Electricity and Natural Gas Linkages: A Forecasting Perspective

Douglas J. Gotham
State Utility Forecasting Group
Purdue University

December 7, 2004
Purdue Energy Research Modeling Groups

PEMRG is a collection of research groups doing large scale systems modeling and analysis of energy policy issues

- Within the School of Industrial Engineering
- Overwhelmingly extramurally funded (approx $900K / year)
- Combination of engagement and discovery missions
- Full time professional staff (6), graduate students (4-6), and affiliated IE faculty

PEMRG:
- State Utility Forecasting Group (SUFG)
- Power Pool Development Group (PPDG)
- Center for Coal Technology Research (CCTR)
State Utility Forecasting Group

- SUFG is oldest (1985) and biggest (2/3 of effort)
- Funding mainly from Indiana commission
- Base mission is providing forecasts of electricity supply/demand (& gas)
- Also engage in research for State and others on policy issues (dereg/mkts, conservation, distributed energy, renewables, …)
SUFG’S Regulated Modeling System

**ENERGY**
- Residential
- Commercial
- Industrial
- Wholesale

**Electric Utility Simulation**

**LMSTM**
- Demand
- Supply
- DSM
- Rates
- Finance

**Supply-Side Resources**
- Statewide Demand
- Statewide Supply Additions
- Utility Supply Additions
Electricity & Natural Gas Interactions

- Electricity and natural gas are substitutes for each other for several end uses
  - The ability to substitute varies by customer sector (residential, commercial, industrial)
  - As the price of one increases, demand for the other increases

- Natural gas is used as a fuel for electricity generation
  - Gas is often the fuel for marginal generators, so it can greatly impact electricity market prices
Residential Sector

• Substitution occurs in space heating, water heating, cooking and clothes drying
• In general, they compete for new loads (new construction); retrofits are rare except under unusual circumstances (early 1980s)
• Technological developments can have a significant impact (microwave ovens)
• A 10 percent increase in natural gas price will lead to a 1 percent increase in residential electricity use
• A 10 percent increase in electricity rates will lead to a 2.4 percent decrease in residential electricity use
Example of Substitution Between Electricity & Natural Gas

- **Net Electric Space Heating Penetration (percent)**
  - net new space heating customers divided by total net new customers

- **Btu-Adjusted Electricity to Natural Gas Price Ratio**
  - accounts for changes in efficiency over time
Commercial Sector

- Substitution occurs in space heating, some water heating and cooking (restaurants)
- Generally compete for new loads
- The most energy intensive establishments (groceries, retail, health care) use a lot of air conditioning, lighting, and refrigeration; therefore, there is less substitution than in other sectors
- A 10 percent increase in natural gas price will lead to a 0.2 percent increase in commercial electricity use
- A 10 percent increase in electricity rates will lead to a 2.5 percent decrease in commercial electricity use
Industrial Sector

• Substitution occurs in space heating, industrial processes
• In addition to competing for new loads, some customers have the ability to switch from one to another
• Natural gas is used as a feedstock instead of a fuel in some industries (fertilizer)
• A 10 percent increase in natural gas price will lead to a 1.4 percent increase in industrial electricity use
• A 10 percent increase in electricity rates will lead to a 4.8 percent decrease in industrial electricity use
Natural Gas as a Fuel for Electricity Generation

- In the 1980s and 1990s, the electricity industry in Indiana could be characterized as having high reserve margins.
- Furthermore, almost all of the capacity was coal-fired baseload.
- Therefore, natural gas prices had a minimal impact on electric rates.
- The last five years have seen a large amount of natural gas-fired capacity (both utility-owned and IPP) and an increase in wholesale purchases.
- Natural gas prices now have a more direct impact on electric rates.
Relationship Between Wholesale Prices

- Examined day ahead and forward (July/August 2005) markets as reported by *Megawatt Daily* from mid-August to mid-November
- Looked at “into Cinergy” and “Mass Hub”
  - relatively high trading volume
  - contrast from different market characteristics
- One bad data point was discarded (previous days numbers were published)
Market Characteristics

Indiana

- According to EIA
  - Indiana has 25,252 MW of generating capacity (13.3% is natural gas-fired)
  - only 3.0% of Indiana’s electrical energy comes from natural gas

New England

- According to EIA
  - New England has 29,991 MW of generating capacity (19.5% is natural gas-fired)
  - but 36.0% of New England’s electrical energy comes from natural gas
Mass Hub

- Scatter plots for next day electricity vs. next day gas (top) and forward electricity vs. next day gas (bottom) are shown.
- Correlation
  - next day electricity vs. next day gas = .950
  - forward electricity vs. next day gas = .876
  - next day electricity vs. forward electricity = .835
• Scatter plots for next day electricity vs. next day gas (top) and forward electricity vs. next day gas (bottom) are shown

• Correlation
  – next day electricity vs. next day gas = .433
  – forward electricity vs. next day gas = .887
  – next day electricity vs. forward electricity = .390
Thank You

- email gotham@purdue.edu

- https://engineering.purdue.edu/IE/Research/PEMRG/