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Prism 2.0: *Preliminary* Insights from EPRI's Regional Model

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Presentation Topics

- Introduction to EPRI and Prism 2.0
- Importance of Regional Details for Renewable Wind Generation
- Prism 2.0 Electricity Sector Test Drive

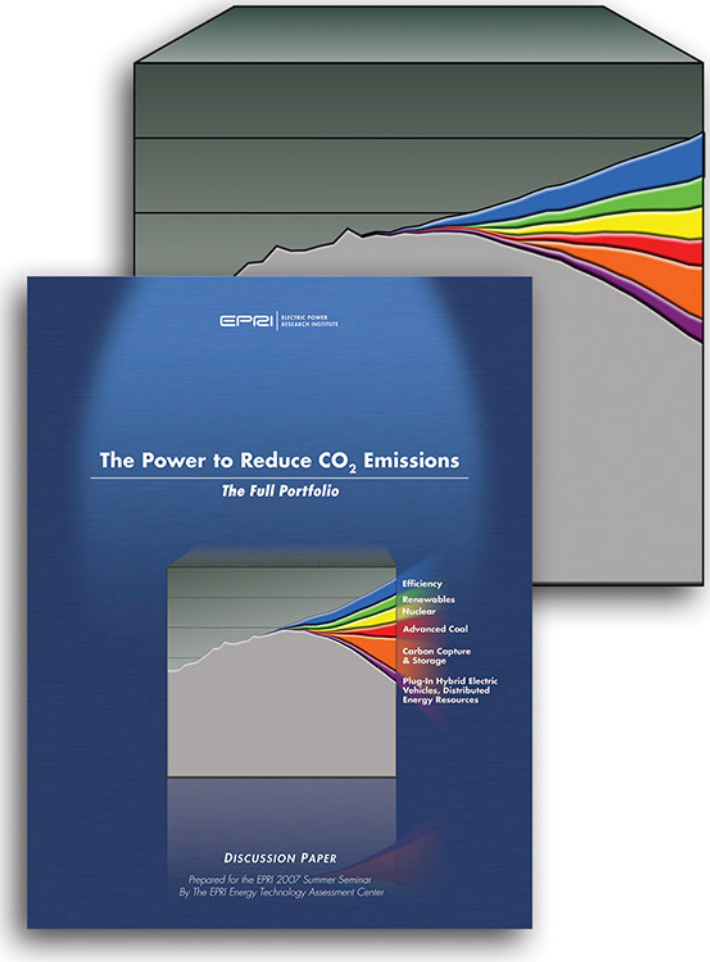
The Electric Power Research Institute

RD&D for the Electricity Industry

- Independent, unbiased, collaborative research organization
- Full-spectrum industry coverage
  - *Nuclear*
  - *Generation*
  - *Environment*
  - *Power Delivery & Utilization*
- 460 participants in more than 40 countries
- More than 500 Engineers and Scientists with Major offices and Laboratories in Palo Alto, CA; Charlotte, NC; Knoxville, TN; Lenox, MA; and Washington, DC.

EPRI's Prism / MERGE Analysis

- Released in 2007, Updated in 2009
- Detailed analysis of a possible pathway to reducing CO_2 emissions across the electricity sector
- MERGE model provided economic analysis to highlight role of technology in reducing CO_2 emissions in the US
- Cited in numerous national and international publications

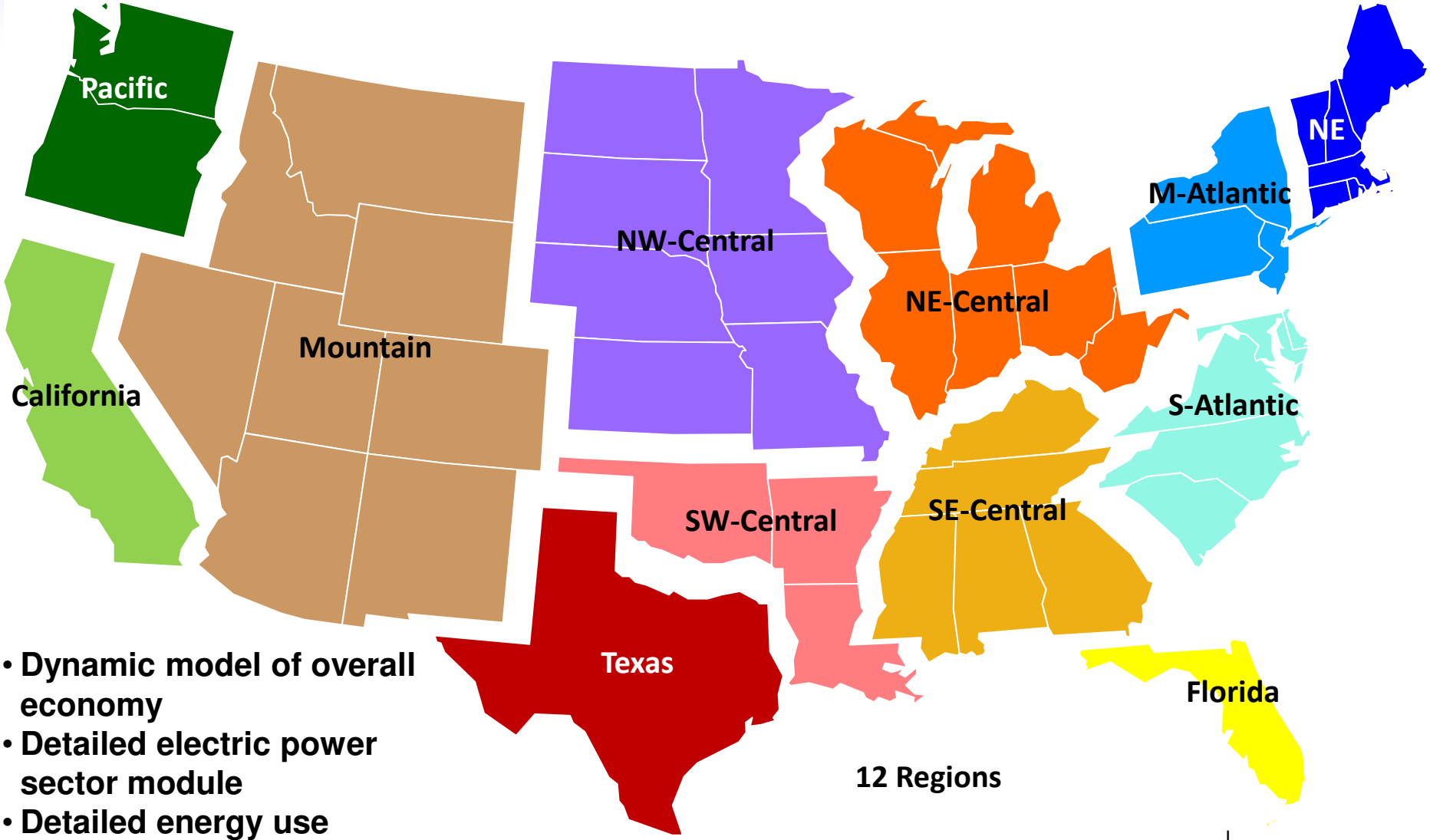


Why Prism 2.0?

- **New Regional Economic Model**
- **Improved treatment of renewable energy**
  - *High-resolution wind and solar resource data*
  - *Full biomass model with resource competition*
- **Expanded demand-side detail**
  - *Energy efficiency potential by region and technology*
  - *Fully developed transportation module*
- **Full complement of environmental regulations**

The Next Generation of EPRI Analysis

Regional Model Structure



- Dynamic model of overall economy
- Detailed electric power sector module
- Detailed energy use

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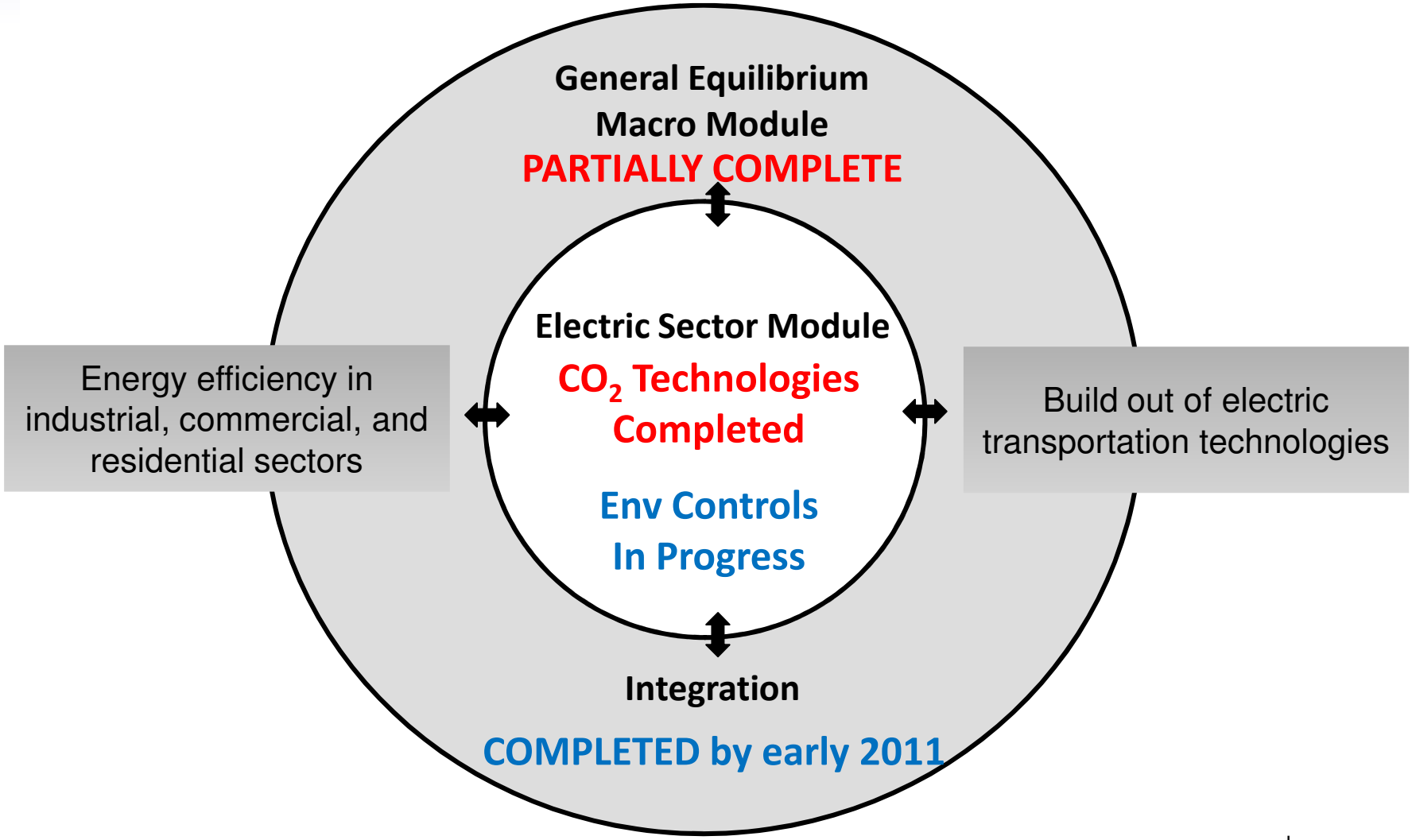
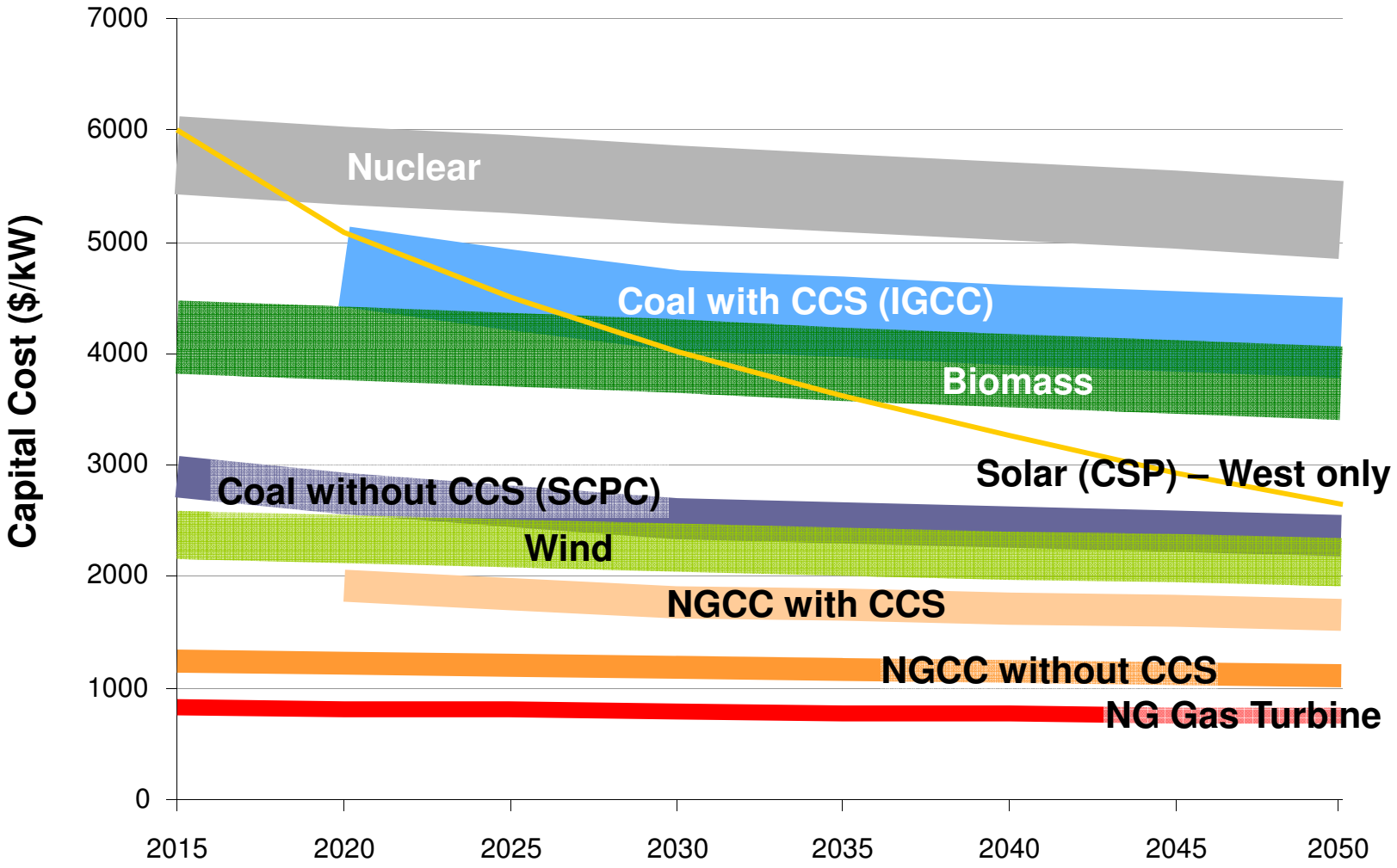
Prism 2.0 Model Status

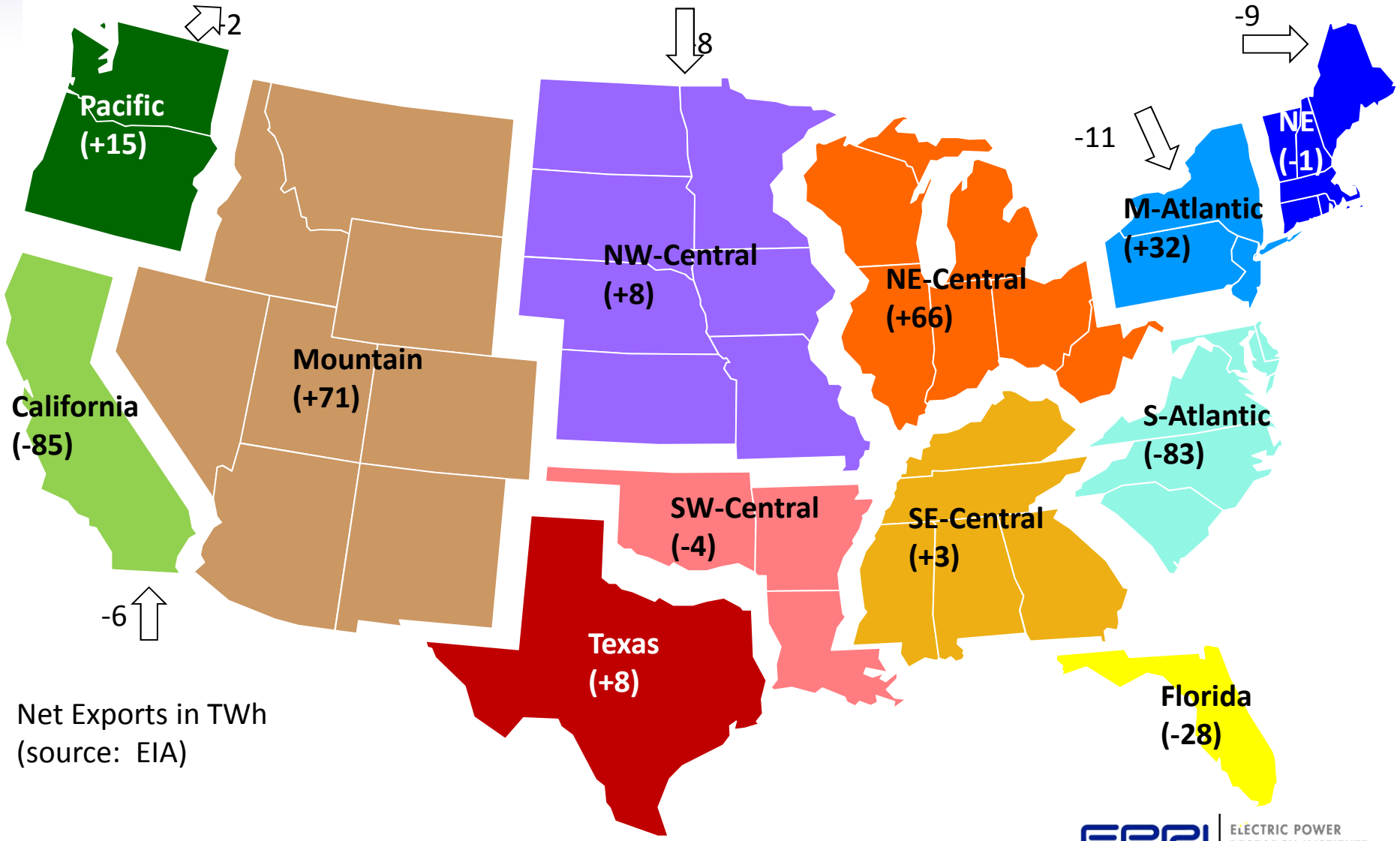


REGIONAL SPECIFICS

New Generation Technology Options: Capital costs vary across regions



Net Inter-Region Trade Positions in 2007



Net Exports in TWh
(source: EIA)

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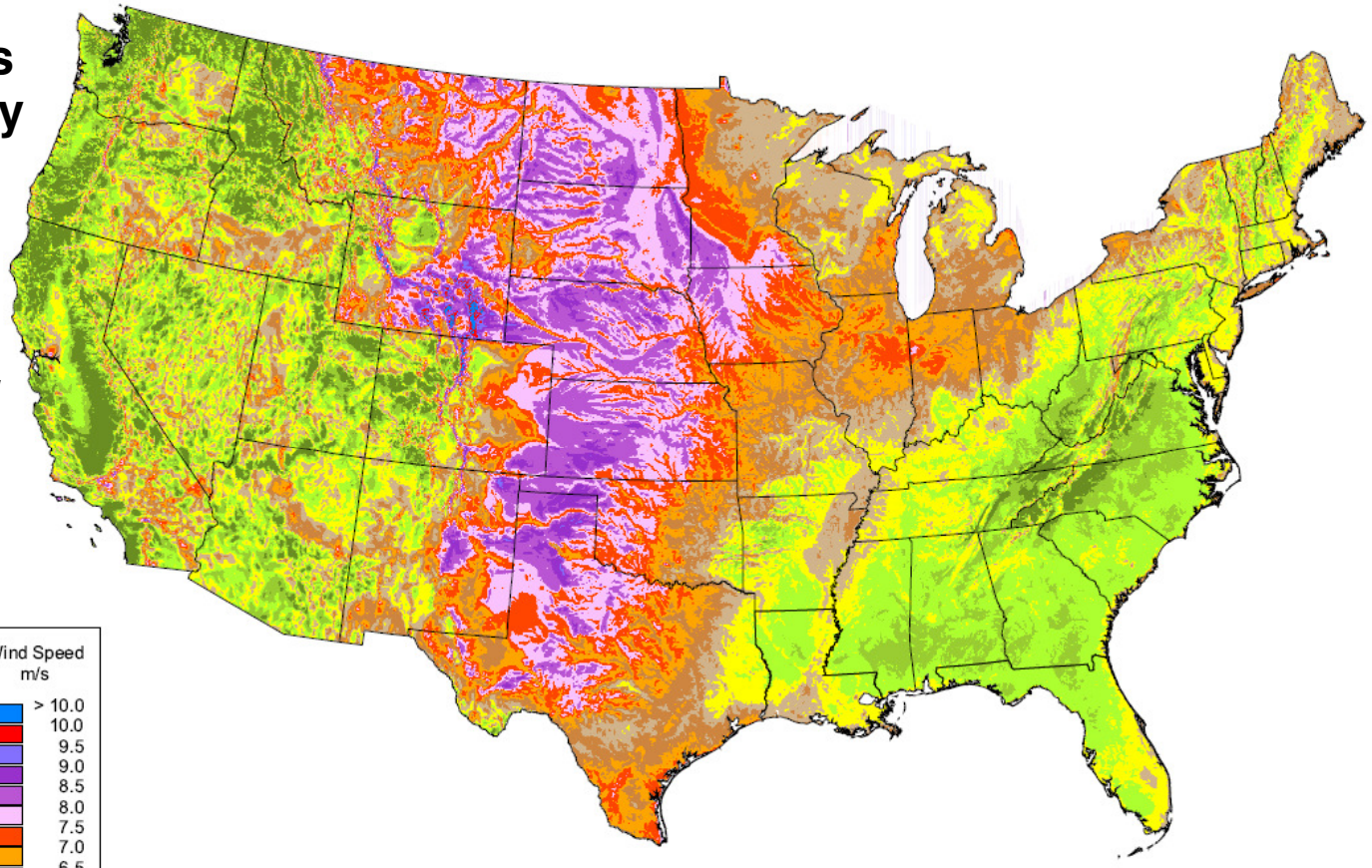
Central U.S. – Significant Wind Energy Resources

- **EPRI's model has 12 years of hourly wind data (AWS Truepower)**
- **Identified 5300+ "utility-scale" sites of >100 MW each**
  - Exclusion areas
  - 100 MW site minimum
  - Distance to grid
  - Terrain/wake effects



Source: Wind resource estimates developed by AWS Truewind, LLC for windNavigator® Web: http://navigator.awstruewind.com | www.awstruewind.com. Spatial resolution of wind resource data: 2.5 km. Projection: Albers Equal Area WGS84.

AWS Truewind

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

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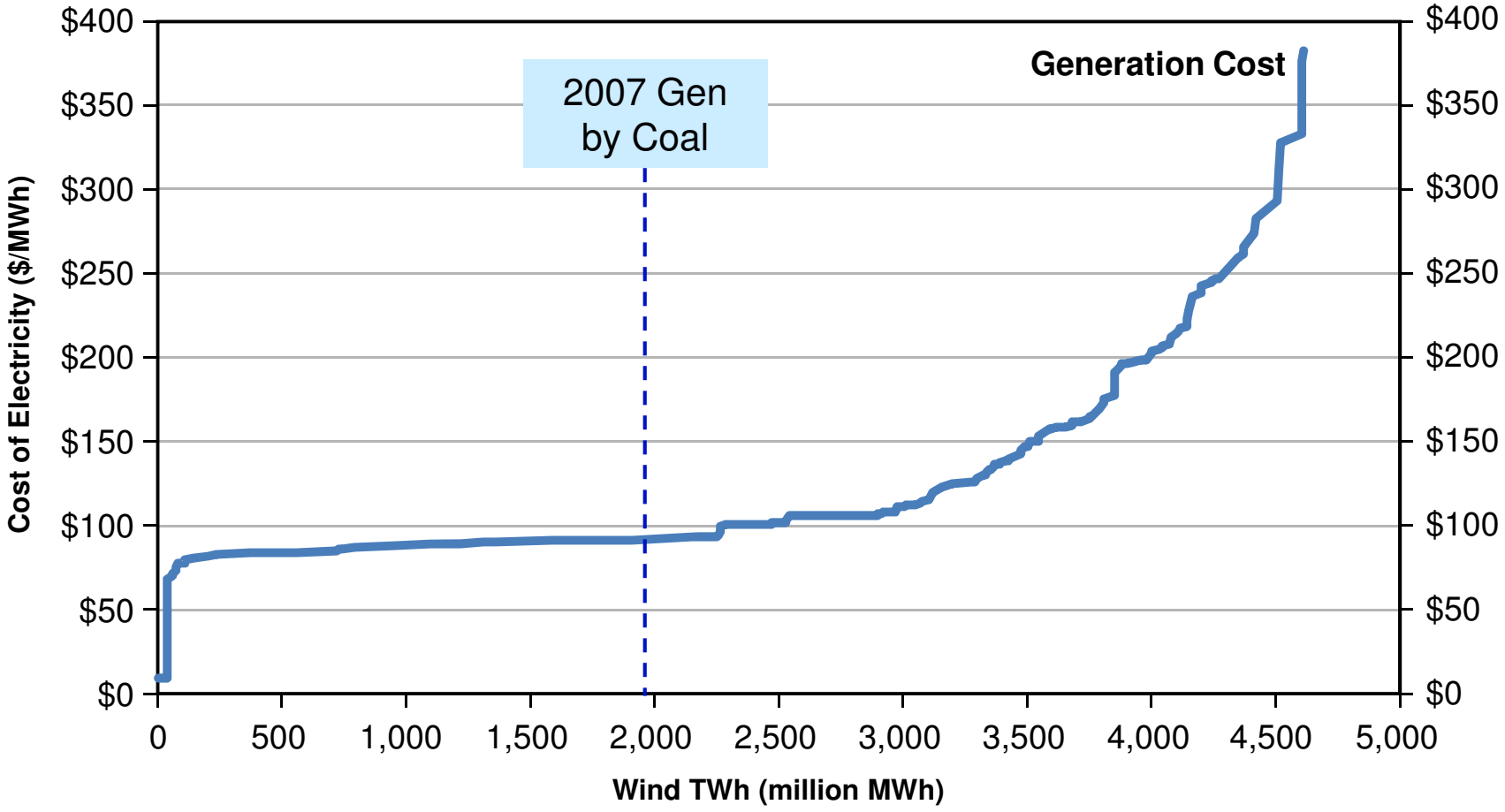
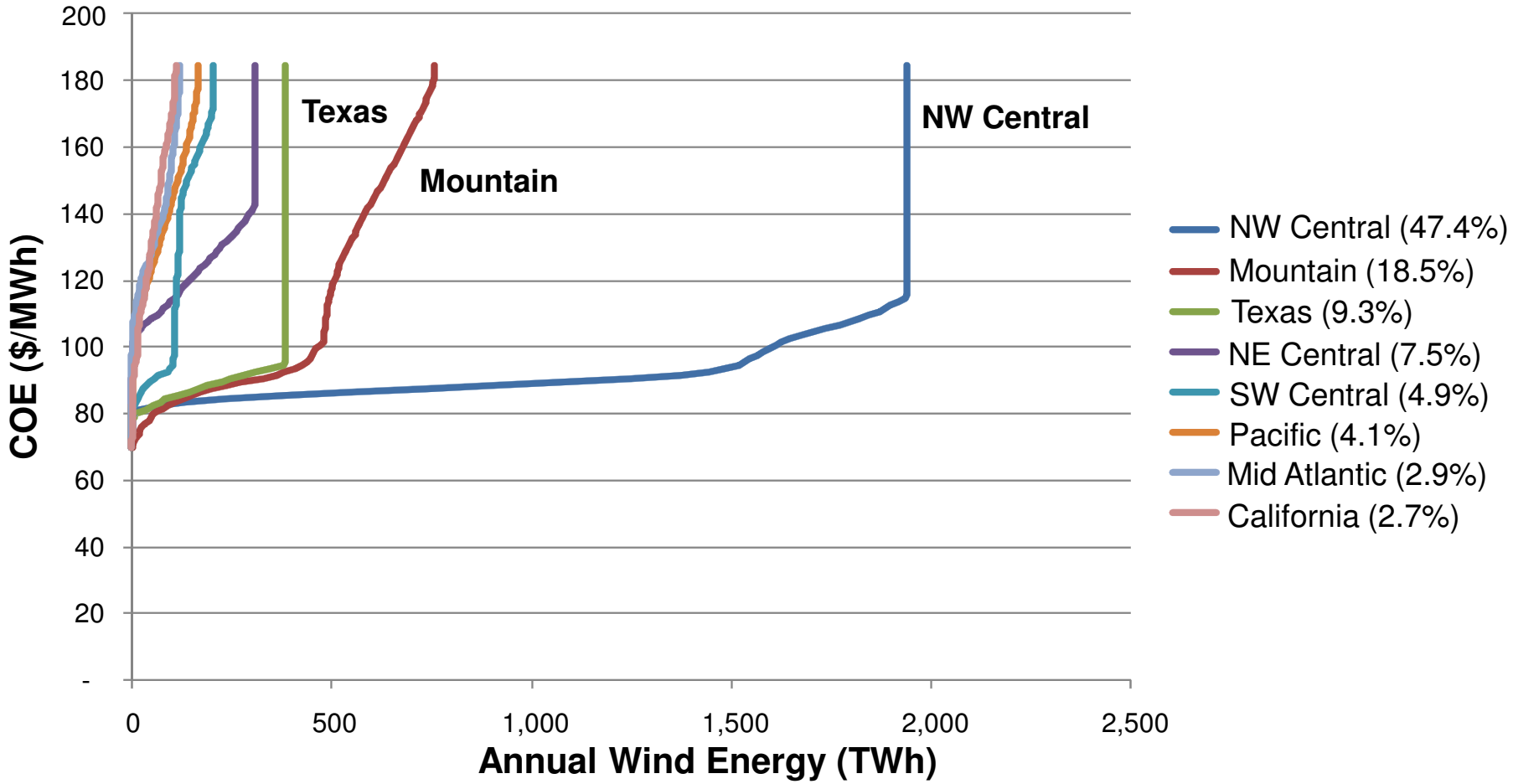
National Wind Energy Potential Supply Curve* (excluding delivery costs)



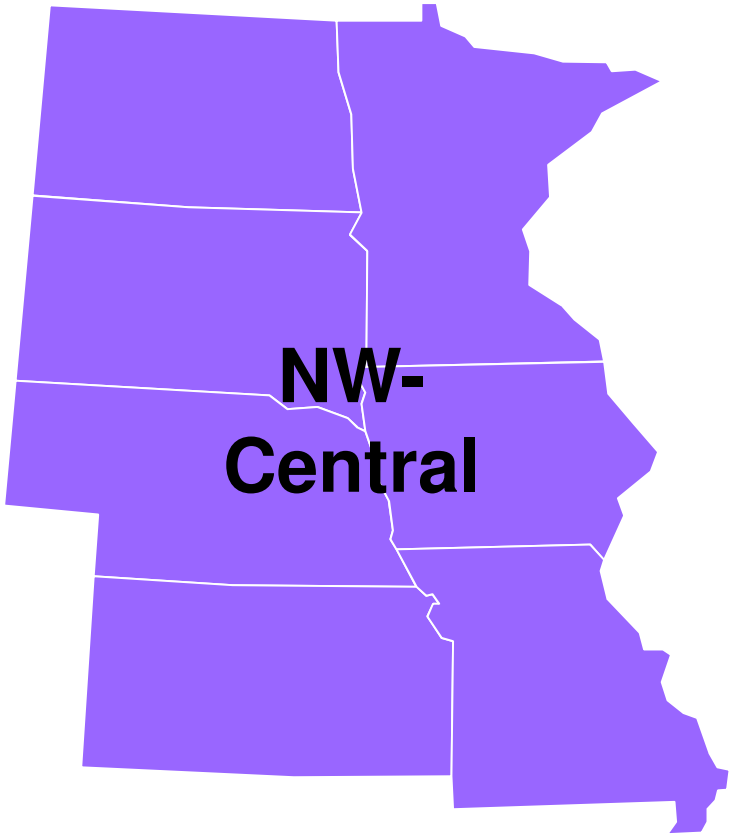
*EPRI – AWS TruePower National Wind Energy Supply Curve

Regional Wind Energy Potential Supply Curve



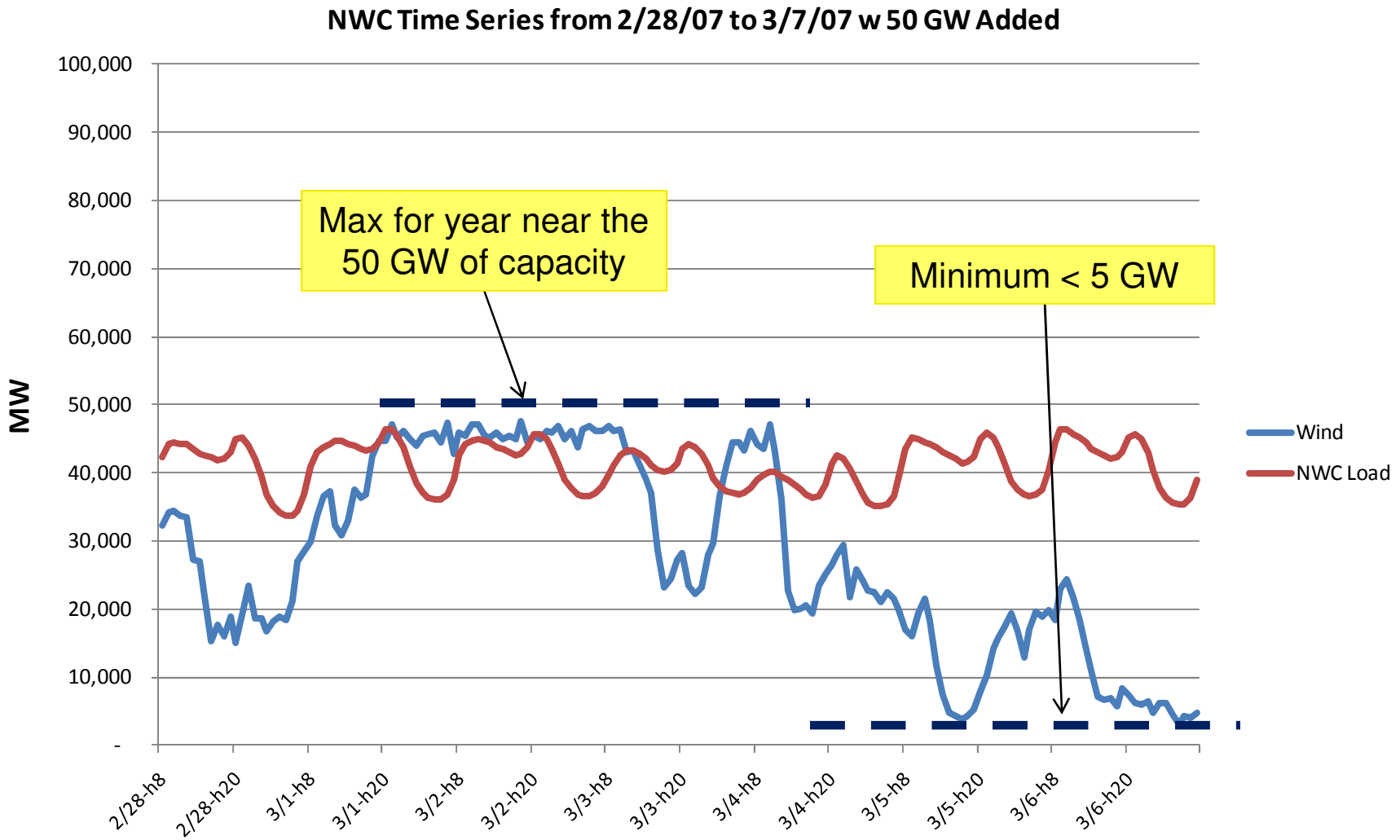
Uneven Regional Distribution…. ~50% of Economic Resource in NW Central

Example Analysis for NW-Central Region

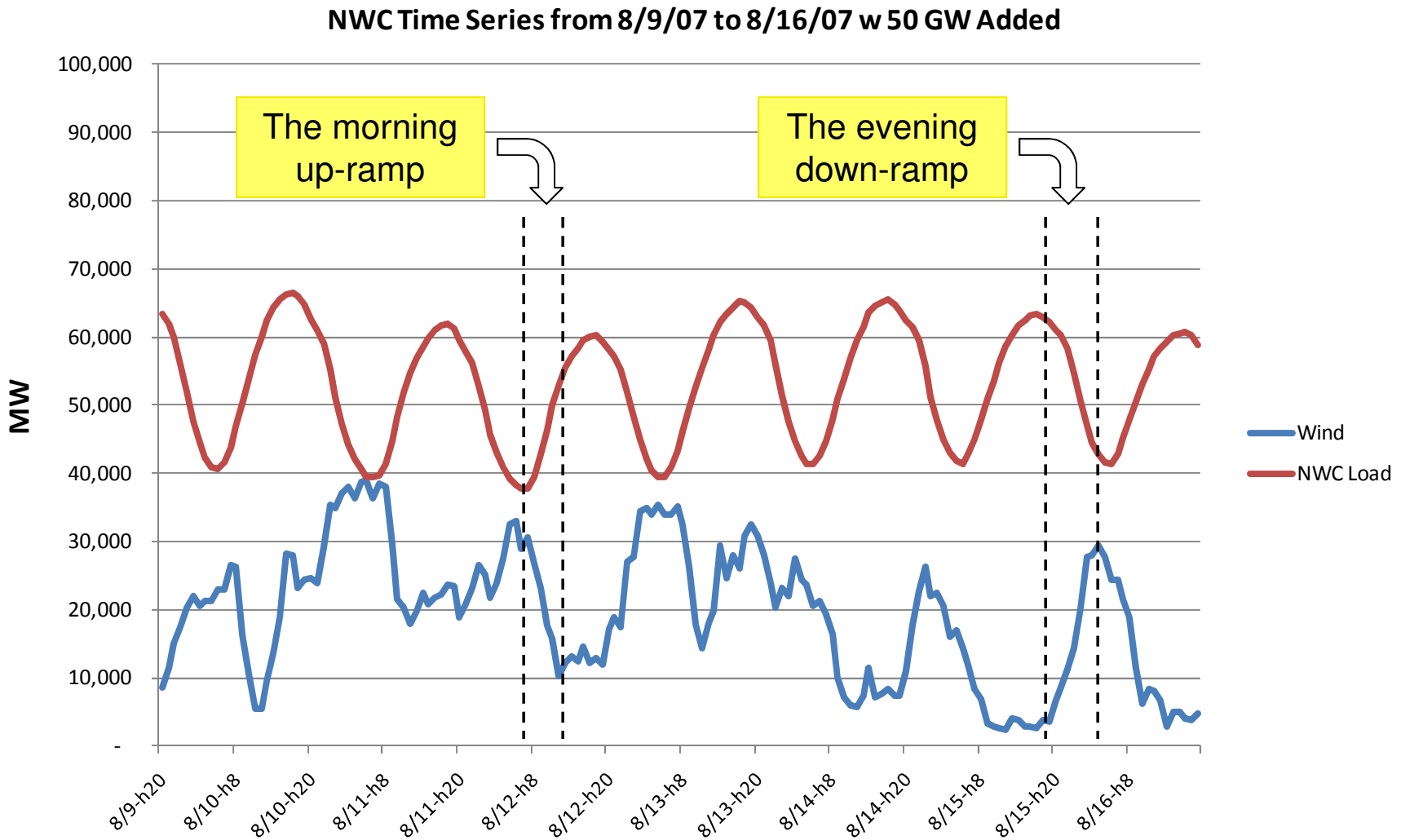


- State hourly load data for 2007 from Energy Velocity
- Hourly loads and wind output synchronized so driven by same 2007 meteorology
- Add 50 GW new installed wind capacity within region
- Rank sites by capacity factor, build best sites first

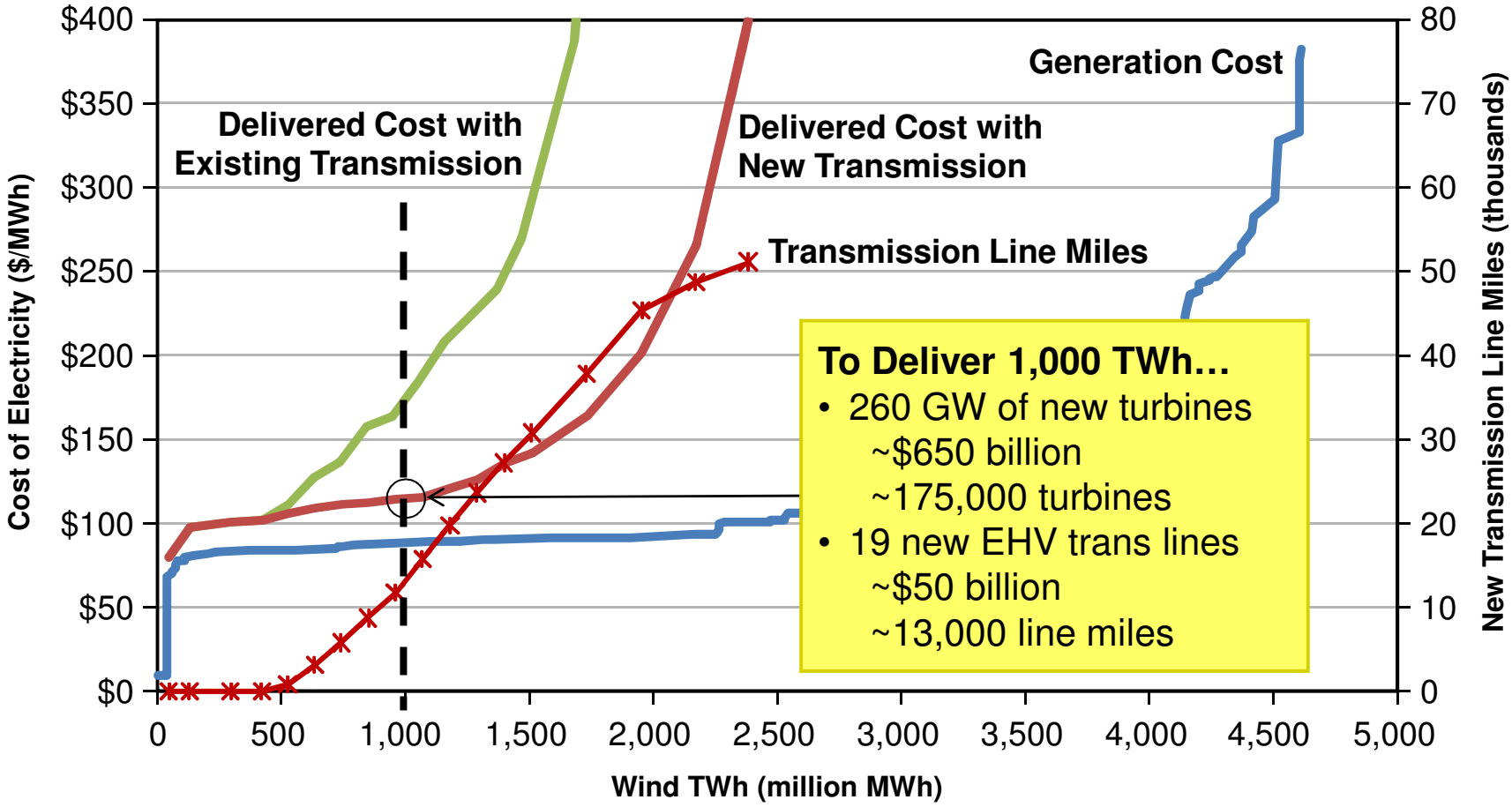
New Wind Data Captures Variability



Anti-correlation of Wind with Load Creates Ramping Issues



National Wind Energy Potential Supply Curves* (including delivery costs)



*EPRI – AWS TruePower National Wind Energy Supply Curves

PRISM 2.0 “TEST DRIVE”

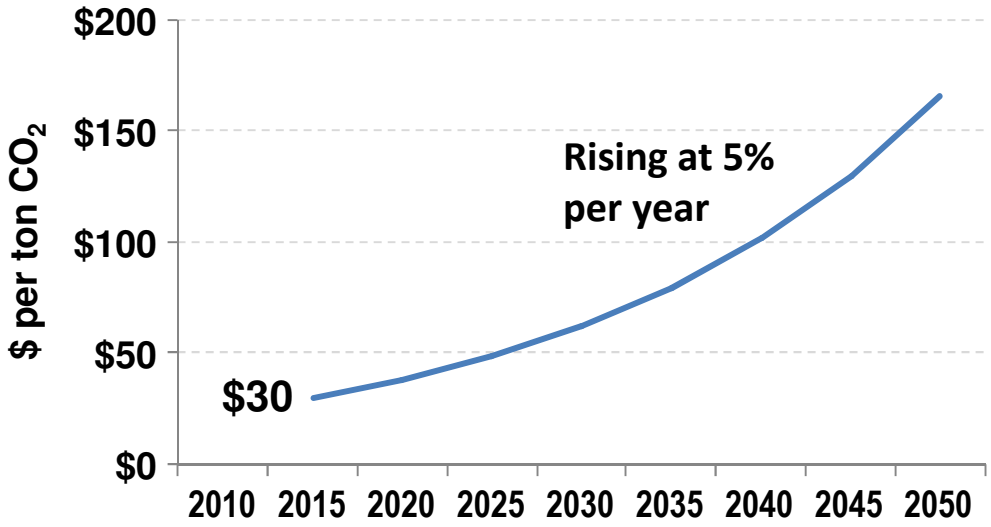
Taking Prism 2.0 for a "Test Drive"

New insights for the role of technology in a carbon-constrained world

- How does regional detail impact the national picture?
- How to represent new economics of CO_2 policy?
  - Details and timing of potential federal action on limiting emissions remain unclear
  - Without specifying a particular approach, we can simulate an aggressive policy with a rising CO_2 price
  - Leads to efficient allocation of abatement options

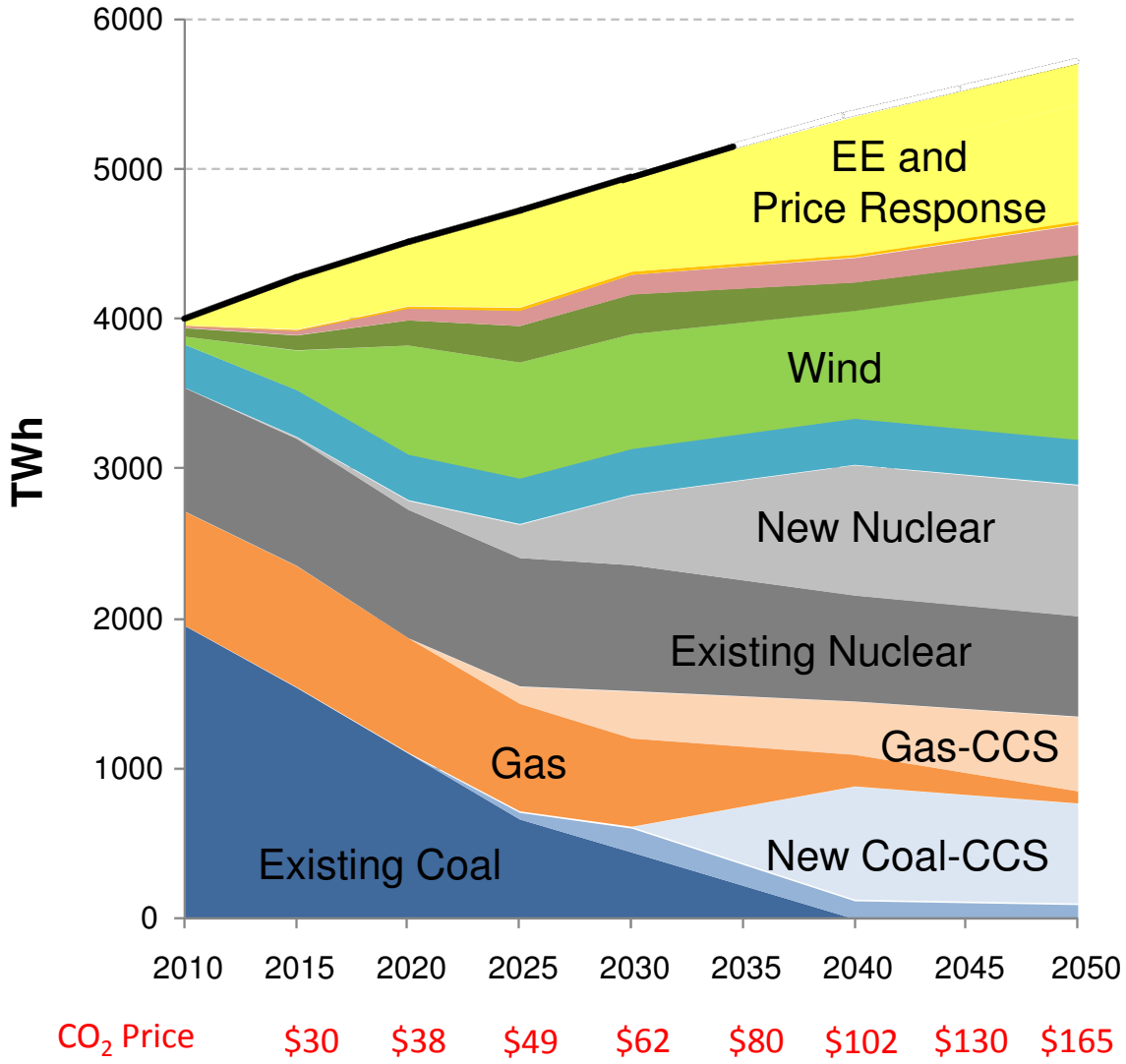
Emissions Reductions at Least Cost

- Actual policy mechanisms may ***not*** lead to a least-cost path (e.g. portfolio standards, regulatory mandates)
- Understanding the least-cost path is still a valuable exercise and can illustrate the interactions between technologies



Results are *preliminary…further development in progress*

Prism 2.0 "Test Drive" Generation Mix



- AEO 2010 Reference Case
- Energy Efficiency*
- Solar
- Geothermal
- Biomass
- Wind
- Hydro+
- Nuclear (New)
- Nuclear (Existing)
- Gas-CCS
- Gas
- Coal-CCS (New)
- CCS Retrofit
- Coal

* Includes new programs, technology, and behavioral price response

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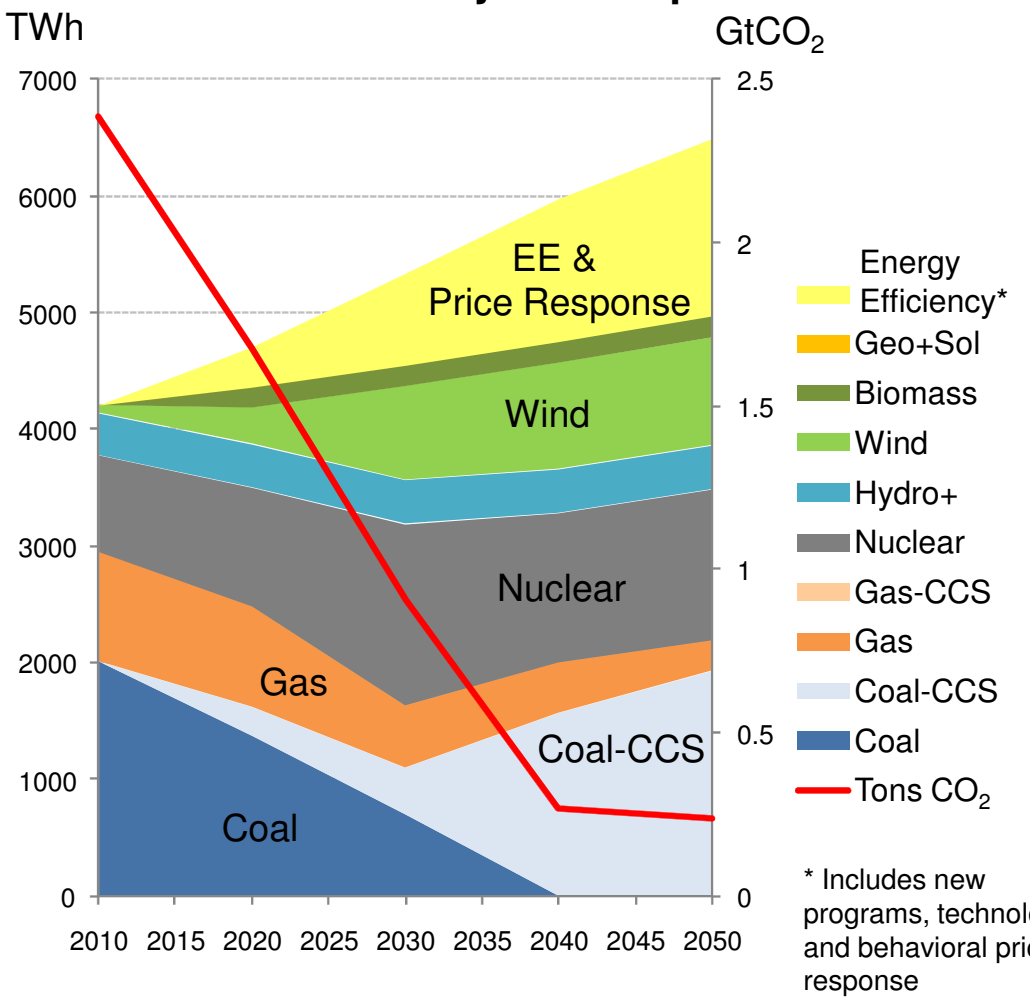
MERGE vs. Prism 2.0 "Test Drive"

Electric sector module only

MERGE with 80% by 2050 Cap



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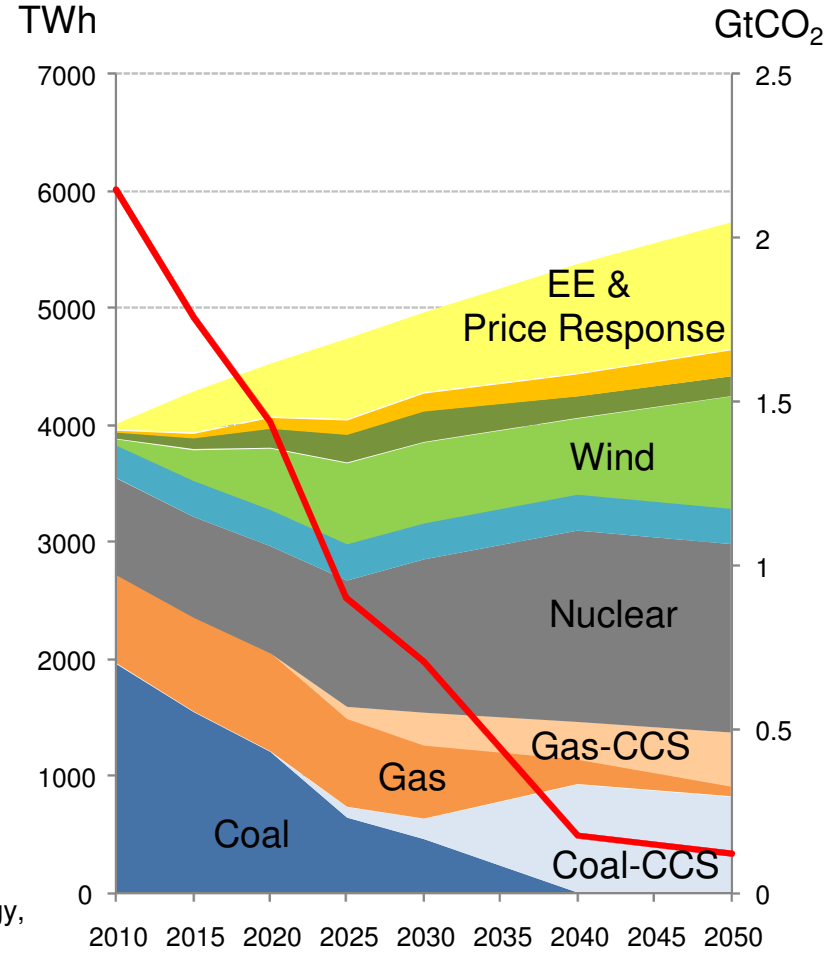

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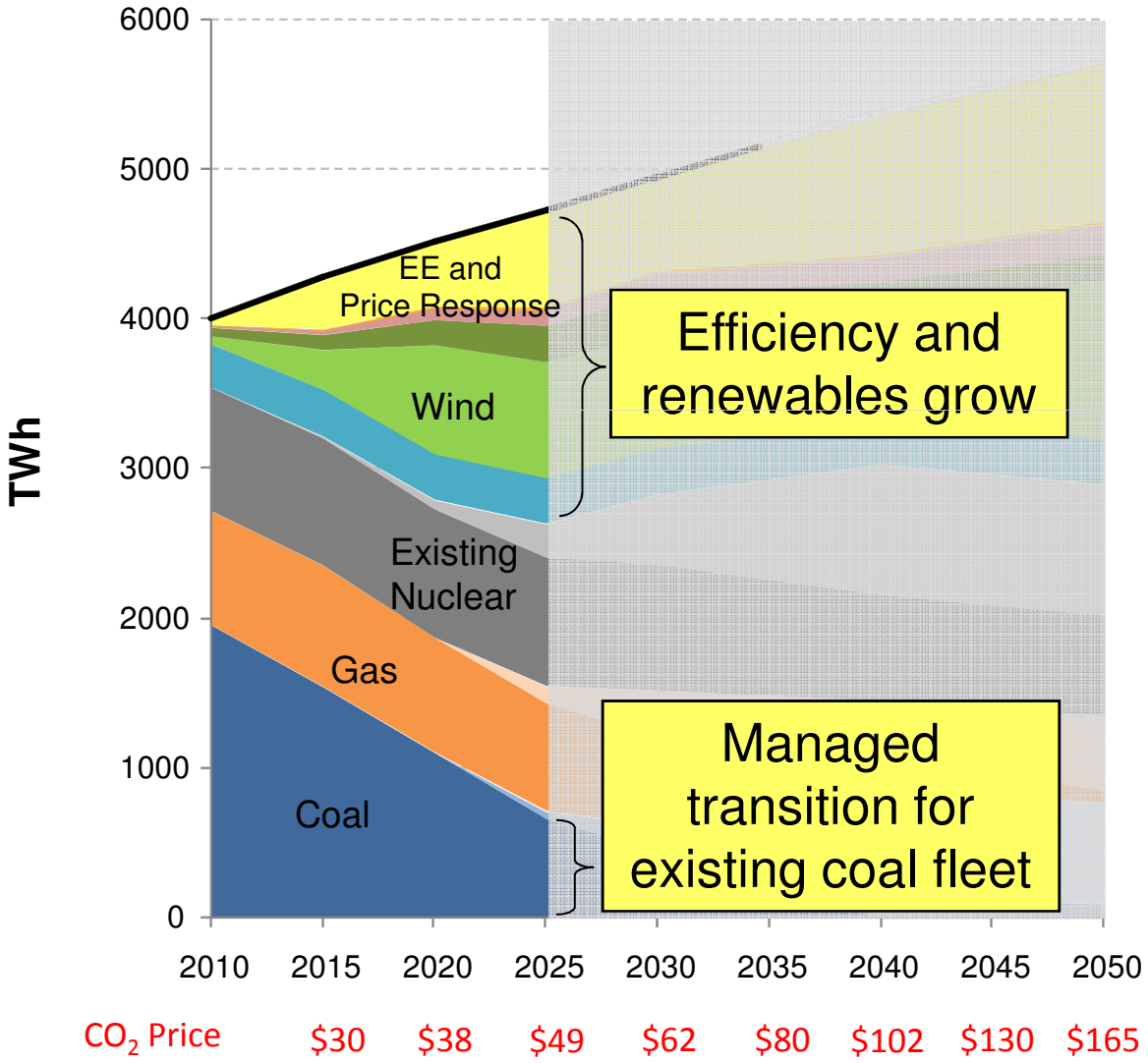
Prism 2.0 "Test Drive" Insights… 2010-2025



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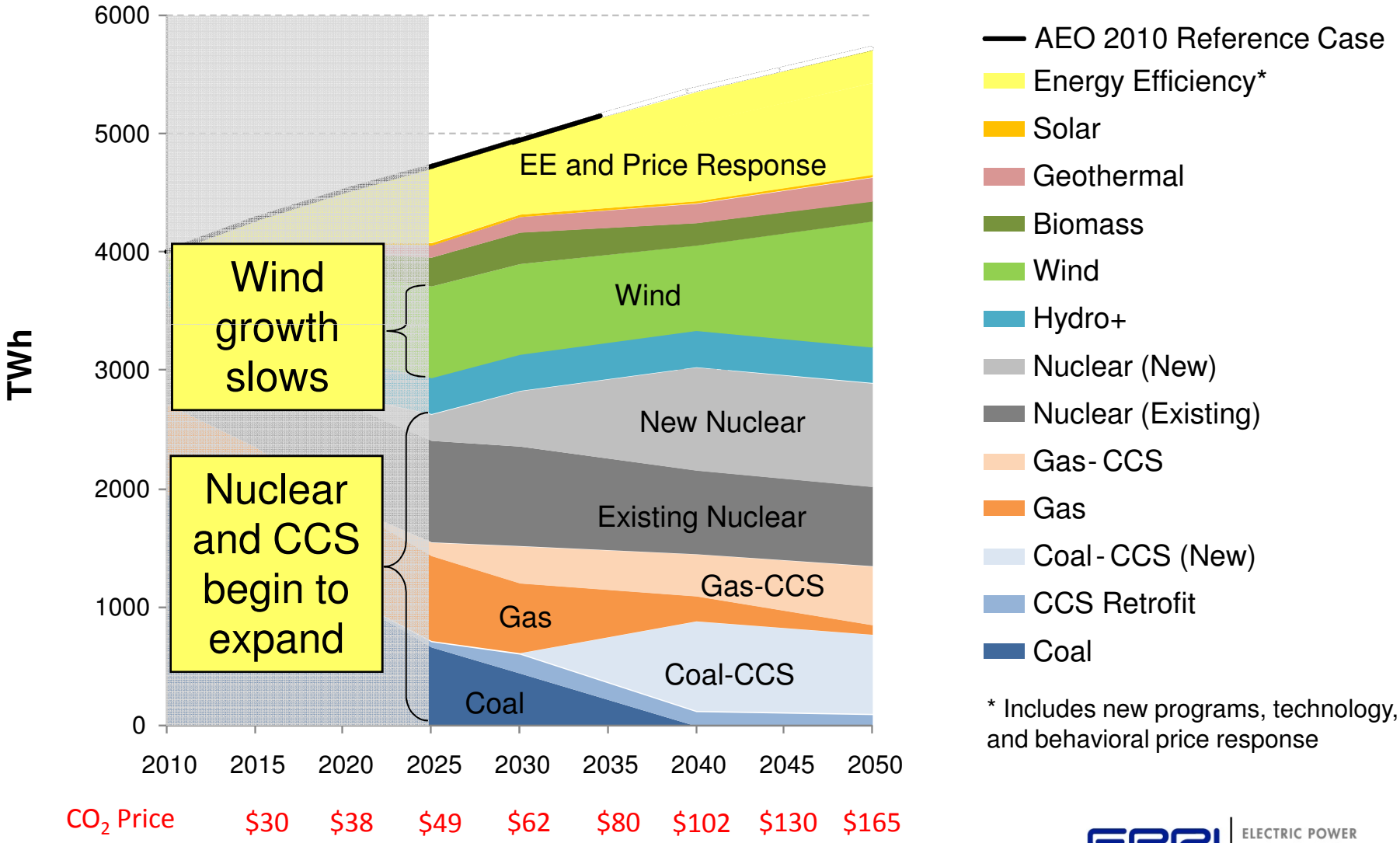
Prism 2.0 "Test Drive" Insights… Post-2025



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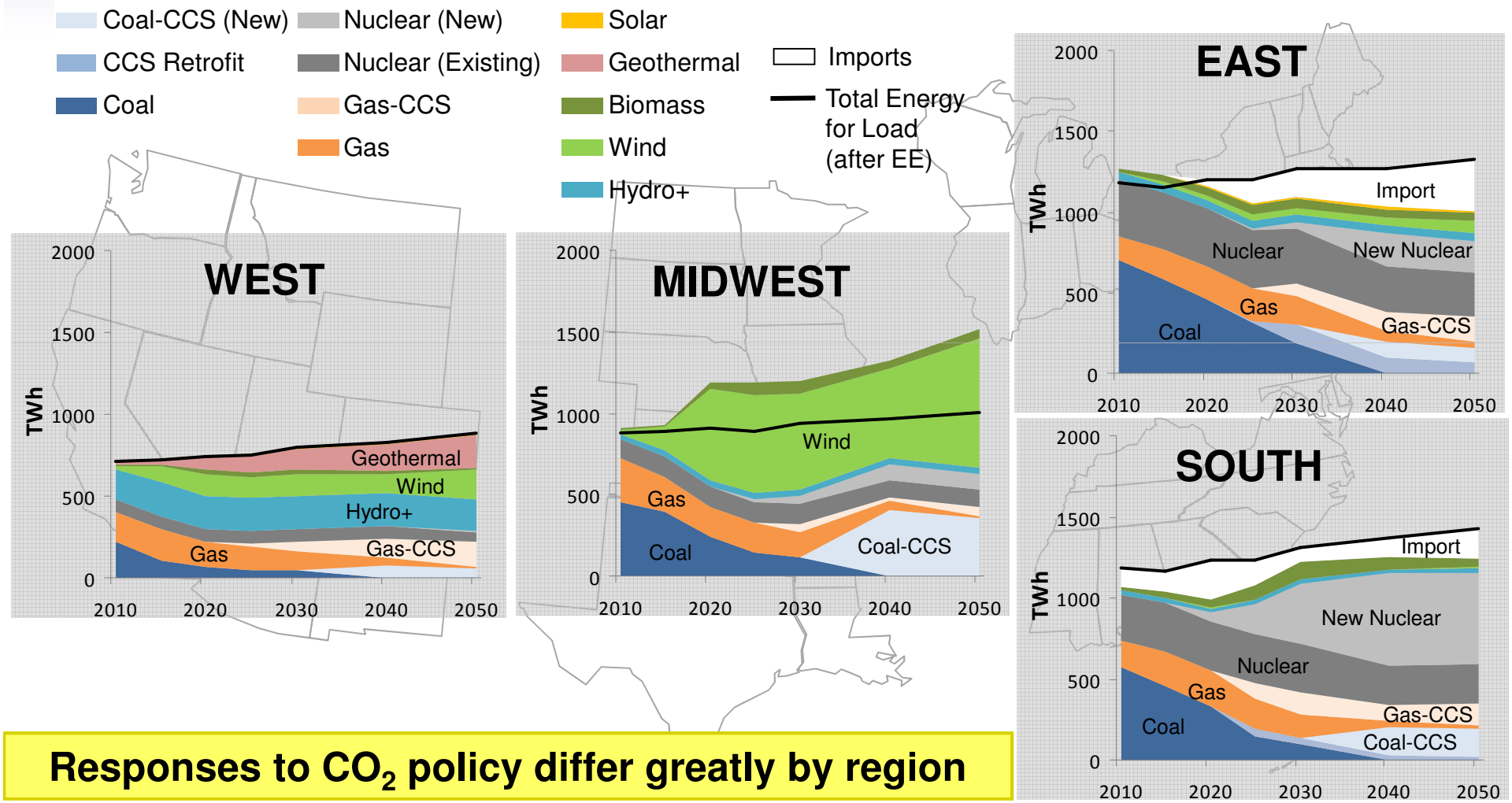
Prism 2.0 "Test Drive" Insights…
Regional Generation Mix



Responses to CO_2 policy differ greatly by region

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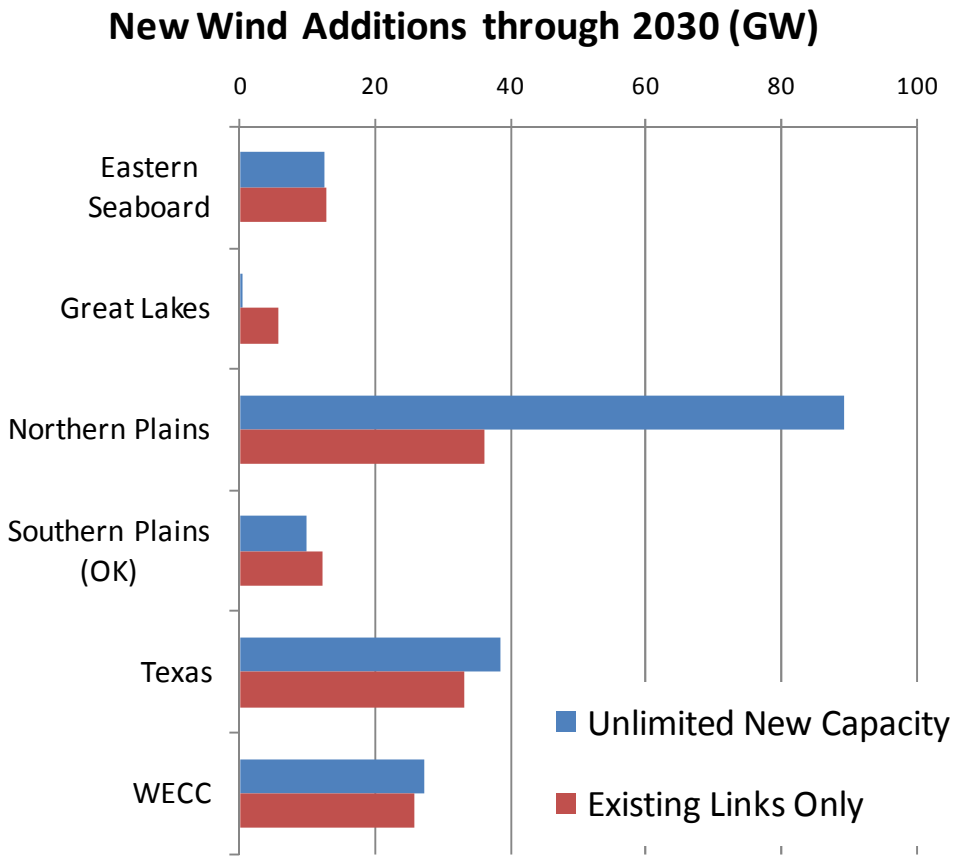
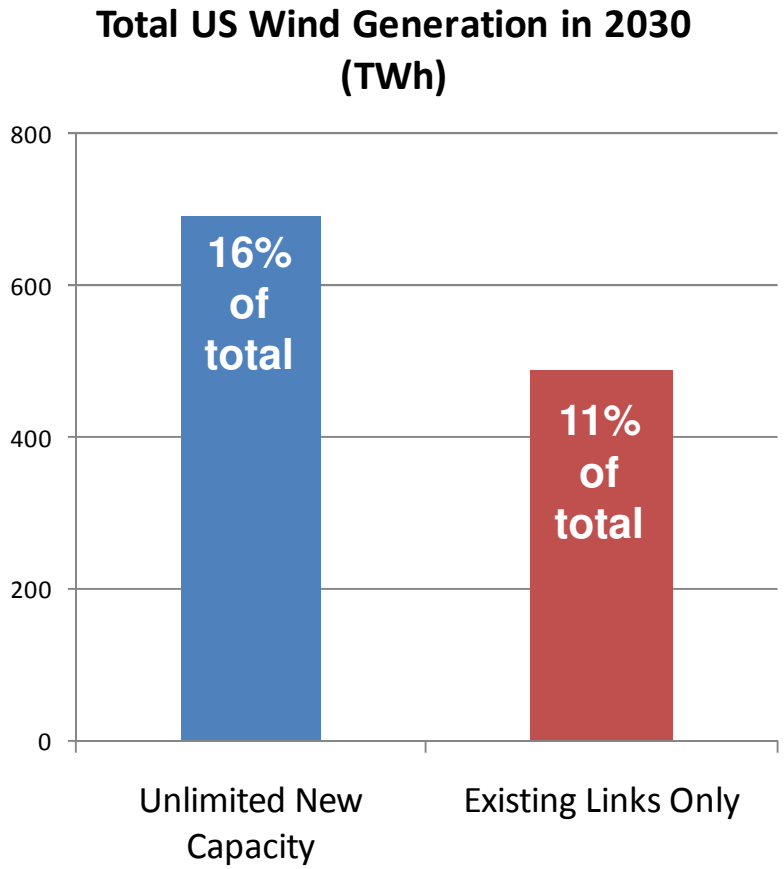
Prism 2.0 "Test Drive" Insights…
What if no new inter-region transmission?





Less wind, more regionally distributed

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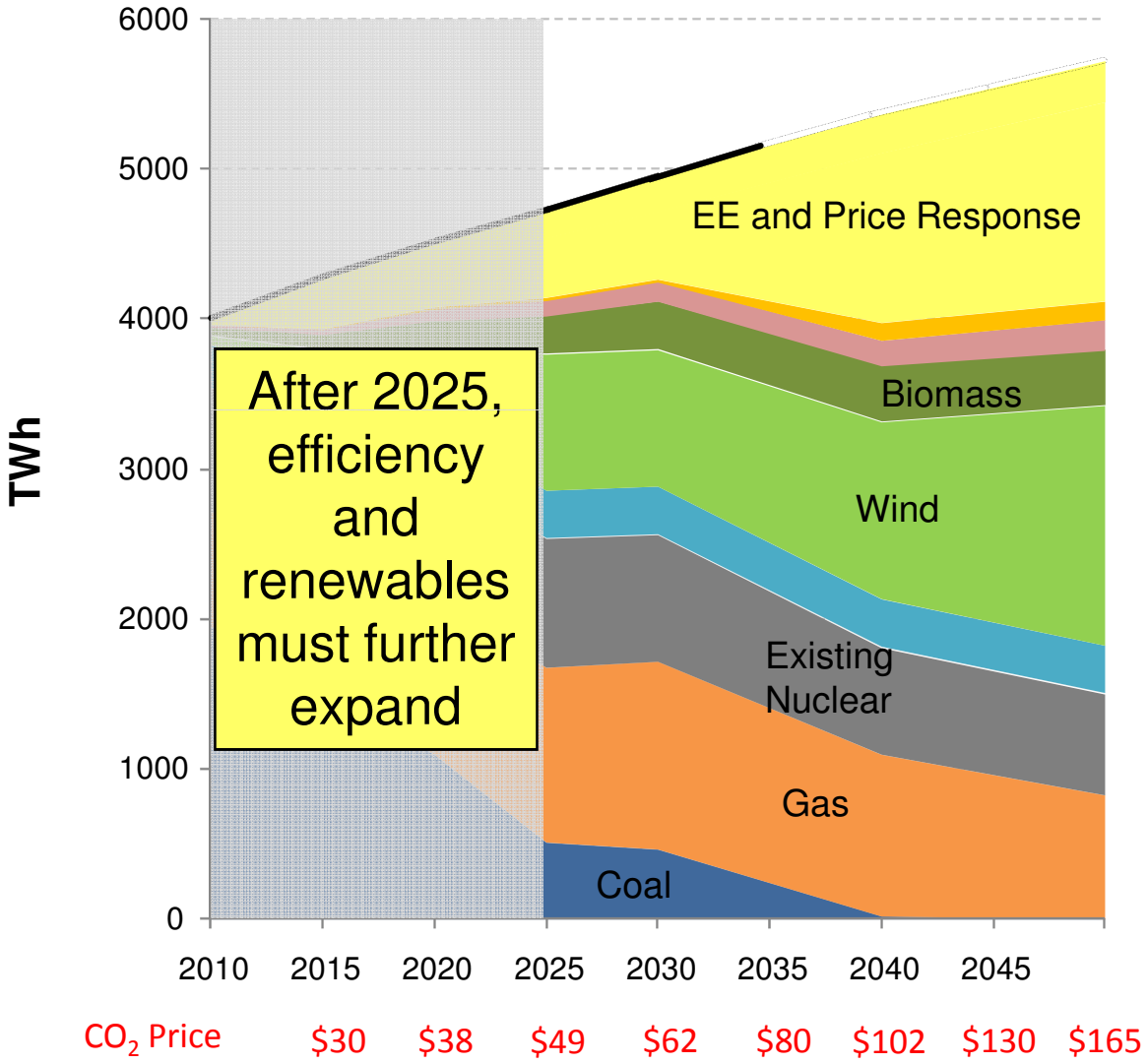
Prism 2.0 "Test Drive" Insights…
What if no new nuclear or CCS?



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What We Are Seeing … *Initial Insights*

- **Near term response to high CO_2 price likely dominated by renewables, efficiency and natural gas**
  - Coal retirements offset by new renewables, efficiency
  - Natural gas fills any remaining demand

- **Wind integration costs significant at high penetration**
  - New balancing resources required (transmission, storage, smart grid, PHEVs)
  - Ramping impacts on thermal fleet → increased O&M

- **Longer term, nuclear and CCS will be important**
  - Without them, rely on more costly renewables, efficiency

Next: Costs of Environmental Controls

- **Identify primary near-term challenges** for existing/new fossil fleet
  - Air pollutants (SO_2, NO_x)
  - Air toxics (Hg)
  - Coal combustion products (CCPs)
  - Water (thermal cooling, effluent)

- **Develop a set of control technologies** for each, and identify costs and performance characteristics using existing assessments

- With project funders, **identify scenarios** for potential Federal/State environmental control regulations

Likely to modify rate of transition in generation mix

Next: Energy Efficiency as a Resource

- **Demand divided into distinct end-uses and sectors**
- **Supply curves constructed for each end-use in each region using EPRI EE Group's potential estimates**
- **Each end-use will respond differently to changes in the wholesale price from reference levels:**
  - Different retail margins depending on sector
  - Different substitution opportunities with capital, other fuels (EE Group's dataset used to calibrate)
  - Different service demand elasticities (i.e. substitution away from energy toward non-energy goods)

Develop demand-side to equivalent level of detail

Next: Fully-Developed Transportation Module

Passenger Cars / Light Trucks

60%

of transport energy

Local Trucks / Busses

5%

of transport energy

Long-Haul Trucks / Rail / Air

25%

of transport energy

Non-Road (e.g. ports, water)

10%

of transport energy

Fuel Demands

Oil Biofuel Electricity Gas

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Prism 2.0: Forward on a Parallel Process

MODEL DEVELOPMENT
Electric Sector Module
- refine CO_2 mitigation technologies
- incorporate environmental controls

Economy-wide Framework
- build out rest of the economy
- incorporate energy efficiency
- incorporate transportation

-Other

SCENARIO SPECIFICATION
- Environmental regulations
- Renewable Energy Standards
- Energy price sensitivities
- CO_2 Legislation and policies
- Other

Detailed Analyses & Communication of Results

Timeline

2nd Half 2010 | 1st Half 2011 | Rest of 2011

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Together...Shaping the Future of Electricity

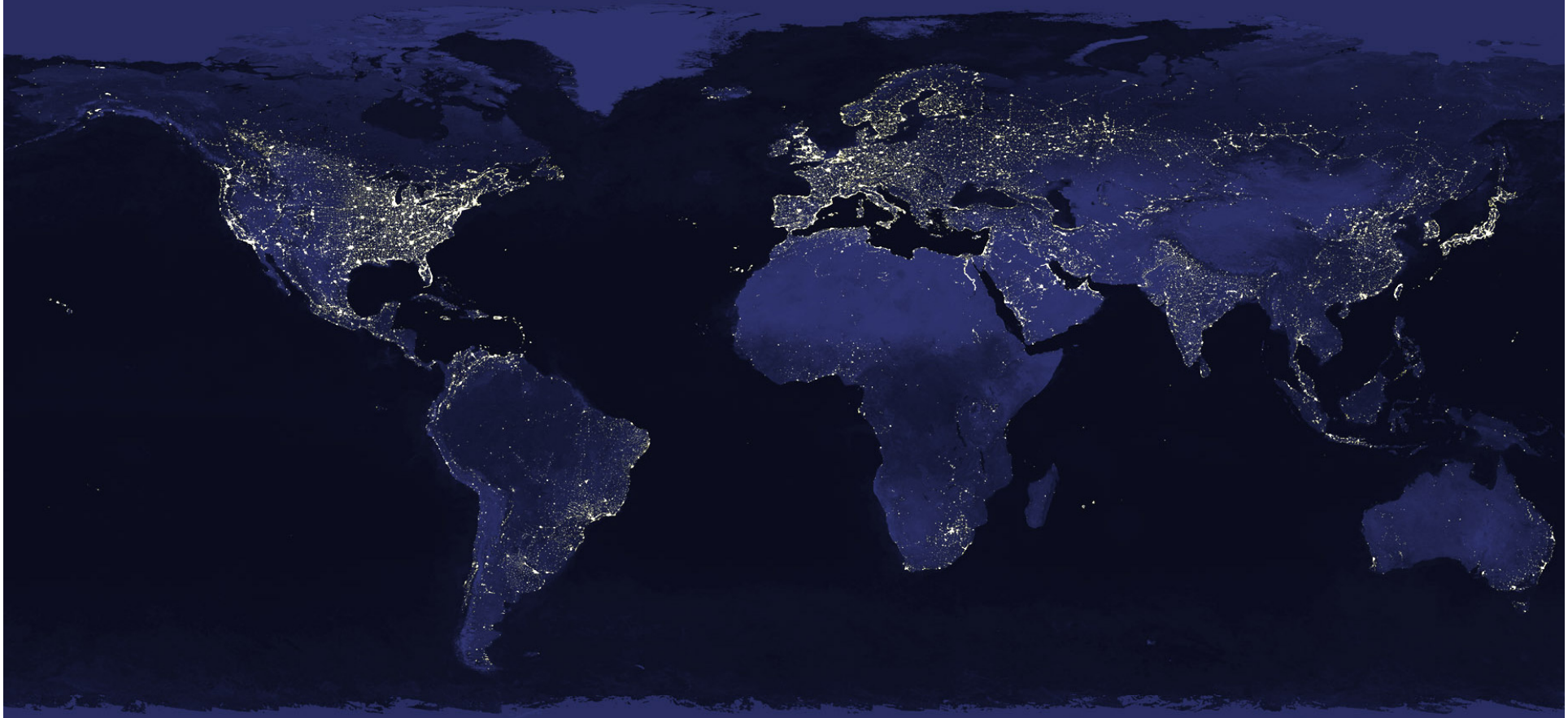

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Image from *NASA Visible Earth*