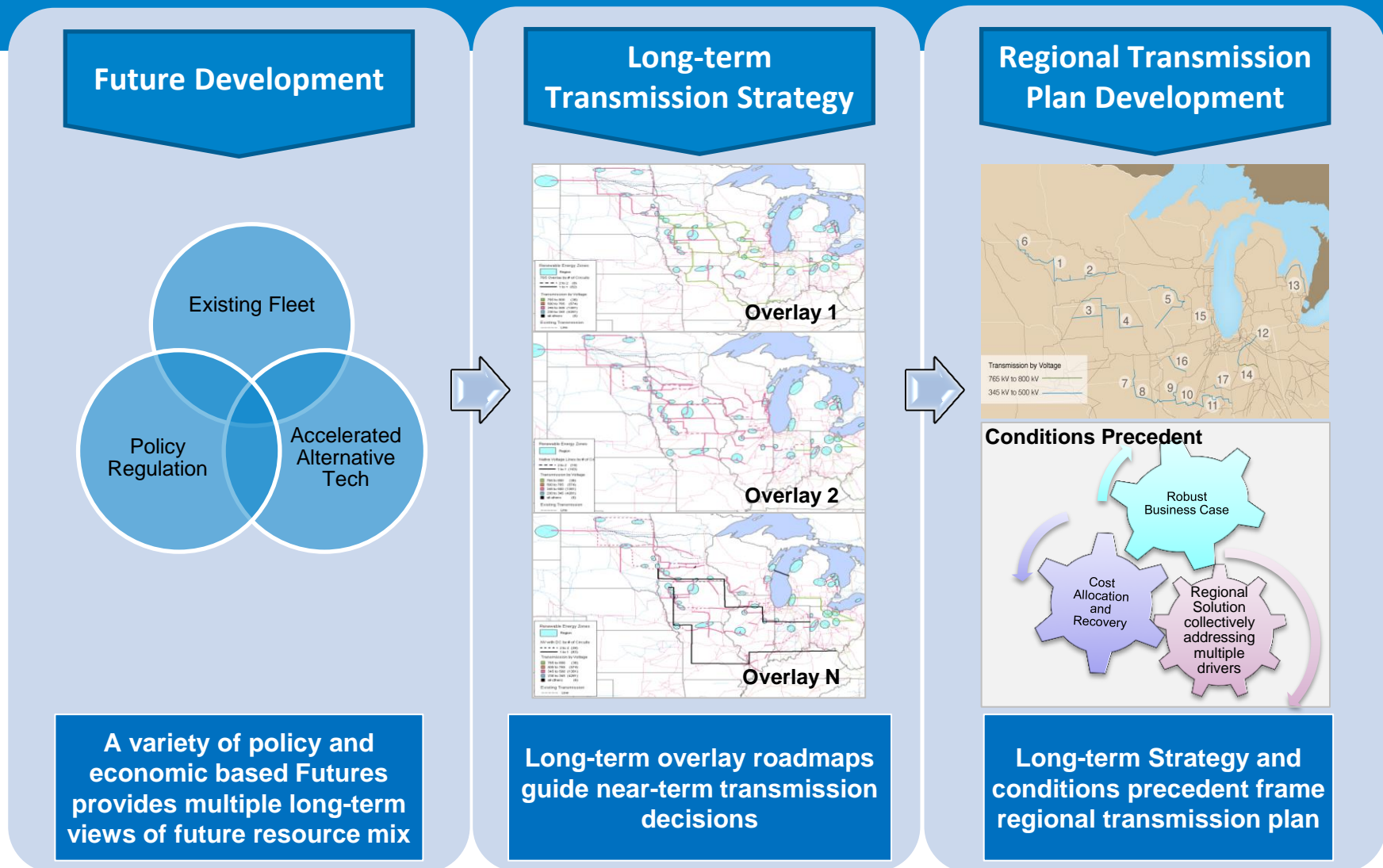


MISO is a “policy taker, not maker” a thought partner that provides independent assessment on policy choices

MISO follows Transmission Planning Guiding Principles to ensure reliability, support policy requirements, and enable a competitive market to benefit all customers

1. Make the benefits of an economically efficient electricity market available to customers by identifying transmission projects which provide access to electricity at the lowest total electric system cost
2. Develop a transmission plan that meets all applicable NERC and Transmission Owner planning criteria and safeguards local and regional reliability through identification of transmission projects to meet those needs
- 3. Support state and federal energy policy requirements by planning for access to a changing resource mix**
4. Provide an appropriate cost allocation mechanism that ensures that costs of transmission projects are allocated in a manner roughly commensurate with the projected benefits of those projects
- 5. Analyze system scenarios and make the results available to state and federal energy policy makers and other stakeholders to provide context to inform regarding choices**
6. Coordinate planning processes with neighbors and work to eliminate barriers to reliable and efficient operations

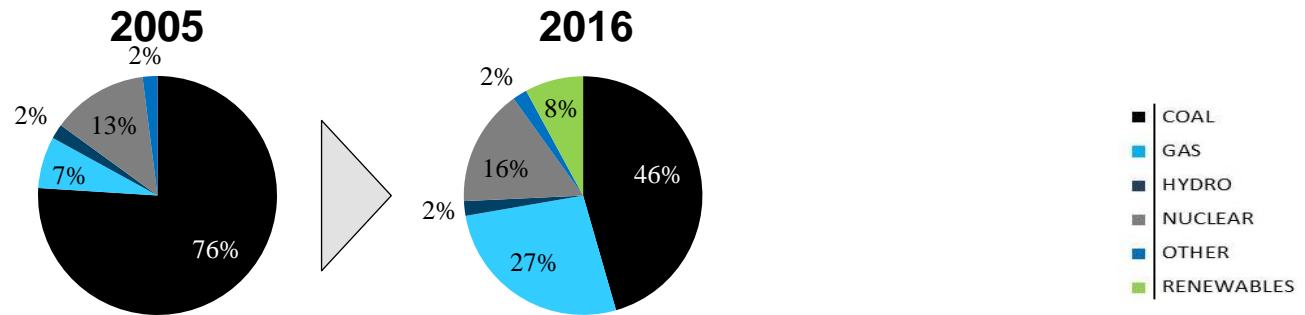
MISO's long-term planning process is designed to identify the most robust transmission plan across future scenarios



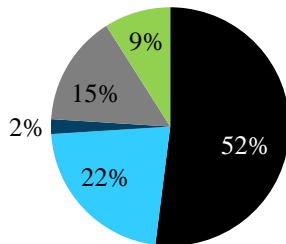
The graphics are for illustrative purposes ONLY

MISO generation fleet is evolving with projected increases in renewables and gas-fired generation

MISO Generation Portfolio Evolution



2031 Future Scenarios



Existing Fleet

No carbon regulations modeled but some reductions expected due to RPS and economics.

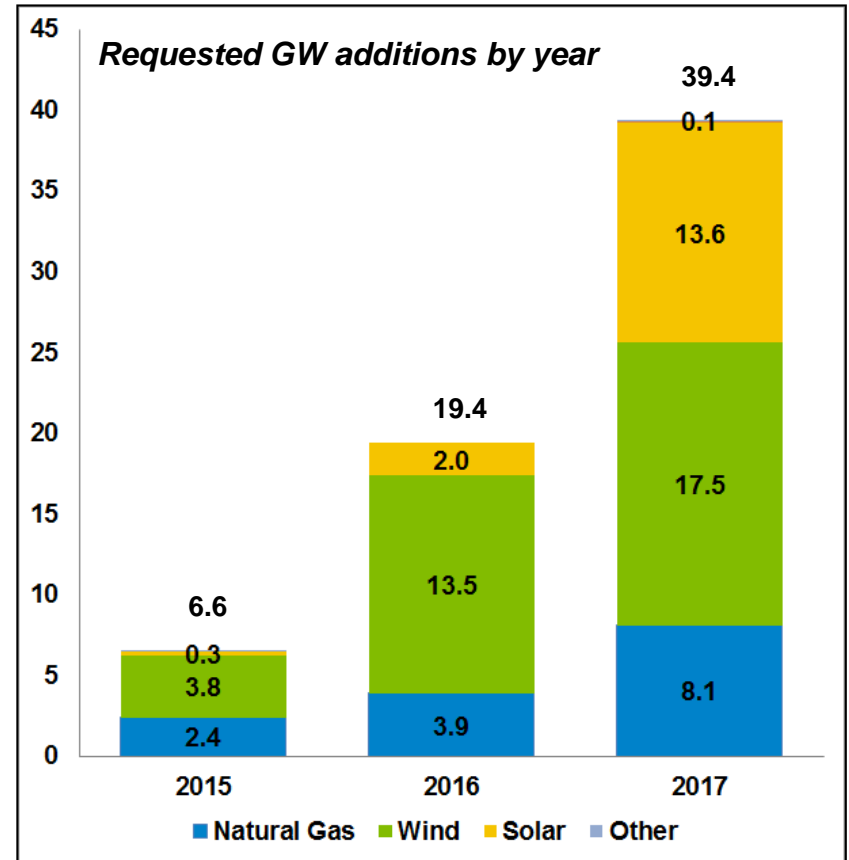
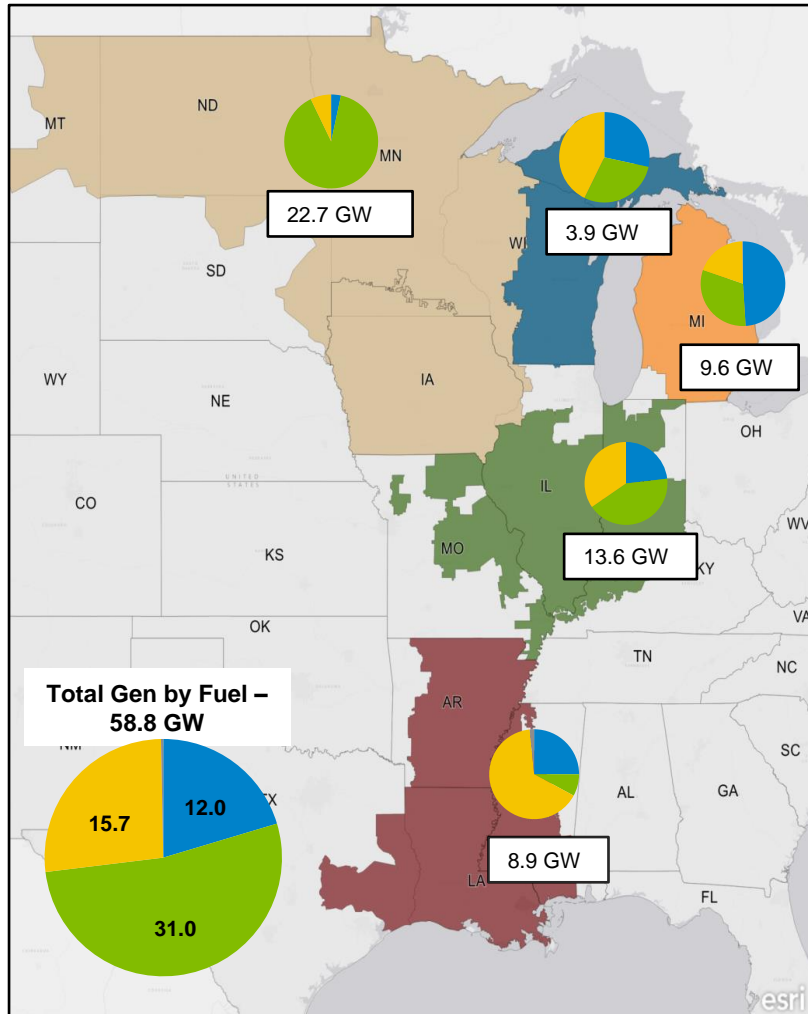
Policy Regulation

Carbon regulations targeting a 25% reduction across all aggregated unit outputs are enacted.

Accelerated Technology

Increase in carbon emissions results in carbon regulations targeting a 35% reduction across all aggregated unit outputs to be enacted.

MISO's Interconnection Queue requests are dominated by wind and solar which are projected to increase



140 MW of battery storage is requesting interconnection, Markets serve as the integrator of the changing system.

Storage is converting energy to potential energy for use at a later time

Many types of energy storage systems exist each with different economics and capabilities:

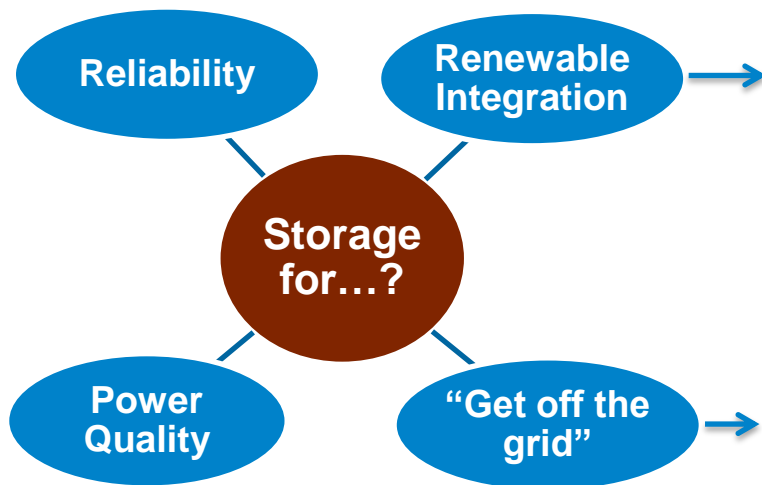
- Short term storage - flywheels, batteries, fuel cells, compressed air
- Longer term storage – hydro, coal pile, linepack gas, nuclear fuel

The grid functions as an energy storage system

- Instantaneously use all intermittent energy and defer production from controllable resources

Policy decisions around storage must factor in both the purpose and the costs

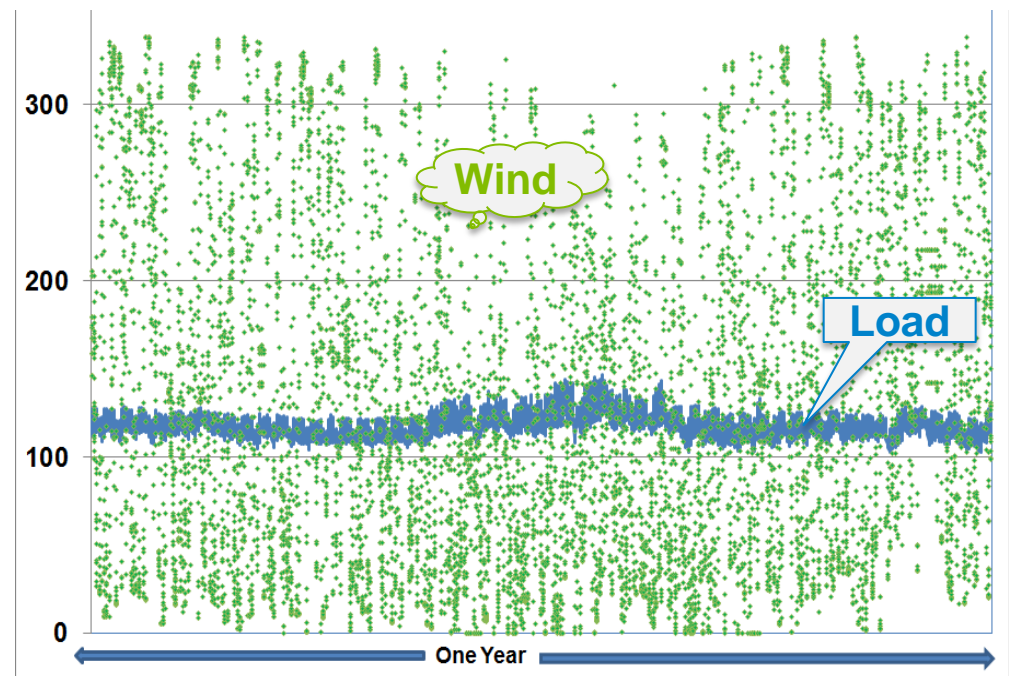
Purpose of Storage....



An Illustrative Example:

150 MW utility with 1,000 GWh annual energy wants to become 100% renewable (self-generation)

Units = MW of hourly **load** and **wind generation**

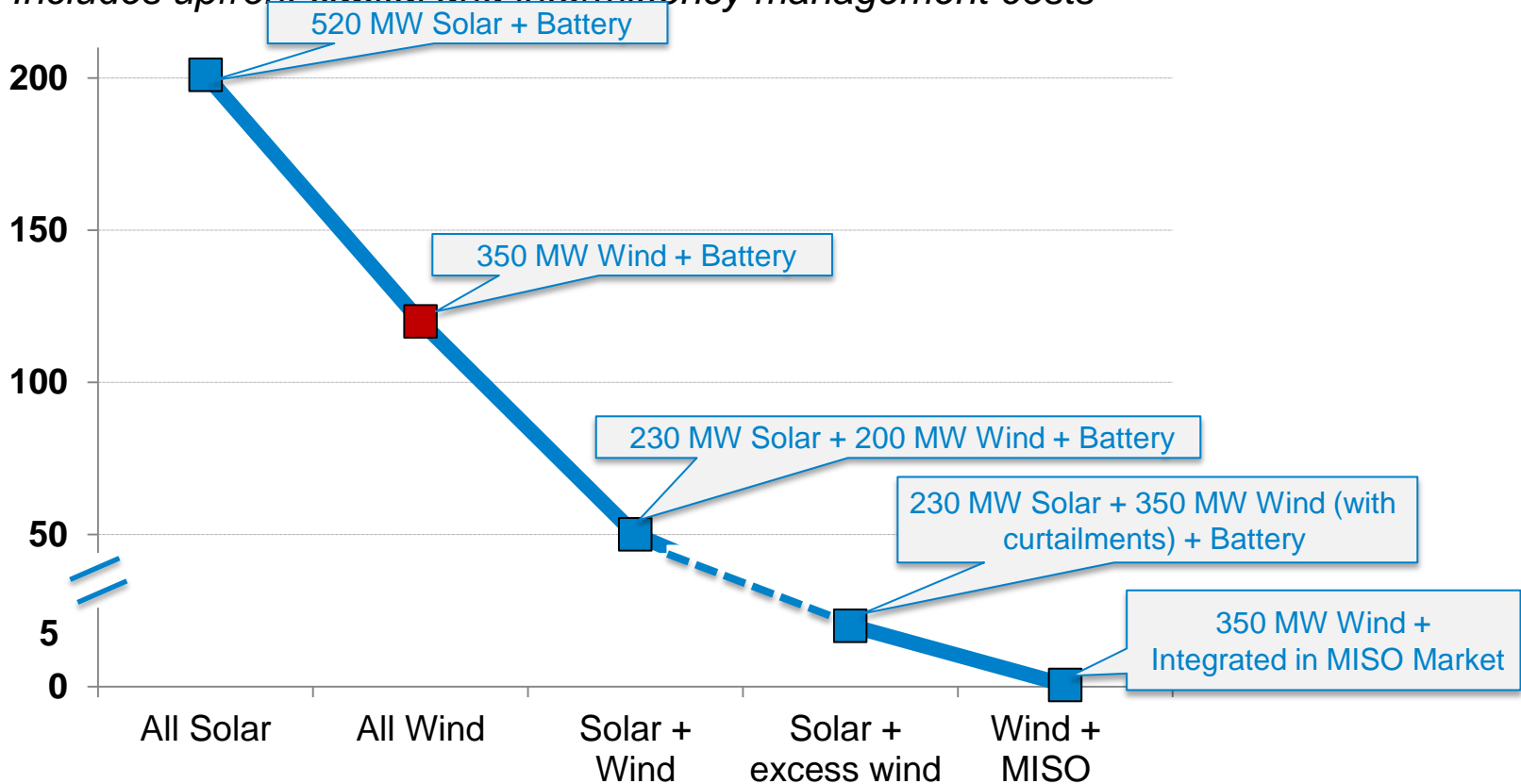


....renewable generation does not align with load

Are batteries the most cost effective storage mechanism to increase renewable penetration?

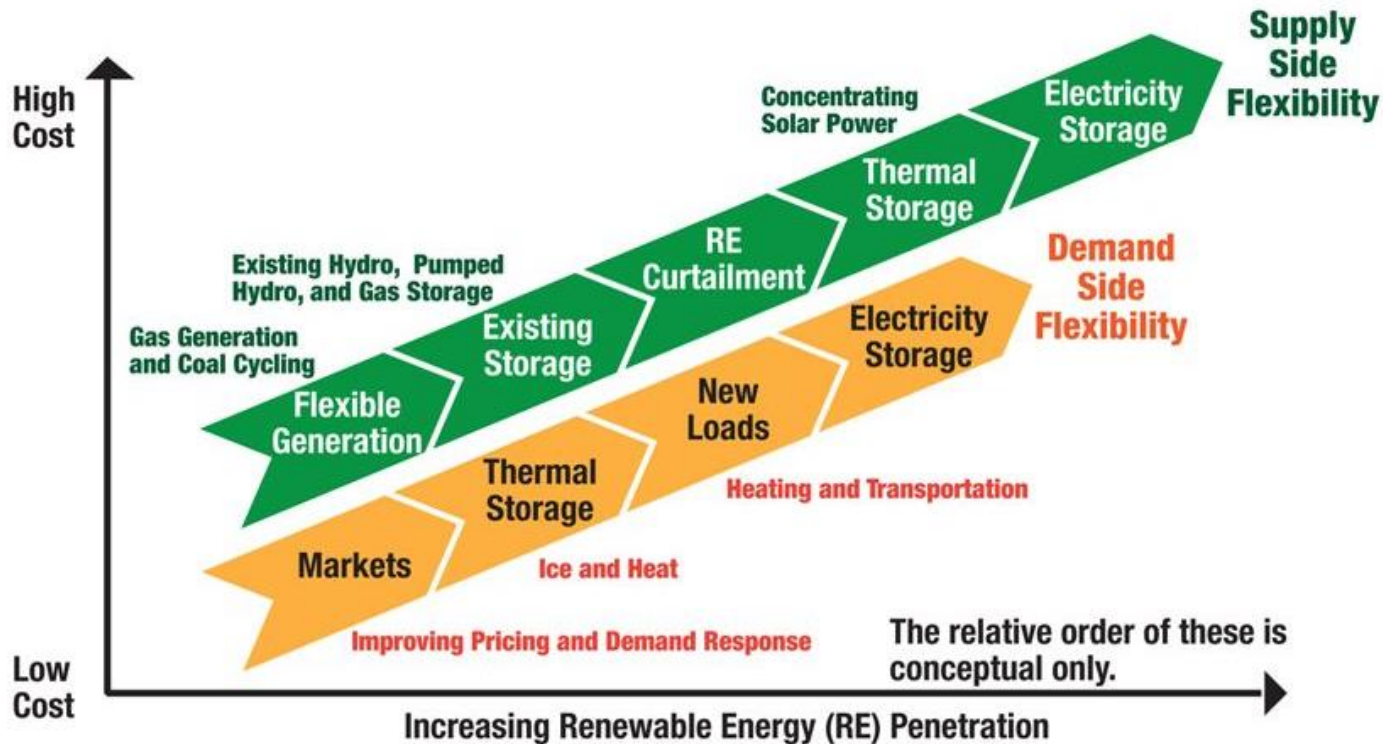
Total System Costs in Billions of Dollars

*Includes upfront capital and intermittency management costs**



Higher levels of renewable grid penetration can be achieved at low cost...

Existing resources are capable of operating flexibly to manage renewable intermittency



The grid has proven to be a technology enabler – wind, solar...storage

MISO is collaborating with stakeholders to develop strategies to enable storage resources on the grid

- MISO formed a stakeholder task force to prioritize and address storage initiatives
 - Review of energy storage categories/types
 - Continuing work on AGC enhancement for fast-ramping resources
- MISO launched a Renewable Integration Impact Assessment
- FERC is likely to issue a Final Rule with requirements and offer guidance on energy storage and distributed energy resources

