MN **SOLAR** PATHWAYS

illuminating pathways to 10% solar

Curtailment and Synthetic Natural Gas: A recipe for a high renewables Minnesota?

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MN Solar Pathways is a 3-year award from US DOE

Core Team

- Commerce Department
- Great Plains Institute
- Center for Energy and Environment
- Clean Energy Resource Teams
- Clean Power Research

Technical Committee

- Boston Scientific
- CUB
- The City of Duluth Minnesota
- Saint Paul
- Clean Grid Alliance
- ESIG Energy Systems Integration Group
- Fresh Energy
- Hennepin
- IPS Solar
- LREC
- Metropolitan Council
- Minnesota Energy Storage Alliance
- Minnesota Power, An Allete Company
- MnSEIA
- MISO
- NREL National Renewable Energy Laboratory
- Otter Tail Power Company
- res Americas powering change
- rpu we pledge, we deliver
- Target
- Xcel Energy

Technical Analysis

- EPRI Electric Power Research Institute
- smarter grid solutions

MN SOLAR PATHWAYS

Solar Potential ANALYSIS

The Solar Potential Analysis estimates the generation cost to achieve 10% solar by 2025 and 70% solar and wind by 2050 in MN*

INPUTS

HOURLY DATA

- Simulated Solar (SolarAnywhere)
- Measured Wind (MISO)
- Utility Load (MISO)

COST FORECASTS

- Solar PV
- Wind Energy
- Storage

SCENARIOS

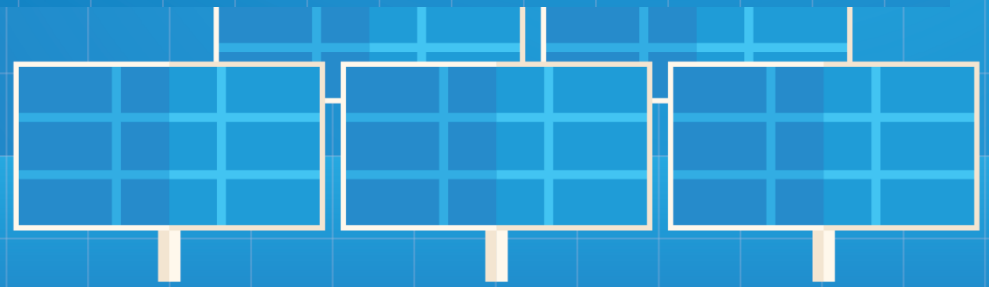
Technology Costs, Solar Distributions & Production Requirements

ANALYSIS

Hourly Energy Balance & Economic Engine

OUTPUTS

Generation Costs & Resource Capacities



Generation costs only

Based upon installed costs

No transmission or distribution costs

Does not address rate structures

* The SPA is a production cost model for solar and wind only, and is specific to MN (does not include integration with MISO)

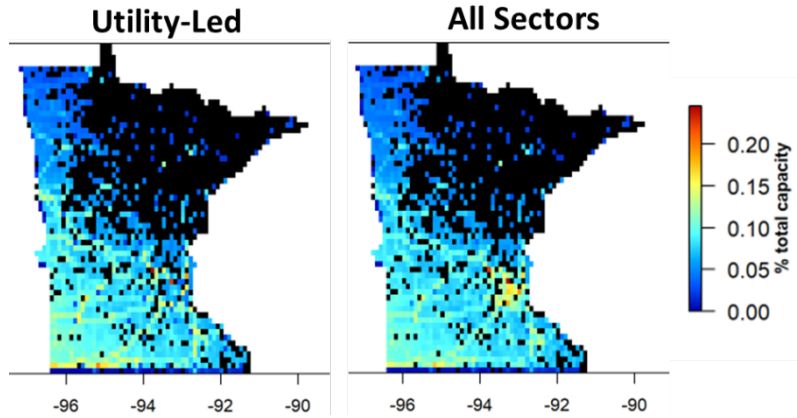
Key Model Components

- Electrification
  - 75% residential heating & DHW
  - 95% light vehicle
- Meets hourly load
  - Fully-dispatchable
- Geographic diversity
  - Wind / Solar distributed throughout the state

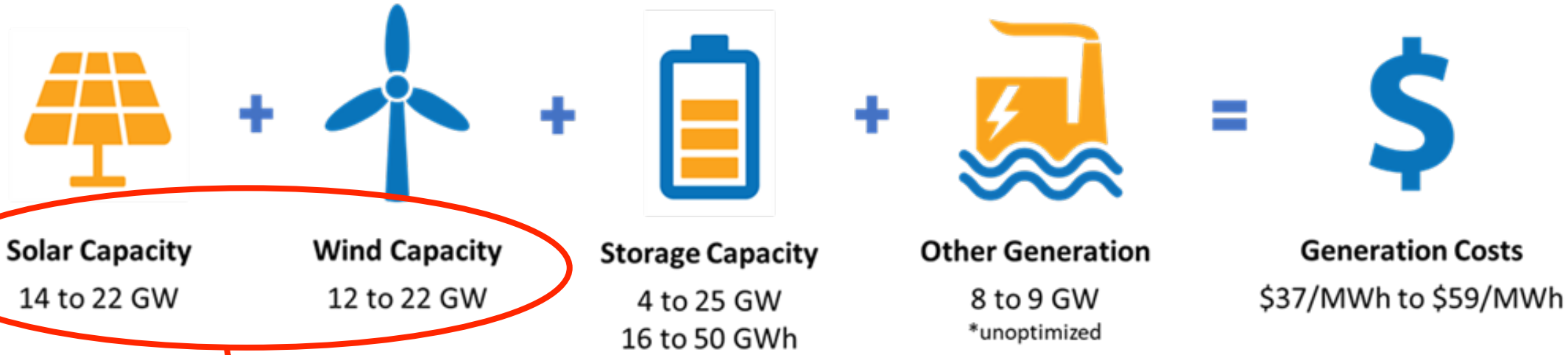
Dispatchability of SPA Production Requirements

Not Dispatchable	Semi-Dispatchable	Dispatchable
Unconstrained (2025 Timeframe)	Predictable (2025 Timeframe)	Seasonal (2025 Timeframe)
		Hourly (2050 Timeframe)
	Seasonal (2050 Timeframe)	

	Scenario	
Sector	Utility-Led	All Sectors
Residential	5%	15%
Commercial	5%	25%
Community	20%	25%
Utility	70%	30%

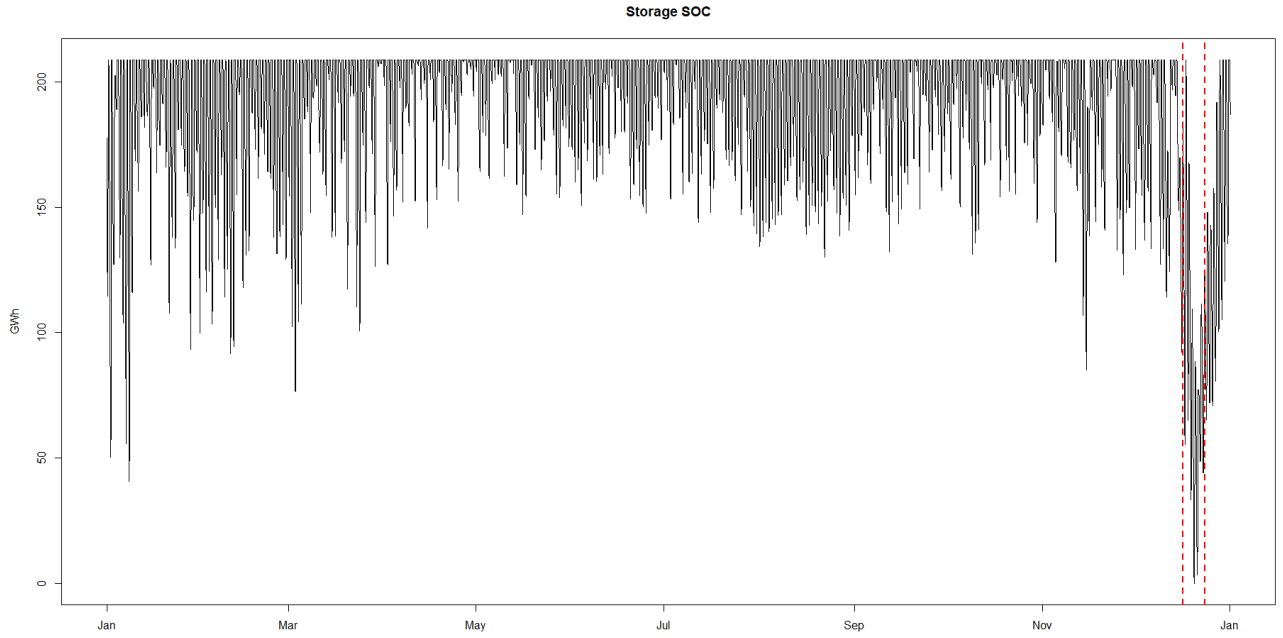


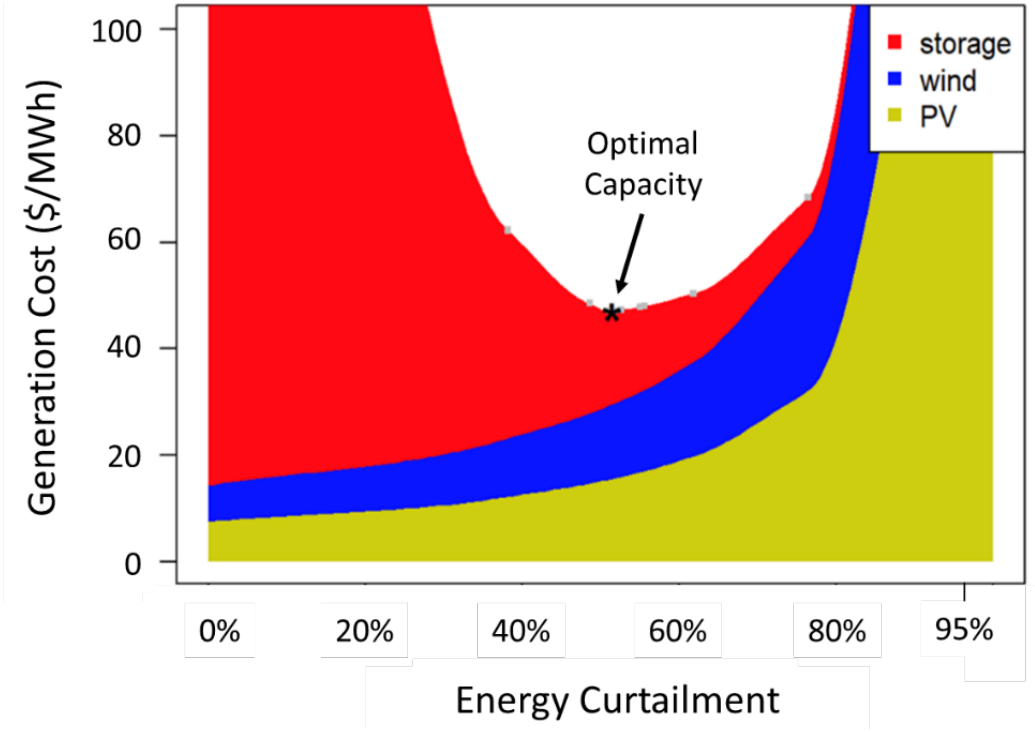
70% Solar and Wind by 2050:



- Economic curtailment of surplus renewables is cheaper than long-term battery storage

Additional Capacity Decreases Storage Needs





- Doubling renewable capacity reduces storage requirements by 6x

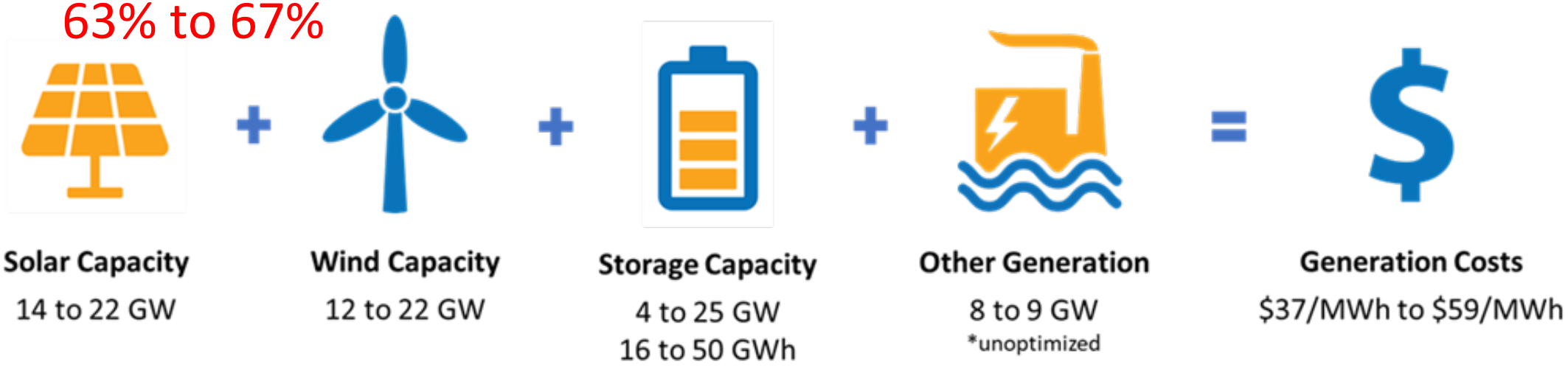
Challenges of Economic Curtailment

- Who curtails what now?
  - 30% to 70% of solar is behind the meter
  - Curtailment may disproportionately fall on large (utility scale) systems

- How to transition from current energy market to one that supports additional capacity and economic curtailment?
  - Lowest system costs are not an incentive for individual systems
  - Uncertainty on future curtailment is large risk

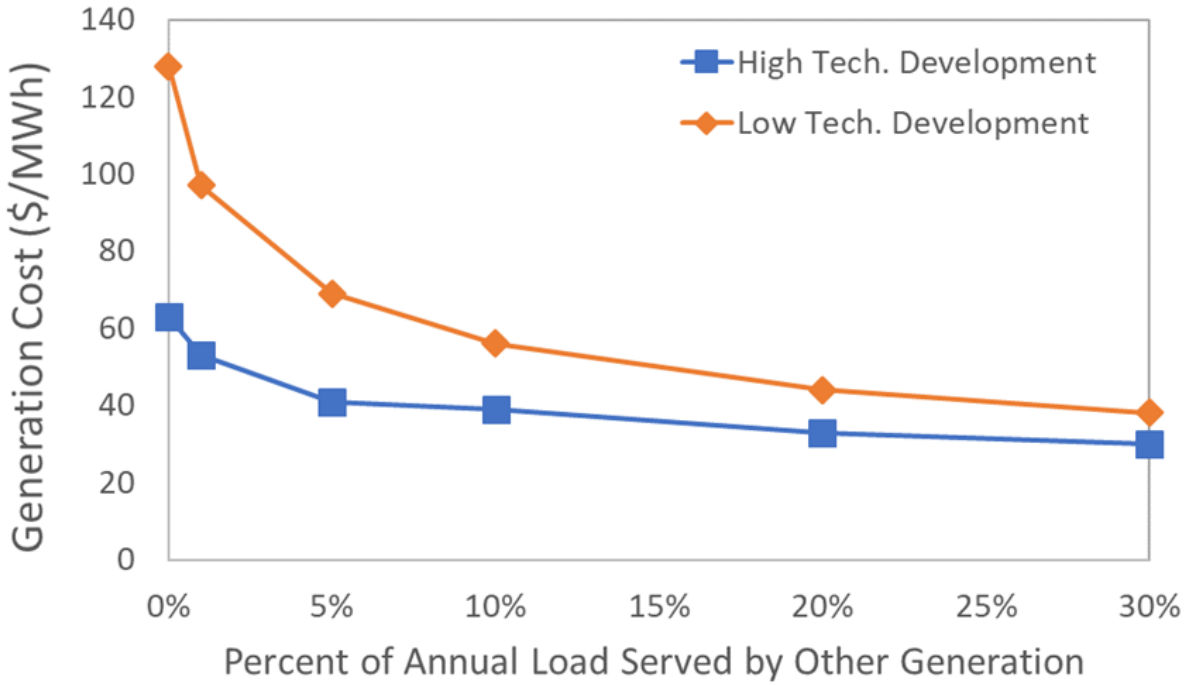
~~70%~~ Solar and Wind by 2050:

63% to 67%



- The incremental cost of the last 10% of renewable kWhs are equal to those of the first 90%
- Using other generation resources during brief periods of low-solar and low-wind production cuts net generation cost by nearly half

Cost Effects of Using Other Generation During Periods of Low Renewables Production



Curtailment: Unprecedented Opportunity?

- 40,000 GWh (~60% of current electricity)
- Large amounts of excess capacity to provide grid services
  - Capacity, frequency, contingency, voltage control
- Hydrogen and synthetic natural gas from Power-to-Gas (P2G) process
  - Supply zero-emissions materials to hard to reach chemical industry
  - P2G to use existing infrastructure into flexible long term energy storage

Conclusions

- Incremental cost of the last renewable kWhs are very high
- Additional capacity with large amounts of economical curtailment is a viable least cost pathway
- Economic curtailment is an unrecognized opportunity and may be a pathway to decarbonization beyond the electric sector

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Thank You!

http://mnsolarpathways.org/

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