Cost Comparison IGCC and Advanced Coal

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Roundtable on Deploying Advanced Clean Coal Plants

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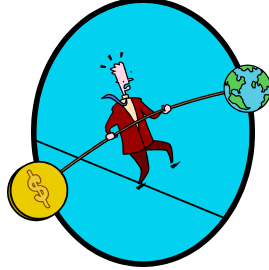
Coal Gasification and Advanced Coal



- **There is no silver bullet technology- cost varies with coal type**
  - IGCC cost of electricity is greater than conventional coal / advanced combustion options – the spread widens for low rank coal. CO_2 capture may change technology choice
- **Reliability and drivers for using IGCC are unclear**
  - Economics, financing, emission limits, sparing, future requirements for CO_2
- **There are few incentives for high efficiency and disincentives in the market for taking risk.**
  - Today "conventional" coal is being proposed at dozens of sites for 2008-2012.
- **Incentives will be needed to get early plants built**
  - Regulatory or market problems can slow acceptance
- **Carbon Sequestration –What is "ready"?**
  - Conditions (pressure, concentration, temperature), space, pretreatment of contaminants...?

Cost and Performance for 500 MW Power Plants

Pittsburgh #8 Bituminous Coal –for National Coal Council Report

	PC Subcritical	PC Supercritical	IGCC (E-Gas) Spare/No Spare	NGCC
Total Plant Cost, $/kW	1,230	1,290	1,350/1,250	440
Total Capital Requirement, $/kW	1,430	1,490	1,610/1,490	475
Fixed O&M, $/kW-yr	40.5	41.1	56.1/52.0	5.1
Variable O&M, $/MWh	1.7	1.6	0.9	2.1
Ave. Heat Rate, Btu/kWh (HHV)	9,300	8,690	8,630	7,200
Capacity Factor, %	80	80	80	80/40
Levelized Fuel Cost, $/MBtu	1.50	1.50	1.50	5.00
Levelized COE, $/MWh (2003$)	46.5	46.6	49.9/47.2	47.3/56.5

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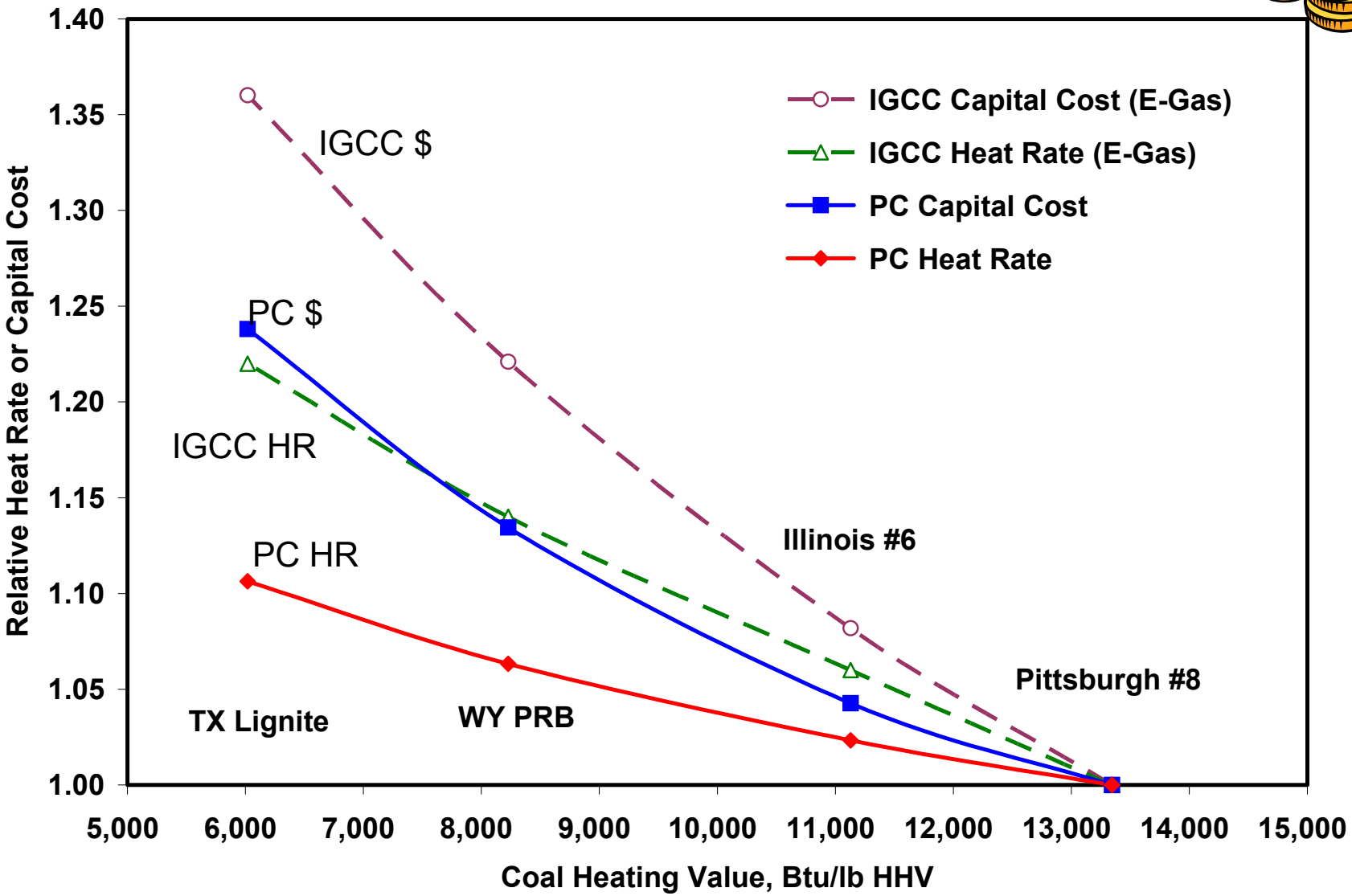
Effect of Coal Quality on PC and IGCC Plant Heat Rates and Capital Cost



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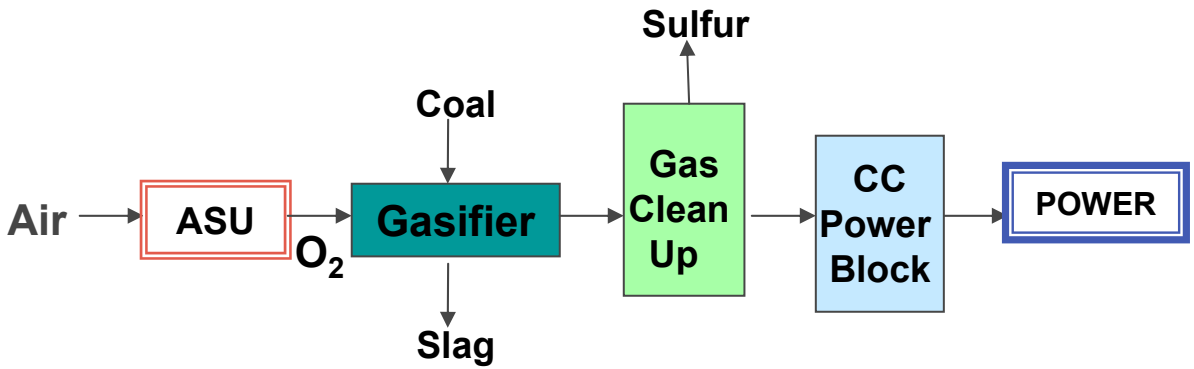
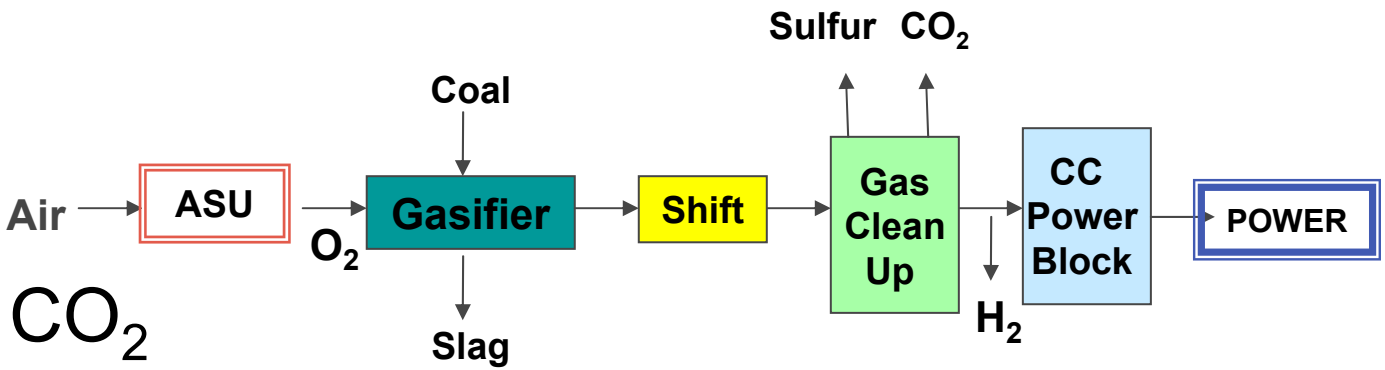
IGCC With and Without CO_2 Removal



IGCC



H_2 & CO_2

(e.g.,FutureGen)

Adds roughly 30-40% to COE to capture and compress CO2

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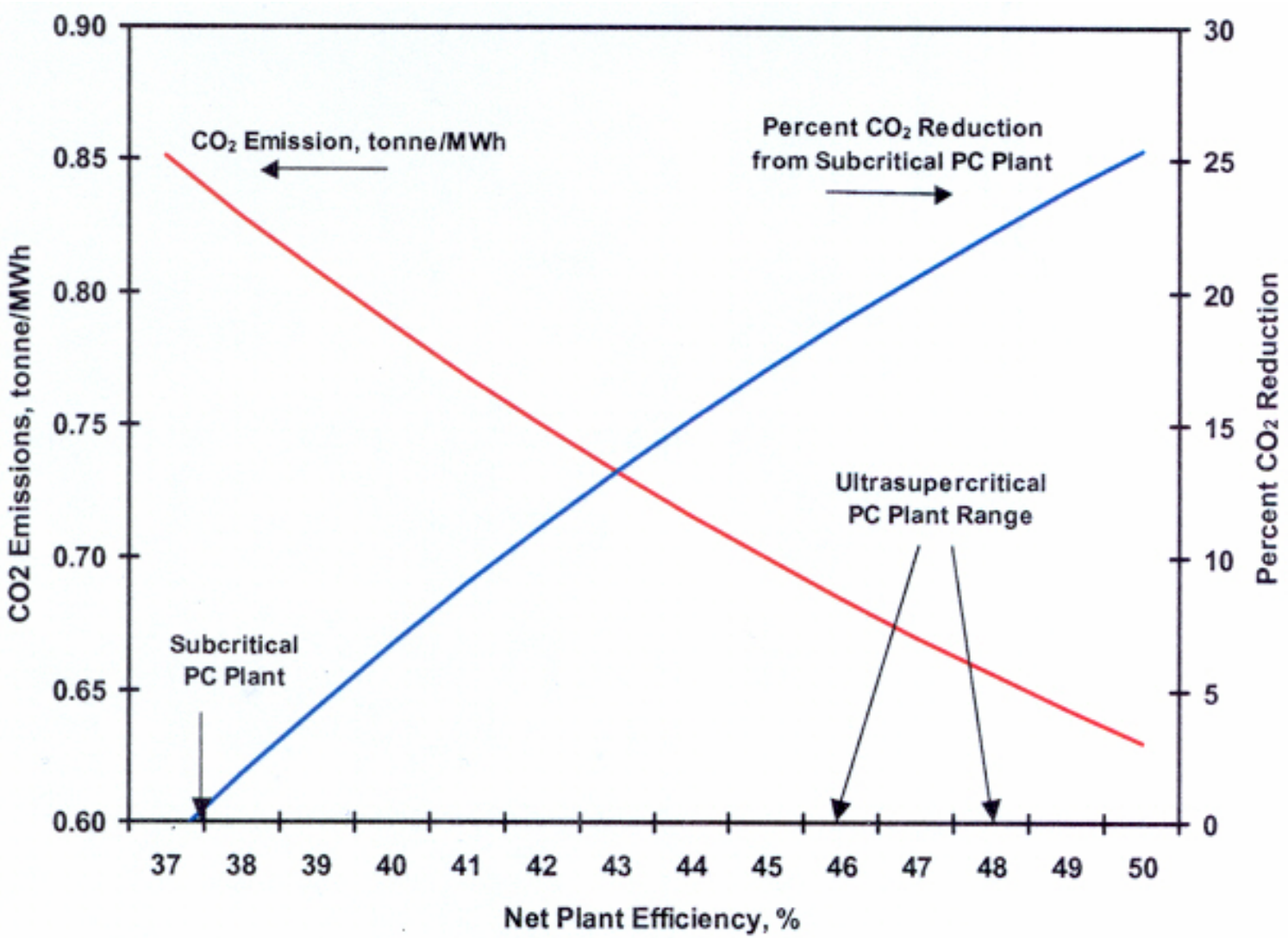
What's Ready to Deploy?

- Ultrasupercritical PC, supercritical FBC, gasification?
- Not really an easy question
  - Ultrasupercritical units with moderate conditions are installed in Europe, Asia where fuel costs are higher. Excellent efficiency, low emissions, higher risk?
  - Supercritical FBC is being built in Europe - fuel flexible
  - Gasification for petroleum residuals is widespread but coal poses questions
- Designs are "one off" in most cases – non standard
  - Costs are higher for first of a kind, no "learning"
- Risks are uncertain so financing costs may be higher
- Future risks (e.g., CO2 control) need to be weighed

Ultrasupercritical Steam Reduces CO_2/MWh



New IGCC/Advanced Coal Deployment Efforts

- Current efforts are underway to reduce the risk and financing costs
- Several Groups are discussing incentives for IGCC or advanced coal use
  - Gasification Technologies Council
  - Harvard
  - IGCC Coalition
  - Coal Utilization Research Council
- DOE Office of Policy is analyzing risk and looking to aim incentives for highest impact
- EPRI and E2I's new collaborative effort **"CoalFleet for Tomorrow"** (includes CO_2 consideration)

EPRI/E2I CoalFleet for Tomorrow

- Kickoff workshop with 70 attendees April 13-14
  - Sense of urgency… we need to do something now
  - Window of new coal opportunity 2008-12 …will it be more of the same?
  - There is no “silver bullet” technology
- Organizing Committee formed
- First phase of work will be complete in 1 year
- EPRI and E2I are engaging partners now

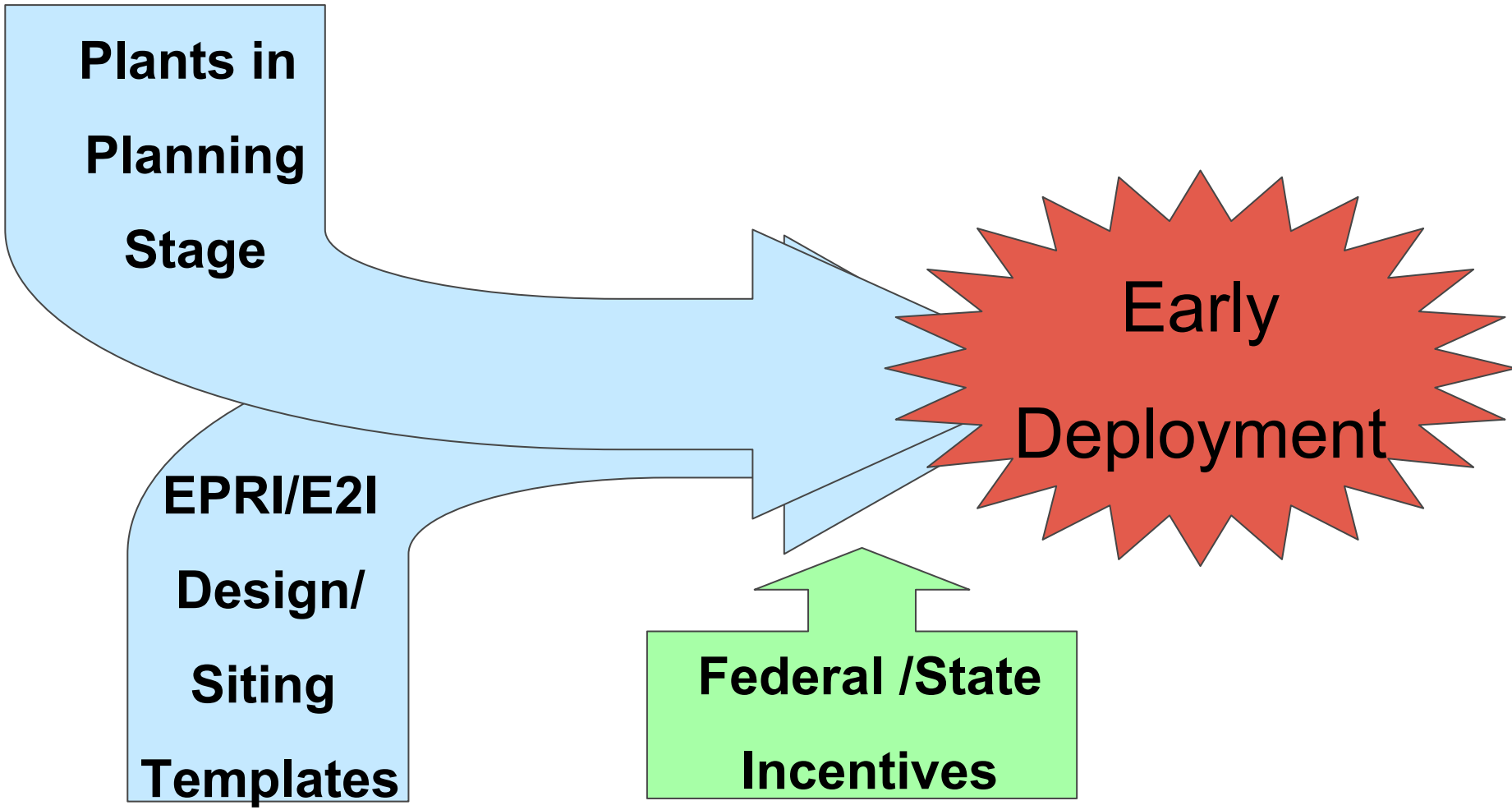
Goals of EPRI/E2I's CoalFleet for Tomorrow

- To accelerate early deployment of 3 to 5 commercial advanced coal plants
  - to be operating in 5 to 10 years
  - with consideration for CO_2 capture adaptability
- To ensure widespread availability of next generation plants
  - To be operating in 2015-2020 timeframe
  - With CO_2 capture adaptability
  - To meet DOE/CURC/EPRI roadmap goals
- Engage industry, government, regulatory and other communities in a partnership to ensure that coal remains a strategic generation option in America's electricity future
- Take advantage of today's "window of opportunity" to ensure the cost-effective and timely transition to the coal fleet of tomorrow

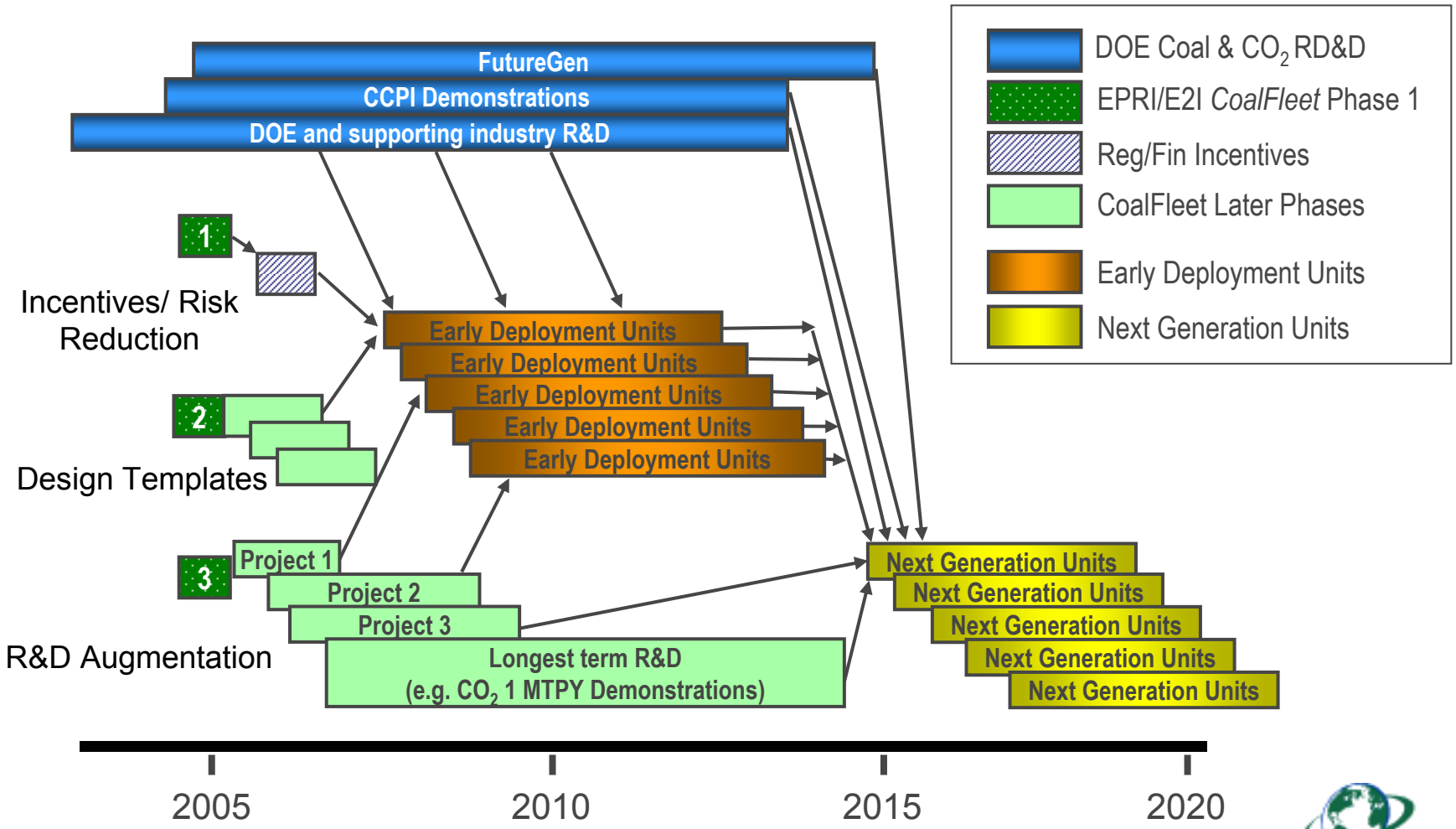
Approach of CoalFleet for Tomorrow

- Initiate an industry-driven public/private partnership
  - Leadership by major coal-based generation owners intending to build advanced coal plants
- Focus efforts on accelerating early deployment
- Involve key stakeholders in active work to ensure commercial viability of advanced coal plants
- Accelerate and augment RD&D for advanced coal generation technology and CO_2 capture and sequestration options
- Three elements of work:
  1. Assess technology risks, trade-offs, and incentives
  2. Develop templates for standardized designs
  3. Accelerate and augment RD&D
- Phase 1 includes first year of work plus plans for Phase 2

CoalFleet for Tomorrow
- A Partnership to Secure Americas Energy Future



How EPRI/E2I *CoalFleet for Tomorrow* Supports Early Deployment



Working Together

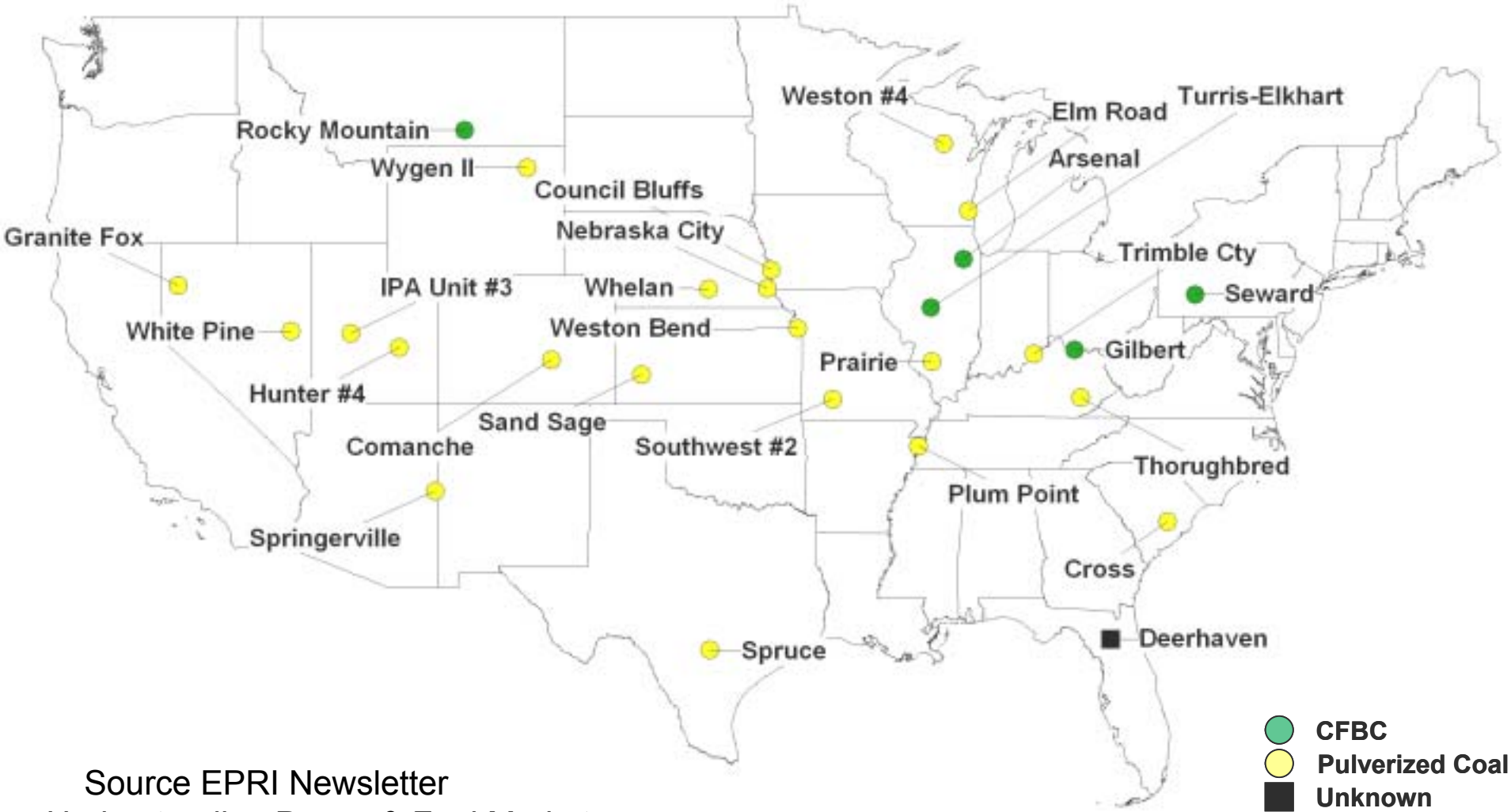
- We see the need for joint review of the options for deployment and the mechanisms to accelerate deployment
- We believe tools and analysis will help identify the options, risks and routes toward a transition of the coal fleet for different coals, technologies and types of companies that will lead the way
- There is both DOE and industry interest in finding ways to accelerate deployment and in developing better, lower cost designs. EPRI and E2I stand ready to work with DOE and others to provide collaborative support.

Summary and Conclusions

- IGCC is more expensive and perceived as less reliable today than conventional coal firing
- Environmental advantages for new technology are clear and costs should come down as new plants are built and improved designs become standard
- To get early plants “on the ground” incentives and /or risk sharing may be needed and this will differ for different coals, types of plant, and types of financing
- We expect to team with many of the participants in this Roundtable to help deploy advanced coal and improve designs

Slides that follow are unpresented

Planned Coal-Fired Power Plants EPRI Considers Higher Probability



Source EPRI Newsletter
Understanding Power & Fuel Markets
P 67 Newsletter 4/04

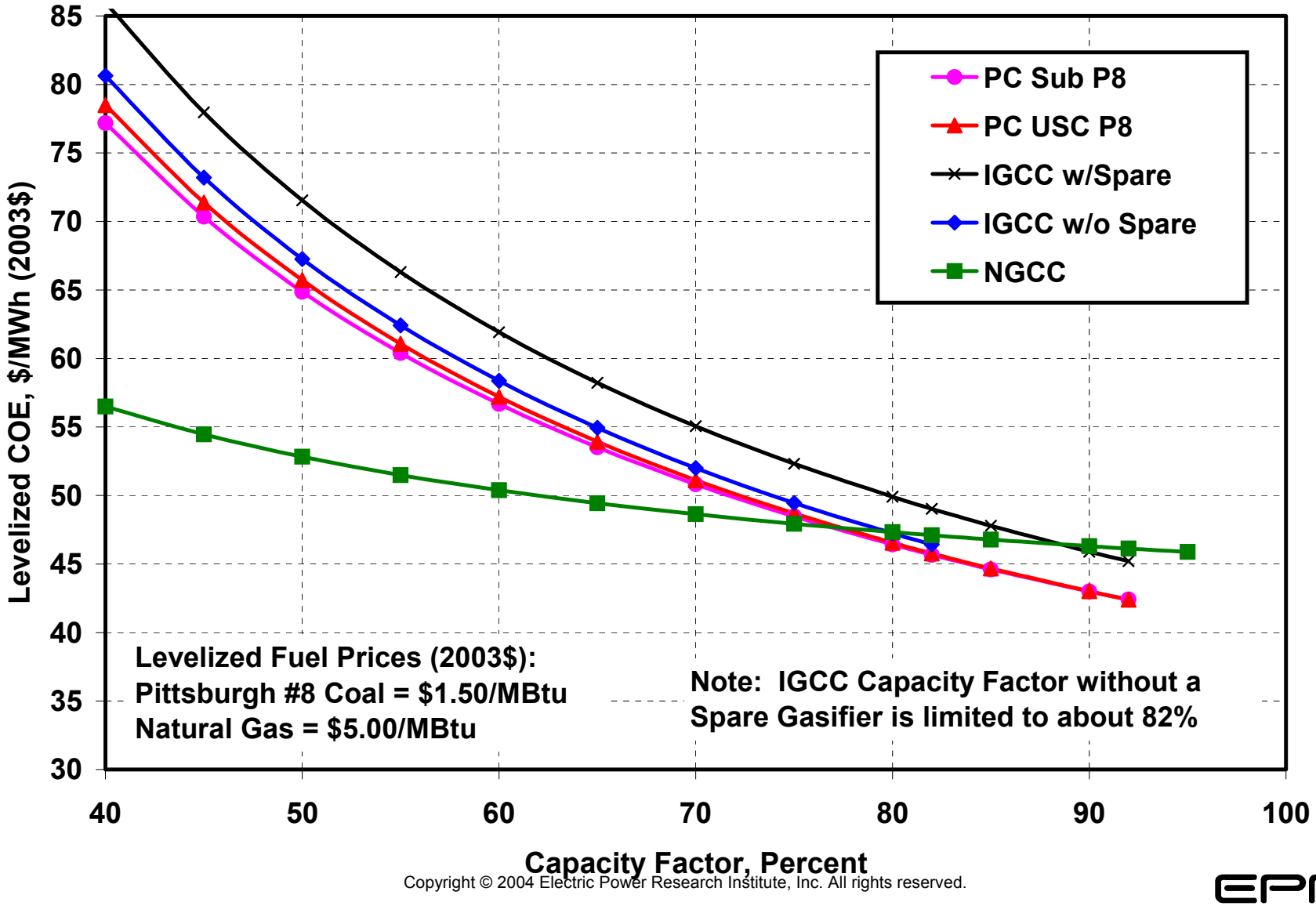
Integrated Gasification Combined Cycle

- IGCC may become the coal technology of choice with carbon constraints
  - Low emissions
  - High efficiency
  - CO_2 capture on Bituminous coal
- Key enabling technology for future coal-based power
- Ability to co-produce hydrogen adds potential for:
  - Clean transportation fuel
  - Significant reduction of green house gas emissions
- But questions remain – cost, reliability

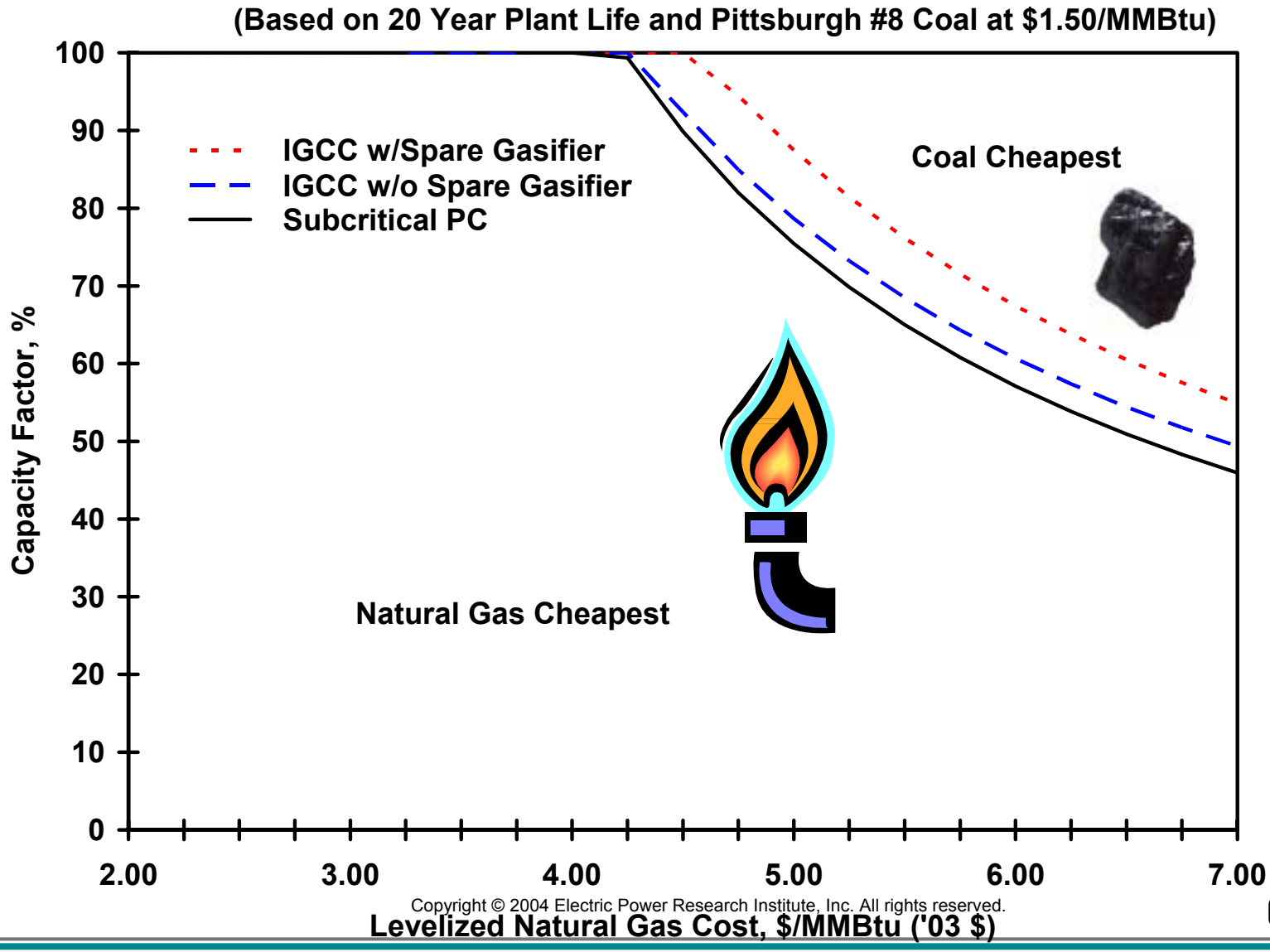
IGCC Environmental Attributes

- Sulfur is removed (98.5-99.99%) from syngas
- NOx emissions are controlled by firing temperature modulation in the gas turbine with SCR possible
- Particulates are removed from the syngas by filters and water wash prior to combustion so emissions are negligible
- Current IGCC design studies plan <3ppmv each of SOx, NOx and CO
- Mercury and other HAP's removed from the syngas by absorption on activated carbon bed
- Water use is lower than conventional coal
- Byproduct slag is vitreous and inert and often salable
- CO2 under pressure takes less energy to remove

Impact of Capacity Factor on Levelized COE



Breakeven Capacity Factor and Fuel Cost for Natural Gas vs Coal



Coal IGCC – Status and Issues

- **Very low SO_2, NOx, and Particulate Emissions** below recent PC plants permit limits
- Global E Gas(CoP), Texaco(C-T- soon to be GE), Shell and Prenflo (Now Shell) gasifiers successfully **demonstrated at commercial size**
- **Cost / Economics is the big barrier**
- Existing single gasifier "train" **IGCC coal plants (no spare) have not yet achieved their yearly availability targets of 85%–** although on a quarterly basis the targets have been achieved. Commercial plants with spare gasifiers should achieve >90% availability allowing 80% capacity factor
- Highly **Integrated designs used in the European IGCC is not recommended**
- **Gasification of petroleum residuals** is providing power, steam and hydrogen worldwide.
- **Future advances** in air separation, gasification, gas clean up, gas turbine and fuel cell technologies **will improve efficiency and lower cost**

Costs of CO_2 Removal from a New Fossil Fuel Power Plant - an EPRI Estimate

Fuel Cost $/MBtu	Technology	COE $/MWh without Capture	COE $/MWh with Capture	COE $MWH with Capture and Sequestration	Avoided Cost $/Metric Ton of Carbon
3.50 NG	NGCC F 525 MW	36.5	59.0	61.1	267
5.00NG	NGCC 525 MW	47.3	72.8	74.9	300
1.50 Pitts #8	Texaco Quench IGCC F 520 MW	48.6	61.0	65.3	88
1.50 Pitts #8	USC PC 600 MW	45.0	75.4	79.8	174

Notes: Pittsburg #8 coal at $1.50MBtu delivered
Natural Gas at $3.50 and $5.00MBtu
Cost of CO_2 Transportation and Sequestration $5/metric ton of CO_2
Plant Size with CO_2 removal ~ 450MW
Capacity Factor 80% for all technologies

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