Developing critical national infrastructure for low carbon futures: Can we/should we do it?

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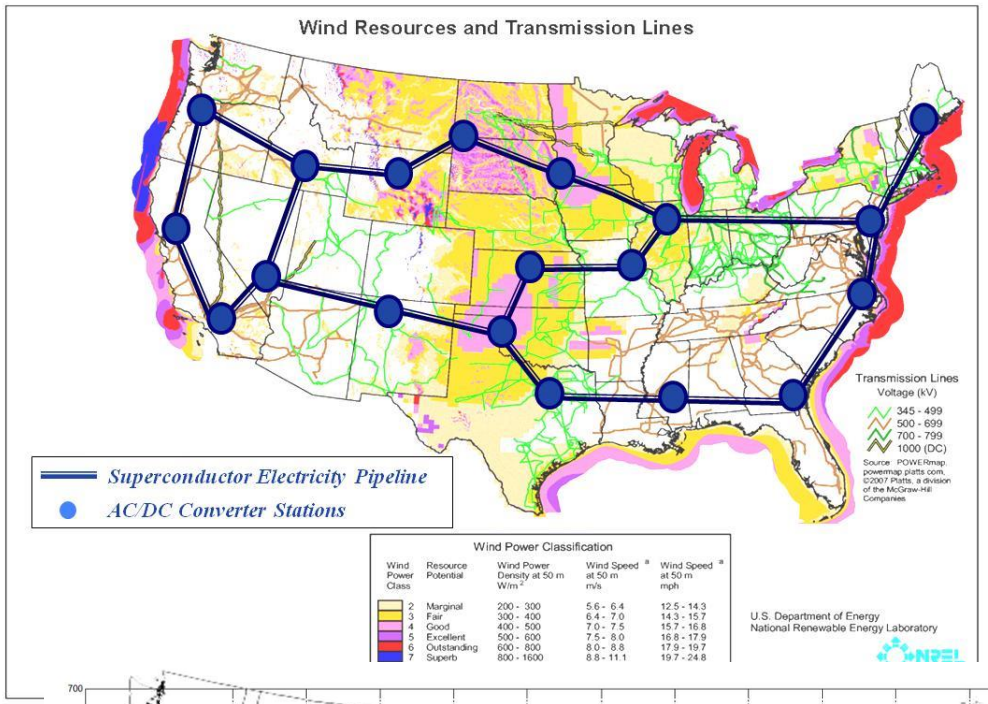
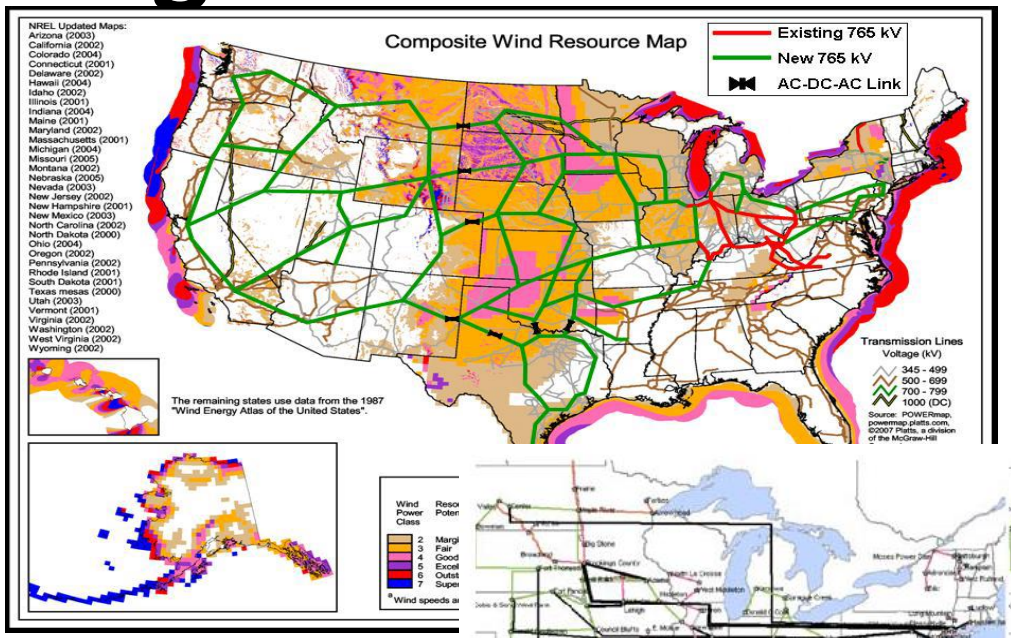
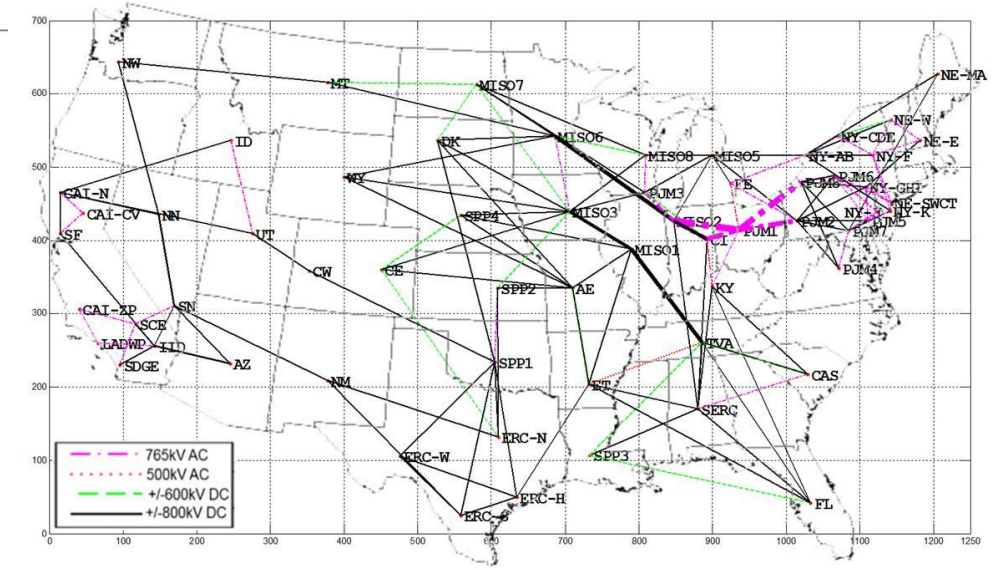
Presentation Overview

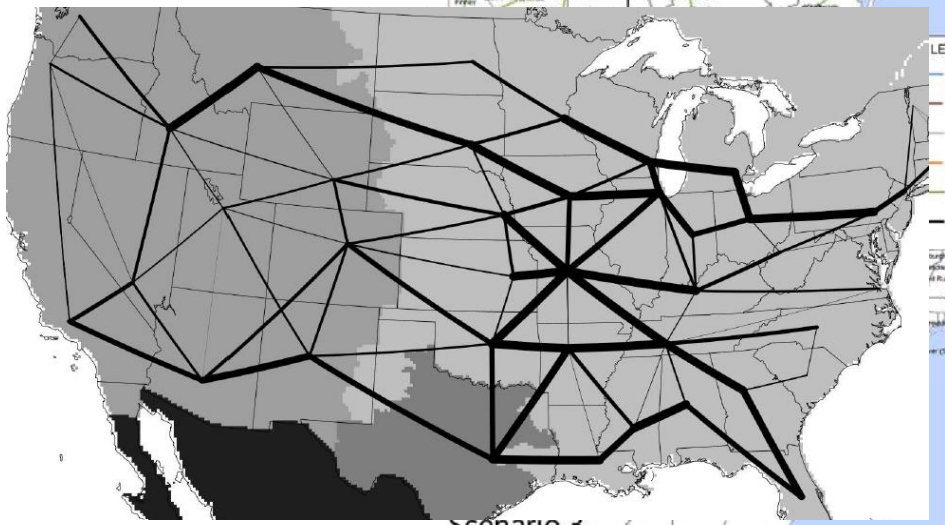
1. High-capacity inter-regional transmission studies
2. The Interconnections Seams Project
3. Project features
4. The macrogrid overlay
5. Issues to building it
6. Possible paths forward
7. Compare to China
8. Conclusions

High-capacity inter-regional transmission studies





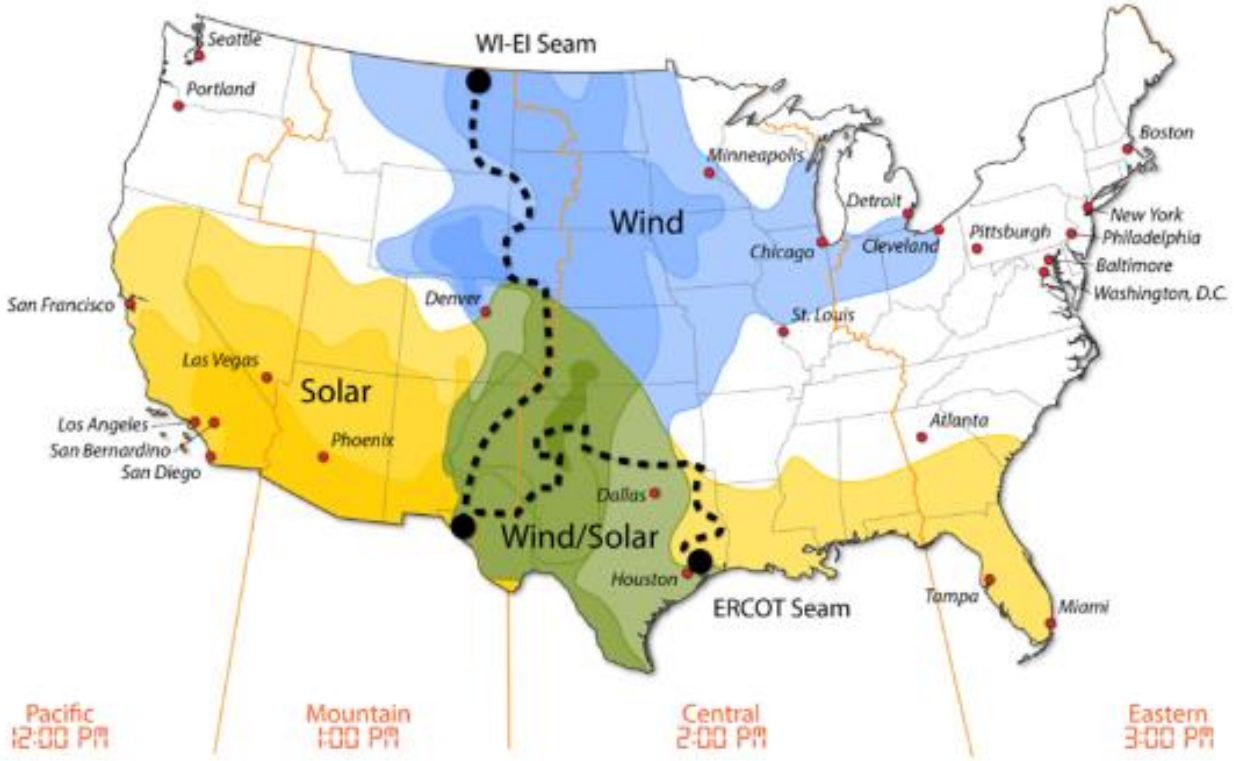




Interconnection Seams Study (DOE Grid Modernization Laboratory Consortium)

- National Renewable Energy Laboratory (lead)
- Pacific Northwest National Laboratory
- Oak Ridge National Laboratory
- Argonne National Laboratory
- Iowa State University
- Southwest Power Pool
- Midcontinent Independent System Operator
- Western Area Power Administration

Objective: Identify economic value for high capacity cross-seam transmission in a high-renewable future.



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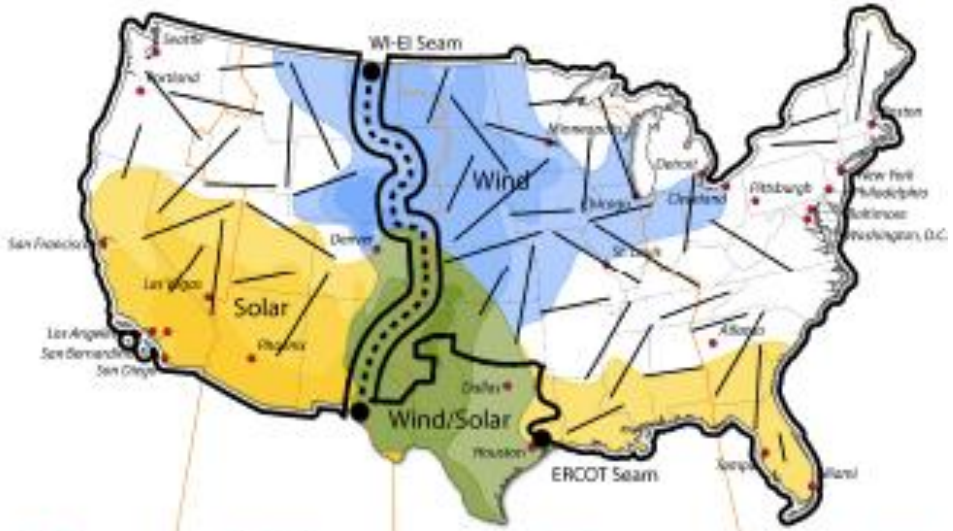
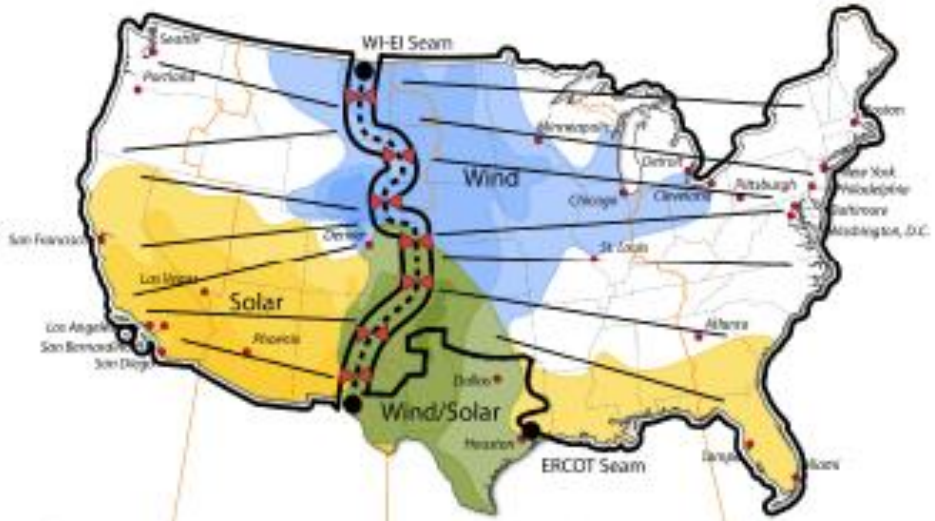
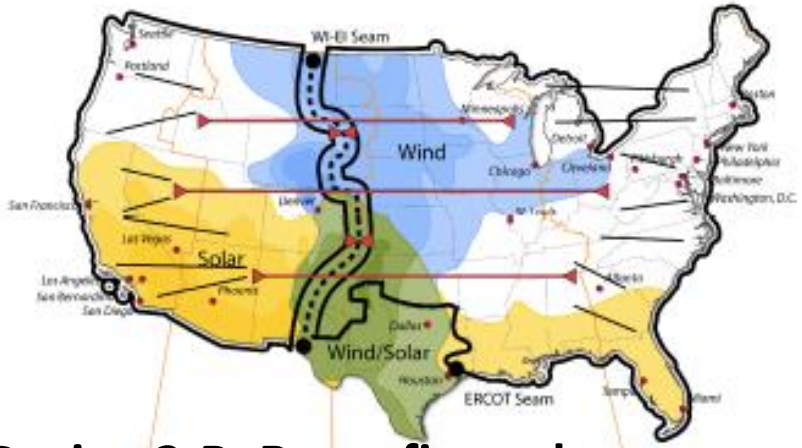


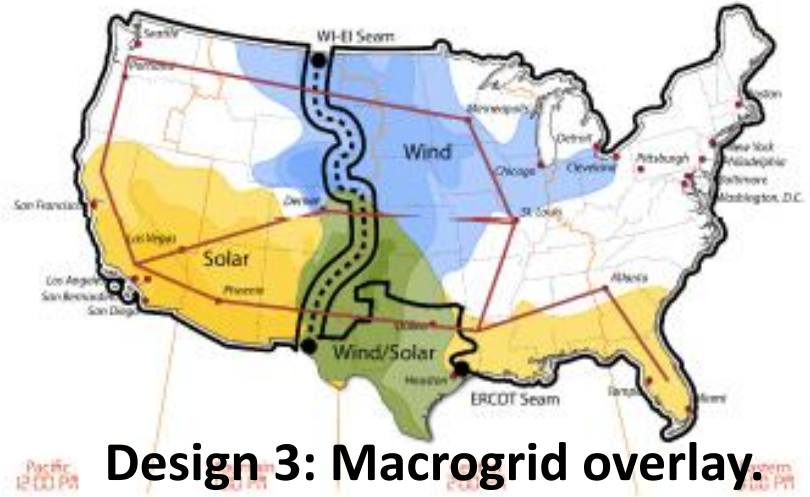
Design 1: No additional cross-seam capacity. This is benchmark.



Design 2A: Reconfigured seam - additional B2B capacity only

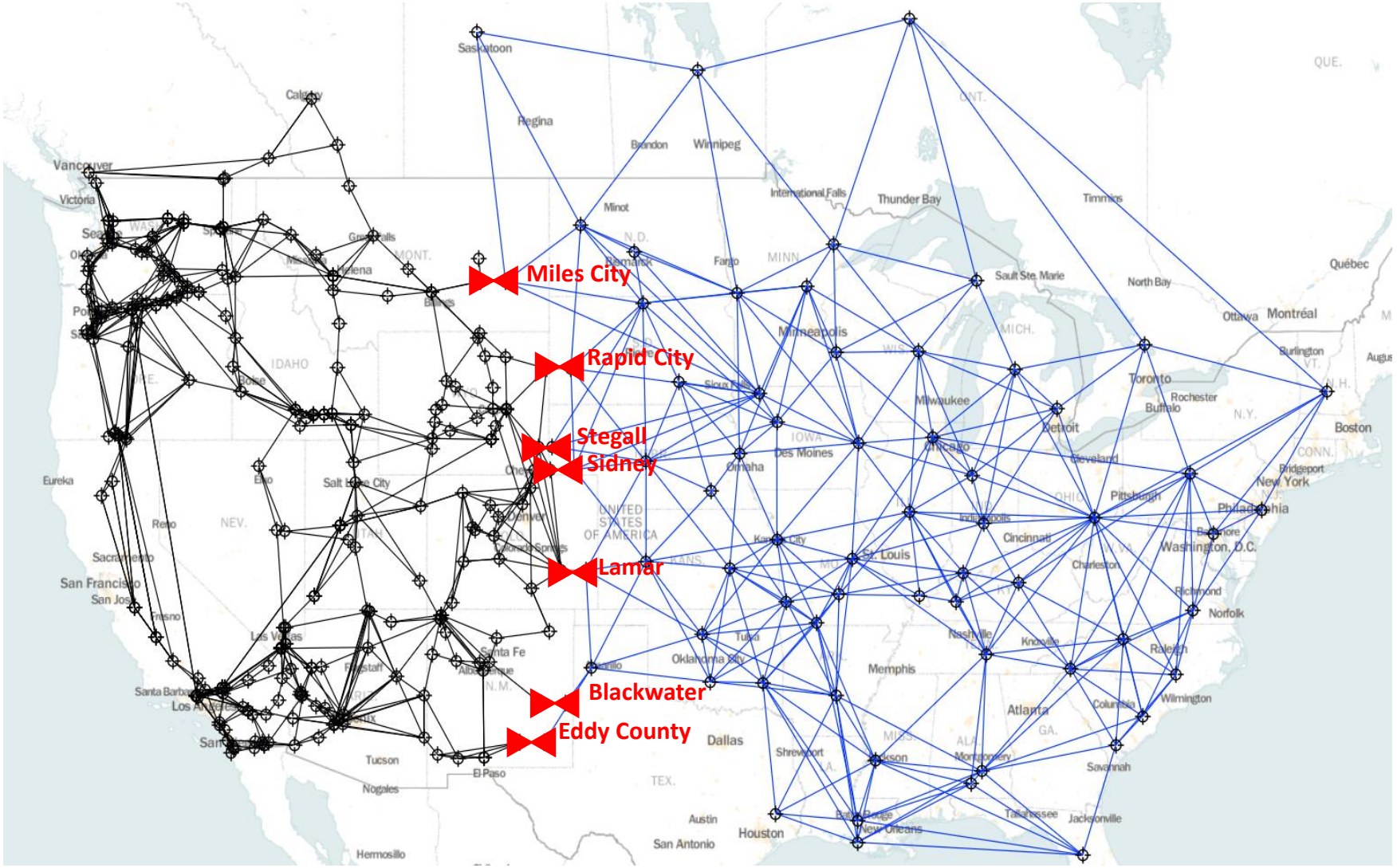


Design 2-B: Reconfigured seam - additional capacity via B2B/HVDC lines



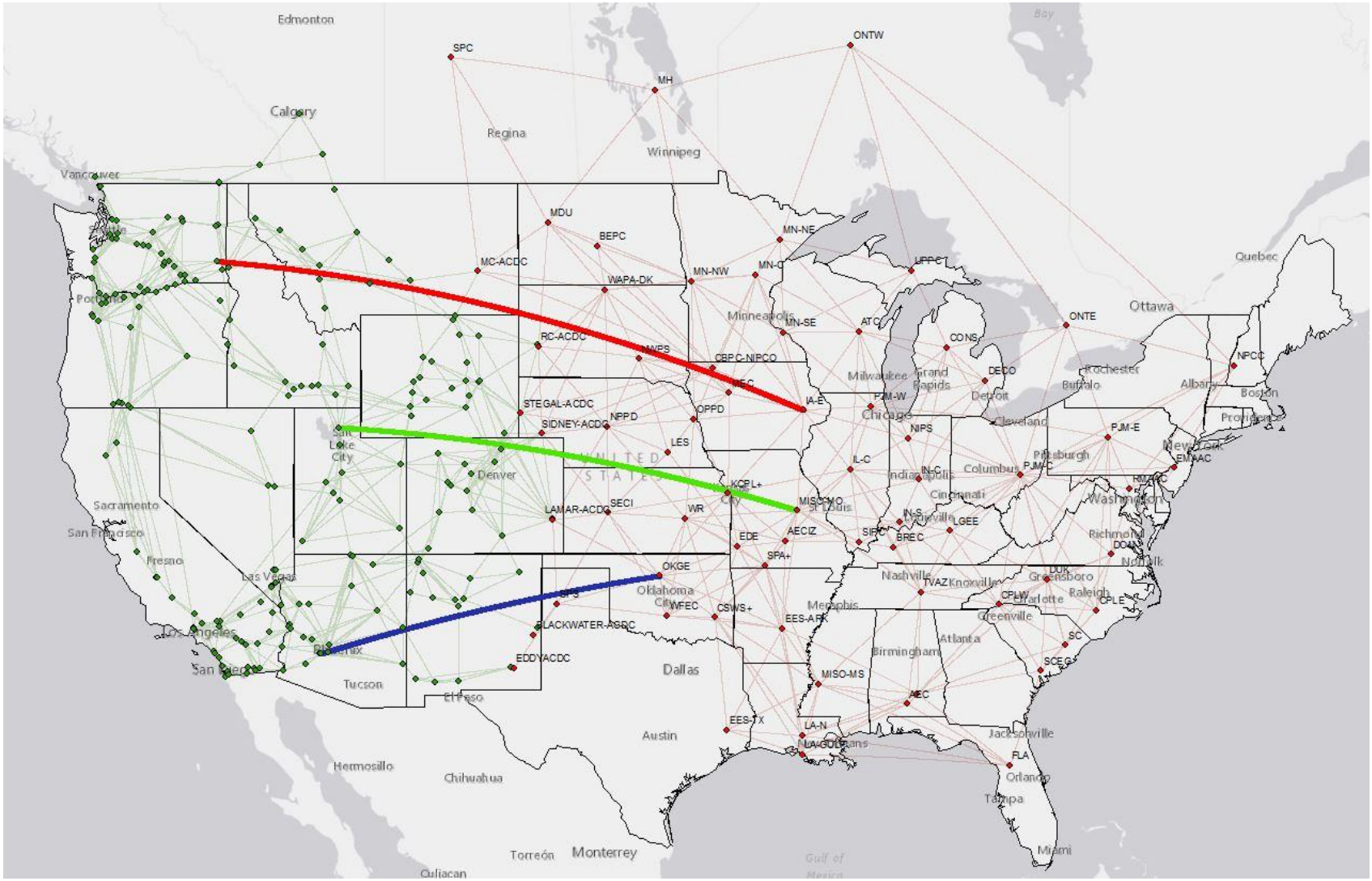
Design 3: Macrogrid overlay.

Interconnection Seams Study (DOE Grid Modernization Laboratory Consortium)



Design 2-A: Reconfigured seam - additional B2B capacity only

Interconnection Seams Study (DOE Grid Modernization Laboratory Consortium)



Design 2-B: Reconfigured seam - additional capacity via B2B/HVDC lines

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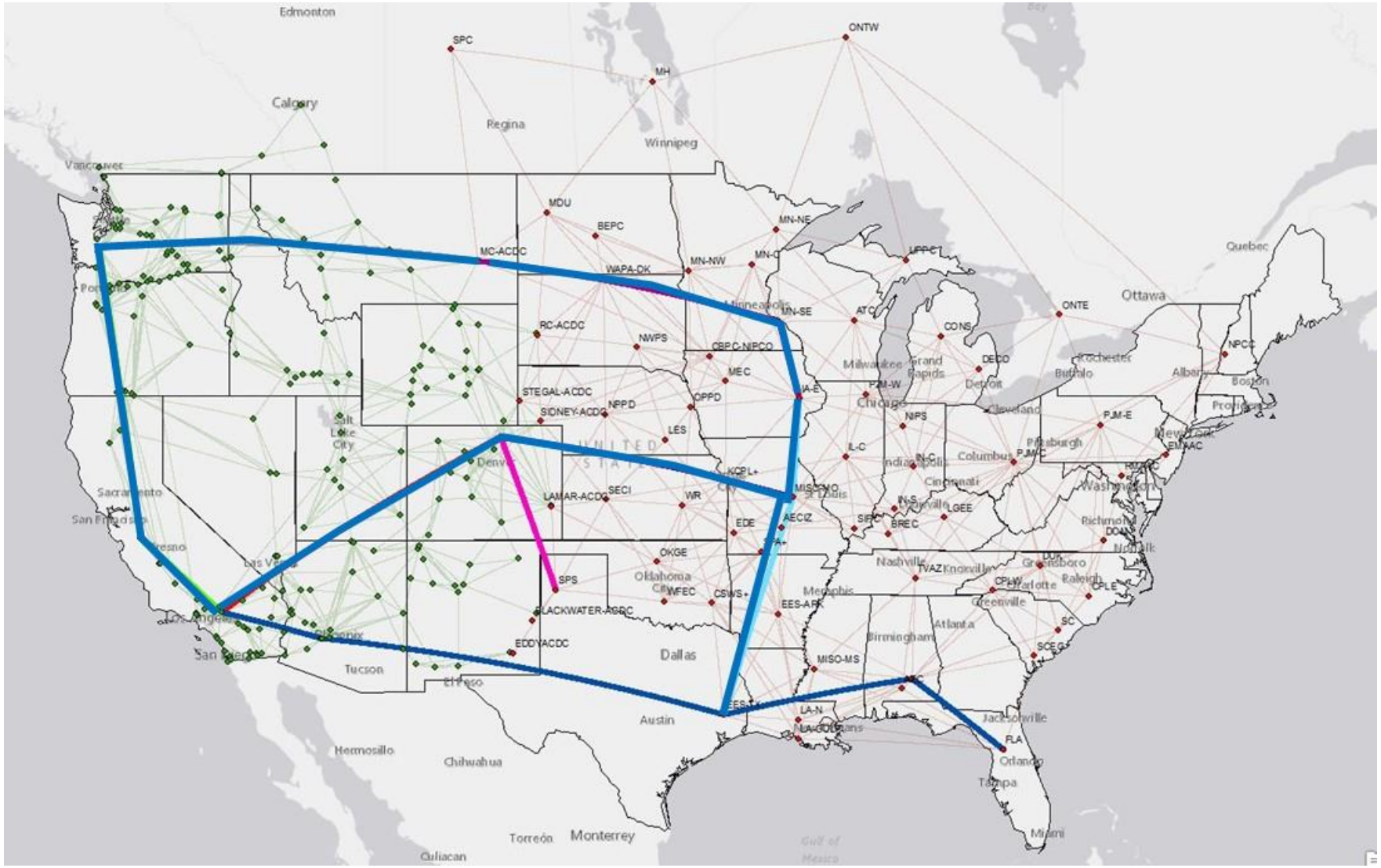
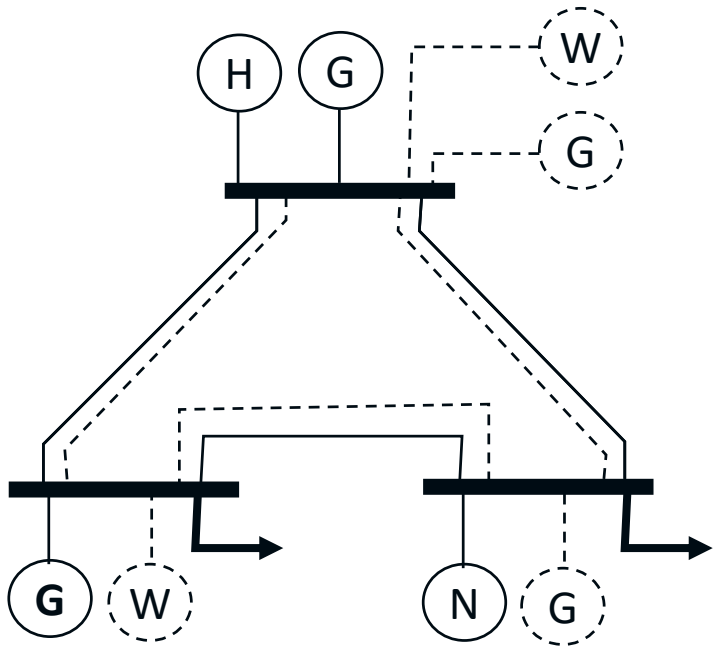


Design 3: Macrogrid overlay.

Project features

Co-optimized generation/transmission planning: identifies future generation and transmission investments to minimize total costs.

Identify investment & retirement decisions to MINIMIZE



PRESENT WORTH

G&T Investment Costs
+ Fixed O&M Costs
+ Var O&M Costs
+ Fuel Costs
+ Reserve Costs
+ Environmental Costs

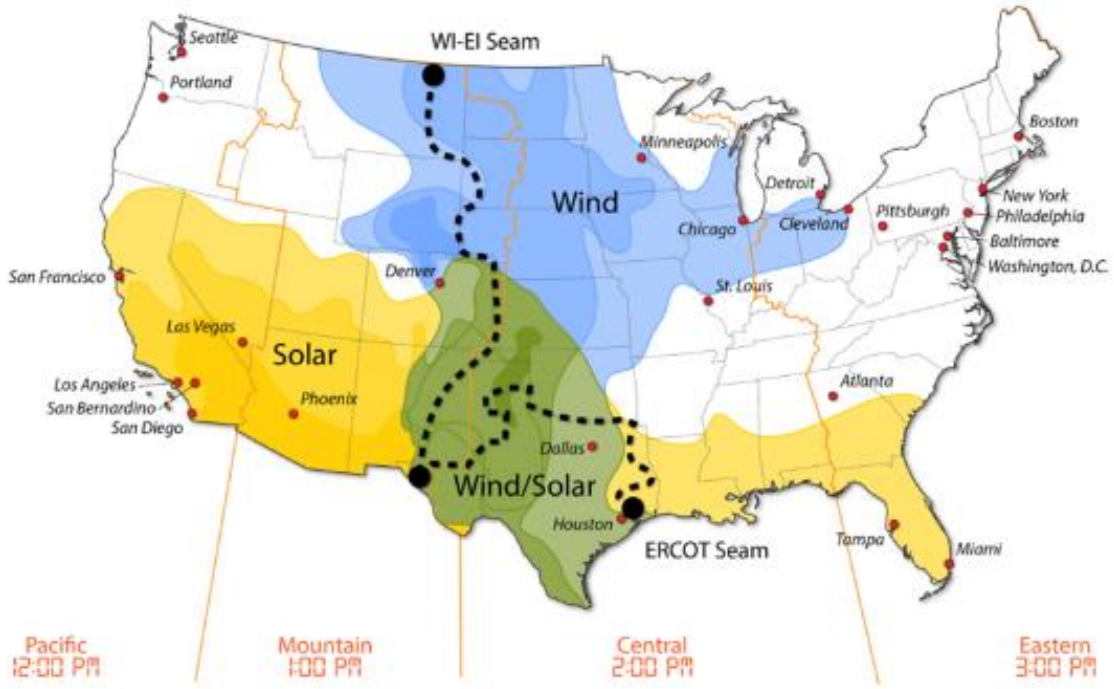
SUBJECT TO:

Investment constraints
Operational, planning, environmental constraints
Uncertainty characterization

Year 1 **Year 2** ••• **Year N**

Project Features

1. Value to increasing cross-seams transmission:
   - ➢ Increases deliverability of highest quality wind & solar
   - ➢ facilitates sharing of energy & ancillary services across time zones
   - ➢ facilitates sharing of planning reserve across regions

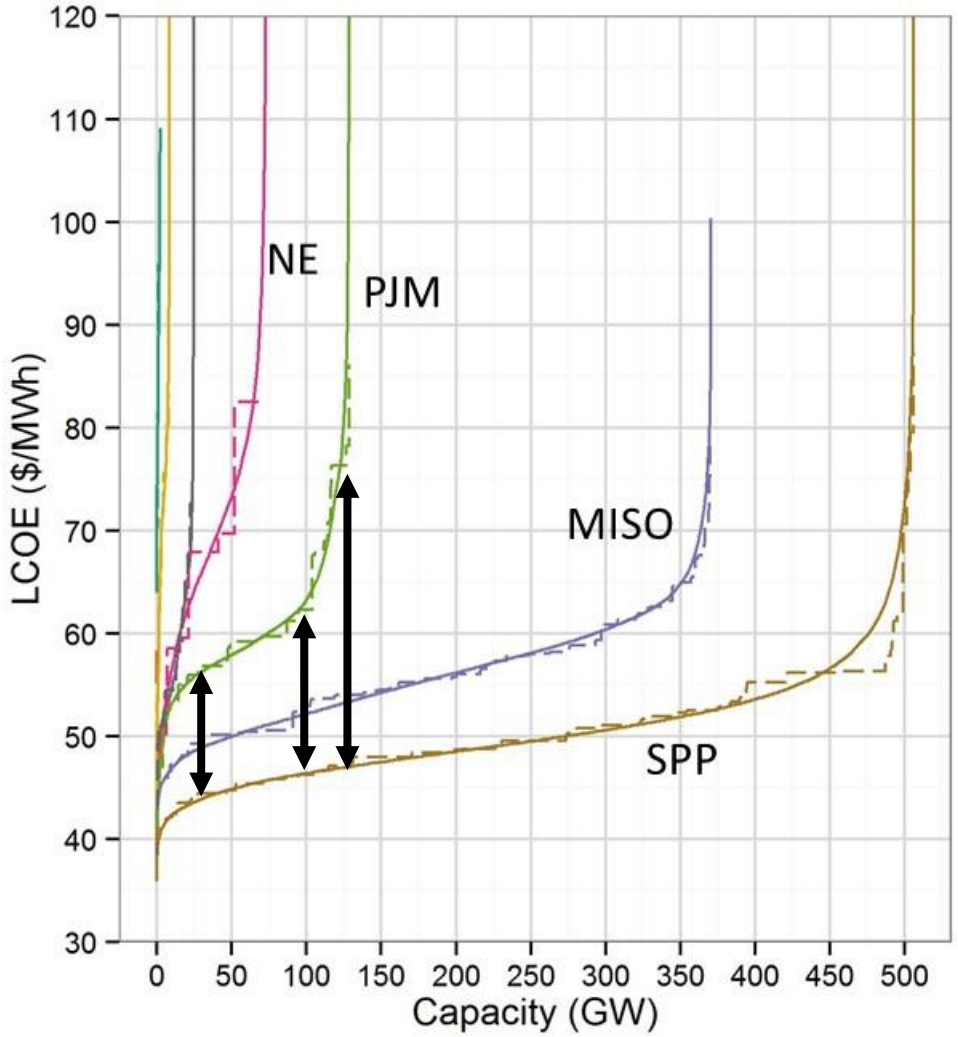


2. Influences affecting this value:
   - ➢ clean energy policies RPS and/or CO_2 cost
   - ➢ Proximity of high quality resources to load centers:
     - ➔ wind, solar, gas, DG
   - ➢ transmission cost

➔Preliminary results of this project to be further described by Armando Figueroa next week…

Observations

3. Data speaks: wind supply curves for 100m data

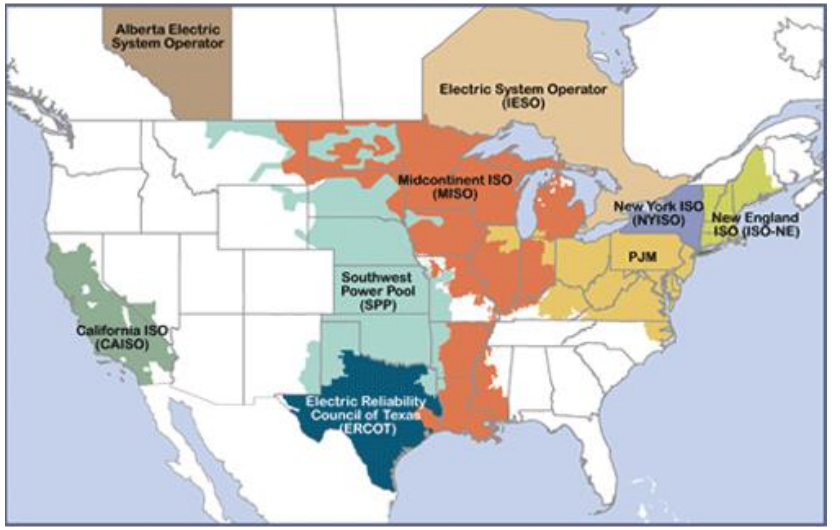


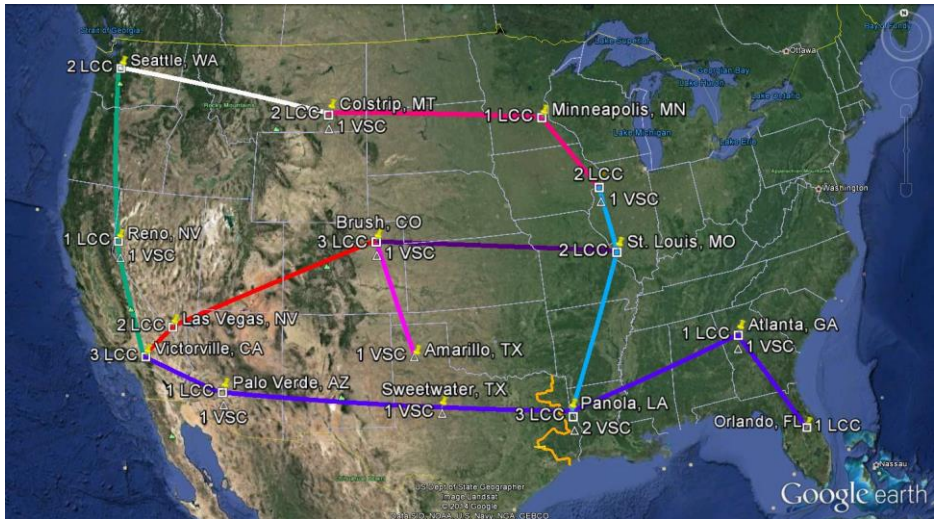
100 meter wind data appears to decrease LCOE differential

Eastern wind investment occurs before Midwestern wind investment until differential between LCOE offsets transmission cost.

The macrogrid overlay (Design 3)

- Designed by Mid-Continent Independent System Operator (MISO)
- Cost of macrogrid is $36B
- MISO indicates $45B in direct benefits:
  - Reserve sharing among regions
  - Regulation sharing among regions
  - Frequency response enhancement
  - Reduced transmission cost
- Studies show decreased cost/MT CO_2 reduction
- Additional benefits from $130B economic development value due to
  - Construction jobs
  - Taxes
  - Land lease payments





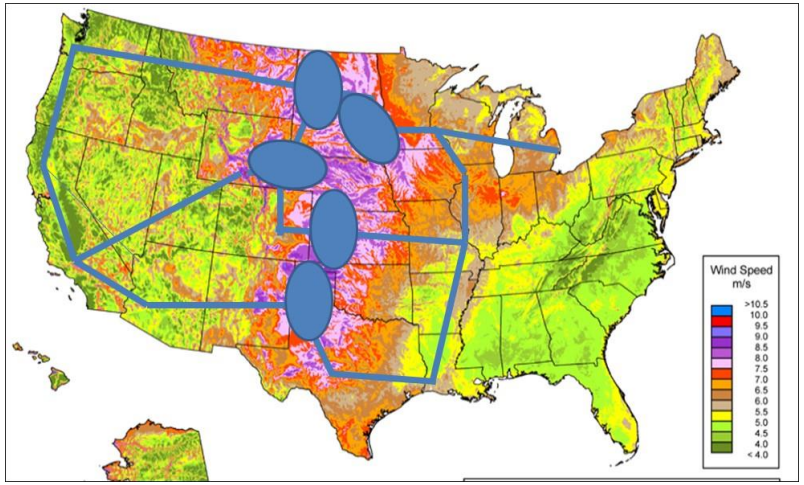
The macrogrid overlay

Cost	Units	$/Unit	Total
Line	7654 Miles	$3 Million/Mile	$23.0 Billion
LCC	22 Terminals	$472 Million/Terminal	$10.4 Billion
VSC	10 Terminals	$285 Million/Terminal	$2.9 Billion
		Grand Total	**$36.2 Billion**

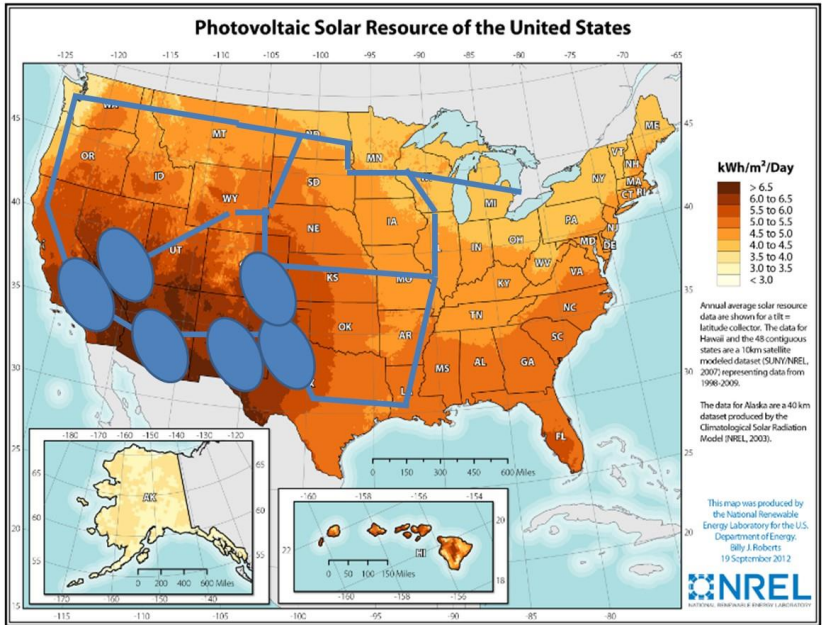
Benefit	Total	
Load Diversity	$ 21.0 Billion	46%
Frequency Response	$ 9.8 Billion	22%
Wind Diversity	$ 2.2 Billion	5%
Other Energy Based Benefits	$ 12.2 Billion	27%
Grand Total	**$45.3 Billion**	

Benefit/Cost Ratio	1.25

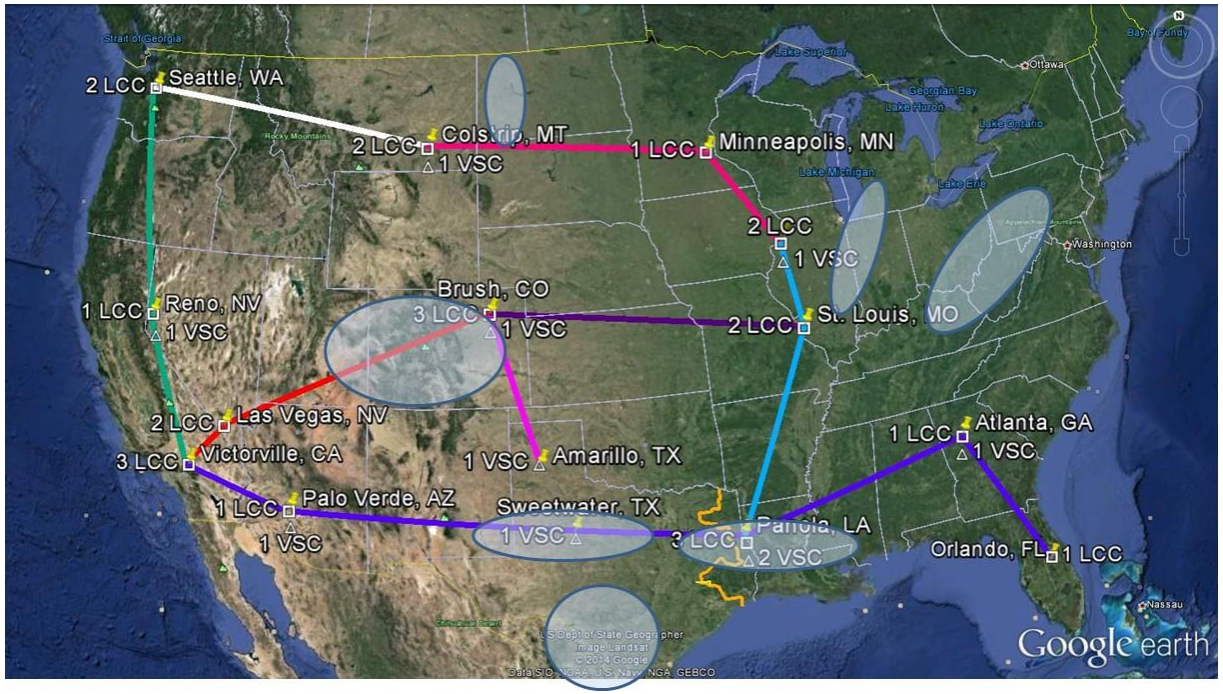
The macrogrid overlay



Delivers best wind resources



Delivers best solar resources



Delivers best gas resources

Issues

- cost allocation: who will pay for it?
- market impacts (winners/losers)
- policy and technology uncertainty
- obtaining right-of-way
- effects on each state's economic development
- resource nationalism (parochialism)

"One problem," he said, is "resource nationalism," in which individual states want to use local resources, whether they are coal or yet-to-be-built offshore wind, rather than importing from neighbors in a way that could be more economical.

James Hoecker, FERC Commissioner 1993-2001,
FERC Chair 1997-2001

in Matthew L. Wald, "Ideas to Bolster Power Grid Run Up Against the System's Many Owners," NY Times, July 12, 2013, www.nytimes.com/2013/07/13/us/ideas-to-bolster-power-grid-run-up-against-the-systems-many-owners.html?emc=eta1&_r=1&

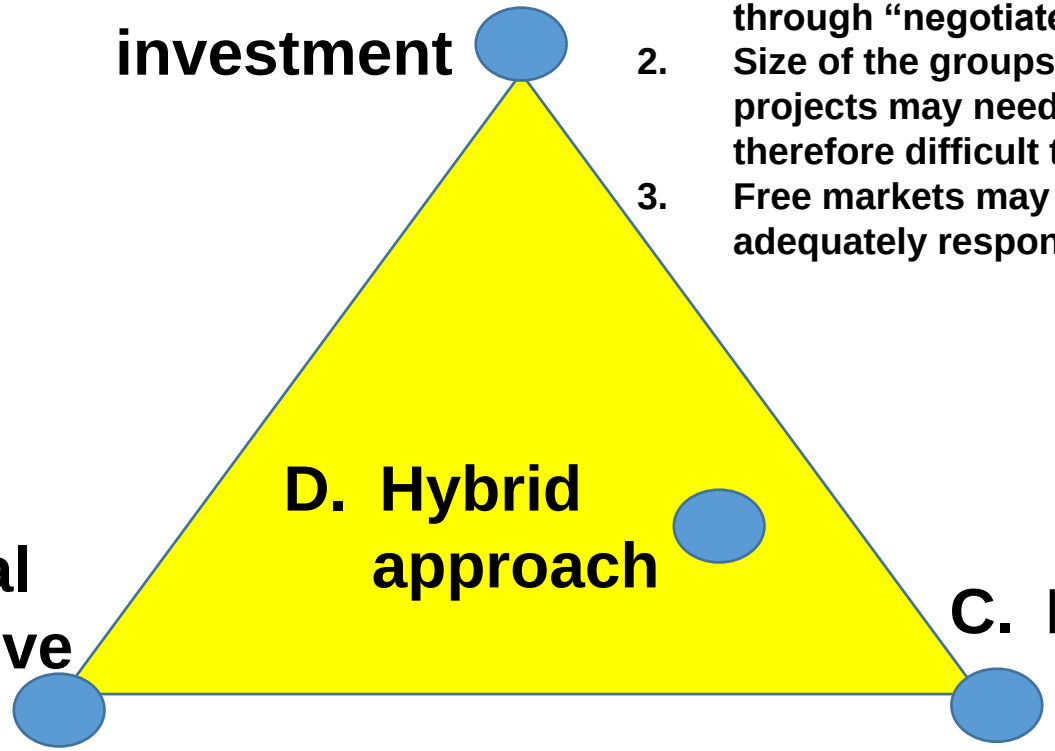
Issues

Organizations comprising the Electric Power Industry

- Investor-owned utilities: 239 (MEC, Alliant, Xcel, Exelon, …)
- Federally-owned: 10 (TVA, BPA, WAPA, SEPA, APA, SWPA…)
- Public-owned: 2009 (Ames, Cedar Falls, Muscatine, …)
- Consumer-owned: 912 (Dairyland, CIPCO, Corn Belt, …)
- Non-utility power producers: 1934 (Alcoa, DuPont,…)
- Power marketers: 400 (e.g., Cinergy, Mirant, Illinova, Shell Energy, PECO-Power Team, Williams Energy,…)
- Coordination organizations: 9 ISO/RTOs (ISO-NE, NYISO, PJM, MISO, SPP, ERCOT, CAISO, AESO, NBSO), 7 are in the US.
- Oversight organizations:
  - Regulatory: 50 state, 1 Fed (FERC)
  - Reliability: 1 National (NERC), 8 regional entities
  - Environment: 50 state (DNR), 1 Fed (EPA)
- Manufacturers: GE, ABB, Toshiba, Schweitzer, Westinghouse,…
- Consultants: Black&Veatch, Burns&McDonnell, HD Electric,…
- Vendors: Siemens, Areva, OSI,…
- Govt agencies: DOE, National Labs,…
- Professional organizations: IEEE PES …
- Advocacy organizations: AEWA, IWEA, Wind on Wires…
- Trade Associations: EEI, EPSA, NAESCO, NRECA, APPA, PMA,…
- Law-making bodies: 50 state legislatures, US Congress

Balkanized authority: With so many decision-makers, many with conflicting preferences, what are possible paths forward to building such geographically expansive infrastructure?

Possible paths forward



1. Market (merchant)-driven investment: no rate-base recovery, costs recovered through "negotiated rates."
2. Size of the groups to form for overlay projects may need to be large and therefore difficult to develop/manage.
3. Free markets may be too short-term to adequately respond.

1. Similar to interstate highway system, Feds paid 90% via gasoline tax, states 10%. States managed program for location, design, ROW acquisition, construction, O&M.
2. Not clear that the interstate highway system had a "pass-through" feature like an overlay may have.

1. Establish permanent multiregional stakeholder group consisting of industry, state governments, advocacy groups.
2. States need to see benefit for taking multiregional view.

Possible paths forward

D. Hybrid Approach

1. **Design it using multiregional collaborative stakeholder group of industry, states, advocacy groups, and DOE, supported by Governors Associations. Impasses addressed by federally-appointed arbiters.**

2. **Incentivize merchant transmission developers to build consistent with design.**

3. **Federalize what merchant developers will not or cannot build, but with careful Fed-State coordination and cooperation.**

Possible paths forward

3/9/2017, FOX Business, www.foxbusiness.com/politics/2017/03/09/trump-starts-to-sketch-1-trillion-infrastructure-plan.html

Trump Starts to Sketch $1 Trillion Infrastructure Plan

Mr. Trump said he would was inclined to give states 90 days to start projects, and asked Scott Pruitt, the new head of the Environmental Protection Agency, to provide a recommendation. He expressed interest in building new high-speed railroads, inquired about the possibility of auctioning the broadcast spectrum to wireless carriers, and asked for more details about the Hyperloop, a project envisioned by Tesla (TSLA) founder Elon Musk that would rapidly transport passengers in pods through low-pressure tubes.

"America has always been a nation of great promise, because we dream big," Mr. Trump said. "We're going to really dream big now."

…

"There's a great of interest in Congress in doing this," Mr. Pence said. "**But there's also just as much interest in listening to leaders in the private sector to identify the capital and identify the needs to be able to finance this in a way that really captures the energy of the American economy**."

The meeting included Richard LeFrak, chief executive of the LeFrak real-estate company, and Steve Roth, chief executive of Vornado Realty Trust (VNO), who are co-chairmen of the infrastructure project. Also in the meeting were Josh Harris, co-founder of Apollo Global Management (APO); Bill Ford, chief executive of General Atlantic LLC; Lynn Scarlett, managing director of the Nature Conservancy; Tyler Duvall of McKinsey & Co.; and Mr. Musk.

Democrats, who saw their efforts to boost infrastructure spending stymied during the Obama administration, have welcomed Mr. Trump's attention to the issue. But they have urged direct federal spending on projects, rather than using new tax credits to lure private investors as Trump advisers have suggested.

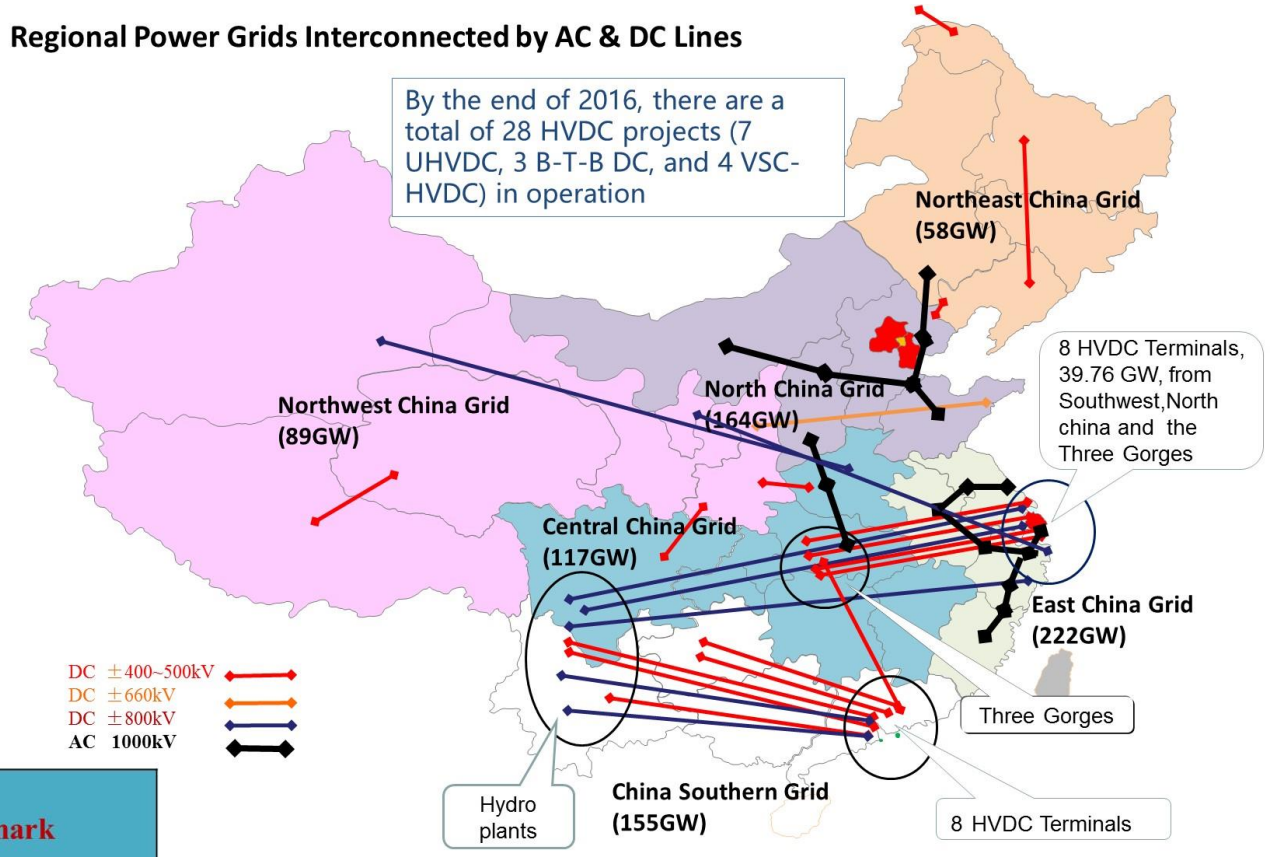
Possible paths forward

1/25/2017, Utility Dive,
www.utilitydive.com/news/trump-infrastructure-priority-plan-includes-transmission-wind-energy-stor/434754/l

Trump infrastructure priority plan includes transmission, wind, energy storage

Of the 50 infrastructure projects, seven focus on the electricity sector:
•#9: The Plains and Eastern transmission project, which aims to move wind power from the Oklahoma panhandle to load centers in Tennessee;
•#12: Hydroelectric Plants operated by the U.S. Army Corps of Engineers, many of which are slated for upgrades;
•#16: The TransWest Express Transmission line, which would deliver renewable energy produced in Wyoming to load centers in California, Nevada and Arizona;
•#17: The Chokecherry and Sierra Madre wind projects, an up-to 3,000 MW wind energy project in Wyoming;
•#20: The Atlantic Coast Pipeline, a multi-utility project that would transport gas from West Virginia down through North Carolina;
•#21: The Champlain Hudson Power Express, a hydropower project that could bring up to 1,000 MW of clean power to the New York metro, and;
•#49: Energy Storage and Grid Modernization in California, which highlights the mitigation efforts taken during the Aliso Canyon natural gas shortage.

Compare to China

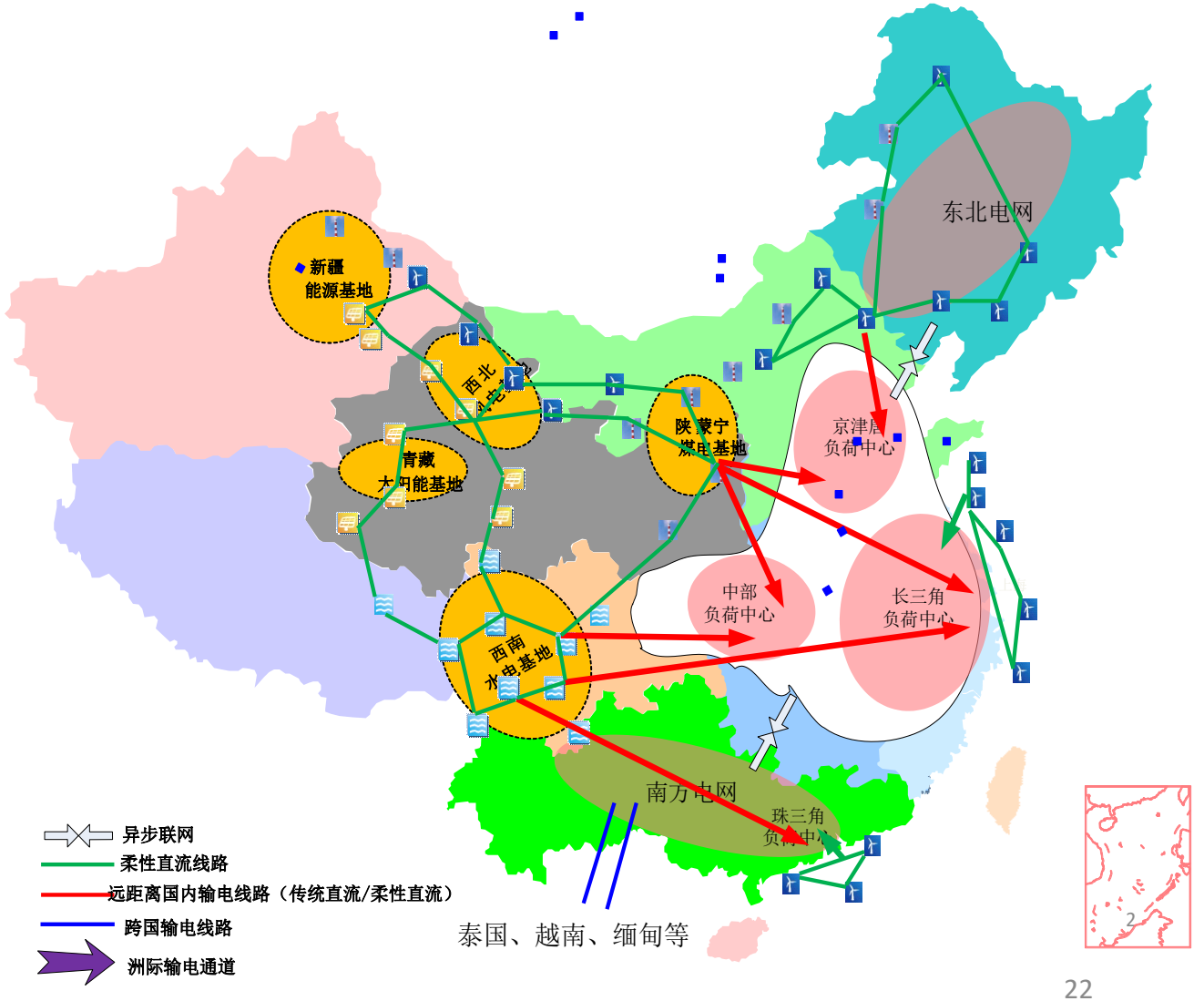


According to “13th Five-Year” Plan for the electrical power development formulated by the government, the UHVDC capacity in operation and under construction is 56GW in northern region. 43GW wind power will be transmitted by those UHVDC lines

UHVDC Projects	State	HVDC capacity (MW)	Coal power capacity (MW)	Wind power capacity (MW)	Remark
Tianshan~Zhongzhou±800kV	operation	8000	6670	8000	wind 8000、solar 1250
Jiuquan~Hunan±800kV	construction	8000	6000	7000	wind 7000、solar 2800
Jinbei~Nanjing±800kV	construction	8000		8000	wind 8000
Ximeng~Taizhou±800kV	construction	10000	7300	7000	
Zhalute~Qingzhou±800kV	construction	10000	2000	6000	wind assembling
Zhundong~Wannan±1100kV	construction	12000		7700	
Total		56000		43700	

Compare to China

In the future, two DC grids may be constructed in west and northeast areas in China. The wind power, solar power and hydropower will be sorted to the grid and transferred to East China and South China.



Reflection

➔Transmission provides many benefits

- Renewable integration:
  - Reserve sharing among regions
  - Regulation sharing among regions
  - Frequency response enhancement
  - Reduced transmission cost;
  - Reduced flexibility cost.
- and others: reliability, resilience, adaptability;

➔China built major interregional transmission infrastructure in short time.

➔US has not built any major interregional transmission infrastructure in many years.

➔Assume it should be done (next week will support). What can be done?

Reflection

Two questions were raised during the presentation of the previous slides.

1. Would not high capacity interregional transmission pose a security risk?

   The benefits far outweigh the risks. The benefits are high and certain. The risks are very low and very uncertain. Other countries understand this.

   - Transmission like this contributes to system flexibility, reliability, resilience, and adaptability. I argue that transmission is the most cost-effective way to improve these four attributes. I can provide explicit definitions for these four ideas and then provide evidence to support the argument.
   - We should not be afraid to build what benefits us. Deciding to not build what benefits us because of the risk that terrorists may target it means that the terrorists win based only on the threat that they may act and not based on any act that they have to take.
   - We have other infrastructure like this (e.g., Pacific DC Intertie, Pacific AC Intertie, IPP DC Line, Quebec-New England, N. Dakota-Minnesota…) and there has never been a dedicated attack on any of it. There are at least two reasons for this: (i) taking it out does not result in much visibility (unlike Twin Towers); (ii) it is hard for non-experts to understand its significance.

2. Would transmission like this be unnecessary if we served all load with microgrids?

   Yes, but…

   - Microgrid concept depends on two ideas: ability to operate as an island and use of distributed energy resources (DER). The need to operate as an island is a need that is very customer-specific; the cost of providing this functionality is not justified for most customer classes (it may be justified for hospitals and military bases, for example, it is not justified for the neighborhoods most of us live in). On the other hand, the use of DER is a good idea and is growing.
   - So the right question here is to what extent is interregional transmission necessary given the option of deploying DER? And the right answer is to let them compete. If we do, I am pretty sure we will find that using both is good; the question will be the relative percentages. Each provides benefits not provided by the other.