



Pulverized Coal and IGCC Plant Cost and Performance Estimates

George Booras
Neville Holt
EPRI
Palo Alto, CA

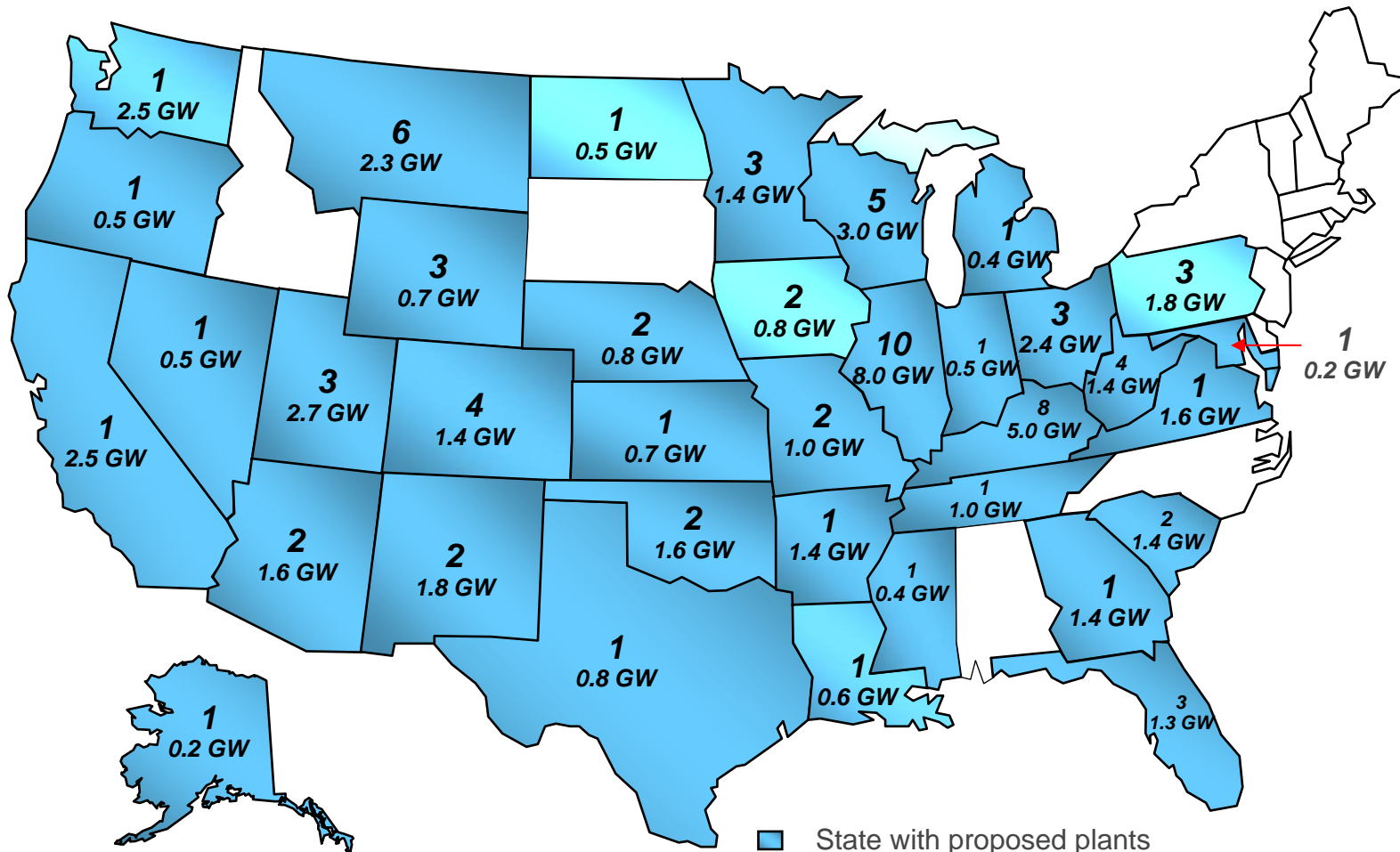
Gasification Technologies 2004
Washington, DC
October 3-6, 2004

Presentation Outline

- Overview of Coal-Fired Generation
- General and Technology Specific Design Bases
- PC and IGCC Performance Estimates
 - Comparison of US and European Heat Rates
- Capital Cost and Economic Analysis Bases
- PC and IGCC Capital Cost Estimates
- Effects of Coal Quality on PC and IGCC Cost and Performance
- Cost of Electricity and Sensitivity Analyses
 - Comparison with Natural Gas-Fired Combined Cycle
 - Impact of Capacity Factor
- Conclusions

Coal-Fired Power Plants are Back!

100 New Coal Plants Announced Since 2000



Number of proposed new coal-fueled generating plants and gigawatts of capacity. Source: U.S. Department of Energy, National Energy Technology Laboratory, February 24, 2004.

What Technology Is Being Planned?

- Primarily pulverized coal-fired plants
- Most use subcritical steam cycle, but supercritical steam cycles are gaining acceptance
- Trend is towards larger plant sizes to get economy of scale
 - Many projects involve multiple partners
- Integrated Gasification Combined Cycle (IGCC) offers improved environmental performance, but higher capital costs and the perception of greater risk are slowing deployment

What technical and economic factors drive the decision to build a new coal-based power plant and the choice of technology?

General Design Basis

- Mid-America plant site (Kenosha, Wisconsin)
- Plant size = nominal 500 MW net
- Design Coals
 - Pittsburgh #8 Bituminous
HHV = 13,260 Btu/lb (30.84 MJ/kg), Ash = 7.1%, Sulfur = 2.1%
 - Illinois #6 Bituminous
HHV = 10,982 Btu/lb (25.54 MJ/kg), Ash = 11%, Sulfur = 3.3%
- Design ambient temperature = 60°F (15.5°C)
- Design ambient pressure = 14.4 psia (0.99 bar)
- Cooling water from mechanical draft cooling towers

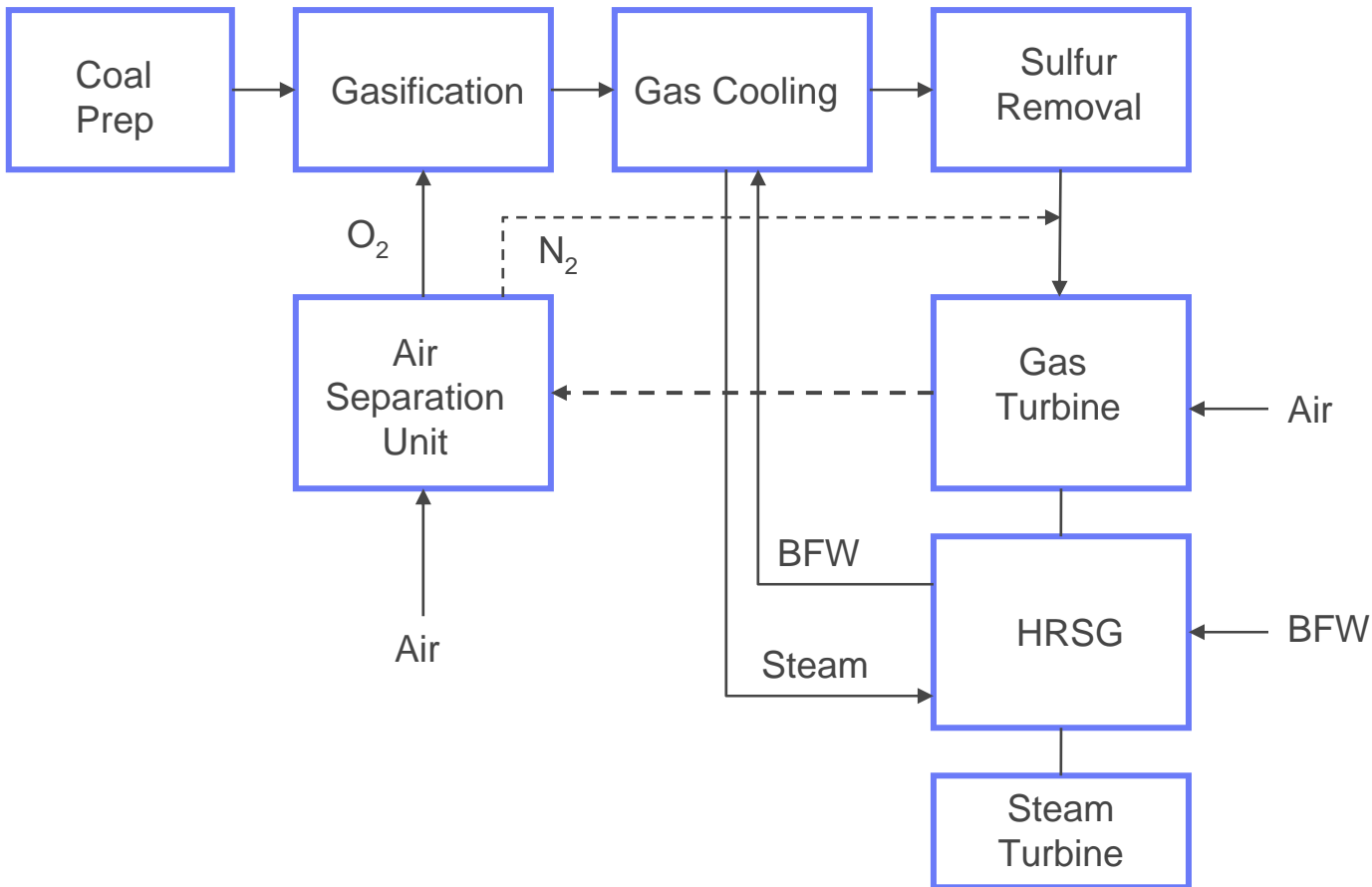
Pulverized Coal Plant Design Basis

- Steam Cycles
 - Subcritical: 2400 psi/1000°F/1000°F
(16.5 Mpa/538°C/538°C)
 - Supercritical: 3600 psi/1100°F/1100°F
(24.8 Mpa/593°C/593°C)
- Condenser pressure = 2.0 in HgA (68 mbar)
- Emission Controls
 - Wet limestone FGD for 95% sulfur removal
 - Low NO_x burners and SCR for emissions <0.1 lb/MBtu
 - Baghouse for particulate control

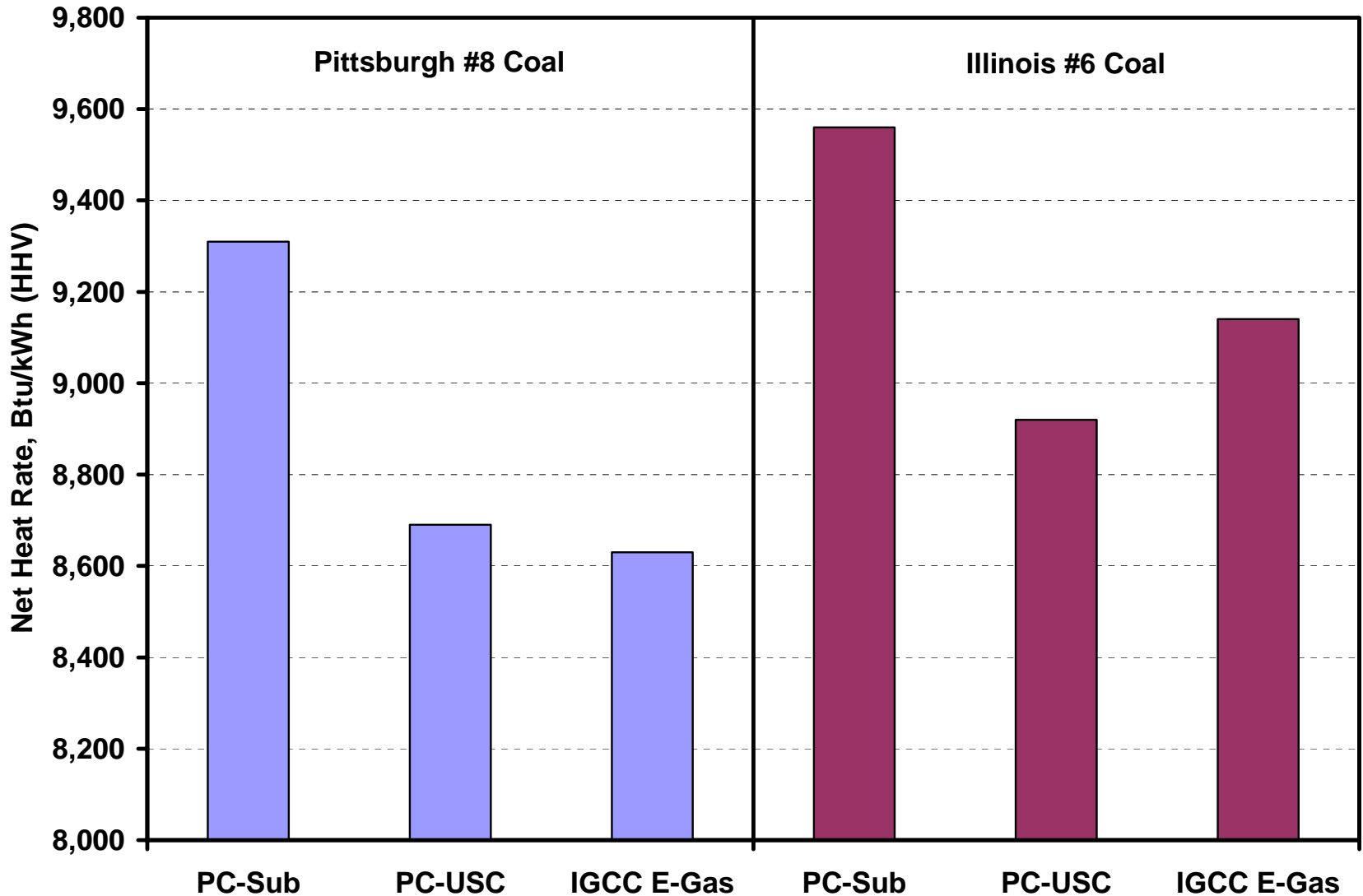
IGCC Design Basis

- Two GE 7FA+e gas turbines
- Two operating E-Gas gasification trains
 - Sized to fully load CT's at 60°F (15.5°C)
- Two cryogenic air separation (ASU) trains
 - 95% oxygen purity
 - Partial air integration with CT (25-35%)
- Reheat steam cycle (1800 psi/1000°F/1000°F)
(12.4 Mpa/538°C/538°C)
- Condenser pressure = 2.0 in HgA (68 mbar)
- Syngas sulfur content = 15 ppmv
- NO_x control by fuel gas moisturization and nitrogen dilution

IGCC with Partial ASU-GT Integration



PC and IGCC Net Plant Heat Rates



Comparison of US and European Heat Rates

- US Utilities prefer Higher Heating Value (HHV) basis
 - Fuel is purchased on HHV basis
- Lower Heating Value (LHV) is used in Europe
 - LHV gives truer measure of recoverable energy
 - LHV calculation formula should include moisture in coal
$$\text{LHV} = \text{HHV} - (91.1436 * \text{H} + 10.3181 * \text{H}_2\text{O} + 0.3439 * \text{O})$$
where H, H₂O, and O are on an as-received basis
- Many European plants use higher quality import coals
 - Improved boiler efficiency due to lower moisture, ash and sulfur content
 - Lower auxiliary power due to lower sulfur content

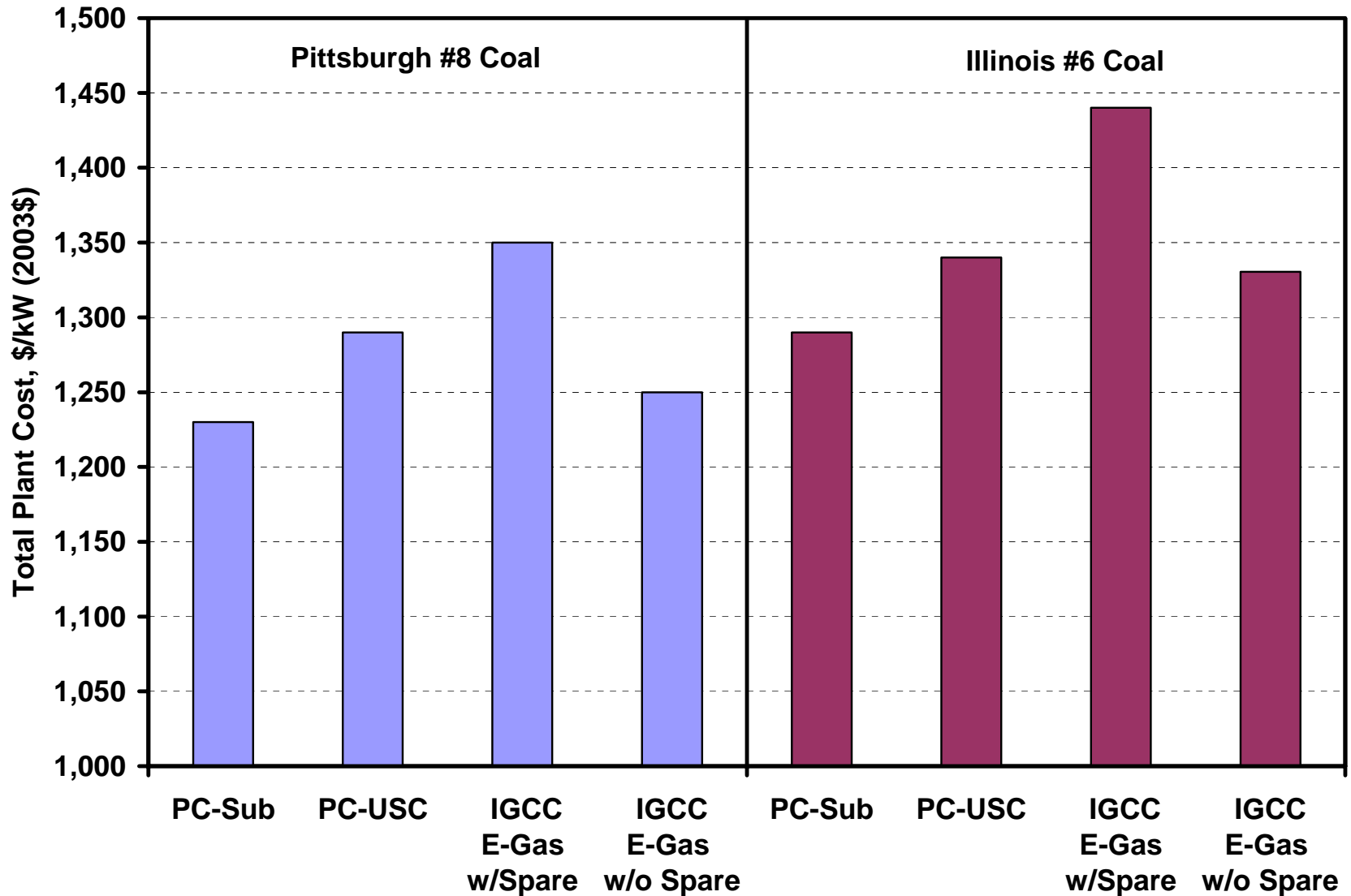
Comparison of US and European Heat Rates (continued)

- Boiler efficiency standards (ASME vs DIN)
 - Heat loss and design margin differences
- Colder European climate
 - Lower cooling water temperatures
 - Lower condenser pressures
 - Greater availability of once-through cooling
 - Reduces auxiliary power requirements
- Combined effects result in European reported heat rates that may be 8-10% lower than US plants with similar steam conditions

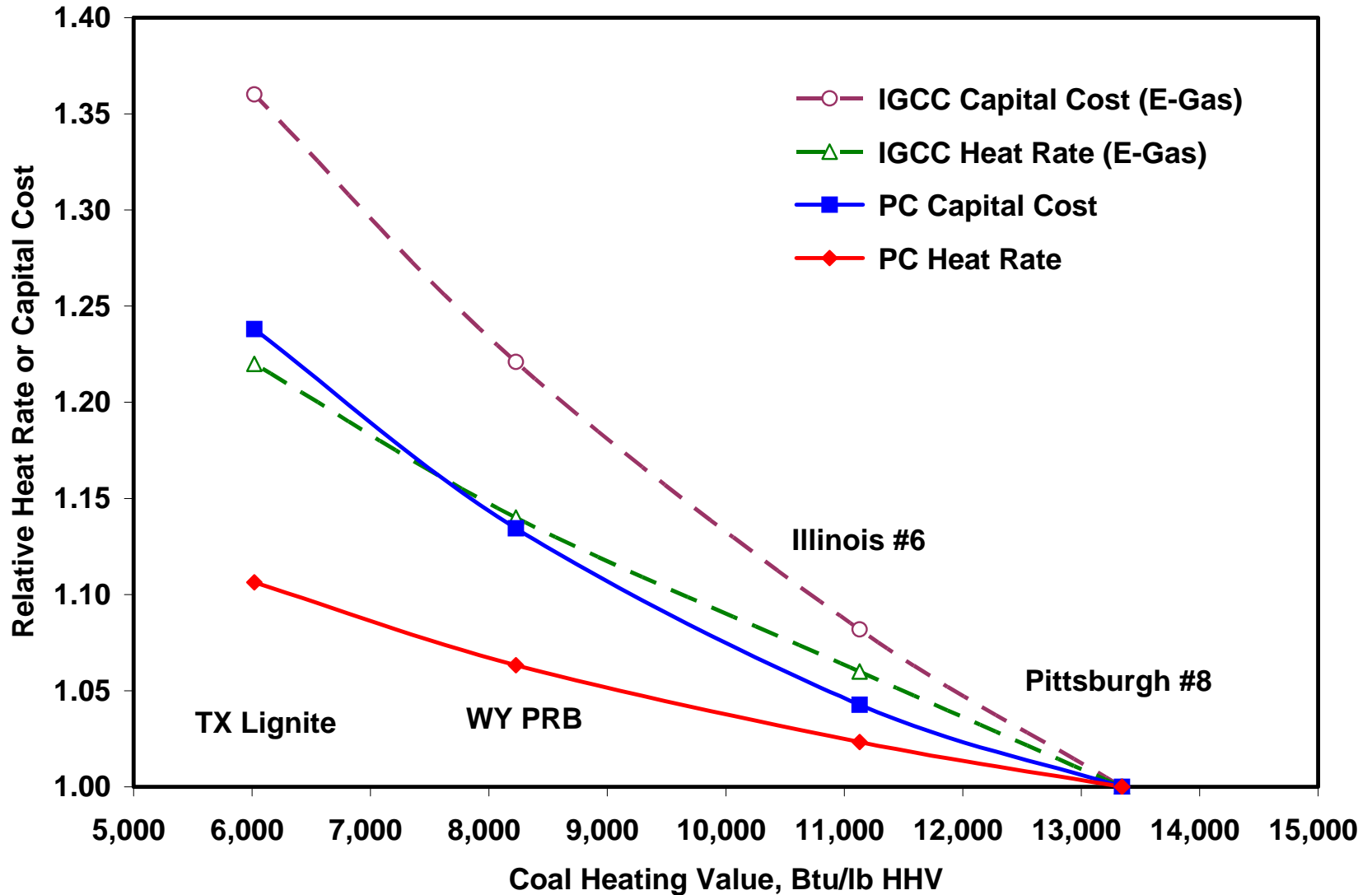
Capital Cost and Economic Analysis Bases

- All costs are in 2003 US dollars
- Construction labor costs based on union wage rates
- Constant dollar levelized cost of electricity based on:
 - EPRI TAG methodology and financial parameters
 - 20 year book life
- Average annual capacity factor = 80%
- Fuel costs (HHV basis):
 - Pittsburgh #8 coal = \$1.50/MBtu (\$1.42/GJ)
 - Illinois #6 coal = \$1.00/MBtu (\$0.95/GJ)
 - Natural gas = \$5.00/MBtu (\$4.74/GJ)

PC and IGCC Capital Costs

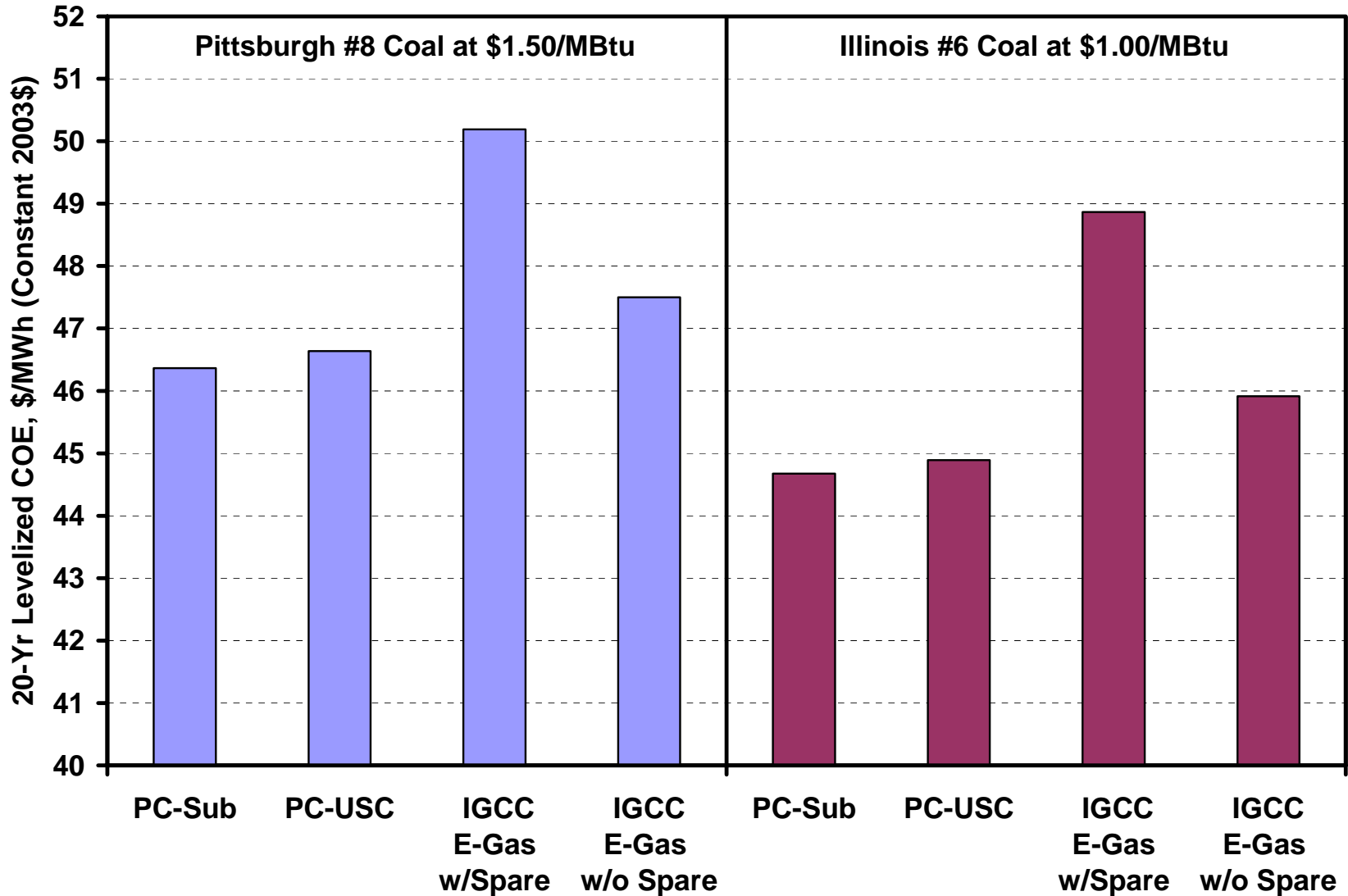


Effect of Coal Quality on PC and IGCC Plant Heat Rates and Capital Cost



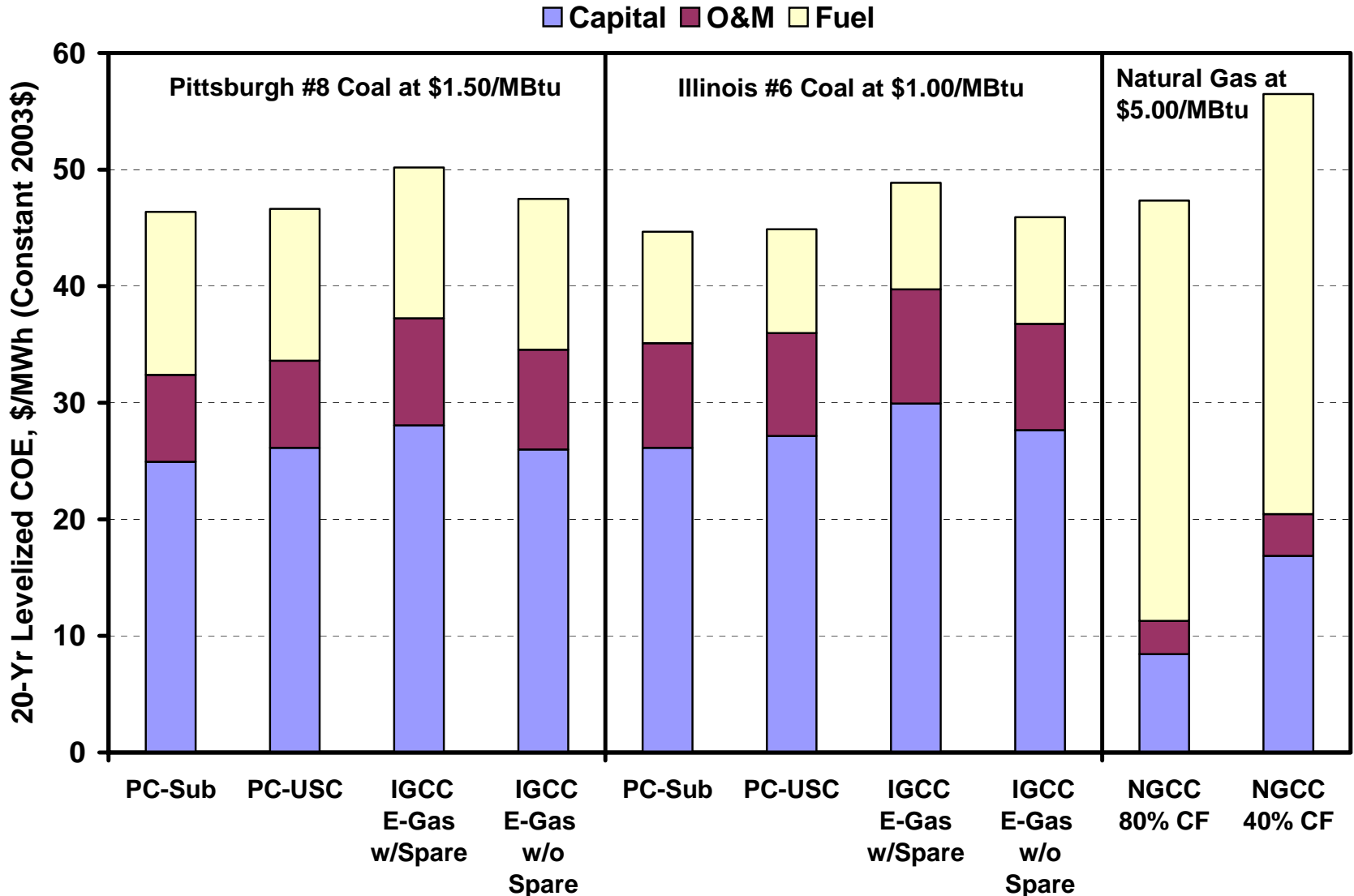
Levelized Cost of Electricity

(Assumes 80% Capacity Factor)

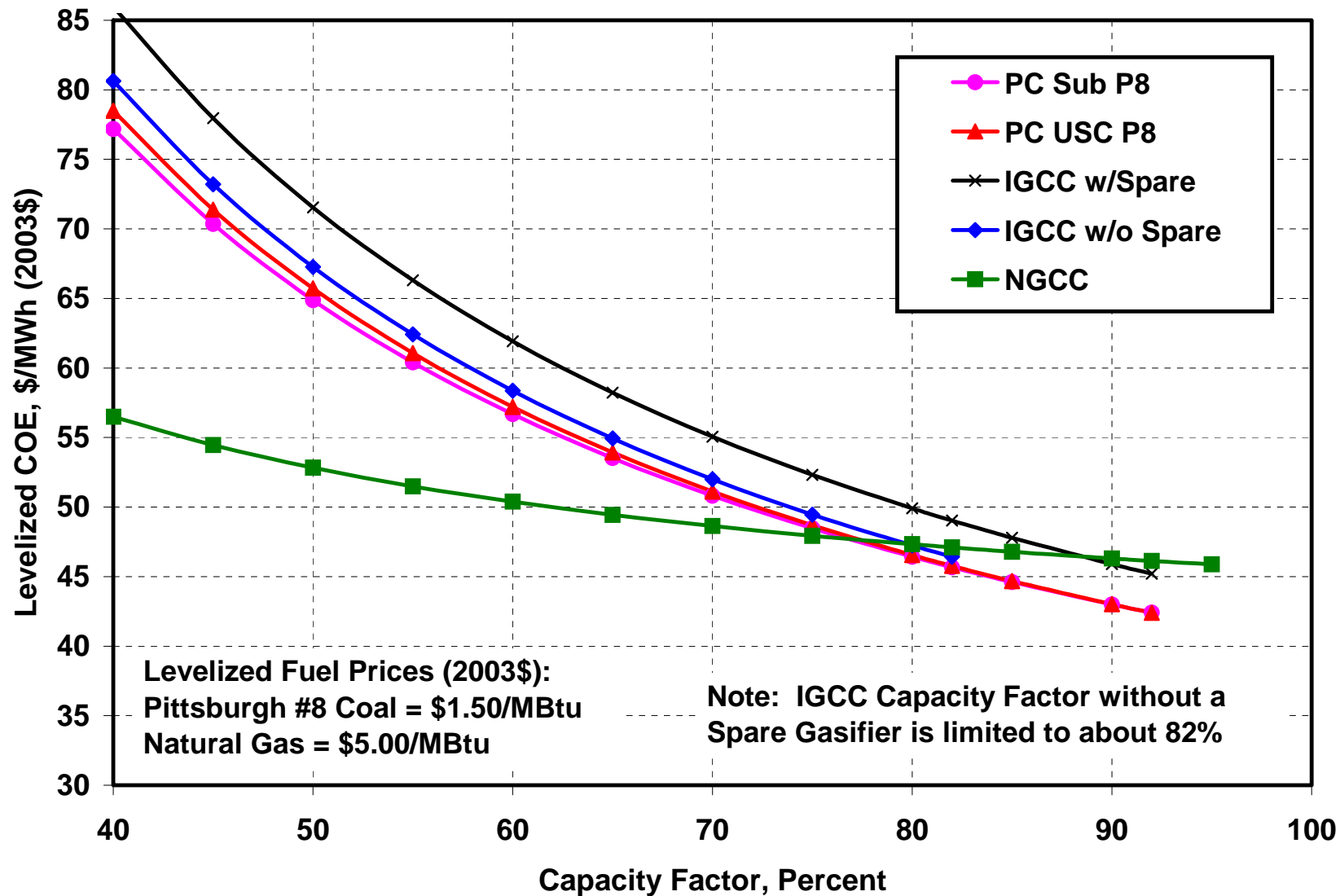


Levelized Cost of Electricity

(Assumes 80% Capacity Factor for Coal Technologies)



Impact of Capacity Factor on Levelized COE



Conclusions

- The improved efficiency of supercritical PC plants is off-set by higher capital costs, resulting in nearly the same cost of electricity as subcritical PC plants
 - However the improved efficiency leads to reduced CO₂ emissions on a per kWh basis
- IGCC plants are nearly competitive with PC plants for Pittsburgh #8 coal, if a spare gasifier is not required
- The gap between IGCC and PC increases for Illinois #6 coal
 - Lower coal rank adversely impacts heat rate and cost
- IGCC has additional cost elements and higher perceived risk
 - Increased owners costs and higher financing costs
 - Additional incentives for IGCC may be required