Interplay Between Natural Gas and Renewable Energy

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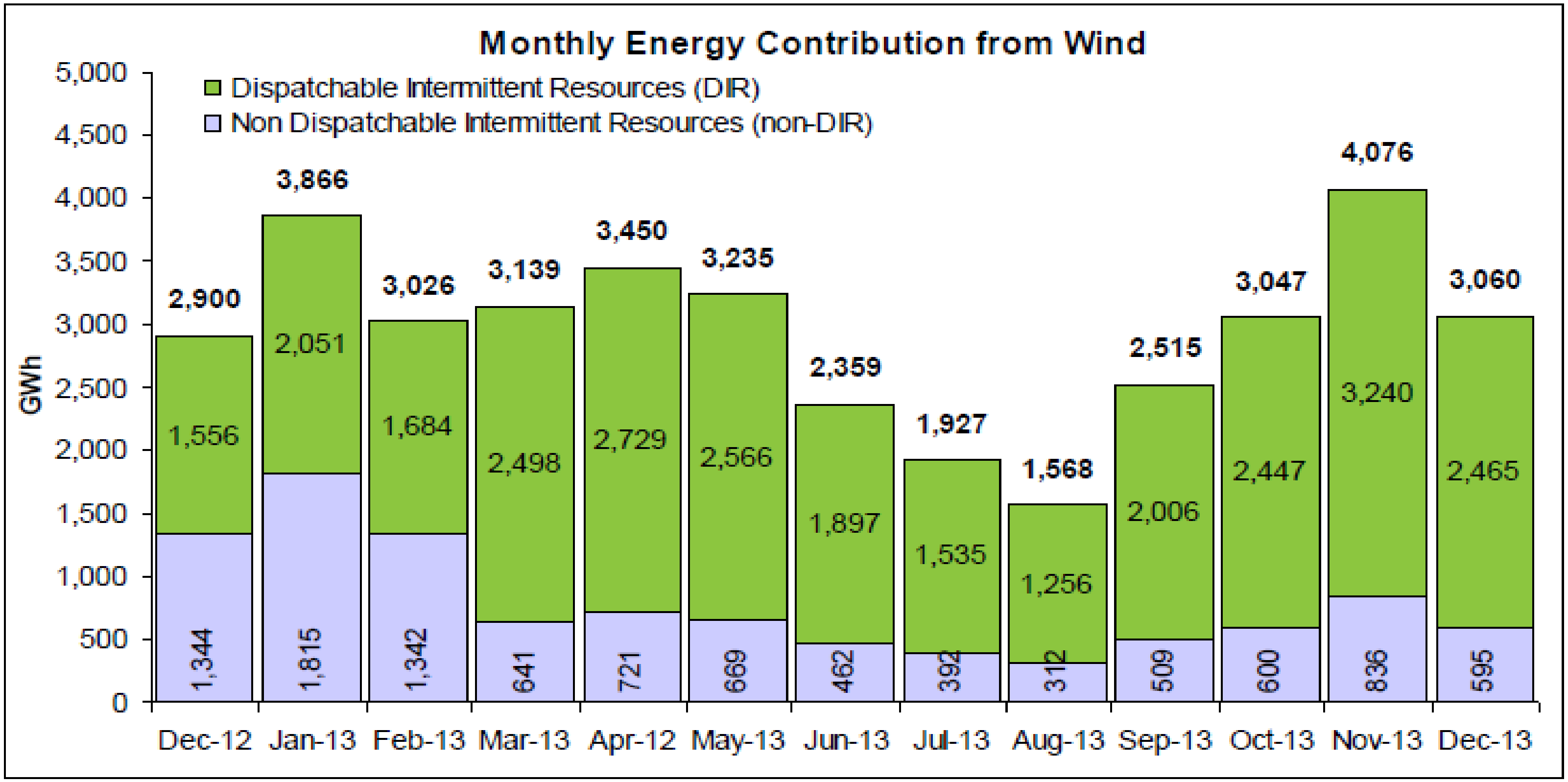
Wind Generation is Increasing

- Wind generation is a major source of renewable energy in the United States.
- Between 2005 and mid-2012, installed wind capacity in the United States increased over 500 percent, to approximately 50 gigawatts. Wind electricity generation increased by more than 700 percent over the same time period.
- Almost every state in the MISO region has a renewable portfolio standard (RPS) requirement.
  - While RPSs will continue to incent deployment of renewable energy in many areas, some states are currently ahead of their renewable deployment schedules.

Renewable Energy Standard Requirements of Midwest States

Year	WI	MN (w/o Xcel)	Xcel MN	IL	MI	OH	MO	MT	PA	SD	ND	IA
	(Of energy served)											(MW)
2015	10.0%	12.0%	18.0%	10.0%	10.0%	3.5%	5.0%	15.0%	5.5%	10.0%	10.0%	105
2016	10.0%	17.0%	25.0%	11.5%	10.0%	4.5%	5.0%	15.0%	6.0%	10.0%	10.0%	105
2017	10.0%	17.0%	25.0%	13.0%	10.0%	5.5%	5.0%	15.0%	6.5%	10.0%	10.0%	105
2018	10.0%	17.0%	25.0%	14.5%	10.0%	6.5%	10.0%	15.0%	7.0%	10.0%	10.0%	105
2019	10.0%	17.0%	25.0%	16.0%	10.0%	7.5%	10.0%	15.0%	7.5%	10.0%	10.0%	105
2020	10.0%	20.0%	30.0%	17.5%	10.0%	8.5%	10.0%	15.0%	8.0%	10.0%	10.0%	105
2021	10.0%	20.0%	30.0%	19.0%	10.0%	9.5%	15.0%	15.0%	8.0%	10.0%	10.0%	105
2022	10.0%	20.0%	30.0%	20.5%	10.0%	10.5%	15.0%	15.0%	8.0%	10.0%	10.0%	105
2023	10.0%	20.0%	30.0%	22.0%	10.0%	11.5%	15.0%	15.0%	8.0%	10.0%	10.0%	105
2024	10.0%	20.0%	30.0%	23.5%	10.0%	12.5%	15.0%	15.0%	8.0%	10.0%	10.0%	105
2025	10.0%	25.0%	30.0%	25.0%	10.0%	12.5%	15.0%	15.0%	8.0%	10.0%	10.0%	105

MISO Wind Utilization



Wind Energy** as a Percentage of MISO Energy**	7.0%	8.9%	7.7%	7.6%	9.2%	8.6%	6.1%	4.4%	3.6%	6.8%	8.2%	10.5%	6.1%
DIR Energy as a Percent of Total Wind Energy**	53.7%	53.0%	55.6%	79.6%	79.1%	79.3%	80.4%	79.7%	80.1%	79.8%	80.3%	79.5%	80.5%

Some Challenges for Renewables

- Given existing cost structures, and the absence of a price on carbon, renewables are generally a social choice or public policy objective, rather than an economic decision.
- Transmission cost allocation is a major issue affecting siting decisions for renewables.
- Planning models with respect to evaluating portfolio risks are evolving. Some improvements in risk analysis include scenario and sensitivity analysis to better incorporate portfolio risk assessment into the expansion planning process.

Natural Gas-Fired Generation is Increasing

- Use of natural gas as a generation fuel has grown in recent years.
  - Coal-to-gas switching plus new gas generation construction.
- U.S. natural gas production traditionally came from conventional oil and gas wells.
- In the last ten years, developments in horizontal drilling and hydraulic fracturing opened up large quantities of shale gas
- Shale gas is now approximately one-third of total gas production.

Competitors or Complements?

- Natural gas generation and renewable energy generation are complementary in many respects:
  – natural gas electricity generation enjoys low capital costs and variable fuel costs, while renewable energy generators have higher capital costs but generally zero fuel costs.

- Complementarities of natural gas and renewable energy technologies can be realized through co-optimized system integration.

Complementarities

- Renewable energy generation does not experience the same long-term and short-term fuel supply concerns as natural gas generation.
- Renewable generation does not face fuel price volatility issues.
- Renewable energy technologies are generally more modular, often with quick deployment timelines.
  - Whereas, natural gas investments tend to be in larger increments (e.g., 500 MW and more) of new capacity.

Complementarities

- While both natural gas generation and renewable energy generation help lower total carbon emissions from current sources, natural gas generation is subject to future, additional carbon restrictions.
- Natural gas generation can be dispatched flexibly.
  - The quick ramping ability of natural gas generators makes them ideal for complementing variable renewable generation.
    - This flexibility may produce additional value as new ancillary service products are designed to accommodate increasing levels of variable generation on the grid.

Dispatching Renewable Generation Resources

- Most renewable resources are primarily an energy resource and not a capacity resource.
  - cannot be relied upon to deliver energy during peak periods or on demand.
- Shorter dispatch and commitment periods better enable wind to hit production targets.
  - Before MISO established its energy markets, the time between commitment and delivery was one hour. MISO's energy markets currently operate on a five-minute interval. These shorter dispatch times reduce the error of forecasting wind generation and load.
- Some resources with quick ramping ability, such as natural gas-fired generation, can be dispatched flexibly, which offers more capacity for system reliability. The quick ramping ability of natural gas generators makes them ideal for complementing variable renewable generation.

Geographical Diversity

- The intra-day, intra-hour variability and uncertainty of variable renewable generation as well as load are reduced when consolidated over larger geographic areas.
  – This results in smaller overall fluctuations in demand and supply, which reduces the need for relatively expensive operating reserves to smooth these fluctuations. This decreases variable generation integration and load balancing costs.

- Regions with small balancing areas can reduce normal load balancing costs as well as better integrate variable generation through pooling mechanisms with neighboring balancing areas.
  - This assumes adequate transmission capacity.

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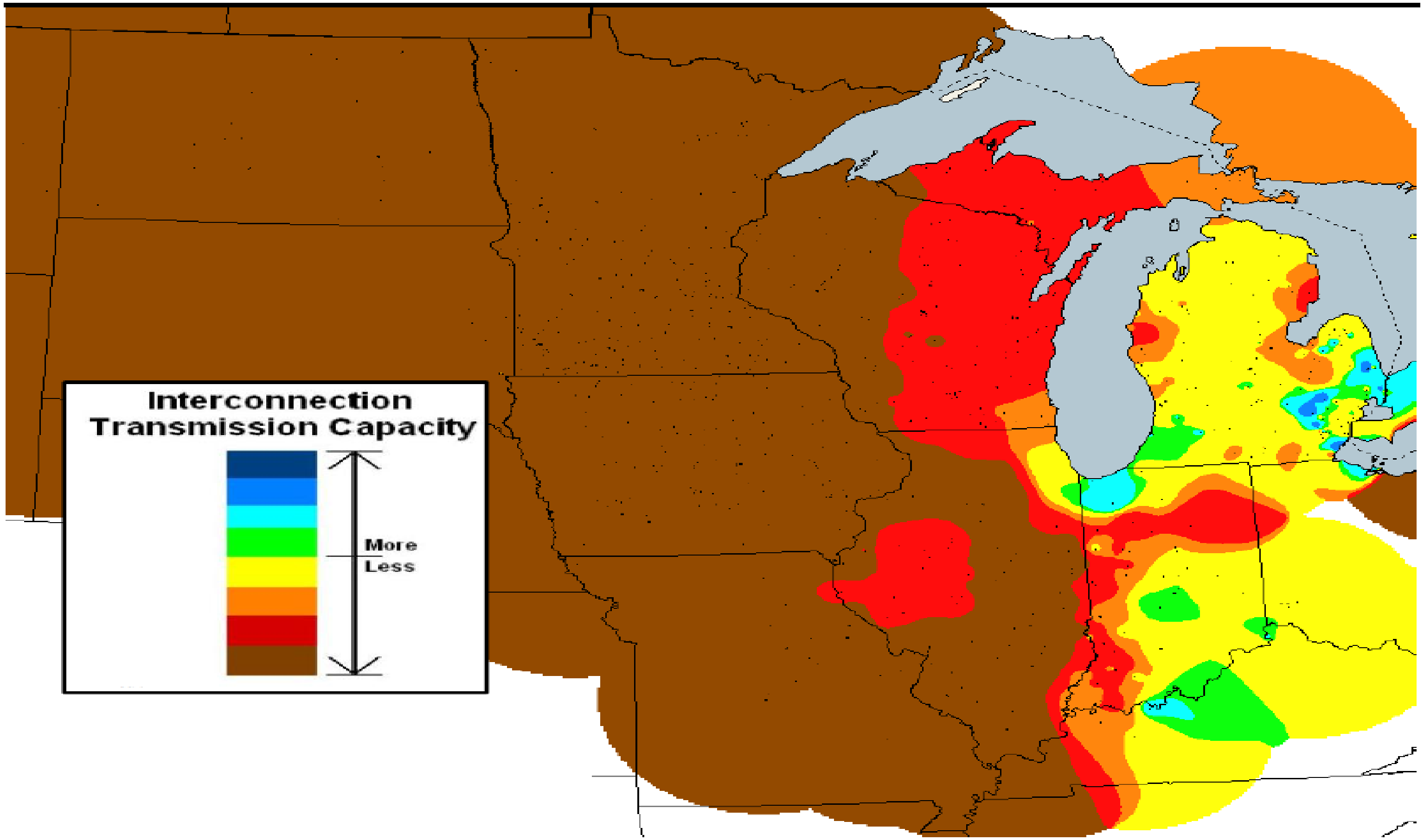
Grid Interconnection

- MISO has integrated over 10,000 MW of wind generation into the energy market under MISO’s generation interconnection processes.
- Much of the wind generation currently operating in MISO’s territory has been connected to existing transmission that required modest transmission upgrades.
- Future interconnections will likely require large investments in transmission.

Transmission Upgrades Frequently Needed to Enable Generator Interconnection (MISO Example)



Transmission Planning

- Transmission planning in MISO must consider the development of wind resources and transporting that power from the west to load centers in the east.

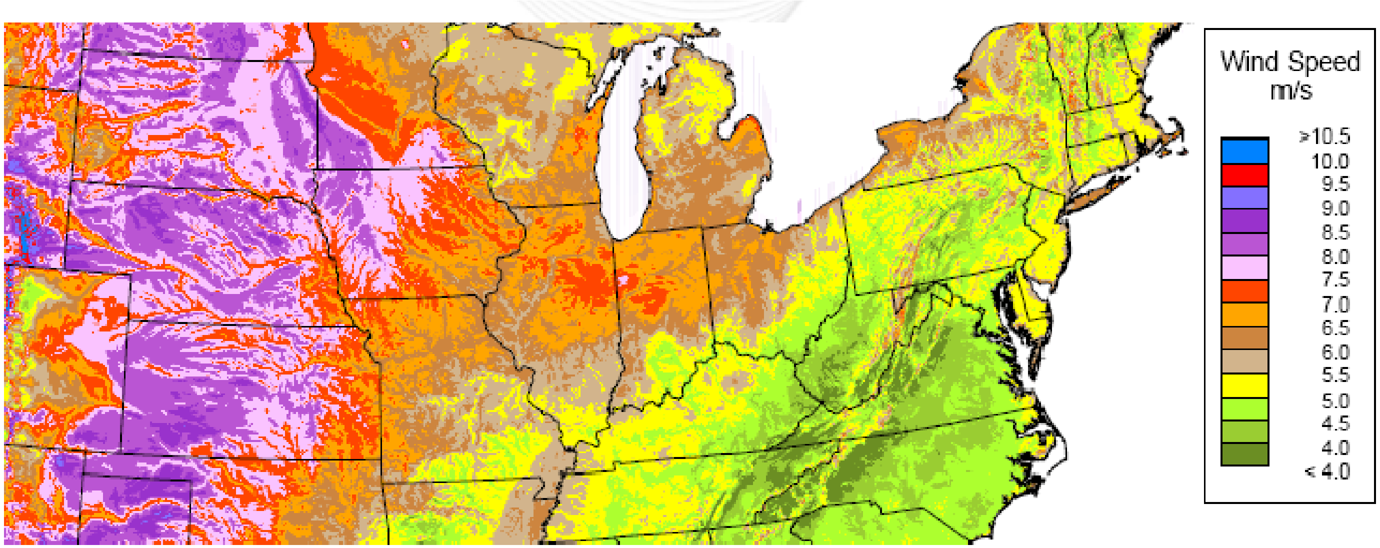
- Large investments in transmission will be required to access areas with the greatest renewable energy potential, such as the high wind potential central regions of the United States, which are mostly far from load centers.

- MISO approved 17 "Multi Value" transmission projects at a cost of $5.2 billion in 2011.
  - Projects expected to enable the interconnection of 21,000 MW of wind generation and the delivery of up to 41 million MWH of wind energy annually by the year 2021.

Locational Opportunities

- Overlaps between natural gas production regions and high wind energy potential regions suggest the possibility of new transmission projects jointly proposed and supported by new wind and natural gas projects to be sited close to each other.
  - Such an approach would likely accelerate construction of the transmission facilities and optimize both the natural gas and electric assets.

Wind Potential



- United States Department of Energy – National Renewable Energy Laboratory Data
- Offshore wind speed from NJ to VA (not pictured above) ranges from 8 – 9 m/s
- Data source
  - http://www.windpoweringamerica.gov/pdfs/wind_maps/us_windmap_80meters.pdf

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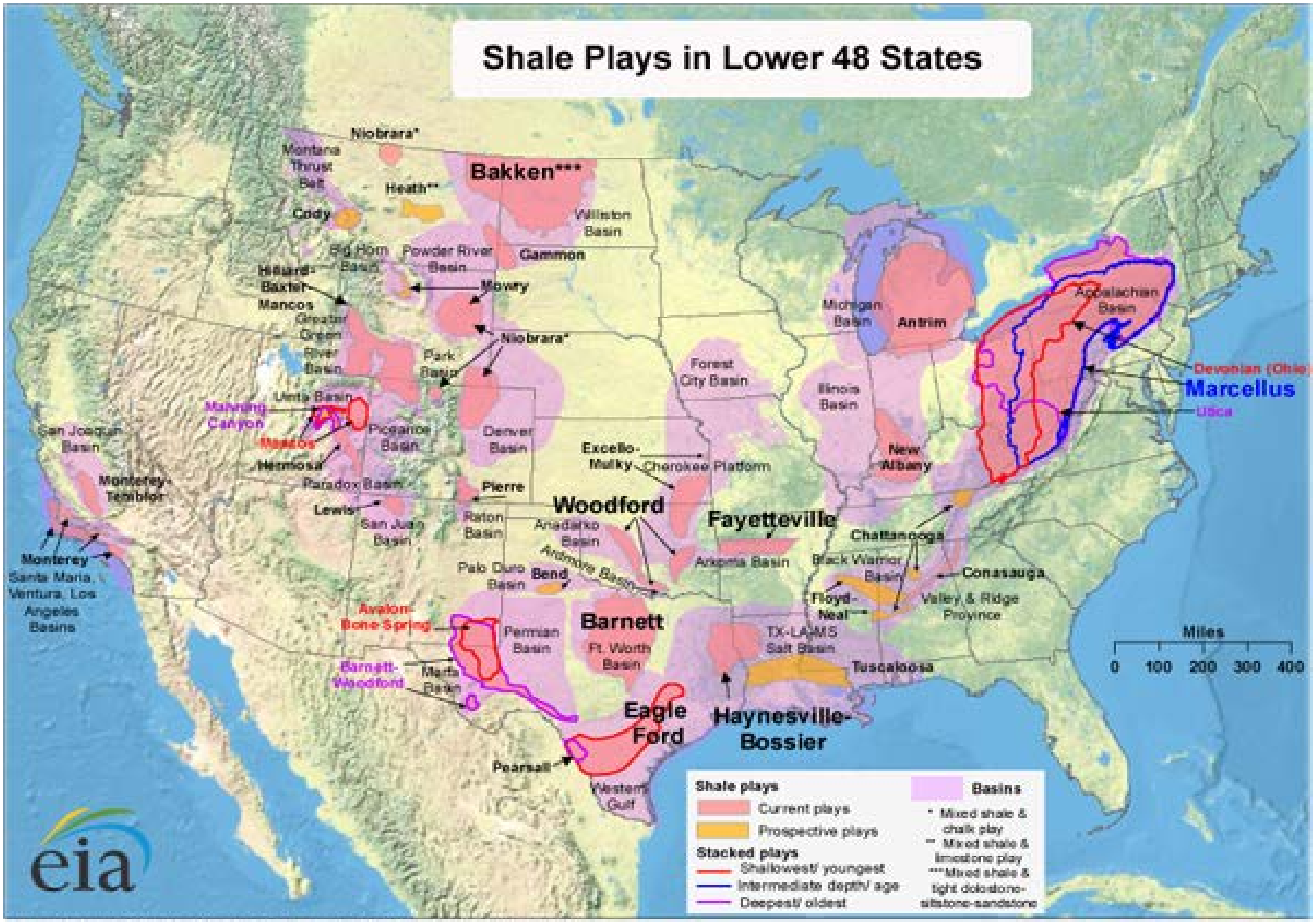

Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Pipeline Service Options

- In the U.S., gas pipeline transportation service options were originally developed to meet the needs of historical gas purchasers, which were mainly gas local distribution utilities.
- Natural gas fired generators have fluctuating and less predictable supply requirements.
- Natural gas fired generators mostly rely on interruptible pipeline service, third-party delivery service, and daily released pipeline capacity from the gas utilities.
- Increased gas generation has exposed greater electricity reliability concerns caused by gas pipeline constraints and reliance on interruptible service.
  - gas curtailments to electricity generators, due to unusually cold weather, are evidence of this growing challenge.

Supporting Pipeline and Gas Storage Expansion

- The growing use of natural gas for electricity has also created the need for more pipeline capacity in some areas.
- Pipeline operators have historically relied on long-term (20-year) fixed supply contracts with gas purchasers to demonstrate project necessity to regulators and acquire the revenue certainty needed to finance the large investments required for new pipelines.
- Natural gas electricity generators often rely on highly dynamic regional electricity markets to determine when and at what price they will be dispatched, are unwilling to sign long-term fixed supply contracts with gas pipelines.