Forecasting and the SUFG

Presented to: Indiana University
School of Public and Environmental Affairs
Electricity Future Capstone Course

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State Utility Forecasting Group

State Utility Forecasting Group

- Executive Order 3-84, which was issued in January 1984 by Indiana's Governor Robert D. Orr, created a special committee designated to address Indiana's utility future. In December 1984, that committee produced a report providing options and specific recommendations.
- The committee recommended four alternatives for forecasting
  - utilities produce their own forecasts independently
  - utilities work together to produce forecasts as a group
  - the Utility Regulatory Commission produces the forecasts
  - another public or quasi-public entity produces the forecasts
- The 4th option was chosen and Purdue was chosen to house the Indiana State Utility Forecasting Group.

Indiana Code 8-1 TO 8-5 (Amended in 1985)

"The commission shall establish a permanent forecasting group to be located at a state-supported college or university within Indiana … This group shall develop and keep current a methodology for forecasting the probable future growth of electricity within Indiana and within this region of the nation."

History of SUFG

- Marble Hill and Bailly – early 1980s
- Public Law 85.5 – 1985
- SUFG forecasts – 1987, 1988, 1990, 1993, 1994, 1996, 1999, 2001, 2003, 2005, 2007
- Regulatory and legislative testimony
- Air emissions studies – 1989, 2000, 2001, 2006, 2008
- Demand-side management – since early 1990s
- Electricity deregulation – 1996-2001
- Annual renewable resources studies – 2003-present
- Natural gas modeling – 2003-present
- Involvement with RTO/FERC issues

Statewide Electricity Projections

- Long-term (20 year) statewide projections
  - Electricity requirements
  - Peak demand
  - Retail prices
  - Resource needs
  - Sectoral (residential, commercial, industrial) detail

Air Emissions Regulations

- 1990 Clean Air Act controls on SO_2 and NO_x emissions expected to cost Indiana electricity utilities 1.0-1.5 billion dollars and lead to rate increases of 10-15 percent to recover cost of compliance.
- Additional restrictions on NO_x emissions that began in 2004 expected to lead to rate increases of 6 to 8 percent.
- Restrictions on SO_2, NO_x, and mercury associated with CAIR/CAMR expected to lead to rate increases of 7 to 15 percent.
- Proposed CO_2 restrictions (Lieberman-Warner) could raise electricity rates by 45 percent by 2025.

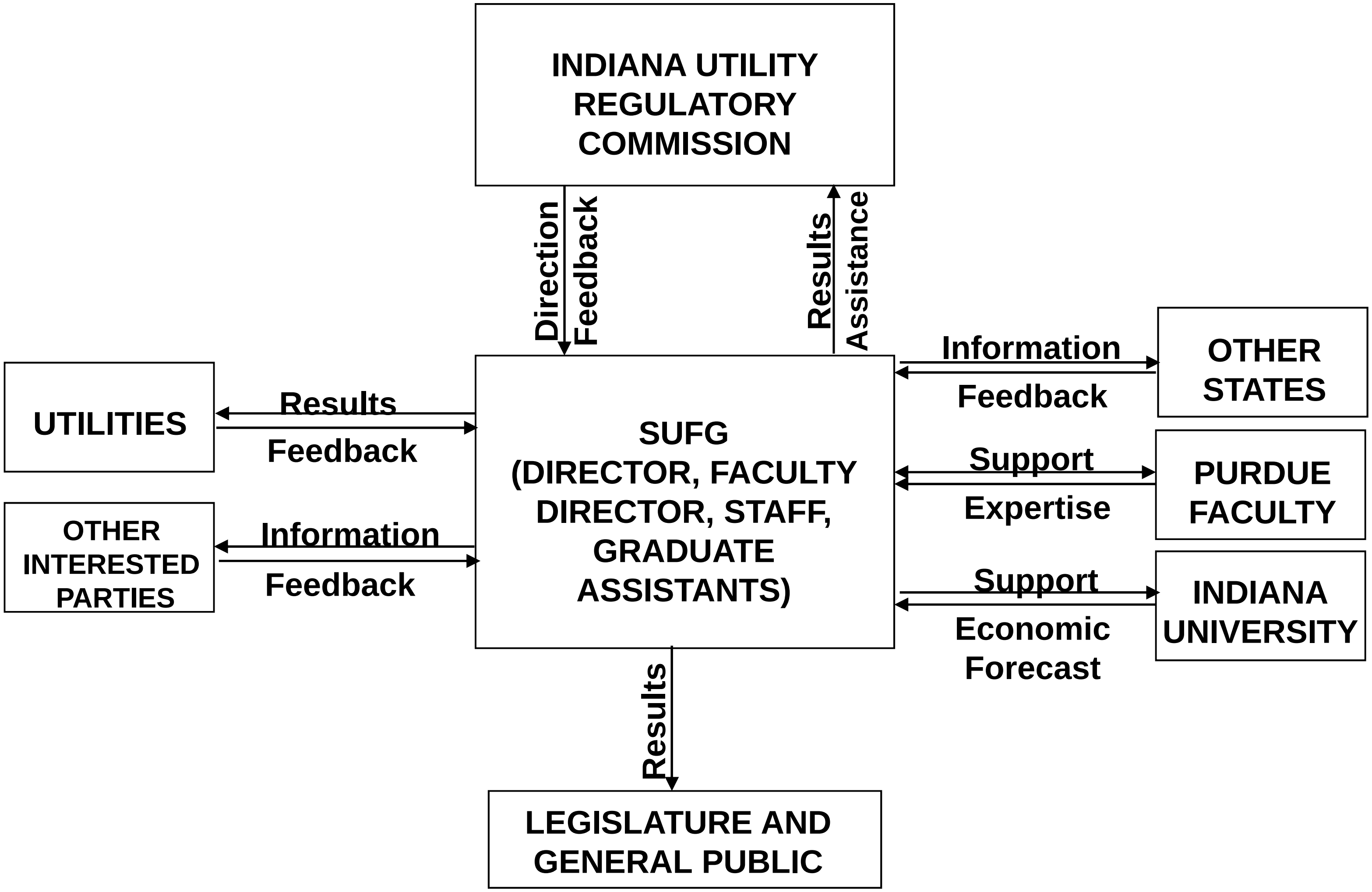
Demand-Side Management

- Cautioned against impact of one class of ratepayers subsidizing another
  - Programs that benefit society should be encouraged with compensation structured such that both participants and non-participants benefit or at least are unharmed.
- Member of utility conservation program oversight board

Other Studies

- Deregulation
  - Deregulation would decrease Indiana electricity prices in the short run, but increase them in the long run because of increased exports to more expensive jurisdictions and because of higher cost of capital with riskier investments. If suppliers could exercise market power, prices would rise further.
- Natural gas
  - Construction of new natural gas-fired electricity generators were not expected to increase overall demand enough to result in an inability of the natural gas system to deliver its product, but could result in increased costs.

Interactions with other Entities



SUFG Structure

- Director, staff, and students at Purdue University
- Under contract with Indiana Utility Regulatory Commission (IURC)
- Subcontract with Indiana University:
  - Economic forecasts
  - Special topic studies
- Access to faculty expertise through Energy Center
- Feedback from utilities and other interested parties

Relationship with IURC

- Cooperative
  - SUFG takes direction from the Commission as to what topics need to be addressed
  - The Commission provides feedback and constructive criticism to SUFG
- Independent
  - While SUFG works under contract with the Commission, it is part of the university
  - SUFG has developed working relationships with the utilities that are separate from the regulator-utility relationship
  - SUFG is responsible for the quality of its models and reports

Relationship with Utilities and Other Interested Parties

- Cooperative
  - SUFG operates under a “no surprises” policy
  - Access to sensitive data
  - Constructive feedback

- Independent
  - SUFG has no financial connection to any of the parties
  - Independence is crucial to SUFG’s credibility

Education

- Workshops, short courses, and tutorials
  - For IURC
    - SUFG's models
    - Electric power systems
    - Risk management
  - Regional interest
    - Market power workshop
- Presentations to the legislature and general public
- Graduate student support

Graduate Research Assistants

- In its history, SUFG has supported a number of graduate students
  - 20 Ph.D. dissertations
  - 18 M.S. theses
- Typically, between 3 and 6 GRAs at any given time

Recent Publications

- *2008 Indiana Renewable Energy Resources Study* September 2008
- *The Projected Impacts of Carbon Dioxide Emissions Reduction Legislation on Electricity Prices in Indiana* February 2008 (with Purdue Climate Change Research Center)
- *Indiana Electricity Projections: The 2007 Forecast* December 2007
- *2007 Indiana Renewable Energy Resources Study* September 2007
- *Clean Coal Technologies* July 2007
- *Energy Trends Report* July 2007

Forecasting

Using the Past to Predict the Future

- What is the next number in the following sequences?

  0, 2, 4, 6, 8, 10, 12, 14 ….

  0, 1, 4, 9, 16, 25, 36, 49, ...

  0, 1, 3, 6, 10, 15, 21, 28, ...

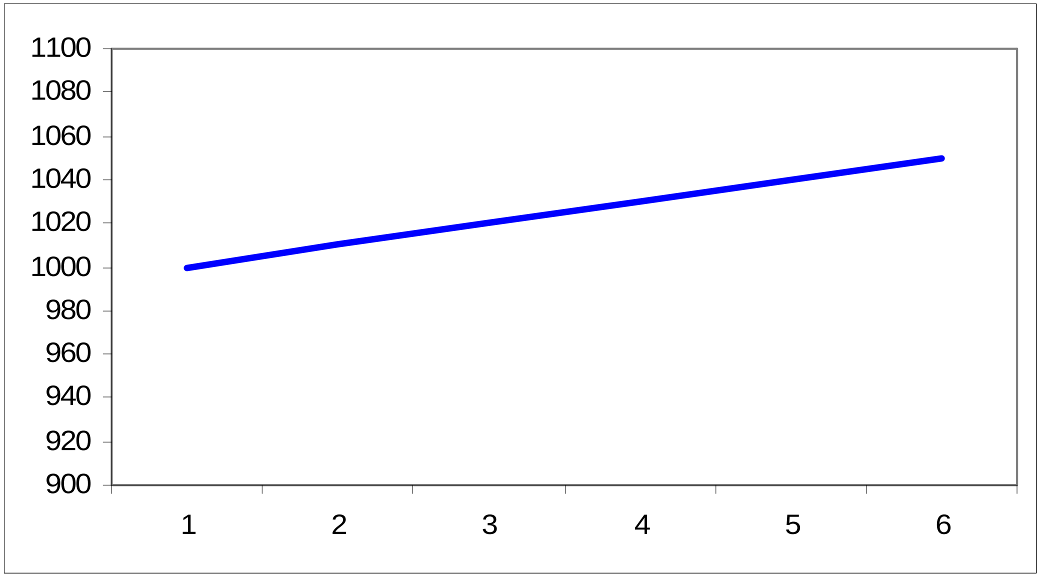
  0, 1, 2, 3, 5, 7, 11, 13, ...

  0, 1, 1, 2, 3, 5, 8, 13, ...

  8, 5, 4, 9, 1, 7, 6, ….

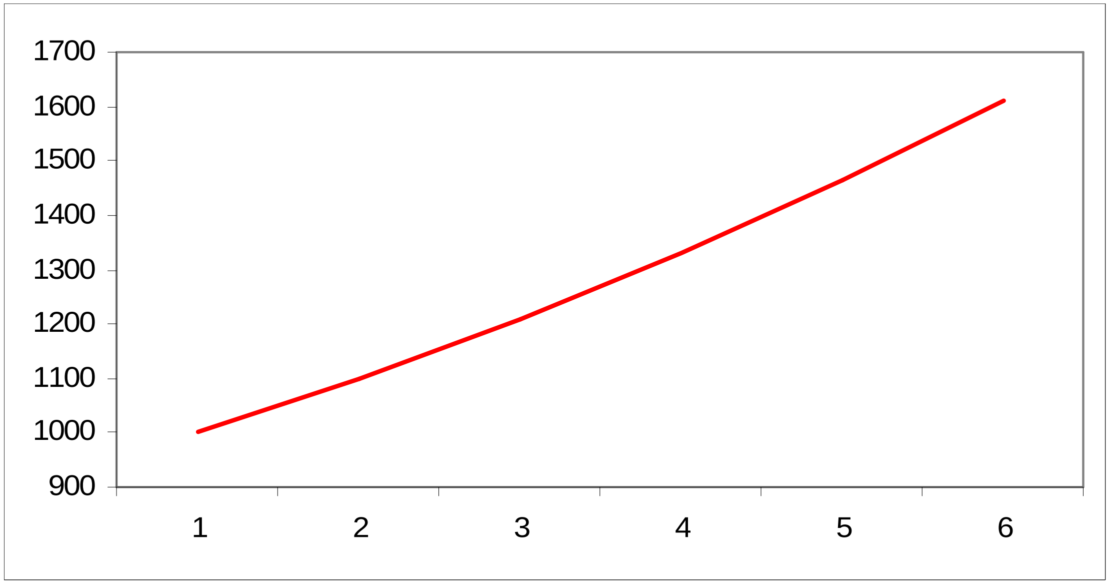
A Simple Example

1000
1010
1020
1030
1040
1050
?
?
?



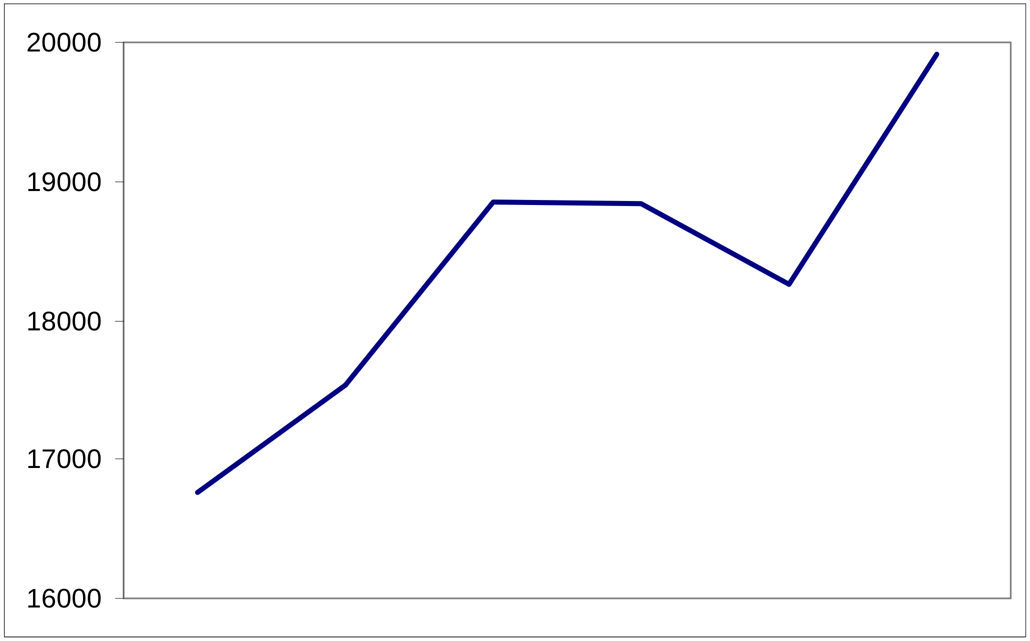
A Little More Difficult

1000
1100
1210
1331
1464
1610
?
?
?



Much More Difficult

16757
17531
18851
18843
18254
19920
?
?
?

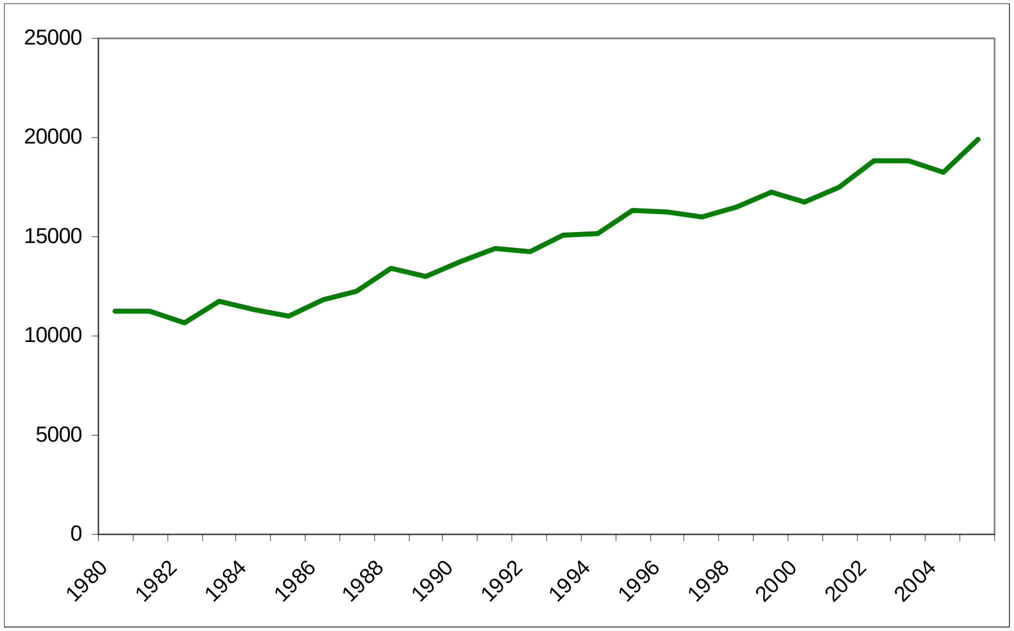


Much More Difficult

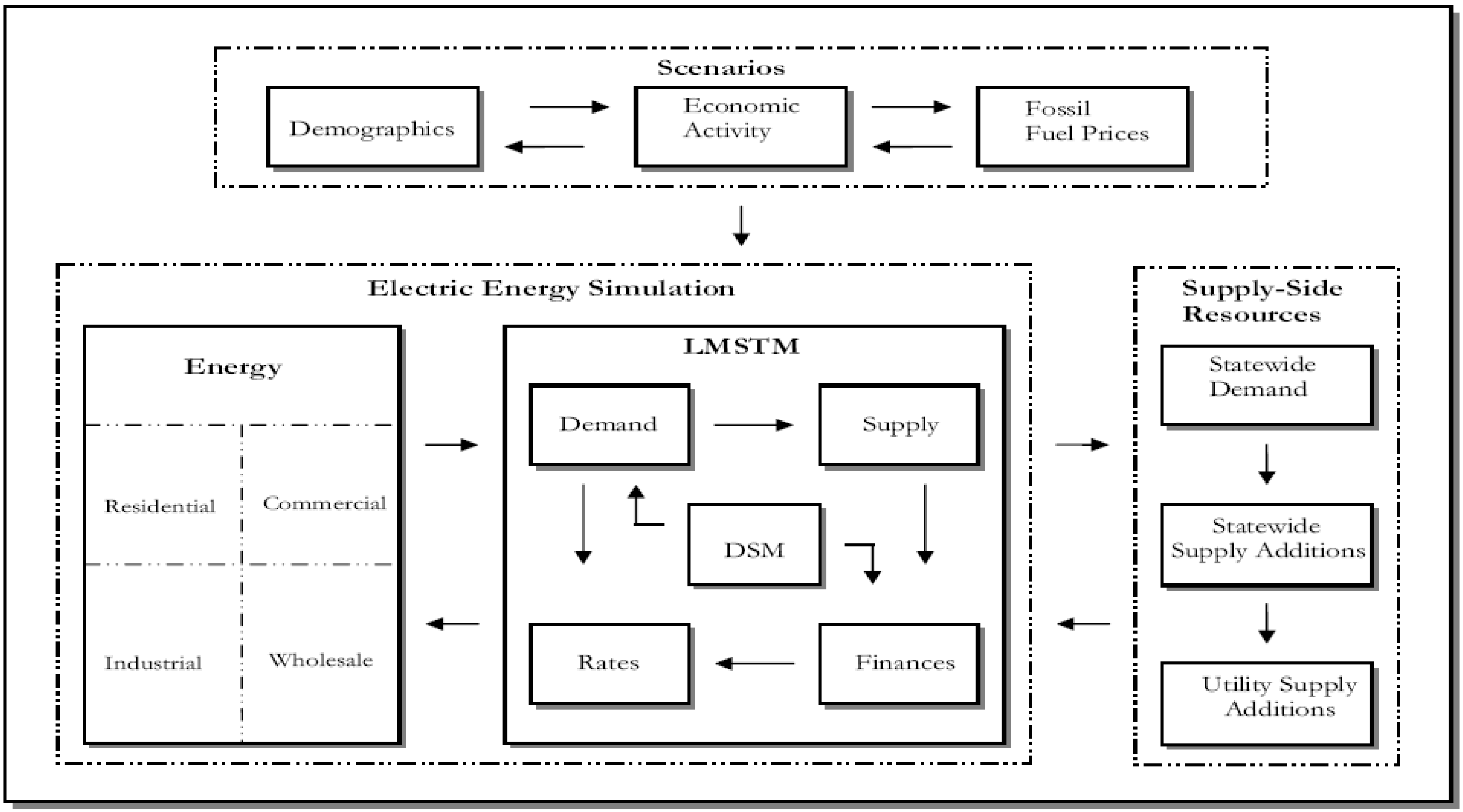
- The numbers on the previous slide were the summer peak demands for Indiana from 2000 to 2005.
- They are affected by a number of factors
  - Weather
  - Economic activity
  - Price
  - Interruptible customers called upon
  - Price of competing fuels

Question

- How do we find a pattern in these peak demand numbers to predict the future?



The Short Answer



Methods of Forecasting

- Palm reading
- Tea leaves
- Tarot cards
- Ouija board
- Crystal ball
- Astrology
- Dart board
- Hire a consultant
- Wishful thinking

Alternative Methods of Forecasting

- Time Series
  - trend analysis
- Econometric
  - structural analysis
- End Use
  - engineering analysis

Time Series Forecasting

- Linear Trend
  - fit the best straight line to the historical data and assume that the future will follow that line (works perfectly in the 1st example)
  - many methods exist for finding the best fitting line, the most common is the ordinary least squares method
    - Ordinary least squares: find the line that minimizes the sum of the squares of the differences between the historical observations and the line

Time Series Forecasting

- Polynomial Trend
  - Fit the polynomial curve to the historical data and assume that the future will follow that line
  - Can be done to any order of polynomial (square, cube, etc.) but higher orders are usually needlessly complex
- Logarithmic Trend
  - Fit an exponential curve to the historical data and assume that the future will follow that line (works perfectly for the 2^{nd} example)

Good News and Bad News

- The statistical functions in most commercial spreadsheet software packages will calculate many of these for you.
- These may not work well when there is a lot of variability in the historical data.
- If the time series curve does not perfectly fit the historical data, there is model error.
  - There is normally model error when trying to forecast a complex system.

Methods Used to Account for Variability

- Modeling seasonality/cyclicality
- Smoothing techniques
  - Moving averages
  - Weighted moving averages
  - Exponentially weighted moving averages
- Filtering techniques
- Box-Jenkins

Econometric Forecasting

- Econometric models attempt to quantify the relationship between the parameter of interest (output variable) and a number of factors that affect the output variable.
- Example
  - Output variable
  - Explanatory variable
    - Economic activity
    - Weather (HDD/CDD)
    - Electricity price
    - Natural gas price
    - Fuel oil price

Estimating Relationships

- Each explanatory variable affects the output variable in different ways. The relationships can be calculated via any of the methods used in time series forecasting
  - Can be linear, polynomial, logarithmic…
- Relationships are determined simultaneously to find overall best fit
- Relationships are commonly known as sensitivities
- A number of techniques have been developed to find a good fit (ordinary least squares, generalized least squares, etc.)

Example Sensitivities for State of Mississippi

A 10 percent increase in:	Results in this increase in electricity sales
Electricity price	-3.0 percent
Cooling degree days	+0.7 percent
Real personal income	+7.8 percent

End Use Forecasting

- End use forecasting looks at individual devices, aka end uses (e.g., refrigerators)
- How many refrigerators are out there?
- How much electricity does a refrigerator use?
- How will the number of refrigerators change in the future?
- How will the amount of use per refrigerator change in the future?
- Repeat for other end uses

The Good News

- Account for changes in efficiency levels (new refrigerators tend to be more efficient than older ones) both for new uses and for replacement of old equipment
- Allow for impact of competing fuels (natural gas vs. electricity for heating) or for competing technologies (electric resistance heating vs. heat pump)
- Incorporate and evaluate the impact of demand-side management/conservation programs

The Bad News

- Tremendously data intensive
- Primarily limited to forecasting energy usage, unlike other forecasting methods
  - Most long-term planning electricity forecasting models forecast energy and then derive peak demand from the energy forecast

Example

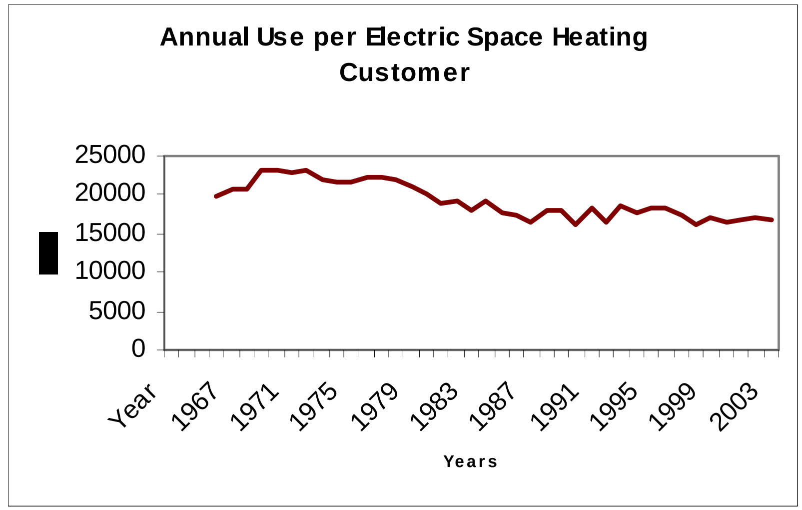
- State Utility Forecasting Group (SUFG) has electrical energy models for each of 8 utilities in Indiana
- Utility energy forecasts are built up from sectoral forecasting models
  - residential (econometric)
  - commercial (end use)
  - industrial (econometric)

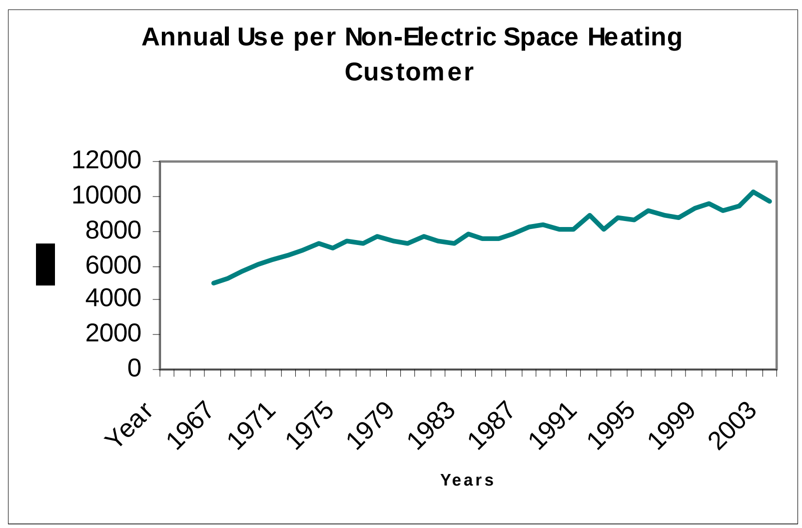
Another Example

- The Energy Information Administration's National Energy Modeling System (NEMS) projects energy and fuel prices for 9 census regions
- Energy demand
  – residential
  – commercial
  – industrial
  – transportation

SUFG Residential Sector Model

- Residential sector split according to space heating source
  - electric
  - non-electric





SUFG Residential Sector Model

- Major forecast drivers
  - demographics
  - households
  - household income
  - energy prices

Residential Model Sensitivities

10 Percent Increase In	Causes This Percent Change in Electric Use
Number of Customers	11.1
Electric Rates	-2.4
Natural Gas Price	1.0
Distillate Oil Prices	0.0
Appliance Price	-1.8
Household Income	2.0

Source: SUFG 2007 Forecast

NEMS Residential Module

- Sixteen end-use services
  - i.e., space heating
- Three housing types
  - single family, multi-family, mobile home
- 34 end-use technologies
  - i.e., electric air-source heat pump
- Nine census divisions

SUFG Commercial Sector Model

- 10 building types modeled
  - offices, restaurants, retail, groceries, warehouses, schools, colleges, health care, hotel/motel, miscellaneous
- 14 end uses per building type
  - space heating, air conditioning, ventilation, water heating, cooking, refrigeration, lighting, mainframe computers, mini-computers, personal computers, office equipment, outdoor lighting, elevators and escalators, other

SUFG Commercial Model

- For each end use/building type combination there is an initial stock of equipment
- Initial stock is separated by age (vintage) and efficiency
- Additional stock for next year is determined by economic drivers
- Some existing stock will be replaced due to failure or early replacement
- Older vintages are more likely to be replaced

Major Commercial Drivers

- Floor space inventory
- End use intensity
- Employment growth
- Population (schools and colleges)
- Energy prices

Commercial Model Sensitivities

10 Percent Increase In	Causes This Percent Change in Electric Use
Electric Rates	-2.5
Natural Gas Price	0.2
Distillate Oil Prices	0.0
Coal Prices	0.0
Electric Energy-weighted Floor Space	12.0

Source: SUFG 2007 Forecast

NEMS Commercial Module

- Ten end-use services
  - i.e., cooking
- Eleven building types
  - i.e., food service
- 64 end-use technologies
  - i.e., natural gas range
- Ten distributed generation technologies
  - i.e., photovoltaic solar systems
- Nine census divisions

SUFG Industrial Sector Model

- Major forecast drivers
  - industrial activity
  - energy prices
- 15 industries modeled
  - classified by Standard Industrial Classification (SIC) system
  - some industries are very energy intensive while others are not

Indiana's Industrial Sector

SIC	Name	Current Share of GSP	Current Share of Electricity Use	Forecast Growth in GSP Originating by Sector	Forecast Growth in Electricity by Intensity by Sector	Forecast Growth in Electricity Use by Sector
20	Food & Kindred Products	3.51	5.61	0.96	-0.79	0.17
24	Lumber & Wood Products	1.95	0.70	0.96	-0.42	0.54
25	Furniture & Fixtures	1.60	0.46	0.62	-0.64	-0.02
26	Paper & Allied Products	1.36	2.96	0.96	-0.56	0.40
27	Printing & Publishing	2.55	1.30	0.96	-0.96	0.00
28	Chemicals & Allied Products	14.25	17.10	3.49	-0.80	2.70
30	Rubber & Misc. Plastic Products	4.77	6.25	4.52	-0.67	3.85
32	Stone, Clay, & Glass Products	1.76	5.30	0.96	-0.67	0.29
33	Primary Metal Products	8.55	31.34	1.02	1.76	2.77
34	Fabricated Metal Products	6.25	5.29	2.51	-0.76	1.75
35	Industrial Machinery & Equipment	6.73	4.44	1.05	-0.68	0.37
36	Electronic & Electric Equipment	16.19	5.54	5.33	-0.56	4.77
37	Transportation Equipment	22.89	9.38	3.87	-0.68	3.19
38	Instruments And Related Products	4.98	0.77	5.33	-0.86	4.47
39	Miscellaneous Manufacturing	1.63	1.06	4.19	-5.24	-1.05
Total	Manufacturing	100.00	100.00	3.48	-0.81	2.67

Source: SUFG 2007 Forecast

Industrial Model Sensitivities

10 Percent Increase In	Causes This Percent Change in Electric Use
Real Manufacturing Product	10.0
Electric Rates	-4.8
Natural Gas Price	1.4
Oil Prices	0.9
Coal Prices	0.2

Source: SUFG 2007 Forecast

NEMS Industrial Module

- Seven energy-intensive industries
  - i.e., bulk chemicals
- Eight non-energy-intensive industries
  - i.e., construction
- Cogeneration
- Four census regions, shared to nine census divisions