PURDUE UNIVERSITY
Discovery Park Energy Center

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

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

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

Annual Percentage Auctioned

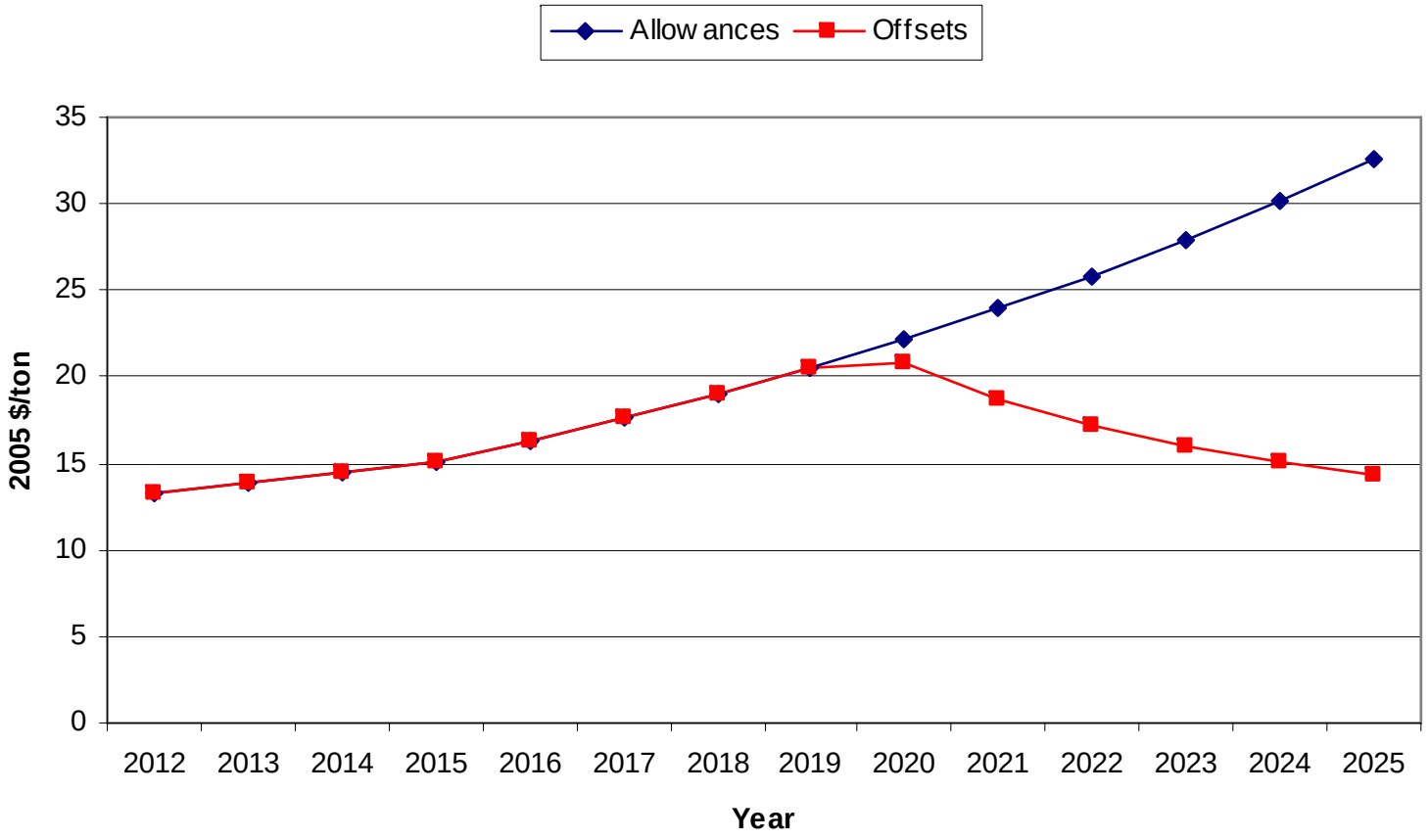
Calendar Year	Auction Allocation (% of total allowances)	Calendar Year	Auction Allocation (% of total allowances)	Calendar Year	Auction Allocation (% of total allowances)
2012	18	2025	47	2038	73
2013	21	2026	49	2039	73
2014	24	2027	51	2040	73
2015	27	2028	53	2041	73
2016	28	2029	55	2042	73
2017	31	2030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

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

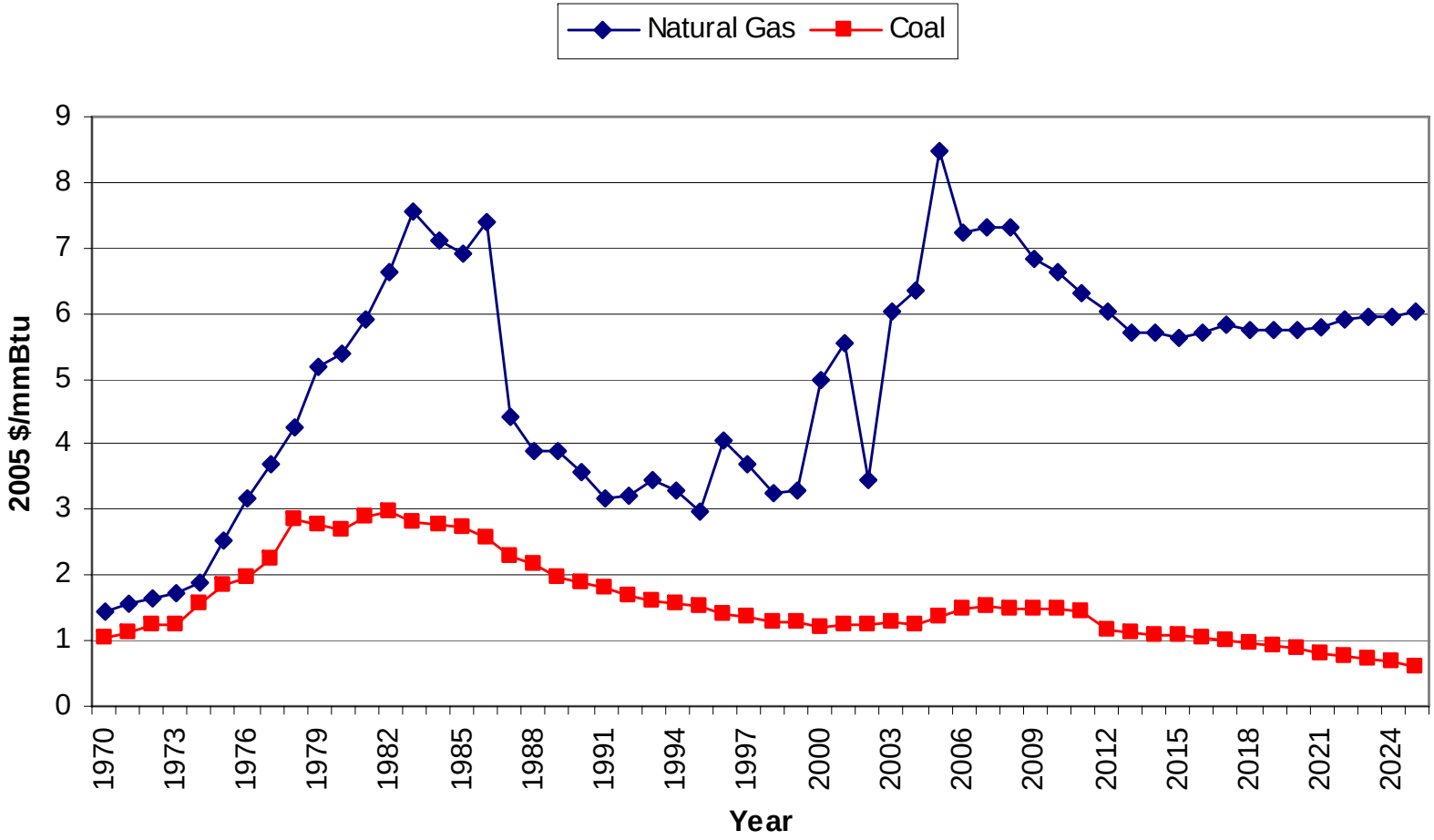
Methodology

- 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



Fossil Fuel Prices



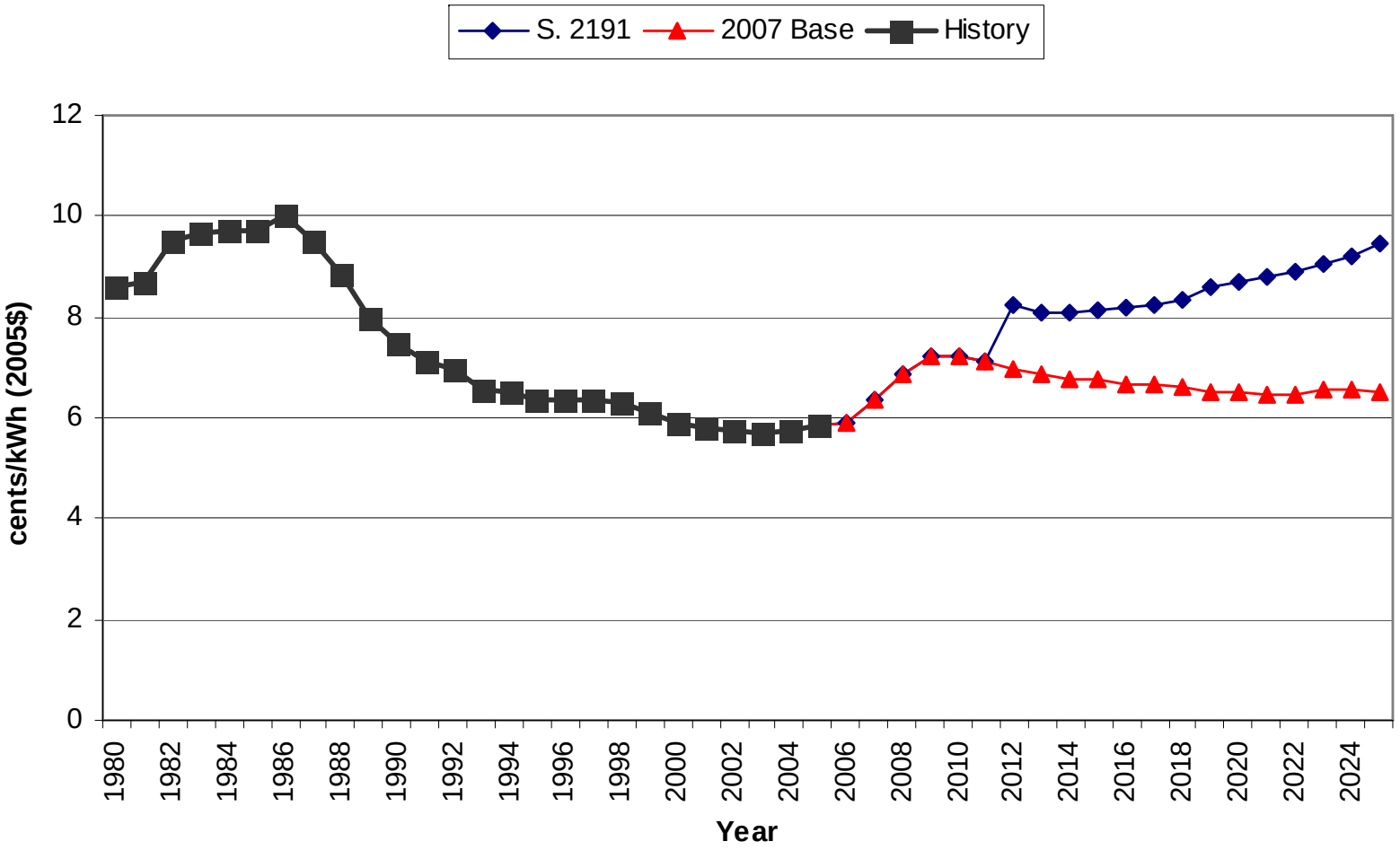
Compliance Strategy

- 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


S. 2191
2007 Base
History
cents/kWh (2005$)
0
2
4
6
8
10
12
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Year

Electricity Price Changes

Indiana Real Electricity Prices in 2012 (2005 cents/kWh)

Sector	2007 Base	S. 2191	Change
Residential	8.766	9.915	13.1 %
Commercial	7.896	8.946	13.3 %
Industrial	5.294	6.662	25.1 %
Total	6.972	8.213	17.8 %

Indiana Real Electricity Prices in 2015 (2005 cents/kWh)

Sector	2007 Base	S. 2191	Change
Residential	8.327	9.671	16.1 %
Commercial	7.567	8.817	16.5 %
Industrial	5.280	6.647	25.9 %
Total	6.745	8.158	21.0 %

Electricity Price Changes

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

Sector	2007 Base	S. 2191	Change
Residential	7.803	10.101	29.4 %
Commercial	7.204	9.224	28.0 %
Industrial	5.318	7.315	37.6 %
Total	6.507	8.695	33.6 %

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

Sector	2007 Base	S. 2191	Change
Residential	7.637	10.670	39.7 %
Commercial	7.088	9.849	39.0 %
Industrial	5.513	8.209	48.9 %
Total	6.525	9.437	44.6 %

Change in Electricity Sales

Sector	2007 Base	S. 2191
Residential	2.44 %	1.79 %
Commercial	2.33 %	1.94 %
Industrial	2.58 %	0.58 %
Total	2.47 %	1.32 %

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

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

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/