

Renewable Integration Impact Assessment

Finding integration inflection points of increasing renewable energy

ESIG Spring Technical Workshop March 20th, 2019

MISO connects a large, diverse generation fleet...





...that is already experiencing high wind levels

	MISO Total	MISO North*
2016 wind % of annual energy	8%	27%
2016 hourly wind peak (Dec. 7 th 11pm)	13.6 GW	11.6 GW
2016 maximum wind as a % of load (Nov. 13 th 4 am)	22%	80%

MISO North Maximum Wind as % of Load



*MISO North has roughly the same annual energy as ISO New England



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





Projections see continued wind growth in the north, while most renewable generation in the south comes from solar







Interim results indicate integration complexity increases sharply by 40% renewable penetration





As renewable penetration increases, so do the integration challenges





Note: Curtailment is undispatched renewable energy. Generation mix shown is after mitigation.

As renewable penetration continues, operating risks shift and become more acute





Minimum system generation levels are reached in some hours between 30-40% annual renewable penetration





More hourly variability will require renewable resource curtailments and/or increased flexibility in ramp of traditional resources



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



Power system stability concerns significantly increase by 40% renewable penetration



- Stability concerns are driven by the reduction in conventional generation and the increase in inverter based (i.e., wind/solar/battery) generation
- Additional system reinforcement is needed (e.g., more transmission, keeping more conventional generation online, grid forming inverters)

Weighted Short Circuit Ratio (WSCR) is used as an indicator of the system's strength to deal with disturbances at high renewable penetrations



Renewable integration complexity increases sharply by 40% penetration, illustrated by increasing amounts of transmission expansion



Integration complexity is measured as the approximate cost of mitigations needed to deliver the renewable energy



Questions?

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

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