Transmission, Generation, and Who Pays

ESIG Spring Workshop

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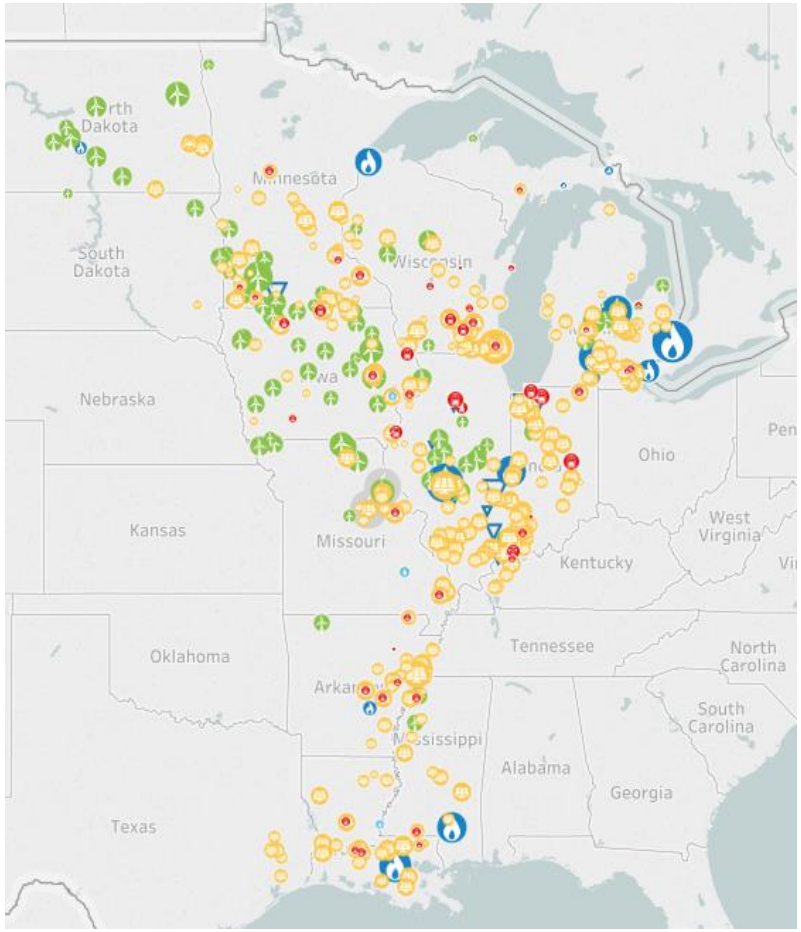
Three new MISO Futures to be created and utilized in the MTEP21 analysis

Future I	Future II	Future III
• The footprint develops in line with 85% of utility announcements/plans, along with State mandates, goals, or preferences. • Emissions decline as an outcome of utility plans. • Load growth consistent with current trends.	• Companies / states meet or exceed all their goals, mandates and announcements. • Changing federal and state policies reduce emissions footprint-wide to 60% by 2040. • EV adoption increases and electrification begins, driving a 30% increase in energy by 2040 footprint-wide.	• Changing federal and state policies support a reduction of carbon emissions footprint-wide to 80% by 2040. • Increased electrification and EV adoption drives a 60% increase of energy by 2040 footprint-wide.

Generation Interconnection (GI) Queue provides competitive environment for supply of the lowest cost energy

- Interest in energy storage and hybrid resource development continues to grow
- Generator replacement opportunities are enabled by recent Tariff changes
- Extensive network upgrades needed to support integration of new resources have a profound effect on overall cost and economic viability of interconnection projects



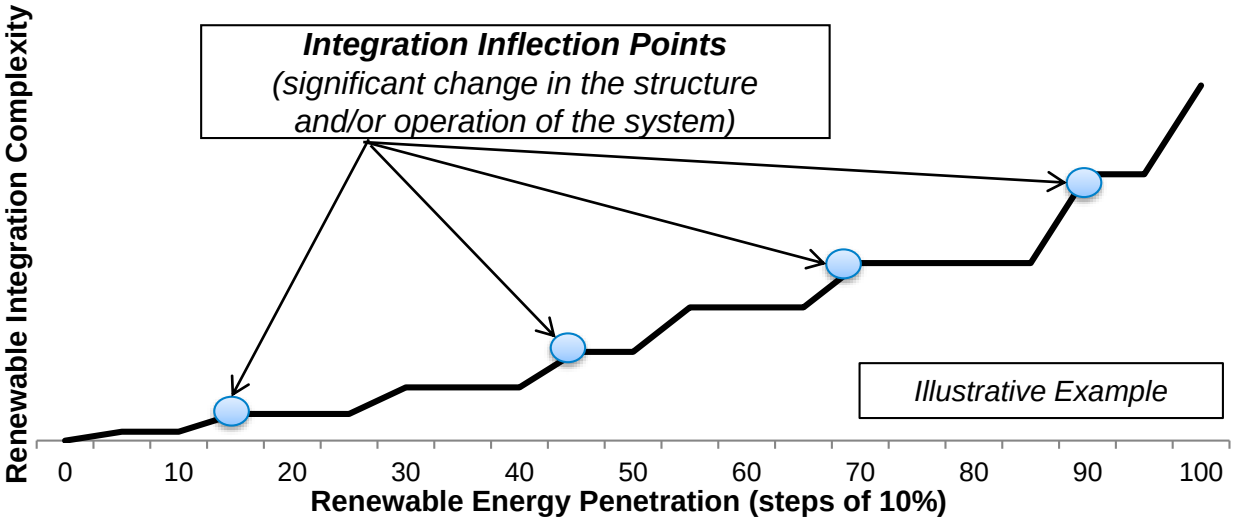
Transmission Investment is vital to successful resource development and ensuring long-term reliability

- The changing characteristics of the resource fleet requires a robust transmission system to maintain reliability
- A comprehensive transmission planning strategy promotes the most cost effective investments to address the needs of diverse stakeholder interests
- Alignment of Transmission Planning processes and Market initiatives (fast ramp) will help promote that comprehensive strategy

Renewable Integration Impact Assessment (RIIA) seeks to find inflection points of renewable integration complexity

Study Focus Areas:

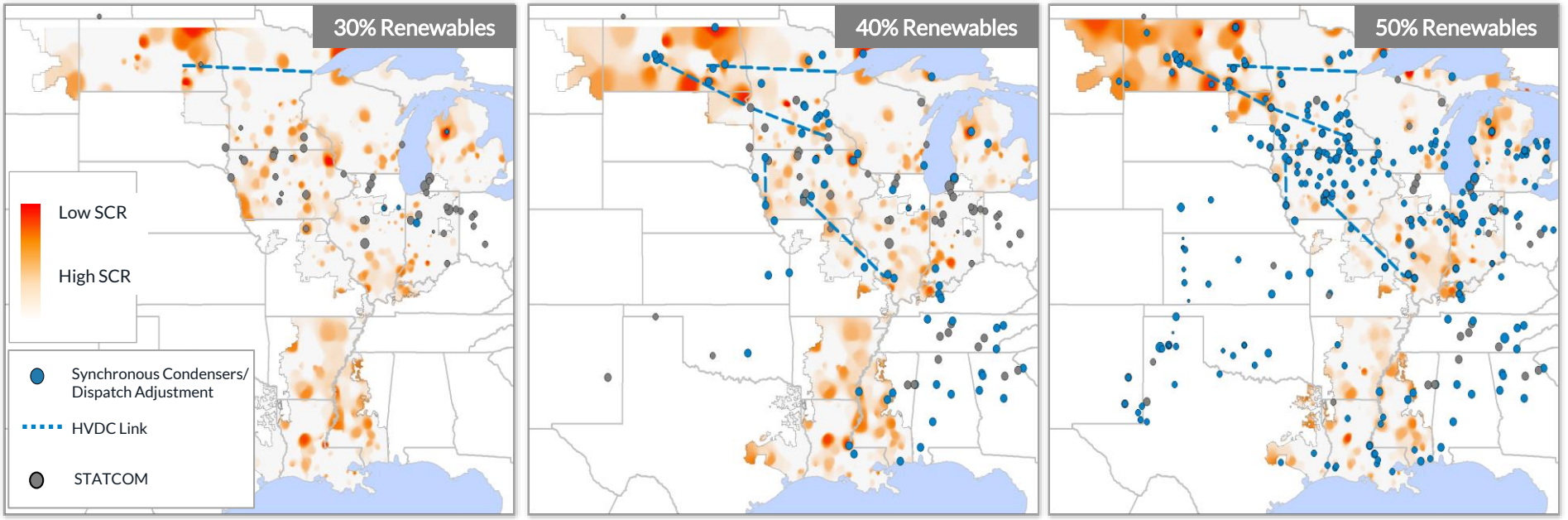
- RENEWABLE PENETRATION LIMITATIONS
- GEOGRAPHIC DIVERSITY
- INCREASE AWARENESS OF ISSUES
- RELIABILITY (OPERATING & PLANING)
- TIMING AND URGENCY



Inflection Point Focus Areas:

- Operational
- Steady State
- System Stability
- Resource Adequacy

Starting at 40%, system-wide voltage stability is the main driver of dynamic complexity and requires transmission technologies equipped with dynamic-support capabilities



* Maps reflect cumulative solutions across milestones

As renewable penetration increases, need more transmission equipped with dynamic voltage support. Innovation in renewable resource technologies may bring down the cost of integration.

Appropriate cost allocation is key for enabling transmission investment, but cost allocation is not easy

- The foundational issue with regional transmission development is who pays (and who benefits)
- Stakeholders have strong and varying views on cost allocation approaches – compromise is difficult to acheive
- MISO has continually looked to enhanced its planning process to promote the identification, appropriate cost allocation, and cost recovery of new transmission facilities

Snapshot
Wind and Solar Program

February, 2020

Fleet Snapshot: The latest wind, solar and battery storage fleet numbers.

Wind:

- Total In-Service Wind: 21.5GW
- Wind with a signed GIA and currently under construction: 9.7GW
  - Of that, expected to be in-service in the next twelve months: 5.2GW*

Solar:

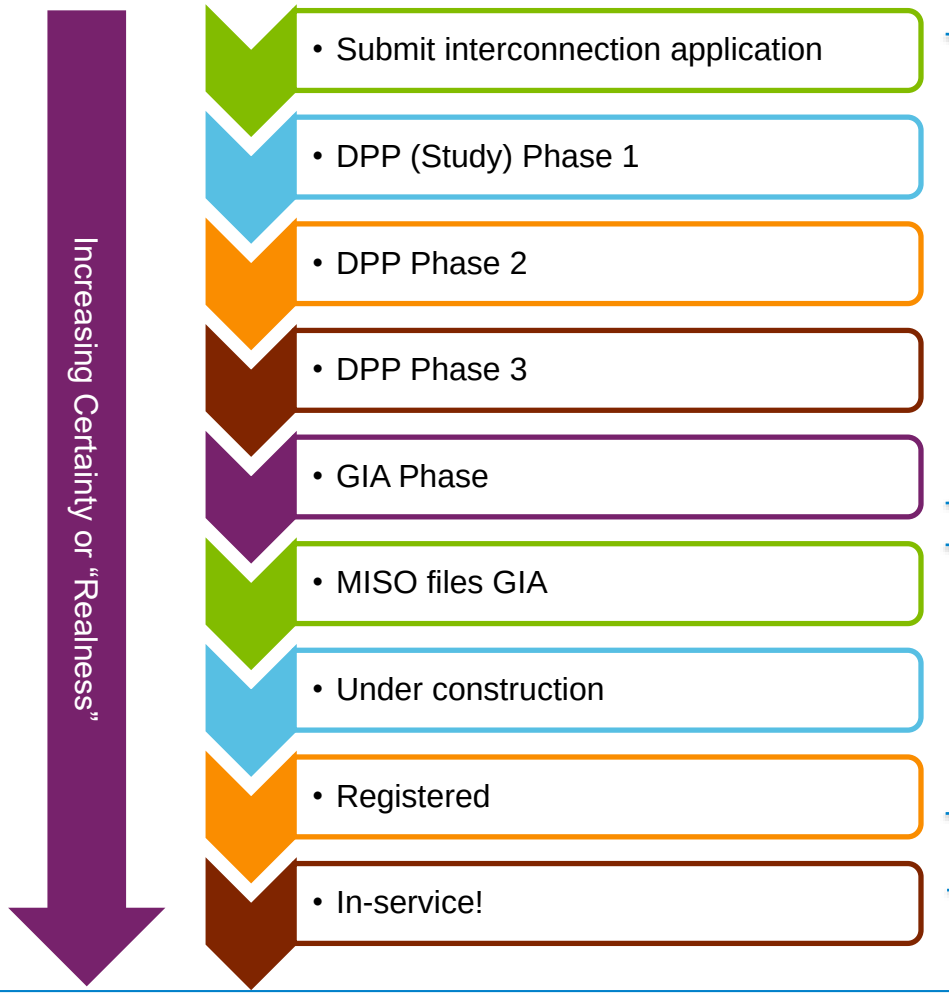
- Total In-Service Solar: 0.3GW
- Solar with a signed GIA and currently under construction: 6.6GW
  - Of that, expected to be in-service in the next 12 months: 1.0GW
- DER solar, per OMS survey: >1.9GW

Battery Storage under study: 2.5GW

Hybrids under study: 2.7GW

* Estimated in-service dates provided by the developers

MISO has 16.3GW of wind/solar generation that has graduated from the queue and is being constructed on our footprint today.

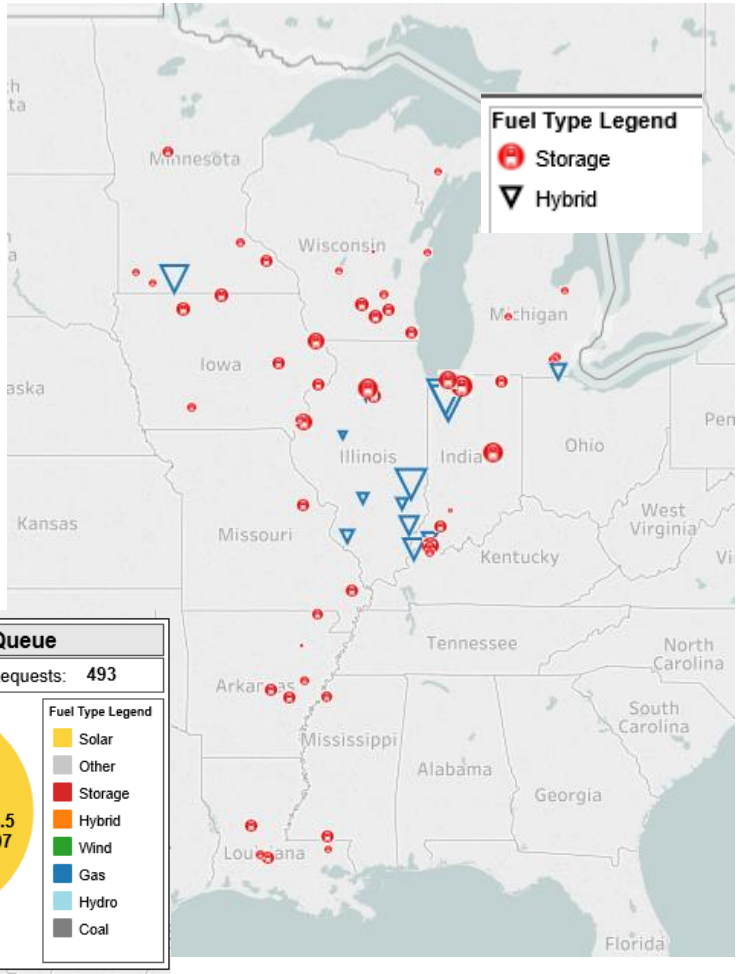


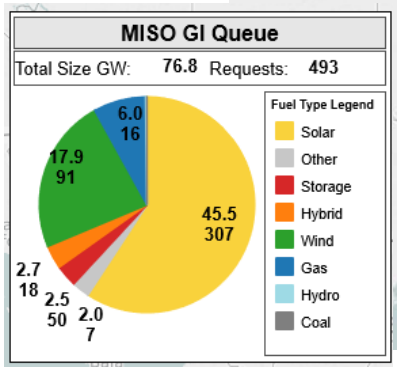
This group of projects makes up MISO's GI queue. As a project moves through the cycles it becomes more certain of being built.

This group of projects have graduated from the queue and are in various build stages. A project registers and is added to the MISO Commercial Model when nearing completion. These projects are "real" and being constructed. 16.3GW in total!

This is the power-producing generation fleet

Storage/Hybrid Queue Snapshot: “Every new solar project we are exploring will have an element of storage.” – MISO developer





A small group of MISO folks with expertise in market design, planning, and customer insights have been conducting an outreach campaign to survey developers in our queue about their plans for hybrids. Spoiler alert! It’s major. Two-page summary coming soon.

As of today, MISO’s queue has 50 storage projects (2.5GW) and 18 that have applied as hybrid projects (2.7GW).

Of note: 20 of the 50 storage projects share the same point of interconnection (POI) as a solar project. Some developers are choosing to apply separately for each co-located generation type.

There is a 798MW hybrid project in our queue in Northern Indiana!

Program moment: AGC for Fast Ramping Resources enhancement, effective February, 2020!

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Criteria to qualify:

- Offered as FRR
- Ramp Rate (>=80MW/min)
- Regulation Max Limit (>= 1MW)
- Duration (>= 20mins)
- RT Regulation Performance (>= 70%)

Why does this matter? As our resource mix is made up of more intermittent wind and solar, we'll need more flexibility. This enhancement was designed to attract better, faster performing resources.

MISO wind ramp records:

Greatest 60 minute rate of change up:

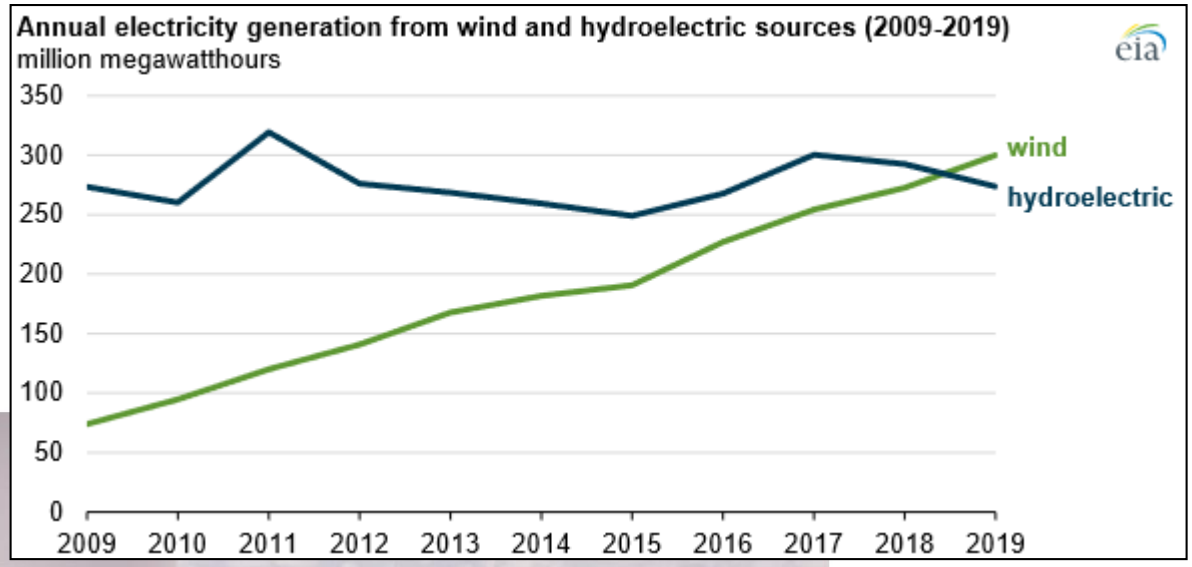
+ 4,267MW (Recorded 2/14/19)

Greatest 60 minute rate of change down:

- 3,649MW (Recorded 9/26/16)

FAQ for Fast First AGC is linked here.

Industry moment: Wind has surpassed hydro as most-used renewables electricity generation source in U.S.



"Annual wind generation totaled 300 million MWh in 2019."

- EIA article linked here.

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← A "bovine sundial"

When the weather is hot, cattle at the Arbuckle Mountain Wind Farm in Murray County, Okla., line up in the shade of the "bovine sundial," a wind turbine tower, and slowly shuffle to the side as the shadow moves with the sun.

- USA Today article linked here