MISO MARKET SYMPOSIUM

Energy Markets Turned Inside Out:
Exploring Innovation for a Changing World
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Storage session at GIZ/USAID/NREL Workshop on Integration of Variable RE - Asia Clean Energy Forum 2016

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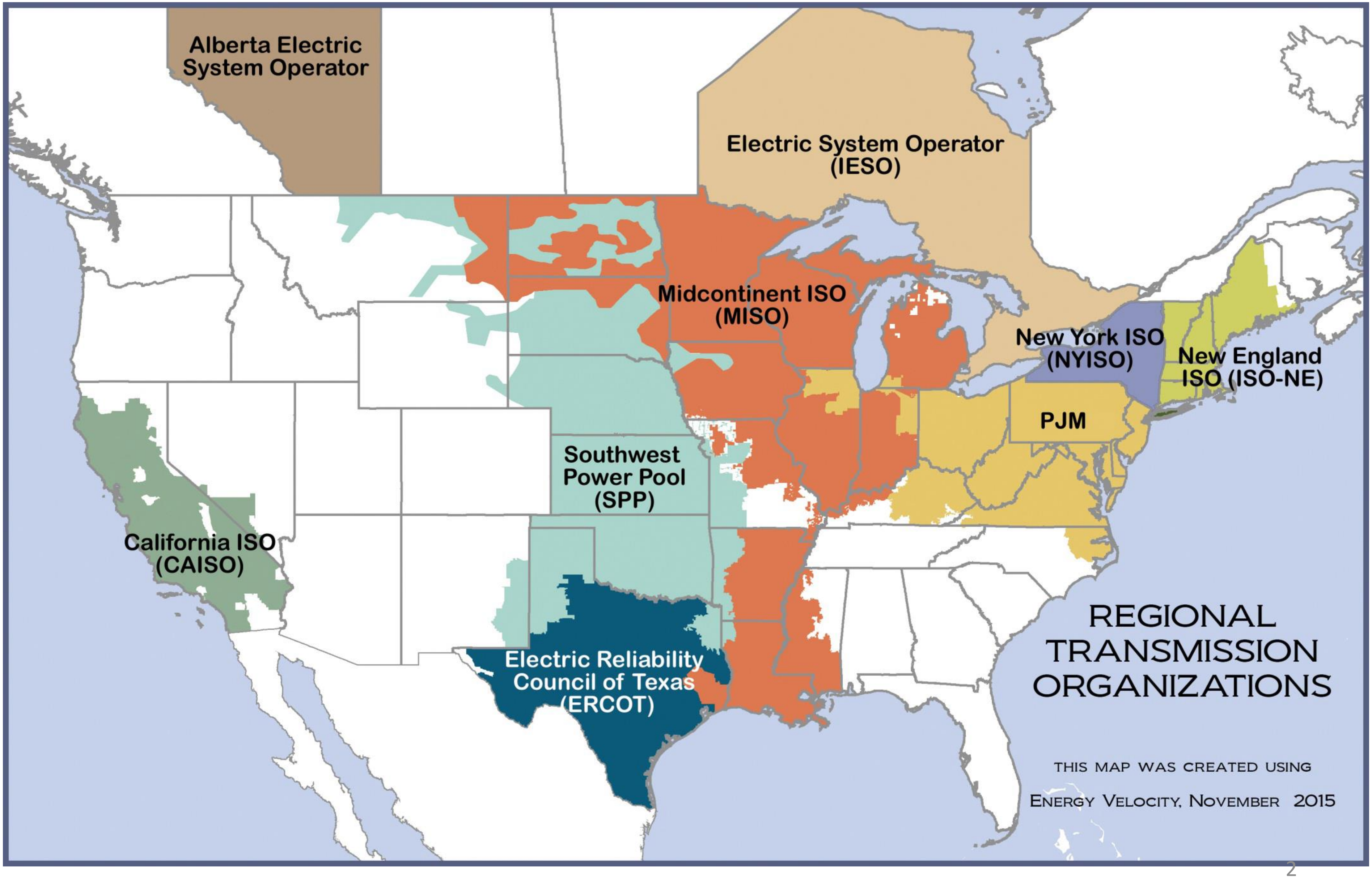
Disclaimer – These are my views, not necessarily MISO's views.

Independent System Operator (ISO)/Regional Transmission Organization (RTO) in North America



(Source - http://www.ferc.gov/industries/electric/indus-act/rto.asp)

Status of use of electricity storages:

Who has installed storages for what purpose, 3-4 examples around the world

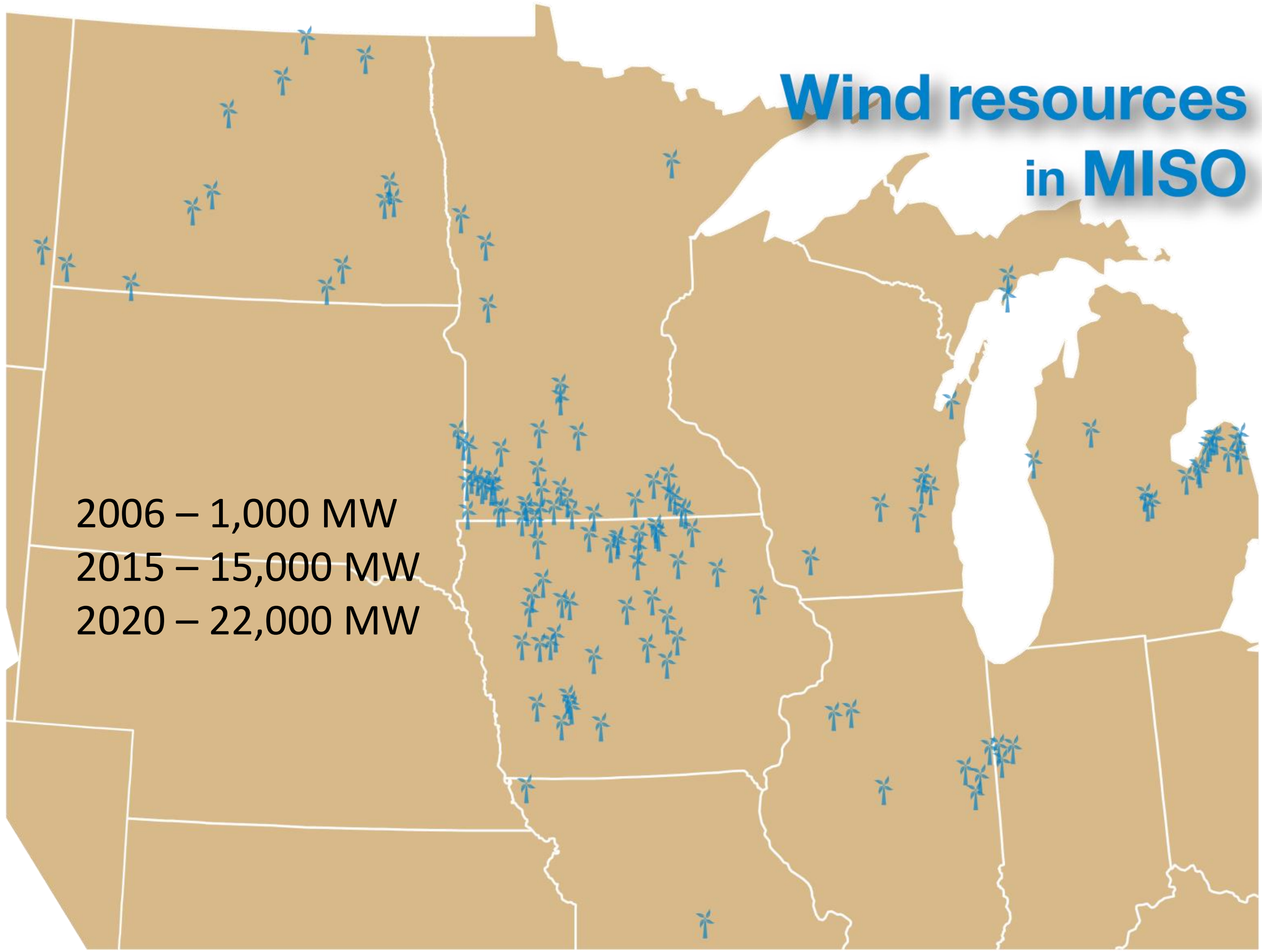
Metric	Size
Total ISO/RTO storage MWs	29,738 MW
PJM total	6,730 MW
CAISO total	6,601 MW
MISO total	2,398 MW
ISO-NE total	1,757 MW
NYISO total	1,463 MW
ERCOT total	485 MW
SPP total	265 MW

Metric at MISO	Size
Open-loop Pumped Hydro Storage	2,370 MW
Lithium-ion Battery	21 MW
Ice Thermal Storage	4.950 MW
Sodium-sulfur Battery	1.000 MW
Flywheel	0.860 MW
Advanced Lead-acid Battery	0.750 MW
Lead-acid Battery	0.297 MW
Lithium Ion Titanate Battery	0.075 MW

Electricity Storage definition – this slide includes pumped storage includes both behind the meter, and In front of the meter. Source – DOE Energy Storage database

Key Takeaways of Today's Discussion

- MISO endeavors to create markets based on services to support the grid not specific assets
- Storage must compete with conventional assets to provide these services
- MISO is going through a process to better accommodate energy storage



Source – MISO Communications Department

Status of use of electricity storages:

Who has installed storages for what purpose, at MISO? - Only about 1.8 MW of energy storage has been driven by renewable integration so far

Metric – 97% is utility owned	Size (kilo Watts)
Consumers Energy	1,872,000
Ameren	440,000
(blank)	63,825
Indianapolis Power & Light	20,000
Detroit Edison Energy	1,750
Xcel Energy	1,000
REC's: Minnesota Valley, Wright-Hennepin, Meeker, Federated	115
Rural Electric Cooperative	94
Duke Energy	75
Austin Utilities	37
Wright-Hennepin Cooperative Electric Association	37

Application	Storage in kW
Electric Energy Time Shift	2,370,214
Electric Supply Reserve Capacity - Spinning	20,860
Electric Bill Management	5,024
Renewables Energy Time Shift	1,000
Renewables Capacity Firming	759
Electric Bill Management with Renewables	575
Onsite Renewable Generation Shifting	500
On-Site Power	15

Status of use of electricity storages:

Who has installed storages for what purpose, 3-4 examples at CAISO?

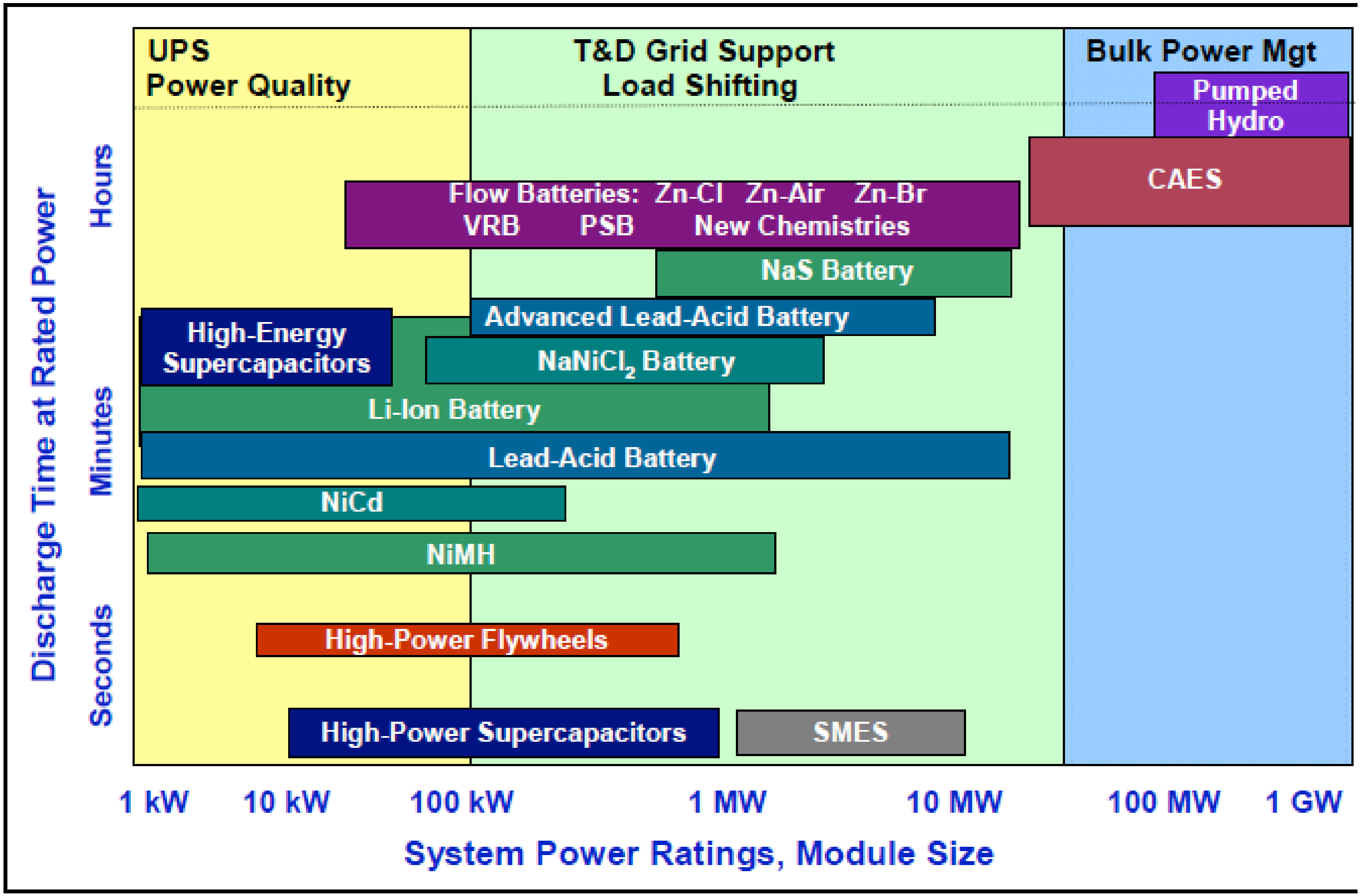
Application	Storage in kW
Electric Energy Time Shift	3,206,792
Electric Supply Capacity	1,228,700
Load Following (Tertiary Balancing)	1,212,525
Grid-Connected Commercial (Reliability & Quality)	505,505
Renewables Capacity Firming	150,434
Electric Bill Management	144,850
Electric Supply Reserve Capacity - Spinning	53,510
Distribution upgrade due to solar	30,077
Distribution upgrade due to wind	30,000
Stationary Transmission/Distribution Upgrade Deferral	15,400
Microgrid Capability	6,960
Electric Bill Management with Renewables	4,676

Application	Storage in kW
Frequency Regulation	4,464
Transportation Services	2,115
Renewables Energy Time Shift	2,095
Onsite Renewable Generation Shifting	1,746
Demand Response	600
Black Start	505
Electric Supply Reserve Capacity - Non-Spinning	400
On-Site Power	215
Grid-Connected Residential (Reliability)	124

Stacking Storage Value Stream – Illustrative only
MISO endeavors to create markets based on services to support the grid not specific assets

Value Stream	Application	Size (MWs)	Market Size ($)
Energy market	LMP price differentials		
Ancillary market	Regulation MWs	400	$ 2,800
	Ramping capability		$ -
Capacity market	Module E capacity credit in planning year	20	$ 900,000
Transmission planning	MISO approved transmission listing		$ -
	System Support Resource deferral		$ -
	Interconnection queue (direct)		$ -
	Subset of queue ie solar, wind		$ -
Distribution side	Distribution system upgrades, deferrals, substations		

When do we need these different storages?



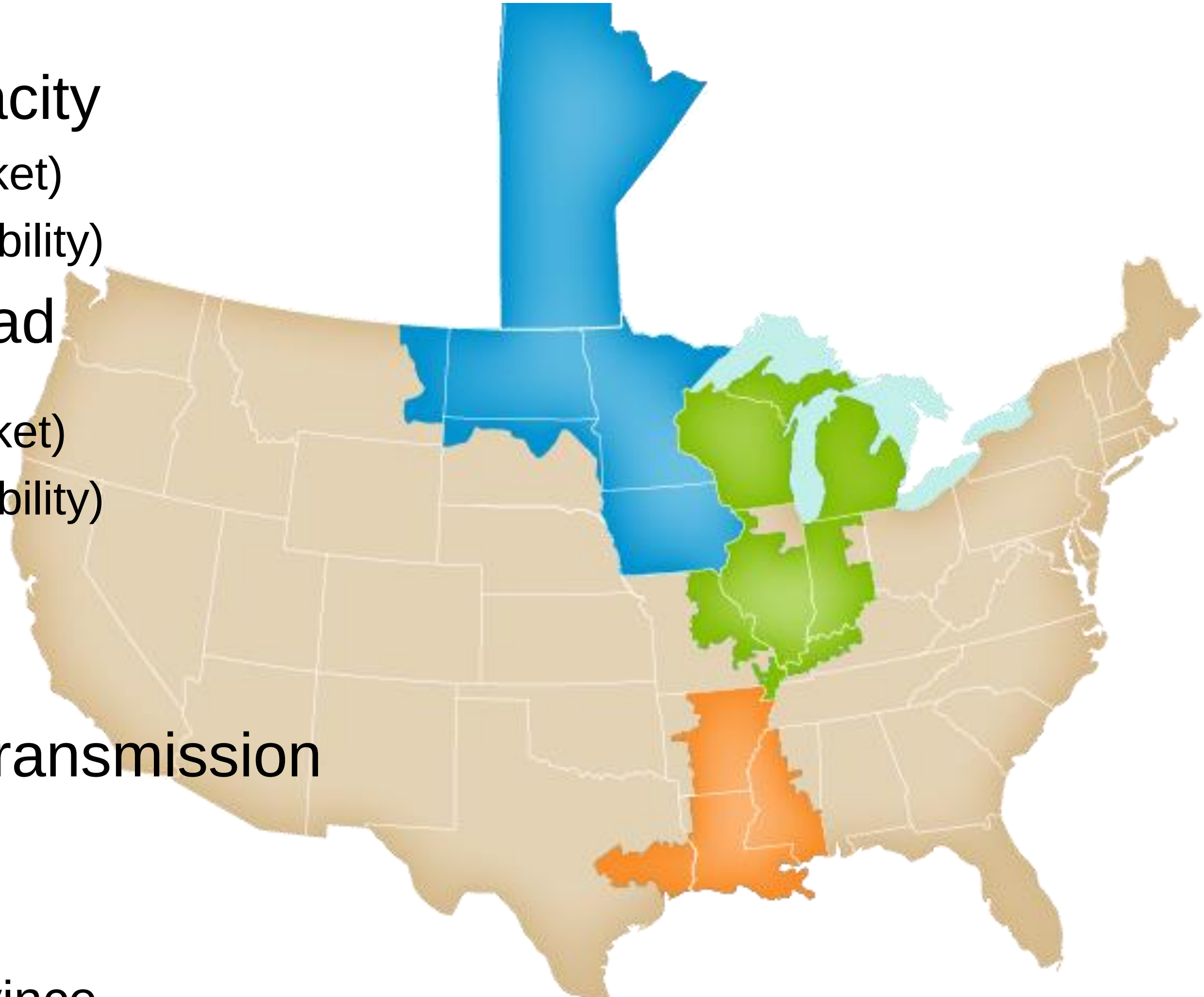
Source - EPRI

When vRE > 40% in energy terms in a larger grid, in small island grids earlier, etc.

then we need first short discharge time storage, etc.

Current Scope of MISO Operations - Storage must compete with conventional assets to provide services

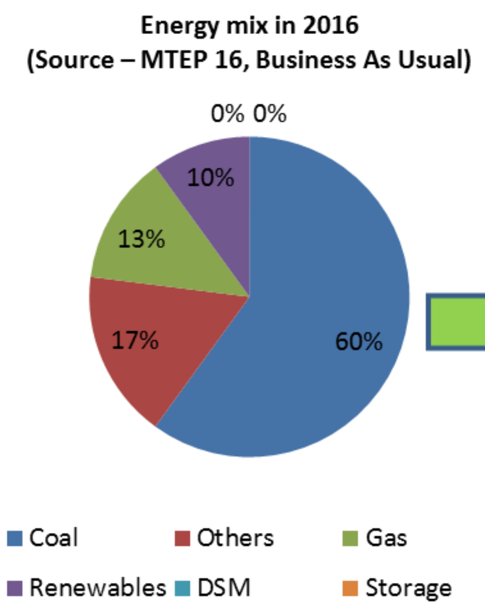
- Generation Capacity
  - 180,711 MW (market)
  - 195,231 MW (reliability)
- Historic Peak Load
  (July 20, 2011)
  - 127,125 MW (market)
  - 133,181 MW (reliability)
- Historic Wind Peak
  (November 19, 2015)
  - 12,613 MW
- 65,800 miles of transmission
- Footprint
  - 15 States
  - 1 Canadian Province
  - City of New Orleans

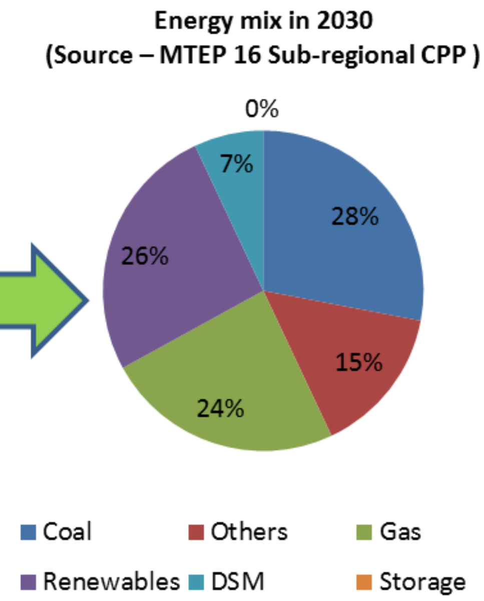


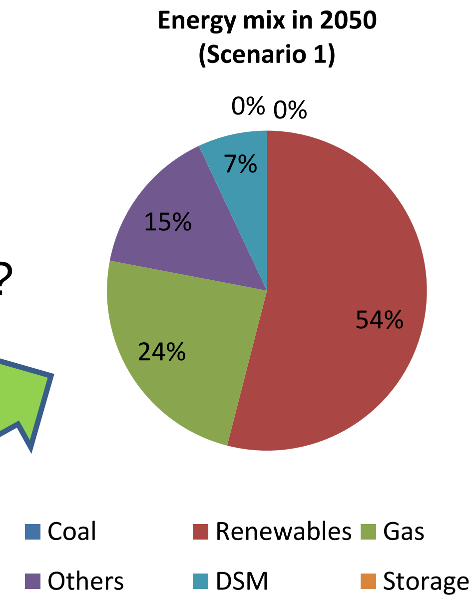
Source – MISO Communications Department

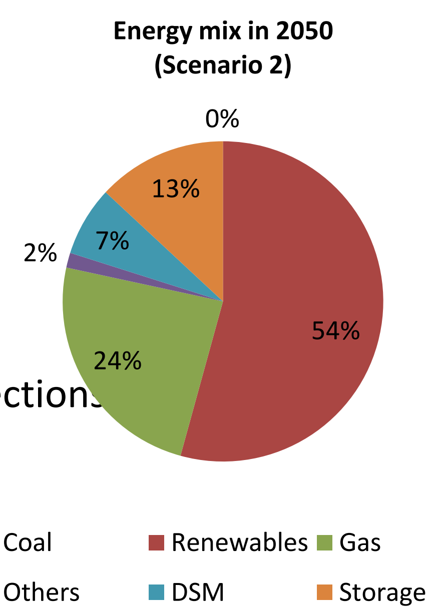
What if

- Scenario 1 – No Coal by 2050, potential for storage?
- Scenario 2 – No Nuclear by 2050, potential for storage?

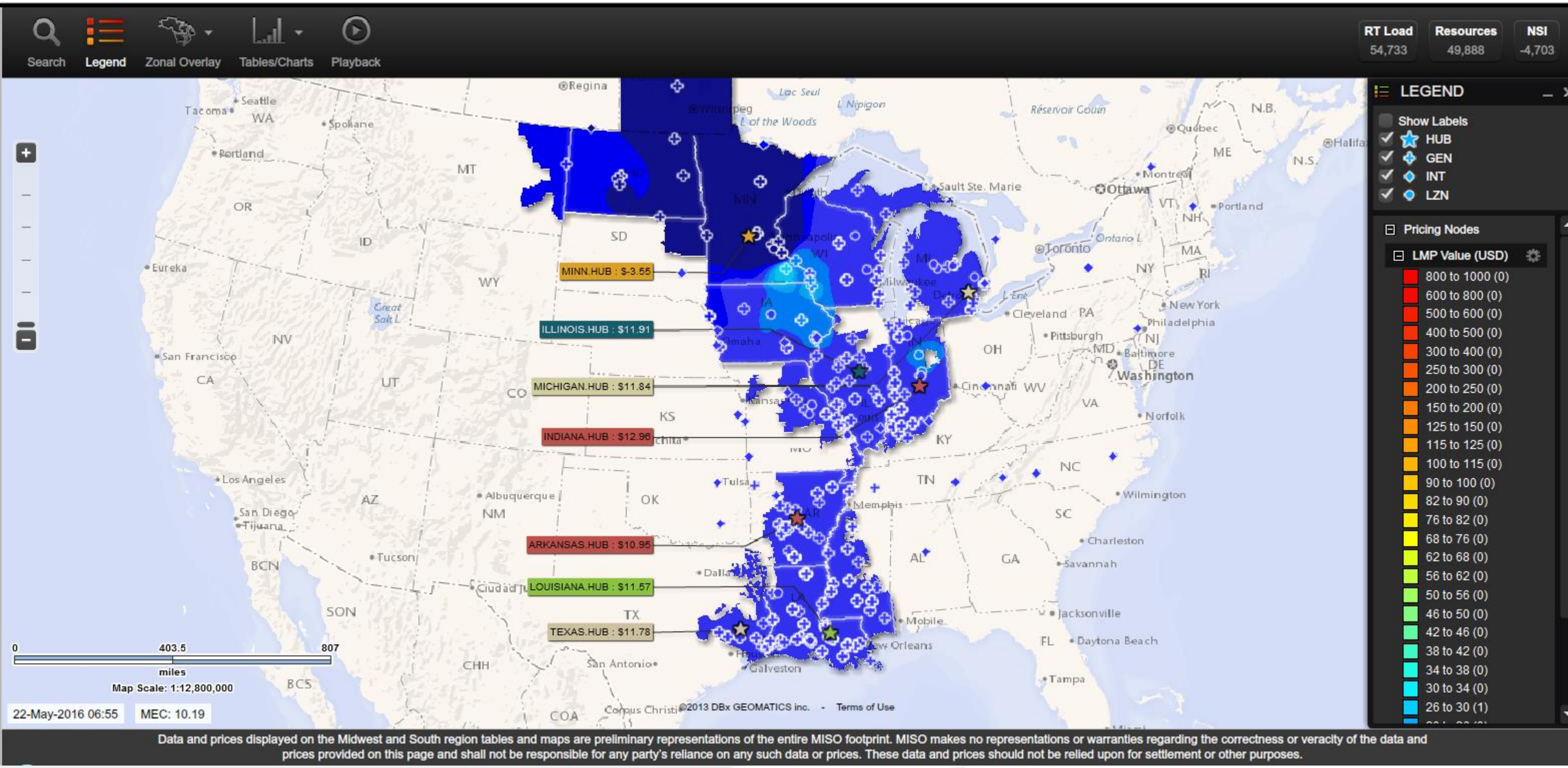








Others – 90% is nuclear, hydro storage is 7%, and remaining via interconnections



Source - https://www.misoenergy.org/LMPContourMap/MISO_All.html

MISO is going through a process to better accommodate energy storage

Current Status of Energy Storage

- Evaluation of current market rules and applications is currently underway.
- Expectation that enhancements are technology-neutral and will allow the asset owner to maximize the value of the resource.
- Energy storage expected to remain part of MISO's study processes.

Context for Energy Storage Dialogue

Why Now?

- Market participants are considering more options relative to generation portfolios in light of federal regulation and the overall economics of producing, buying and selling a MW
- Technology and market design has improved
- The energy landscape is changing

What is Driving this Discussion?

- MISO has been approached by several Market Participants who are considering battery storage options for the future
- One of MISO's Market Participants has a project already under construction
- MISO has been working with stakeholders to harness new technology and integrate non-traditional resources

Philosophy on development of market resources

Market products: technology neutral

- Capacity
- Energy
- Regulating reserve
- Spinning reserve
- Supplemental reserve
- Ramp products: Up ramp capability / Down ramp capability

Market resources are defined based on characteristics

- Generator
- Demand Response Resource (DRR)-Type I and DRR Type-II
- Stored Energy Resource (SER)
- External Asynchronous Resource (EAR)
- Dispatchable intermittent resource (DIR)

Market resources and current eligibility for market products

	Energy	Regulating Reserve	Spinning Reserve	Supplemental Reserve	Ramp Product	Capacity
Generator	Y*	Y*	Y*	Y*	Y*	Y*
DRR-I	Y*	N	Y*	Y*	N	Y*
DRR-II	Y*	Y*	Y*	Y*	Y*	Y*
SER	N	Y*	N	N	N	N
EAR	Y*	Y*	Y*	Y*	Y*	Y*
DIR	Y*	N	N	N	Y*	Y*

* Subject to qualification, offer status and commitment

Examples of other services not settled through market

- Reactive power supply and voltage control (transmission settlement)
- Blackstart service (transmission settlement)
- Primary frequency response (no compensation)

Key Areas/Issues for Consideration

- **Classification of resources/assets**
  - Examples
    - Generation/transmission asset, LMRs, non-transmission alternatives, non-generating resources similar to CAISO or new resource types
- **Tariff and Business Process Manual (BPM) considerations**
  - Examples
    - Use Limited Resource, SER, DRR2, Load Modfiying Resources (LMRs), Generators
- **New market design enhancements and tools**
  - Examples
    - 2nd Automatic Generation Control (AGC), elimination of barriers including min. size requirement, manage state of charge
- **Market compensation**
  - Examples
    - Pay for performance, fast ramp cost recovery, flexibility to choose cost recovery mechanisms, station power
- **Long-term resource adequacy considerations**
  - Examples
    - Should be examined periodically, if reliability issues surface, or as penetration increases.

MISO

Phase-In Approach for Energy Storage

Goal- Prioritize initiatives while balancing costs and benefits

- **Near-term (2016-early 2017)**
  - Relatively straight forward and low cost items
    - Require minor tariff and BPM clarification, and minimum system changes
    - Provide clear picture of how storage can participate in the near term
- **Medium-term (mid 2017-forward)**
  - Items that have been prioritized through market roadmap
  - Tie to other on-going initiatives and stakeholder discussions
- **Long-term (2017-2019)**
  - Items involving complexity
    - Requiring broader regulatory or stakeholder discussion, or greater investment

What is needed to prepare for an active role of storages in 5 -10 years?

- Observe the international development, learn from first examples around the world
  - District of Columbia – storage situation – retail jurisdiction versus Federal (PJM) price signal
  - Texas/Oncor – NoTres situation – Decoupled market – Distribution company cannot own Generation asset
  - MISO/IPL – Is Battery a transmission asset? If so, was it identified as a solution in a public stakeholder process, to a need in the MISO transmission expansion plan (MTEP)?
  - Understand front of the meter versus behind the meter
  - How to treat a battery that acts as generator when dis-charging, and load when charging? In the market models.
  - How many hours does the battery serve a “market” need?
- Design and test different energy market instruments to give storages an economic chance, etc.

What shall a utility and/or an energy department in Asia do concerning storage?

- Do some own pilot test with battery storages in grids for stabilization to get real experience with technologies and how to integrate them best
- Establish demand for different kind of discharge time storage capacities
- Establish Cost/Benefit of storages, etc.