Eastern Wind Integration and Transmission Study

NY-ISO Stakeholder Meeting
February 17th, 2010

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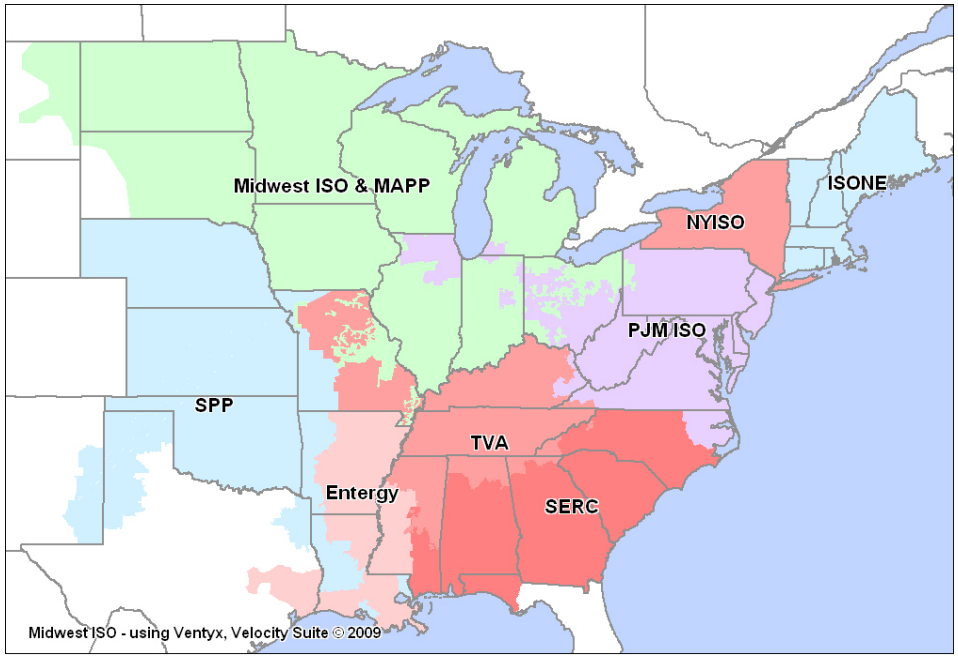
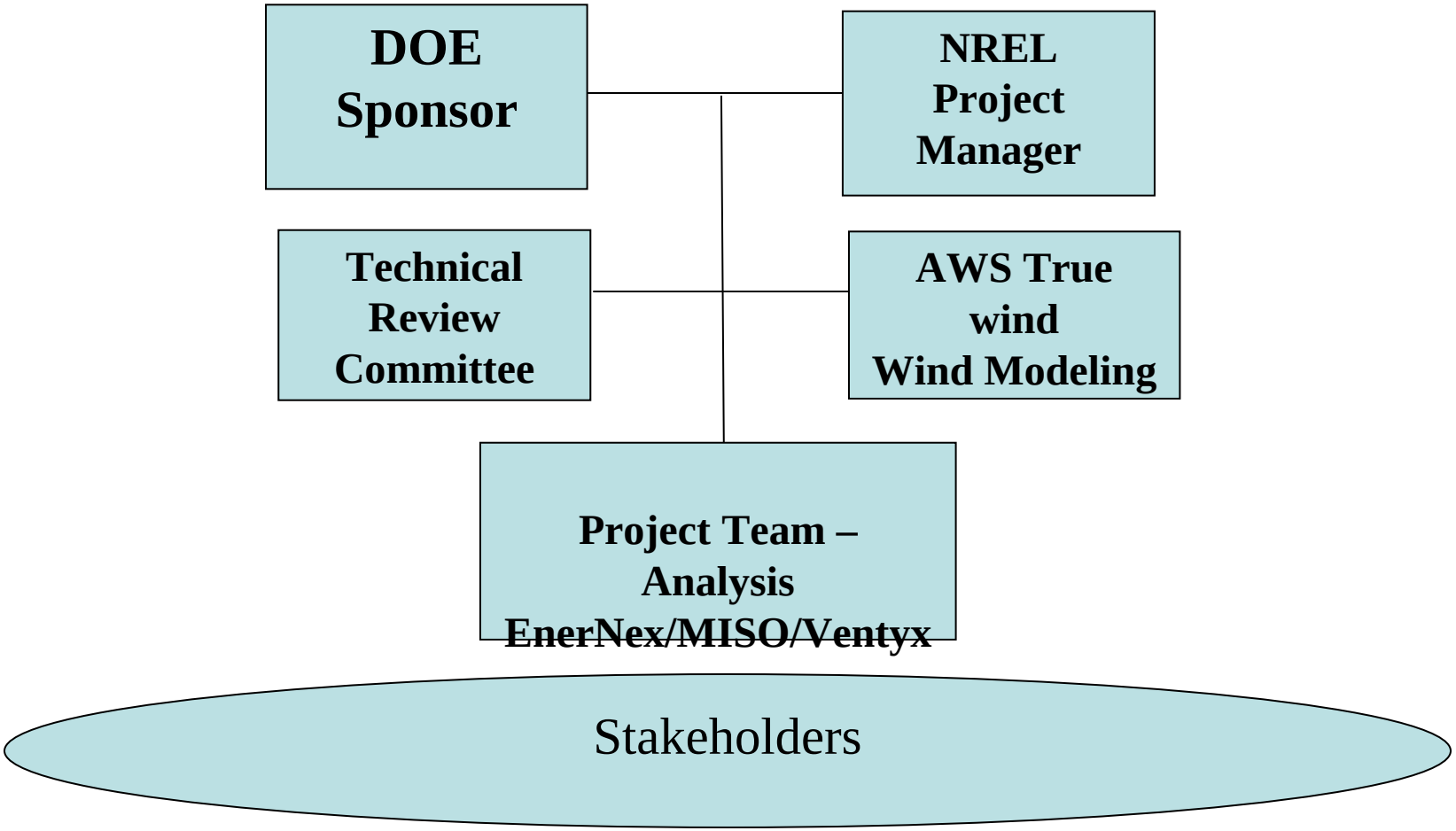
National Renewable Energy Lab

What is Needed to Integrate 20% Wind in the Eastern Interconnect?

- Evaluate the power system operating impacts and transmission associated with increasing wind energy to 20% and 30%
  - Impacts include operating with the variability and uncertainty of wind
- Build upon prior wind integration studies and related technical work;
- Coordinate with current regional power system study work;
- Produce meaningful, broadly supported results
  - Technical Review Committee



EWITS Study Organization



Technical Review Committee

- Includes representation from the following organizations

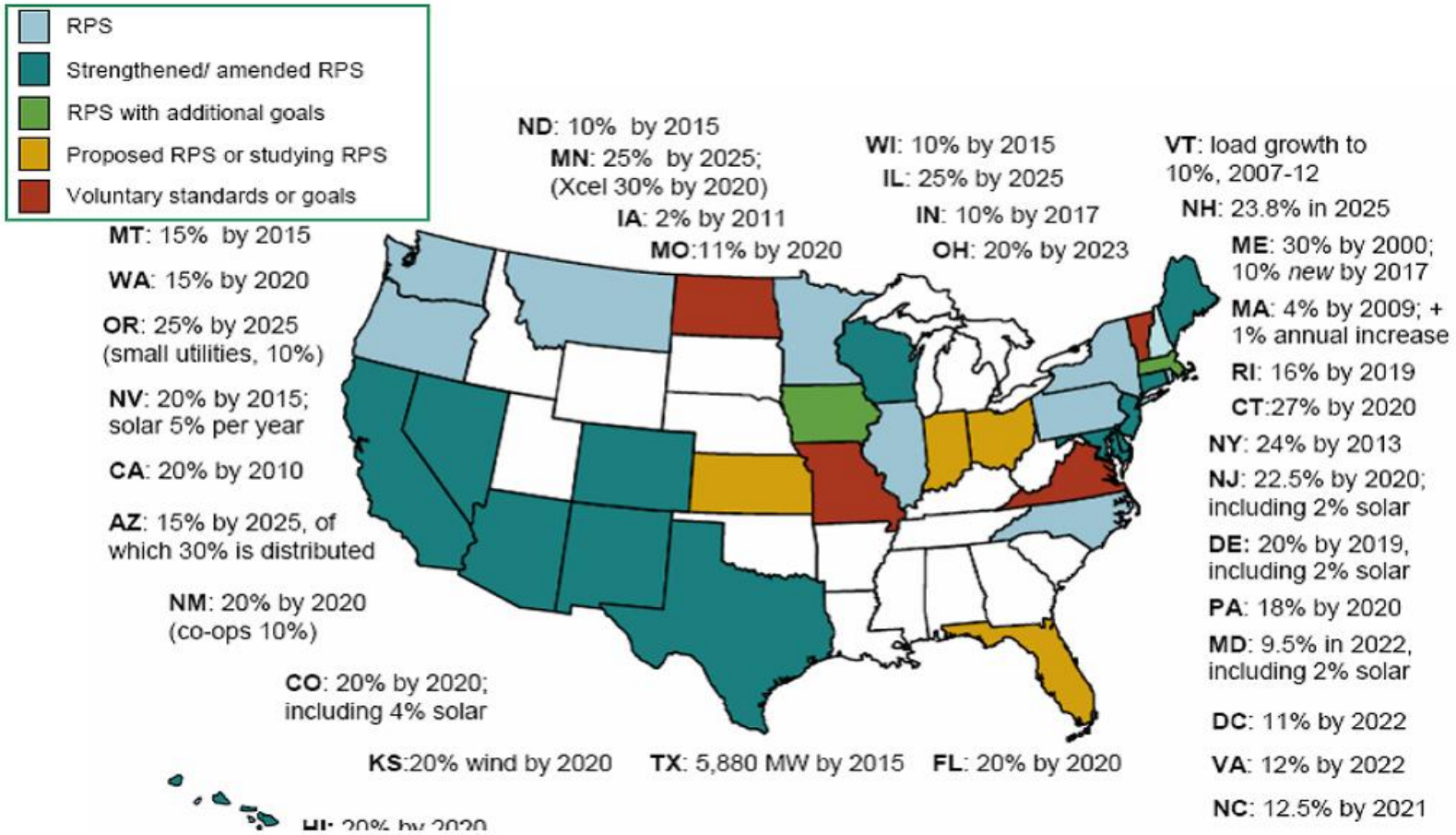
New York Independent System Operator (NYISO)
Xcel Energy
Southern Company
PJM Interconnection
Southwest Power Pool(SPP)
U.S. Department of Energy
Midwest ISO (MISO)
Michigan Public Service Commission
Area Power Pool (MAPP)
American Wind Energy Association (AWEA)

Federal Energy Regulatory Commission (FERC) – observer status
North American Electric Reliability Corporation (NERC)
CapX 2020 (Great River Energy)
Windlogics
National Renewable Energy Lab
General Electric (GE)
Regulatory Assistance Project
University College Dublin
Organization of MISO States (Wisconsin Public Service Commission)

EWITS Analysis Provides Detailed Information on

- Wind generation required to produce 20% and 30% of the projected electric energy demand over the U.S. portion of the Eastern Interconnection in 2024
- Transmission concepts for delivering energy economically for each scenario
- Economic sensitivity simulations of the hourly operation of the power system with wind generation, future market structures and transmission overlay
- The contribution made by wind generation to resource adequacy and planning capacity margin

Why 20% and 30% Wind?



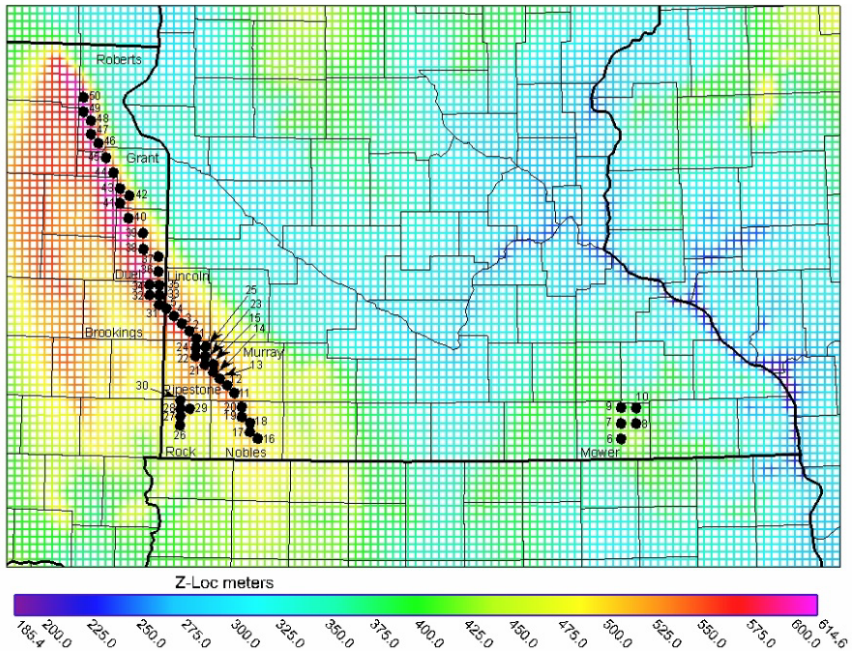
Key Tasks- Eastern Wind Integration & Transmission Study

- Wind plant modeling, data development, and Siting
  - Develop high quality wind resource data sets for the wind integration study area
  - Develop wind power plant outputs
  - Identify wind sites and develop siting scenarios
- Transmission study – Develop transmission concepts for different wind scenarios
- Wind integration study
  - Evaluate operating impacts
  - Evaluate resource adequacy
  - Compare scenario costs

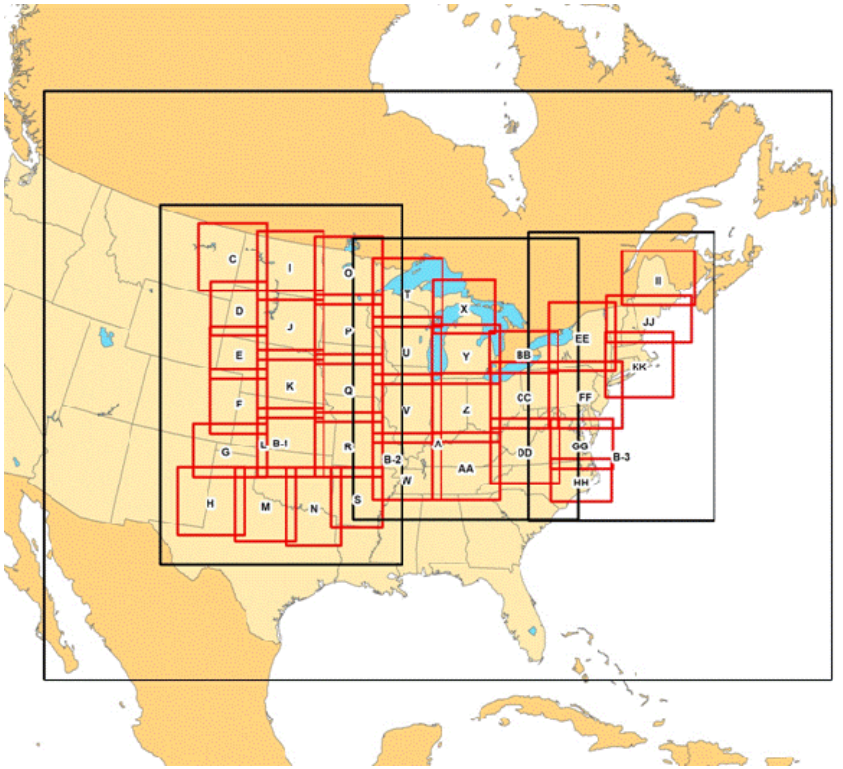
Key Tasks–Wind Plant Modeling & Siting

- Develop high quality wind resource data sets for the wind integration study area
  - Mesoscale modeling
  - 3 years of time series data (2004-2006)
  - 10-minute data at 2 km spatial resolution
- Develop wind power plant outputs
- Identify wind sites

Wind Plant Modeling Approach: "Re-creating" the Weather



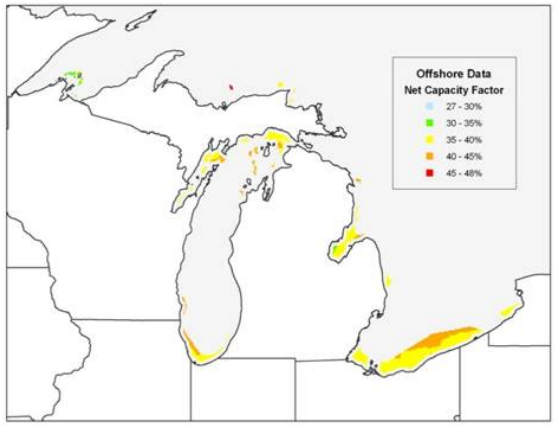
Wind plant siting

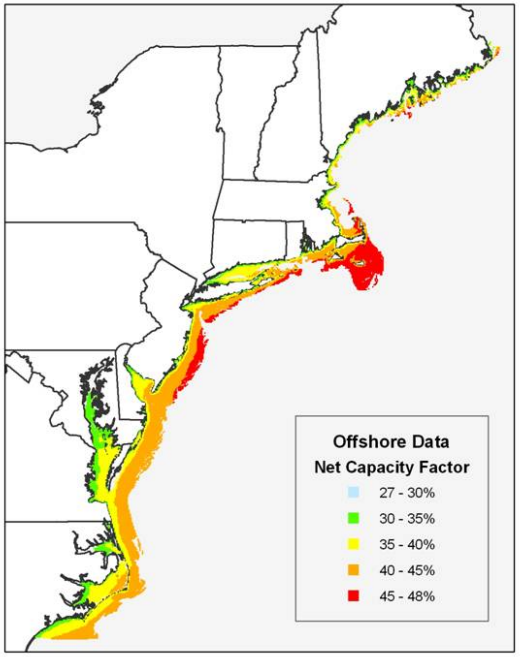


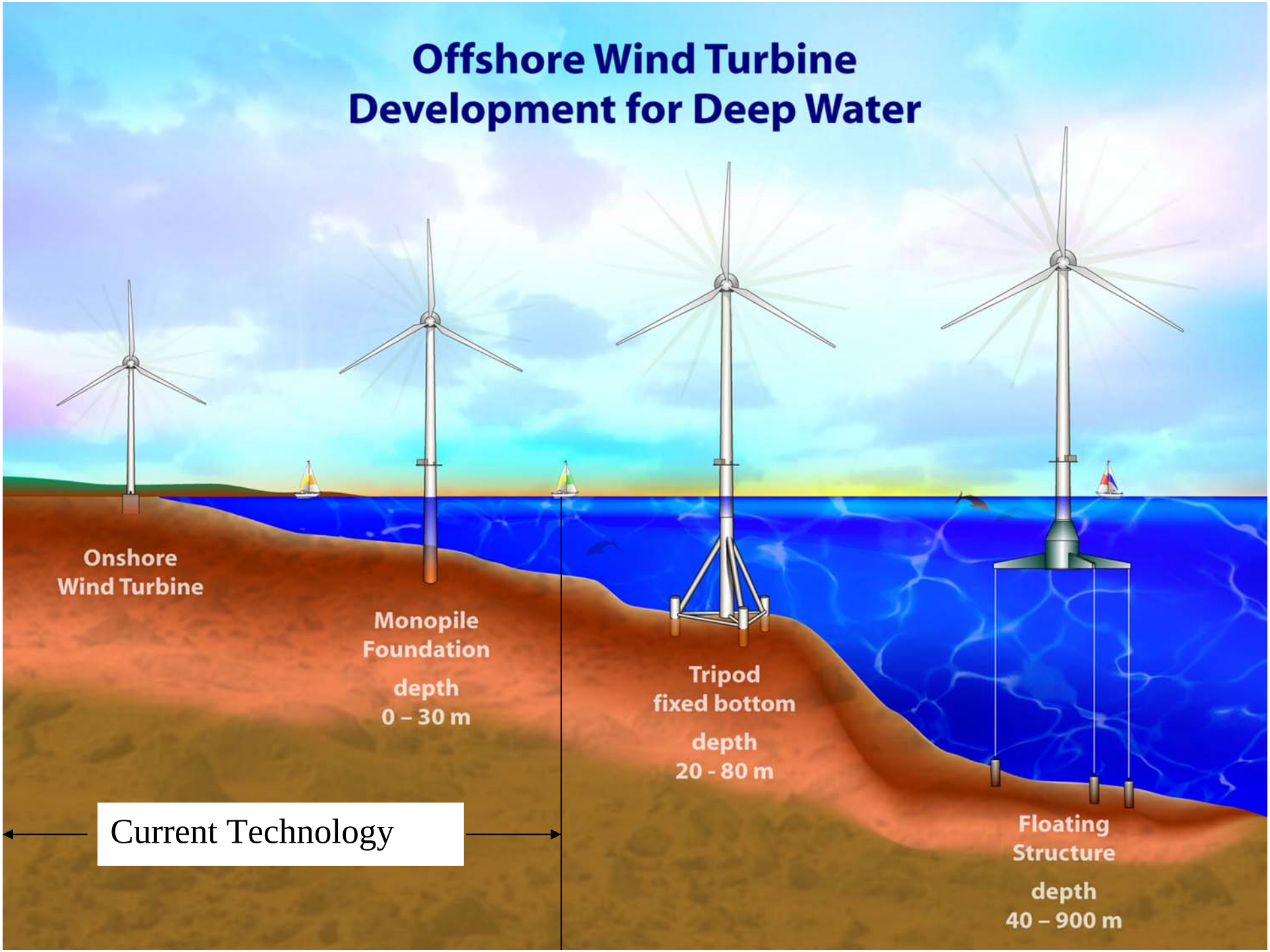
Mesoscale model grids

Offshore Wind

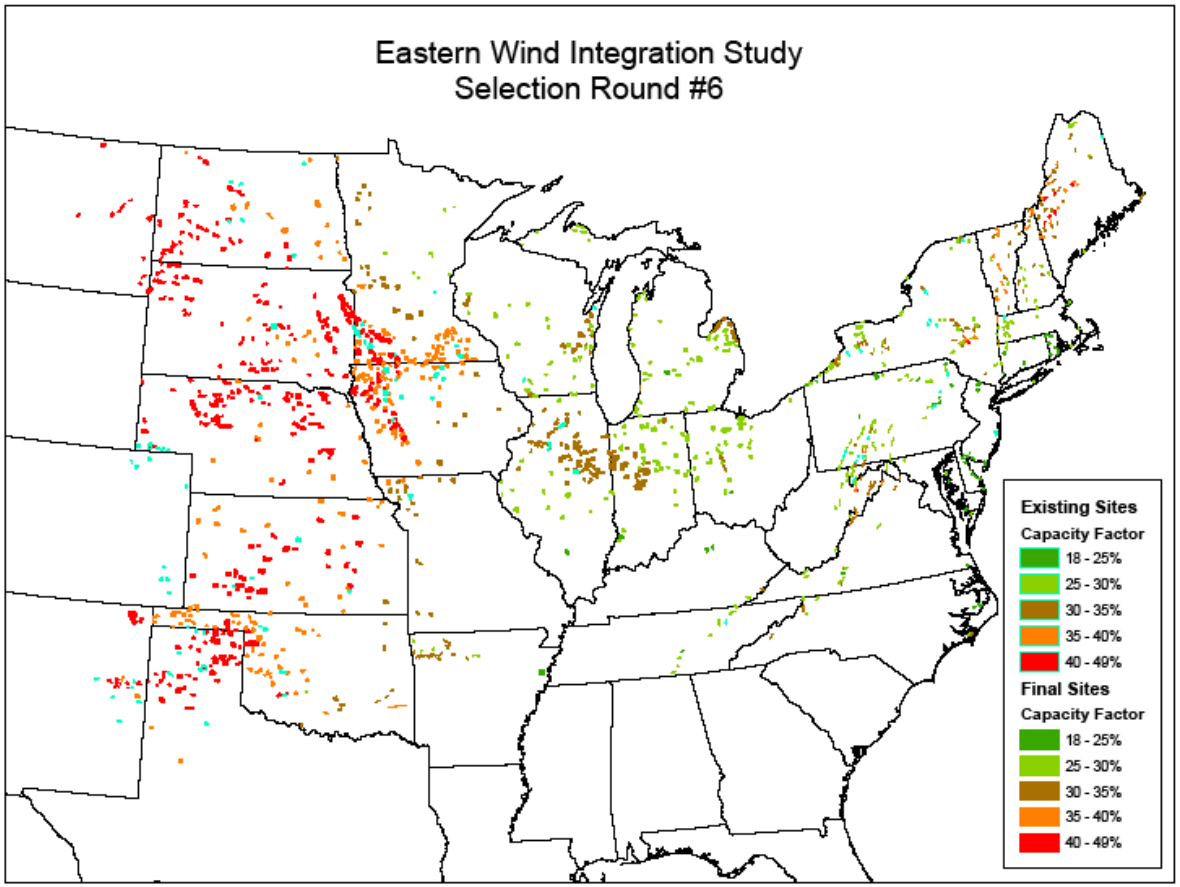
- Great resource
- Well correlated with load and close to load centers
- More expensive!






Offshore Wind Turbine
Development for Deep Water
Onshore
Wind Turbine
Monopile
Foundation
depth
0 – 30 m
Tripod
fixed bottom
depth
20 - 80 m
Floating
Structure
depth
40 – 900 m
Current Technology

579 GWs of Wind Sites from Wind Site Selection process for EWITS



Scenario Development and Siting

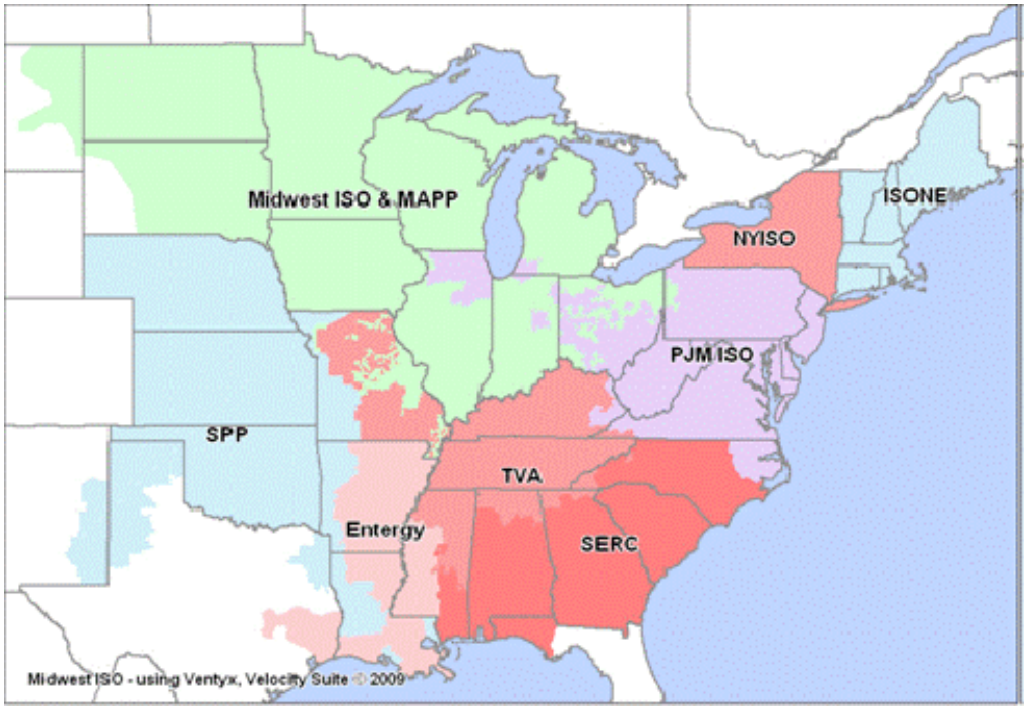
- Reference Case and Four Different Scenarios
  - Three 20% and one 30% wind scenarios
    - Scenario 1 – Focus on higher wind speed sites in the Midwest with larger transmission component
    - Scenario 3 – Focus on local wind near cities with lower capacity onshore wind and offshore wind
    - Up to 4 GW Canadian hydro and wind scheduled
- All of the four scenarios require a lot of wind and transmission!

Scenarios and Siting – A Few Things to Keep in Mind

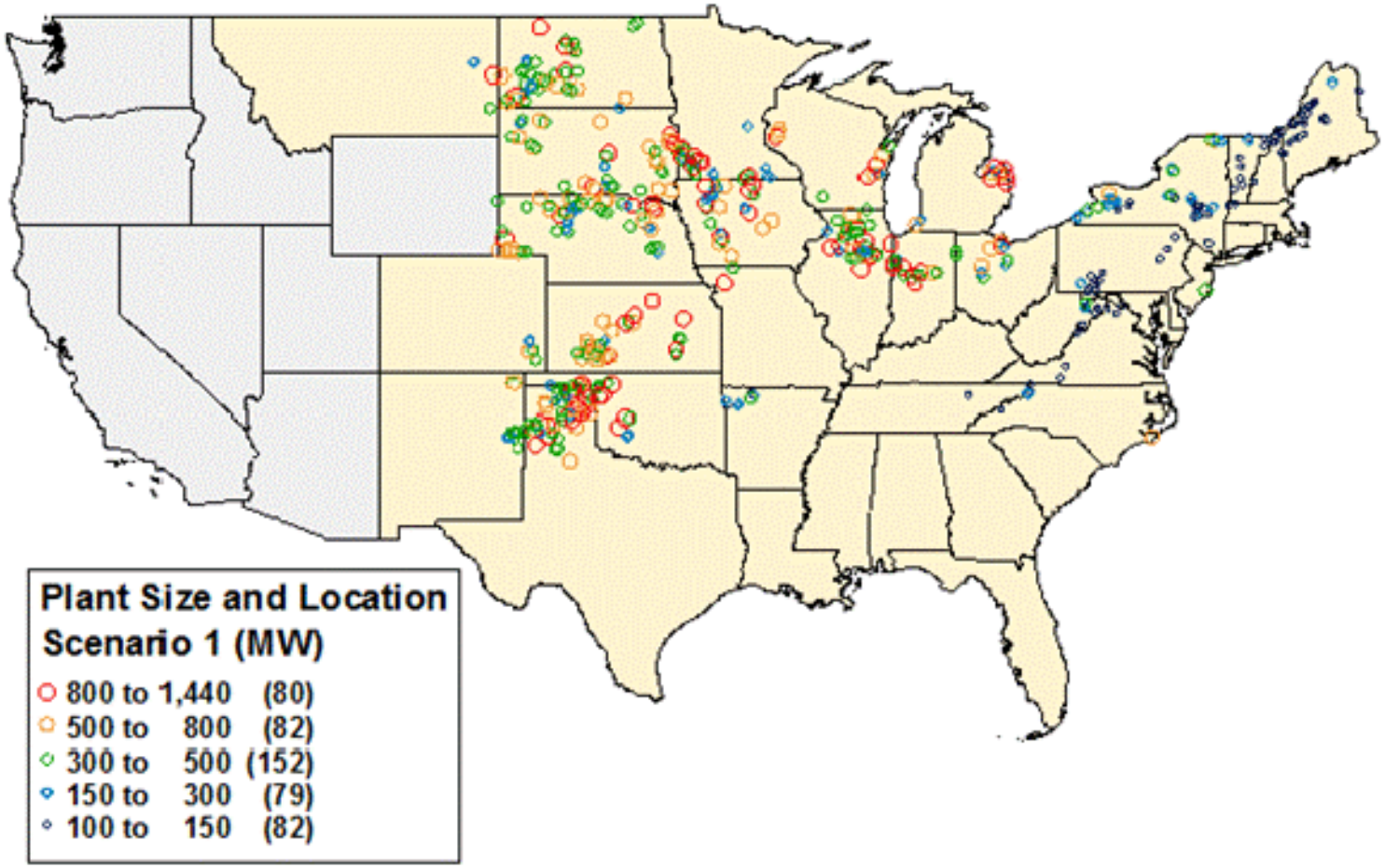
- How much capacity can be reasonably exported (imported) at each area?
- Assume constant energy between scenarios rather than constant number of plants:
  - Great Plains capacity factor/Ohio C.F.= 45/30 = 1.5
  - ~Roughly 2 MW of wind in Great Plains produces the same energy as 3 MW of wind in Ohio neglecting transmission losses.

20% Wind Requires Some Regions to Supply More Based on Resource Availability

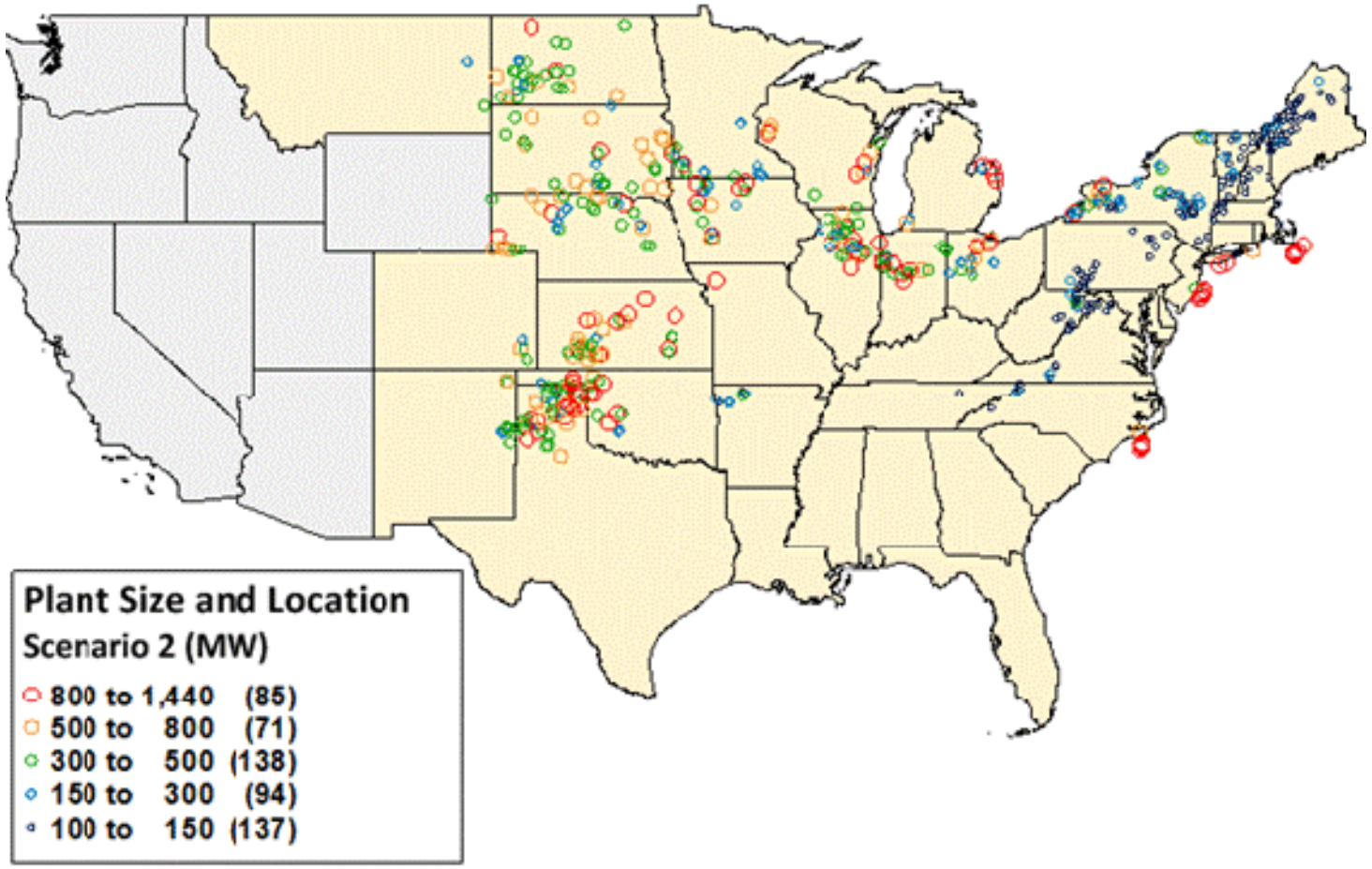
- Areas that meet 20% wind energy on a regional basis, by scenario
  - Scenario 1: Midwest ISO, MAPP, SPP
  - Scenario 2: Midwest ISO, MAPP, SPP, New England ISO (ISO-NE), New York ISO (NYISO)
  - Scenario 3: MAPP, SPP, PJM, ISO-NE, NYISO
  - Scenario 4: Midwest ISO, MAPP, SPP, PJM, ISO-NE, NYISO



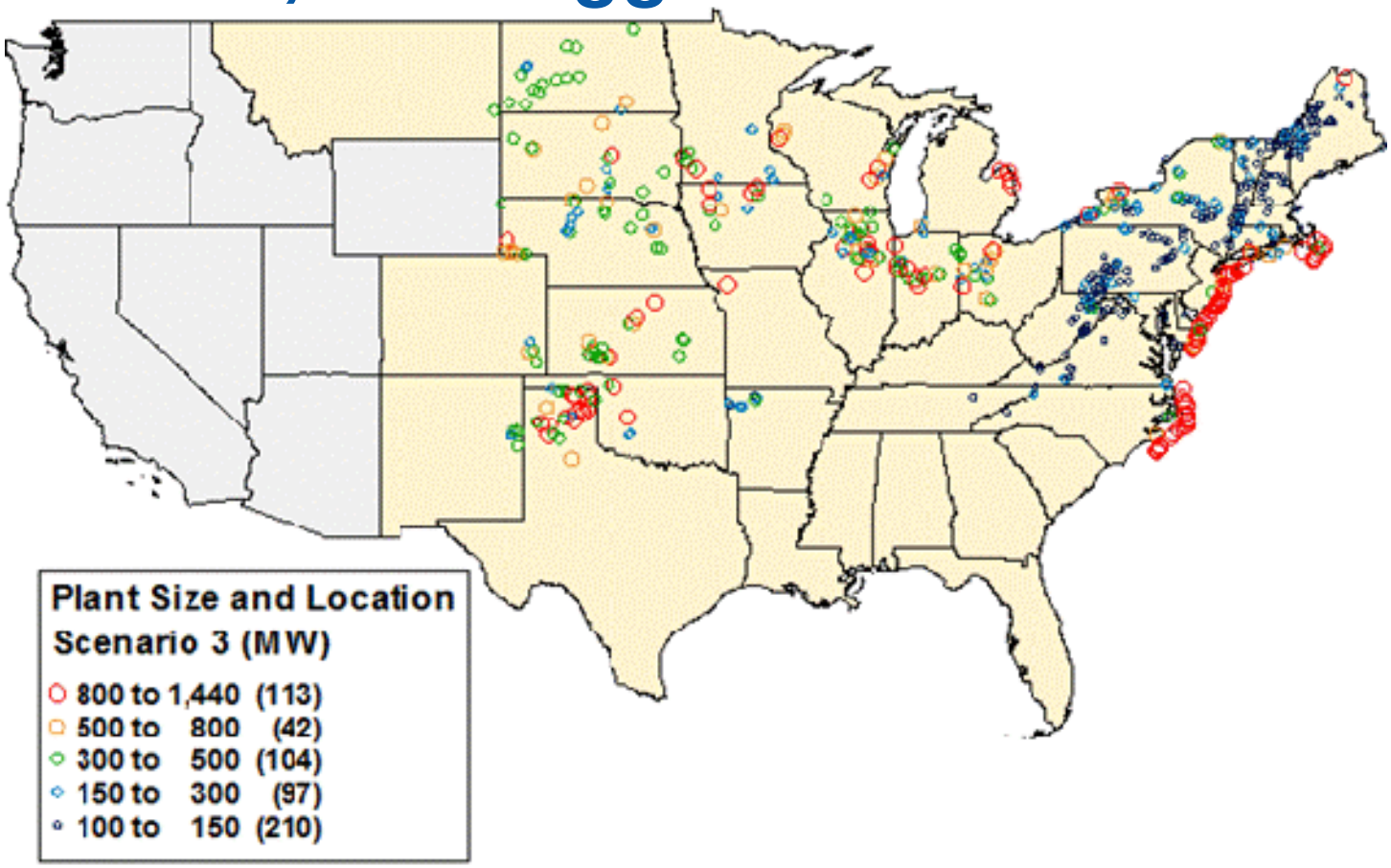
Scenario 1 – 20%
"High Capacity Factor, On shore"



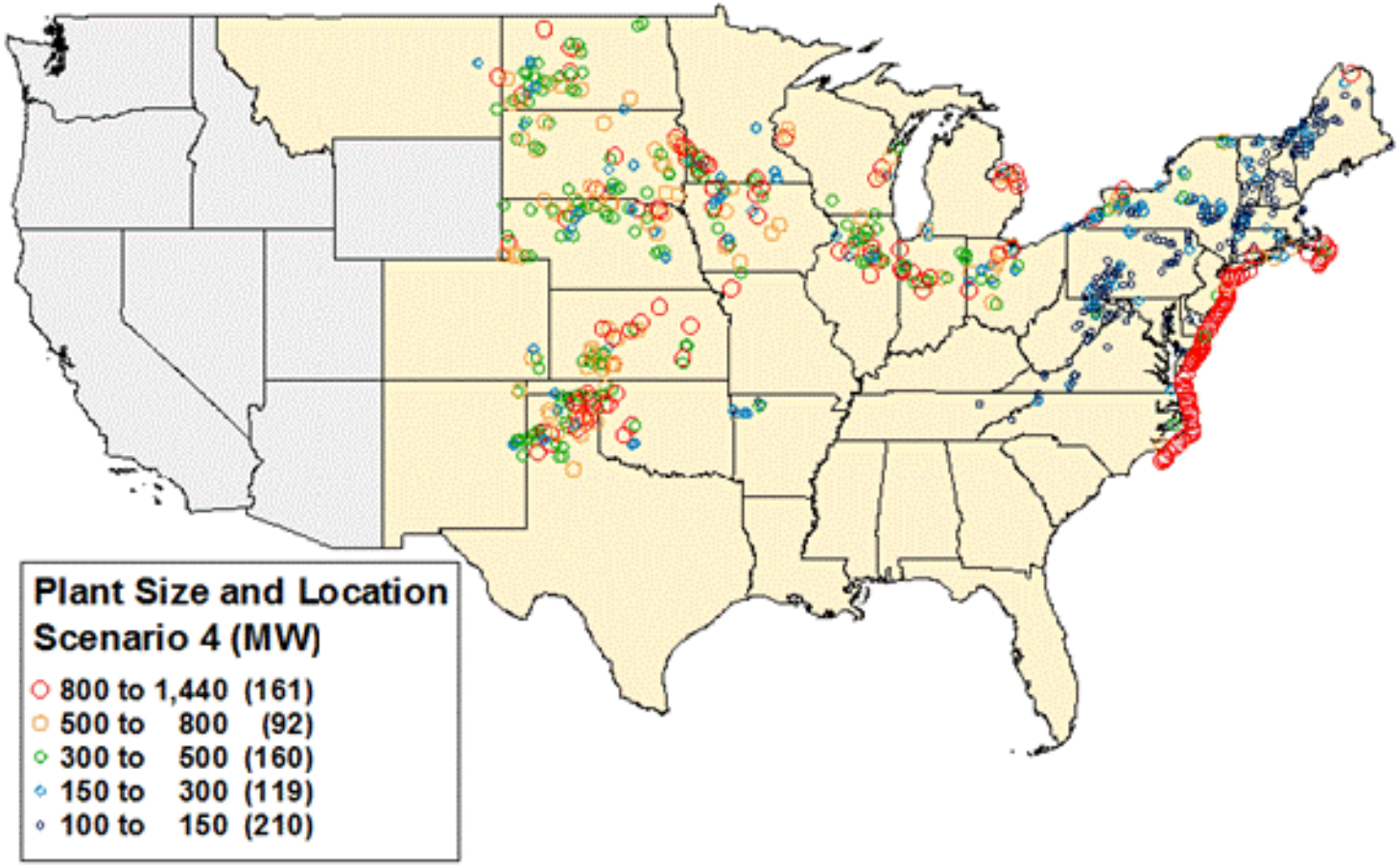
Scenario 2 - 20%
"Hybrid with Offshore"



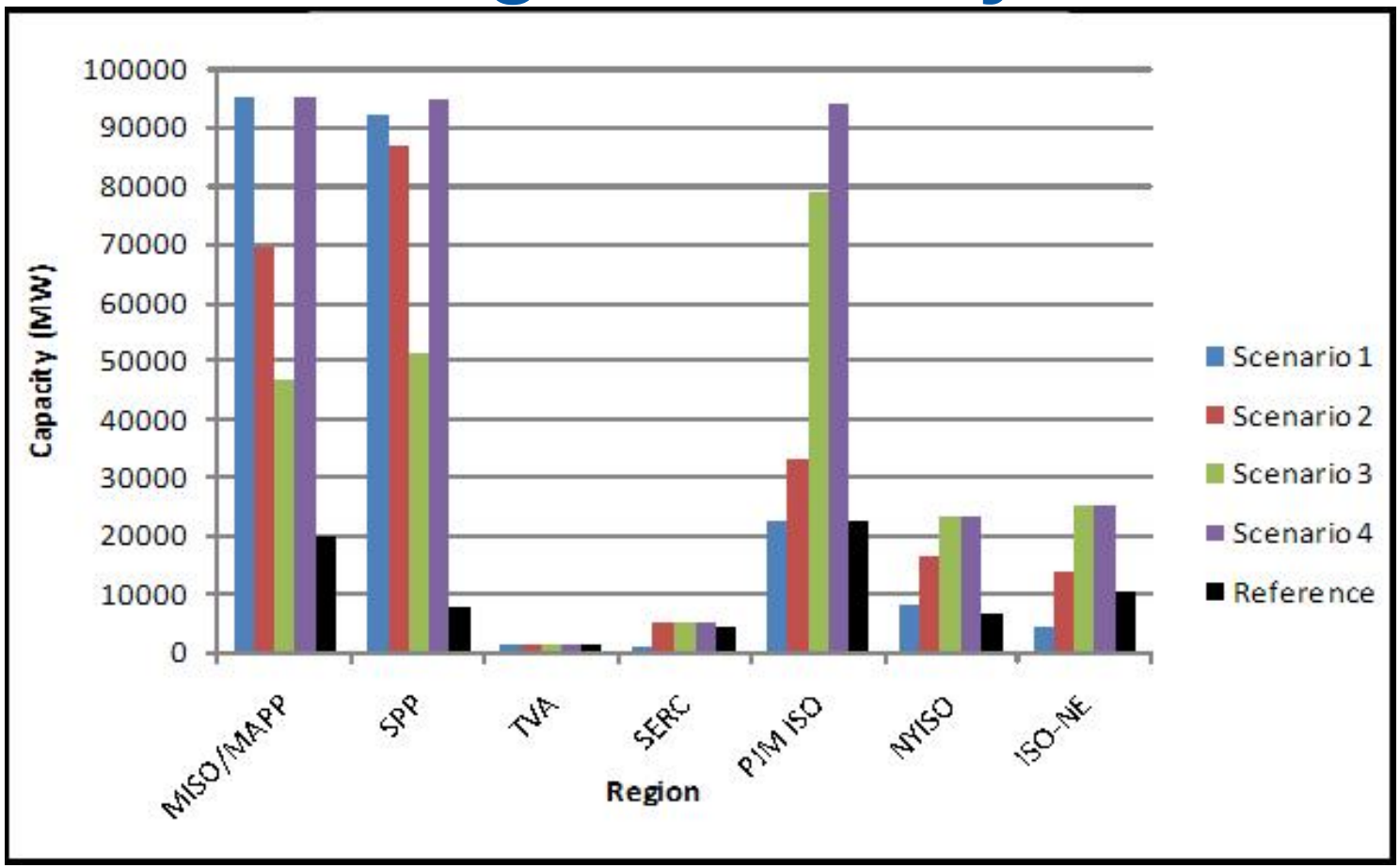
Scenario 3 - 20%
"Local, with Aggressive Offshore"



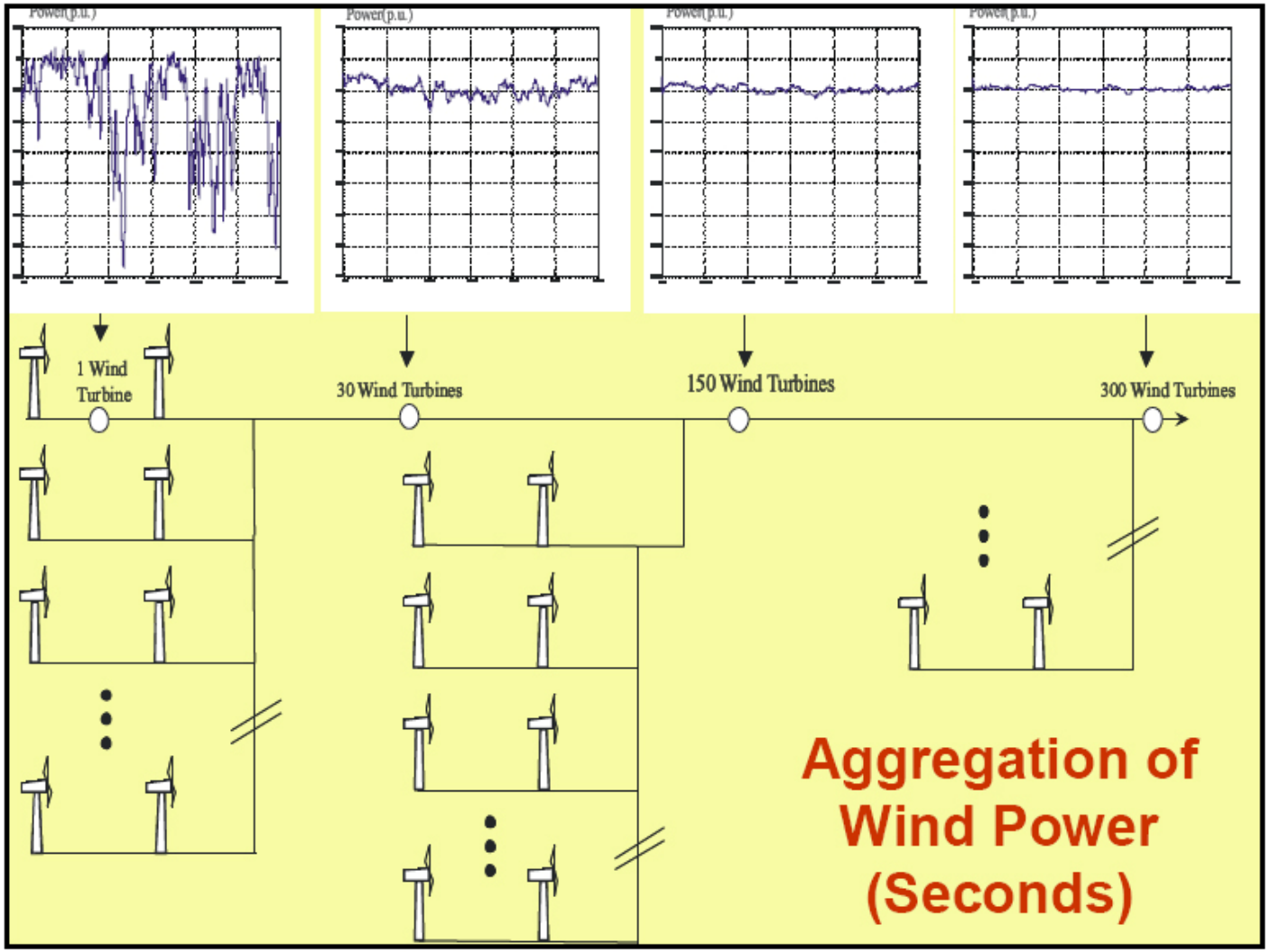
Scenario 4 - 30%
"Aggressive On- and Off-Shore"



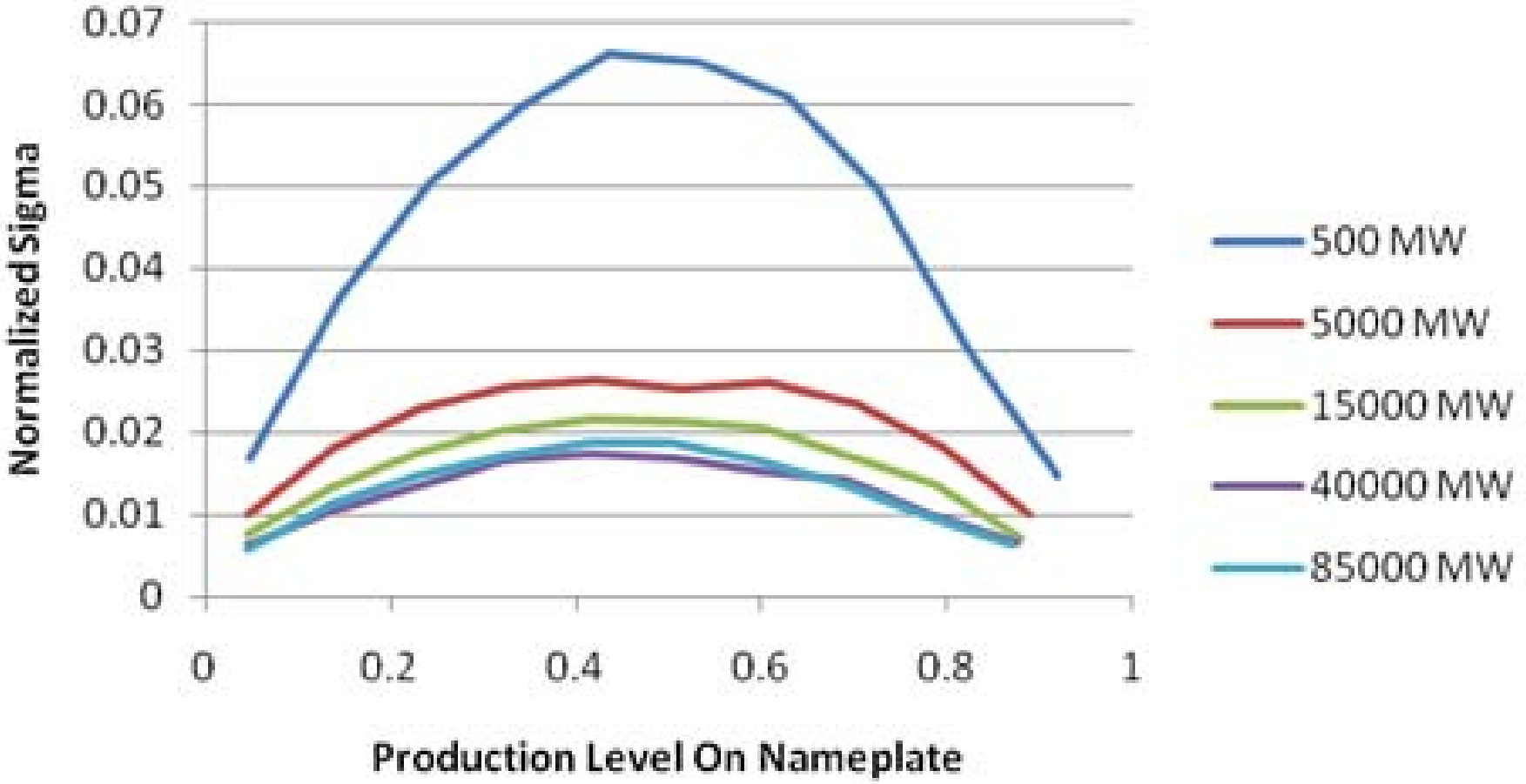
Wind Capacities by Scenario and Regional Entity



The Power of Aggregation and Geographic Diversity



Geographic Diversity – 10-Minute Variability for Five Regions



EWITS Methods & Assumptions

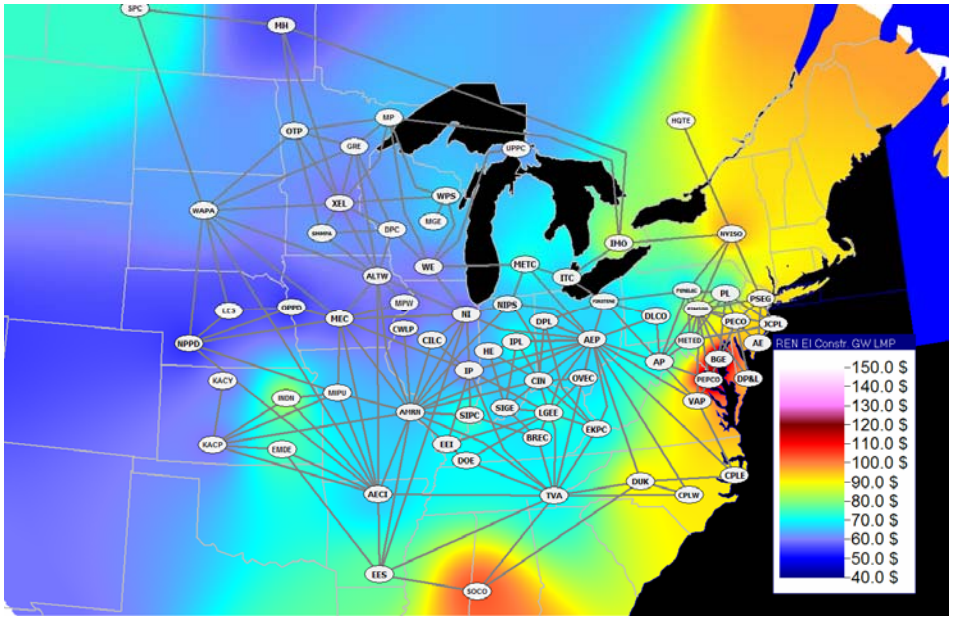
- 2024 wind scenario development
- Power system models for 2024
- Conventional generation expansion
- Develop conceptual transmission overlays
- Evaluate operating impacts
- Evaluate resource adequacy
- Estimate annualized costs

Key Task - Transmission

- High levels of new transmission are needed across the 4 scenarios
  - **Some transmission elements are common to all overlays**
- Reference case, 20% and 30% wind scenarios all require a significant transmission build out, otherwise they are not feasible
- Transmission reduces variability and provides capacity benefits in its own right, and enhances the reliability contribution of wind generation
- The conceptual transmission overlays consist of multiple 800kV HVDC and EHV AC lines

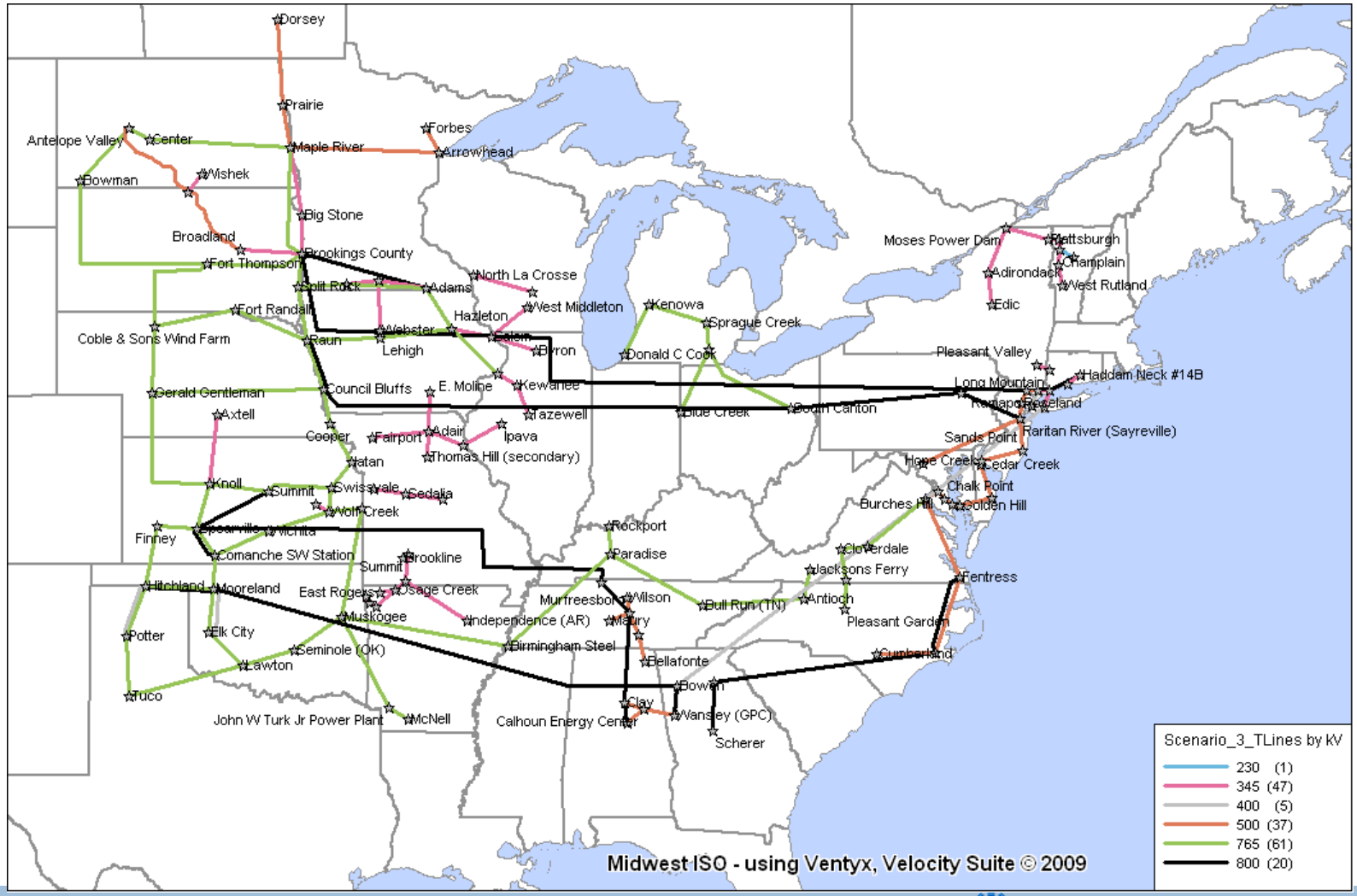
Key Tasks- Develop Transmission Plan

- Reference future and 20% wind and 30% wind scenarios
  - Builds on JCSP work
  - SPP EHV Conceptual Transmission Overlay
  - Regional Generation Outlet Study – Scenario T 765kV Conceptual Overlay
- Analyze different transmission alternatives for different wind scenarios
  - 765 AC and HVDC

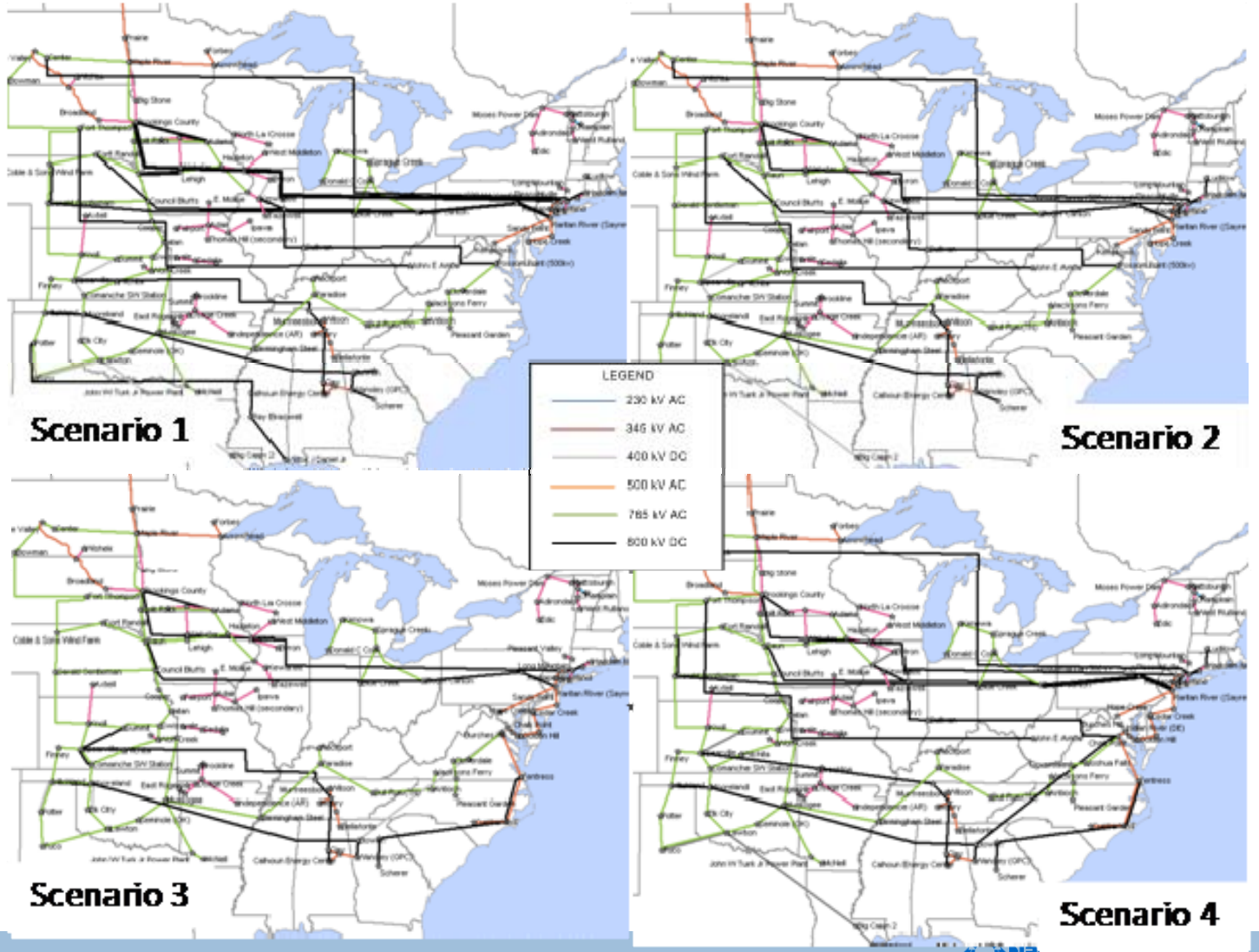


Texas Panhandle Wind

Transmission Overlay for Scenario 3



Conceptual Transmission Overlays



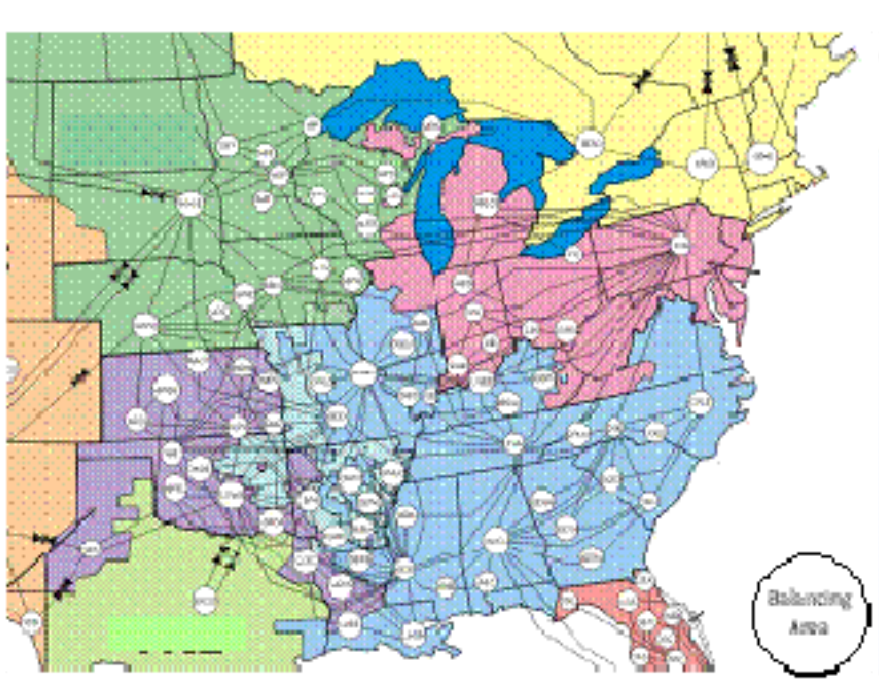
Key Task - Wind Integration Study

- Evaluate operating impacts- Four scenarios plus two sensitivity studies
  - Regulation
  - Load Following
  - Unit Commitment
- Evaluate reliability impacts (ELCC/LOLP)
- EWITS is first and foremost a wind integration study
  - What are the integration costs and issues for 20 and 30% wind?
  - How is other generation affected?

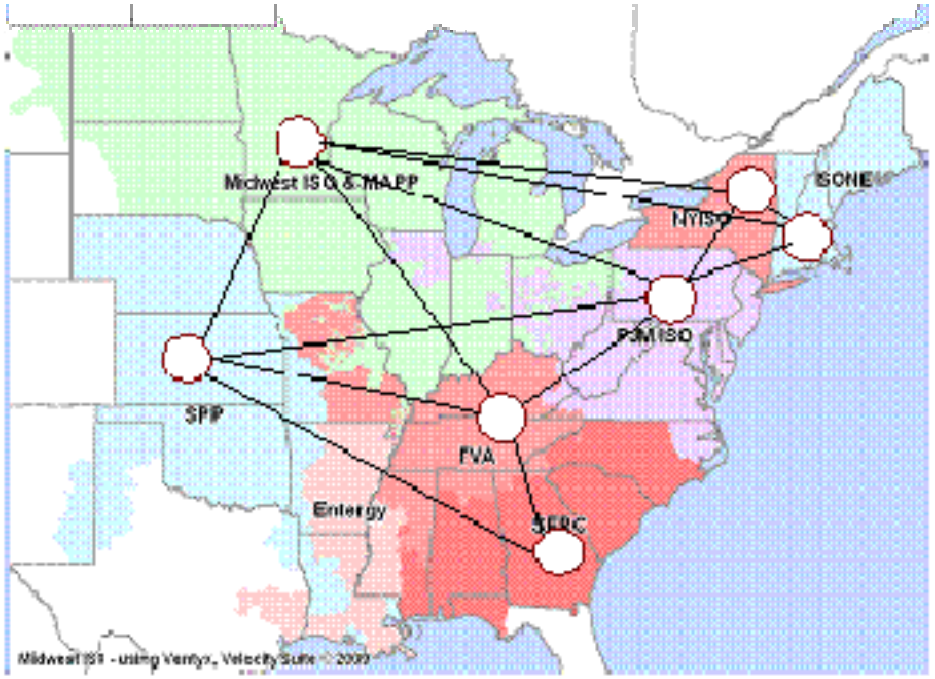
Hourly Modeling

- Objective
  - Chronological simulation of operational planning and power system operation using PROMOD hourly model
  - Mimic
    - Day-ahead unit commitment and scheduling based on load and wind generation forecasts
    - Real-time operation with actual wind and load
- How do we simulate the Eastern Interconnection in 2024?
  - Period-ahead planning (e.g. day-ahead unit commitment)
  - Real-time operations (at minimum of hourly granularity)
  - Operational structures
    - 11 regions

Assumed operational structure for the Eastern Interconnection in 2024 (white circles represent balancing authorities)

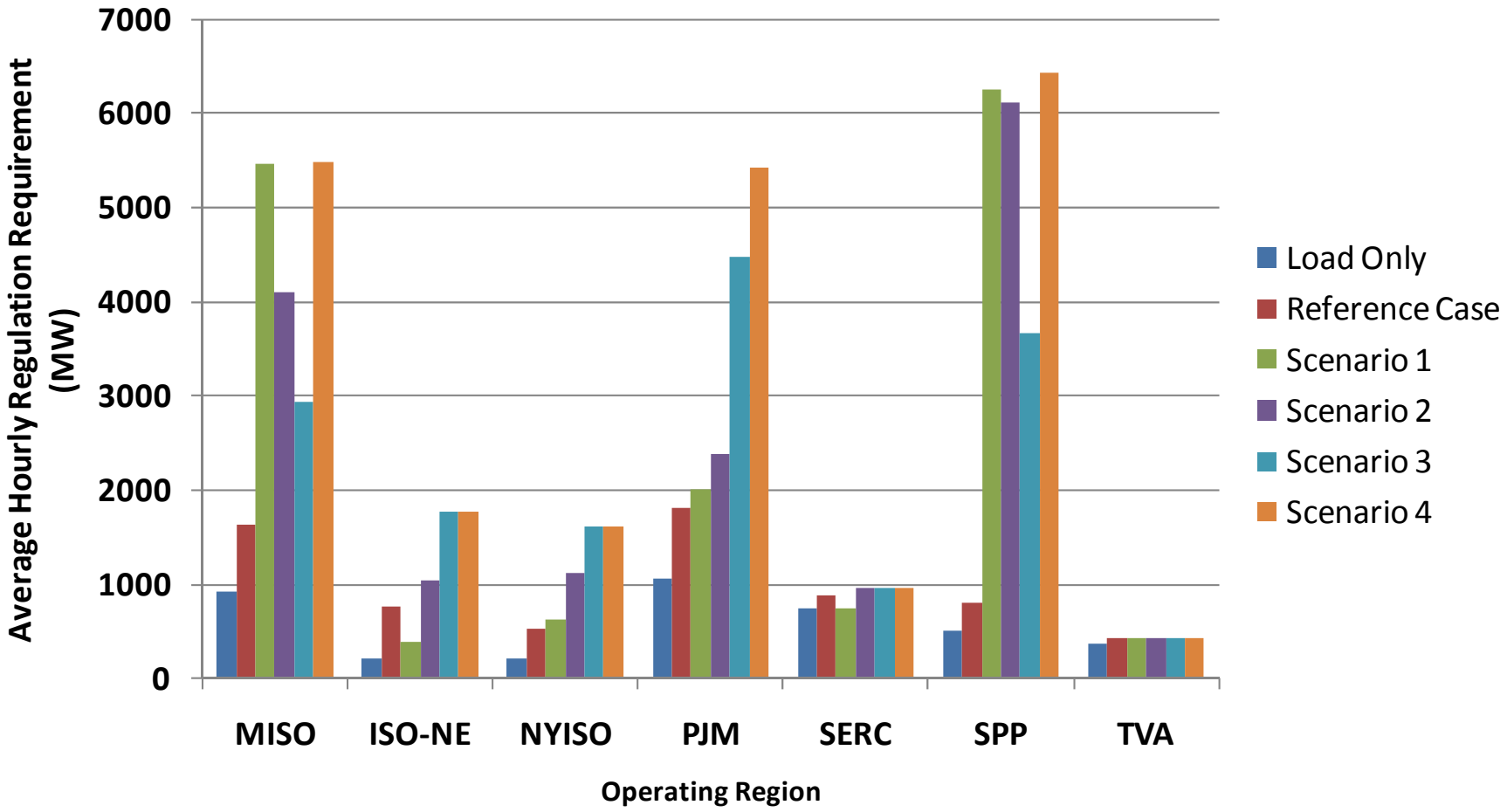


As of August 1, 2007

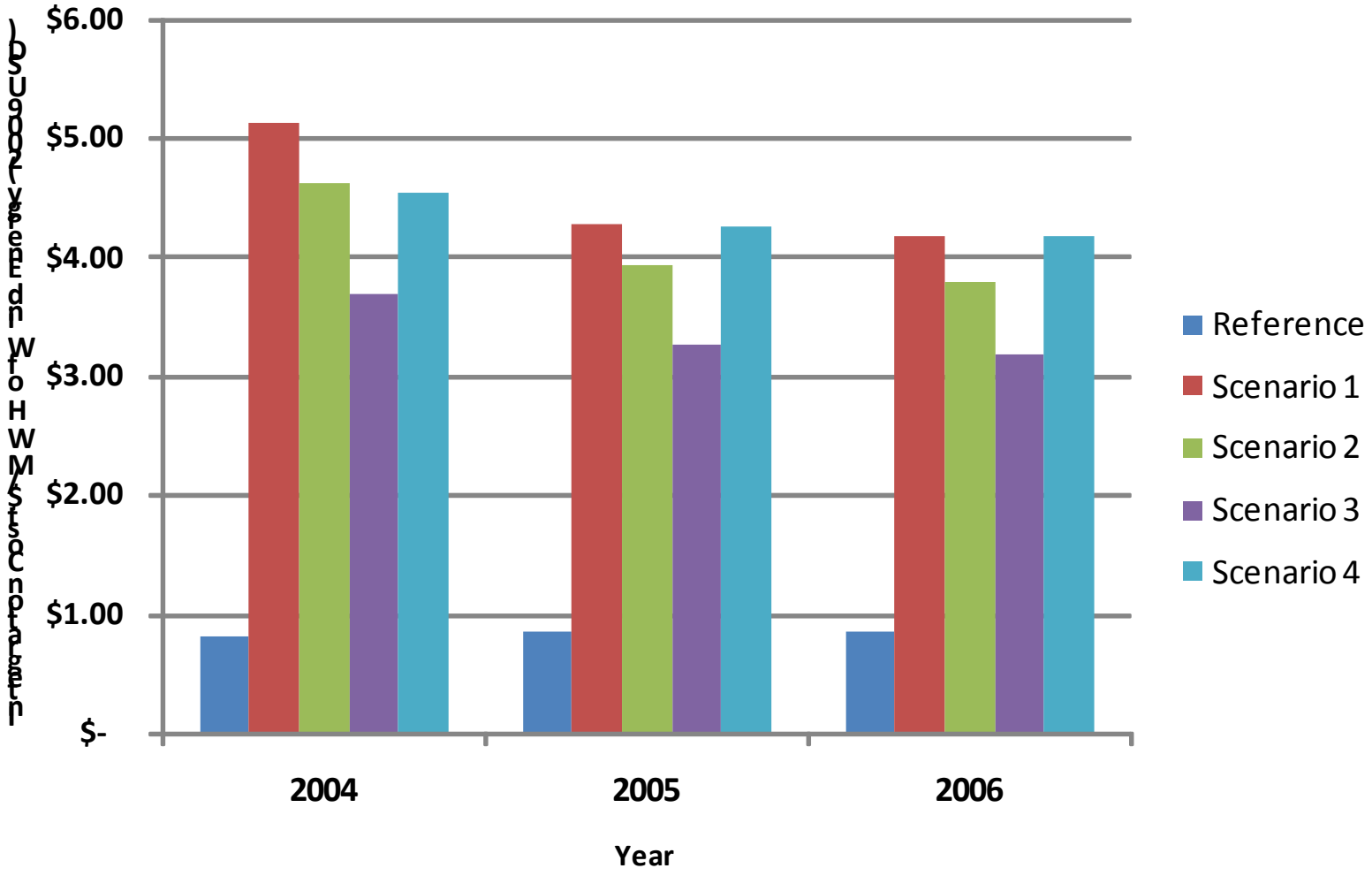


Assumption for 2024

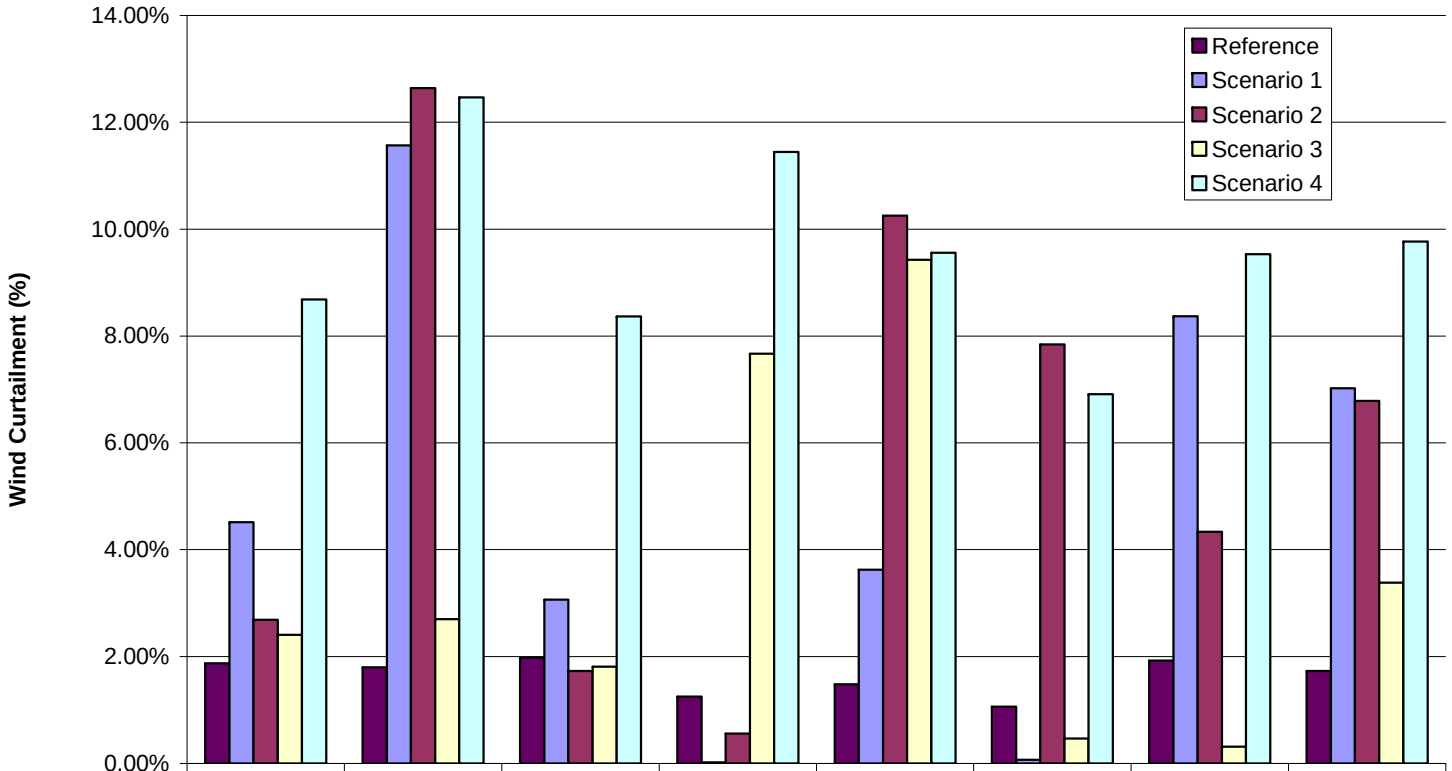
Additional Reserve Requirements by Region and Scenario



Wind Integration Costs



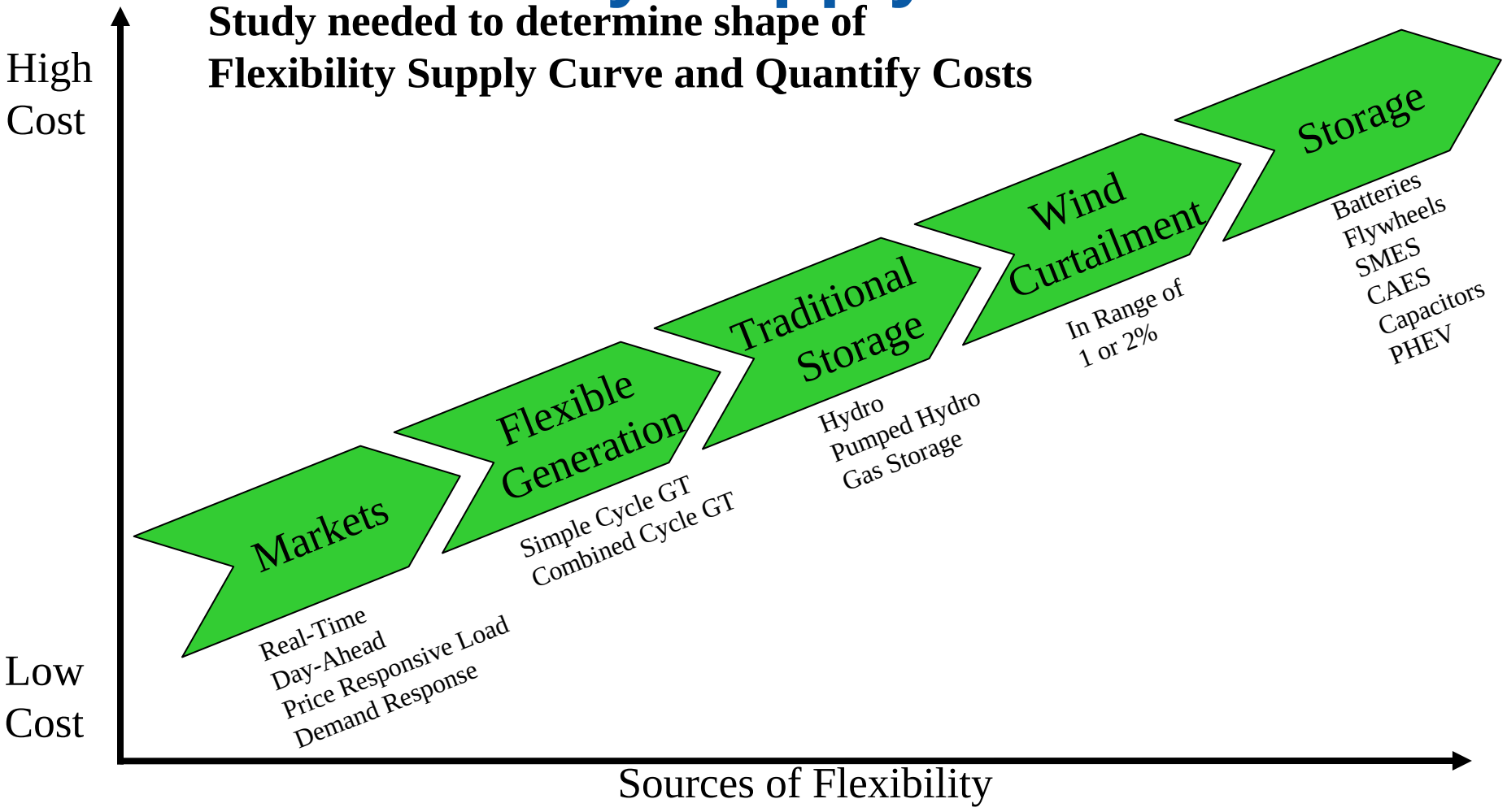
Wind Curtailment by Scenario



	MISO/MAPP	SPP	PJM	ISONE	NYISO	SERCNI	TVASUB	Total Footprint
Reference	1.87%	1.80%	1.98%	1.25%	1.48%	1.06%	1.93%	1.73%
Scenario 1	4.51%	11.57%	3.07%	0.02%	3.63%	0.07%	8.37%	7.02%
Scenario 2	2.69%	12.64%	1.73%	0.56%	10.25%	7.84%	4.34%	6.79%
Scenario 3	2.41%	2.70%	1.81%	7.67%	9.43%	0.47%	0.32%	3.39%
Scenario 4	8.69%	12.46%	8.37%	11.45%	9.56%	6.91%	9.53%	9.77%

Flexibility Supply Curve

Study needed to determine shape of Flexibility Supply Curve and Quantify Costs



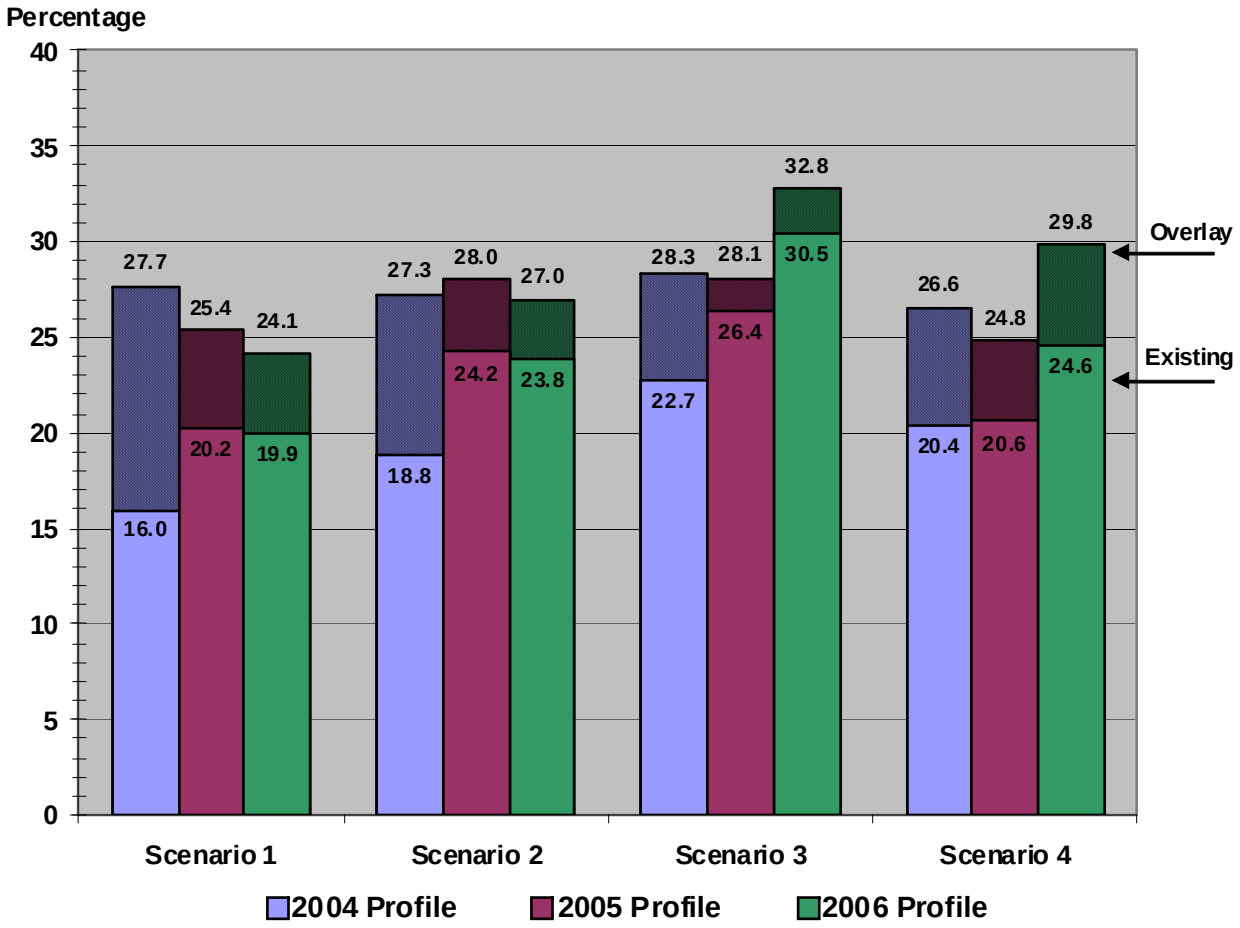
LOLP and ELCC Analysis

- Objective
  - Determine contribution of wind generation to Eastern Interconnection resource adequacy
  - Assess resource adequacy value of transmission only
- Issues
  - Transmission overlay could have significant impact on existing LOLE zones
  - Transmission will serve as capacity resources for some zones;
- Predecessor tasks
  - Requires PROMOD to determine new area import limits
  - GE MARS model developed from PowerBase
  - Resource constraints may necessitate staging

Resource Adequacy Analysis

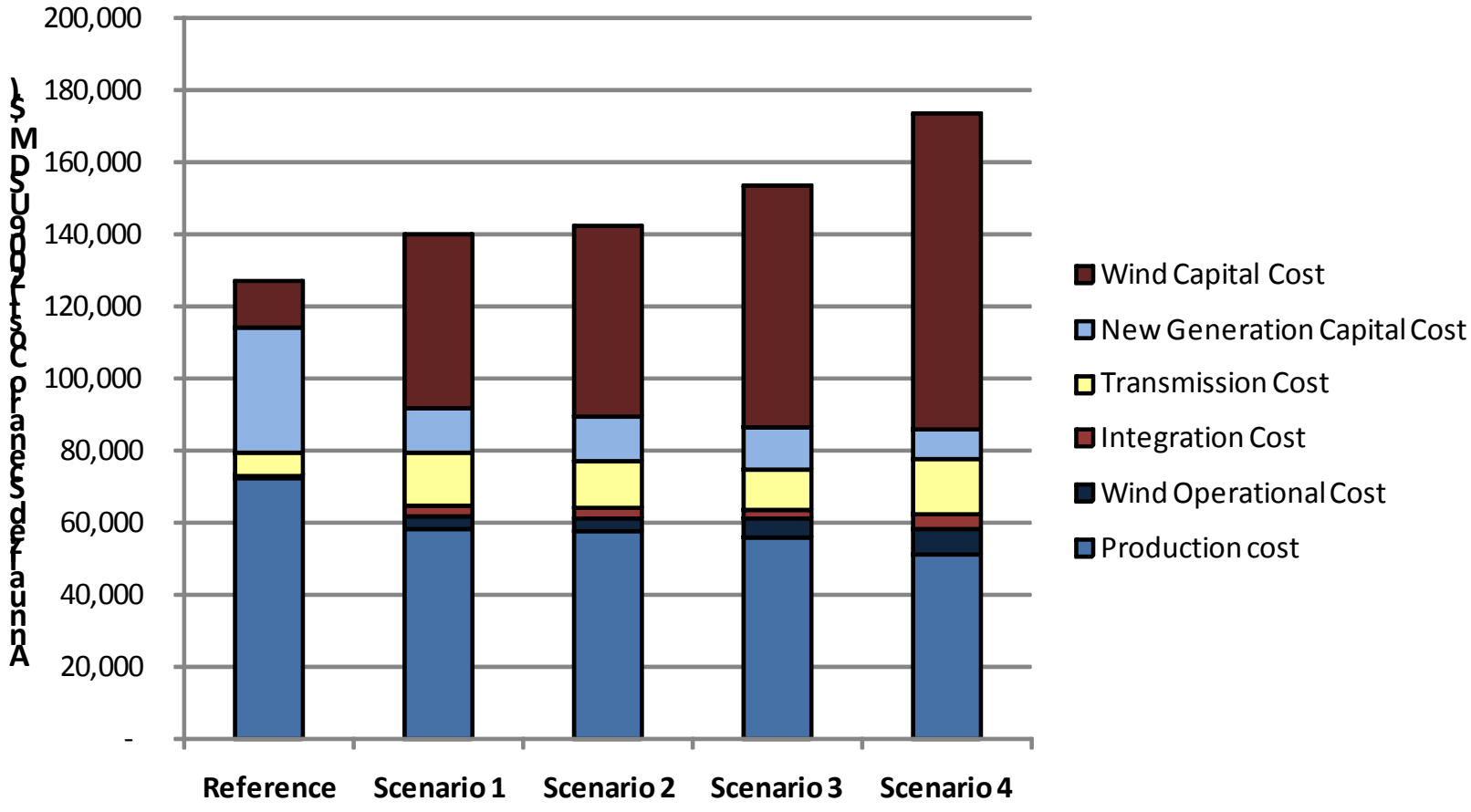
- GE MARS
  - Monte-Carlo based chronological reliability simulation
  - Now in use at MISO
- Objectives
  - Calculate ELCC for wind generation based on comparative LOLE cases
  - Zone-by-zone basis
- Input data
  - Network, resource, and load data input developed from PowerBase
  - Wind as load modifier

An Energy Resource in an Capacity World



LOLE/ELCC results for high penetration scenarios, with and without transmission overlays

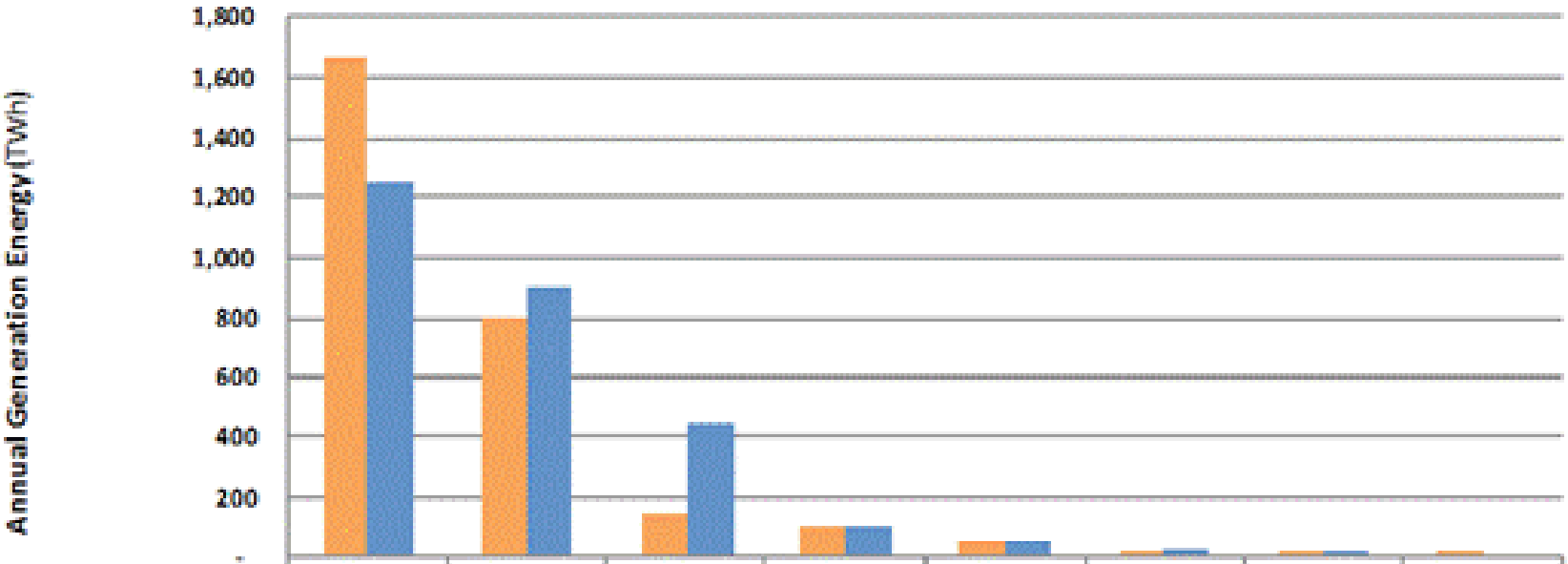
Total Annualized Scenario Costs



Sensitivity Studies

- Carbon Price sensitivity using PROMOD
  - Run EGEAS generation expansion model to determine carbon price sensitivities
  - Re-run PROMOD for scenario 2

Carbon Sensitivity Case



	ST Coal	Nuclear	Combined Cycle	Hydro	CT Gas	IGCC	ST Gas	Other
Scenario 2	1,567	801	146	106	55	16	13	16
Scenario 2, Carbon 100$/Ton	1,249	906	444	106	53	18	14	5

Change in Energy Generation by Fuel Type

The results of this study pose some interesting policy and technology development questions

- Could the levels of transmission, including the Reference Case, be permitted and built and what is a realistic time frame?
- Could the level of offshore wind energy infrastructure be ramped up fast enough to meet the aggressive offshore wind assumption in scenario 3
- Would a different renewable profile or transmission overlay arise from a bottom-up planning process?
- How can states and the federal government best work together on regional transmission expansion and the massive development of onshore and offshore wind infrastructure?
- What is the best way for regional entities to collaborate to make sure wind is integrated into the bulk electrical grid optimally and reliably ?
- What is the difference between applying a carbon price versus mandating and giving incentives for additional wind and renewables

EWITS – Not an End All Catch All but a Link in the Chain

- The scenarios developed do not constitute a plan but an initial perspective on a top-down, high-level view of four different 2024 futures.
- The study assumptions were developed in close coordination with the TRC
  - Changes in the assumptions, such as the cost of various fuels, the impact of regulation and policy would have a major influence
- A complete evaluation of any of the scenarios would require additional technical analysis including
  - An AC analysis that includes power flows that look at voltage and reactive compensation issues, dynamic and transient stability, and HVDC terminal control.

EWITS Conclusions

- 20 and 30% wind penetrations are technically feasible with significant expansion of the transmission infrastructure.
  - New transmission will be required for all the future wind scenarios in the Eastern Interconnection,
- Without transmission enhancements, substantial curtailment of wind generation will occur
- Interconnection-wide costs for integrating large amounts of wind generation are manageable with large regional operating pools, where benefits of load and wind diversity can be exploited and large numbers of supply resources are efficiently committed and dispatched.

EWITS Conclusions

- Transmission helps reduce the impacts of the variability of the wind and….
  - Reduces wind integration costs
  - Increases reliability of the electrical grid
  - Helps make more efficient use of the available generation resources
- Costs for aggressive expansions of the existing grid are significant, but they make up a relatively small piece of the total annualized costs in any of the scenarios studied
- Wind generation displaces carbon-based fuels, directly reducing carbon dioxide (CO_2) emissions

and the conclusion is…

- There are no fundamental technical barriers to the integration of 20% and 30% wind energy into the electrical system, but…

- There needs to be a continuing evolution of transmission planning and system operation policy and market development for this to be achieved

Future Work

- Further analysis of regional results
- Demand response and smart grid load sensitivities
- Fuel sensitivity, unit commitment/optimization
- Plug in electric vehicle charging
- Sequencing of transmission
- Include more detailed representation from Canada
- Curtailment under transmission constrained scenarios and storage analysis

EWITS Schedule & Contacts

- http://www.nrel.gov/ewits
- Development of Phase II of EWITS in first quarter 2010
- Roll out January 20th, Washington DC.
- Contact: Dave Corbus at David.Corbus@nrel.gov