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

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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

12 Regions
Prism 2.0 Model Status

General Equilibrium
Macro Module
PARTIALLY COMPLETE

Electric Sector Module

CO₂ Technologies
Completed

Env Controls
In Progress

Integration

Energy efficiency in industrial, commercial, and residential sectors

Build out of electric transportation technologies

COMPLETED by early 2011
REGIONAL SPECIFICS
New Generation Technology Options: Capital costs vary across regions

- **Nuclear**
- **Coal with CCS (IGCC)**
- **Biomass**
- **Coal without CCS (SCPC)**
- **NGCC with CCS**
- **Solar (CSP) – West only**
- **Wind**
- **NGCC without CCS**
- **NG Gas Turbine**
Net Inter-Region Trade Positions in 2007

Net Exports in TWh (source: EIA)

- Pacific (+15)
- California (-85)
- Mountain (+71)
- Texas (+8)
- SW-Central (-4)
- NE-Central (+66)
- NE (-1)
- M-Atlantic (+32)
- S-Atlantic (-83)
- SE-Central (+3)
- Florida (-28)

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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

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

*EPRI – AWS TruePower National Wind Energy 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

NWC Time Series from 2/28/07 to 3/7/07 w 50 GW Added

Max for year near the 50 GW of capacity

Minimum < 5 GW

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Anti-correlation of Wind with Load Creates Ramping Issues

NWC Time Series from 8/9/07 to 8/16/07 w 50 GW Added

The morning up-ramp

The evening down-ramp
National Wind Energy Potential Supply Curves* (including delivery costs)

To Deliver 1,000 TWh...
• 260 GW of new turbines ~$650 billion ~175,000 turbines
• 19 new EHV trans lines ~$50 billion ~13,000 line miles

*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

CO₂ Price
$30  $38  $49  $62  $80  $102  $130  $165
MERGE vs. Prism 2.0 “Test Drive”

Electric sector module only

MERGE with 80% by 2050 Cap

Prism 2.0 “Test Drive”

* Includes new programs, technology, and behavioral price response

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Prism 2.0 “Test Drive” Insights… 2010-2025

- Efficiency and renewables grow
- Managed transition for existing coal fleet

**Energy Efficiency**
- Solar
- Geothermal
- Biomass
- Wind
- Hydro+

Efficiency and Price Response

**CO₂ Price**
- $30
- $38
- $49
- $62
- $80
- $102
- $130
- $165

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Prism 2.0 “Test Drive” Insights... Post-2025

**Wind growth slows**

**Nuclear and CCS begin to expand**

*Includes new programs, technology, and behavioral price response*
Prism 2.0 “Test Drive” Insights... Regional Generation Mix

Responses to CO₂ policy differ greatly by region
Prism 2.0 “Test Drive” Insights...
What if no new inter-region transmission?

New Wind Additions through 2030 (GW)

- Eastern Seaboard
- Great Lakes
- Northern Plains
- Southern Plains (OK)
- Texas
- WECC

Unlimited New Capacity
Existing Links Only

Total US Wind Generation in 2030 (TWh)

- Unlimited New Capacity: 16% of total
- Existing Links Only: 11% of total

Less wind, more regionally distributed

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Prism 2.0 “Test Drive” Insights... What if no new nuclear or CCS?

After 2025, efficiency and renewables must further expand.

CO₂ Price $30 $38 $49 $62 $80 $102 $130 $165
What We Are Seeing … Initial Insights

• Near term response to high CO₂ 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
Prism 2.0: Forward on a Parallel Process

MODEL DEVELOPMENT
Electric Sector Module
- refine CO\textsubscript{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\textsubscript{2} Legislation and policies
- Other

Timeline
| 2\textsuperscript{nd} Half 2010 | 1\textsuperscript{st} Half 2011 | Rest of 2011 |

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