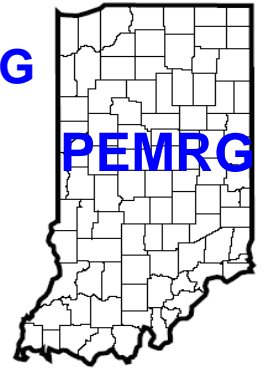


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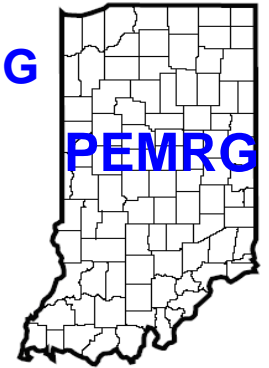
Factors that Affect the Design & Implementation of Clean Coal Technologies in Indiana (Interim Report)

Presentation to the
Center for Coal Technology Research

Bloomington, Indiana - June 10, 2005

by

Ronald L. Rardin, Principal Investigator and Director
Purdue Energy Modeling Research Groups (PEMRG)



The Project Team

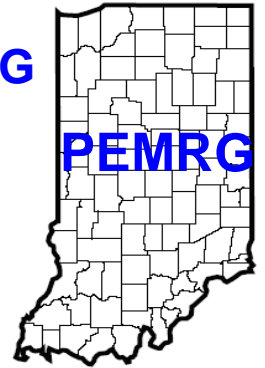
PURDUE:

- Ronald L Rardin, PI
- Zuwei Yu, CoPI
- Forrest Holland, CoPI
- Tony Black, GRA
- Jesse Oberbeck, GRA

(with help from other
SUFGR staff)

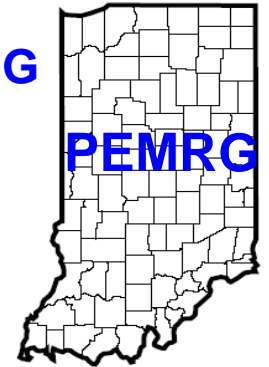
ADVISORS:

- Dick Foltz (& Gayle Mayo), IMPA
- Allen McKee, WVPA
- John Rupp (& Maria Mastalerz), IGS
- Francois Botha, ICCI
- Bill Simmons, Coalteck



Scoping Study Vision

- How emerging Clean Coal Technology (CCT) solutions can be shaped & encouraged within Indiana
- Goal to increase environmentally responsible use of Indiana coal
- Focus on electric power generation, although chemical & other byproducts also considered



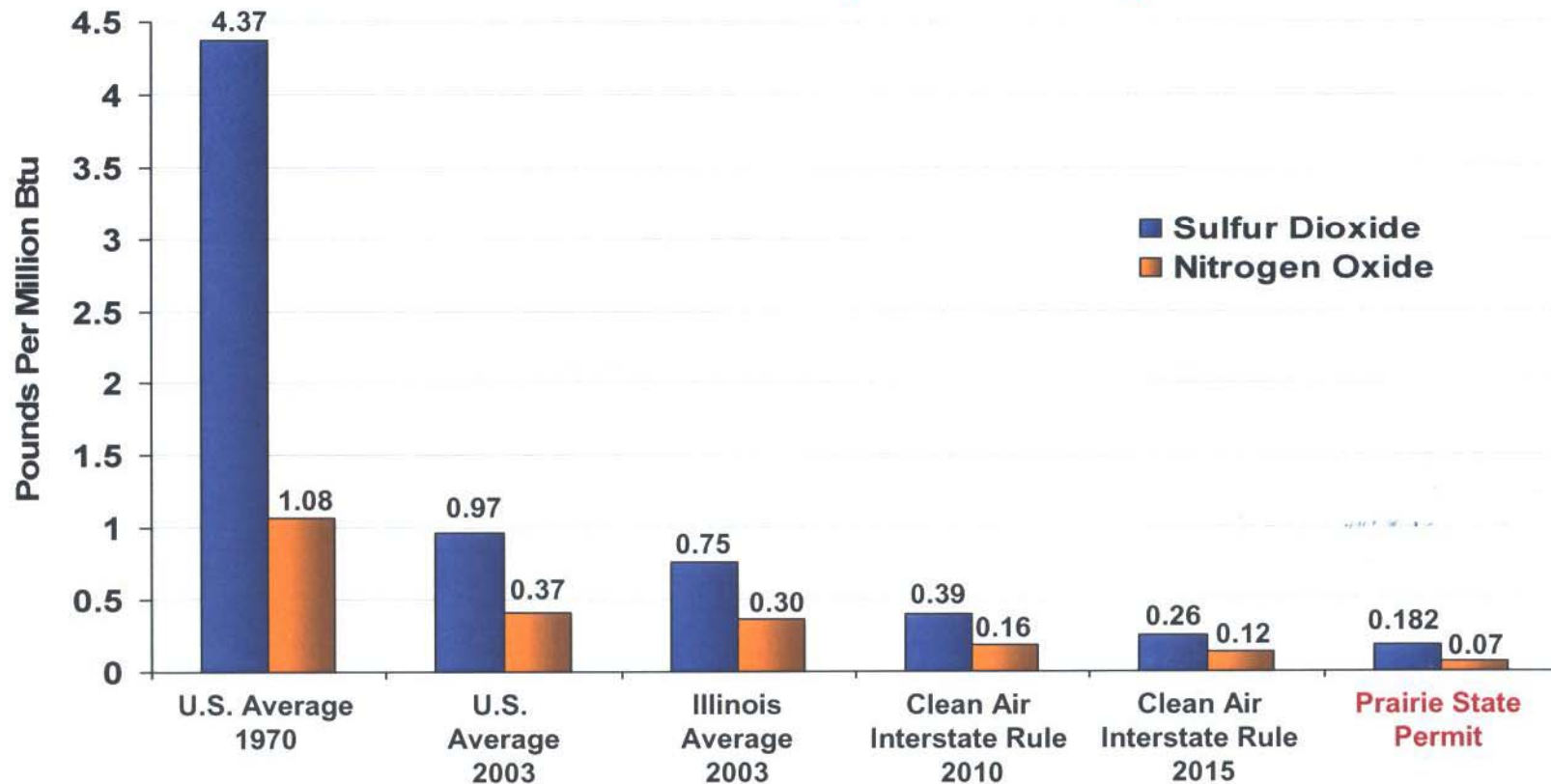
Clean Coal Technology (CCT)

- CCT \approx methods for using coal with substantially reduced environmental emissions
- Includes Integrated Gasification Combined Cycle (IGCC) with near zero emissions
- What coal-fired & combinations to include?
 - Supercritical PC (high temp & pressure)
 - Circulating Fluidized Bed (input with limestone)
 - Flue Gas Recycling (using & concentrating effluent)



Difficulty of Defining CCT

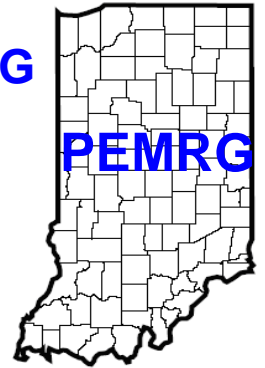
Prairie State's emissions will be one-fifth
the U.S. coal plant average





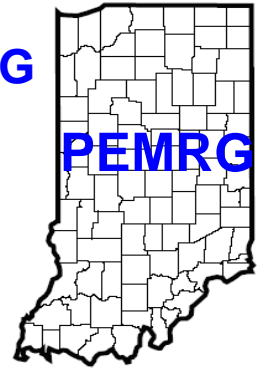
Two Dimensions

- Study considers two dimensions or issue bundles
- First is the technologies: how they work, history & maturity, preferred fuels, estimated costs, new & retrofit plants, pollution removal, reliability/availability, coke & chemical production, external R&D funding



Two Dimensions

- Second is the Indiana environment: Indiana coal types, utility regulation, environmental regulation & compliance, human infrastructure, electricity demand growth, legacy boiler population, power transmission network, gas transmission network, coal transportation infrastructure

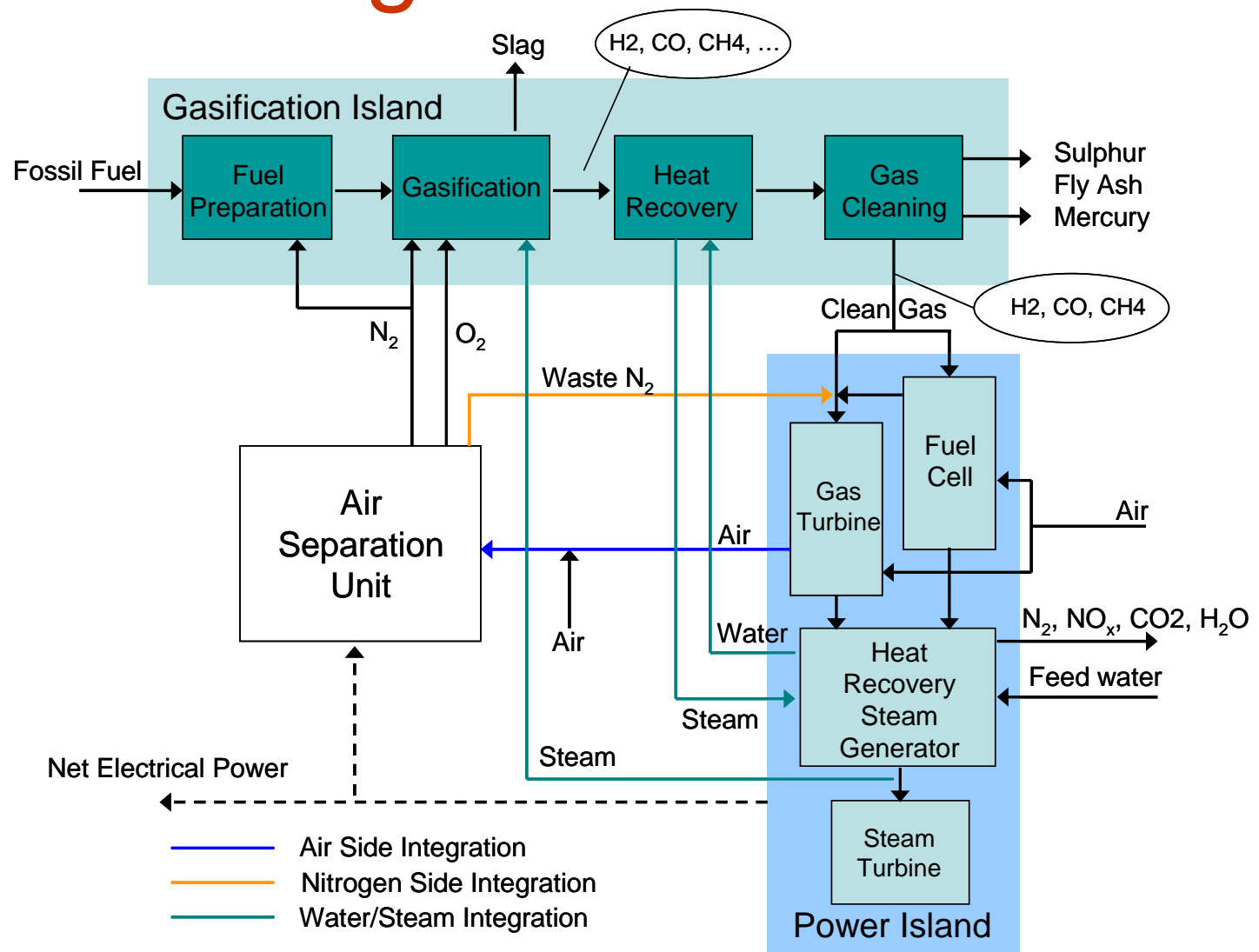


Interim Report

- Summarizes Tasks 1 & 2 to collect relevant information about all the topics of both dimensions
 - As much as possible, get everything in one place
- Anticipate further interviews with experts & data search as the study proceeds
- Comments and additions from the Board are encouraged

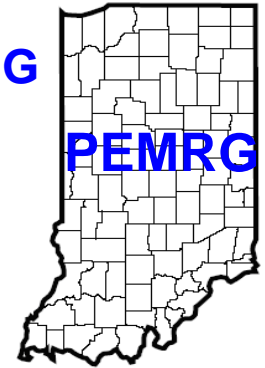


IGCC Design



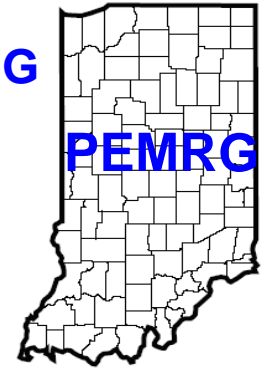
IGCC Cost Studies

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Tech	Whose Est?	Cap (MW)	CO ₂ Cap?	Unit cost	Backup gasifier	
Entrained flow	1. Bechtel [5], [6]	1,000 (E-Gas)	No	\$1099/kW	no	
	2. EPRI [11], [12]	520 (E-Gas)	No	\$1350/kW	2 on 1	
			Yes	\$1900/kW	2 on 1	
	3. Flour [13]	1073	No	\$1111/kW	3 on 1	
	4. Harvard [14]	n/a	No	\$1400/kW	n/a	
5. DOE	n/a	No	\$1300/kW	n/a		

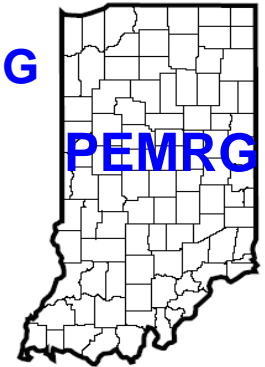
**Table 2.04c.
Capital Cost and
Efficiency
Estimates for
IGCC (near
future).**



PC Cost Comparison

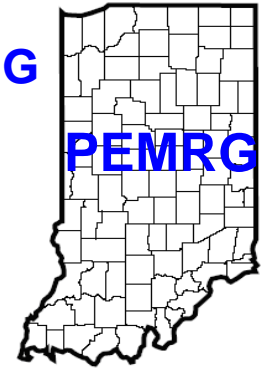
Technology	Whose Est?	Capacity (MW)	CO ₂ capture	Unit cost			
SC or USC	1. Bechtel [15]	800 (SC)	No	\$1100/kW			
		600 (SC)	Yes	\$1950/kW			
	2. EPRI [11], [12]	600(USC)	No	\$1235/kW			
			Yes	\$2150/kW			
	3. Siemens [16]	600(USC)	No	\$1000/kW			
	4. Harvard [14]	n/a (SC)	No	\$1200/kW			
5. DOE	n/a	No	\$1300/kW				

Table 1.04d. Capital Cost and Efficiency Estimates for SC/USC-PC Plants (near future).



EPRI Capital Cost Recap

	Without CO2 Cap	With CO2 Cap	Percent Change
Ultra Super Critical	\$1235/kW	\$2150/kW	+74%
IGCC	\$1350/kW	\$1900/kW	+41%
Percent Change	+9.3%	-13.2%	



Impact of Capacity Factor

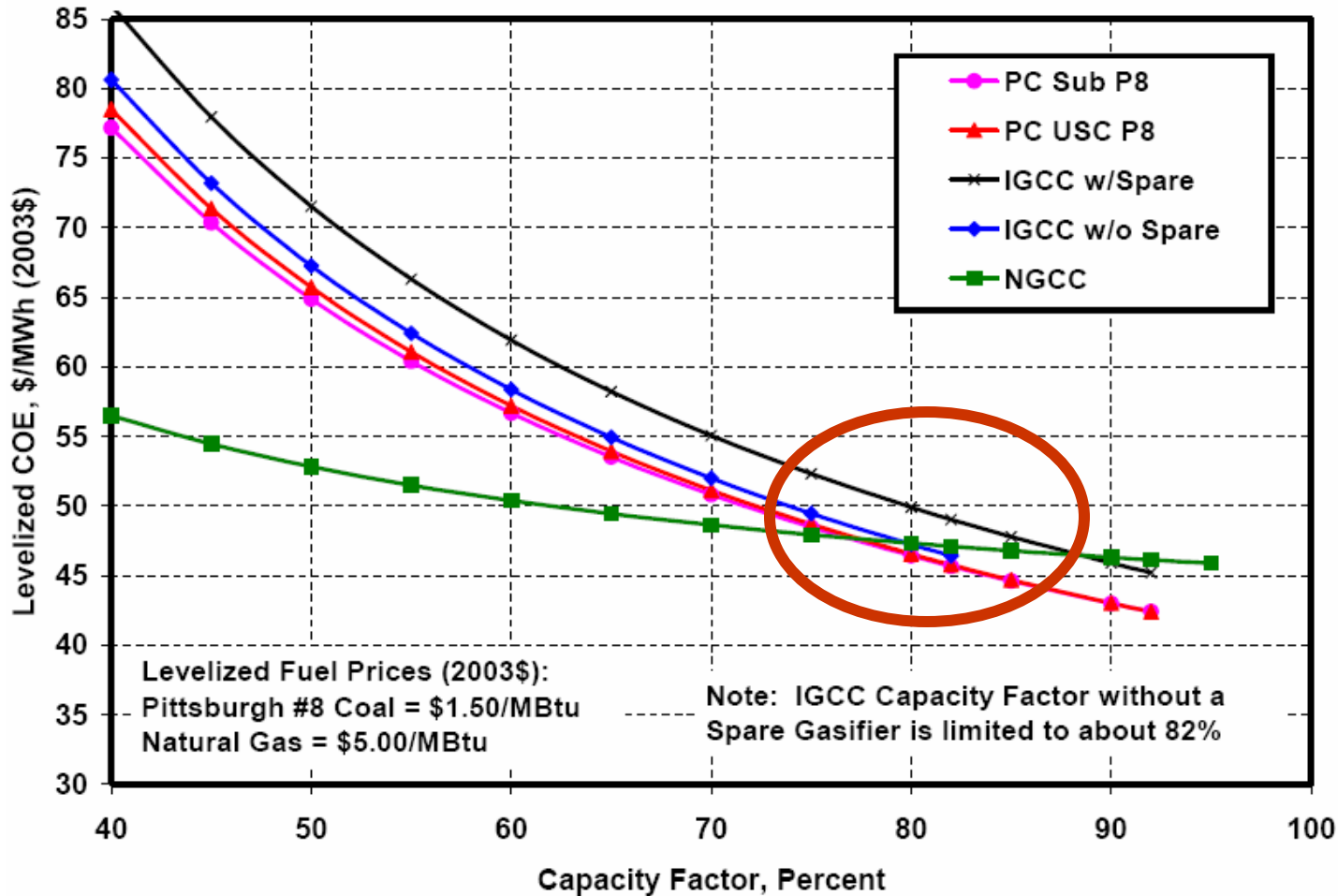
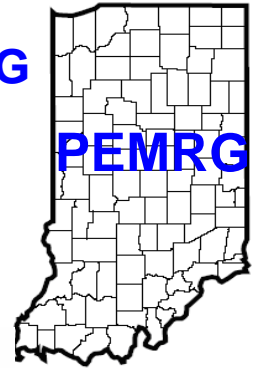


Figure 1.04e. Estimated Cost of Electricity vs. Capacity Factor (no CO2 capture)¹³



Impact of Coal Quality

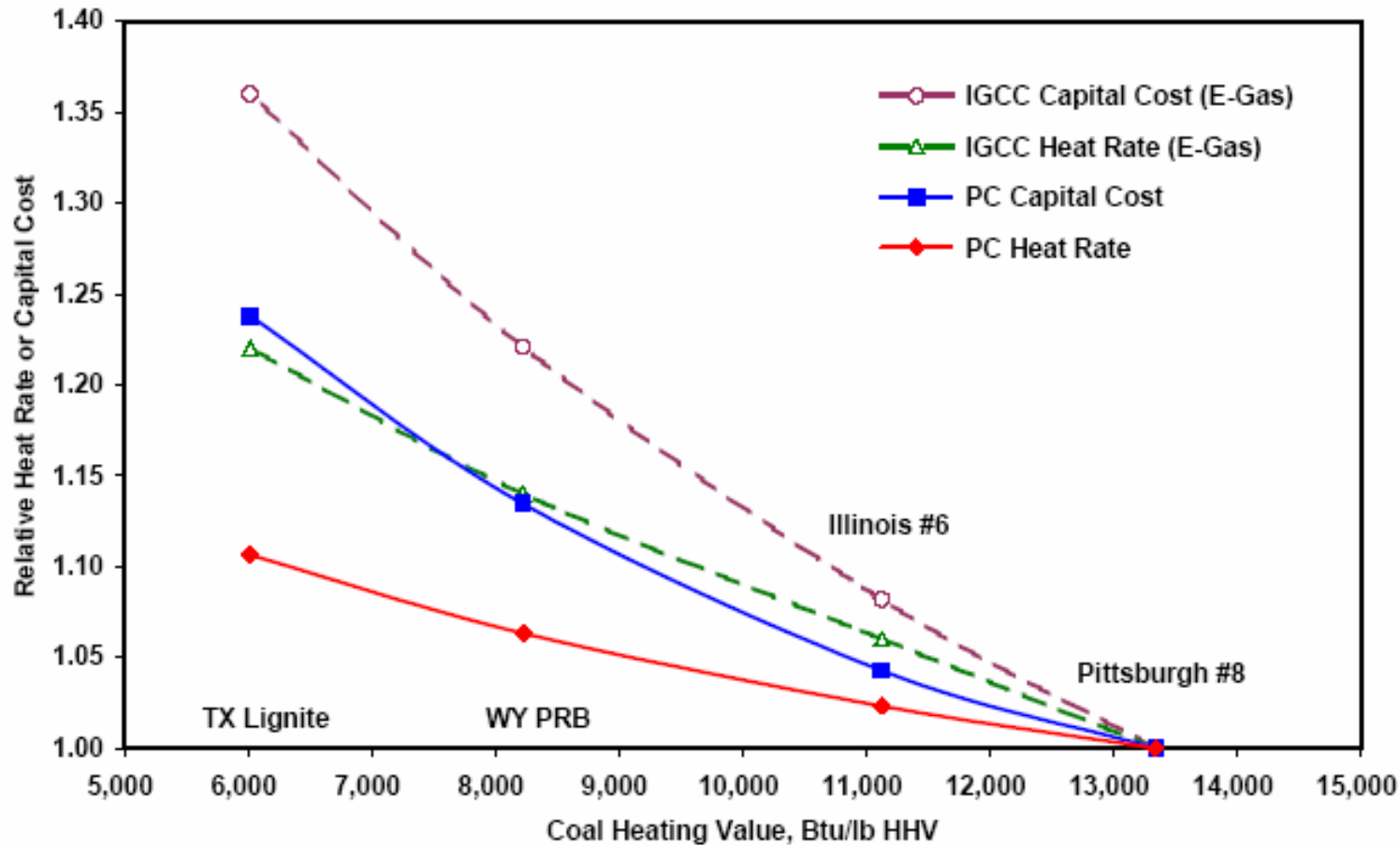
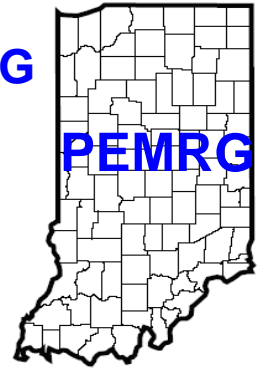
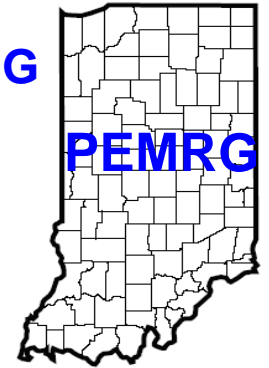


Figure 1.03. Effect of coal quality on heat rate and capital cost



Upcoming Activities

- Scenario Investigation: analysis of how CCTs might evolve in the Indiana power context under alternative environmental regulation, cost & technology penetration hypotheses
- Hope to very roughly estimate implications for Indiana coal demand & electricity prices
- Also focus thinking about policy needs & research gaps



Final Report in November

- Summary of analysis to date
- Public/Private Action Plan: What can & should be done to enhance CCT & Indiana coal use in the state?
- CCTR Research Plan: What topics critical to CCT & Indiana coal use in the state require additional research?