



MN SOLAR PATHWAYS

Solar 20/20

 SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy



Pathways to 100% Renewables across the region

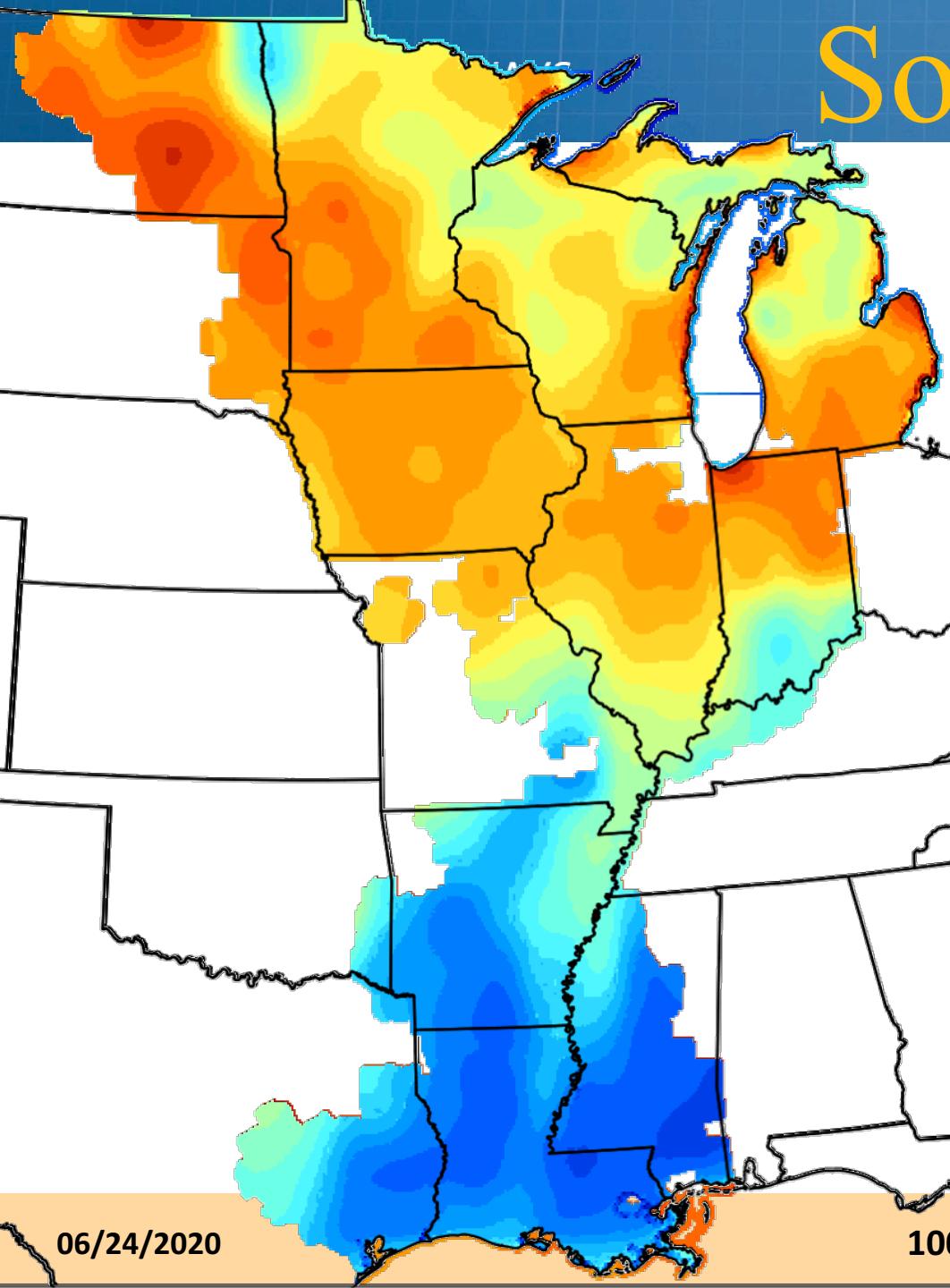
Firm, *Cost-Optimal* Power Delivery with Wind, PV + Storage

Wednesday 24th June, 2020

Marc Perez, Ph.D.

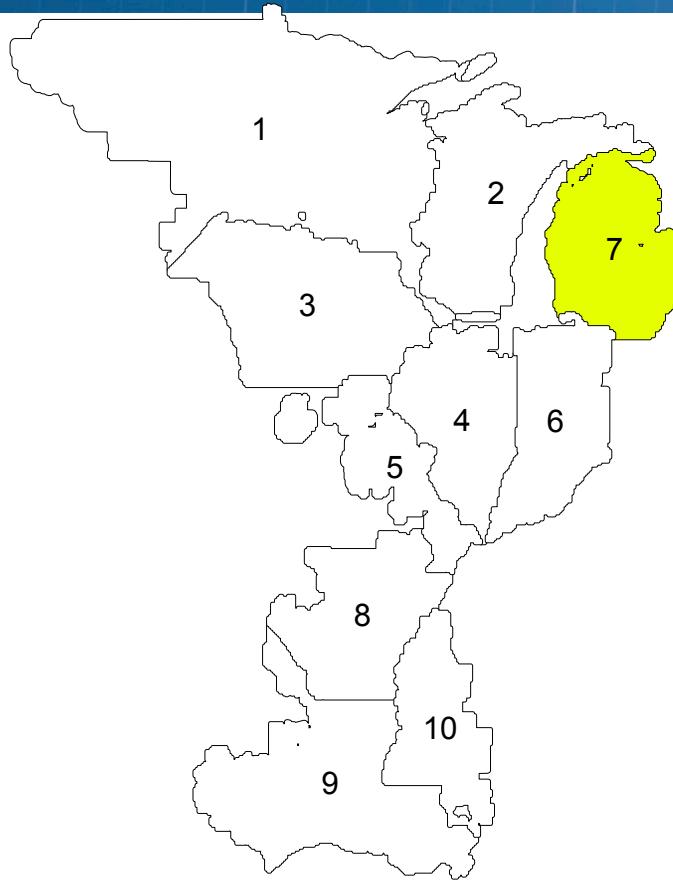


Solar 20/20

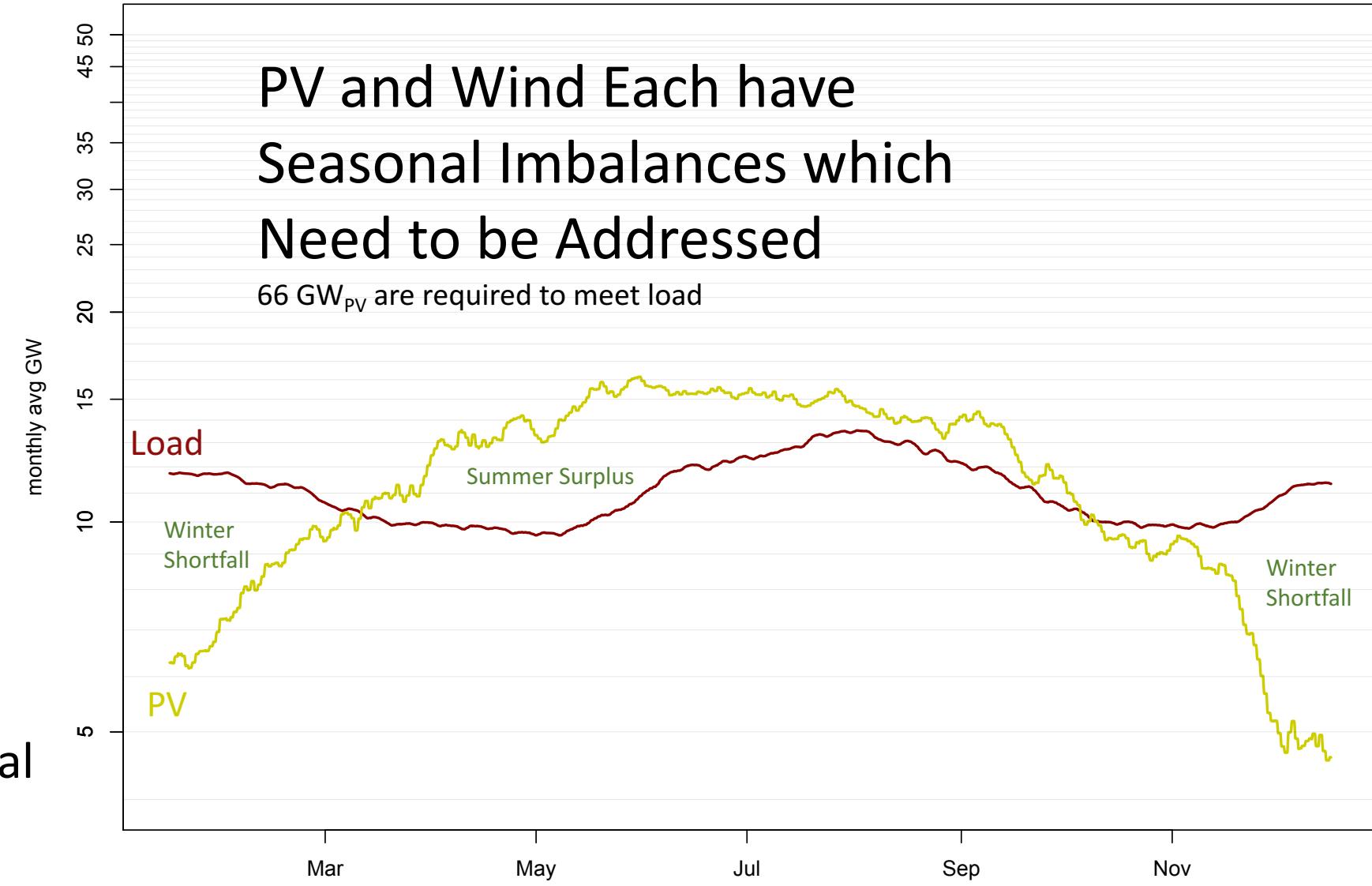


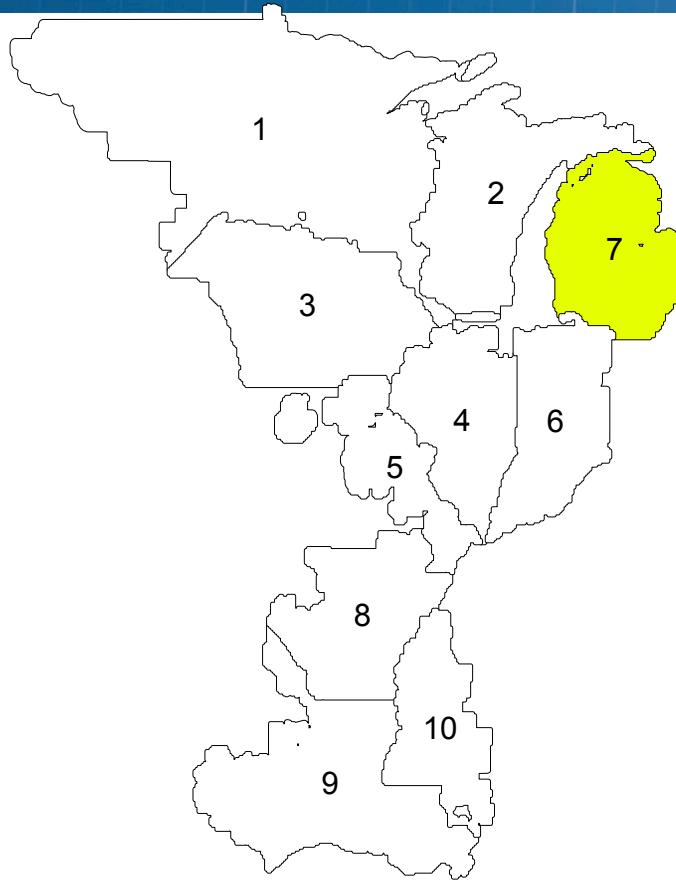
Why 100% across MISO?

- Environmental Prerogative
- Socio-Economic Prerogative
- Helps to set a realistic high water mark for costs when firmly meeting load with high levels of renewables.
- We've shown energy transformation can be cost-effective across MN using optimized capacity expansion and dispatch. Will these same things hold true for MISO?
- Solar and Wind resource have different spatial and temporal characteristics across the territory: how does this affect cost?
- What value does an interconnected MISO region deliver in terms of reduced energy cost relative to smaller sub-regions?
- How does a 100% renewable optimized capacity expansion portfolio change with the cost of system components over time?

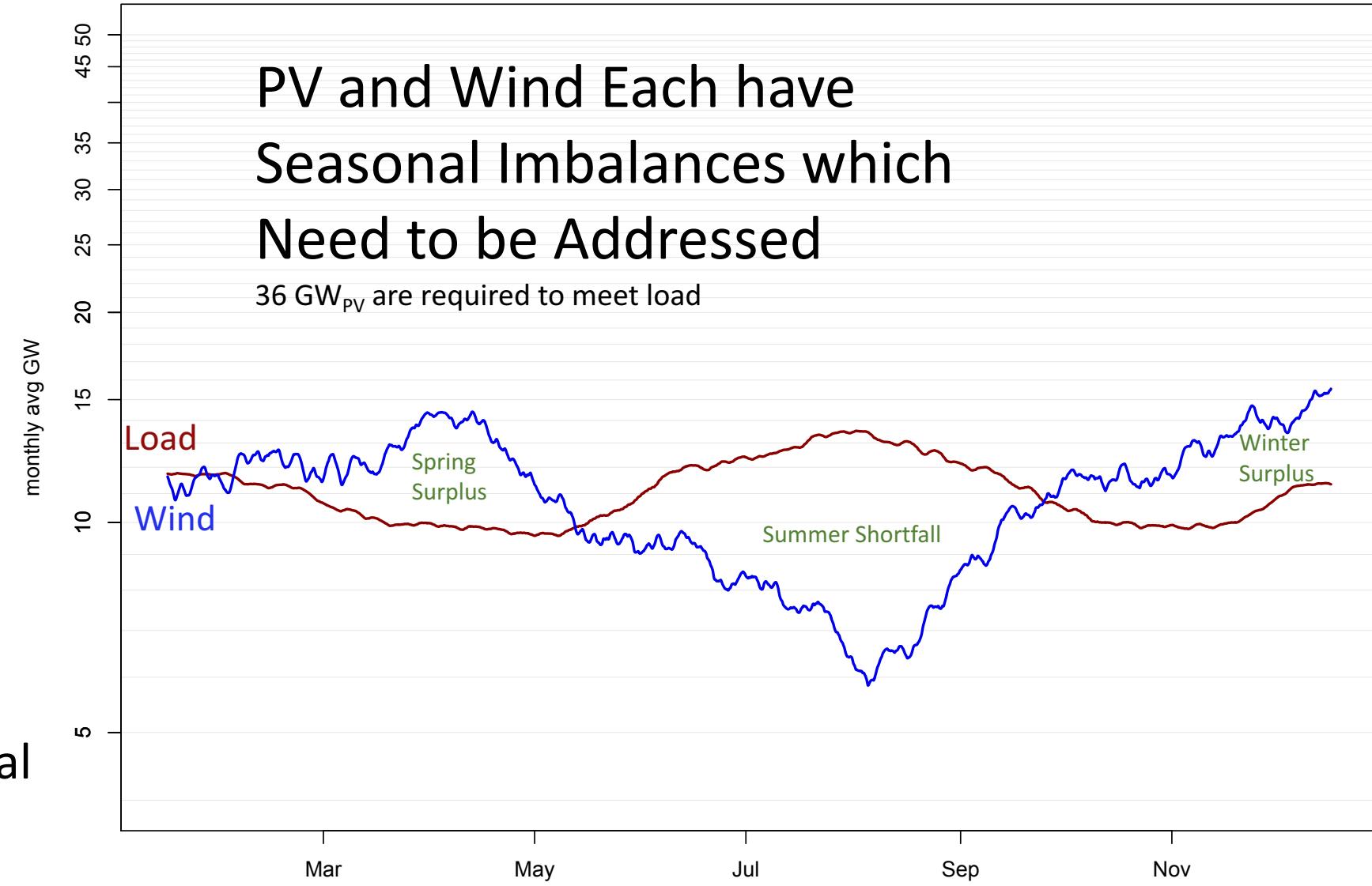


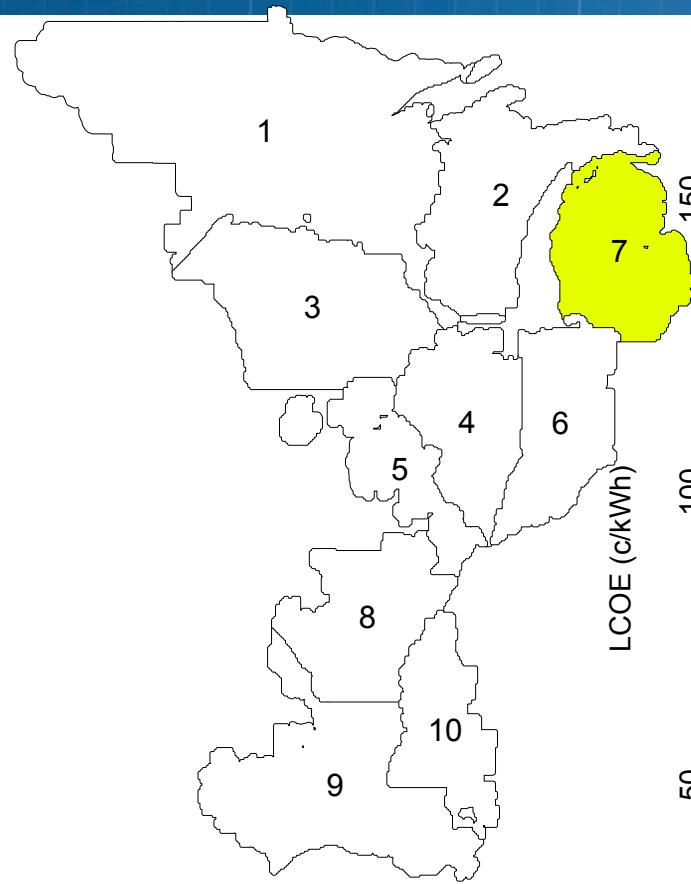
Consider LRZ 7
2025, low technological
development, PV
alone, no overbuild



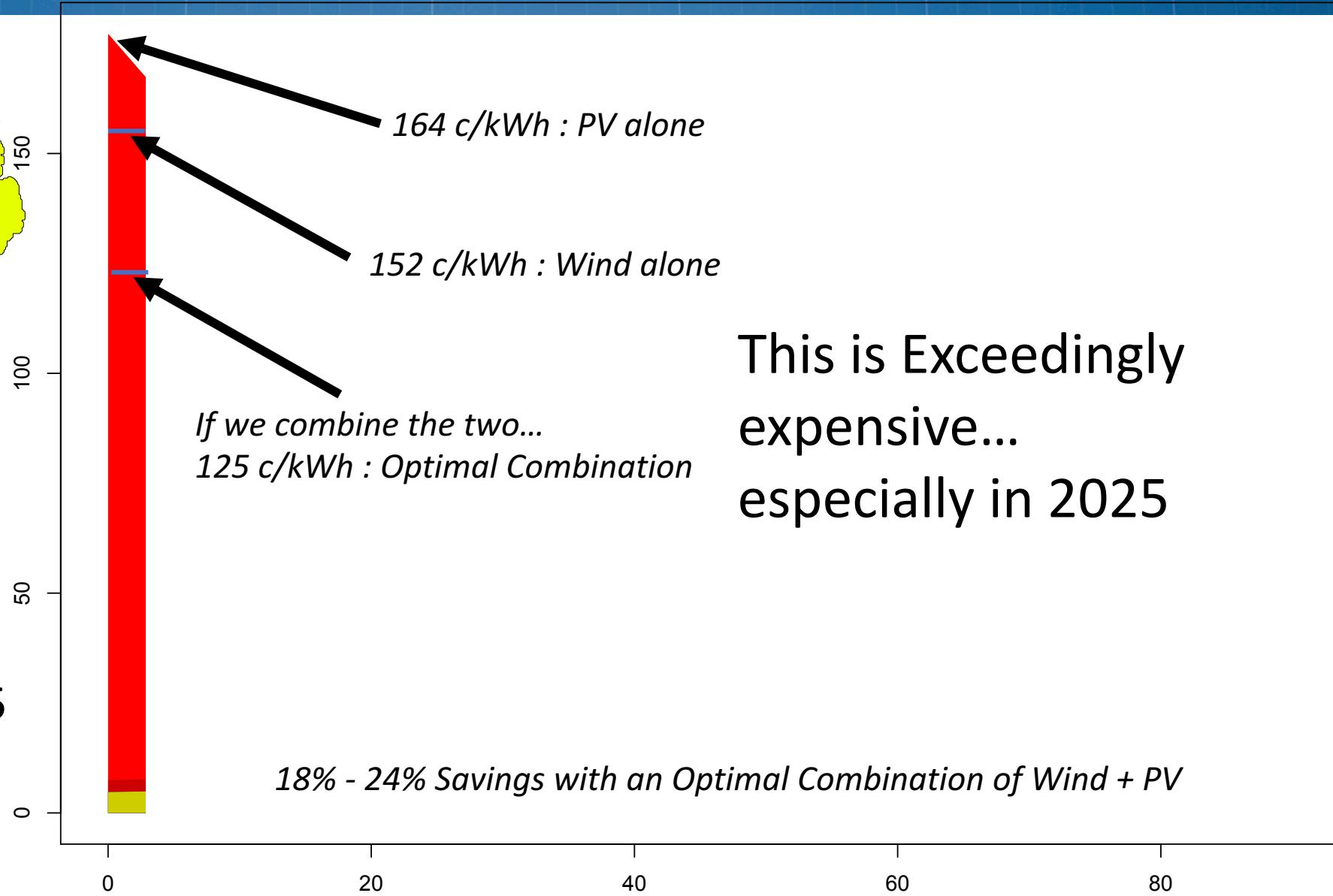


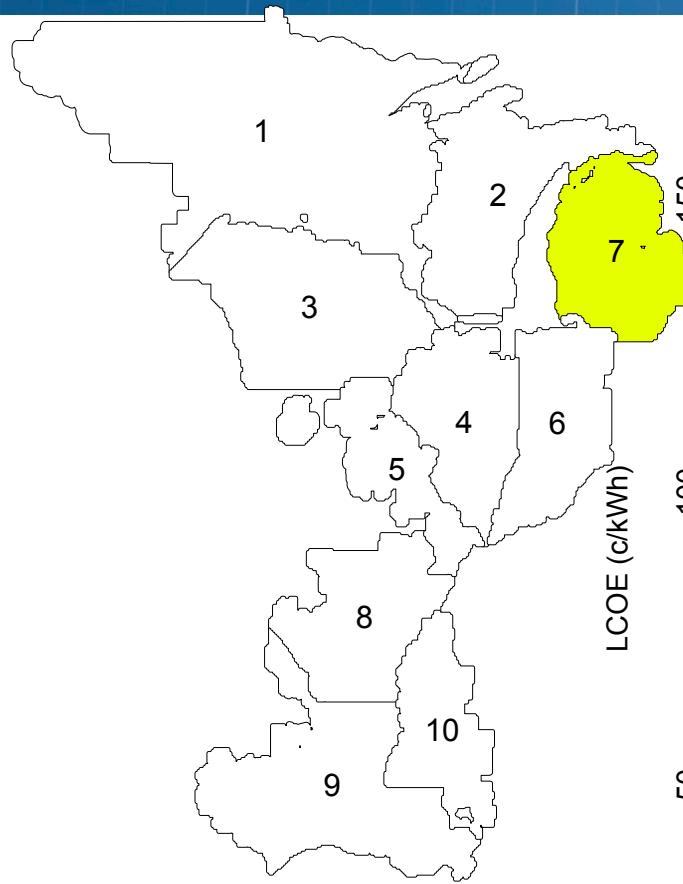
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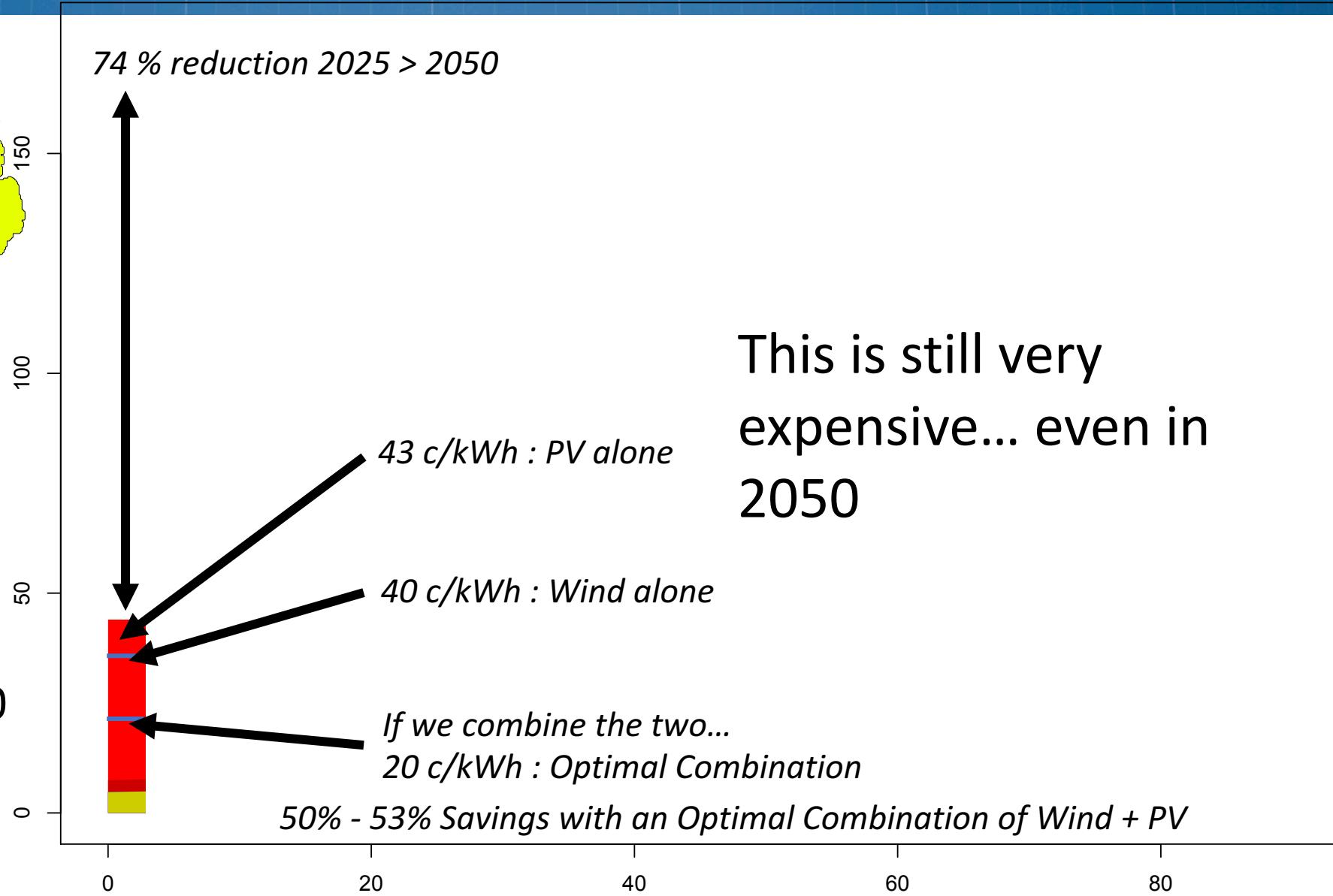


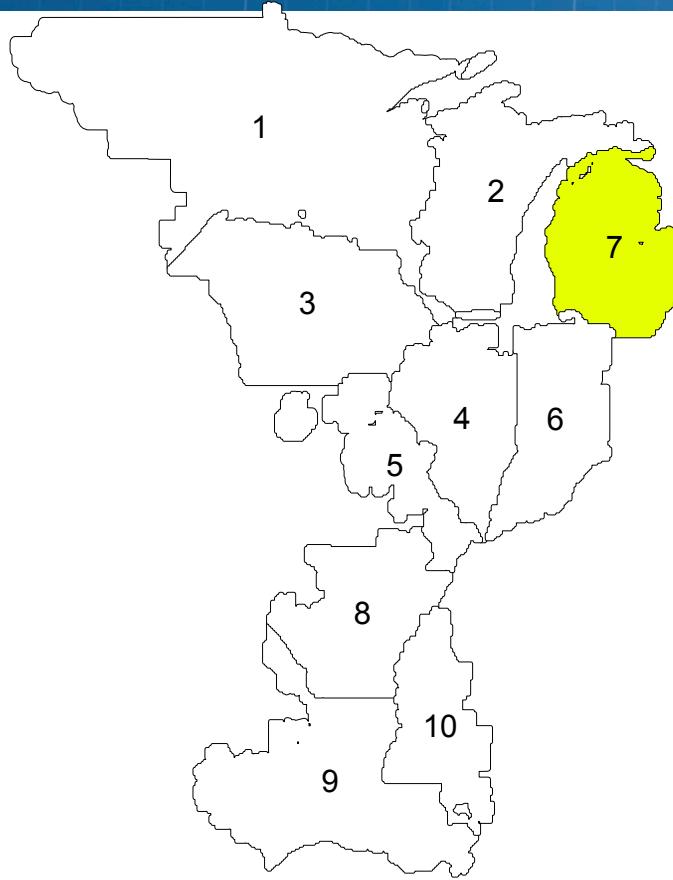
Consider LRZ 7 2025



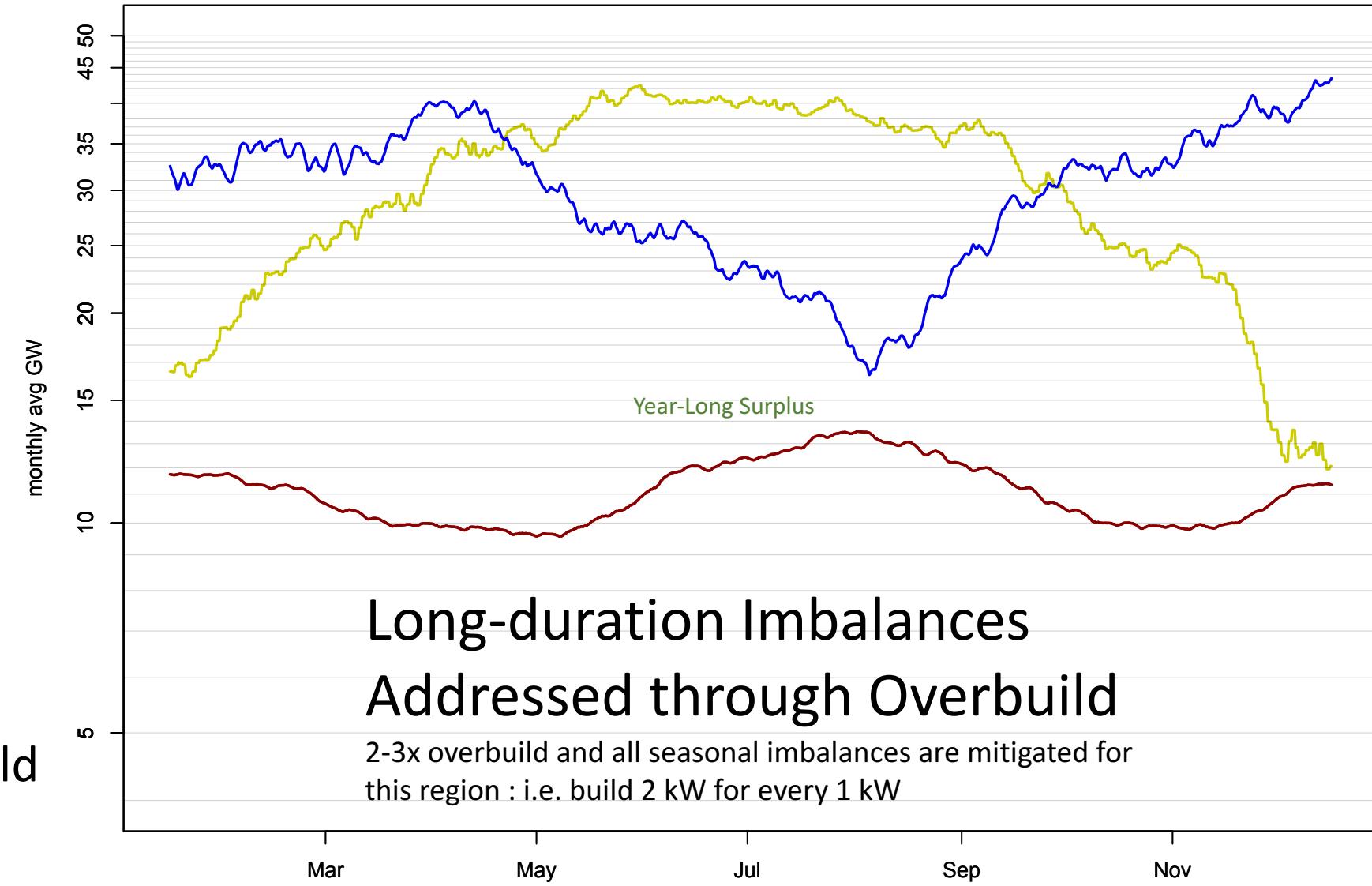


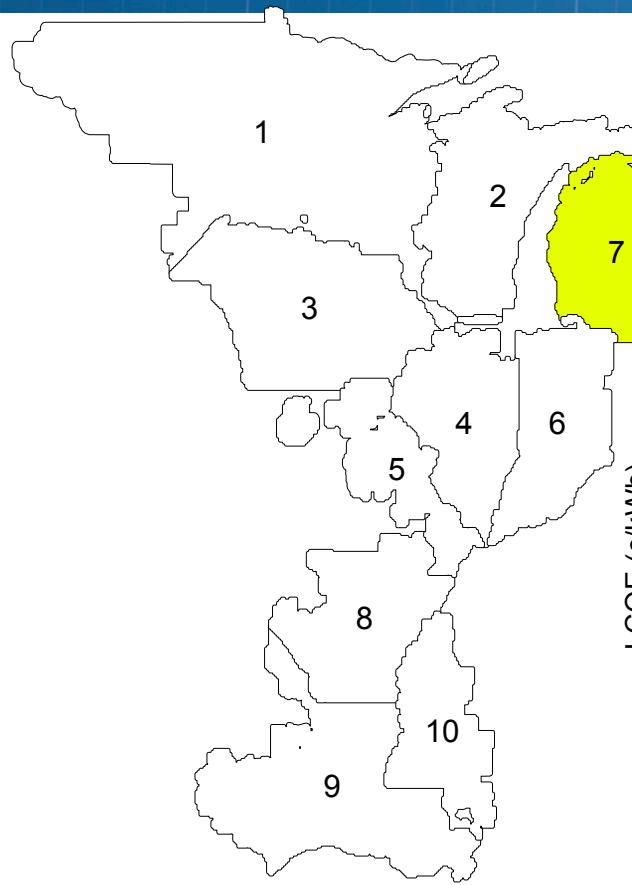
Consider LRZ 7 2050



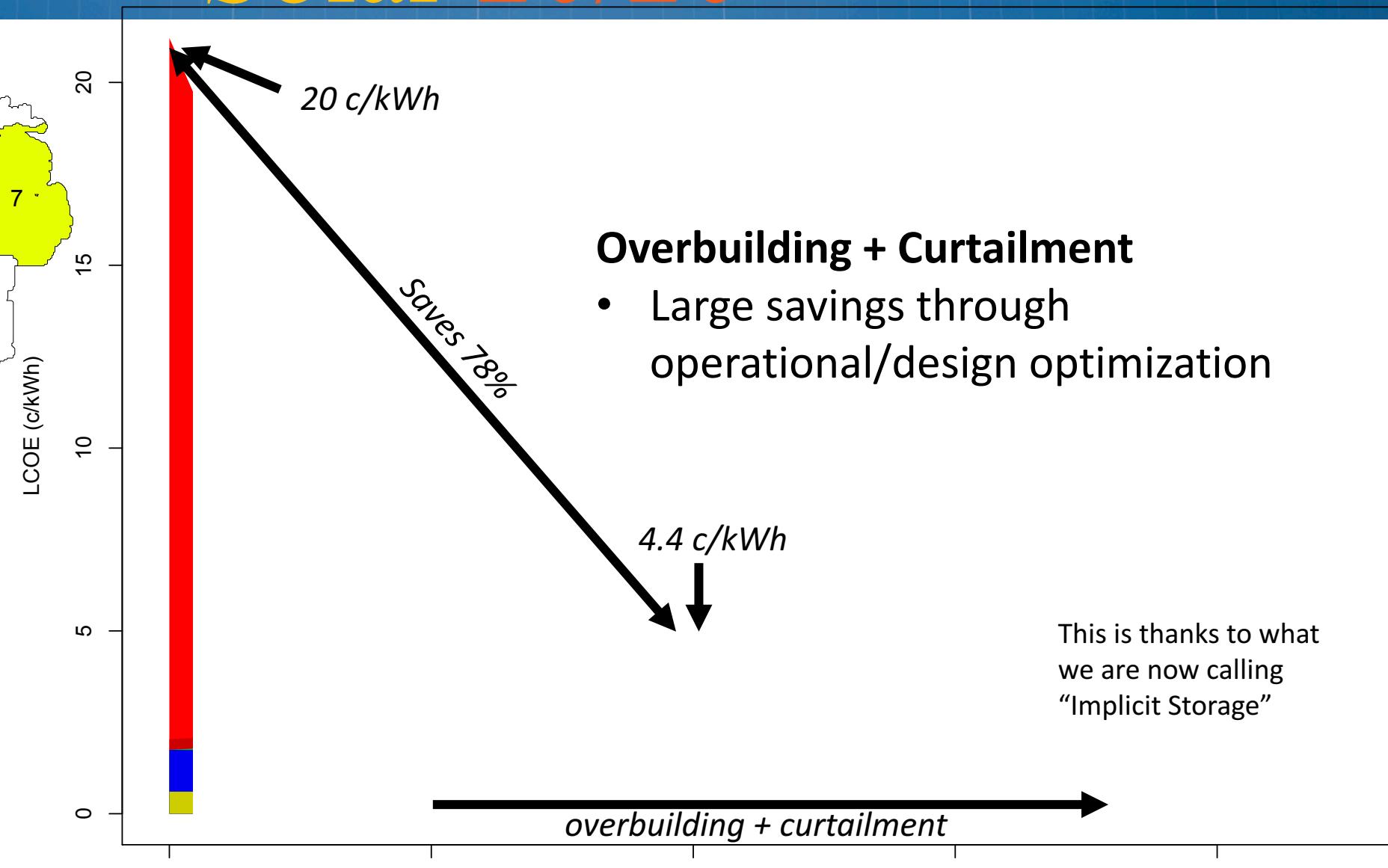


Consider LRZ 7
2025, Optimal Overbuild



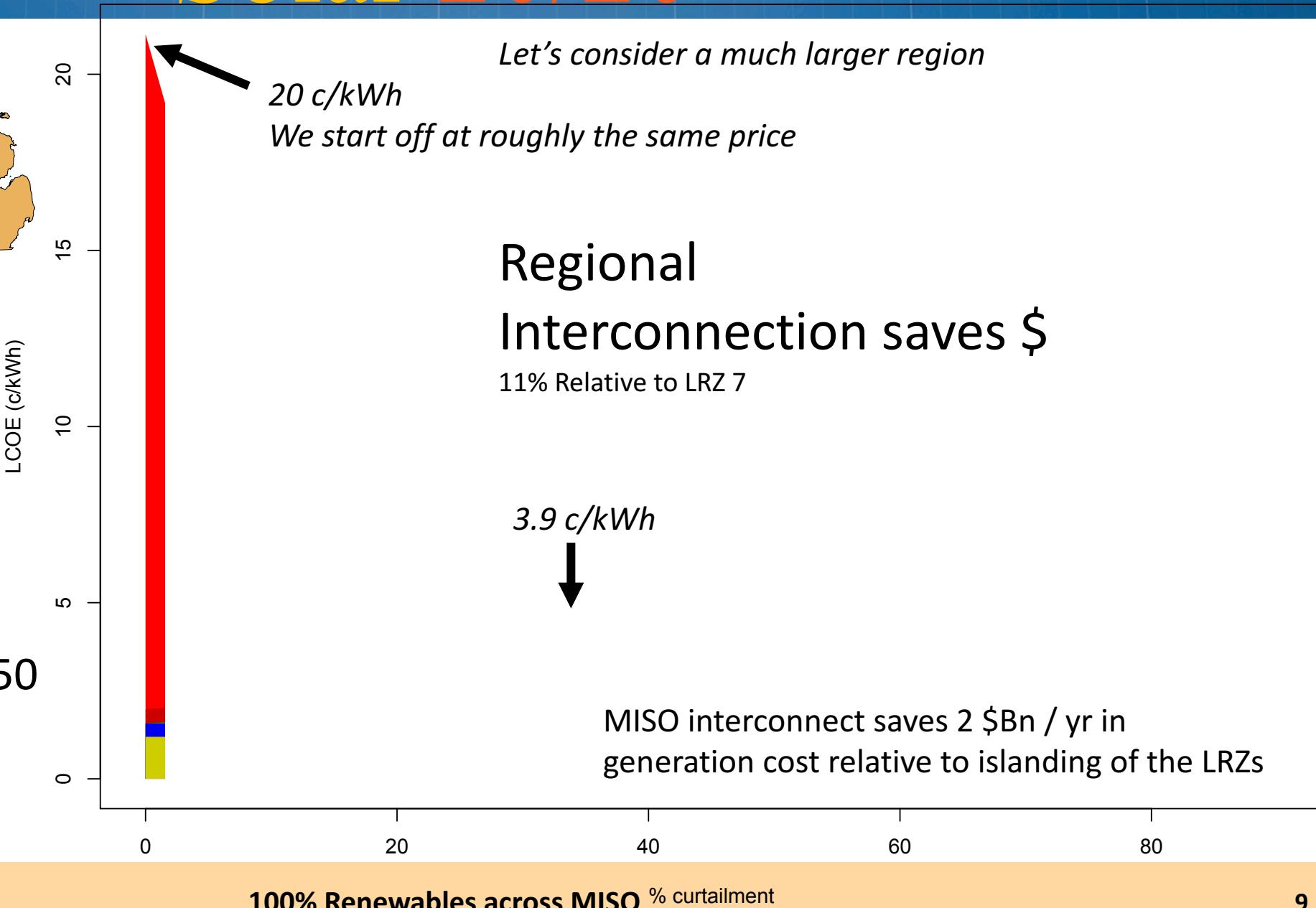


2050





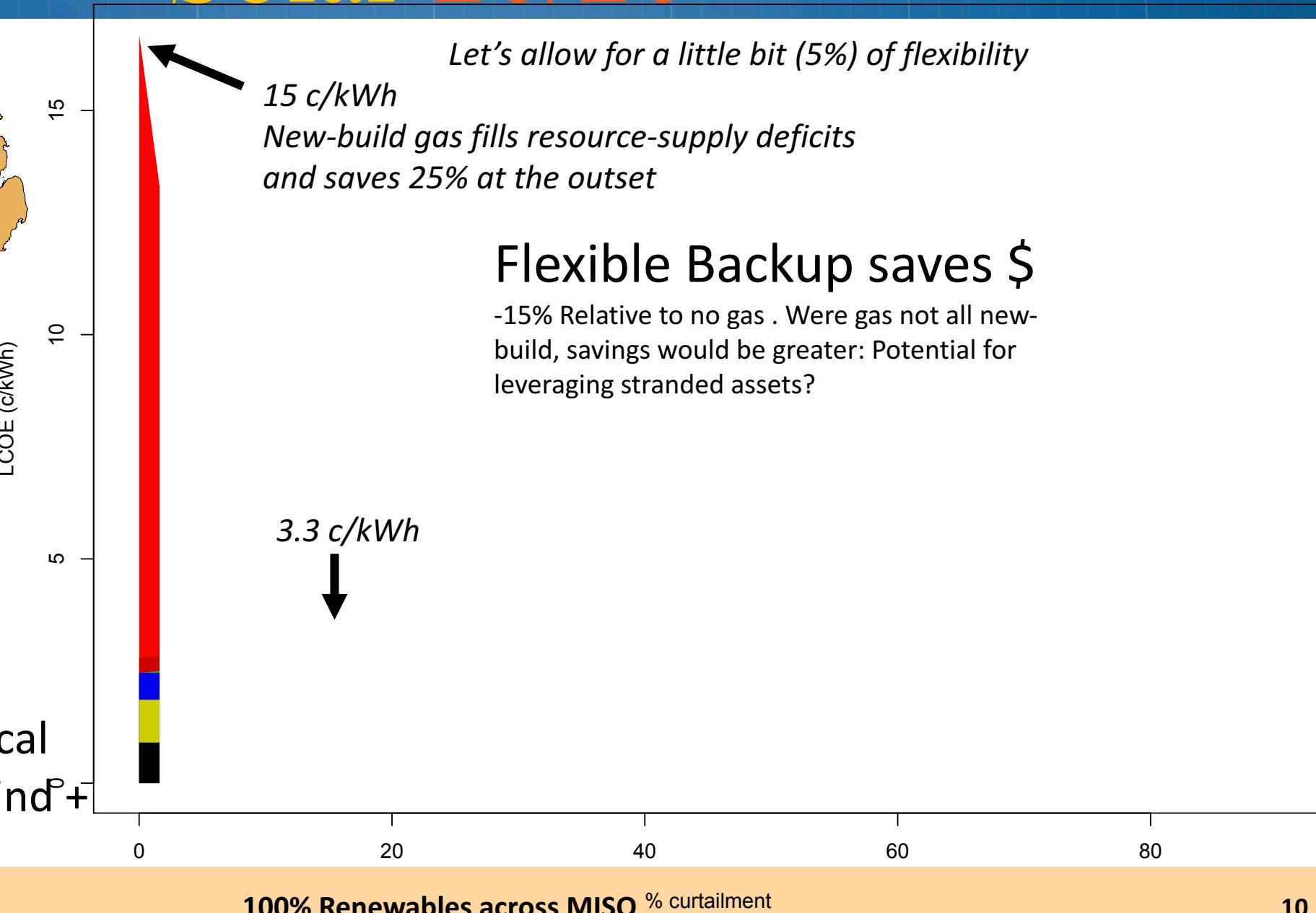
Consider MISO 2050





Consider MISO

2050, high technological development, 95% Wind^{P+}
PV, 5% new-build gas

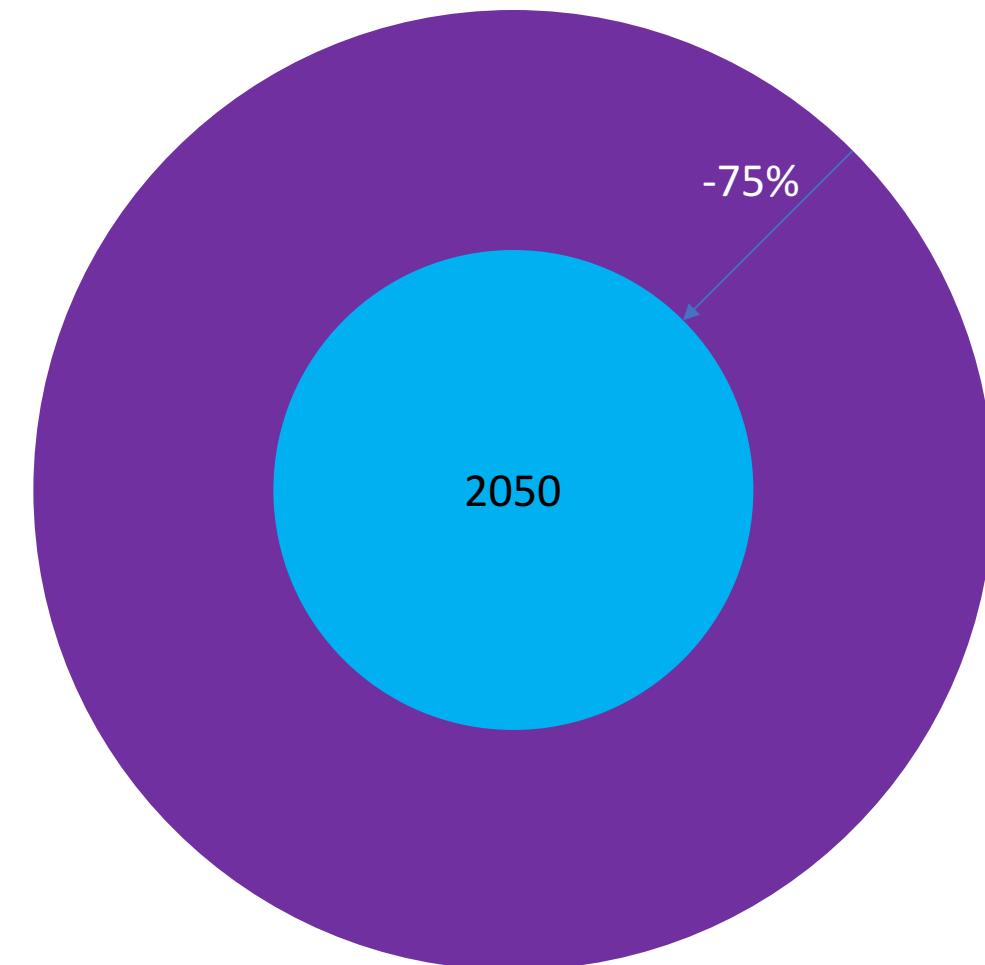




2025

-75%

2050



Key Takeaways

- **The Impacts of Cost** Technological costs change the LCOEs and the technological mix:
 - Raise wind cost relative to PV cost, decrease optimal wind percentage
 - Raise storage cost relative to renewables, increase implicit storage use
 - Confidence and consensus surrounding cost will help solidify the planning process

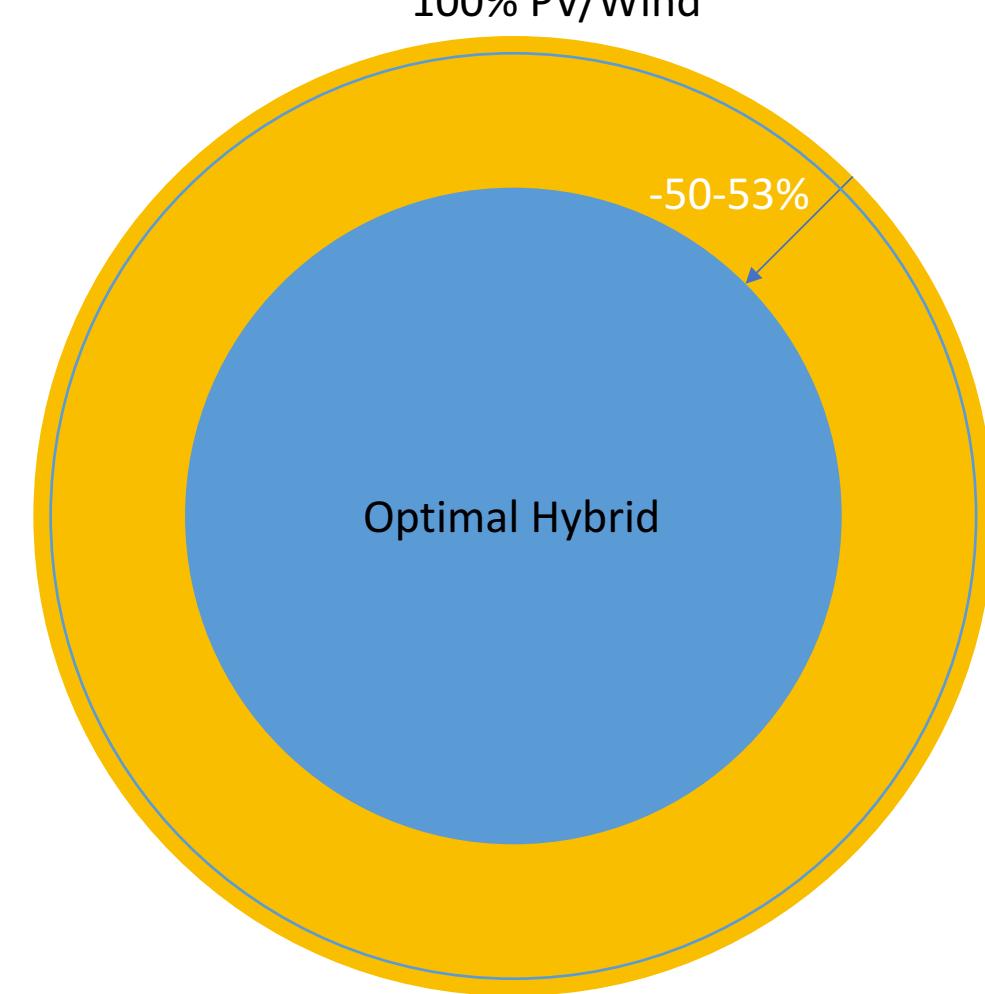
150+ c/kWh > 40 c/kWh



100% PV/Wind

-50-53%

Optimal Hybrid



40 c/kWh > 20 c/kWh

Key Takeaways

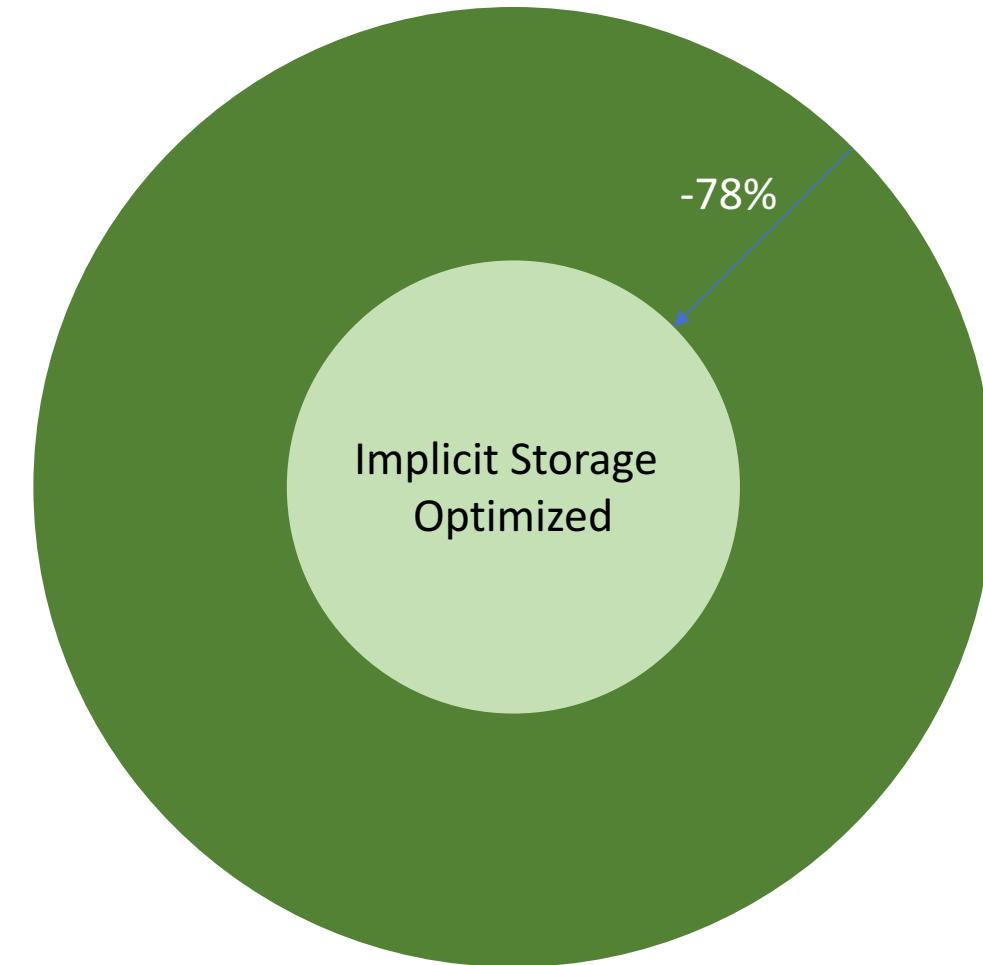
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- **The Value of Hybridizing Wind+PV** Wind + PV hybrid resourcing is significantly cheaper than either alone due to seasonal resource anticorrelations, even in areas that have a dominant resource.



No Implicit Storage

Implicit Storage
Optimized

-78%



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- **The Value of Implicit Storage** Implicit Storage (Overbuilding + Curtailment) is highly cost-effective in every case

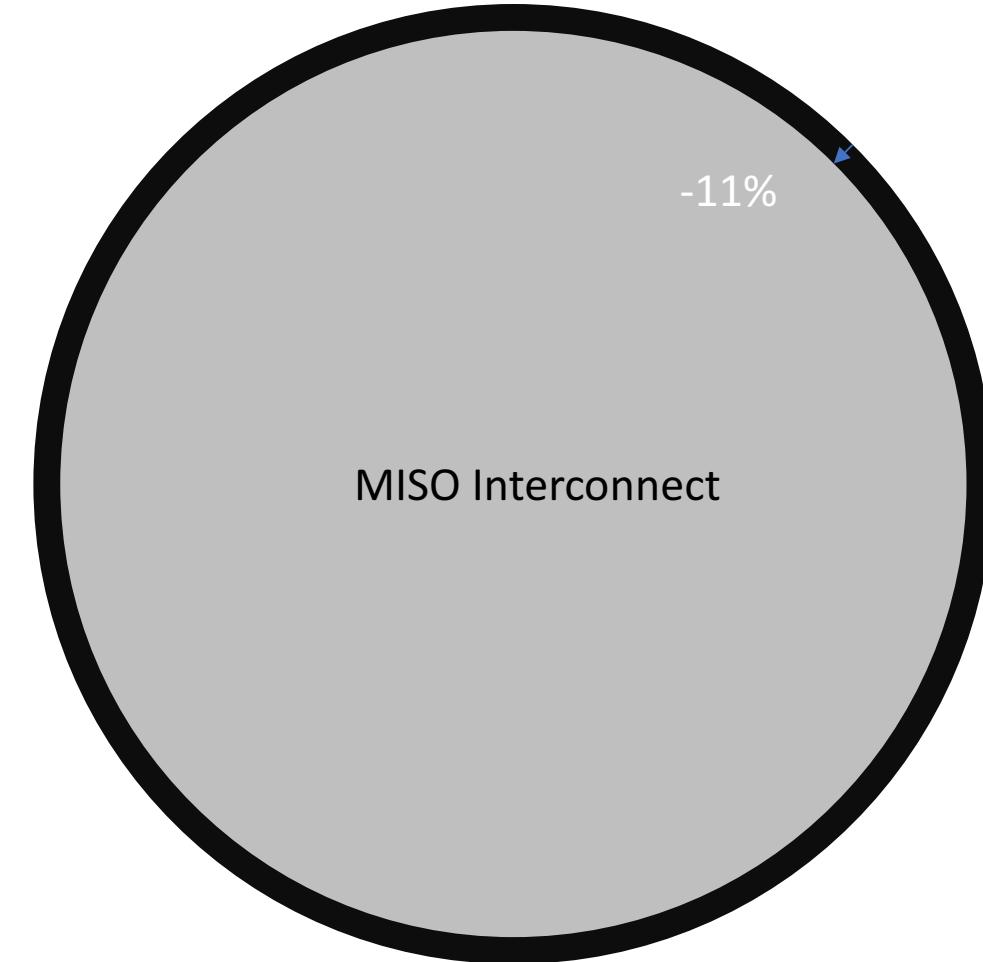
20 c/kWh > 4.4 c/kWh



Isolated Regions

-11%

MISO Interconnect



Key Takeaways

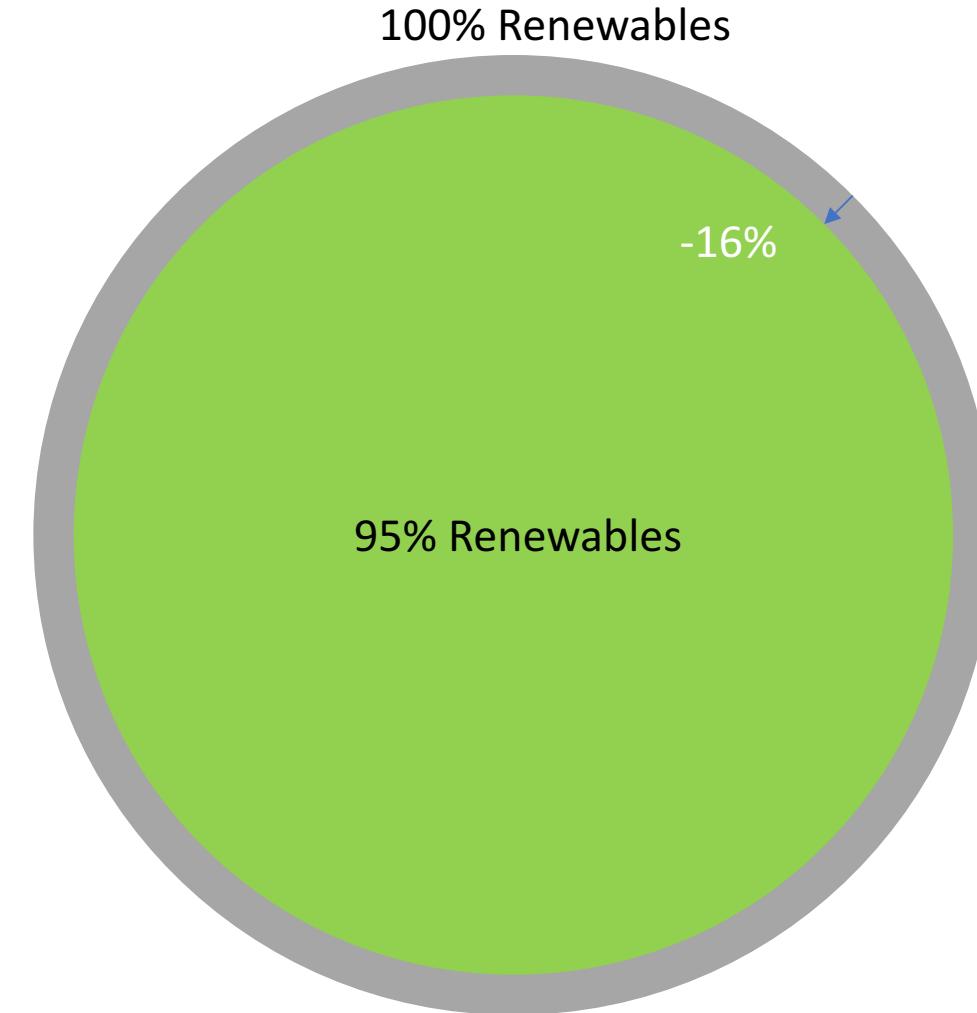
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- **The Value of Implicit Storage** Implicit Storage (Overbuilding + Curtailment) is highly cost-effective in every case
- **The Value of MISO** The larger the region we interconnect across, the lower the aggregate cost. On the whole this will save ratepayers billions annually.



100% Renewables

-16%

95% Renewables

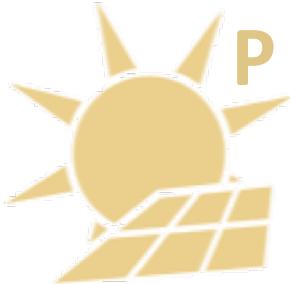


3.9 c/kWh > 3.3 c/kWh

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- **The Value of Implicit Storage** Implicit Storage (Overbuilding + Curtailment) is highly cost-effective in every case
- **The Value of MISO** The larger the region we interconnect across, the lower the aggregate cost. On the whole this will save ratepayers billions annually.
- **95% Renewables is significantly cheaper** Allowing 5% gas or some other dispatchable gas to perform some of the work otherwise done by storage (both implicit and real). It may also be more acceptable as it correspondingly reduces the amount of optimal curtailment.

100%  MISO Load



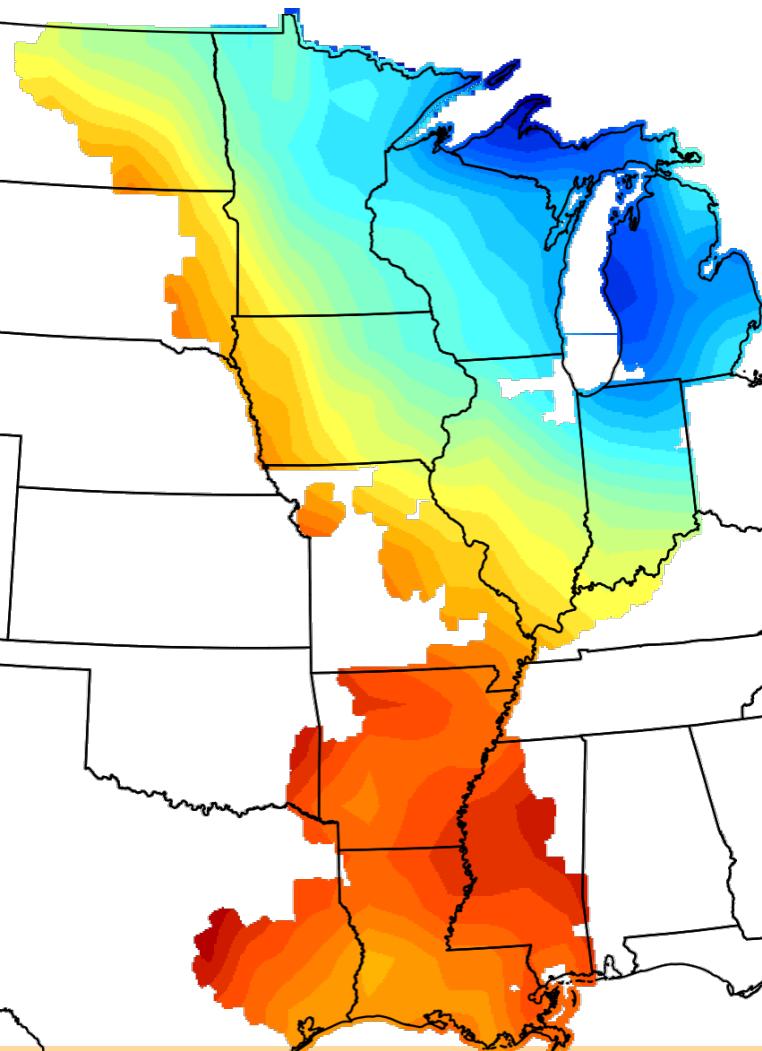
30% Wind 65% Solar 5% Gas

3.5 c/kWh

Not bad!



MN Solar Pathways Project: 3-year DoE-SETO-funded project administered by the MN DoC with the following stakeholders:



Core Team



Technical Committee



Technical Analysis

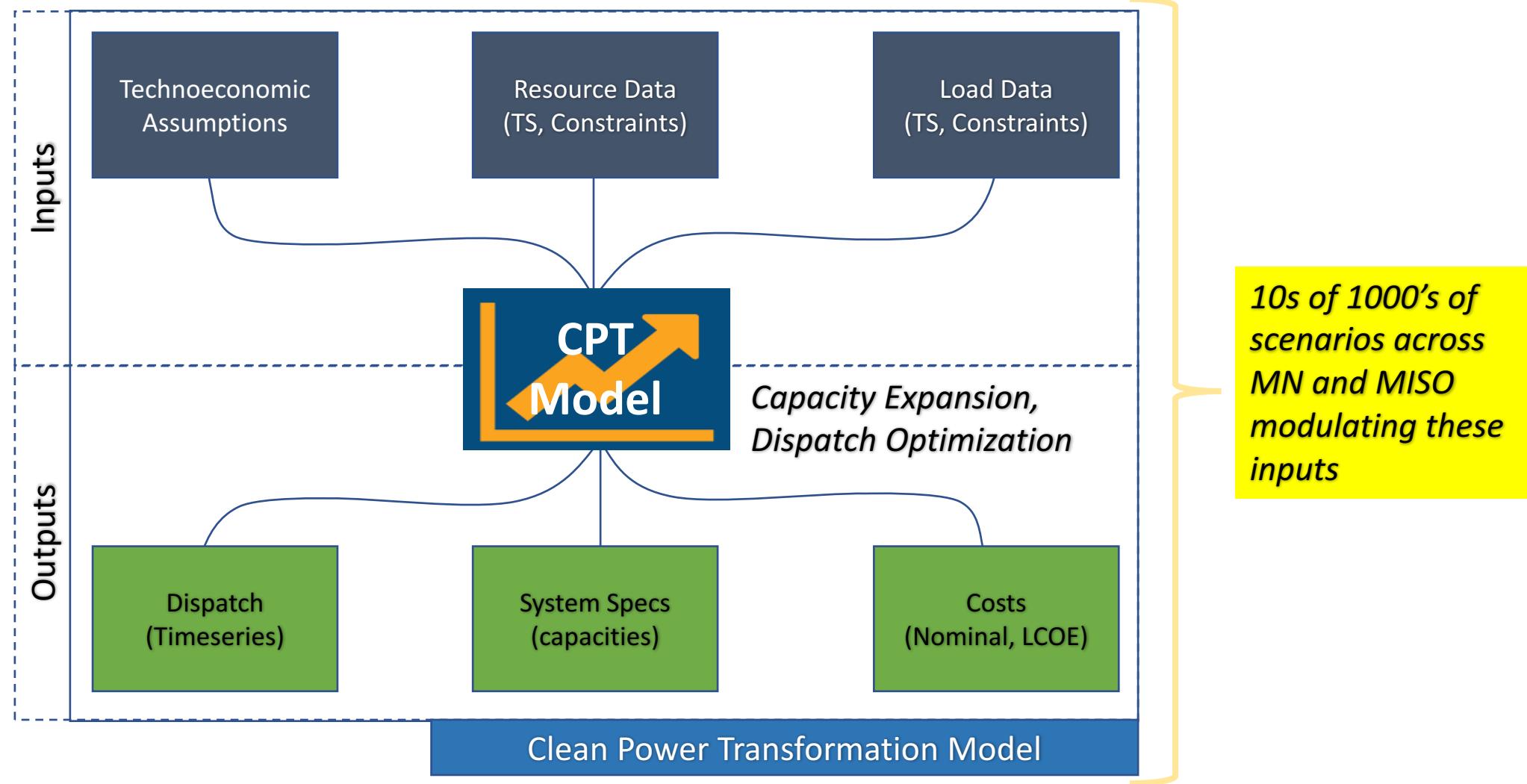


Disclaimers

- DoE EERE-SETO funding under DE-EE00007669
- Views expressed do not necessarily reflect those of SETO or any agency of the US Govt



A scenario-based capacity expansion and dispatch optimization model with \$-minimization as a prerogative





Resources to dive into results

Results Website / Report



<http://mnsolarpathways.org/spa/>



<http://mnsolarpathways.org/miso-spa/>

ShinyApps Dashboard

[Link](#)

[Link](#)

Let's dive into a sample of the recent results to build an understanding of what we have done



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