EFRI RESIN

The Interface of Infrastructures, Markets, and Natural Cycles: Innovative Modeling and Control Mechanisms for Managing Electricity, Water and Air Quality in Texas

David Allen, Michael Webber and Rob Williams
University of Texas

Ron Prinn and Mort Webster
MIT
How can a smart electrical grid balance water use, regional air quality, carbon emissions, and electricity demand and cost?

**Before:** Today’s electricity dispatching decisions are based on price and availability of power.

**After:** Integrated electricity dispatching decisions also include advanced markets, infrastructure resiliency, air quality impacts, and water availability.
Develop Decision Support Tools at three time scales

• Daily dispatching decisions (influenced by air quality)
• Seasonal dispatching decisions (influenced by air quality and water quantity)
• Siting of new generation capacity (multi-year, influenced by air quality, water quantity and carbon emissions)
Why Texas?

• Grid entirely contained within the state
• Water-rich east, water-poor west
• Air quality limits in the east but not in the west
• A diverse base of Electricity Generating Units (EGUs), including more installed wind power than any other state

• The ERCOT grid:
  – One of 9 ISO’s in North America
  – Covers 75% of Texas land
  – Serves 85% of Texas load
  – 38,000 miles of transmission lines
  – >550 generation units
  – 62,429 Megawatts peak demand (set 8/17/06)
  – Single point of control Interconnection
Focus in today’s presentation

• Early success in influencing daily dispatching decisions
• Challenge of balancing competing objectives: Case study of carbon and NOx emissions
Daily Environmental Dispatching of Electric Power Generation to meet Air Quality goals

• Basic principles behind the idea
• The Austin “Big Push” and prognostic modeling
• Modeling results
• Actions taken by the utility
• Planned retrospective analyses
Basic principles behind Environmental Dispatching: Air quality impacts of EGUs are significant and different EGUs produce different air quality impacts.
Different power plants, different impacts, depending on the day; What advice do we give to the utility?
Daily Environmental Dispatching of Electric Power Generation to meet Air Quality goals

- Basic principles behind the idea
- The Austin “Big Push” and prognostic modeling
- Modeling results
- Actions taken by the utility
- Planned retrospective analyses
The “Big Push” and prognostic modeling

- Austin on cusp of violating federal ozone standard
- Community consensus to implement aggressive strategies for ozone reduction in summer of 2009
- Environmental dispatch by EGUs is highest impact strategy in Big Push
- Our team performed modeling to develop strategies
Daily Environmental Dispatching of Electric Power Generation to meet Air Quality goals

- Basic principles behind the idea
- The Austin “Big Push” and prognostic modeling
- Modeling results
- Actions taken by the utility
- Planned retrospective analyses
Actions taken at utility

• Commitment to dispatch power away from Decker on days with predicted ozone concentrations between 70 and 80 ppb
• But at what time?
  – Additional modeling analyses showed that late morning and early afternoon emissions far more important than late afternoon
• Utility develops delayed spin-up strategies for Decker
Net outcome and planned retrospective analyses

- Utility performed environmental dispatching on multiple days
- Austin met ozone standard, and dispatching probably made the difference
- Planned modeling: Business as usual case versus environmental dispatch for actual 2009 meteorology
- Assess cost effectiveness
Focus in today’s presentation

• Early success in influencing daily dispatching decisions

• Challenge of balancing competing objectives: Case study of carbon and NOx emissions
Electricity Dispatching Model for Emissions, Costs, and Policy

• Represent the electric power system (generation and transmission) for Texas

• Use to explore interactions between air quality regulation, climate regulation, energy policy

• Project air quality impacts, water impacts, cost impacts
ERCOT Capacity Mix

- Natural Gas: 71.0%
- Coal: 18.1%
- Nuclear: 4.4%
- Wind: 5.9%
- Hydro: 0.2%
- Other: 0.5%

ERCOT Generation Mix

- Natural Gas: 45.8%
- Coal: 39.0%
- Nuclear: 13.0%
- Wind: 1.4%
- Hydro: 0.3%
- Other: 0.4%
Question: What are the tradeoffs between $\text{NO}_x$ and $\text{CO}_2$ regulation?

- $\text{NO}_x$ regulation to reduce ozone

- $\text{CO}_2$ price under climate policy

- Both would induce redispachting of existing generation mix
  - Redispachting to different units depending on which emission targeted
Results for Off-Peak Hour

Carbon Prices: Reduce more CO$_2$, less NO$_x$
NO$_x$ Prices: Reduce more NOx, less CO$_2$
CO₂ Prices on CO₂ Emissions (off-peak)

![Graph showing the relationship between CO₂ emissions rates and generation. The x-axis represents CO₂ emissions rates (lb/MWh) ranging from under 400 to over 3000, and the y-axis represents generation (MW) from 0 to 25000. Different colored bars indicate different CO₂ prices ($0/ton CO₂, $10/ton CO₂, $25/ton CO₂, $50/ton CO₂). The graph highlights the impact of CO₂ prices on generation, with clean plants turning up and dirty plants turning down at various emission rates.]
CO₂ Prices on CO₂ Emissions (peak)

Why?
Transmission Constraints!

Can’t Get Rid of Worst Offender
CO₂ Prices on NOₓ Emissions (peak)

Can Cause Dirtiest NOₓ-Emitters to Increase

Generation (MW)

NOₓ Emissions Rate (lb/MWh)

$0/ton CO₂
$10/ton CO₂
$25/ton CO₂
$50/ton CO₂
Ongoing Work

• Analysis of intermittent renewable generation (wind/solar)
• Integration with air quality and water models
• Analysis of alternative emissions market designs
• Addition of capacity planning component for future projections
Tasks and Management

- **Task 1.** Create integrated economic, engineering and resource sciences models of infrastructures, markets, and natural cycles
- **Task 2.** Use the integrated model to test the resiliency and sustainability of target infrastructures
- **Task 3.** Develop and test the value of modifications to the interdependent systems
- **Task 4.** Test resiliency of strategies using probabilistic risk analysis methods applied to the integrated system model
EFRI RESIN
The Interface of Infrastructures, Markets, and Natural Cycles:
Innovative Modeling and Control Mechanisms for Managing Electricity,
Water and Air Quality in Texas

David Allen, Michael Webber and Rob Williams
University of Texas

Ron Prinn and Mort Webster
MIT