Impacts of CO2 Restrictions on Indiana Electricity Prices

presented by:
Douglas J. Gotham
State Utility Forecasting Group

presented to:
Indiana Utility Regulatory Commission
April 9, 2008
Outline

• Background
• Summary of proposed legislation
• Methodology
• Compliance strategy
• Results
• National studies
• Caveats
Background

- Analysis based on proposed Lieberman-Warner Climate Security Act
- Focuses on price impacts of CO2 limitations on Indiana’s electric utility industry
  - does not address benefits
- Uses the traditional regulation forecasting model developed by the State Utility Forecasting Group (SUFG)
- Collaboration with the Purdue Climate Change Research Center
Lieberman-Warner Act

- “Cap and trade” reduction of six greenhouse gases
  - we focus on CO2
- Declining cap from 2012 to 2050
- Emissions allowances can be traded, banked, or borrowed from the future
- An increasing percentage of allowances are auctioned over time
- Offsets can be purchased from non-covered sources
# National Emissions Cap

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Emission Allowances (in millions)</th>
<th>Calendar Year</th>
<th>Emission Allowances (in millions)</th>
<th>Calendar Year</th>
<th>Emission Allowances (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>5,200</td>
<td>2025</td>
<td>3,952</td>
<td>2038</td>
<td>2,704</td>
</tr>
<tr>
<td>2013</td>
<td>5,104</td>
<td>2026</td>
<td>3,856</td>
<td>2039</td>
<td>2,608</td>
</tr>
<tr>
<td>2014</td>
<td>5,008</td>
<td>2027</td>
<td>3,760</td>
<td>2040</td>
<td>2,512</td>
</tr>
<tr>
<td>2015</td>
<td>4,912</td>
<td>2028</td>
<td>3,664</td>
<td>2041</td>
<td>2,416</td>
</tr>
<tr>
<td>2016</td>
<td>4,816</td>
<td>2029</td>
<td>3,568</td>
<td>2042</td>
<td>2,320</td>
</tr>
<tr>
<td>2017</td>
<td>4,720</td>
<td>2030</td>
<td>3,472</td>
<td>2043</td>
<td>2,224</td>
</tr>
<tr>
<td>2018</td>
<td>4,624</td>
<td>2031</td>
<td>3,376</td>
<td>2044</td>
<td>2,128</td>
</tr>
<tr>
<td>2019</td>
<td>4,528</td>
<td>2032</td>
<td>3,280</td>
<td>2045</td>
<td>2,032</td>
</tr>
<tr>
<td>2020</td>
<td>4,432</td>
<td>2033</td>
<td>3,184</td>
<td>2046</td>
<td>1,936</td>
</tr>
<tr>
<td>2021</td>
<td>4,336</td>
<td>2034</td>
<td>3,088</td>
<td>2047</td>
<td>1,840</td>
</tr>
<tr>
<td>2022</td>
<td>4,240</td>
<td>2035</td>
<td>2,992</td>
<td>2048</td>
<td>1,744</td>
</tr>
<tr>
<td>2023</td>
<td>4,144</td>
<td>2036</td>
<td>2,896</td>
<td>2049</td>
<td>1,646</td>
</tr>
<tr>
<td>2024</td>
<td>4,048</td>
<td>2037</td>
<td>2,800</td>
<td>2050</td>
<td>1,560</td>
</tr>
</tbody>
</table>

Source: S. 2191, Title I, Subtitle B, section 1201 (DEC07762.xml)
# Annual Percentage Auctioned

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Auction Allocation (% of total allowances)</th>
<th>Calendar Year</th>
<th>Auction Allocation (% of total allowances)</th>
<th>Calendar Year</th>
<th>Auction Allocation (% of total allowances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>18</td>
<td>2025</td>
<td>47</td>
<td>2038</td>
<td>73</td>
</tr>
<tr>
<td>2013</td>
<td>21</td>
<td>2026</td>
<td>49</td>
<td>2039</td>
<td>73</td>
</tr>
<tr>
<td>2014</td>
<td>24</td>
<td>2027</td>
<td>51</td>
<td>2040</td>
<td>73</td>
</tr>
<tr>
<td>2015</td>
<td>27</td>
<td>2028</td>
<td>53</td>
<td>2041</td>
<td>73</td>
</tr>
<tr>
<td>2016</td>
<td>28</td>
<td>2029</td>
<td>55</td>
<td>2042</td>
<td>73</td>
</tr>
<tr>
<td>2017</td>
<td>31</td>
<td>2030</td>
<td>57</td>
<td>2043</td>
<td>73</td>
</tr>
<tr>
<td>2018</td>
<td>33</td>
<td>2031</td>
<td>59</td>
<td>2044</td>
<td>73</td>
</tr>
<tr>
<td>2019</td>
<td>35</td>
<td>2032</td>
<td>61</td>
<td>2045</td>
<td>73</td>
</tr>
<tr>
<td>2020</td>
<td>37</td>
<td>2033</td>
<td>63</td>
<td>2046</td>
<td>73</td>
</tr>
<tr>
<td>2021</td>
<td>39</td>
<td>2034</td>
<td>65</td>
<td>2047</td>
<td>73</td>
</tr>
<tr>
<td>2022</td>
<td>41</td>
<td>2035</td>
<td>67</td>
<td>2048</td>
<td>73</td>
</tr>
<tr>
<td>2023</td>
<td>43</td>
<td>2036</td>
<td>73</td>
<td>2049</td>
<td>73</td>
</tr>
<tr>
<td>2024</td>
<td>45</td>
<td>2037</td>
<td>73</td>
<td>2050</td>
<td>73</td>
</tr>
</tbody>
</table>

Source: S. 2191, Title III, Subtitle B, section 3201 (DEC07762.xml)

State Utility Forecasting Group
Methodology

- Reduce utility CO2 emissions at the overall national rate specified by the proposed legislation
- Incorporate emission allowance purchase costs
- Incorporate emission offset purchase costs
- Adjust fossil fuel price projections
- Other model inputs kept the same as in SUFG 2007 forecast
Allowance and Offset Prices

![Chart showing Allowance and Offset Prices over years from 2012 to 2025. The graph indicates a rising trend for Allowances and a declining trend for Offsets.](chart.png)
Fossil Fuel Prices

State Utility Forecasting Group
Compliance Strategy

- Purchase the maximum amount of offsets allowable
- Switch the basis for new baseload resources from pulverized coal-fired to a combination of wind and natural gas
- Retire older coal units that have not been retrofitted with equipment to remove SO2 and NOx
- Bank allowances in the early years for use in the later years
Other Resource Options

- Nuclear
- IGCC with carbon capture and storage
- Carbon capture from existing facilities
- Fuel switching
- Energy efficiency programs
Results

![Graph showing electricity rates over years]

- **S. 2191**
- **2007 Base**
- **History**

**cents/kWh (2005$)**

Year:
- 1980
- 1982
- 1984
- 1986
- 1988
- 1990
- 1992
- 1994
- 1996
- 1998
- 2000
- 2002
- 2004
- 2006
- 2008
- 2010
- 2012
- 2014
- 2016
- 2018
- 2020
- 2022
- 2024
Electricity Price Changes

<table>
<thead>
<tr>
<th>Sector</th>
<th>2007 Base</th>
<th>S. 2191</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>8.766</td>
<td>9.915</td>
<td>13.1 %</td>
</tr>
<tr>
<td>Commercial</td>
<td>7.896</td>
<td>8.946</td>
<td>13.3 %</td>
</tr>
<tr>
<td>Industrial</td>
<td>5.294</td>
<td>6.662</td>
<td>25.1 %</td>
</tr>
<tr>
<td>Total</td>
<td>6.972</td>
<td>8.213</td>
<td>17.8 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>2007 Base</th>
<th>S. 2191</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>8.327</td>
<td>9.671</td>
<td>16.1 %</td>
</tr>
<tr>
<td>Commercial</td>
<td>7.567</td>
<td>8.817</td>
<td>16.5 %</td>
</tr>
<tr>
<td>Industrial</td>
<td>5.280</td>
<td>6.647</td>
<td>25.9 %</td>
</tr>
<tr>
<td>Total</td>
<td>6.745</td>
<td>8.158</td>
<td>21.0 %</td>
</tr>
</tbody>
</table>
# Electricity Price Changes

**Indiana Real Electricity Prices in 2020**  
(2005 cents/kWh)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2007 Base</th>
<th>S. 2191</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>7.803</td>
<td>10.101</td>
<td>29.4 %</td>
</tr>
<tr>
<td>Commercial</td>
<td>7.204</td>
<td>9.224</td>
<td>28.0 %</td>
</tr>
<tr>
<td>Industrial</td>
<td>5.318</td>
<td>7.315</td>
<td>37.6 %</td>
</tr>
<tr>
<td>Total</td>
<td>6.507</td>
<td>8.695</td>
<td>33.6 %</td>
</tr>
</tbody>
</table>

**Indiana Real Electricity Prices in 2025**  
(2005 cents/kWh)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2007 Base</th>
<th>S. 2191</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>7.637</td>
<td>10.670</td>
<td>39.7 %</td>
</tr>
<tr>
<td>Commercial</td>
<td>7.088</td>
<td>9.849</td>
<td>39.0 %</td>
</tr>
<tr>
<td>Industrial</td>
<td>5.513</td>
<td>8.209</td>
<td>48.9 %</td>
</tr>
<tr>
<td>Total</td>
<td>6.525</td>
<td>9.437</td>
<td>44.6 %</td>
</tr>
</tbody>
</table>
# Change in Electricity Sales

<table>
<thead>
<tr>
<th>Sector</th>
<th>2007 Base</th>
<th>S. 2191</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>2.44 %</td>
<td>1.79 %</td>
</tr>
<tr>
<td>Commercial</td>
<td>2.33 %</td>
<td>1.94 %</td>
</tr>
<tr>
<td>Industrial</td>
<td>2.58 %</td>
<td>0.58 %</td>
</tr>
<tr>
<td>Total</td>
<td>2.47 %</td>
<td>1.32 %</td>
</tr>
</tbody>
</table>
National Studies

- Energy Information Administration (EIA)
  - study released in July based on McCain-Lieberman bill (S. 280)
  - used National Energy Modeling System (NEMS)
  - Lieberman-Warner analysis is expected soon
- Environmental Protection Agency (EPA)
  - study released in March
  - used two models
    - Applied Dynamic Analysis of the Global Economy (ADAGE)
    - Intertemporal General Equilibrium Model (IGEM)
National Studies

• Nicholas Institute for Environmental Policy Solutions, Duke University
  – study released in October
  – based on earlier version of Lieberman-Warner bill
  – used ADAGE model

• CRA International (formerly Charles River Associates)
  – Congressional testimony in January
  – used in-house MRN-NEEM model
National Studies

• Clean Air Task Force (CATF)
  – presentation in January
  – used NEMS model
## Comparison to National Studies

<table>
<thead>
<tr>
<th></th>
<th>SUFG-PCCRC</th>
<th>EIA (S. 280)</th>
<th>EPA</th>
<th>Duke</th>
<th>CRAI</th>
<th>CATF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope</strong></td>
<td>Indiana</td>
<td>National</td>
<td>National</td>
<td>National</td>
<td>National</td>
<td>National</td>
</tr>
<tr>
<td><strong>Change in CO2 prices from EIA</strong></td>
<td>None</td>
<td>None</td>
<td>50-75% higher</td>
<td>10-20% higher</td>
<td>About 3 times higher</td>
<td>Very similar</td>
</tr>
<tr>
<td><strong>Electricity price increase in 2020</strong></td>
<td>33.6%</td>
<td>10.4%</td>
<td>≈30%</td>
<td>21.5%</td>
<td>32%</td>
<td>≈5%</td>
</tr>
</tbody>
</table>
Caveats

• Large-scale wind development
  – 3,400 MW needed by 2012
  – 9,800 MW needed by 2025
  – significant transmission investment
  – operational issues due to intermittency
  – ability of turbine manufacturers to meet demand
  – analysis does not include federal production tax credit
Caveats

• Demand-side management (DSM)
  – higher cost makes DSM more attractive
  – quantifying amount and cost not feasible for this study

• Price elasticity
  – SUFG modeling system uses historical observations to project the future
  – price increases are greater than previously experienced
Caveats

• Macroeconomic effects
  – SUFG model captures microeconomic effects of price increases
    • customer switches from electricity to another resource
    • customer uses electricity more efficiently
  – SUFG model does not capture macroeconomic effects of price increases
    • customer shuts down business
    • customer elects not to open facility in the state
Caveats

• Technological innovations
  – Restrictions are likely to provide incentives for new developments
    • better carbon capture methods for fossil-fuel generators
    • better energy storage for wind intermittency
  – It is not possible to predict what developments will occur and when
Caveats

• Compliance strategy
  – least cost options have been chosen when possible, but should not be construed to be optimal

• Modeling of Lieberman-Warner bill
  – Analysis is based on the proposed legislation, but does not model it exactly
    • allowance allocation
    • carbon capture bonus allowances
    • fuel, allowance, and offset prices from analysis of earlier bill
Further Information

• Doug Gotham
  – 765-494-0851
  – gotham@purdue.edu

• http://www.purdue.edu/dp/energy/SUFG/