SUFG Indiana Forecasting Modeling System

IURC State Impacts Assessment Stakeholder Meeting
August 22, 2019
Modeling System Components

- Forecasting models
- Production costing and resource expansion model
- Finance and rates models
Cost-Price-Demand Feedback Loop
Forecasting Models

• 3 sector-specific models for each of the 5 investor-owned utilities
• A single econometric model for each of the 3 major not-for-profit utilities
Residential Sector Models
IOU Residential Models

• For each IOU, we use an end-use model, REDMS, that was developed for us by Jerry Jackson & Associates

• 3 building types
  – single family, multiple family, mobile

• 3 fuel types
  – electricity, natural gas, fuel oil

• 10 end use per building type
  – water heat, refrigeration, etc.
SUFG Residential End-use Model

• For each end use/building type combination there is an initial stock of equipment (provided by model developer)
• 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
Structure of Residential End-Use Energy Modeling System

 Fundamental Energy Equation

Q_t = U * EUI * P * FSA * d

- Q_t: Energy
- U: Utilization
- EUI: Energy Use Intensity (kWh/Dwelling)
- P: Penetration
- FSA: Floor Space Additions
- d: Fraction Remaining

Efficiency and Fuel Choice Models

Actual Technology Choices

Distribution of Decision Makers:
- Required Payback
- Hours Use
- Price Expectations

Sample Decision-Maker Payback

<table>
<thead>
<tr>
<th>Years</th>
<th>Percent</th>
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</thead>
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<tr>
<td>0</td>
<td>10</td>
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<tr>
<td>1</td>
<td>10</td>
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<tr>
<td>2</td>
<td>30</td>
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<td>3</td>
<td>10</td>
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<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
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</table>
Major Drivers & Sources

• Demographic projections – Indiana Business Research Center (IBRC) at IU
• Real personal income projections – Center for Econometric Model Research (CEMR) at IU
• Electricity price projections – SUFG models
• Natural gas price projections – EIA Annual Energy Outlook
Commercial Sector Models
IOU Commercial Models

• For each IOU, we use an end-use model, CEDMS, that was developed for us by Jerry Jackson & Associates
• 21 building types modeled
  – office, grocery, etc.
• 3 fuel types
  – electricity, natural gas, fuel oil
• 10 end uses per building type
  – space heat, cooking, etc.
SUFG Commercial End-use Model

• Structure is similar to the residential end-use model, except it is modeled based on the amount of floor space to account for size differences among commercial buildings
Structure of Commercial End-Use Energy Modeling System

- **Business Types:**
  - Office
  - Retail
  - Retail mail
  - Grocery
  - Refriger warehouse
  - Dry warehouse
  - Assembly
  - Educational
  - Restaurant
  - Hospital
  - Nursing home
  - Hotel
  - Religious
  - College office
  - College dorm
  - College other
  - Federal gov office
  - Federal gov other
  - State local gov office
  - State local gov other
  - Miscellaneous

- **End Uses:**
  - Space heating
  - Water heating
  - Air conditioning
  - Ventilation
  - Refrigeration
  - Cooking
  - Interior lighting
  - Exterior lighting
  - Equipment
  - Other

- **Fundamental Energy Equation**

\[ Q_t = U \times EUI \times P \times FSA \times d \]

- **Efficiency and Fuel Choice Models**

- **Utilization Models**

- **Vintaging Flowspace Model**

- **Sample Decision-Maker Payback**

- **Actual Technology Choices**

- **Distribution of Individuals:**
  - Required Payback
  - Hours Use
  - Price Expectations

- **Microsimulation**
Major Drivers & Sources

• Non-manufacturing employment – CEMR
• Demographics – IBRC
  – schools, religious, assembly
• Electricity price projections – SUFG models
• Natural gas price projections – EIA
Industrial Sector Models
IOU Industrial Models

• For each IOU, we use an econometric model, INDEED, that was developed by EPRI

• 15 industry types modeled
  – chemicals, primary metals, etc.

• Given a projection of the output of each industry type, the model examines the tradeoff of different potential inputs to find the least cost option
Structure of Industrial Energy Modeling System

\[ Q_t = f(K, L, E, M) \]

Industry Output = f(Capital, Labor, Energy, Materials)

Inputs

Quantities

Prices

INDUSTRIES

K L E M

Energy sources

Electricity
Natural Gas
Petroleum
Coal

Minimizing cost of producing output

Electricity Purchases
## Indiana’s Industrial Sector

<table>
<thead>
<tr>
<th>SIC</th>
<th>Name</th>
<th>Current Share of GSP</th>
<th>Current Share of Electricity Sales</th>
<th>Current Intensity</th>
<th>Forecast Growth in GSP Originating by Sector</th>
<th>Forecast Growth in Electricity Intensity by Sector</th>
<th>Forecast Growth in Electricity Sales by Sector</th>
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</thead>
<tbody>
<tr>
<td>20</td>
<td>Food &amp; Kindred Products</td>
<td>4.39</td>
<td>6.59</td>
<td>0.53</td>
<td>3.16</td>
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<td>24</td>
<td>Lumber &amp; Wood Products</td>
<td>2.44</td>
<td>0.79</td>
<td>0.11</td>
<td>3.16</td>
<td>-1.11</td>
<td>2.05</td>
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<td>25</td>
<td>Furniture &amp; Fixtures</td>
<td>2.16</td>
<td>0.48</td>
<td>0.08</td>
<td>0.96</td>
<td>-0.67</td>
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<tr>
<td>26</td>
<td>Paper &amp; Allied Products</td>
<td>1.70</td>
<td>2.56</td>
<td>0.54</td>
<td>3.16</td>
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<tr>
<td>27</td>
<td>Printing &amp; Publishing</td>
<td>3.20</td>
<td>1.18</td>
<td>0.13</td>
<td>3.16</td>
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<td>28</td>
<td>Chemicals &amp; Allied Products</td>
<td>15.25</td>
<td>20.39</td>
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<td>3.16</td>
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<td>30</td>
<td>Rubber &amp; Misc. Plastic Products</td>
<td>3.15</td>
<td>6.13</td>
<td>0.69</td>
<td>2.20</td>
<td>-0.72</td>
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<tr>
<td>32</td>
<td>Stone, Clay, &amp; Glass Products</td>
<td>2.19</td>
<td>5.43</td>
<td>0.88</td>
<td>0.96</td>
<td>-0.51</td>
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<td>33</td>
<td>Primary Metal Products</td>
<td>8.58</td>
<td>29.37</td>
<td>1.21</td>
<td>-1.23</td>
<td>3.31</td>
<td>2.07</td>
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<td>34</td>
<td>Fabricated Metal Products</td>
<td>5.23</td>
<td>6.28</td>
<td>0.43</td>
<td>2.07</td>
<td>-0.74</td>
<td>1.33</td>
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<tr>
<td>35</td>
<td>Industrial Machinery &amp; Equipment</td>
<td>7.44</td>
<td>4.63</td>
<td>0.22</td>
<td>1.70</td>
<td>-0.28</td>
<td>1.42</td>
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<tr>
<td>36</td>
<td>Electronic &amp; Electric Equipment</td>
<td>3.93</td>
<td>2.14</td>
<td>0.19</td>
<td>0.51</td>
<td>-0.42</td>
<td>0.09</td>
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<tr>
<td>37</td>
<td>Transportation Equipment</td>
<td>30.76</td>
<td>6.08</td>
<td>0.07</td>
<td>2.95</td>
<td>1.07</td>
<td>4.02</td>
</tr>
<tr>
<td>38</td>
<td>Instruments And Related Products</td>
<td>2.94</td>
<td>1.13</td>
<td>0.14</td>
<td>0.96</td>
<td>-1.56</td>
<td>-0.60</td>
</tr>
<tr>
<td>39</td>
<td>Miscellaneous Manufacturing</td>
<td>1.59</td>
<td>1.23</td>
<td>0.27</td>
<td>0.96</td>
<td>-2.15</td>
<td>-1.20</td>
</tr>
<tr>
<td></td>
<td><strong>Total Manufacturing</strong></td>
<td><strong>100.00</strong></td>
<td><strong>100.00</strong></td>
<td><strong>0.35</strong></td>
<td><strong>2.40</strong></td>
<td><strong>-0.34</strong></td>
<td><strong>2.05</strong></td>
</tr>
</tbody>
</table>

Source: SUFG 2017 Forecast
Major Drivers & Sources

• Manufacturing employment – CEMR
• Manufacturing gross state product by industry type – CEMR
• Electricity price projections – SUFG models
• Natural gas, petroleum, and coal price projections – EIA
NFP Econometric Models

• SUFG constructed unique econometric models for each of the 3 major NFP utilities

• Drivers & sources
  – Population – IBRC
  – Electricity price – SUFG models
  – Weather – held at long-term norms
Low and High Growth Forecasts

• CEMR provides alternate low and high economic growth projections
  – SUFG uses these to produce alternate low and high load growth scenarios

• CEMR builds its state projections from its national projections using a model to project Indiana’s share of the national economy
  – low and high projections are developed by adjusting the share model, not the national projection
Production Costing and Resource Expansion
Modeling Considerations

• SUFG does not do a statewide IRP

• The primary purpose of the supply-side modeling is to estimate the costs associated with future supply and demand resources, so that we can develop projections of rates for the forecasting models
Aurora

• Beginning with the 2017 forecast, SUFG has used the Aurora model to perform production costing and resource expansion

• Previously, SUFG used LMSTM for production costing and resource expansion was done in house (not optimized)
Aurora

- Minimizes total production cost for the system, subject to defined constraints
- Can be done on a chronological hourly basis or more/less temporal detail
- Future supply is least cost subject to system-wide and utility-specific planning reserve requirements
  - uses iterative MIP approach
Additional Options

- Can use other constraints
  - emission/fuel/pipeline limits, RPS
- Has the capability to model energy storage
- Can model DSM/DR as selectable resources
- Stochastic/risk and portfolio analysis
- Can determine economic retirements
EE/DR Modeling

- EE is modeled at a given cost and energy/peak savings rather than as an option to be selected
  - Mostly based on IRP and EE plan filings
  - We lack the information needed to model as a selectable resource (program level potential and cost)
- DR is modeled as an existing asset that is available for dispatch
Transmission Modeling

• While Aurora has the functionality to model transmission flows and limitations, we use a simpler representation

• All utilities are interconnected by lines that have a small cost hurdle and no flow limits
  – economic trade is allowed among utilities
  – we do not model the MISO and PJM markets
Battery Modeling

• While the latest version of Aurora has improved modeling of battery storage, we have not yet tried to incorporate that functionality
Unit Retirements

• We lack unit-specific information regarding future capital costs that may affect economic retirement decisions, so we do not make our own retirement decisions

• Unit retirements are taken from the most recent IRP filings, potentially supplemented with data obtained through our utility data requests
Important Factors

• While there are numerous inputs to Aurora, I will try to identify some of the key factors to be considered when developing scenarios/sensitivities, along with the sources that we are currently using
  – If a scenario indicates that other values are to be used, we would need those values (or a source) to be provided
<table>
<thead>
<tr>
<th>Key Factors</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy &amp; peak demand projections</td>
<td>SUFG forecasting models</td>
</tr>
<tr>
<td>Fuel cost projections</td>
<td>EIA Annual Energy Outlook</td>
</tr>
<tr>
<td>Current purchase and sales agreements</td>
<td>Utility data requests</td>
</tr>
<tr>
<td>Future EE/DR projections</td>
<td>IRPs, DSM plans, utility data requests</td>
</tr>
<tr>
<td>Existing unit retirements</td>
<td>IRPs, utility data requests</td>
</tr>
<tr>
<td>Existing unit characteristics (heat rate, O&amp;M costs,</td>
<td>Utility data requests</td>
</tr>
<tr>
<td>forced outage rate, maintenance outage requirements)</td>
<td></td>
</tr>
<tr>
<td>New unit characteristics (above list plus capital</td>
<td>EIA with future cost declines based on NREL</td>
</tr>
<tr>
<td>cost)</td>
<td></td>
</tr>
<tr>
<td>Planning reserve margins</td>
<td>Based on current MISO and PJM requirements, adjusted for peak load</td>
</tr>
</tbody>
</table>
Finance and Rates Modeling
SUFG Rates Models

• When we switched to Aurora, we lost LMSTM’s functionality to project retail rates within the utility simulation

• We adapted the ORFIN model (developed at ORNL for DSM analysis) to produce our own utility finance and rates models
Rates Models

• Spreadsheet models that determine future revenue requirements, which are then used to project future electricity rates

• Revenue requirements are determined by functional category (production, transmission, distribution and general/integrated plants)
Rates Models

• Revenue requirements for each functional category are allocated to different customer sectors (residential, commercial, industrial, and other)
• Rates by customer class are determined from revenue requirements and sales (from the forecasting models)
NFP Rates

- NFP rates are modeled as a single wholesale rate to the utility’s members, rather than at the retail level
<table>
<thead>
<tr>
<th>Key Factors</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing financial information (debt, deferred</td>
<td>FERC Form 1, annual reports, utility data requests</td>
</tr>
<tr>
<td>taxes, rate base)</td>
<td></td>
</tr>
<tr>
<td>Future capital expenditures</td>
<td>Aurora (for future resources), utility data requests (for existing</td>
</tr>
<tr>
<td></td>
<td>production resources and for non-production plant)</td>
</tr>
<tr>
<td>Fuel &amp; production O&amp;M costs</td>
<td>Aurora</td>
</tr>
<tr>
<td>Non-production O&amp;M costs</td>
<td>Utility data requests</td>
</tr>
<tr>
<td>Purchases/sales (both contractual and opportunity)</td>
<td>Aurora</td>
</tr>
<tr>
<td>Sales</td>
<td>SUFG forecasting models</td>
</tr>
<tr>
<td>Return on equity, debt-to-equity ratio</td>
<td>SUFG assumption based on typical values</td>
</tr>
<tr>
<td>Depreciation</td>
<td>Fixed percentage by functional category based on typical values</td>
</tr>
</tbody>
</table>
Work with LBNL

• We include costs associated with the transmission and distribution systems, but we do not model the systems themselves.

• We will work with LBNL to identify the impact of scenarios/sensitivities on capital and operating costs for T&D – this will provide a more accurate assessment of the impacts.
Further Information

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