FORECASTING INDIANA COAL USE

F.T. Sparrow
F.T. Sparrow & Associates
West Lafayette IN

CCTR Spring Meeting
Bloomington IN
June 5, 2008

"There is something fascinating about … [forecasting] – one gets such wholesale returns on conjecture out of such a trifling investment of fact"

with apologies to Mark Twain

"The future is very much like the present, only longer"

Kehlog Albran

Four Developments which will make the Future Different than the Present:

- Likely passage of some form of legislation limiting CO_2 emissions
- Phases I and II of Clean Air Interstate Rule (CAIR) go into effect in 2009/2010 and 2015, for 28 eastern states, including Indiana, requiring reductions in SO_2 and NO_x emissions
  - "Main impact of (current) widespread installation of scrubbers is that quality differences among coal producing basins will have a lesser influence on buying decisions: rather, the lowest delivered coal cost, on a BTU basis, will win the business" [Compass Energy, October 2006]

Four developments (continued)

- Dramatic rise in transportation fuel costs, including rail; fuel surcharge rate for coal unit trains has doubled in last 2 years – surcharge per ton for 1,000 mile haul alone now more than mining cost for PRB coals!
  ["BNSF Rules book 6100-Coal Mileage based scenarios"]

- Non-recovery coke ovens used as standard for coke oven emissions

Total Coal Delivered in Indiana plus Exports, 2006

- Delivered to Indiana Utilities
  - 30.53 million tons from Indiana mines
  - 5.7 million tons from Illinois mines
  - 0.8 million tons from Kentucky mines
  - 11.7 million tons from Wyoming mines
  - 2.2 million tons from Montana mines
  - 1.1 million tons from Virginia mines
  - 0.7 million tons from other mines
  - **Total: 52.9 million tons**

Source: EIA, "Domestic Distribution of U.S. Coal by Destination State … 2006"

- Note: 52.9 million tons shipped, 60 million tons consumed in 2006; data on use by source not available. Source: EIA, "US Coal Consumption by End Use by State, 2006"

Total Coal Delivered in Indiana plus Exports, 2006 (continued)

- Delivered to Coke Plants
  - 0.9 million tons from Alabama
  - 0.7 million tons from Virginia
  - 4.5 million tons from West Virginia
  - **Total: 6.1 million tons**
    [amount consumed withheld by EIA]
- Delivered to Industrial Plants
  - 2.4 million tons from Indiana
  - 1.8 million tons from West Virginia
  - 0.8 million tons from Illinois
  - 0.5 million tons from Kentucky
  - 0.4 million tons from other
  - **Total: 5.9 million tons** [5.6 million tons consumed]

Source: EIA, "Domestic Distribution of U.S. Coal by Destination State … 2006"

Total Coal Delivered in Indiana plus Exports, 2006 (continued)

- Exports
  - 2.67 million tons to utilities
  - 0.57 million tons to industry
  - 0.17 million tons to other
  - **Total: 3.41 million tons**

- Grand Total
  - Shipments: 65.046 million tons
  - Exports: 3.4 million tons
  - **Total: 68.4 million tons**

Source: EIA, "Domestic Distribution of US Coal by Origin State … 2006"

PART I:

Forecasting Indiana Coal Use for Electricity Generation

Basis for the Estimate

- Projections contained in SUFG/PCCRC report, "The Projected Impacts of Carbon Dioxide Emissions Reduction Legislation on Electricity Prices in Indiana," available at:

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

- Historical uses of Indiana Coal – EIA and ICC
- Various studies predicting impact of CAIR legislation
- Coal transportation cost trends

Basis for the estimate (continued)

CO_2 Impact

- Lieberman-Warner Climate Security Act (SB2191)
  - Bill proposes "cap and trade" system
    - Cap starts at 5200 million tons of CO_2 in 2012
    - Drops to 3592 tons in 2025, end of SUFG/PCCRC horizon
    - Can also purchase non-covered offsets up to specified maximum
    - Applies to all fossil fueled generating units, industrial units which emit more than 10,000 tons CO_2 equivalent tons/yr of greenhouse gases

Projection Methodology

- Develop coal use estimates for three compliance scenarios; all meet or exceed CO_2 limits of proposed legislation

  A. Wind/CC Scenario
     - Purchase maximum amount of offsets available
     - Switch new baseload needs from PC to Wind/CC
     - Retire enough older units in 2012 to meet cap

  B. IGCC Scenario (more expensive than A.; same CO_2 release)

  C. Wind/IGCC (12% more expensive than A., but lower CO_2 release)
     - Same as A., except switch to Wind/IGCC

New Baseload Requirements

INDIANA	(units in MW)
Year	***Baseload***
2006	120
2007	120
2008	240
2009	480
2010	730
2011	1020
2012	2020
2013	2090
2014	2270
2015	2520

Year	***Baseload***
2016	2860
2017	3130
2018	3380
2019	3700
2020	4000
2021	4300
2022	4660
2023	5040
2024	5440
2025	5890

Note: MW are cumulative
Source: SUFG/PCCRC report

New Baseload Requirements

- All start with
  - 2006 Indiana utility coal use of 60e6 tons
  - Retire following facilities in 2012:

	Nameplate
Tanners Creek 1-3 (1.2e6 tons BIT)	519 MW
Eagle Valley/Pritchard 3-6 (0.79e6 tons BIT)	301 MW
Bailly 7, 8 (1.3e6 tons BIT)	615 MW
Edwardsport 7, 8 (0.18e6 tons BIT)	109 MW
Gallagher 1-4 (1.3e6 tons BIT)	600 MW
Wabash River 2-5 (1.65e6 tons BIT)	472 MW
Warrick 4 (1.1e6 tons BIT)	323 MW
TOTAL: ~ 8e6 tons BIT (3.4 non-IN)	**2939 MW retired**

Source: EIA Form 767 data
Note: 2006 Indiana utility coal tonnage is use, not deliveries

What would Happen to Utility Coal Use if:

I. Use continued to grow at historical rates?
   79.8e6 tons by 2025

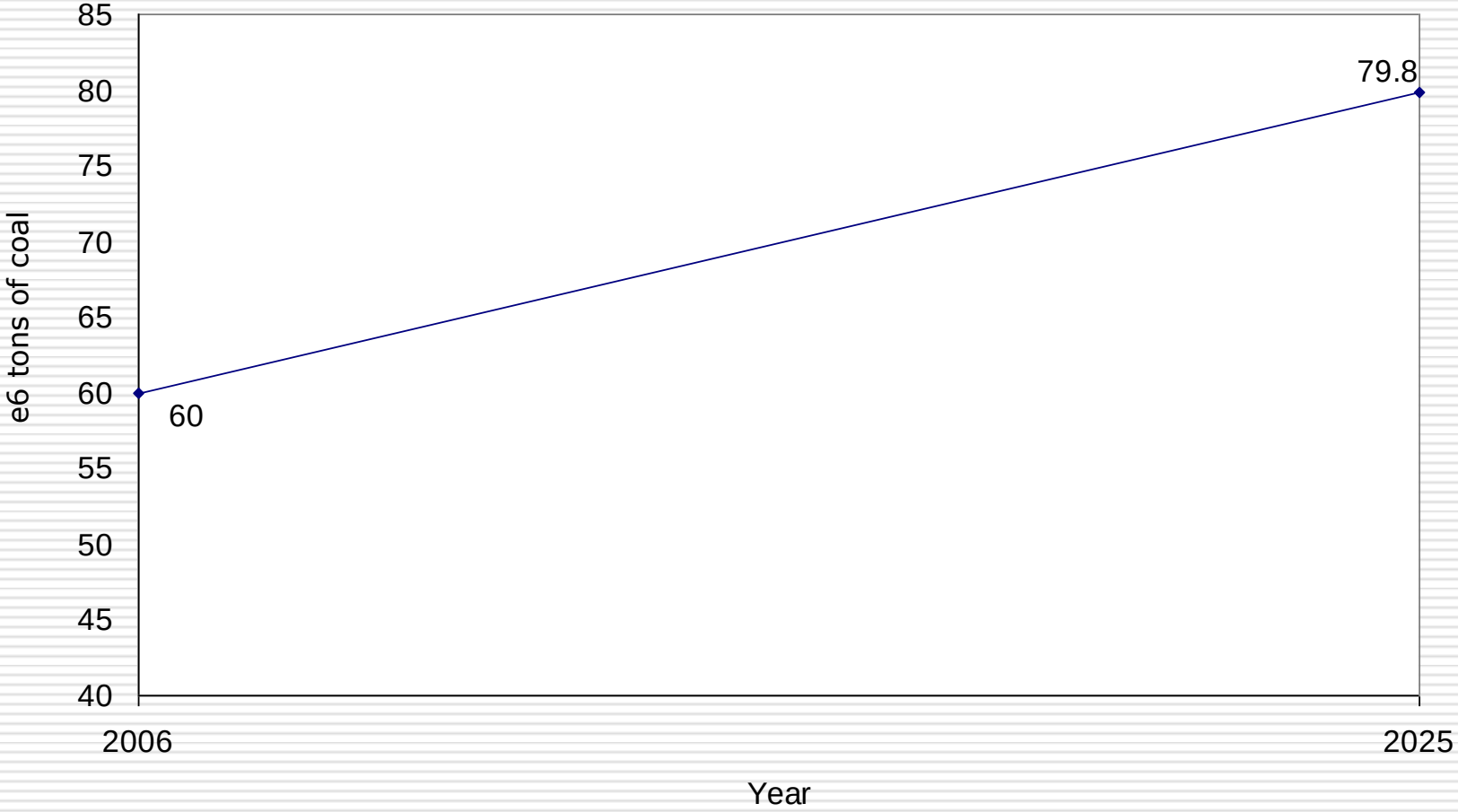
II. It was assumed all new baseload plants SUFG forecasts will be needed by 2025 – are IGCC?
   77.7e6 tons by 2025

III. It was assumed all new baseload plants were a combination of wind and IGCC?
   63.4e6 tons by 2025

IV. It was assumed all new baseload plants were a combination of wind and CC?
   52.0e6 tons by 2025

Note: I is not a CO_2 compliance scenario; II, III, and IV are

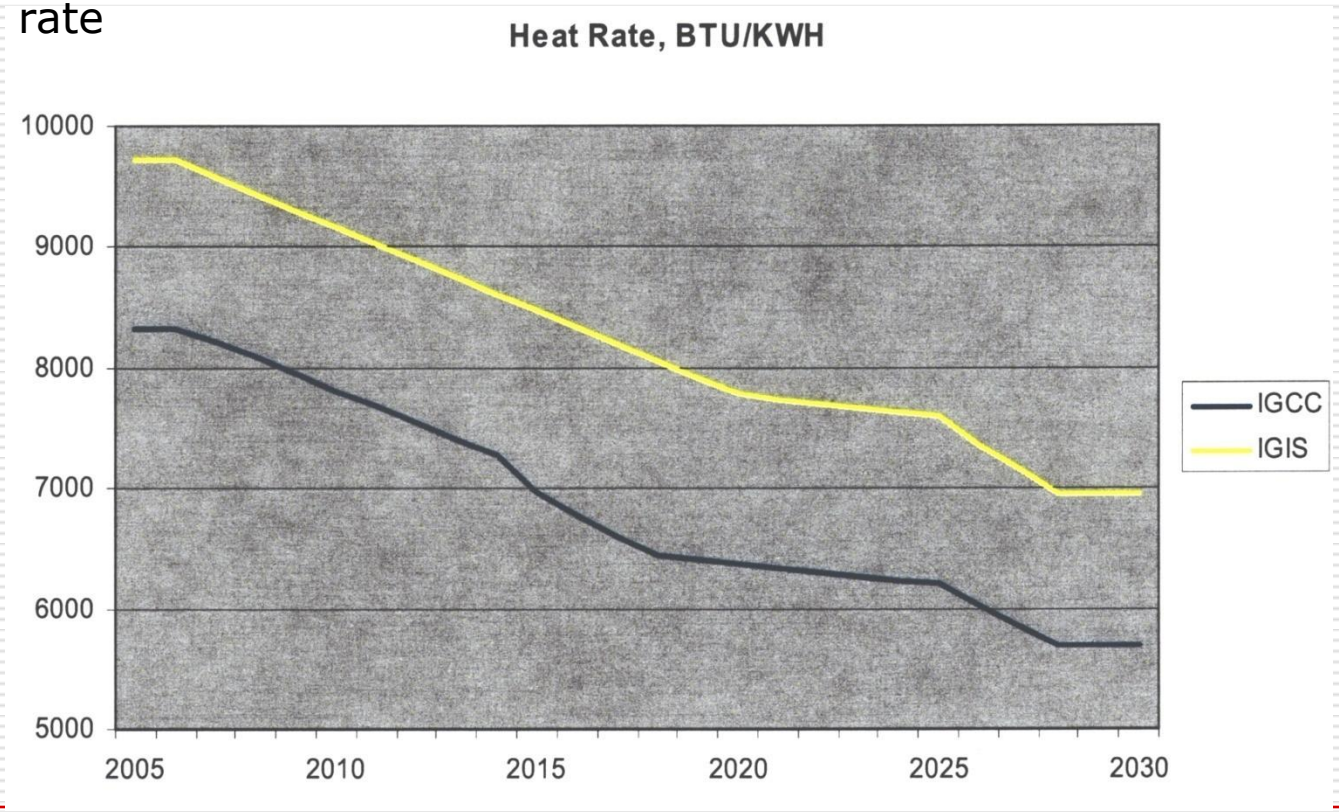
Case I:
Continuation of Historical Rate of Growth



Source for growth rate: EIA Table 12, "Electric Power Consumption Estimates, 1960-2006, Indiana"

Case II: Calculation of Coal Use Projections by Utilities in Indiana for IGCC Scenario

- IGIS Heat Rate is about 25% higher than IGCC heat rate in the important 2015-2030 time frame, but still less than present average Indiana rate

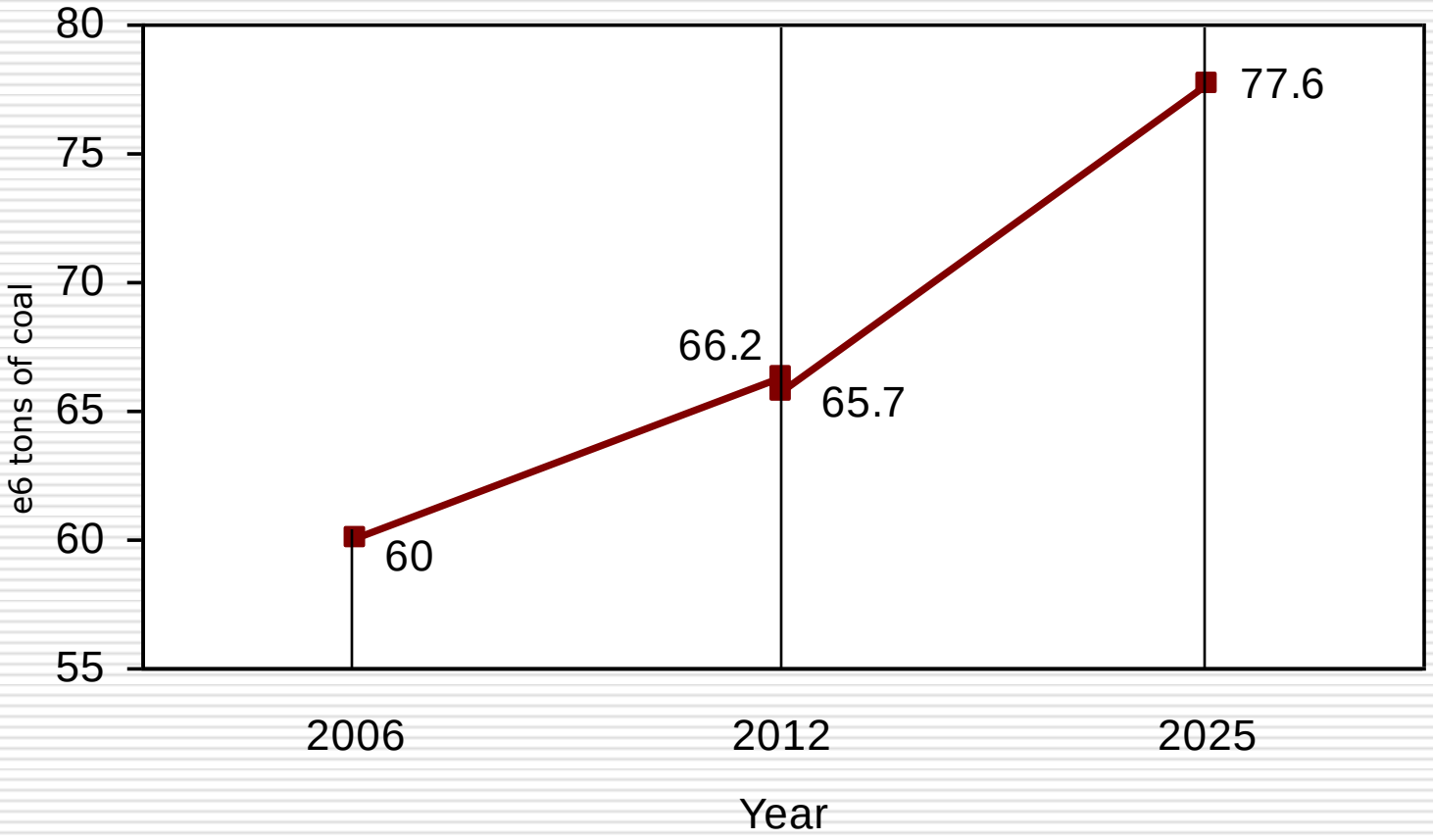


Source: Repowering Coal-Fired Power Plants for Carbon Dioxide Capture and Sequestration–Further Testing of NEMS for Integrated Assessments, DOE/NETL-2008/1310, January 23, 2008, Fig. 4.

Case III: Calculation of Coal Use Projections by Utilities in Indiana for IGCC Scenario

- Coal use will be current 60 million tons, plus use by new IGCC plants which follow baseload addition path until 2012
- In 2012, 8 million ton drop due to retirement, mostly offset by increase in consumption by IGCC plants
- Assumptions: IGCC operates at 90% capacity factor, heat rate (after injection derate of 25%) of 9750 BTU/kWh in 2012 (DOE/NETL 2008/1310)
- Trajectory dependent on derated heat rate assumed; projections range from 7843-11,200 BTU/kWh

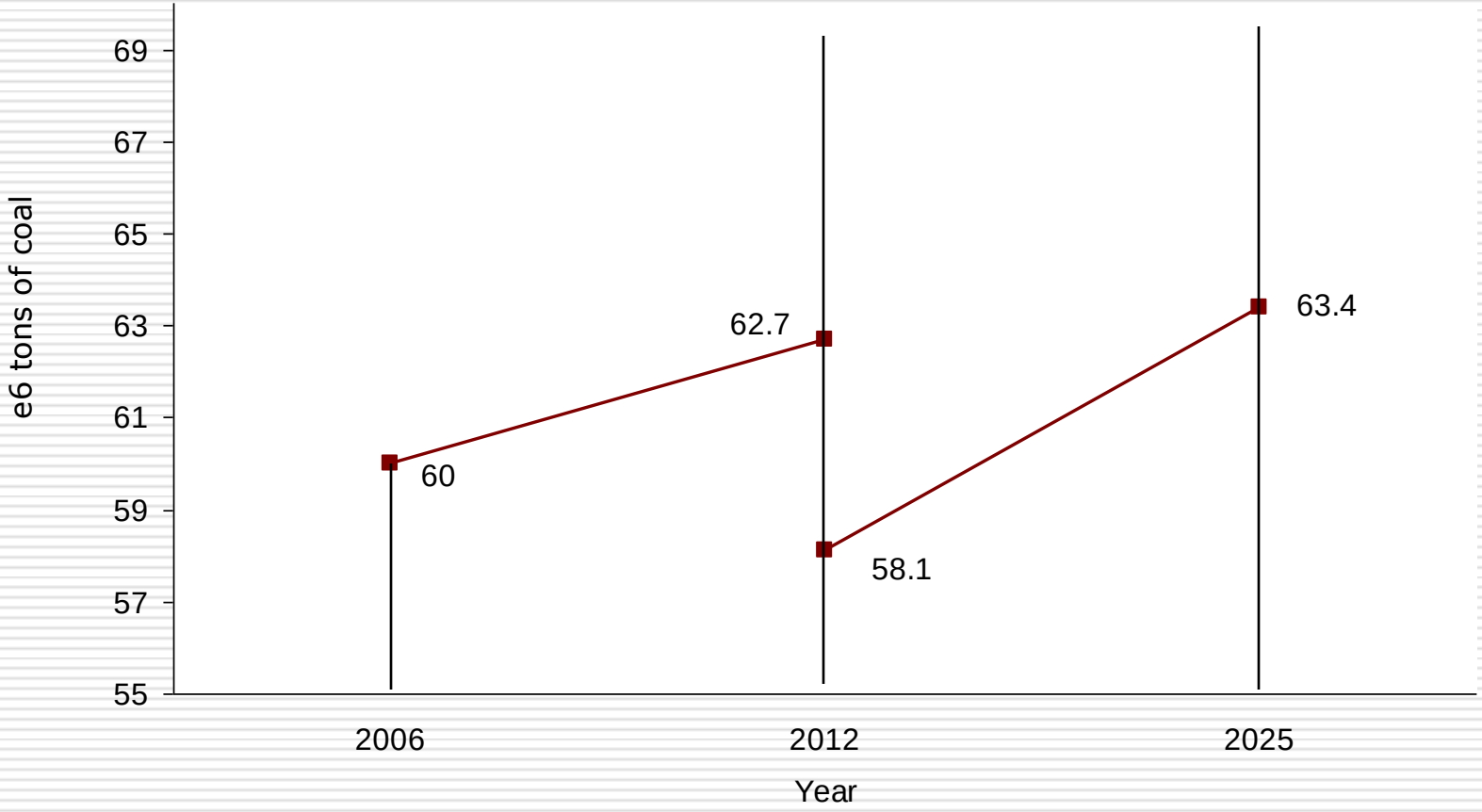
Case II:
IGCC alone



Case III: Calculation of Coal Use Projections by Utilities in Indiana for Wind/IGCC Scenario

- Coal Use: current 60 million tons, plus use of Wind/IGCC plants to meet needs
- SUFG/PCCRC assumption: each 60 MW of baseload generation requires 50 MW of IGCC generation
- Assume IGCC operates at 48% capacity factor (SUFG/PCCRC), heat rate of 9750 BTU/kWh after CO_2 injection derate
- CO_2 release lower than either all IGCC or Wind/CC
- 12% more expensive than Wind/CC; same CO2 release, according to SUFG/PCCRC report

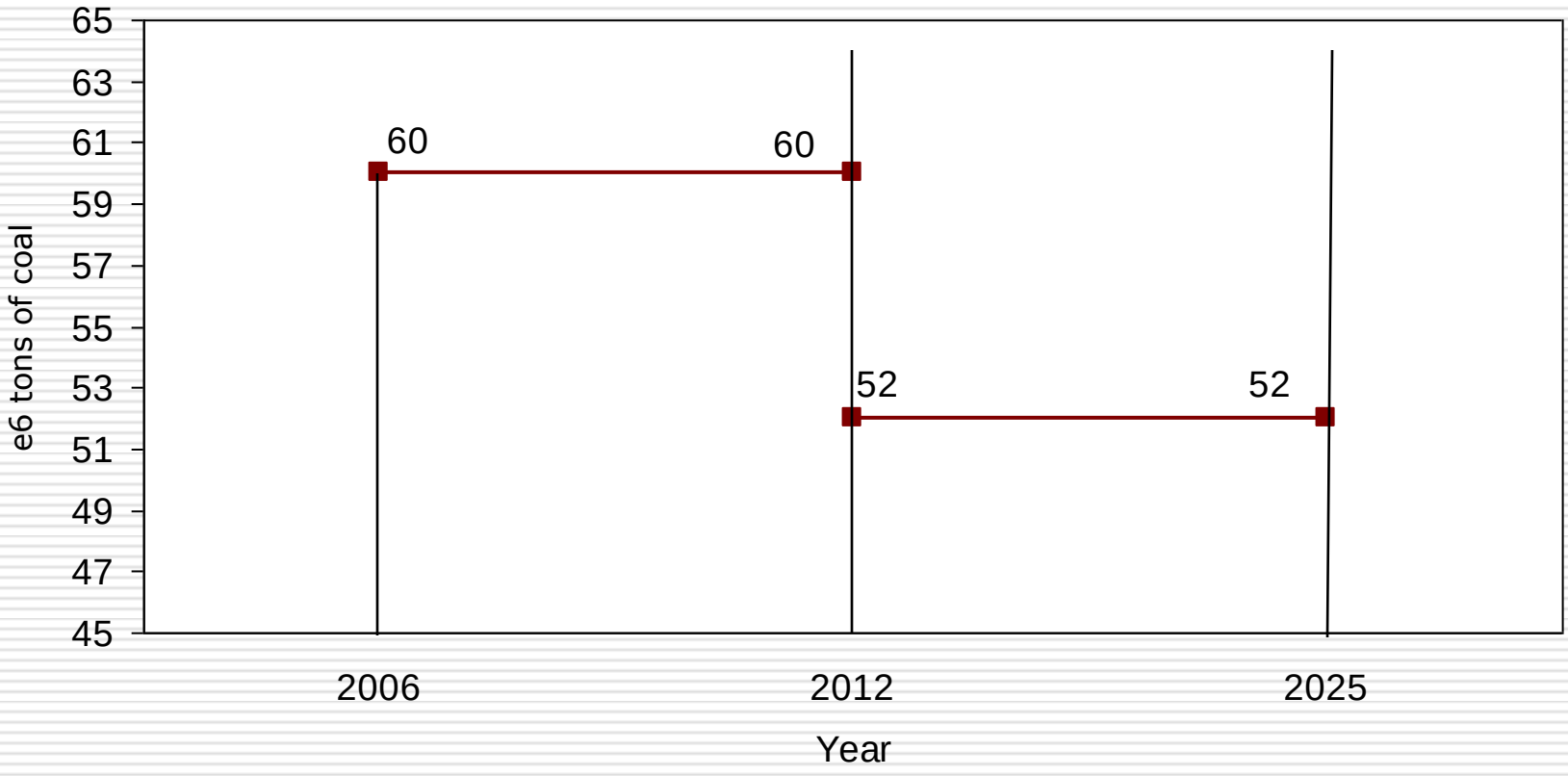
Case III: Wind/IGCC



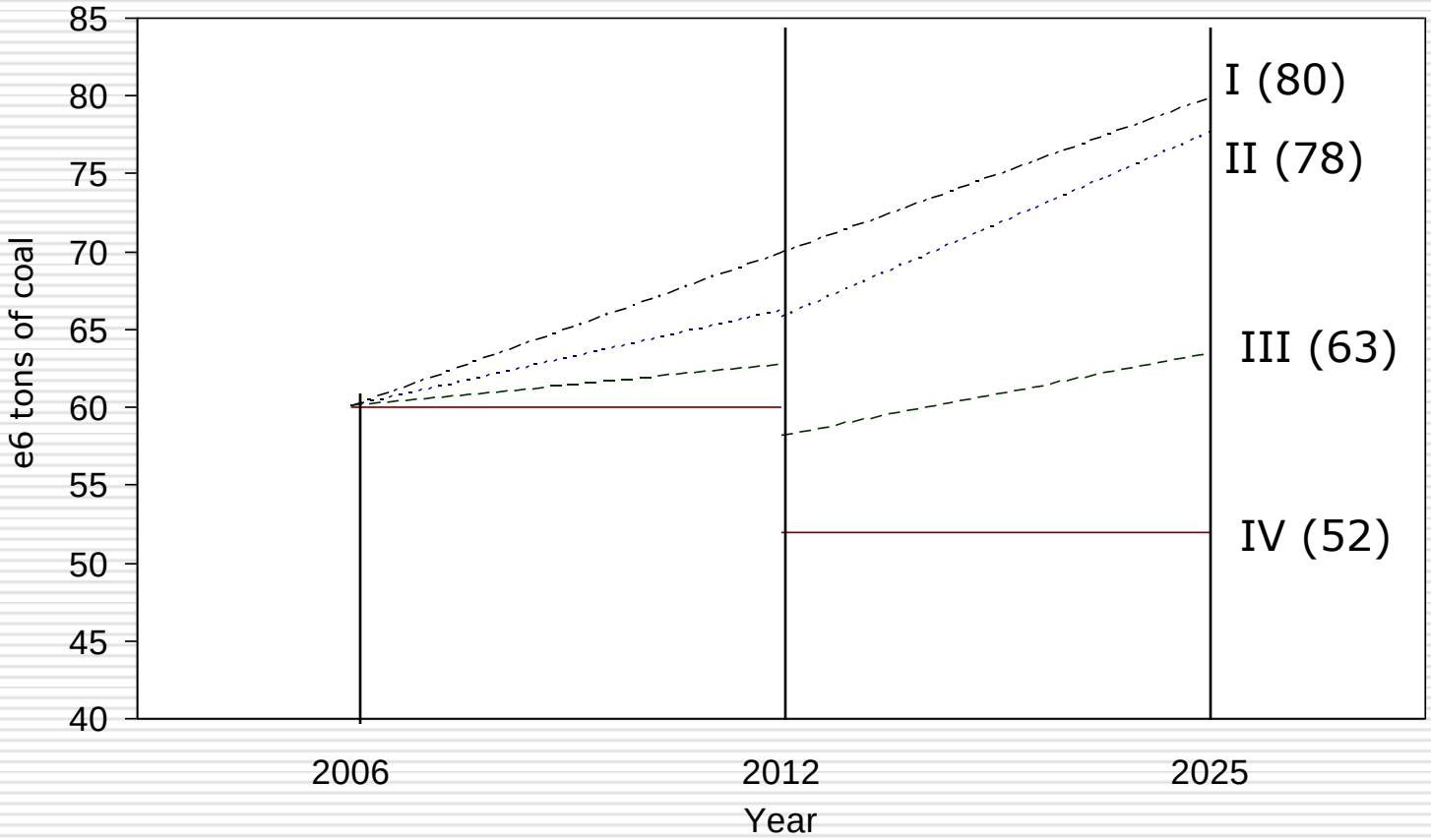
Case IV: Calculation of Coal Use Projections by Utilities in Indiana for Wind/CC Scenario

- Utility coal use constant at 60 million tons from now until 2012, since all demand growth met by new Wind/CC units
- In 2012, coal use drops by 8 million tons to 44.9 million, as old PC units are retired, replaced by Wind/CC units (4.6 million of drop Indiana coal)
- Coal use after 2012 constant at 44.9 million ton level as new demand met by Wind/CC

Case IV:
Wind/CC Coal Use



All Cases:
Coal Use, 2006-2025



I: Continued growth: CO_2 non-compliance scenario
II: All growth IGCC: CO_2 compliance scenario
III: Wind/IGCC: CO_2 compliance scenario
IV: Wind/CC: CO_2 compliance scenario

Conclusions – I

- Future could look like the past, if all new plants and retirements are IGCC
- Future will not look like the past, if Wind/IGCC or Wind/CC scenarios take place

Conclusions – II

- What does all this mean for coal mined in Indiana?
  - Could be IGCC use in new plants restores IB competitiveness with PRB coals in new plants
  - Could be need for SO_x/NO_x scrubbers on old units restores IB competitiveness with PRB coals in old plants; however, it would take very high allowance costs to justify installing FGD if burning PRB now
  - But – beware! PRB will not sit idly by as their markets are challenged

What is Indiana Coal's Potential Share of this Market?

- First, focus on potential in new plants, assumed to be governed by CO_2 legislation compliance strategies
- Second, focus on potential in existing plants, assumed to be governed by CAIR compliance strategies
- Some overlap
- Potential market only; actual will depend on a host of factors – PRB response, transport availability, Indiana share of IB markets

Use of Indiana Coals in New Plants

- New plants are (a) baseload plants to meet new demand; (b) replace old plants retired to meet CO_2 limits
- Two assumptions:
  - All IGCC scenario
  - IGCC/Wind scenario

Use of Indiana Coals in Existing Plants

- Low likelihood any more plants that now use Indiana high sulfur coals in scrubbed plants will switch to PRB – can satisfy CAIR requirements with Indiana coals, and transport cost (>50% of total) of PRB coals will likely increase

- What about plants now using PRB coals (State Line, Clifty Creek, Rockport, Tanners Creek, Michigan City, Schahfer) – will CAIR encourage them to use Indiana coals?

- 2006 IDEM study of likely CAIR compliance plants found that those who are expected to add FGD units all now burn IB coal

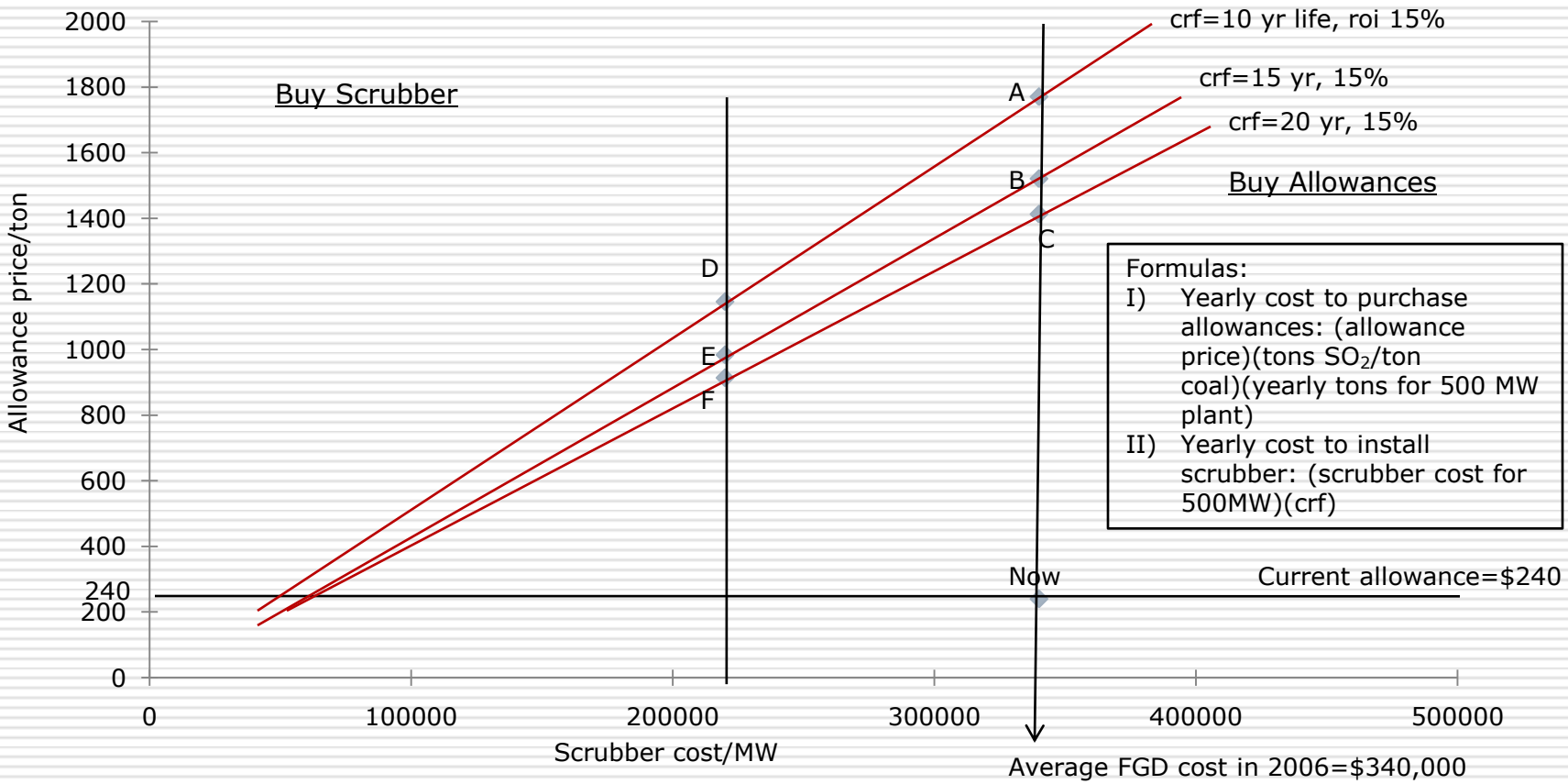
Use in Existing Plants (continued)

- Earlier EPA study found that units now burning PRB coals which are expected to add FGD units now use 2.9 million tons of PRB coal [IDEM study]

- Conclusion: CAIR compliance plans can be expected to increase IB potential by 2.9 million tons in 2015 [CCTR Factsheet, EIA 2005 Boiler Inventory]

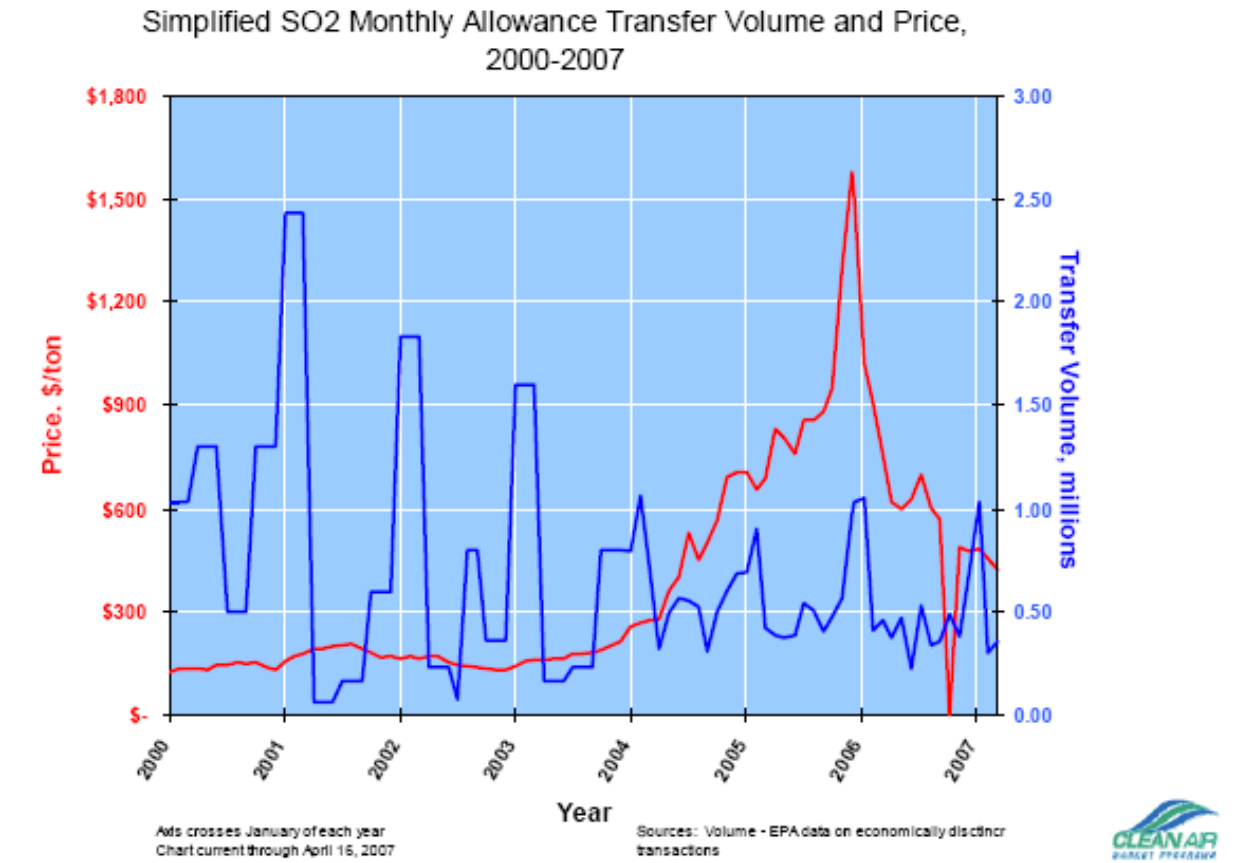
- Little chance for other units now burning PRB to install scrubbers, unless SO_2 allowance costs rise and stay at very high levels

PRB Coal User Choice: Buy/Not Buy Scrubber?



Assumptions: 500 MW PC plant, 90% utilization rate, heat rate 10,000 BTU/kWh, using PRB coal with 20 lbs/ton CO_2, heat content 17-20e6 BTU/ton

Simplified Historic SO_2 Price and Volume



Source: http://www.epa.gov/airmarkets/presentations/docs/EMA2007.pdf

Current Exports of Indiana Coal to Utilities

- Very small in 2006 – 1.8 million tons to other IB states, 0.7 to Alabama, total 2.7 million tons [EIA]

- Much higher in earlier years:
  - 1990: 9 million tons
  - 1995: 3.8 million tons
  - 2000: 1.5 million tons

    [Indiana Coal Council]

- Markets presumably lost to PRB

What about Export Potential for Indiana Coal Use by Utilities?

CURRENT USE, e6 tons (2004/2006)

To From	KY	OH	IL	MI	WI	Total
West	7.1/6.0	7.3/20.3	42.2/51.4	28.6/25.4	25.1/26.3	110/129
East (incl E Ky)	5.6/9.4 **	23/37	0.3/0	5.1/7.8	0.2/0.53	34.2/55
IB (incl W Ky)	2.4/1.9 **	0.6/1.6 *	0.4/0.3 *	0/0	0.5/0.3	3.9/4.1
Home	13.8/23.9	14.4/15.1	5.7/4.1	0/0	0/0	33.9/43.1
Totals	29.4/41.4	45.3/74	45.3/56	34.2/33.6	25.9/27.1	

* Non home only ** E & W KY included in home
Source: EIA Distribution of US Coal by Destination

- Transport costs on rise, fuss about railroad fuel surcharges

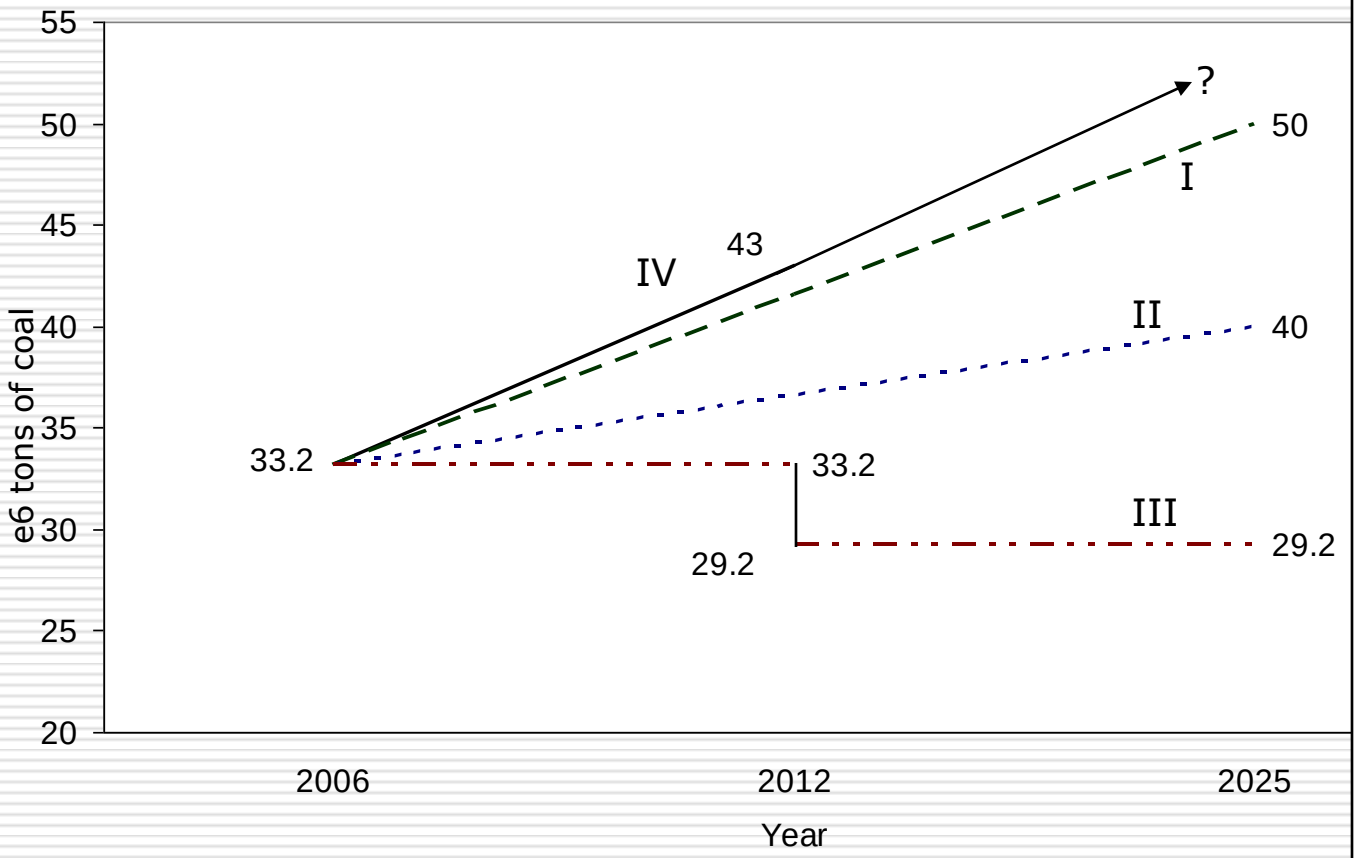
Focus on PRB Coals brought in by Train

KY	OH	IL	MI	WI	Total
6.0	20.3	50.1	20.0	25.7	122.1

(2006 data, e6 tons)

- Michigan is logical target for export development: no in-state coal, Michigan unit trains come through Indiana (?), 1200 mile haul from PRB
- Problems getting coal from Southern Indiana to Northern Indiana
- PRB response – will they always underbid IB coals?

Forecast Use of Indiana Mined Coal for Electric Generation



I: Continuation of 97-06 growth
II: New IGCC plants called for in SUFG CO_2 all IGCC scenario case use Indiana coal
III: SUFG Wind/CC CO_2 compliance scenario; all new plants CC, lose 4 million tons of Indiana coal when plants now using Indiana coal are retired in 2012
IV: Increased coal export scenario; hold onto all existing Indiana coal use, plus meet 10 million tons of new coal demand by 2014 associated with projected new baseload growth needs in Michigan and Wisconsin

Note: 33.2 million tons shipped to Indiana and out of state utilities.
Source: EIA "Distribution of US Coal by Destination, 2006"

PART II:

Forecasting Indiana Coal Use by the Indiana Iron & Steel Industry

Prospects for Increased Indiana Coal Use by Indiana's Iron & Steel Industry

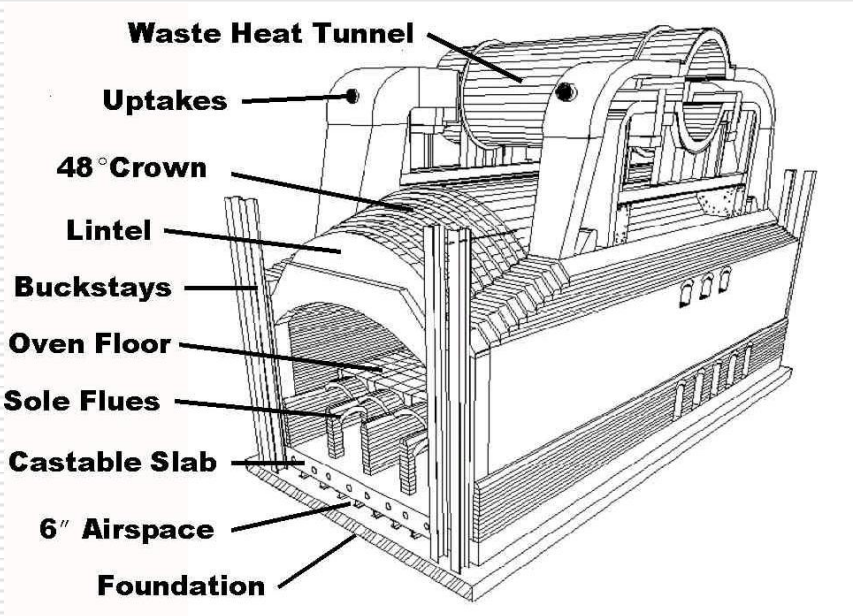
- Use in Coal Blends for Coke Production
  - 2.1 million tons potential at present coke use levels
- Use in Pulverized Coal into Blast Furnace (PCI)
  - 1.3 million tons potential at present coke use levels
- Major development: 1994 EPA coke oven emission rules, which limit emissions to those associated with non-recovery coke ovens

Present Coal Use for Coke Production in Indiana

- 4 Coke Plants
  - Indiana Harbor Coke Company (Ispat/Inland), a non-recovery coke plant, 1,300,000 tpy coke production capacity [~1,800,000 tpy coal], 94 MW electric generation unit
  - Burns Harbor (Mittal Steel), a by-product recovery plant, 1,800,000 tpy coke oven capacity capacity [~2,400,000 tpy coal], COG and BFG used in 177 MW electric generation unit
  - Gary (U.S. Steel), a by-product recovery plant, 1,600,000 tpy coke production capacity [~2,200,000 tpy coal], COG used in various steelmaking processes
  - Citizens Gas & Coke [500,000 tpy] - closed in July 2007
- 6.1 million tons of coal shipped in 2006 to units from West Virginia (4.5), Virginia (0.7), and Alabama (0.9)

Non-Recovery Oven

Jewell-Thompson Heat Recovery Coke Oven



Indiana Harbor Coke Co

Source: http://www.epa.gov/guide/ironsteel/pdf/jewell.pdf

Use of Indiana Coals in Coal Blends for Coke

- Kramer study for CCTR indicated that 2.1 million tons of Indiana coal could be blended with 4 million tons of eastern coals to satisfy coke oven demand

- Drawback: coke produced from Indiana coal has less strength than coke produced from metallurgical coal

Source: "Development of Coking/Coal Gasification Concept to Use Indiana Coal …" – Final CCTR report, Sept. 30, 2007

Use of Indiana Coals as Blast Furnace Injectants

- 1995-1998: DOE demonstration project at Burns Harbor indicated that coal could replace coke on a near pound per pound basis; renewed interest due to extraordinary coke prices
- Injection rates using low volatile Virginia coals were 270 pounds/ton of hot metal, or about 30% of the total 930 lbs/ton coal/coke charge
- Could use a wide range of commercially available coals

Use of Indiana Coals as Blast Furnace Injectants (continued)

- Such a substitution would reduce coal required per ton of hot metal from 1,280 lbs/ton to 1,180 lbs/ton, or 8%
- Could result in the use of up to 1.4 million tons of Indiana coal
- All 3 Indiana integrated mills won't inject a range of 200-400 lbs/ton
- Drawback: high moisture content of IB coals – blends may be solution

PART III:

Forecasting Indiana Coal Use by Other Industries

2006 Total Use of 5.6 million tons composed of:

- 2.7 million tons at Alcoa Warrick units 1-4 for electric generation [EIA Form 767 boiler inventory 2005]
- 0.87 million tons at 5 large cogeneration sites (Citizens, IU/PU/ND, Tate & Lyle)
  [IDEM ICI >100e6 BTU/hr boiler reports, assuming 24e6 BTU/ton]
- 0.53 million tons at 6 large process steam plants (Central Soya, Seagrems, GE Plastic, Lilly, Danisco, New Energy) [IDEM ICI >100e6 BTU/hr boiler reports, assuming 24e6 BTU/ton]
- 1.5 million tons unaccounted for
- Most of this is probably IB coals – low volume precludes PRB unit trains

Forecast Movement in Industrial Use of Coal

- Warrick use should be included in electricity generation forecast
- Co-generation coal use growth governed by forecasts of gap in price increase between purchased electricity and coal/gas prices, government incentives for plants, grid reliability
- Process steam coal use growth governed by competition between coal and gas for steam demand
- Outlook uncertain for both uses

Implications of All This for CCTR Planning?

I. Coal to Generate Electricity:

- Need a careful look at IB coal versus PRB coal in the new environment. How far west has the line of equal cost for the use of PRB and IB coals moved, as a result of the 3 developments mentioned earlier
- Need a way to get IB coals north to serve Indiana/Michigan/Wisconsin demands
- Need a study to pin down least-cost combination of wind and back-up power – Wind/CC? Wind/CC with coal gasification? Wind/IGCC? Other?

Implications for CCTR Planning (continued)

II. Coal to the Iron & Steel Industry:

- Are IB coke blending and BF injection forecasts additive?
- Need a study of IB coal use for PCI

III. Coal for Industrial Use:

- Need a study, but small market compared to I. and II.