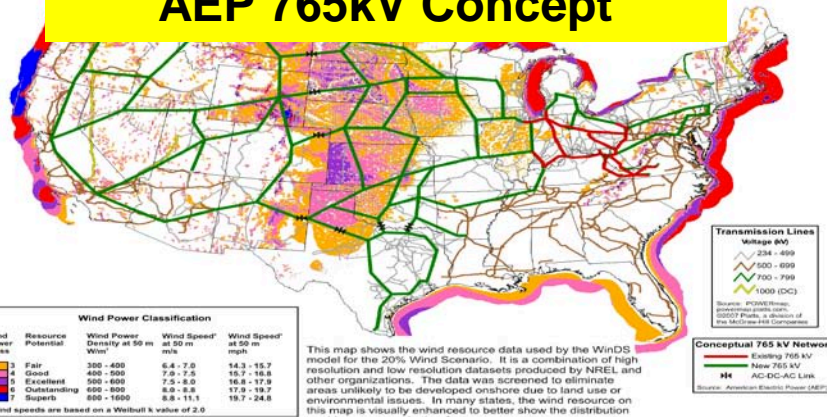


Interregional transmission design & benefit assessment

AEP 765kV Concept



James McCalley

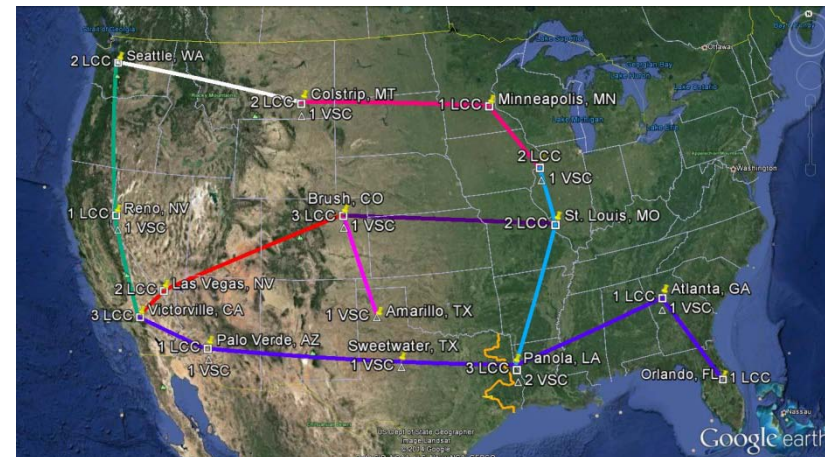
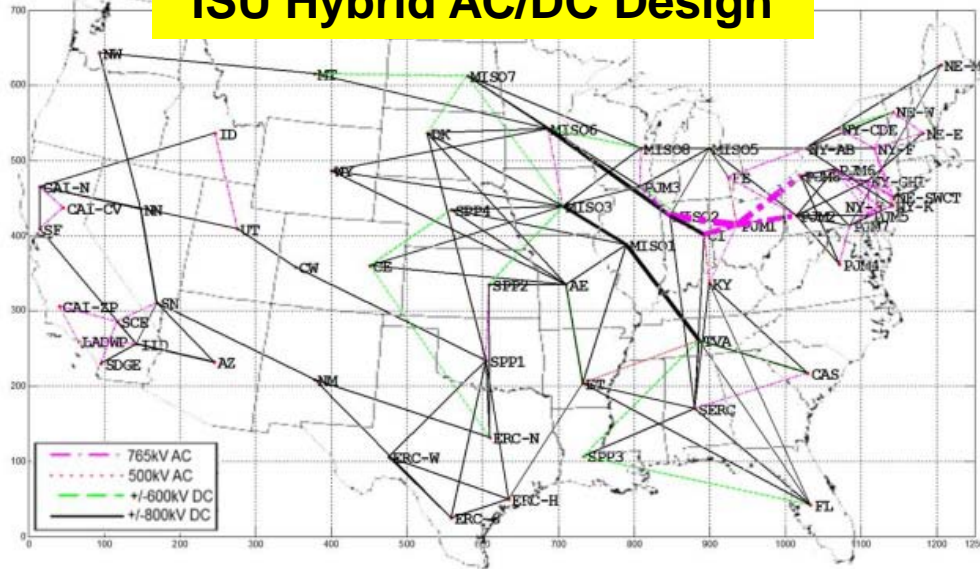
Harpole Professor of
Electrical & Computer Engineering

Yifan Li

Iowa State University
CIGRE USNC

Grid of the Future Symposium
Oct 21, 2014

ISU Hybrid AC/DC Design



MISO HVDC Design

Motivation

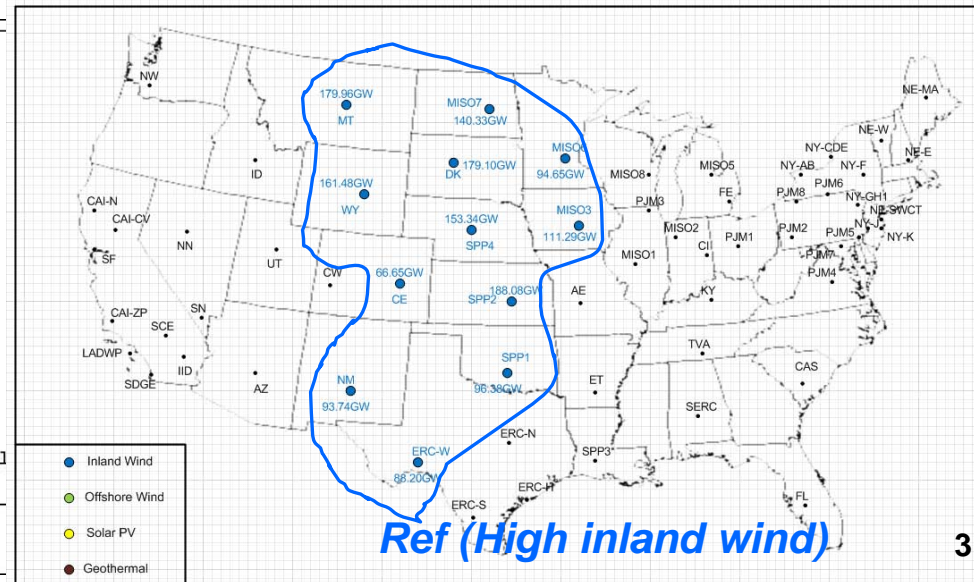
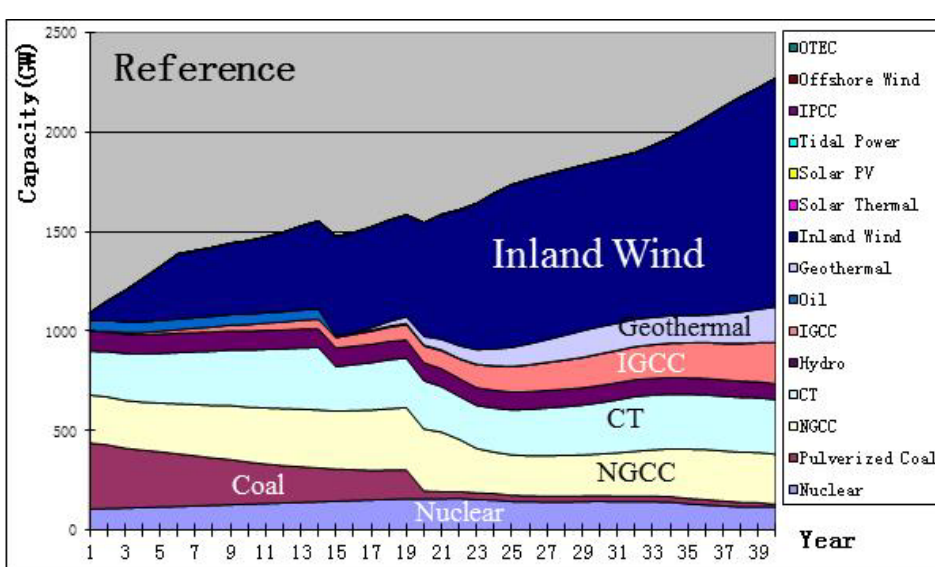
1. Decreased cost of reaching renewable and emissions goals via access to higher capacity-factor renewable energy
2. Capacity investment deferral
3. Decreased cost of operating reserves
4. Increased resilience to extreme events
(Katrina)
5. More adaptable to future uncertainties
(drought, Fukushima-type impacts, policy changes)

Step 1: Generation forecast

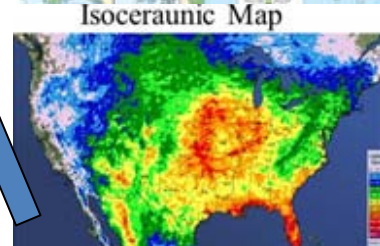
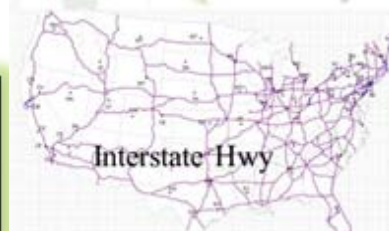
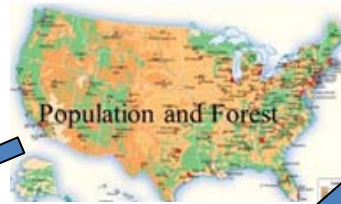
- 62 nodes



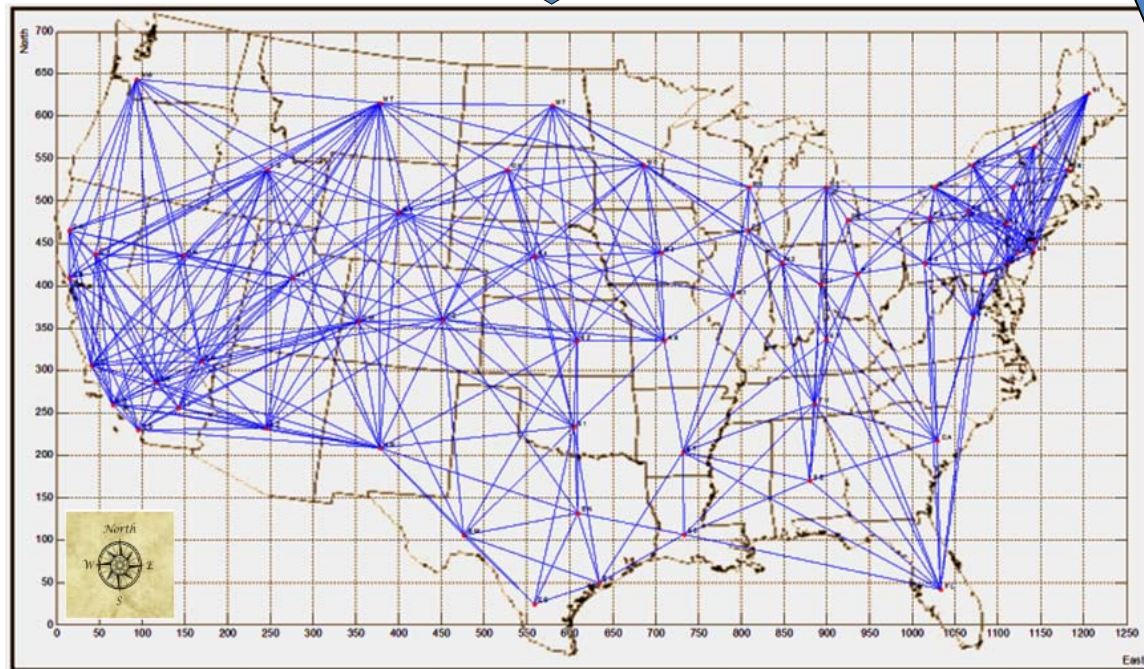
- Accurate representation of existing gen
- 15 candidate gen technologies
- Invested gen based on technlgy & location
- Observed NERC regional reserve requirements.



Step 2: Xmission Candidates



Iterative Reweighting Minimum Distance Spanning Tree Algorithm
→ Captures any arc which is “good” in any sense.



383 Candidates, N-1 connected set

Step 3: Network Expansion Optimization

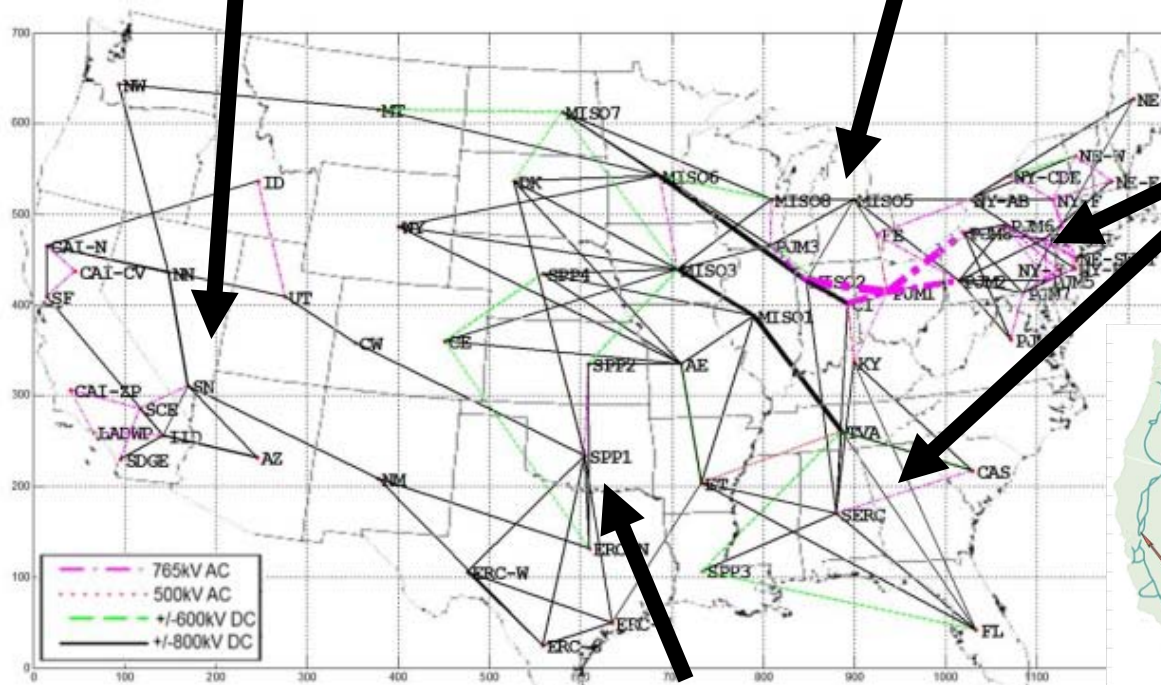
A multi-period, mixed-integer linear program

→ Chooses from 600, 800kV HVDC; 500, 765kV EHVAC

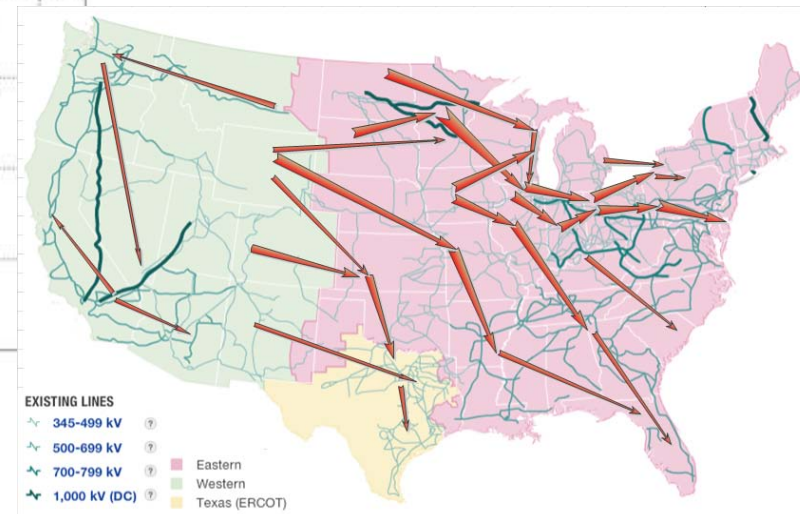
800kV DC lines supply SW, where limited renewable resources are available.

Major investments around Great Lakes, consistent with MISO-MTEP2010 results

Investments in PJM & SERC move renewable gen to load centers.

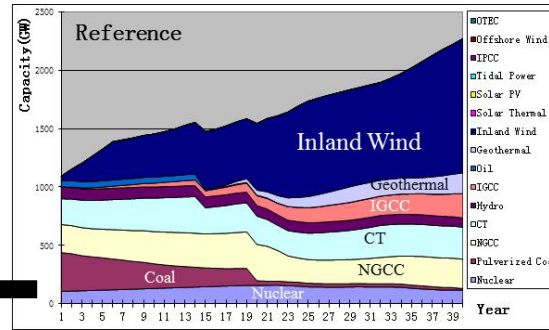
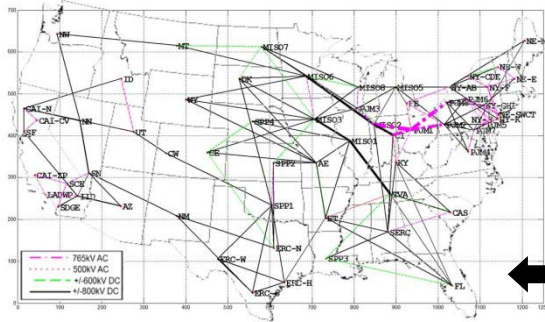


WECC, EI, and ERCOT interconnected near SPP.

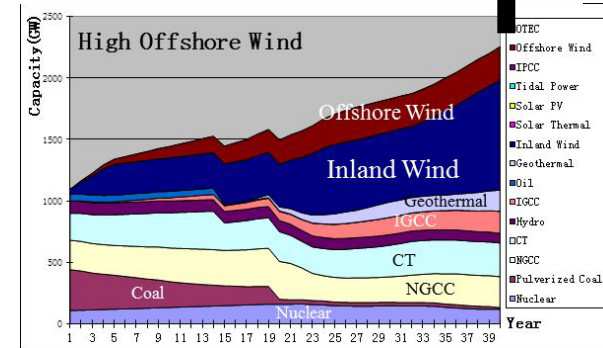
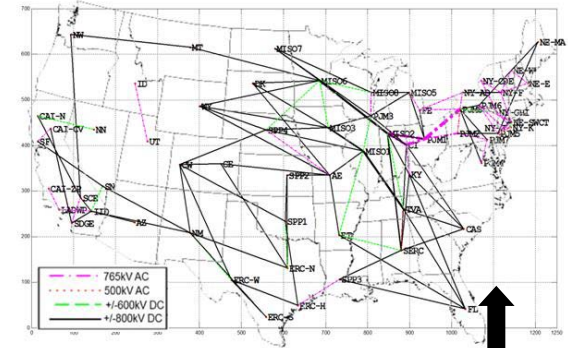


Design Results for 4 Gen Futures

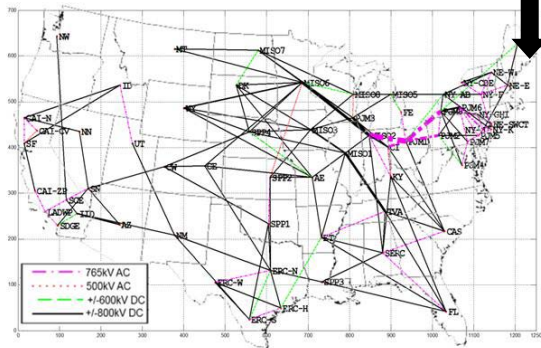
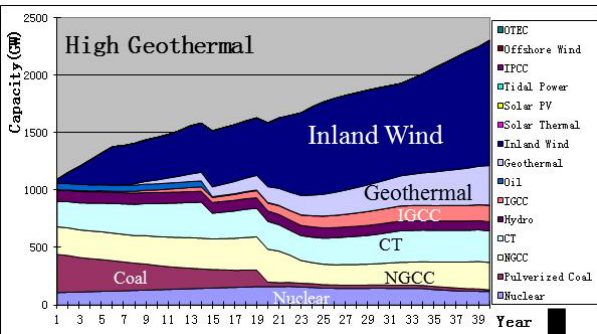
Ref (high inland wind)



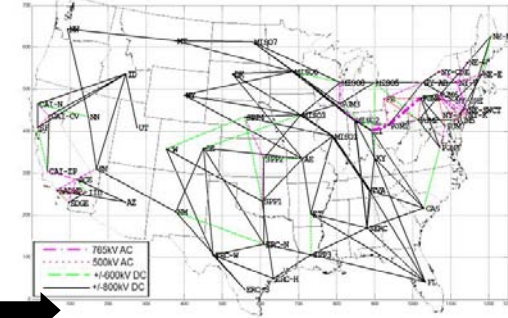
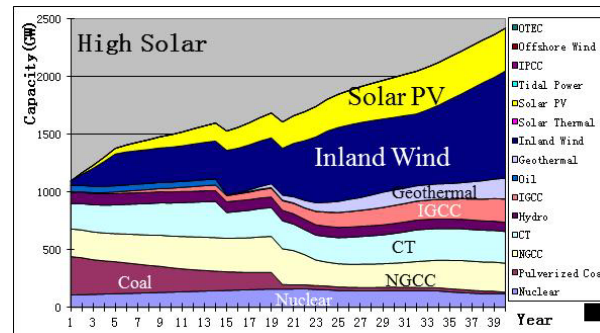
High Offshore Wind



Designs selected to minimize 40yr investment+operational costs, accounting for existing transmission, terrain, population density, forest areas, elevation, wind, ice-loading, right-of-way.



High Geothermal



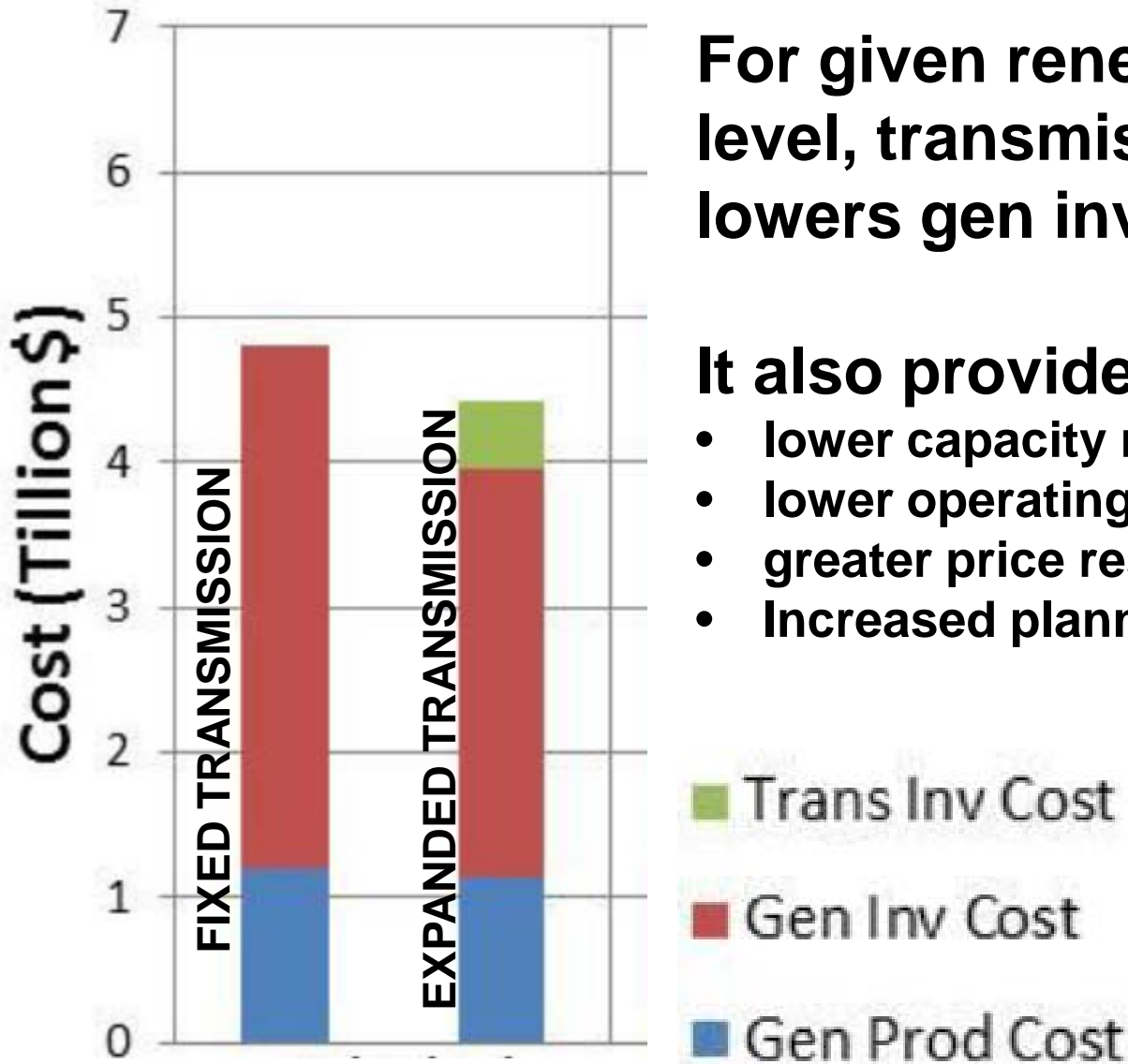
High Solar

Benefits

For given renewable penetration level, transmission expansion lowers gen invest/prod cost.

It also provides:

- lower capacity requirements
- lower operating reserve requirements
- greater price resilience;
- Increased planning adaptability.



Paths forward: frameworks

A. Market-driven investment

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 very large and difficult to develop/manage.

B. Federal initiative

D. Hybrid approach

C. Multiregional coordination

1. Similar to interstate highway system, where Feds paid 90% via gasoline tax, states 10%. States managed program for location, design, ROW acquisition, construction, O&M.
2. Differences: (a) Transmission “pass-through” feature is not shared with interstate highway system; (b) Economic development more at sending end.

1. Establish permanent multiregional stakeholder group consisting of industry, state governments, advocacy groups to address:
2. States need to see benefit for taking multiregional view.
3. The above is evolving.

Paths forward: Frameworks

D. Hybrid approach

- 1. Design it using multiregional collaborative stakeholder group of industry, states, advocacy, DOE, supported by Governors Associations. Impasses addressed by federally-appointed arbiters. Compensate losers.**
- 2. Incentivize merchant transmission developers to build consistent with design → A “transmission market”?**
- 3. Federalize what merchant developers will not or cannot build, but with careful Fed-State coordination and cooperation.**

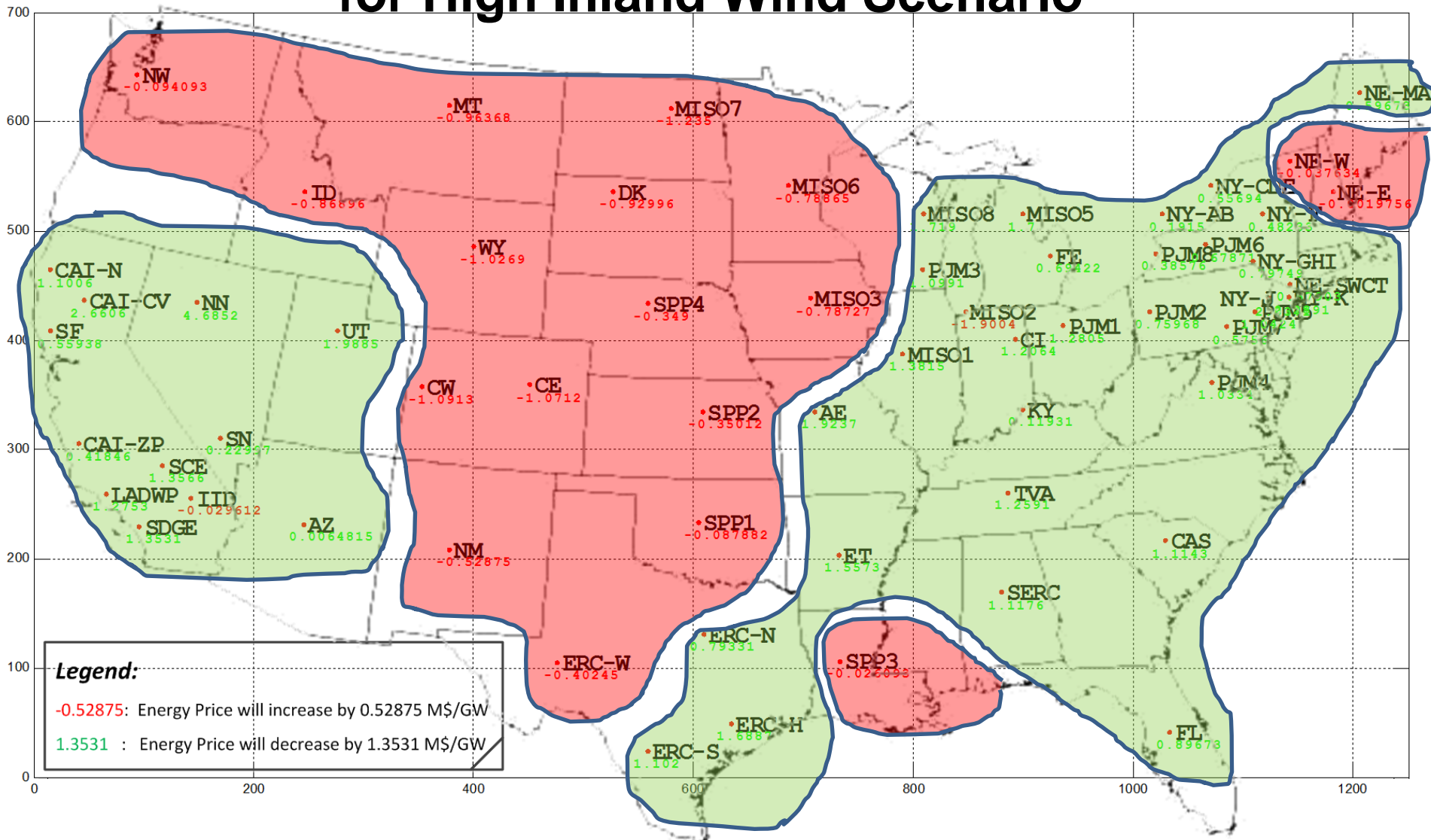
Resource Nationalism?

“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.

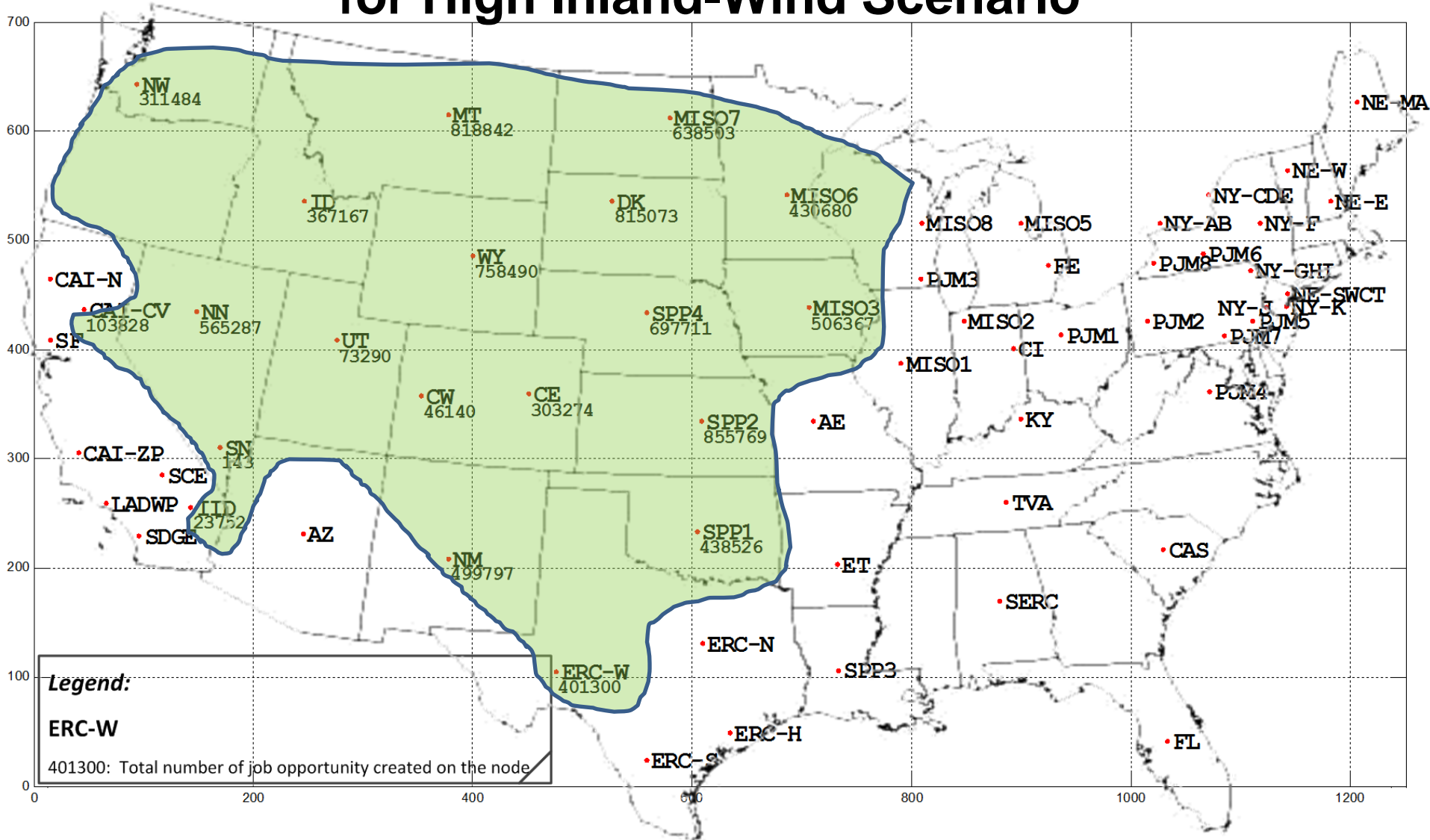
James Hoecker,
FERC Commissioner 1993-2001,
FERC Chair 1997-2001

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&

Impact of Transmission Expansion on Average LMPs for High Inland Wind Scenario



Impact of Generation Expansion on Job Creation for High Inland-Wind Scenario



Concluding comments

- Transmission lowers \$/unit-CO₂-red; increases resilience adaptability.
- Interregional transmission development and its cost-allocation difficult in US (but not China or Europe!) – developing socio-political-economic processes & procedures to address balkanization is an essential step.
- Developing interregional designs is useful even if entire design never built, because it identifies attractive transmission paths and it develops tools/approaches applicable to regional and sub-regional planning.

July 17, 2014: “A new executive action”

Build America Interagency Working Group: To expand and increase private investment and collaboration in infrastructure beyond the transportation sector, a federal inter-agency working group, co-chaired by Cabinet Secretaries Lew and Foxx, will do a focused review with the best and the brightest from the public and private sector. **This group will work with state and local governments, project developers, investors and others to address barriers to private investments and partnerships in areas including municipal water, ports, harbors, broadband, and the electrical grid.** The effort will include a particular focus on improving coordination to accelerate financing and completion of projects of regional and national significance, particularly those that cross state boundaries.