

Purdue  
Energy  
Modeling  
Research  
Groups

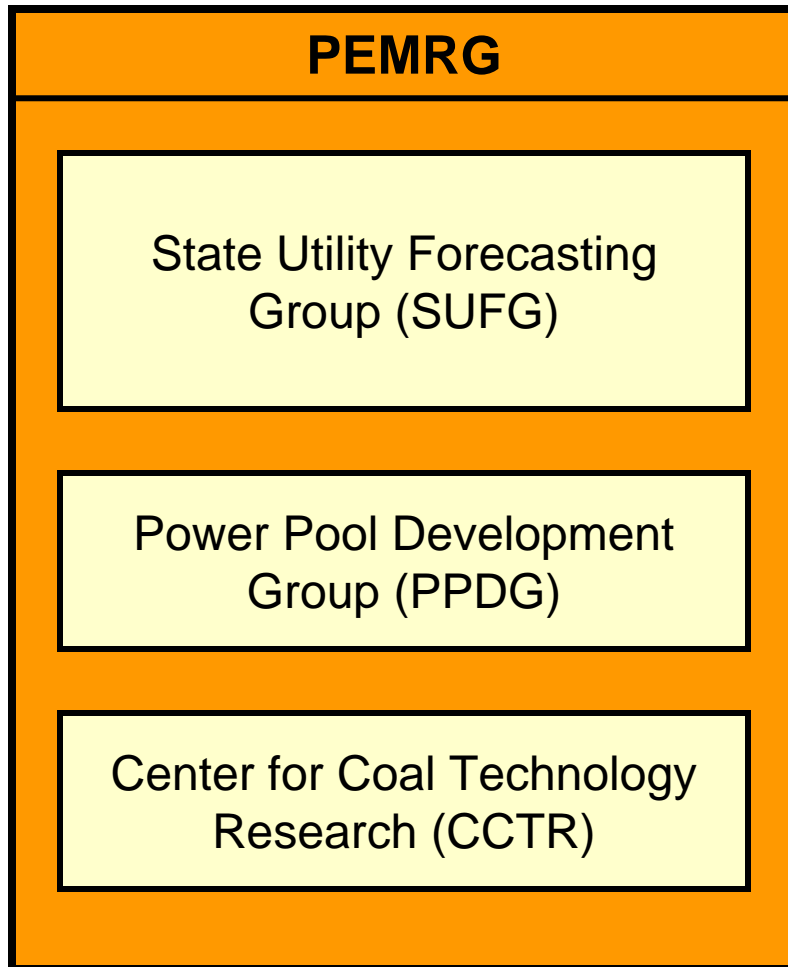
# Electricity and Natural Gas Linkages: A Forecasting Perspective

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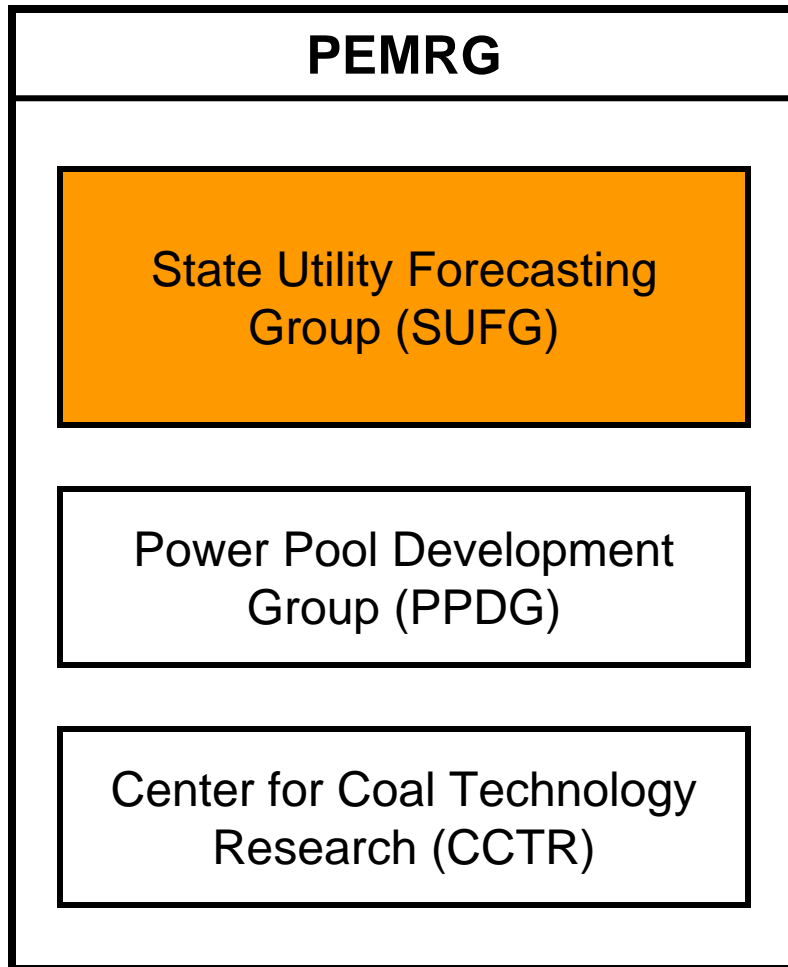
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# Purdue Energy Research Modeling Groups



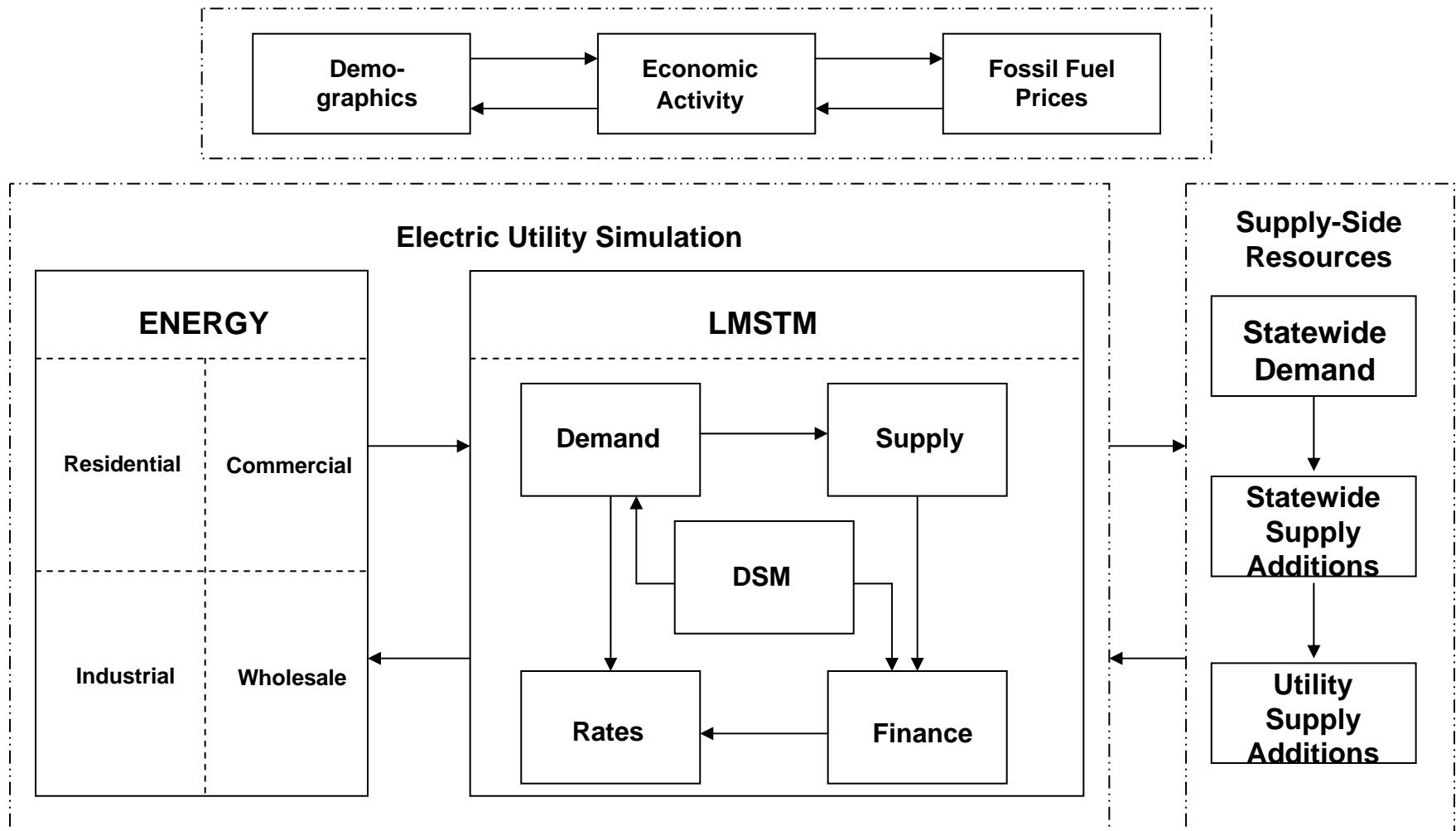
- **PEMRG is a collection of research groups doing large scale systems modeling and analysis of energy policy issues**
- **Within the School of Industrial Engineering**
- **Overwhelmingly extramurally funded (approx \$900K / year)**
- **Combination of engagement and discovery missions**
- **Full time professional staff (6), graduate students (4-6), and affiliated IE faculty**

## 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



## Electricity & Natural Gas Interactions

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- **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**

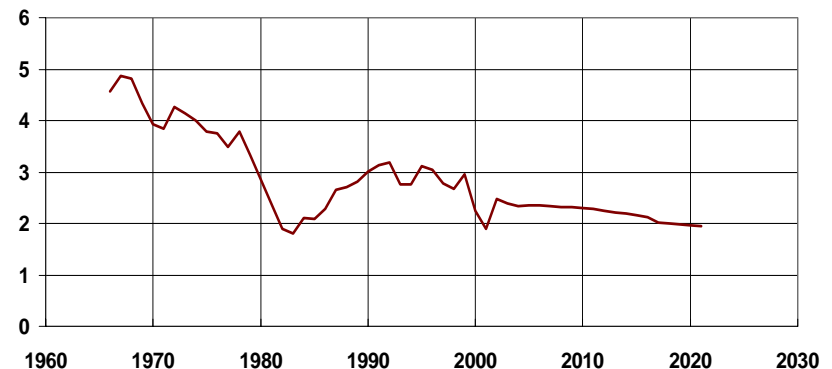
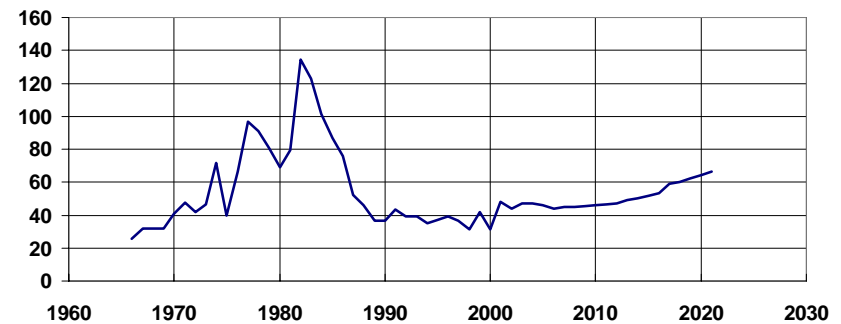
## Residential Sector

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- **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

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- **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

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- **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

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- 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

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- 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

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## Indiana

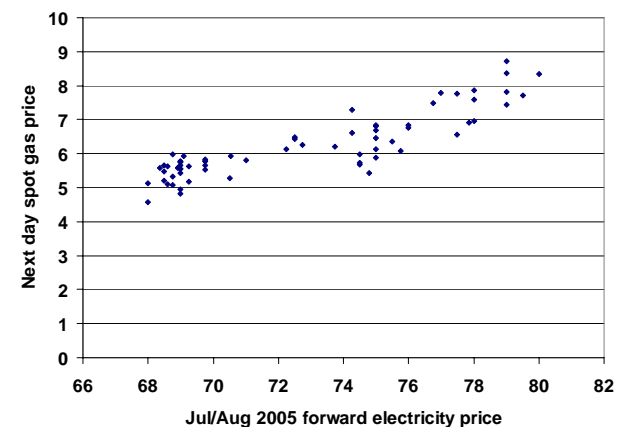
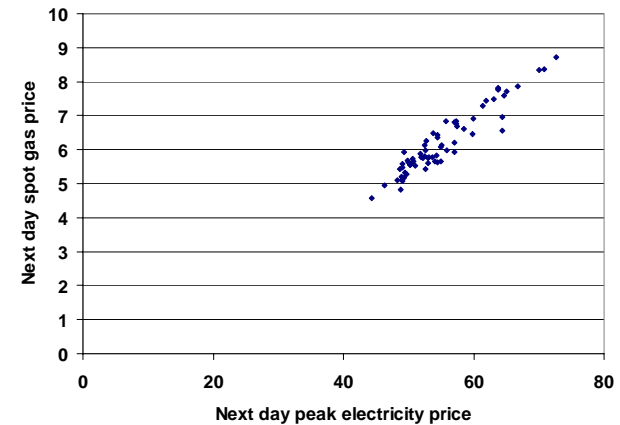
- **According to EIA**
  - **Indiana has 25,252 MW of generating capacity (13.3% is natural gas-fired)**
  - **only 3.0% of Indiana's electrical energy comes from natural gas**

## 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**

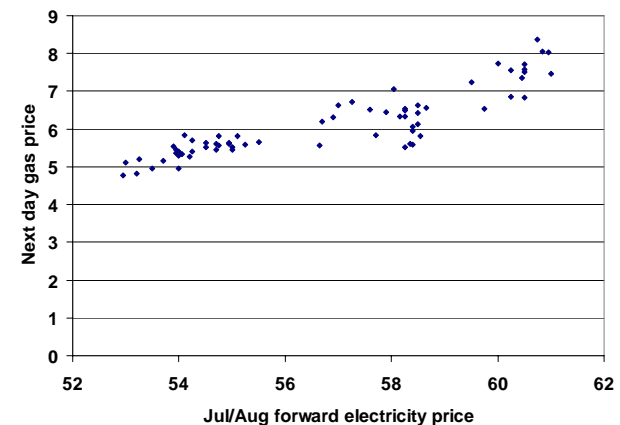
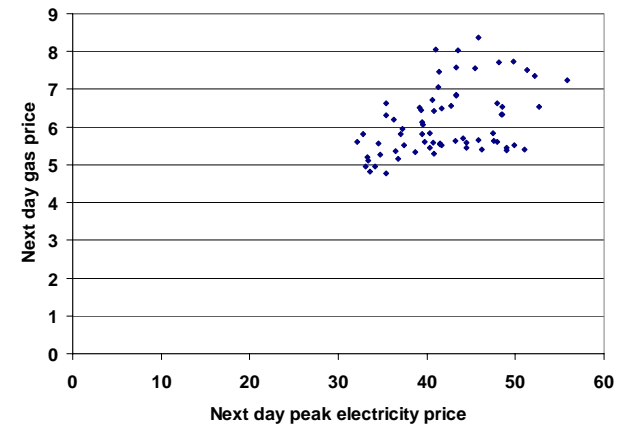
# Mass Hub

- **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



# Into Cinergy

- **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

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