Transmission Planning for 100% Clean Electricity

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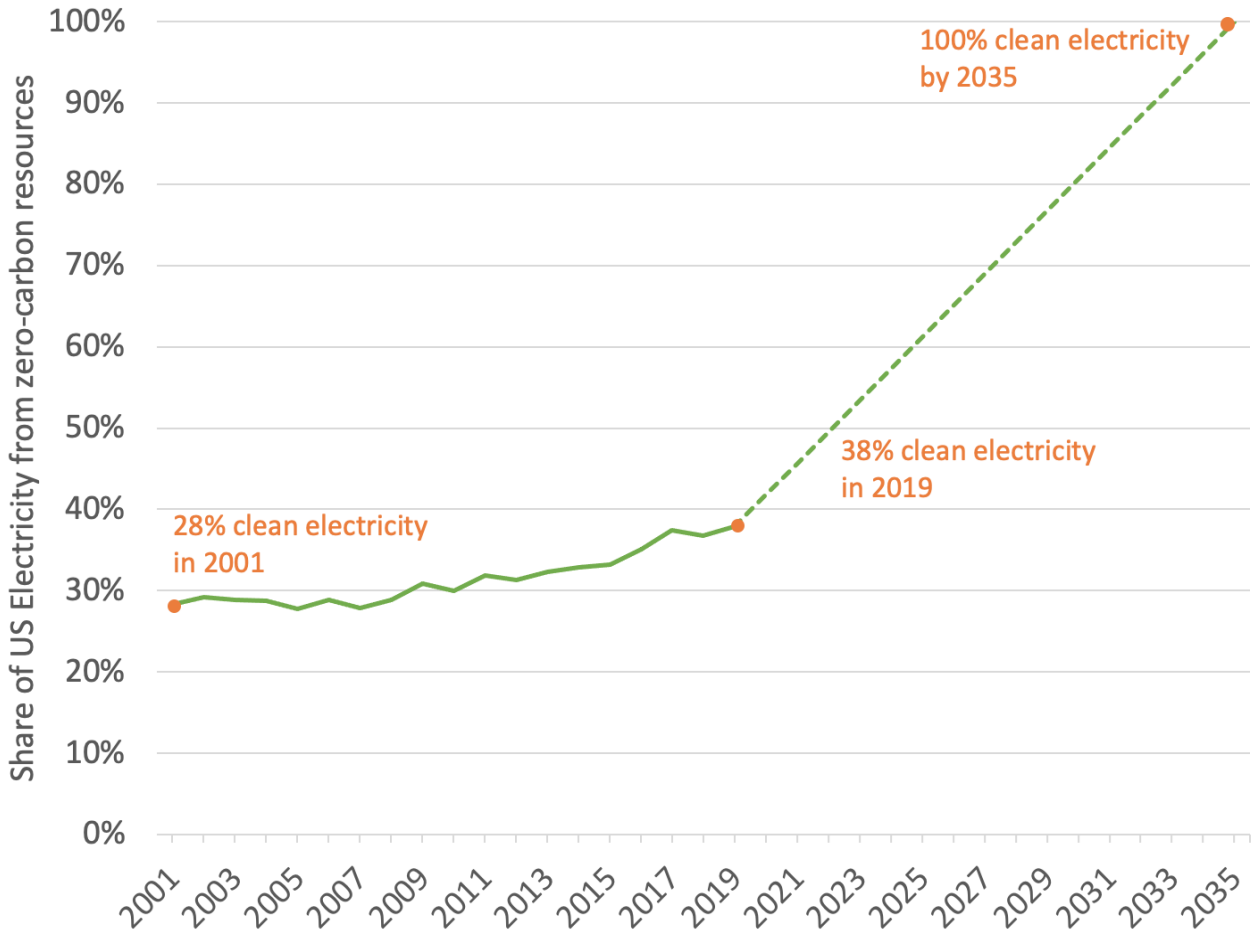
How can we enable cleaner electricity while maintaining affordability and reliability?

Decarbonization requires action on a transformative scale



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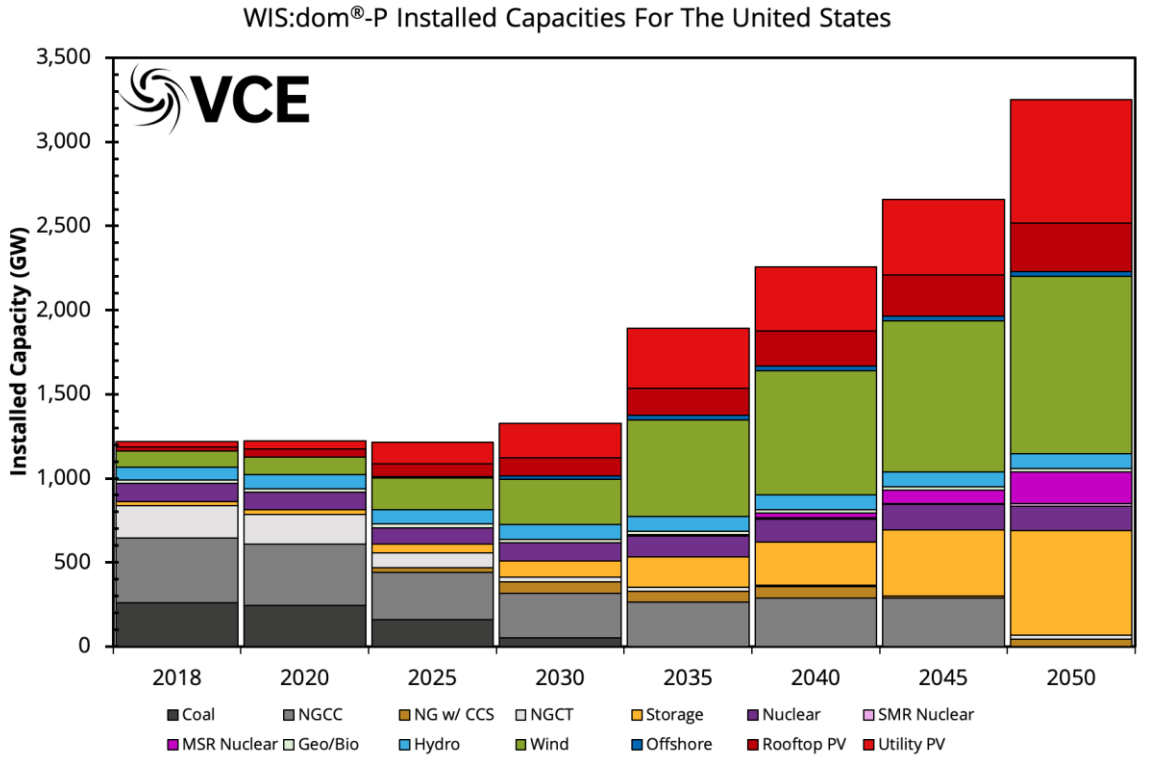
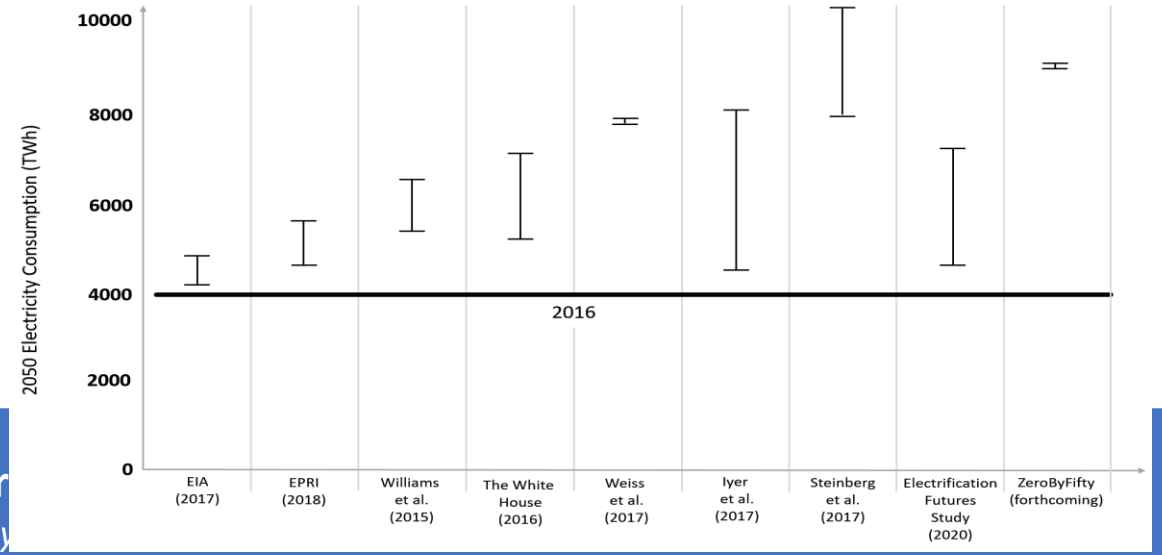
We need transmission to deliver significant resources

- We may need 1000 GW+ of new wind and solar for 100% clean electricity goals.
- Electrification will lead to significantly increased demand.
- Distributed energy resources (DERs) will contribute but are not sufficient on their own





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
Total	**215,279**	**461,550**	**411,147**

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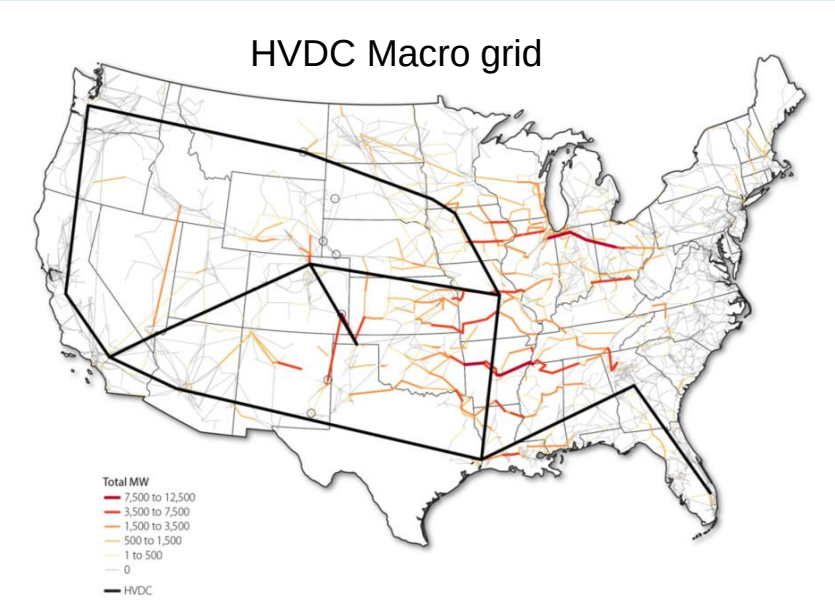
Charting the Future of Energy

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

A macro grid saves money – especially if you are decarbonizing

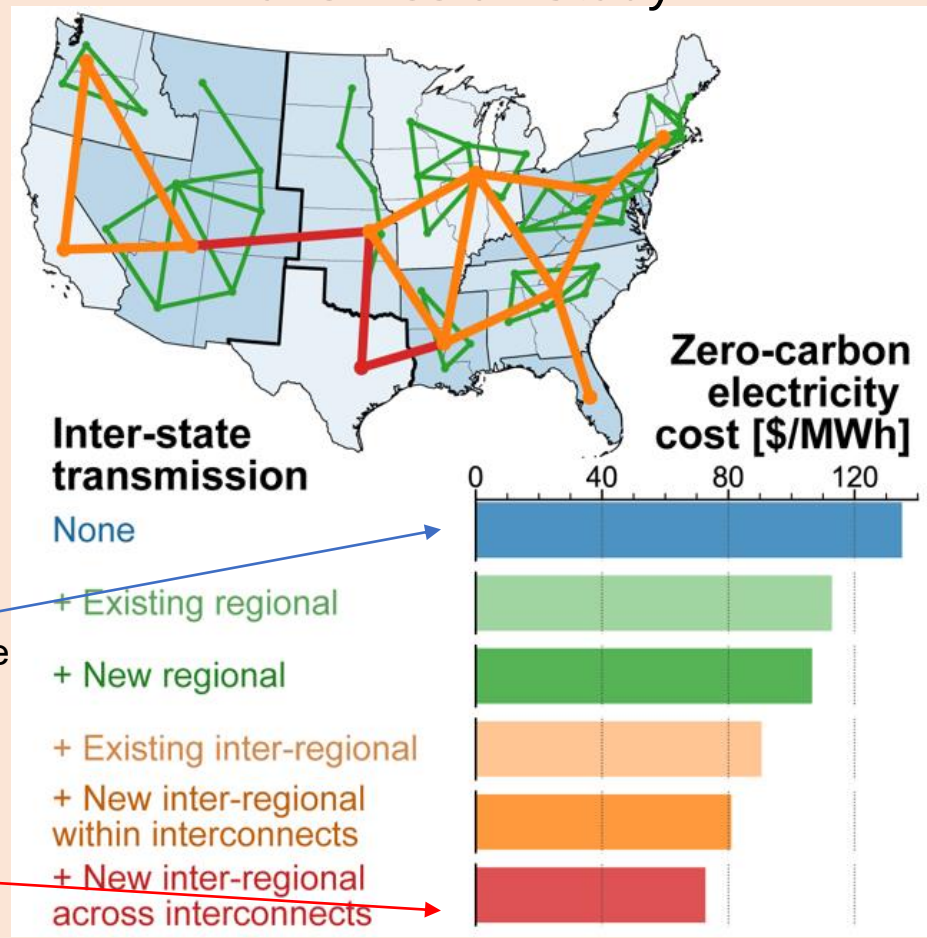
NREL Interconnection Seams Study



- With a 50% renewables goal, this HVDC macro grid has a benefit-to-cost ratio of 2.5
- With a 85% renewables goal, this HVDC macro grid has a benefit-to-cost ratio of 2.9

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

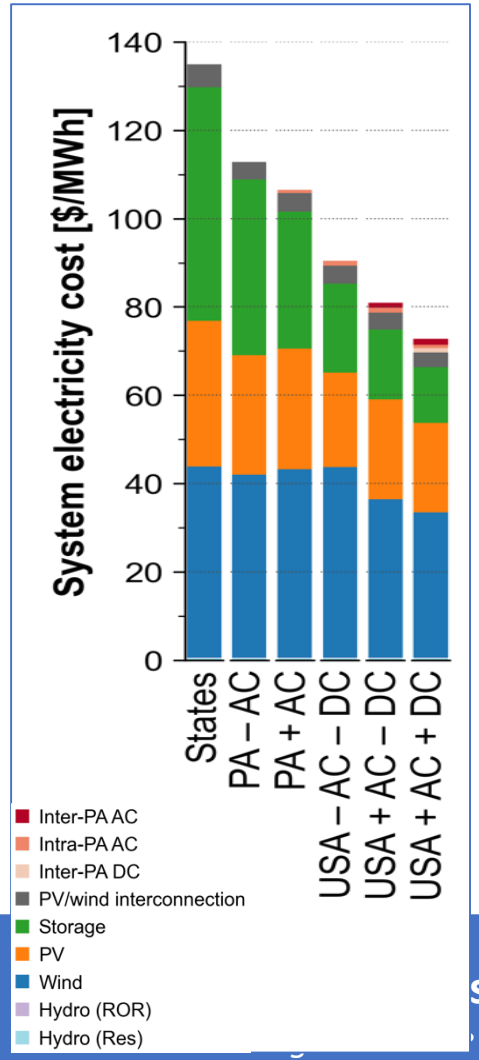
MIT Transmission Study

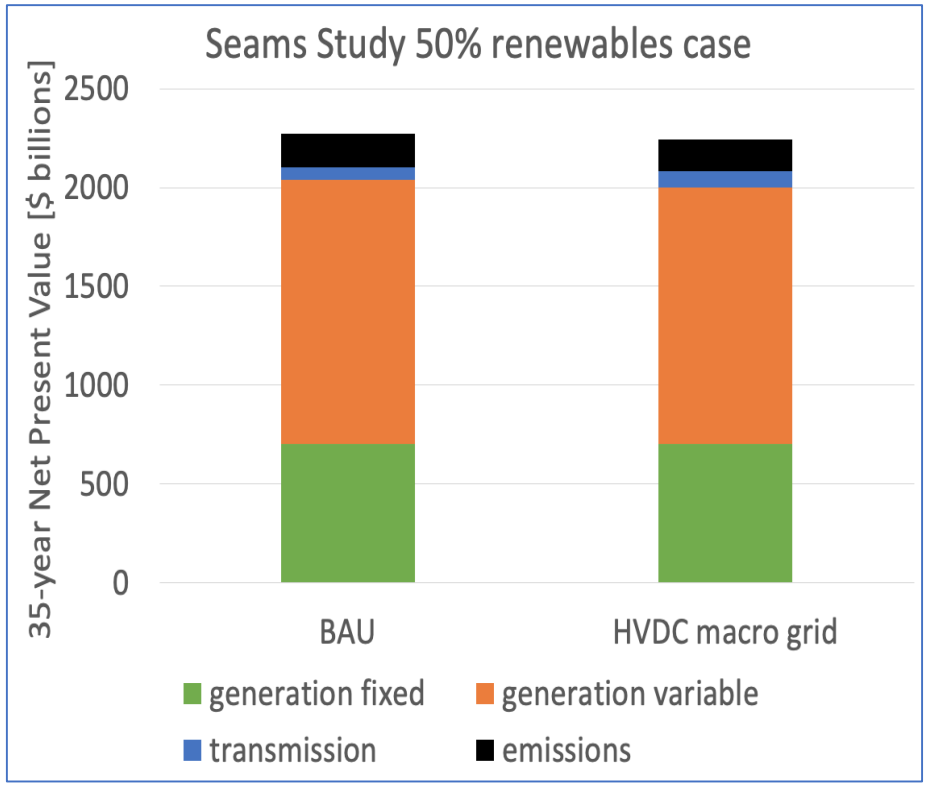


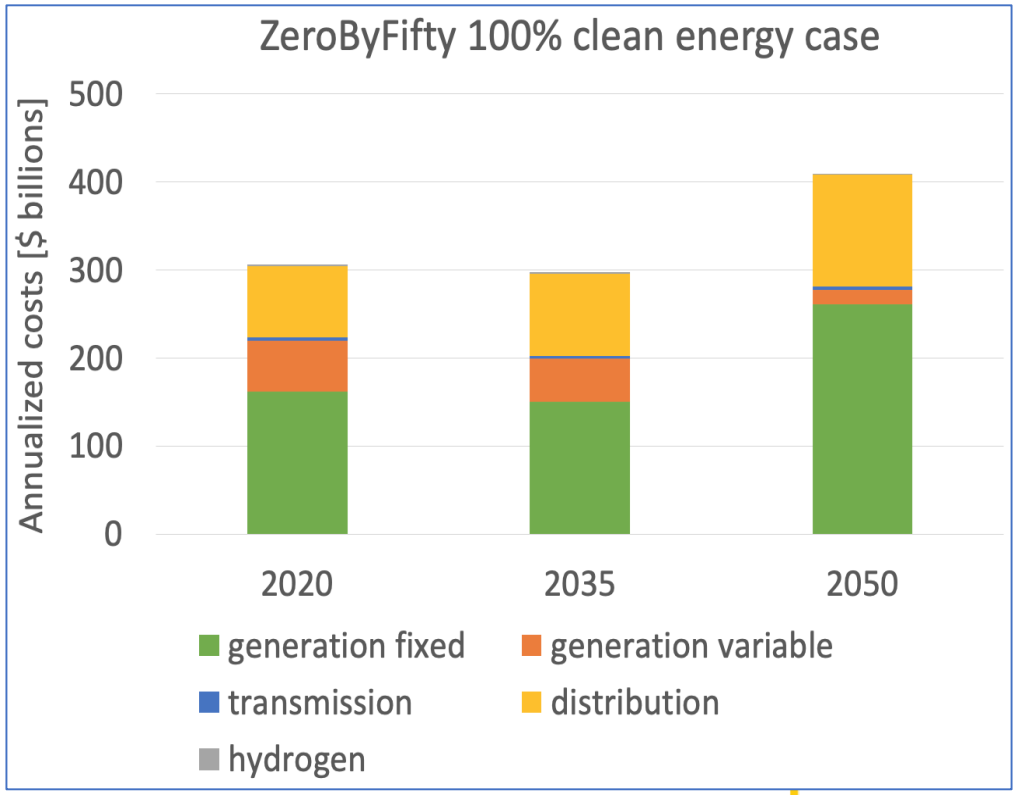
”Every state for itself” costs twice as much as the nationally optimized and coordinated approach

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

Transmission costs are tiny compared to other clean resources/infrastructure







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Brown and Botterud, 2020; NREL Interconnection Seams study; Preliminary results from VCE's ZeroByFifty Study

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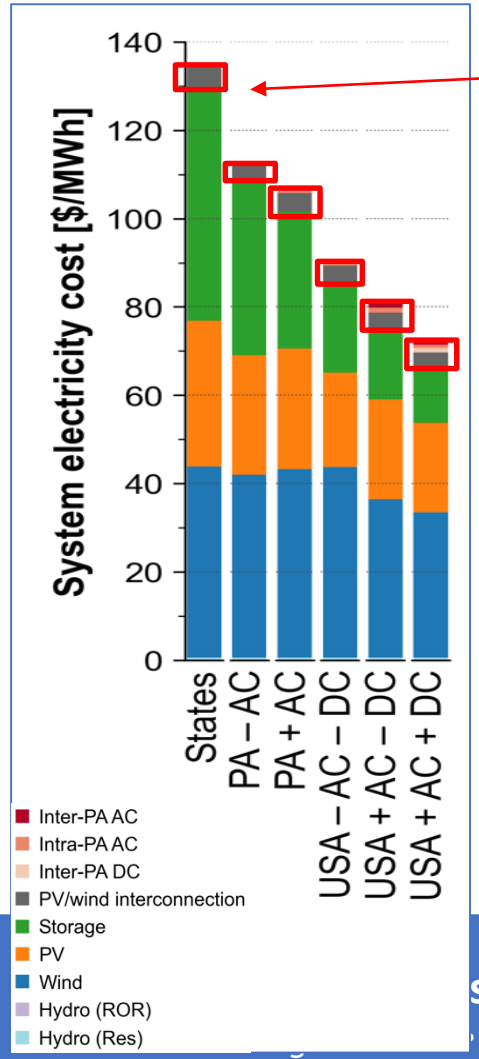
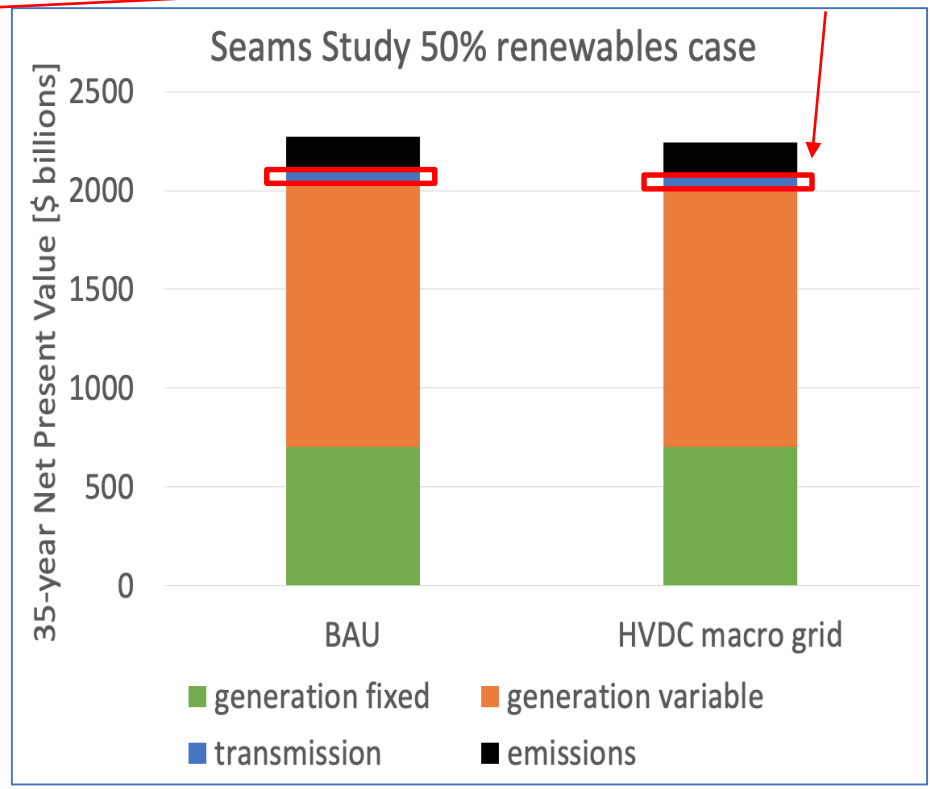
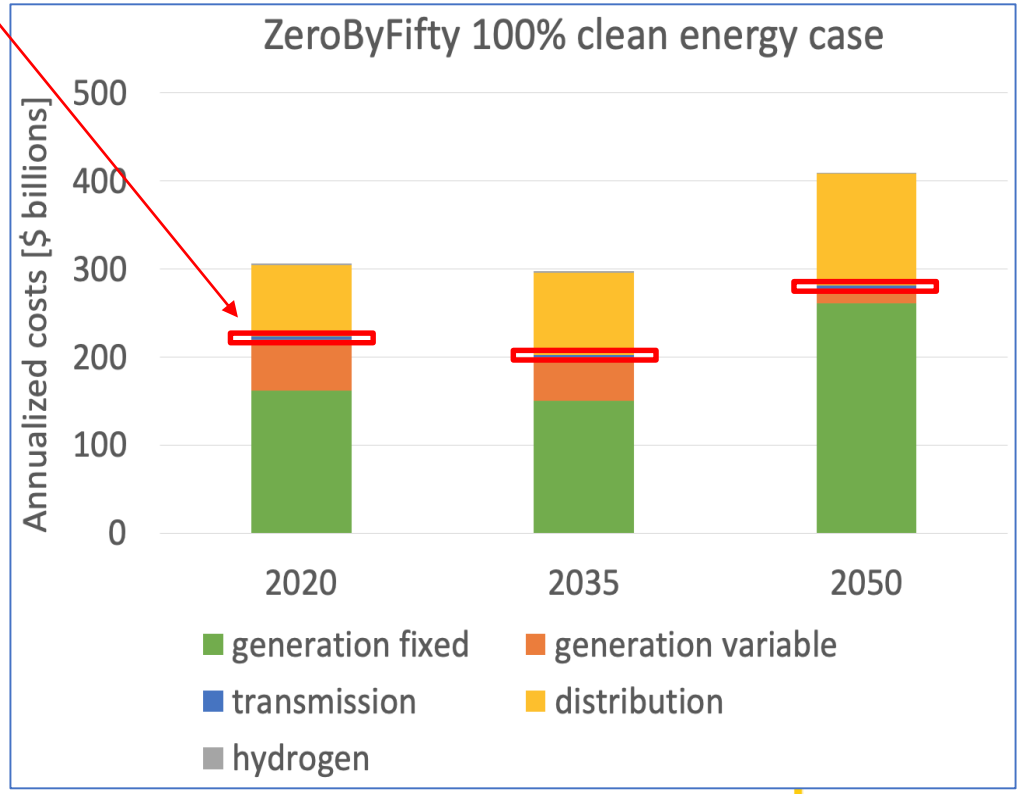
Transmission costs are tiny compared to other clean resources/infrastructure

TRANSMISSION COSTS







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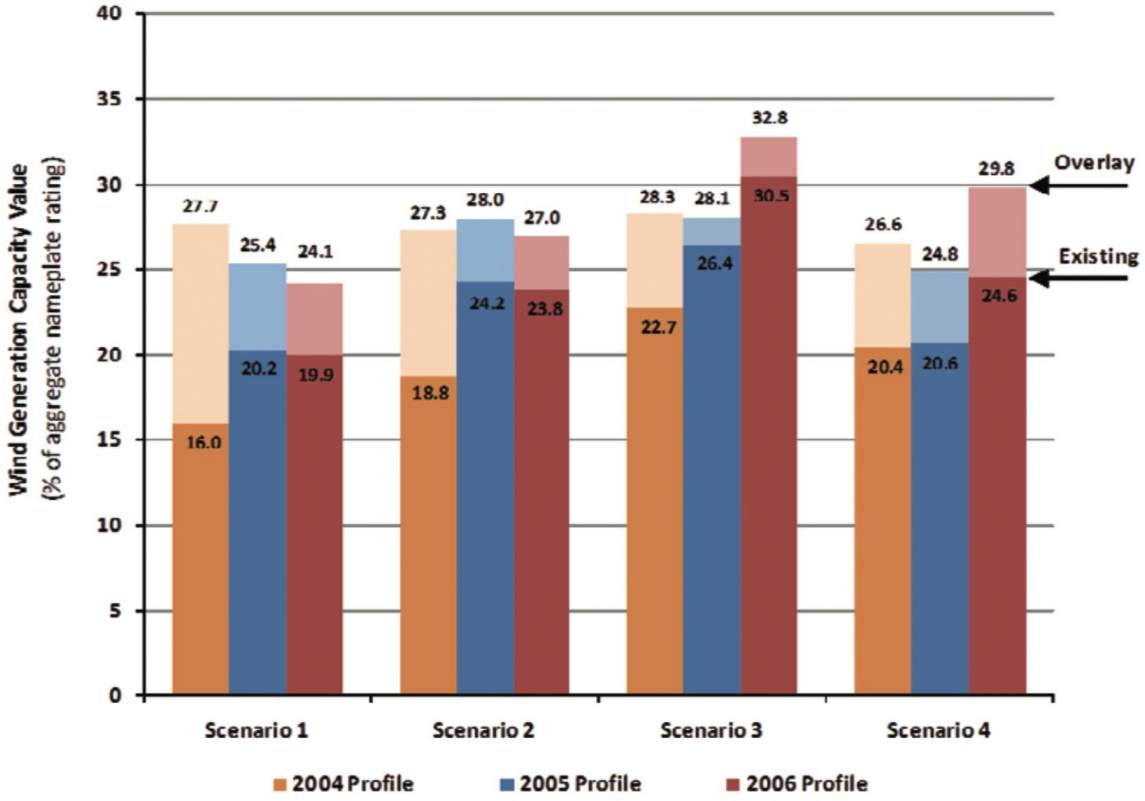
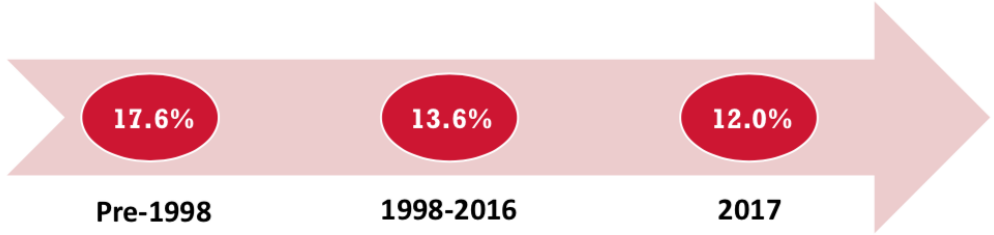
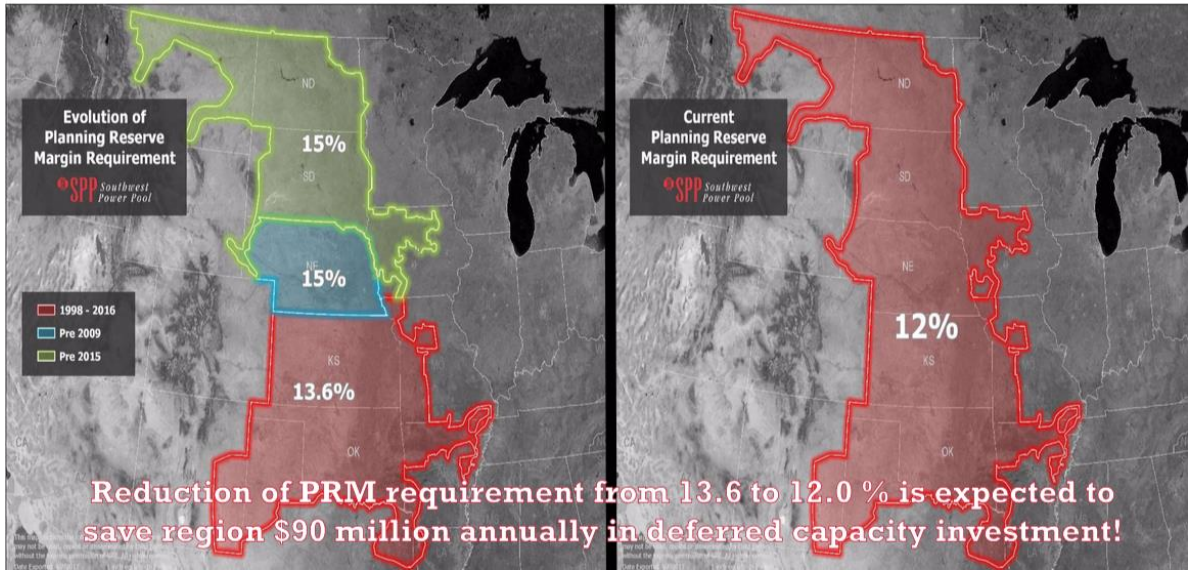
Transmission is not just about delivering resources to load

Transmission contributes to resource adequacy



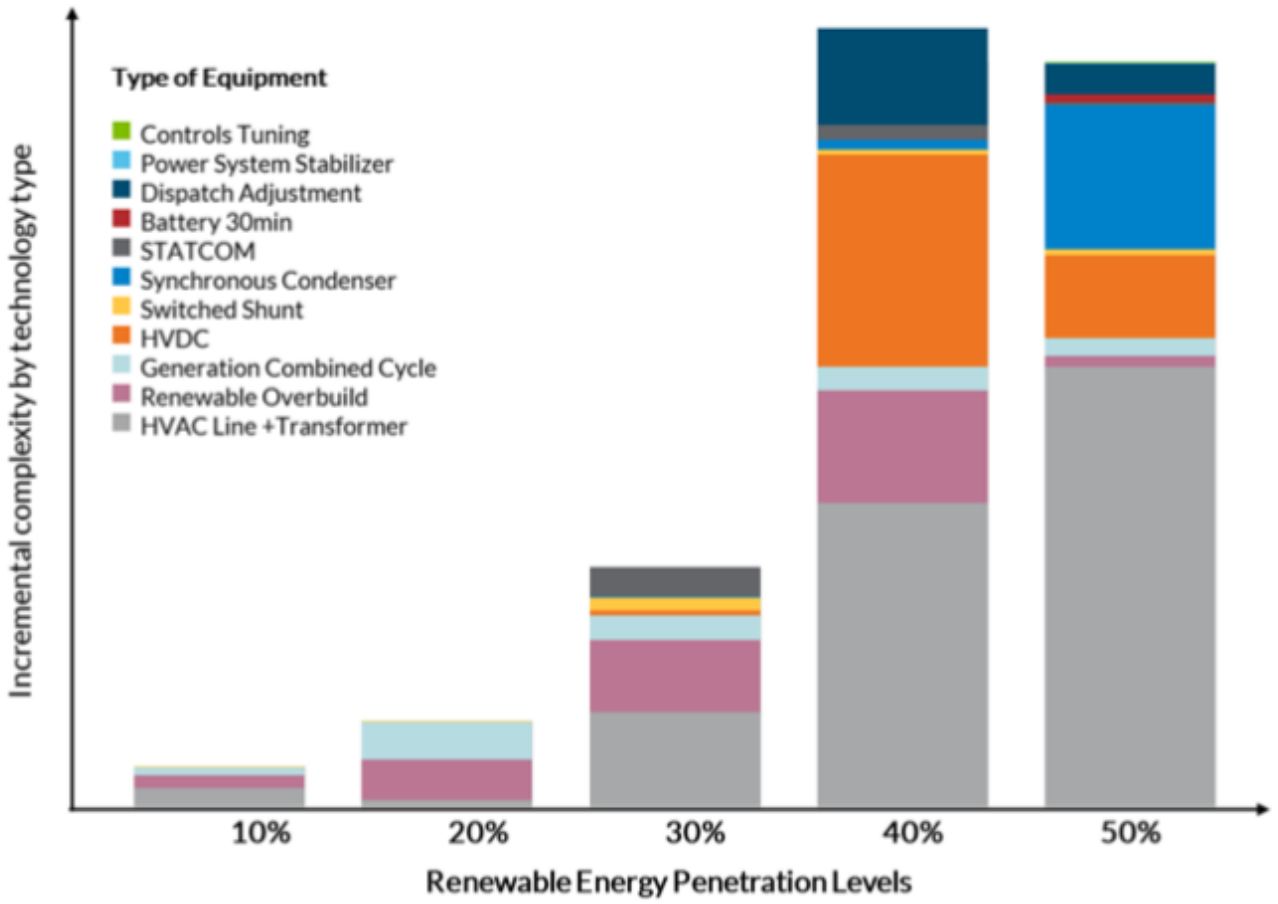


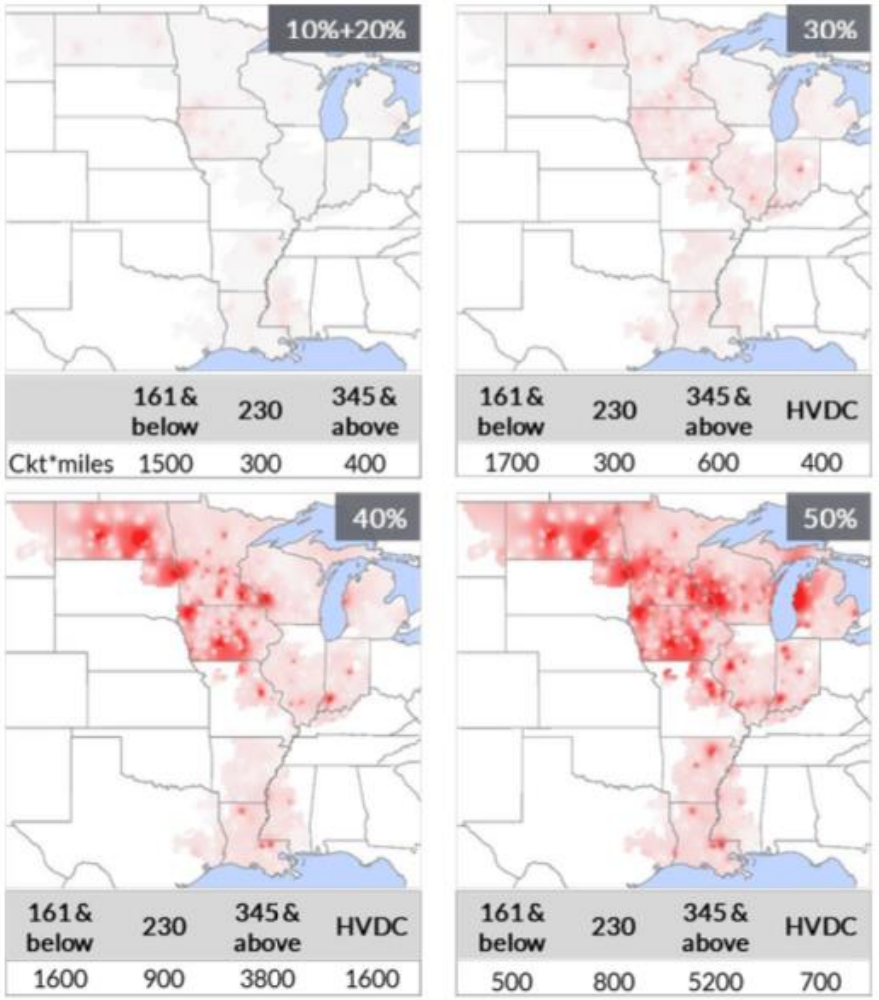


Transmission smooths all time scales of weather variability

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

MISO found that transmission was the key enabler to meet reliability standards at 50% wind/solar





	161 & below	230	345 & above
Ckt*miles	1500	300	400

	161 & below	230	345 & above	HVDC
	1700	300	600	400

	161 & below	230	345 & above	HVDC
	1600	900	3800	1600

	161 & below	230	345 & above	HVDC
	500	800	5200	700

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

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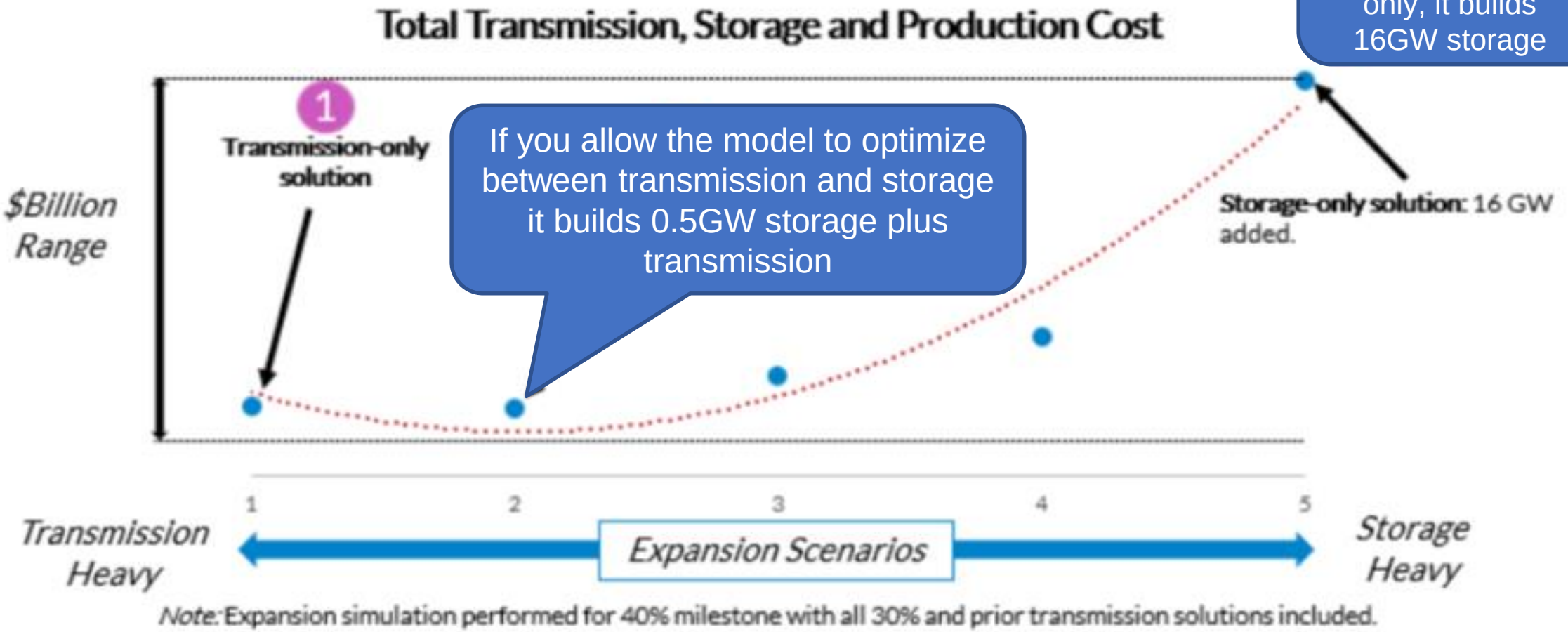
Can’t we do this with storage? Or DERs?

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

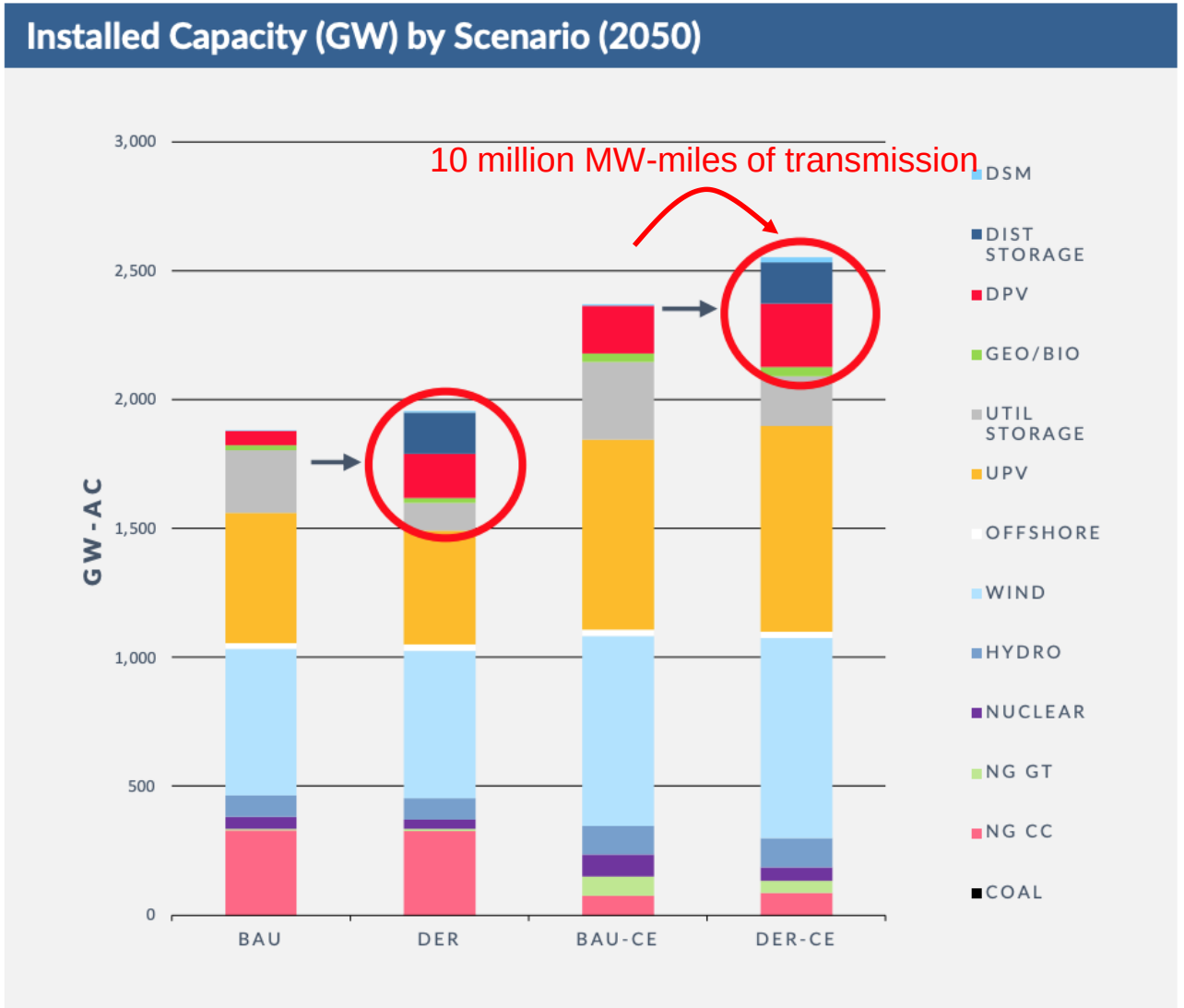


https://cdn.misoenergy.org/RIIA%20Summary%20Report520051.pdf

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
- Optimizing G, T&D builds more DERs and also builds more transmission

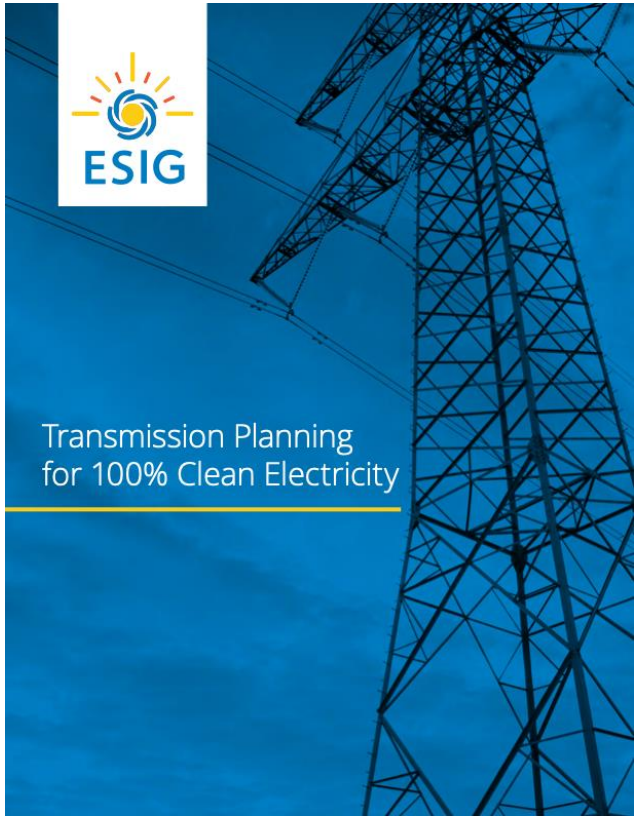
https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf



ESIG Recommendations

1. Create a national transmission planning authority that conducts ongoing national transmission planning
2. Identify renewable energy zones
3. Design a national macro grid

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



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Extra slides

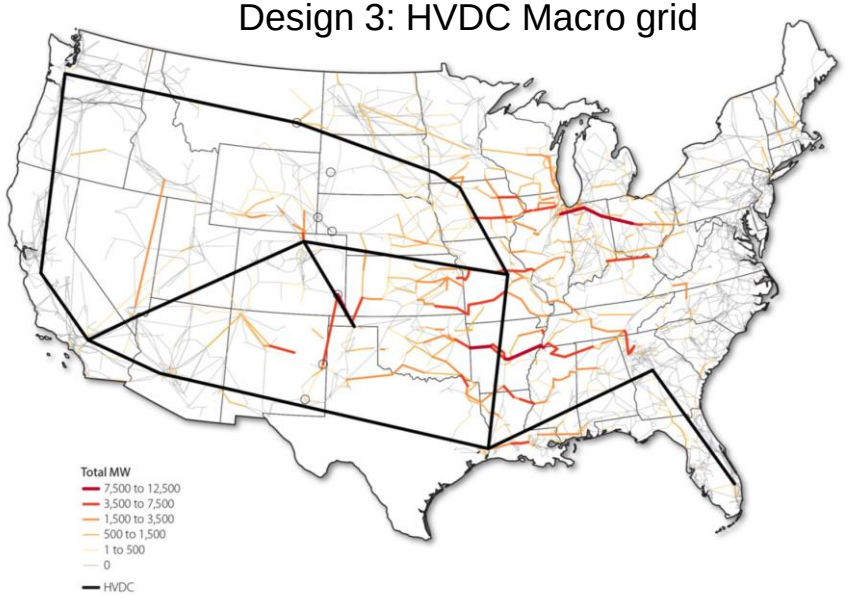
We evaluated a number of studies

Study	Region	Renewable Capacity	Clean Energy Level(s)	Annual Electricity Demand	Target Year
Electrification Futures Study	United States and Canada	600 GW (wind) 1,000 GW (solar)	23% to 75% renewable energy	7,000 TWh	2050
Interconnections Seam Study	United States (except Texas) and Canada	600-900 GW (wind and solar)	63% to 95% carbon free electricity	4,900 TWh	2038
MIT study	United States	1,200 GW (wind) 1,100 GW (solar)	100% clean electricity	5,000 TWh	2040
Renewable Integration Impact Assessment	United States - Eastern Interconnection	411 GW (wind) 677 GW (solar)	Up to 100% clean electricity for the eastern interconnection	2018 demand	N/A
ZeroByFifty	United States	1,100 GW (wind) 1,000 GW (solar)	100% clean energy	9,000 TWh	2050

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

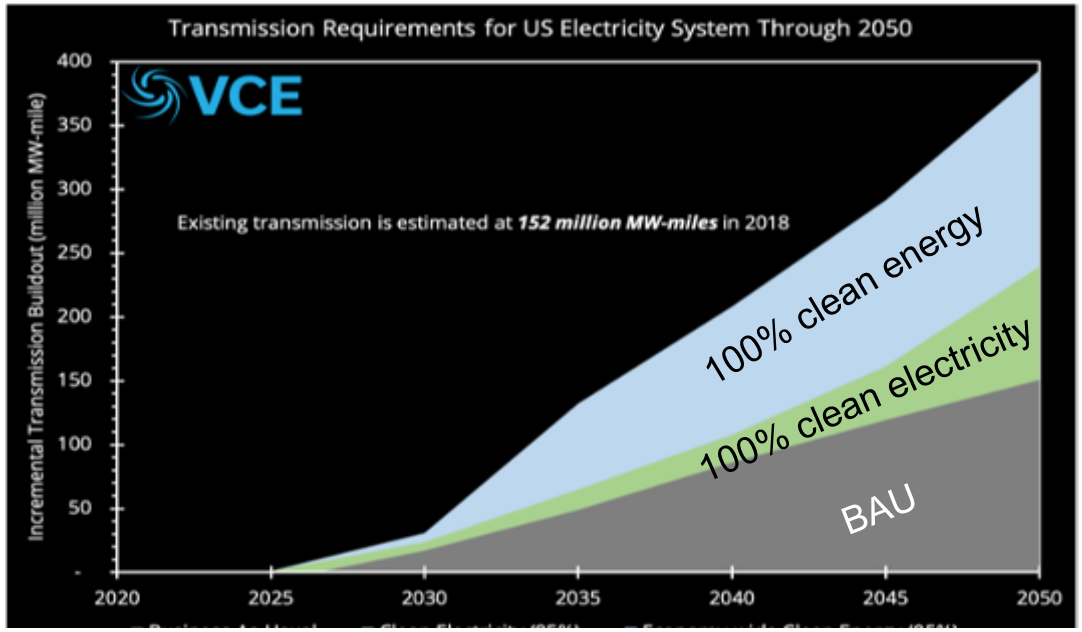
Design 3: HVDC Macro grid

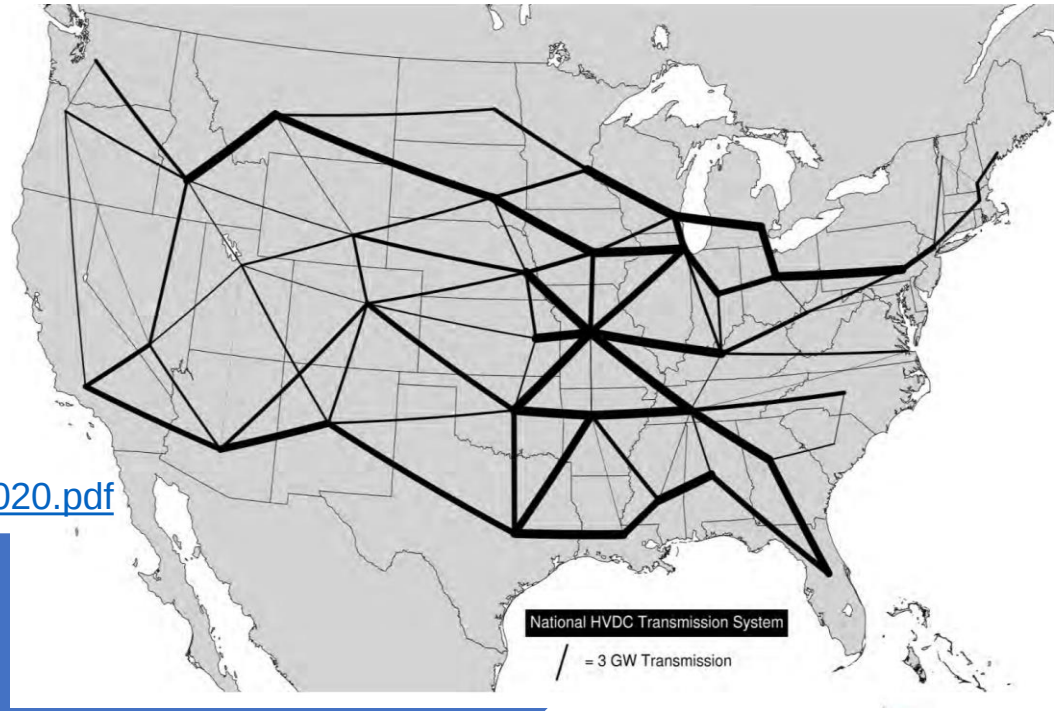


50% Renewables case	BAU across seams	HVDC Macro grid	
Objective function	**Design 1**	**Design 3**	**Delta**
Line investment (B$)	61.21	80.10	18.89
Generation investment (B$)	704.03	700.51	-3.52
Operation and maintenance (B$)	1336.36	1300.70	-35.66
Emission cost (B$)	171.10	162.50	-8.60
35-yr B/C ratio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

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
- Transmission expansion costs are $200B and $350B for 100% clean electricity and energy, respectively
- Transmission depends on scenario: ~38GW between east/west; 30GW between east and ERCOT; 8 GW between west and ERCOT
- Finds that if a macro grid is NOT built, it costs an additional $1 Trillion to get to 100% clean energy by 2050

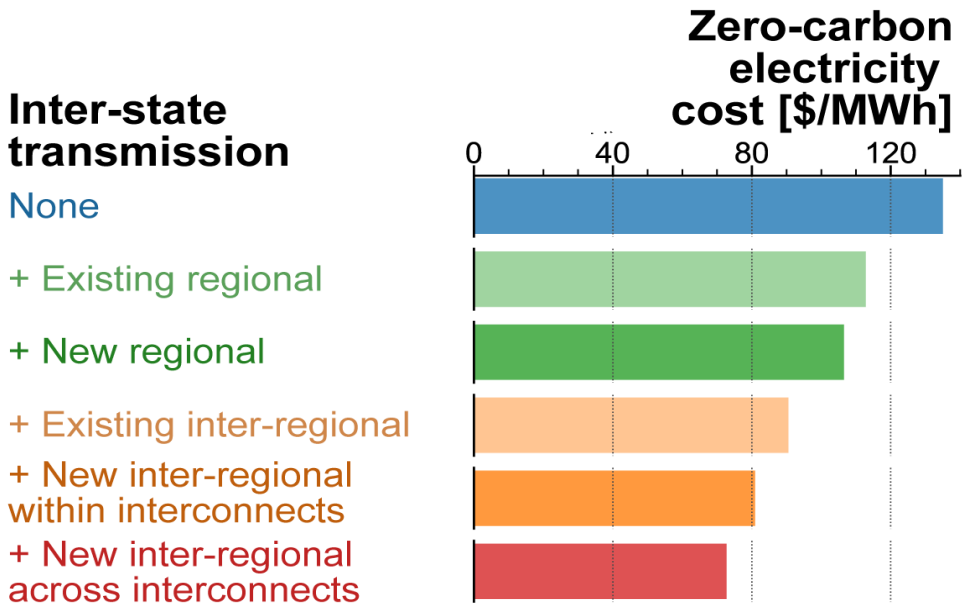


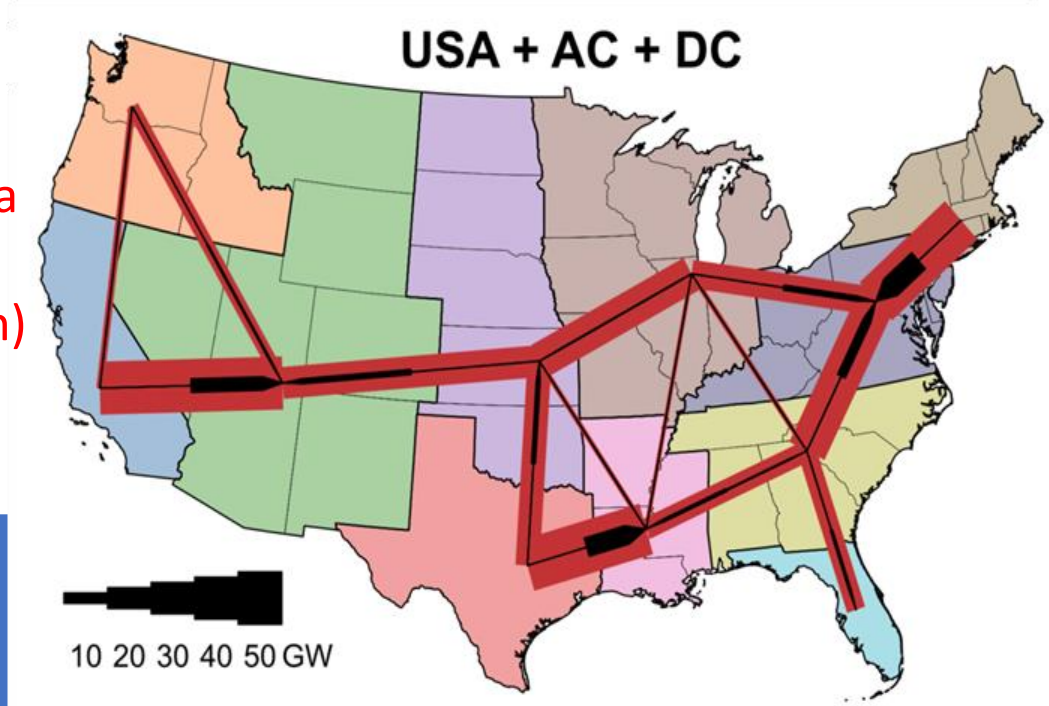


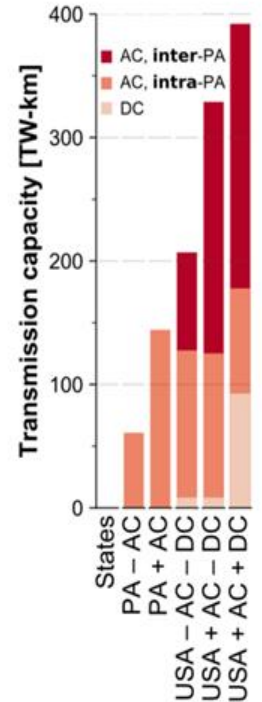
https://www.vibrantcleanenergy.com/wp-content/uploads/2020/11/ESIG_VCE_11112020.pdf

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 29 GW transfers between east and west and 74 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







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