CRA's North American Electricity and Environment Model (NEEM)

January 22, 2009

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NEEM Overview

- **NEEM represents the US electric power system and portions of the Canadian system**
- **NEEM forecasts the following key variables**
  - **Electricity prices**
  - **Inter-regional transfers of energy**
  - Dispatch of generating units to meet demand
  - **Unit-level gross margins**
  - Mix and timing of new capacity additions
  - Retrofits of existing generating units with pollution control equipment
  - Retirement or continued operation of existing units
  - Fuel switching between types/grades of coal
  - Emission allowance sales, purchases, and banking
  - Scheduling of maintenance for generating units

Types of NEEM Projects

- **Electricity price forecasts**
- **Unit-level analysis**
- **Plant or portfolio valuation**
- **Greenhouse gas scenario analysis (coupled w/ MRN)**
- **Assessment of transmission projects**
- **Evaluation of environmental policies (e.g., SO2 / NOx, Hg, RPS, etc.)**

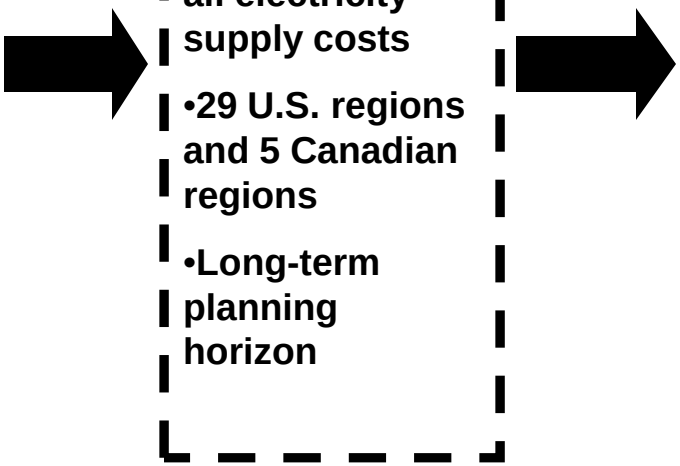
NEEM is a Linear Program

- **Over the time horizon modeled (typically 30-70 years) NEEM minimizes the present value of the following costs**
  - **Dispatching generating units (fuel + variable O&M)**
  - Constructing new generating units
  - Installing and operating environmental retrofits
  - Maintaining existing generating units
- **Constraints in NEEM ensure that**
  - Electricity demand is met
  - **Limits on interregional power flows are not exceeded**
  - Reserve margin requirements are met
  - Environmental constraints are satisfied (*e.g.,* SO2 / NOx caps)
  - Renewable Portfolio Standards are met
  - Unit operational limits and energy limits are not exceeded
  - Unit maintenance requirements are met

NEEM Model

NEEM Inputs

- Fuel prices (oil, gas)
- Coal supply curves
- Peak Demand
- Energy Demand by Load Block
- Unit-level inputs (capacity, emissions controls, heat rates, O&M costs)
- Cost information for new builds and retrofits
- Emissions caps (or prices)
- RPS requirements
- Reserve margin requirements
- Inter-regional transmission constraints and wheeling charges



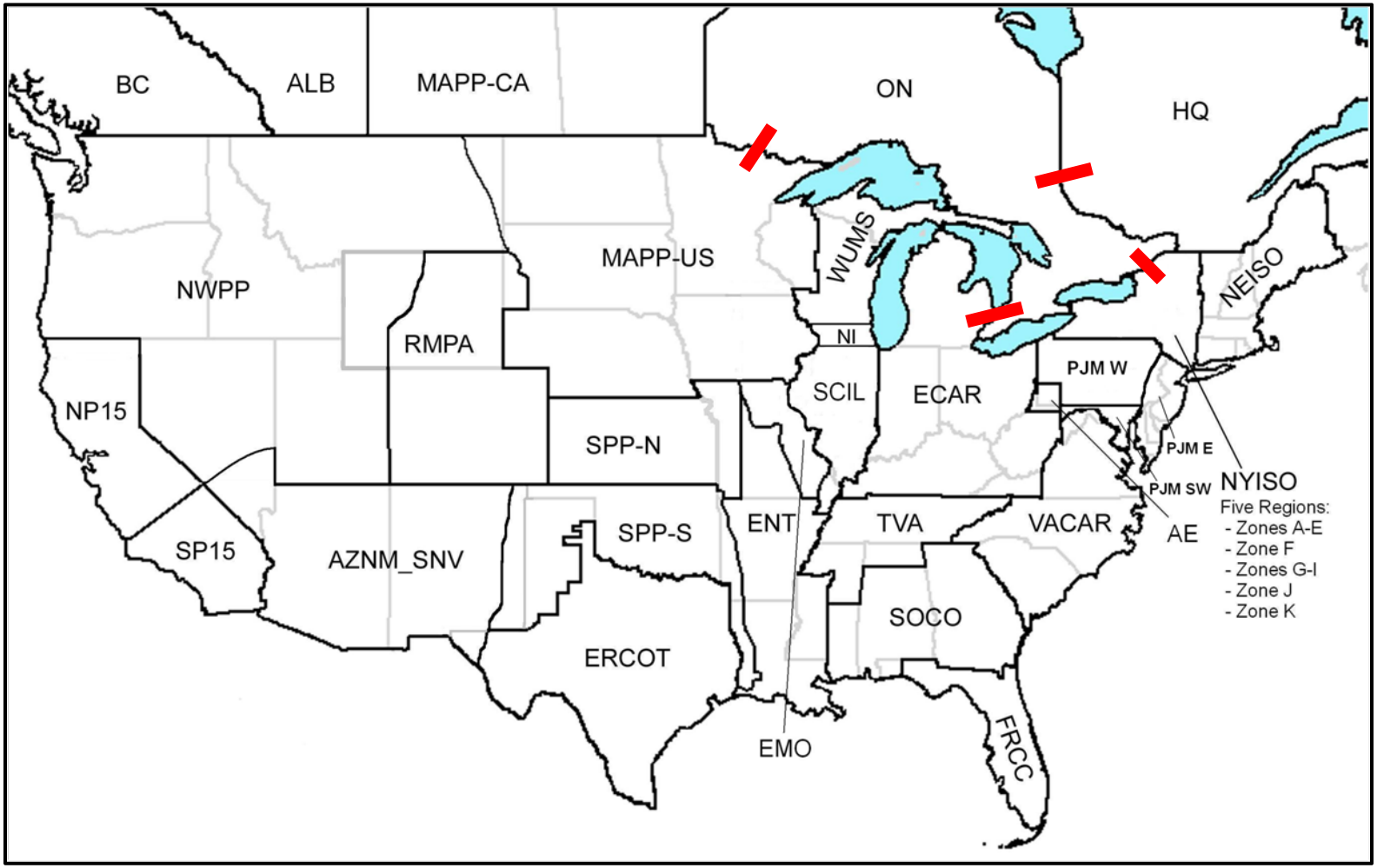
NEEM Outputs

- Regional wholesale peak and off-peak electricity prices
- Inter-regional power flows
- Coal prices by coal type, reflecting supply and demand
- Allowance and REC prices
- New builds and retrofit decisions
- Retirement and mothball decisions

NEEM Input Data

- **NEEM input data are primarily from public sources**
  - Load forecasts (ES&D, FERC Form 714)
  - Unit data (EIA-411, Energy Velocity, NERC GADS)
  - Cost and performance of retrofits (EPRI, EPA)
  - Emission regulations and emission limits from state and federal rules
  - Costs and characteristics of new units (EIA, CRA estimates)
  - Transmission interface limits (NERC regional and interregional studies)
  - Unit emission rates (EPA)
  - State and regional planning data
- **Fuel prices and fuel supply assumptions are derived from other CRA models or analysis**
  - Coal is modeled as 21 supply curves, with transportation from supply sources to plants
  - Point estimate gas prices are an input, with appropriate basis differentials for each region

NEEM Transmission Regions



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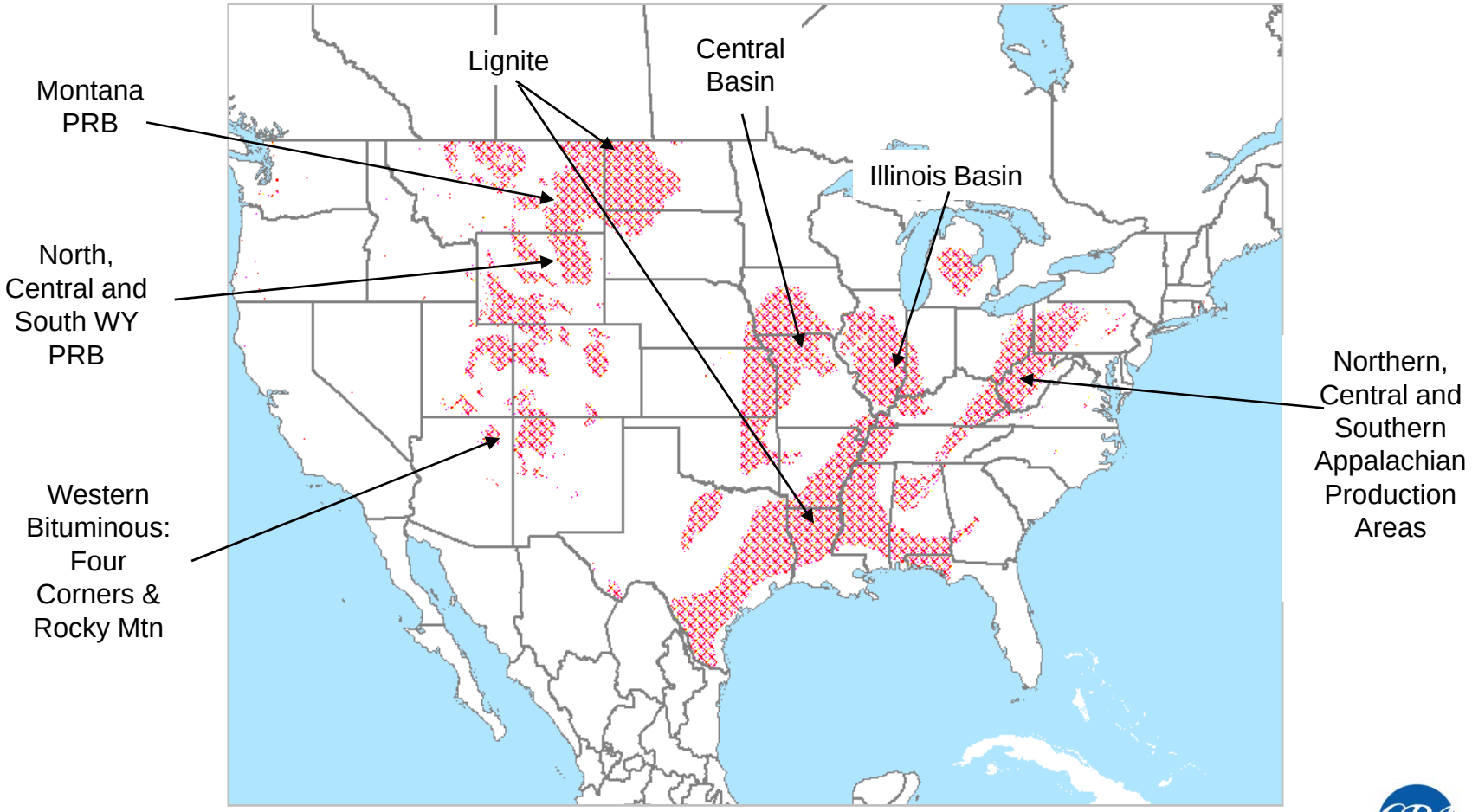
NEEM Coal Supply and Transportation Infrastructure

21 individual curves representing distinct domestic production areas, Latin American imports, and different coal qualities (sulfur and Btu)



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NEEM Allowance Markets

- **Title IV SO_2 – Cap & Trade, annual, entire US**
- **NO_x SIP Call – Cap & Trade, ozone season, Eastern US**
- **CAIR SO_2 – Cap & Trade, continuation of Title IV market with trade-in ratios changing over time for Eastern US (scheduled to begin in 2010)**
- **CAIR NO_x (Annual and Ozone Season) – Cap & Trade, Eastern US, replaces SIP Call (scheduled to begin in 2009)**
- **SO2 and NOx cap in place for Ontario**
- **National and regional greenhouse gas policies can be modeled**

NEEM Enviromental Modeling

- **Emissions**
  - Current SO_2, NO_x, Hg emission rates estimated for all units
  - Existing units have known control equipment, known or estimated emission rates
  - New units assumed to have the “best available” emission controls
  - SO_2 emissions from coal plants determined by coal burned and reduction efficiency of control equipment
- **Retrofits selected as part of NEEM optimization**
  - Retrofits modeled as transitions from one retrofit “state” to another state (these can also be limited or prohibited in NEEM)
  - Over time, multiple retrofits are permitted to the same unit for different pollutants

NEEM Emission Control Options

- **Controlling SO_2**
  - Scrubbers - FGD
  - Coal switching/blending
- **Controlling NO_x**
  - Selective Non-Catalytic Reduction - SNCR
  - Selective Catalytic Reduction – SCR
- **Controlling Carbon**
  - Fuel switching
  - Renewables builds
  - Carbon capture and sequestration

Appendix

- **MRN-NEEM**

CRA's Modeling System