Transmission in an era of Distributed Energy Resources

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ENERGY SYSTEMS INTEGRATION GROUP

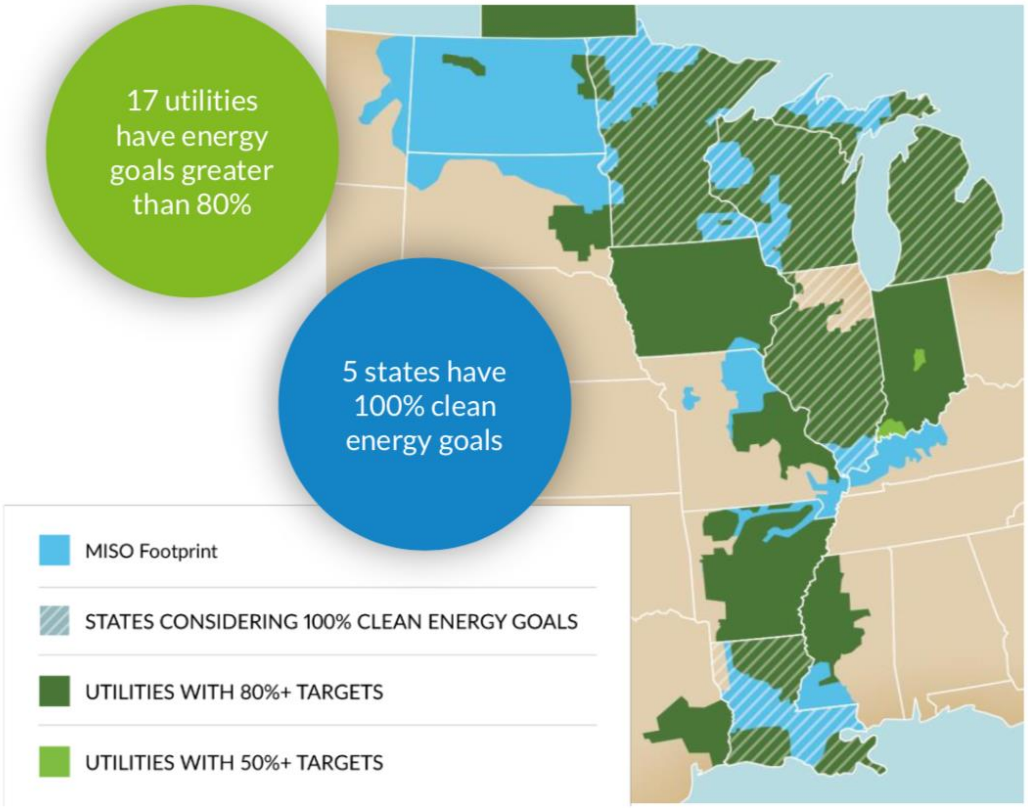
How do states consider transmission in an era of DERs?

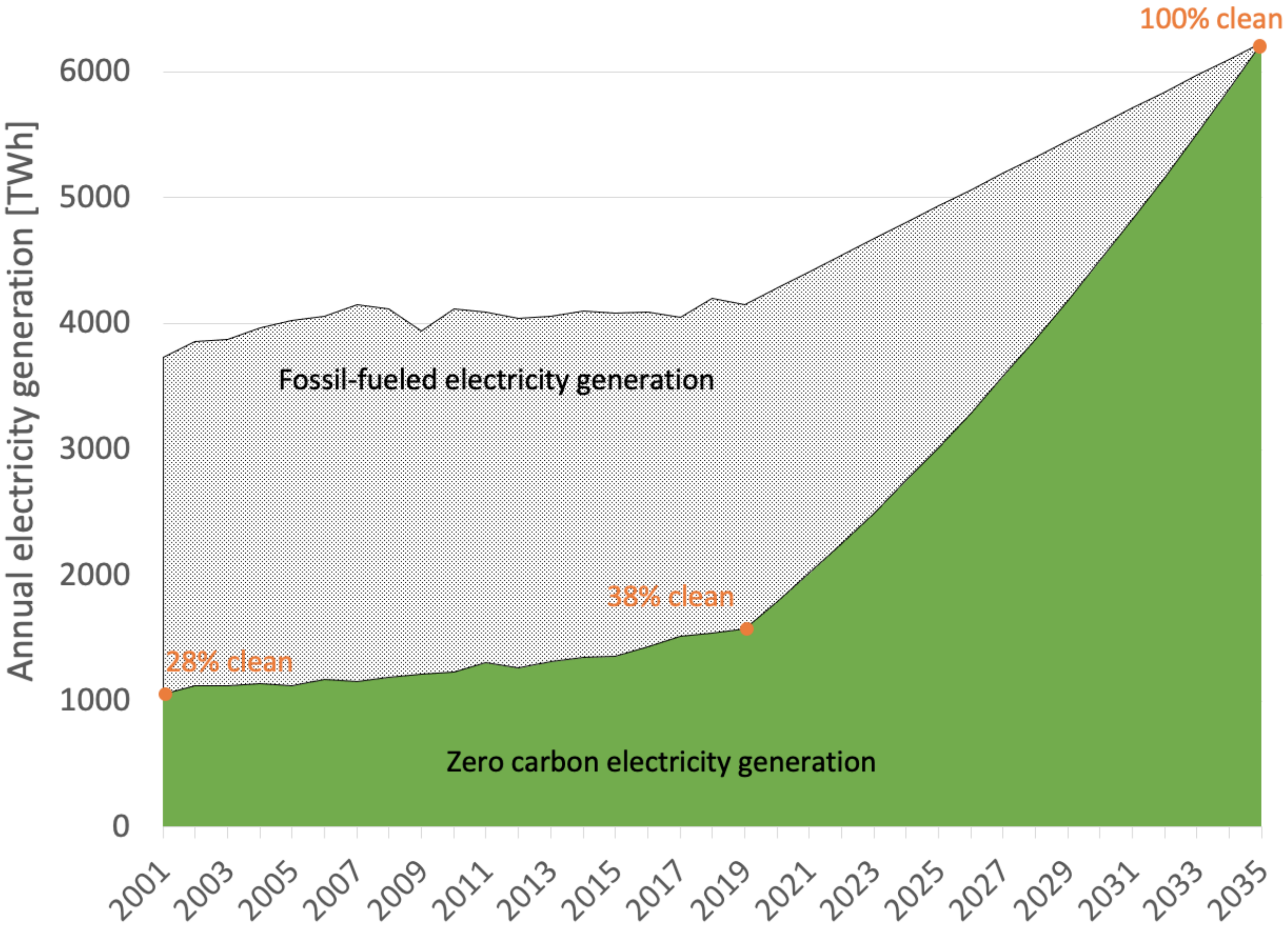
- If we want to maximize use of local renewables, do we need additional transmission to other states/regions?
- If our state is planning a high level of distributed energy resources (DERs), do we still need to build significant transmission?
- When and how can DERs substitute for transmission?
- What are the transmission needs of a clean energy future?

How can we enable cleaner electricity while maintaining affordability and reliability?

The scale of the clean energy challenge is significant

- There are numerous states, utilities, cities and corporations that have 100% clean goals.
- Biden's goals of 100% clean electricity by 2035 and 100% clean energy by 2050





https://cdn.misoenergy.org/20210211%20RECBWG%20Item%2002%20Long%20Range%20Transmission%20Planning%20Update520801.pdf

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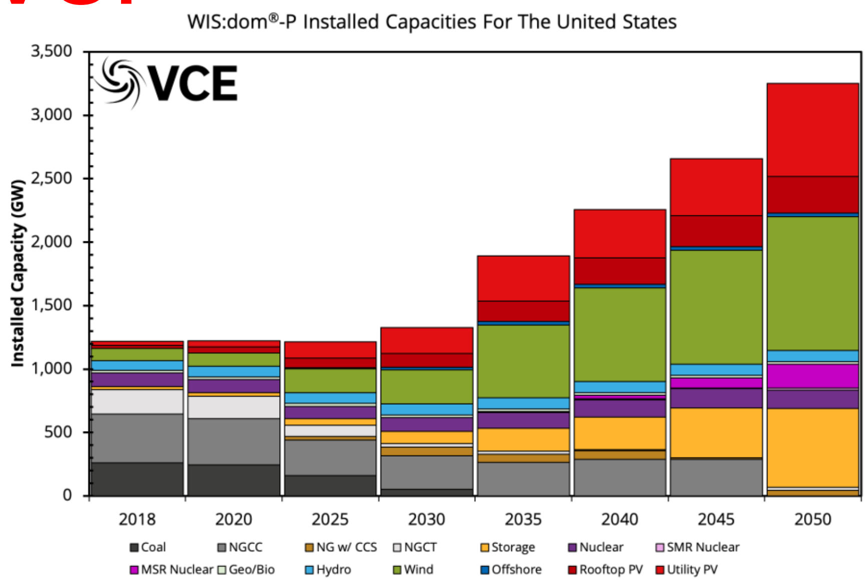
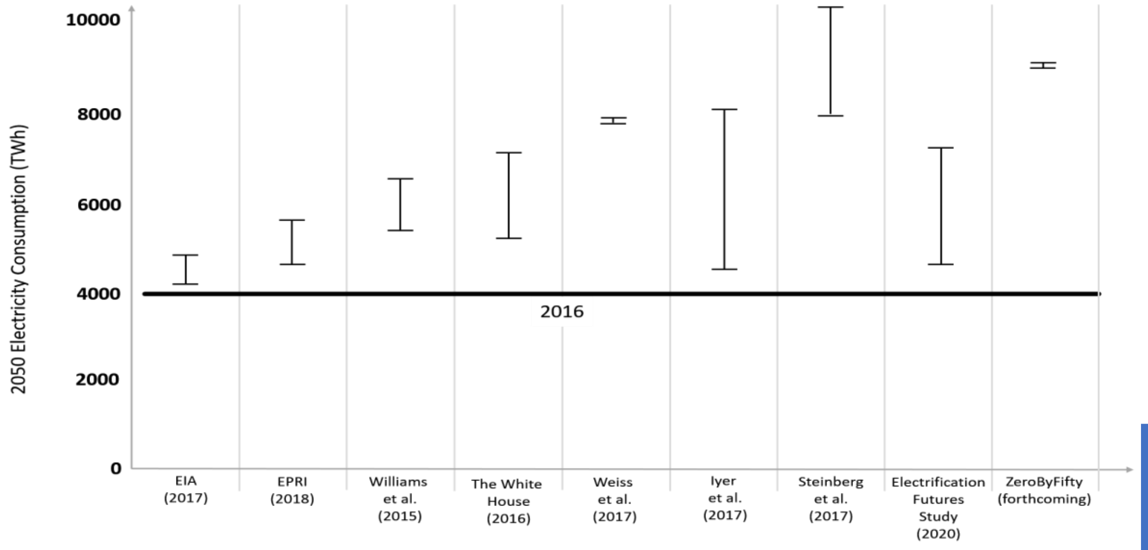
We need transmission to deliver significant resources

- Accessing the large levels of resources needed
- Electrification will lead to significantly increased demand
- DERs will contribute but are insufficient on their own to supply the increased demand





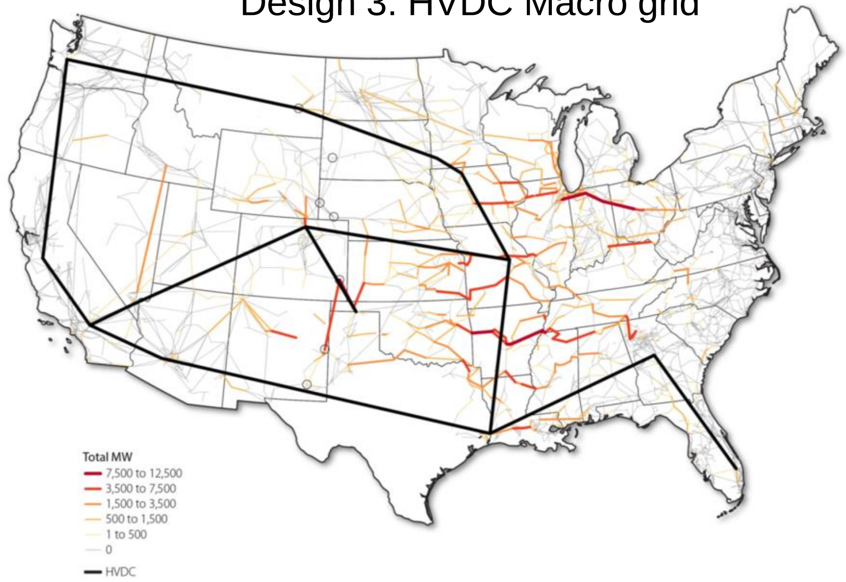
MISO RIIA 100% buildout [MW]			
	DPV	UPV	wind
MISO	32,190	67,975	129,647
SPP	8,139	14,700	41,750
TVA	40,174	85,275	7,300
SERC	85,119	180,825	15,250
PJM	41,174	93,100	185,600
NYISO	8,483	19,675	31,600

Source: MISO RIIA Study, Preliminary results from VCE's ZeroByFifty Study, NREL Electrification Futures Study

Interconnections Seam Study

- What's the value of interconnecting the east and west?
- Crossing the seam allows you to build the solar in the west and the wind in the east and share
- 50% renewables case: macro grid adds $19B to transmission costs but saves $48B (generation capacity, O&M and emissions), for a benefit/cost ratio of 2.5
- 85% renewables case (95% clean electricity): macro grid builds 40GW transfers across seam with a benefit/cost ratio of 2.9

Design 3: HVDC Macro grid

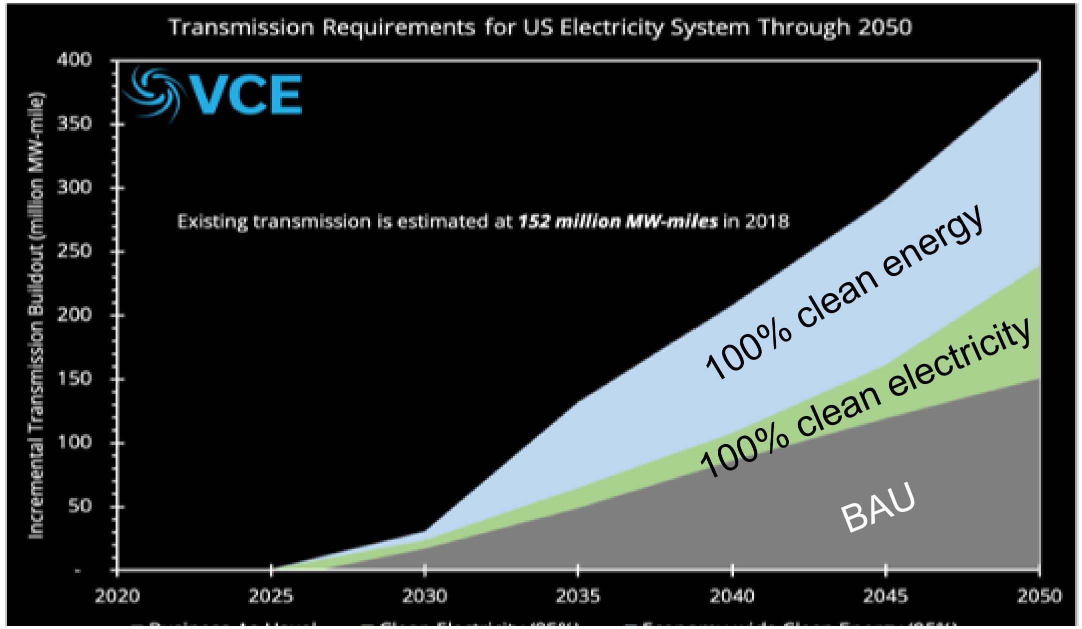


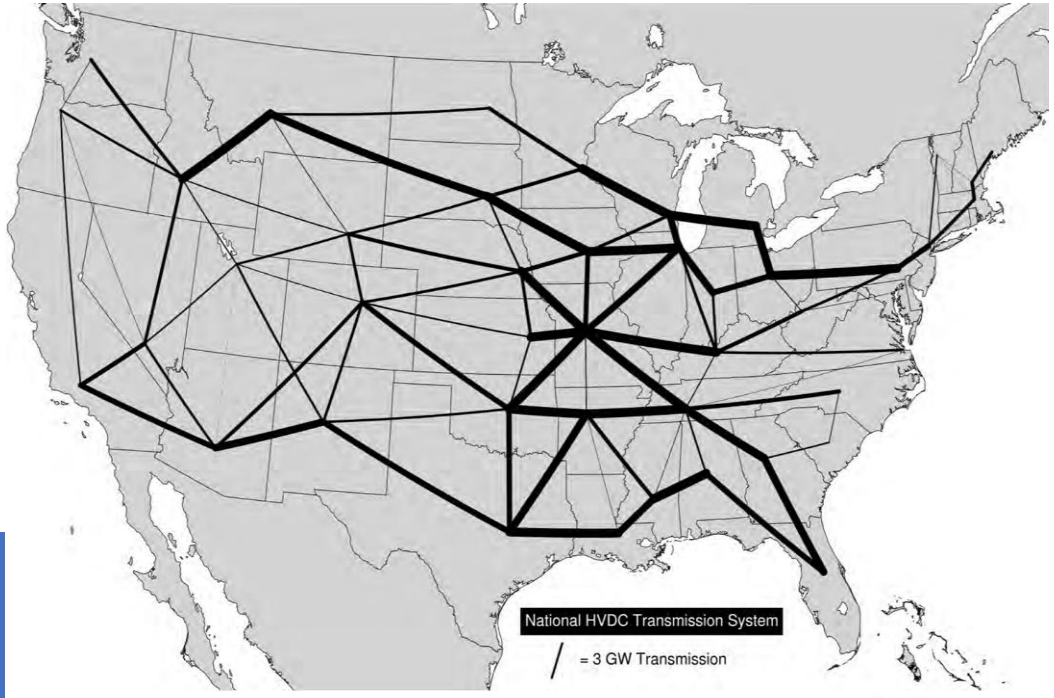
50% Renewables case	BAU across seams	HVDC Macro grid	
Objective function	**Design 1**	**Design 3**	**Delta**
Line investment (B$)	61.21	80.10	18.89
Generation investment (B$)	704.03	700.51	-3.52
Operation and maintenance (B$)	1336.36	1300.70	-35.66
Emission cost (B$)	171.10	162.50	-8.60
35-yr B/C ratio	-	-	2.52

https://www.nrel.gov/analysis/seams.html

ZeroByFifty

- What is the optimal resource and transmission expansion to decarbonize the whole energy economy including massive electrification?
- Considers widespread DERs, new nuclear, CCS, and hydrogen
- Co-optimize generation (utility-scale and distributed), storage and transmission; combines capacity expansion and production simulation
- Finds that if a macro grid is NOT built, it costs an additional $1 Trillion to get to 100% clean energy by 2050

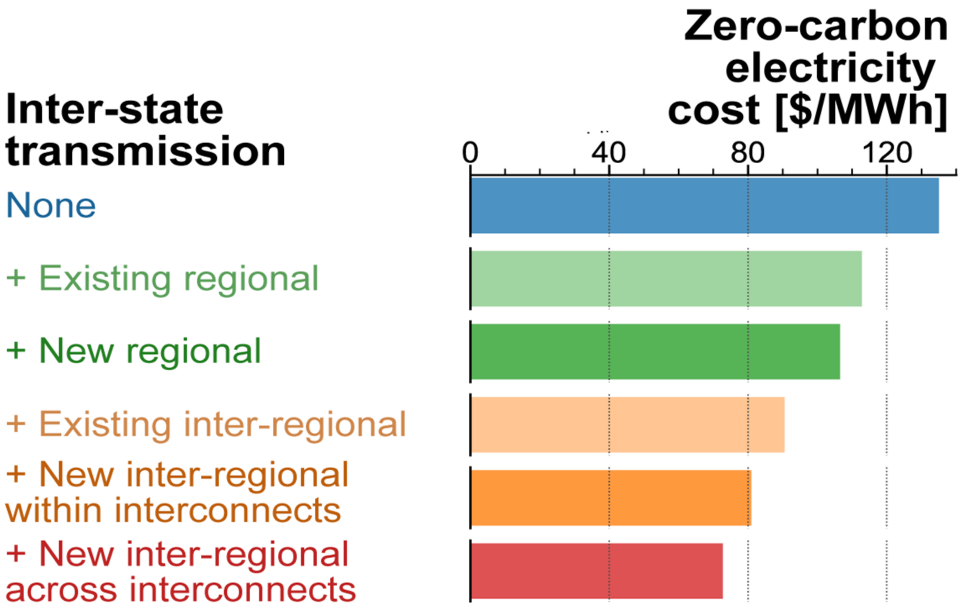


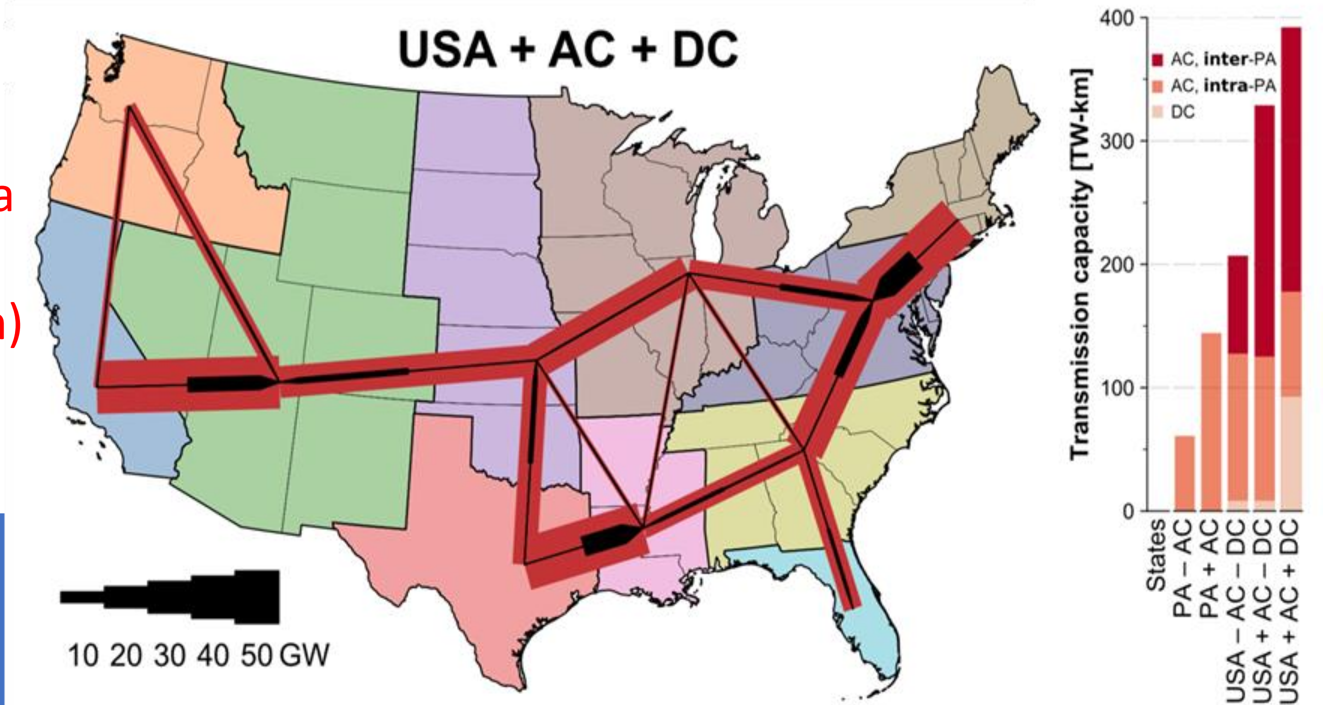


https://www.vibrantcleanenergy.com/wp-content/uploads/2020/11/ESIG_VCE_11112020.pdf

MIT Study - Value of Transmission for Decarbonization

- What is the value of coordination within regions, between regions and nationally?
- Co-optimized capacity expansion and dispatch model with 7 years of hourly weather
- Least-cost plan results in nearly double today's transmission system (in MW-miles) with 40 GW transfers between east and west and 70 GW between ERCOT and east
- Finds that an "every state for itself" approach has a levelized capital and O&M cost of $135/MWh and that this cost can be reduced by 46% (to $73/MWh) with inter-regional coordination and transmission expansion

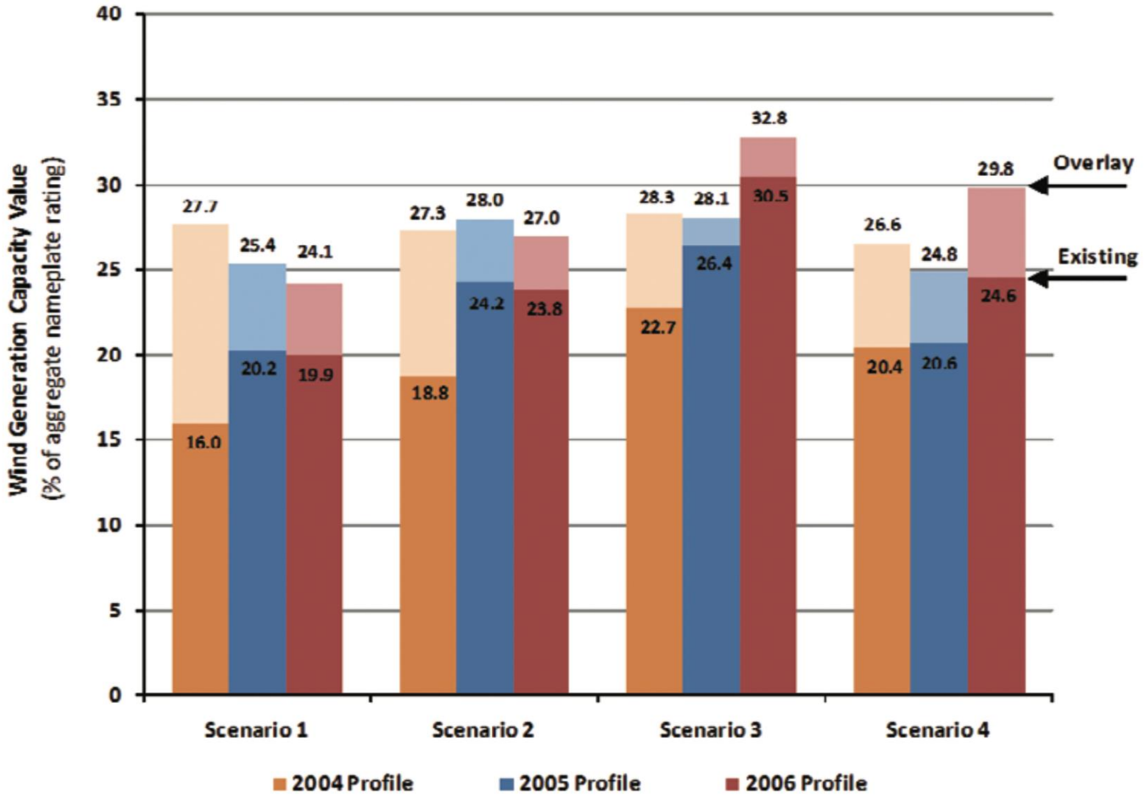


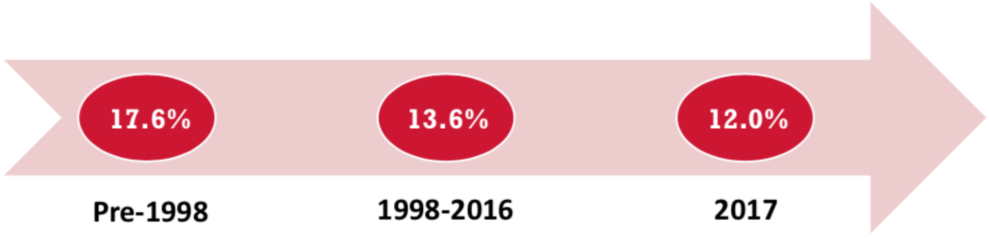


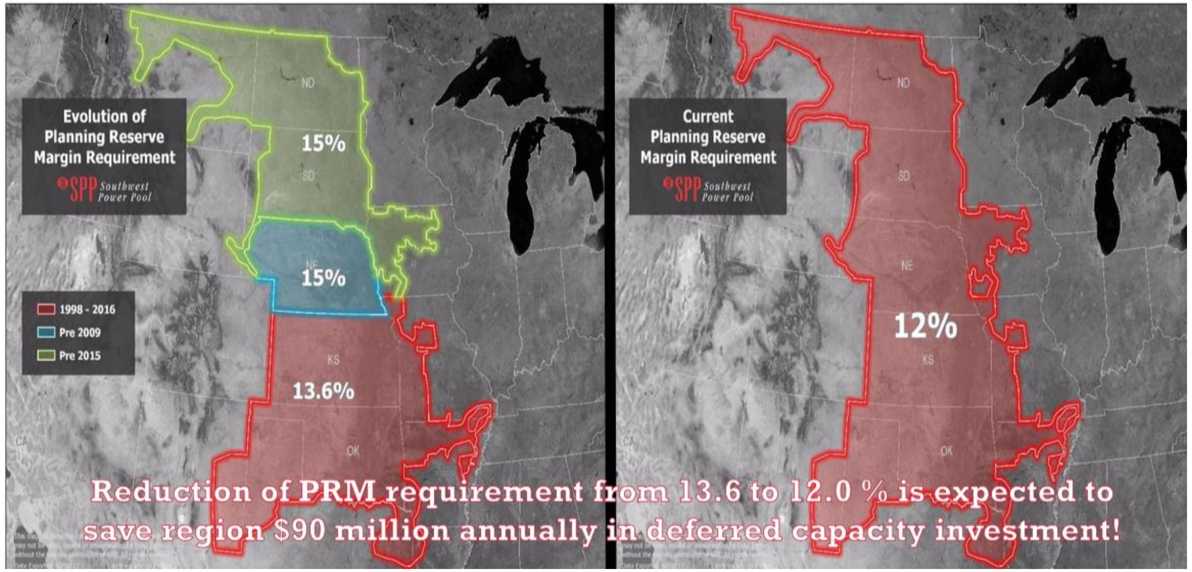
https://doi.org/10.1016/j.joule.2020.11.013

Transmission is not just about delivering resources to load

Transmission contributes to resource adequacy





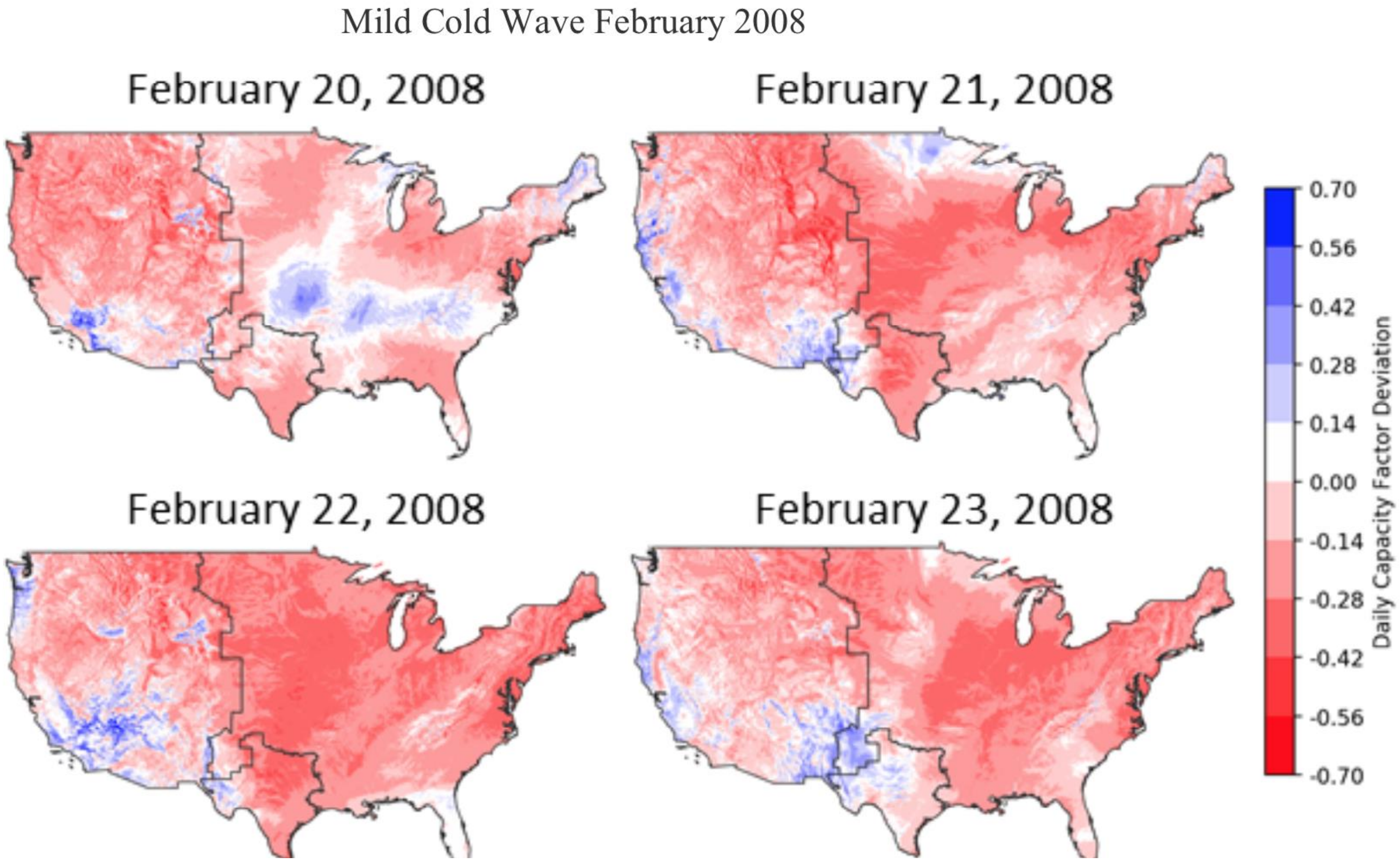


Transmission smooths all time scales of weather variability

Source: Enernex, EWITS, NREL/SR-550-47078, 2010; L. Nickell, SPP, CREPC Spring meeting, 2017

Challenging Weather Events

- Extreme weather isn't as challenging as benign conditions for high penetrations of wind and solar
- Cold waves can severely reduce wind availability
- Extreme events drive interchange and alter dispatch
- Study is still ongoing

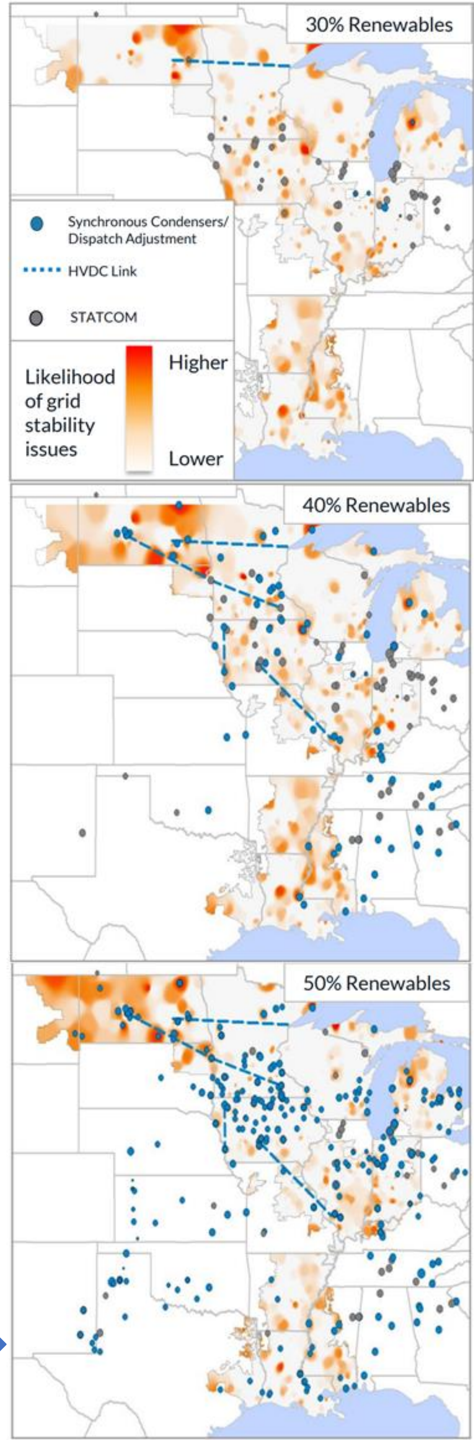


Source: Novacheck et al, "Extreme Weather Event Project", Nov 2020. Used with permission.

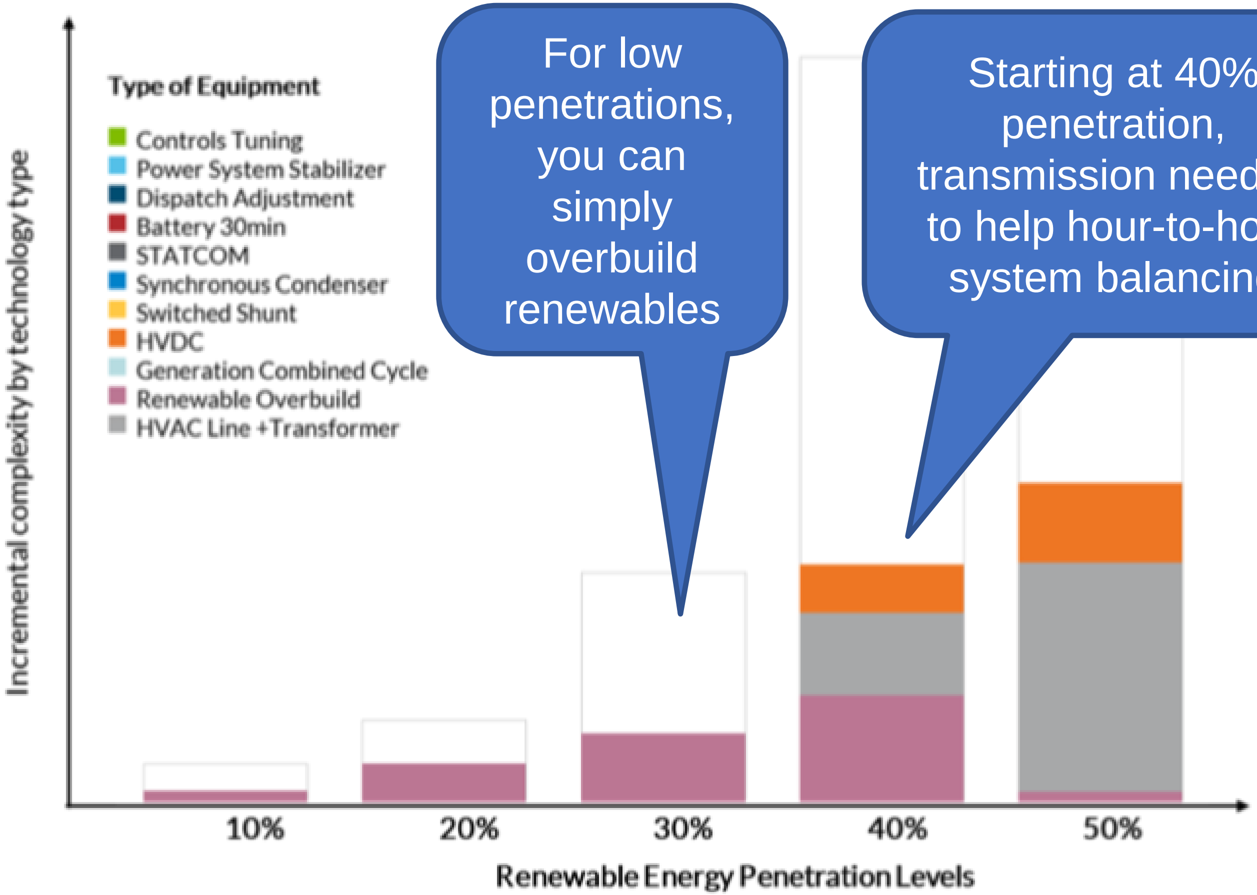
Renewable Integration Impact Assessment

- Resource and transmission expansion / Resource adequacy / System balancing / Steady-state stability / Dynamics – examines all aspects of system reliability
- Increase annual wind and PV penetration in 10% increments up to 100% for Eastern Interconnection
- At each increment, reliability issues are identified and fixed using least-cost, commercially available solutions

https://cdn.misoenergy.org/RIIA%20Summary%20Report520051.pdf



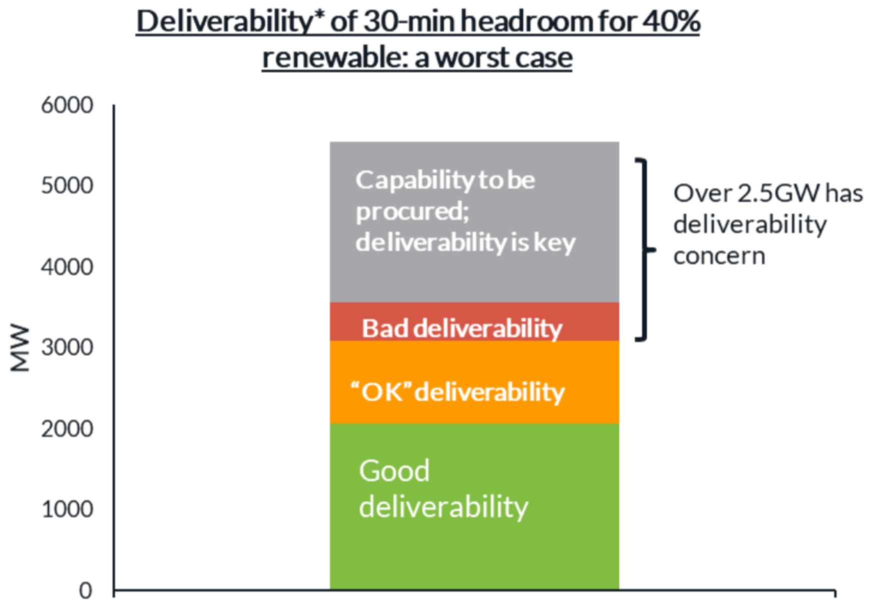
Transmission needed to help system balancing



For low penetrations, you can simply overbuild renewables

Starting at 40% penetration, transmission needed to help hour-to-hour system balancing

Transmission needed to deliver ancillary services



Transmission is critical to maximizing flexibility

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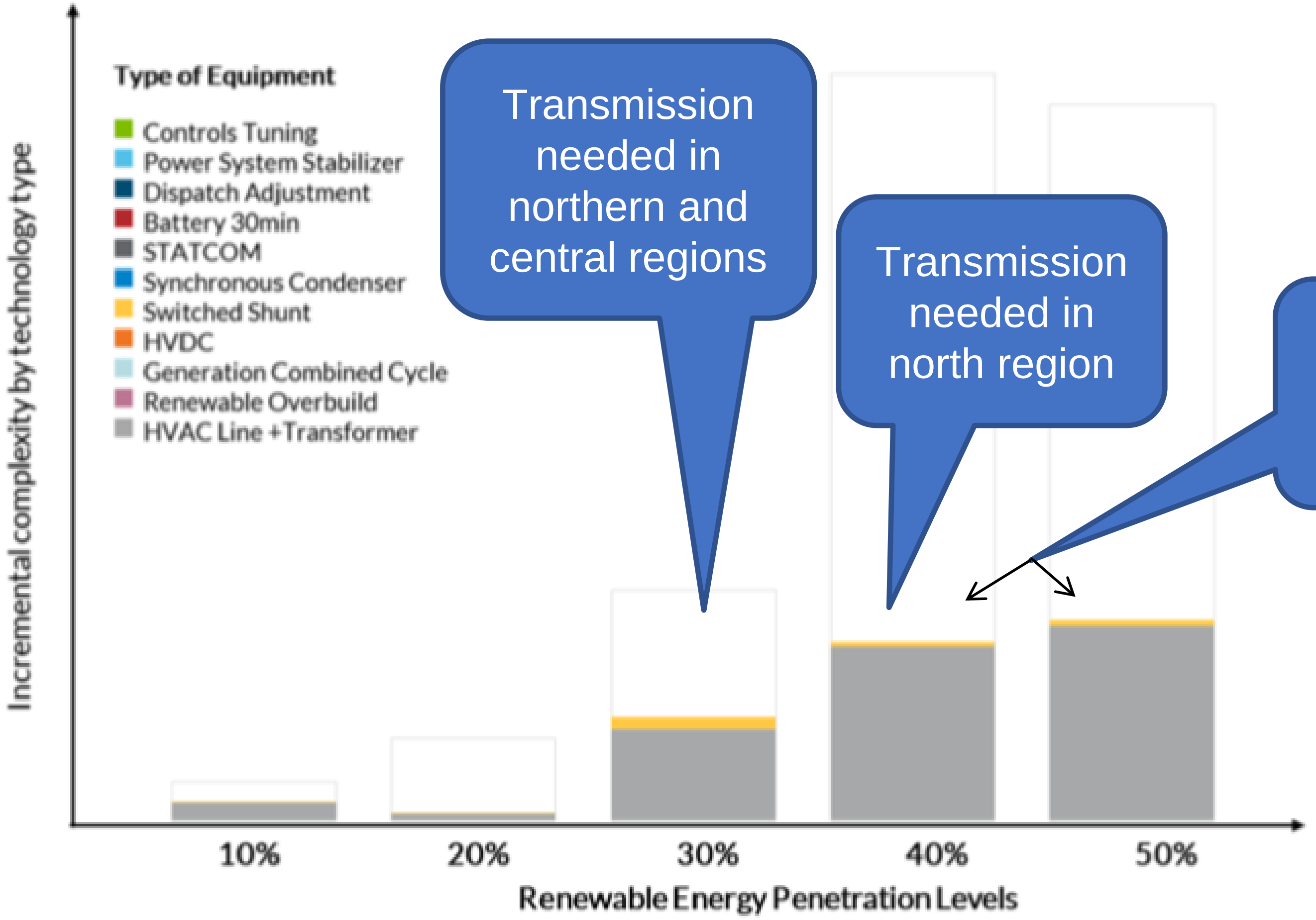
Transmission needed for steady-state reliability



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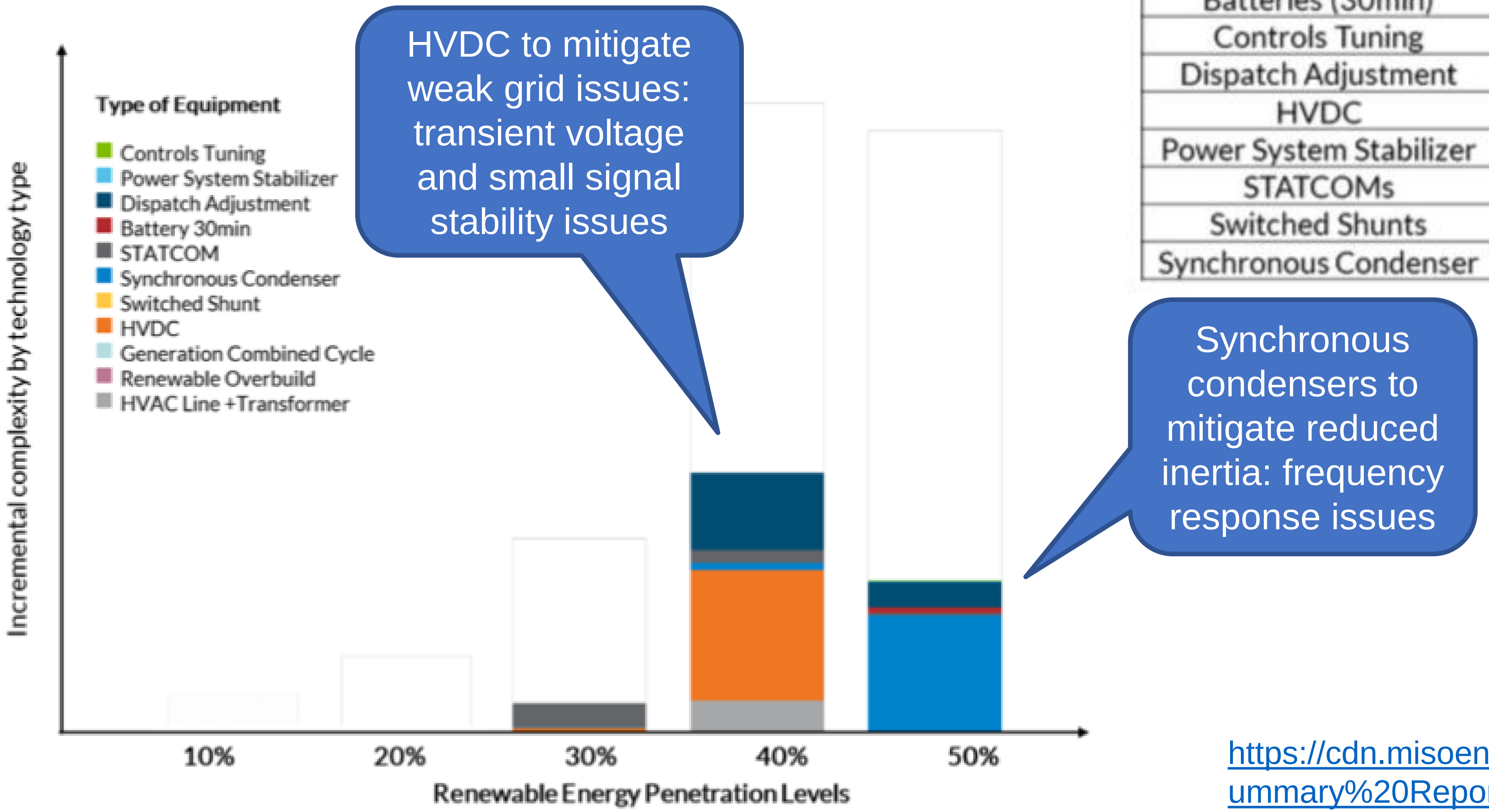
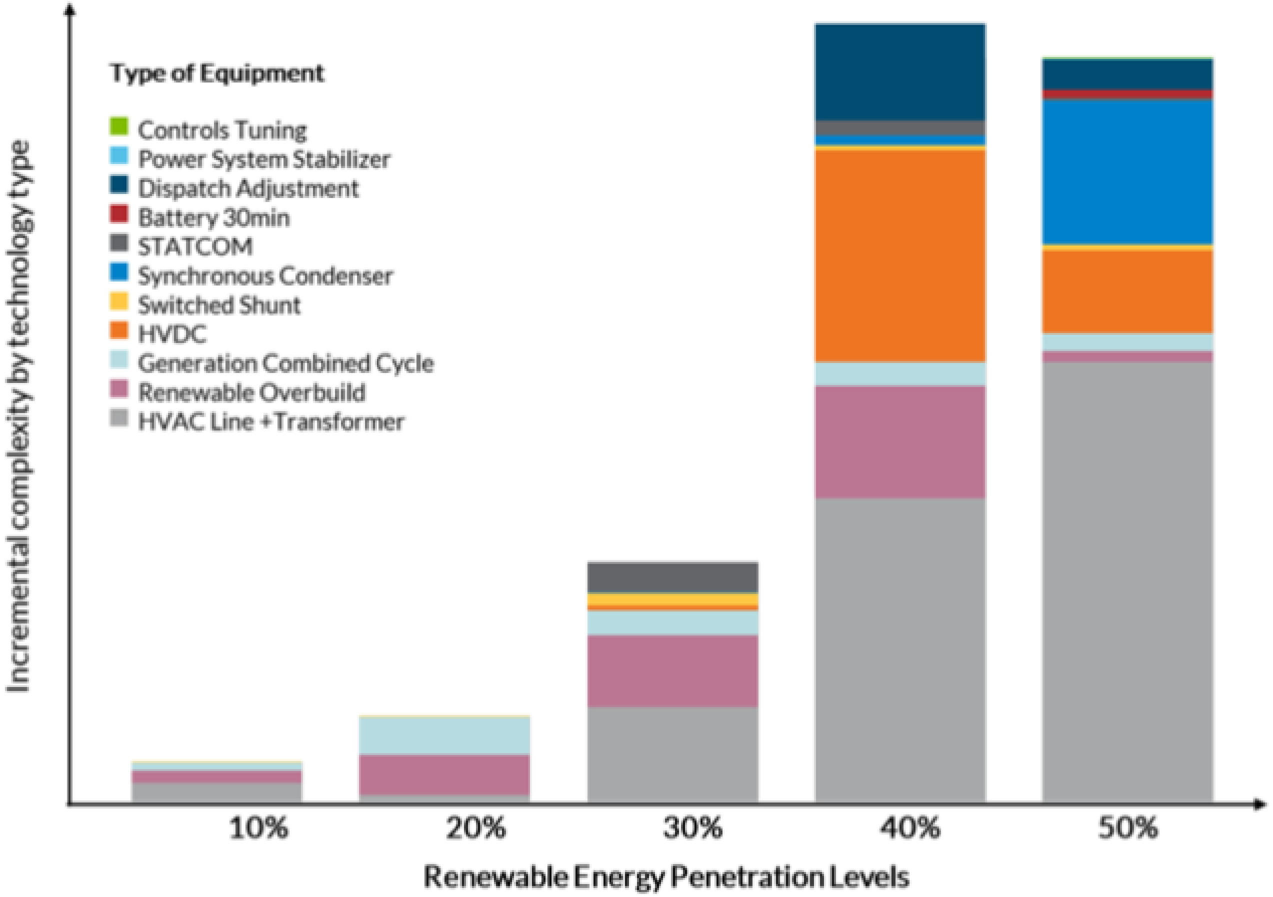
Transmission infrastructure needed for dynamic stability

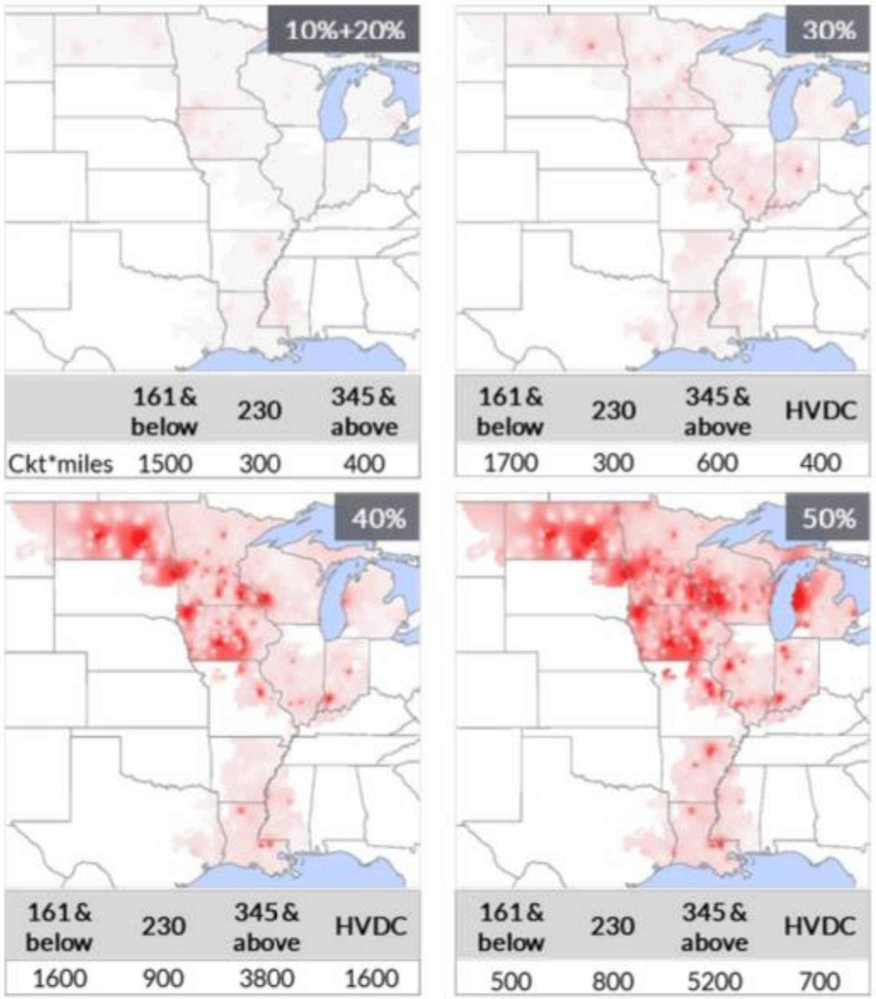


# of equipment per milestone	MISO + Eastern Interconnect			
	30%	40%	50%	Total
Batteries (30min)	-	-	1,233	1,233
Controls Tuning	-	-	1,787	1,787
Dispatch Adjustment	-	169	60	229
HVDC	1	4	-	5
Power System Stabilizer	-	-	109	109
STATCOMs	47	31	23	101
Switched Shunts	-	-	1	1
Synchronous Condenser	5	14	248	267

https://cdn.misoenergy.org/RIIA%20Summary%20Report520051.pdf

Transmission infrastructure is the biggest investment needed to make the 50% wind/PV case work





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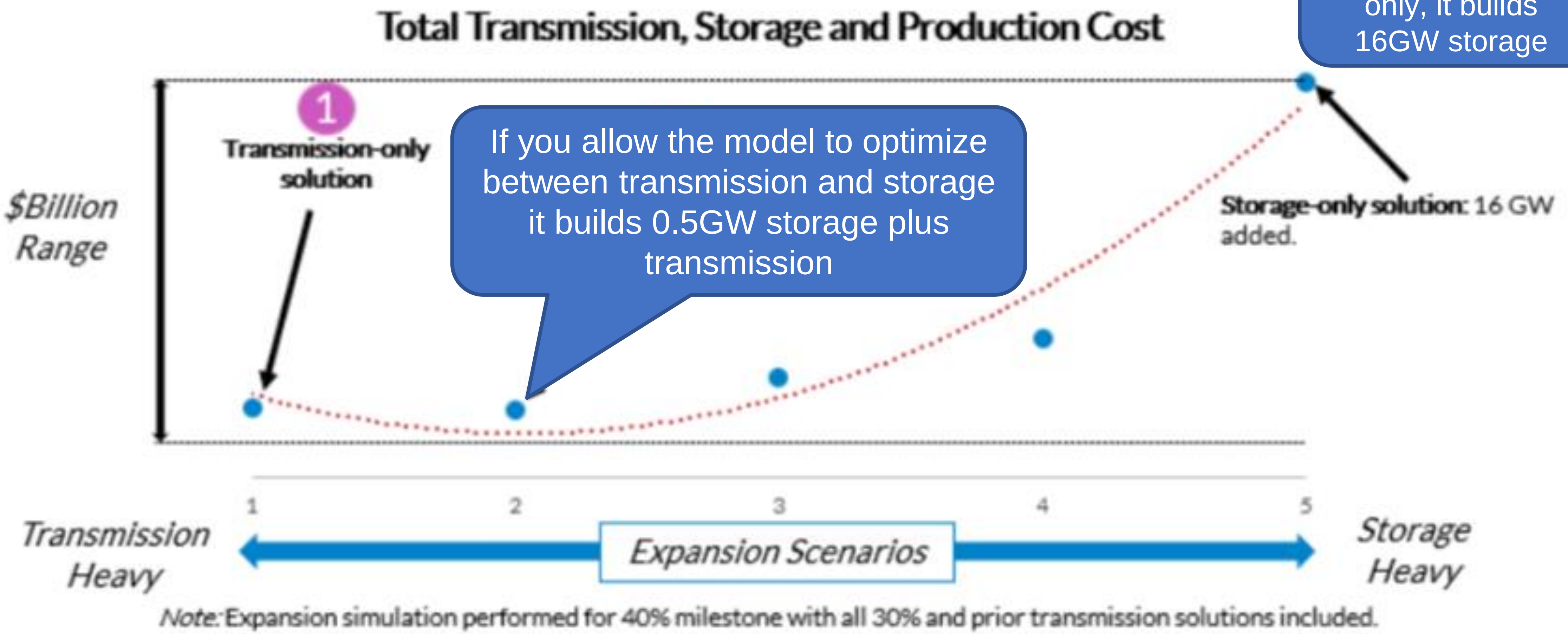
Can’t we do this with storage? Or DERs?

Storage-only solutions are more expensive and don't address all the issues

If you allow the model to optimize size of storage only, it builds 16GW storage



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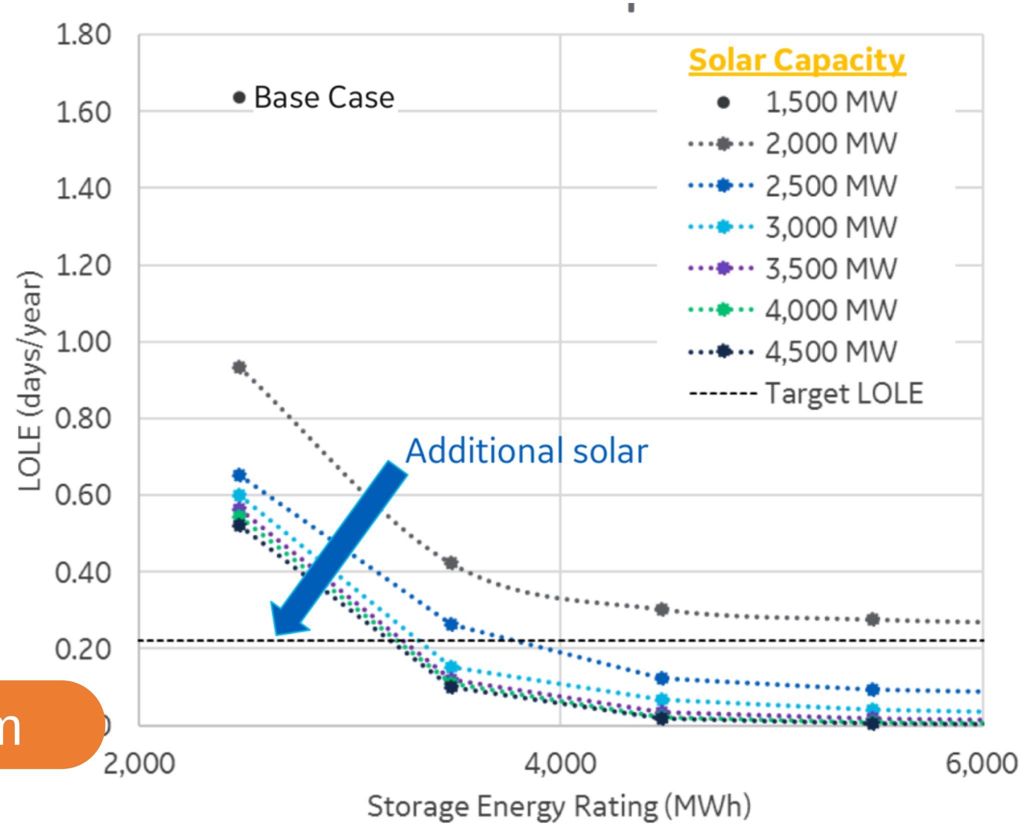
There are limits to what you can do with battery storage

2,500 MW solar & 3,800 MWh storage
or…
3,000 MW solar & 3,400 MWh of storage
or….
115 MW of firm capacity

For example, Hawaiian Electric had a PV/battery-dominant scenario that resulted from a capacity expansion model and worked in a production cost model, but when tested in a resource adequacy study, it did not come close to meeting the loss-of-load expectation metric (2 days in 10 years)



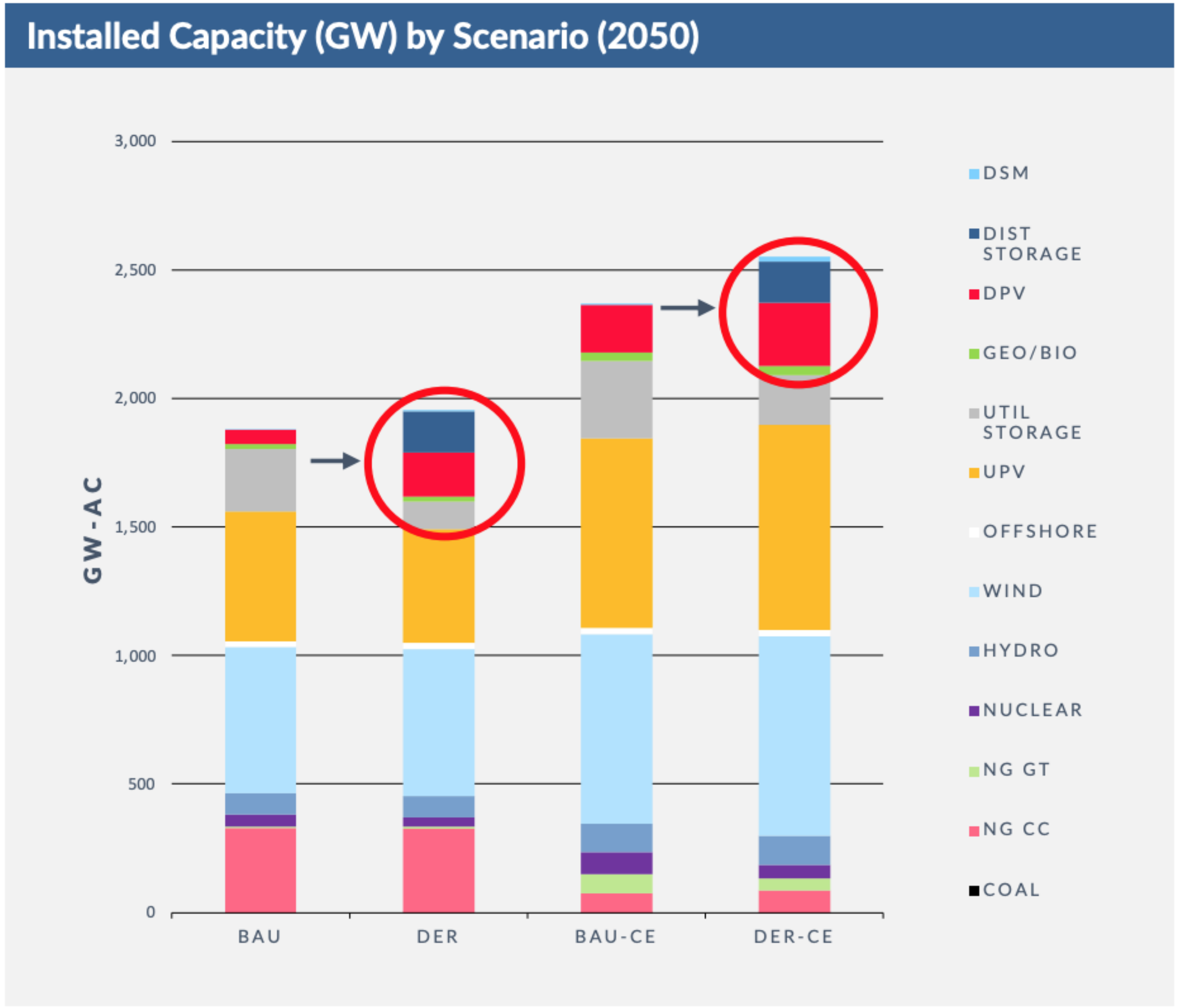
Problem becomes an **energy**, not a **capacity** problem

Stenclik, et al., *Energy Storage as a Peaker Replacement*, IEEE Electrification Magazine, September 2018

DERs are part of the solution.
We still need utility-scale wind/PV

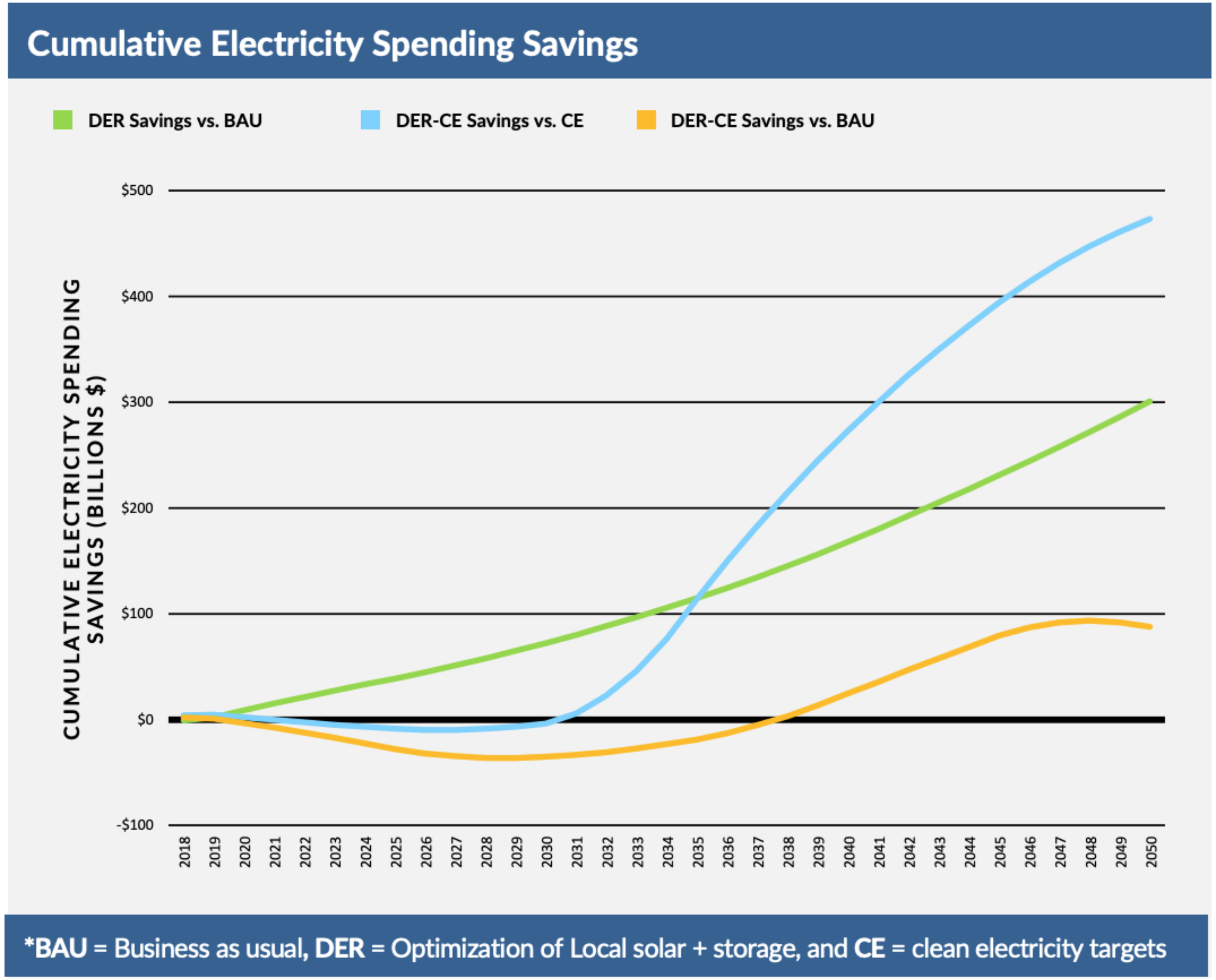
- Optimizing G, T&D saves money vs not including distribution in optimization
- Benefits are even bigger if you have clean energy goals - save $473B by optimizing G, T&D

https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf

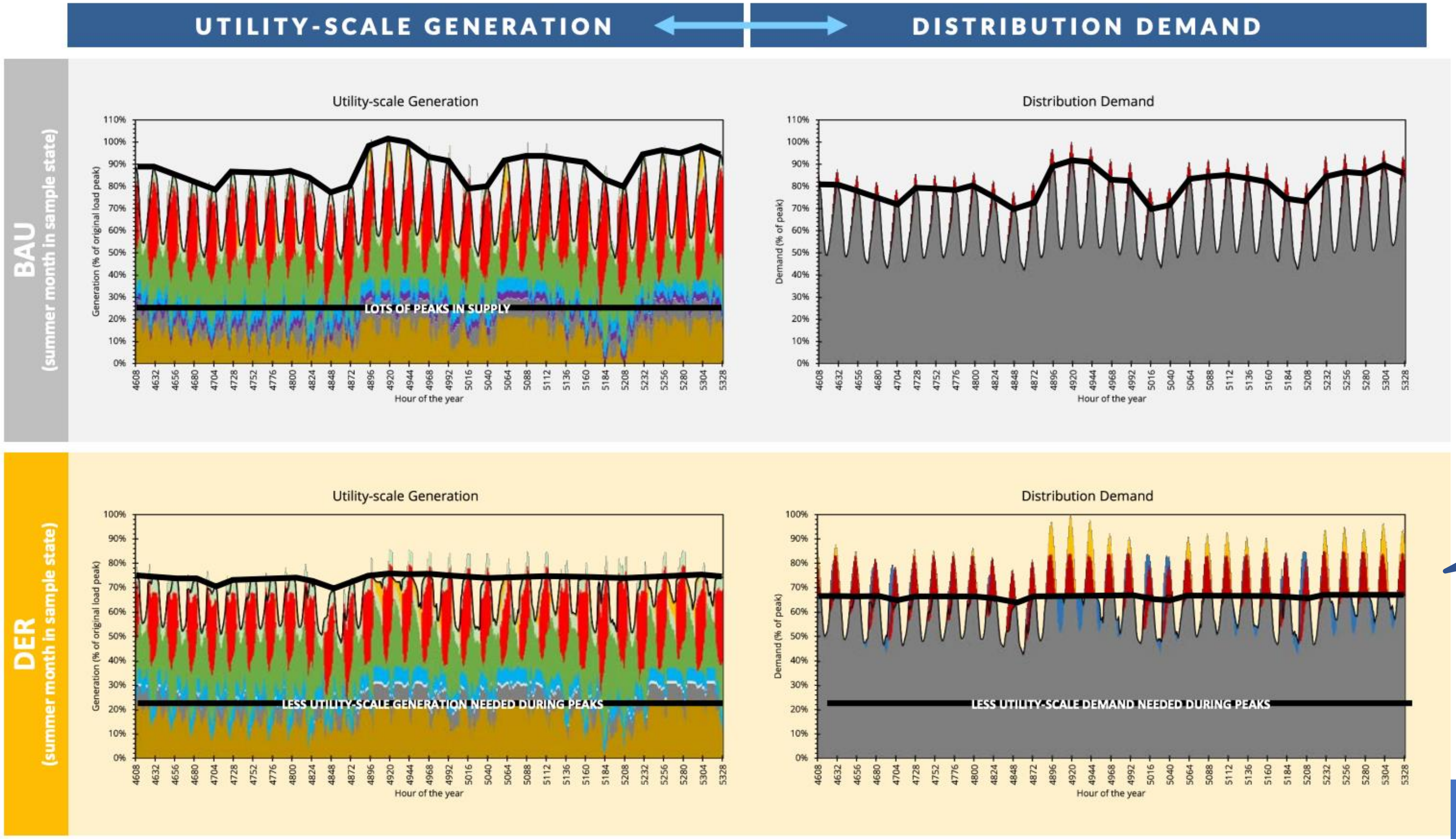


VCE DER study

- Optimizing G, T&D saves money vs not including distribution in optimization
- Benefits are even bigger if you have clean energy goals - save $473B by optimizing G, T&D

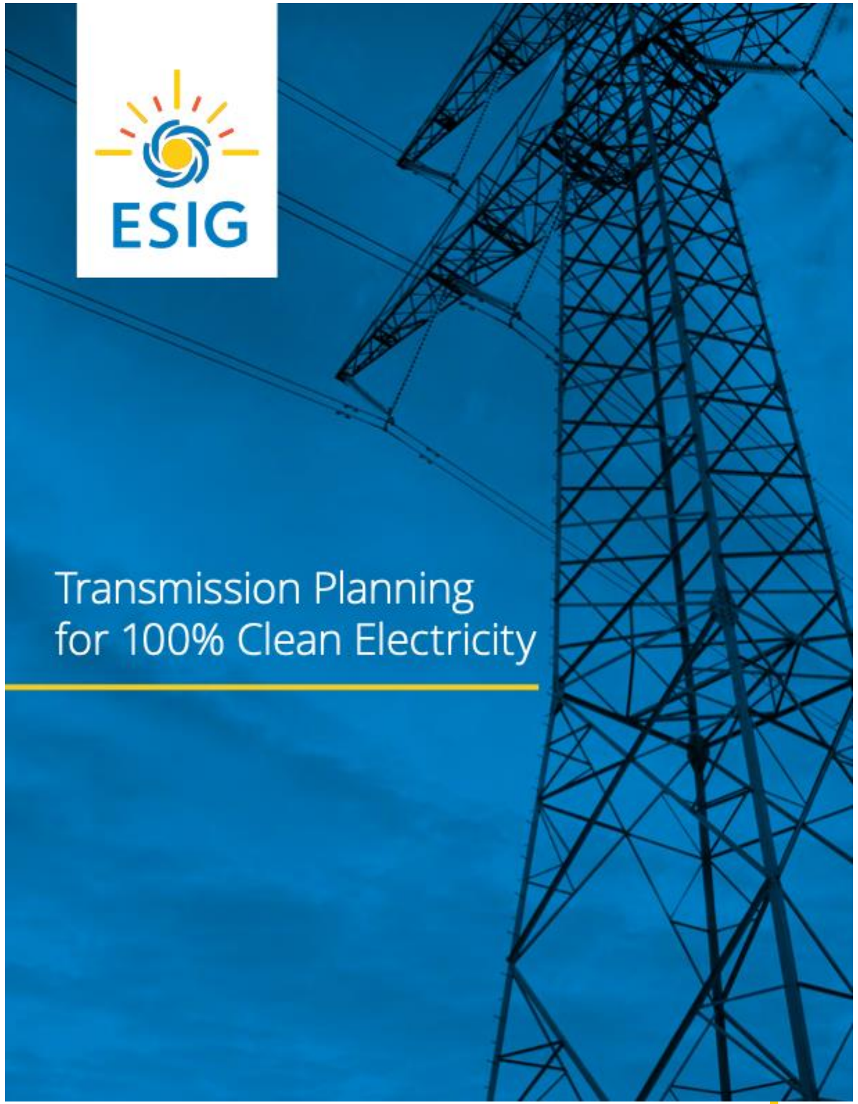


DERs reduce utility peak demand by 16% by 2050 and smooth demand



Assumes economic dispatch of DERs (DPV is NOT must-take)

For more information on transmission planning to reach clean energy goals



https://www.esig.energy/transmission-planning-for-100-clean-electricity/

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