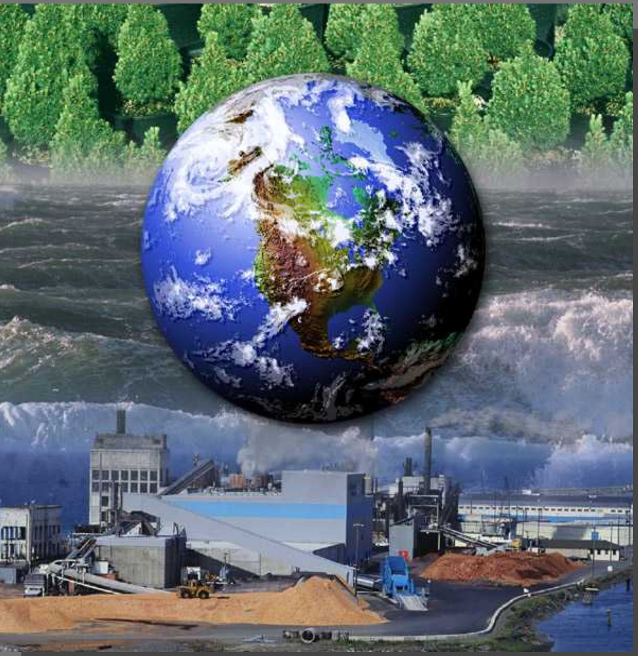

Economic Analysis of Ultrasupercritical PC Plants

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August 4, 2003

EPRI

Presentation Outline

- Economic Analysis Methodology
  - Capital Cost Estimating Basis
  - Revenue Requirement Methodology
  - EPRI PC Plant Cost & Performance Model
- Assessment of Competing Technologies
  - Conventional Pulverized Coal Plants
  - Integrated Gasification Combined Cycle
- Breakeven Capital Cost for USC Plants
- Sensitivity Analysis
- Conclusions

Economic Analysis Methodology

- USC plants offer very high efficiencies
  - Greater than 45% (HHV) vs today's 36 to 39%
- Advanced materials for USC plants will be expensive
  - How much can you afford to pay for the higher efficiency?
- Determine allowable USC capital cost resulting in same cost of electricity the competing technology (i.e., conventional PC)
  - Higher net plant efficiency leads to lower fuel cost and lower $/kW pollution control & BOP costs (less coal feed)
  - Boiler/steam turbine costs can be higher
- Use EPRI PCCost model for estimating capital costs
- Use TAG revenue requirement methodology for cost of electricity

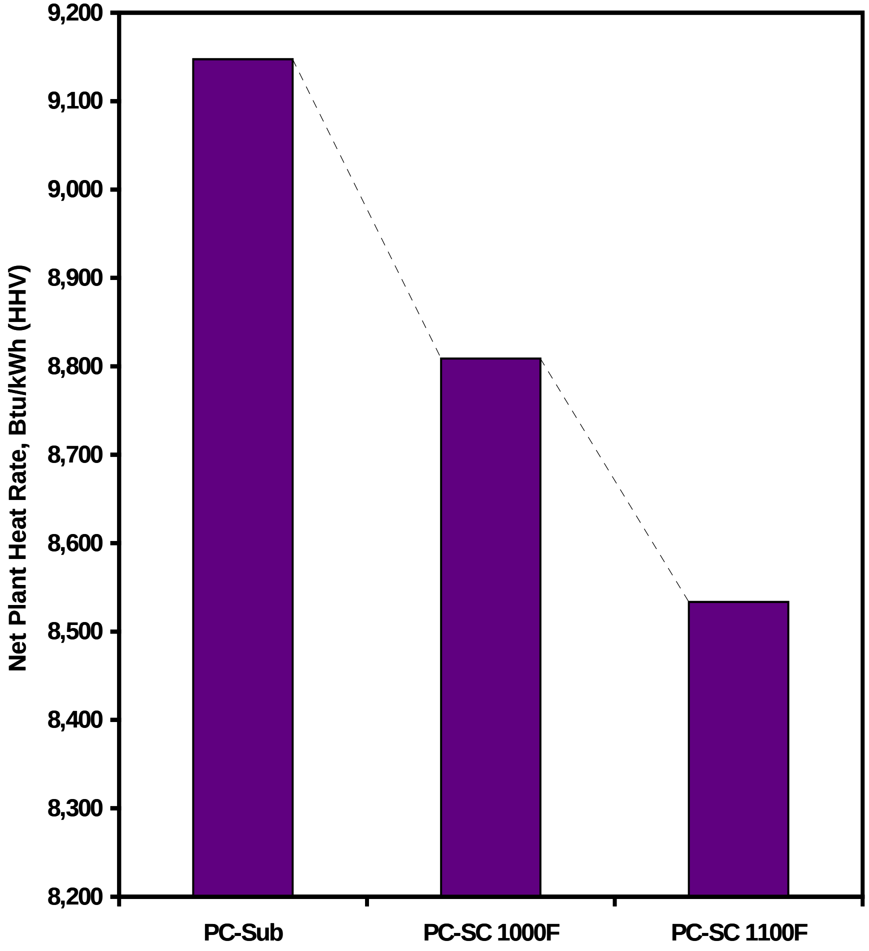
Assessment of Competing Technologies

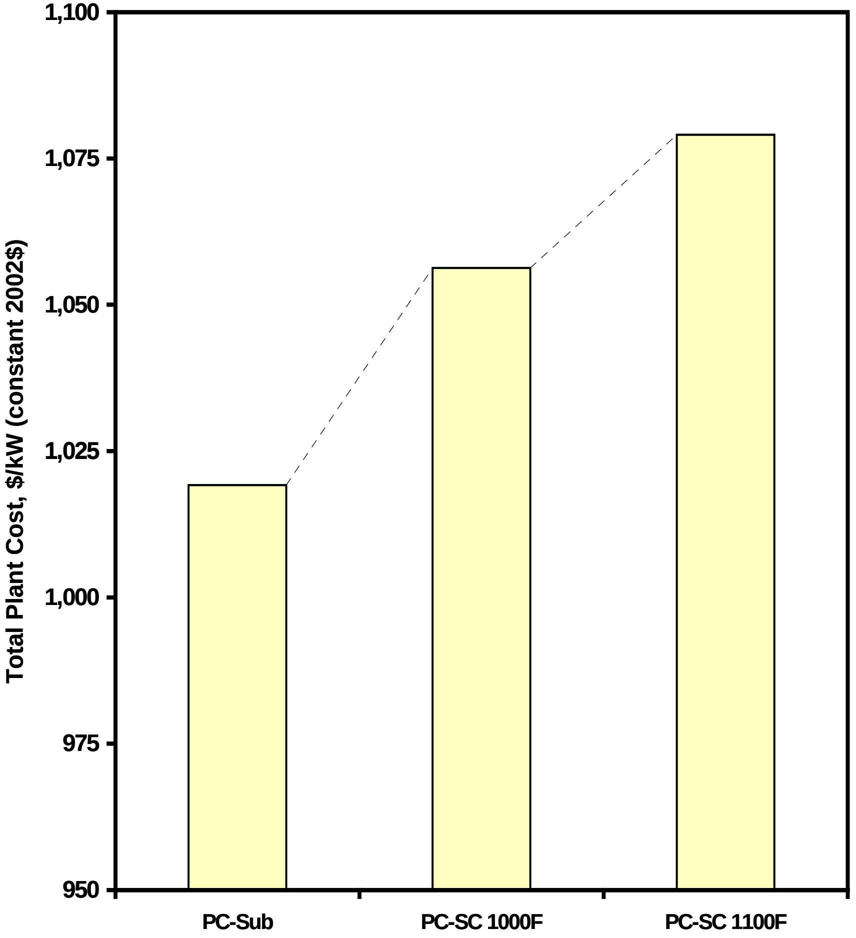
Conventional Pulverized Coal Plants

- Plant Size = 745 MW
- Steam Cycles
  - Subcritical: 2400 psig/1000°F/1000°F
  - Supercritical: 3600 psig/1000°F/1000°F
  - Supercritical: 3600 psig/1100°F/1100°F
- Condenser pressure = 2.0 in HgA
- Design Coal
  - Pittsburgh Bituminous

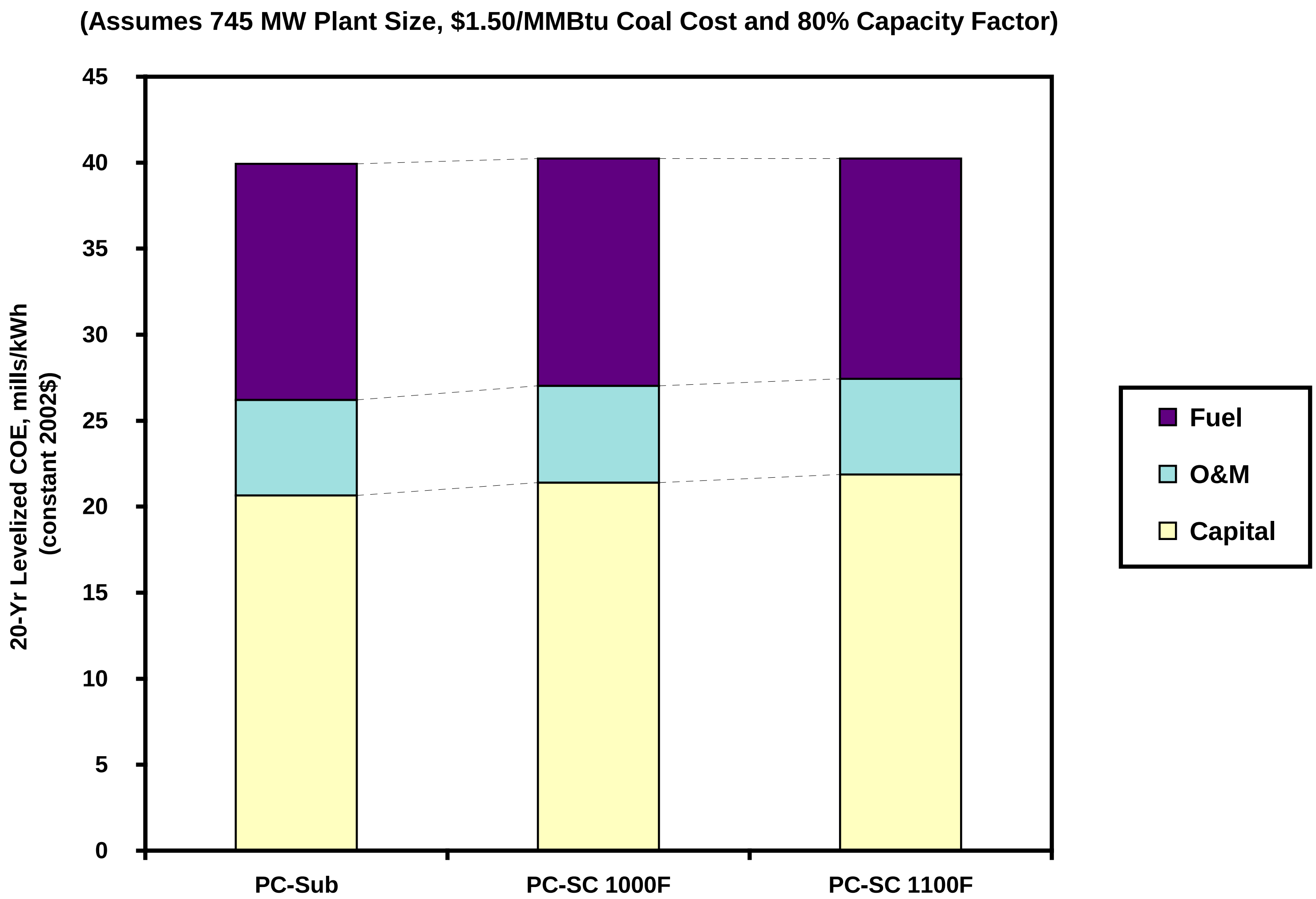
    HHV = 13,260 Btu/lb, Ash = 7.1%, Sulfur = 2.1%

PC Heat Rates & Cost vs Steam Cycle
(Based on 745 MW Plant Sizes)

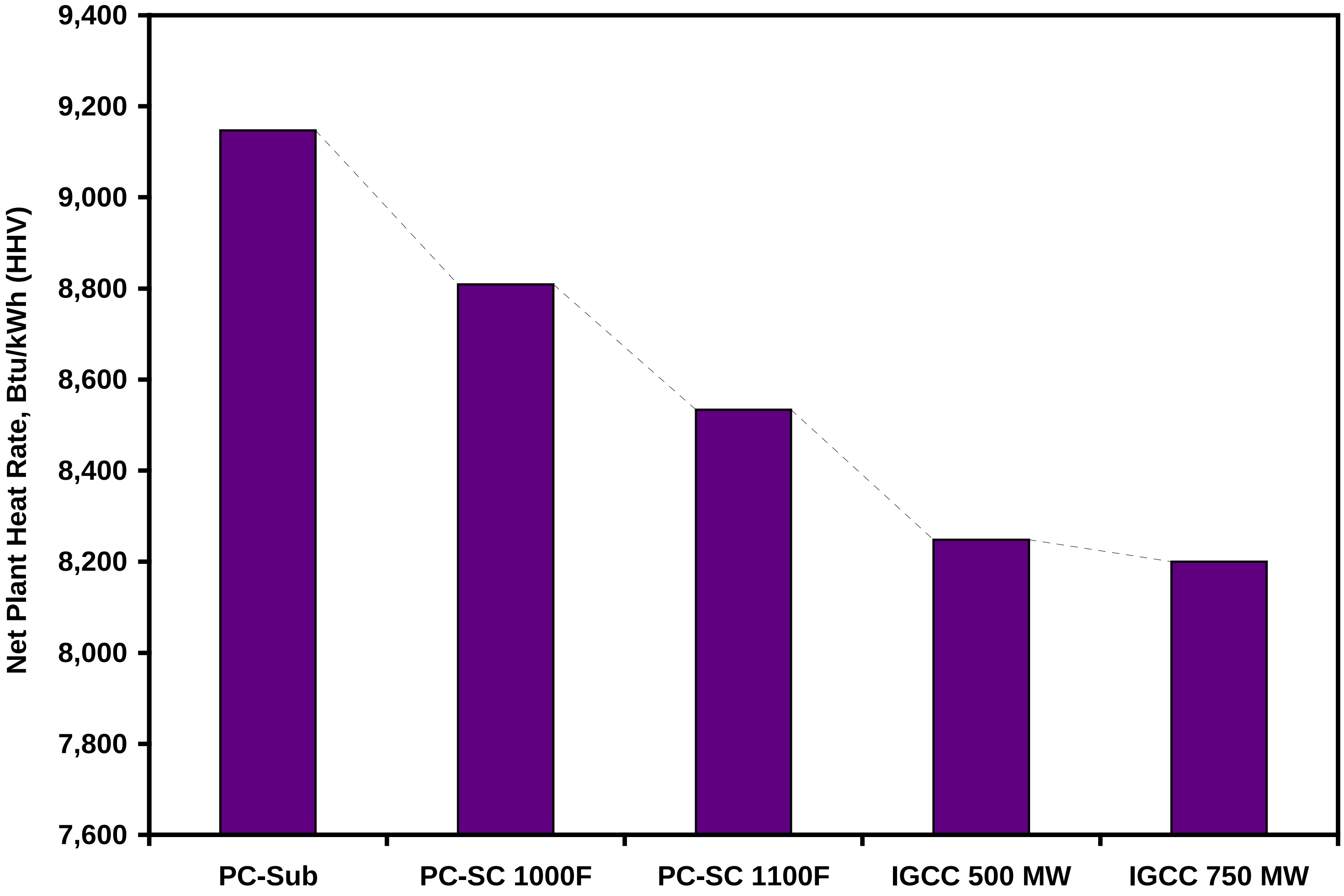




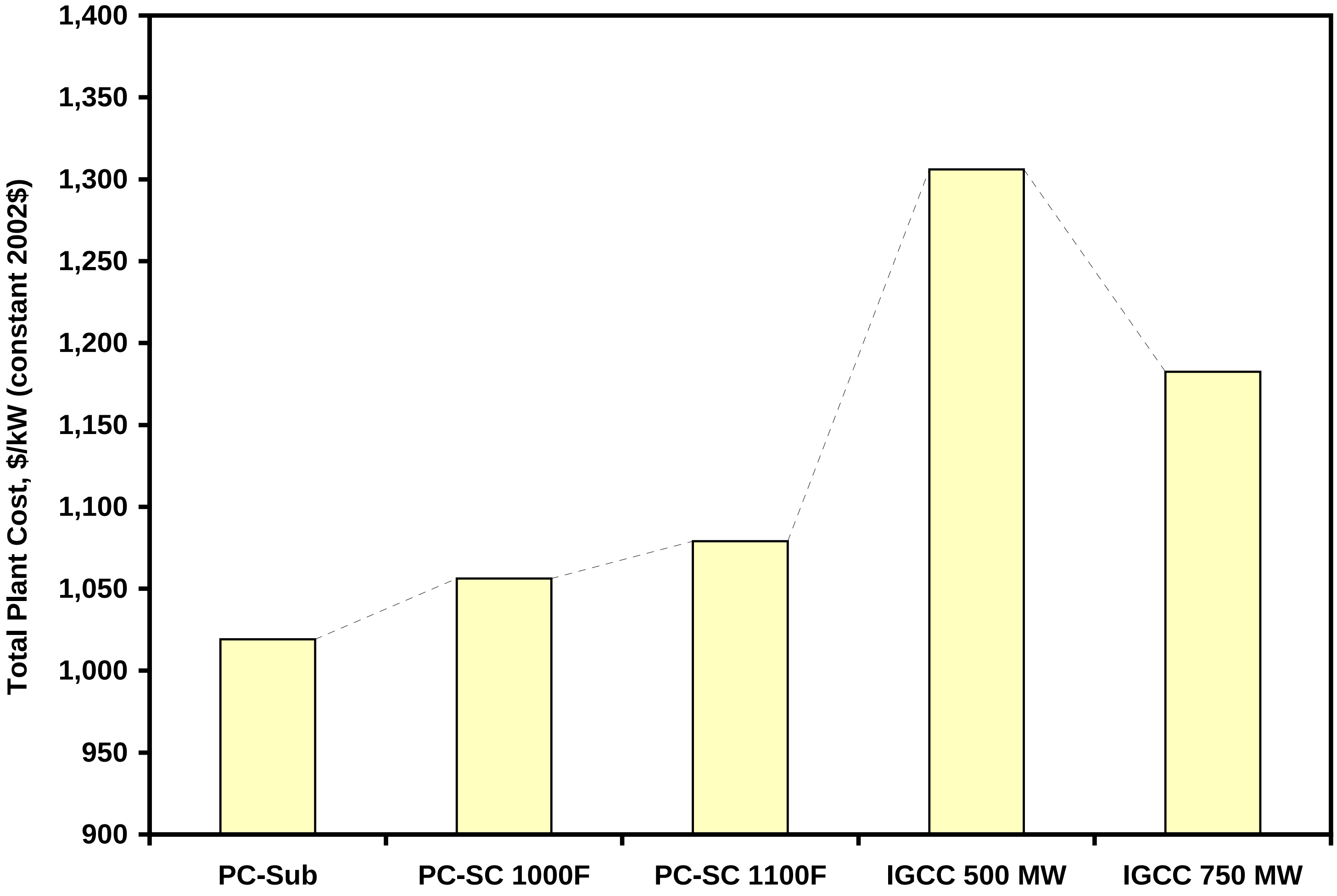
Levelized Cost of Electricity vs Plant Size and Steam Cycle



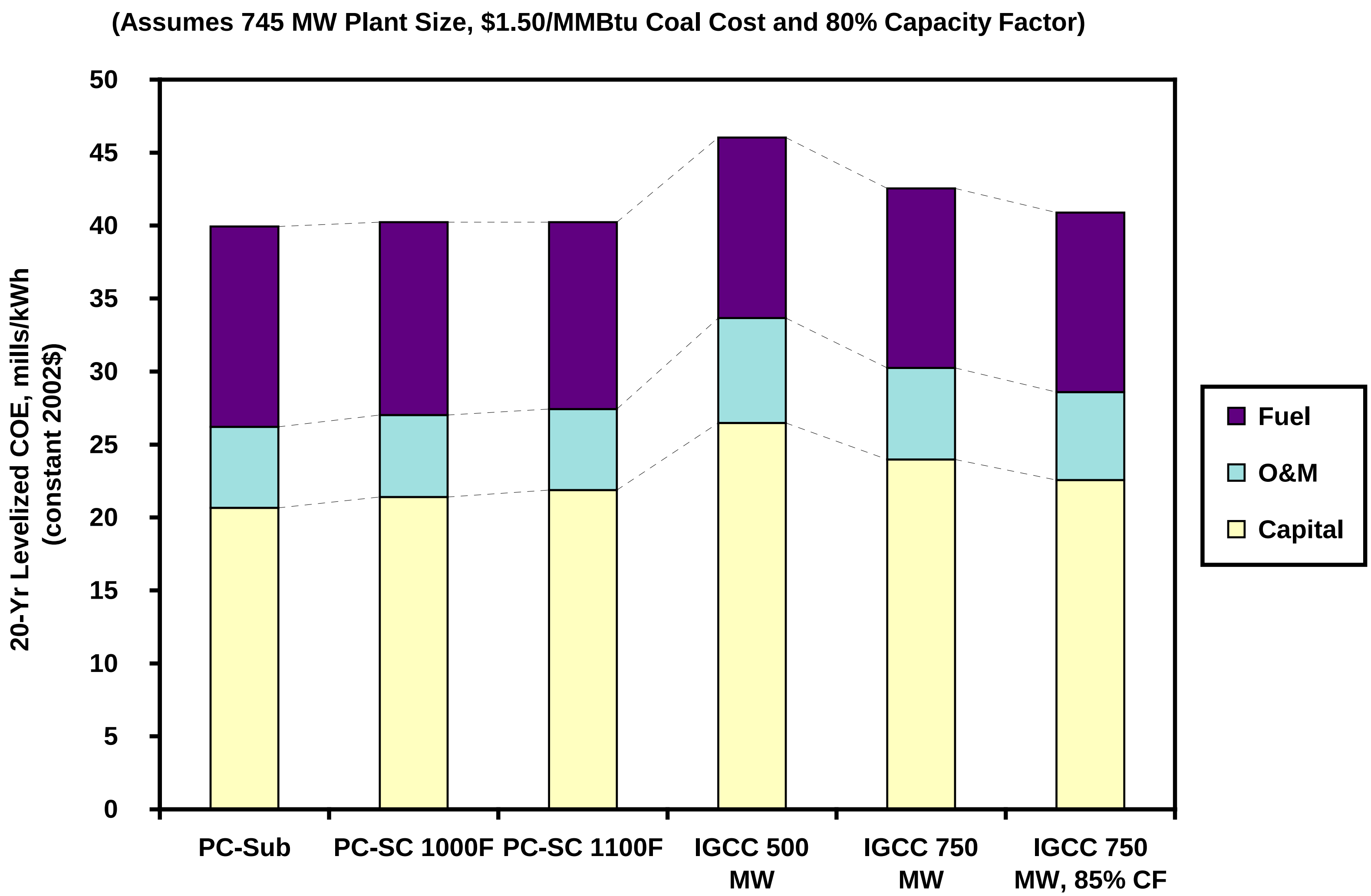
PC vs IGCC Heat Rates
(Based on 745 MW Plant Sizes)



PC vs IGCC Capital Costs
(Based on 745 MW Plant Sizes)



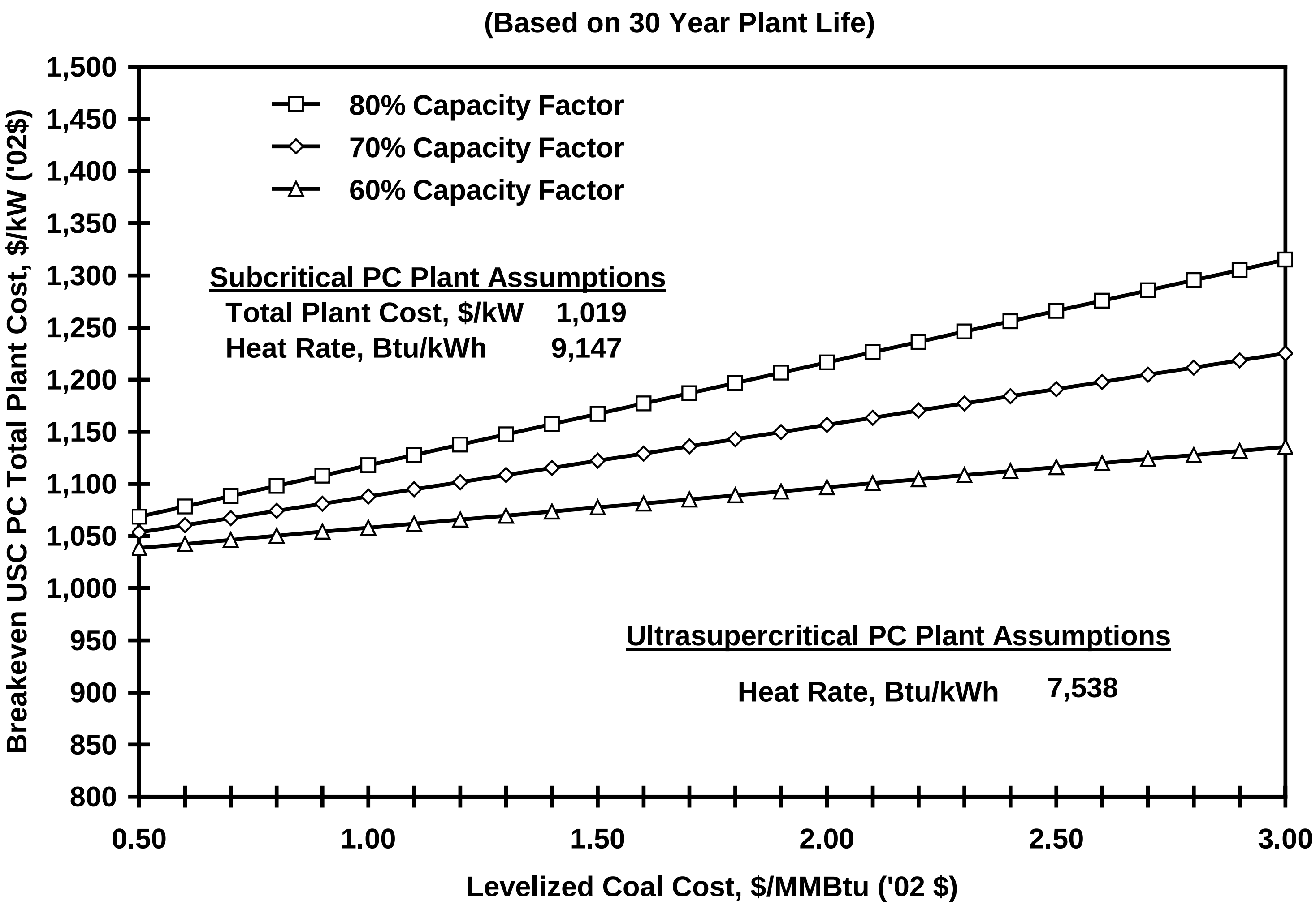
Levelized Cost of Electricity for Subcritical & Supercritical PC vs IGCC



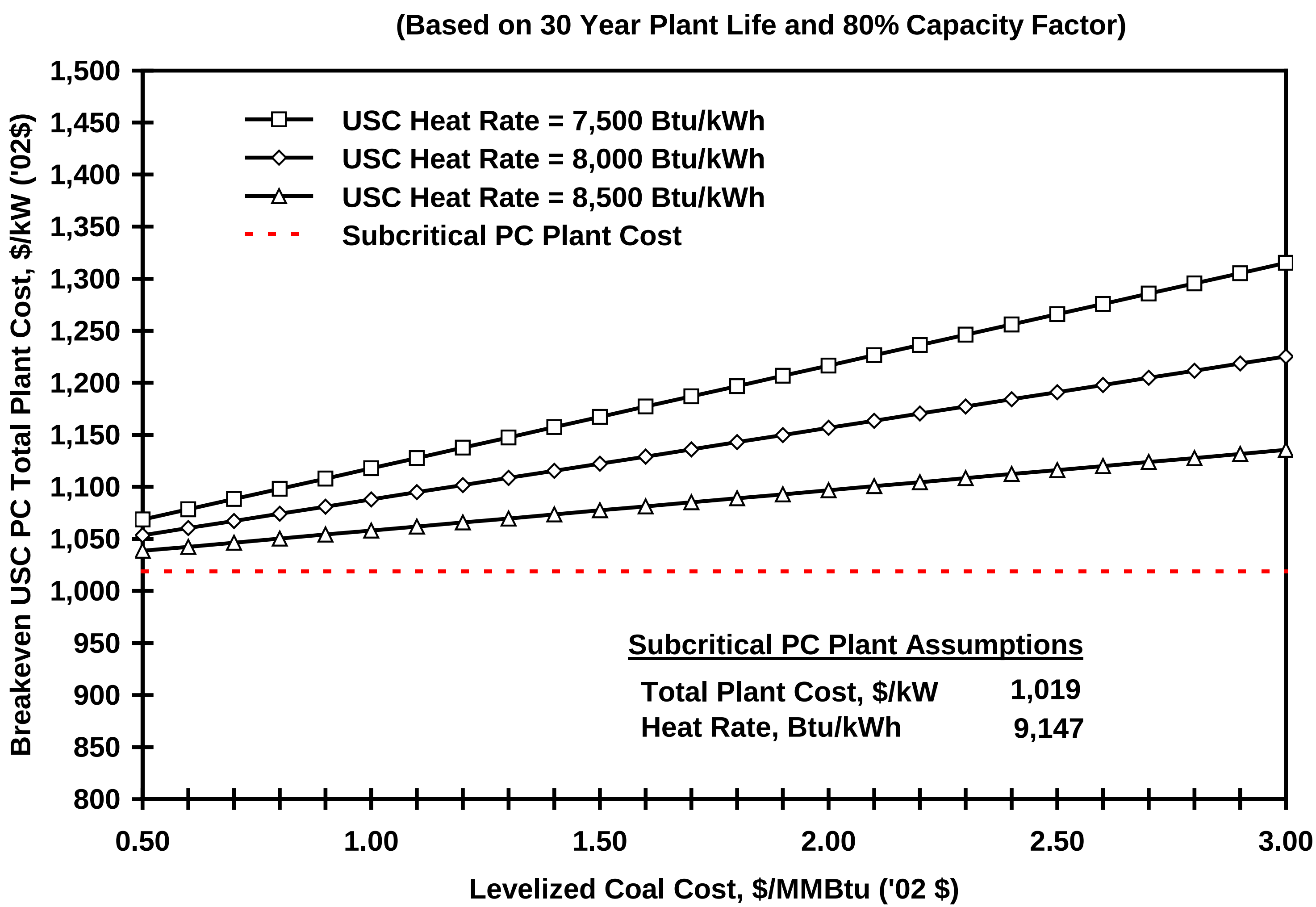
USC PC Plant Economic Assessment

- USC Steam Cycle Parameters
  - 5000 psig/1350°F/1400°F and 5000 psig/1400°F/1400°F
  - Condenser pressure = 2.0 in HgA
- Overall Plant Efficiency ~ 45 to 46% based on B&W heat balances
  - Net Heat Rates ~ 7400 to 7600 Btu/kWh
  - B&W efficiencies for 1350°F were 44.70 to 44.85%
  - B&W efficiencies for 1400°F were 44.95 to 45.27%
- Assume highest efficiency for breakeven cost analysis
  - 45.27% (HHV basis) or 7,538 Btu/kWh

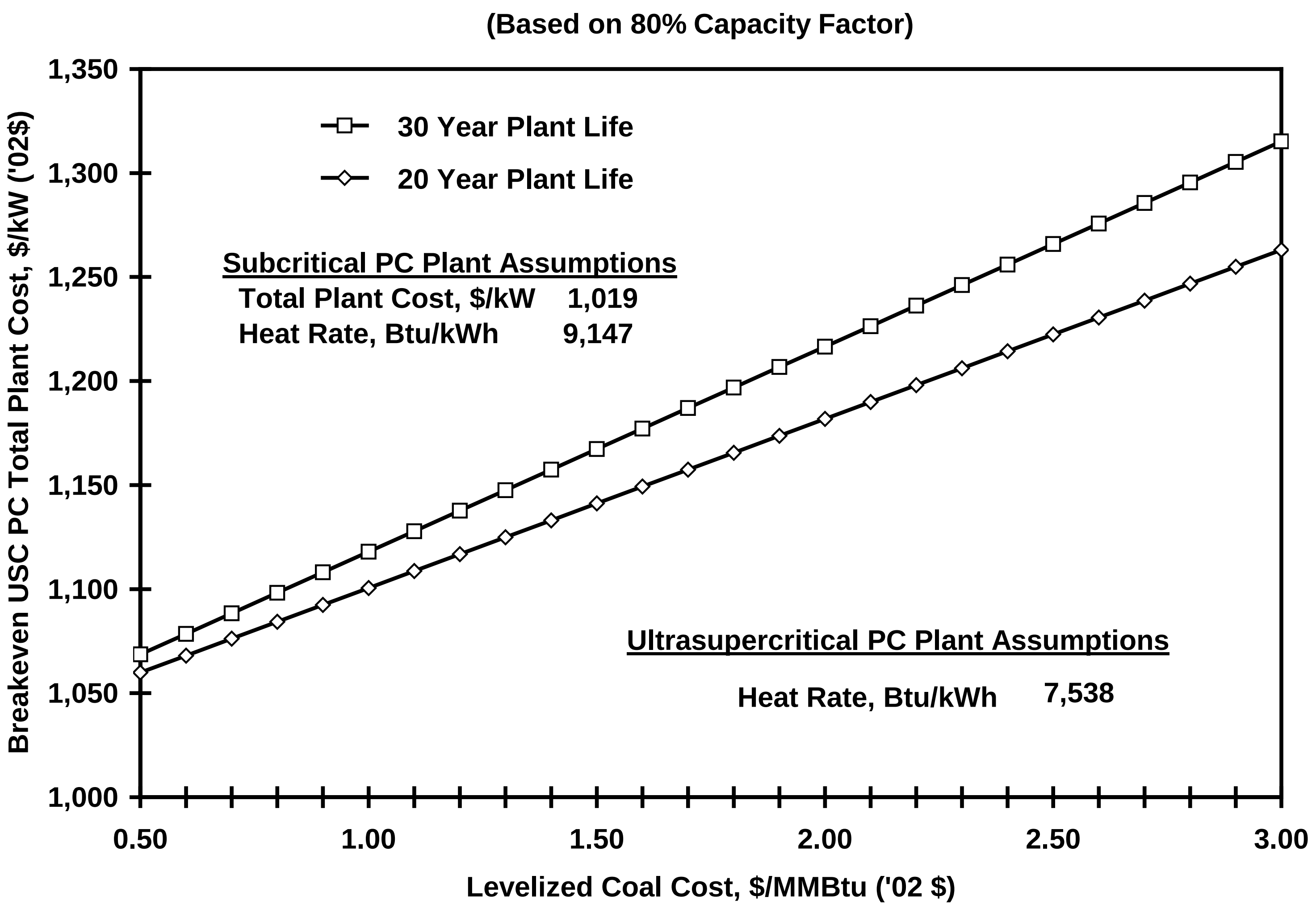
Breakeven Total Plant Cost and Fuel Cost - Sensitivity to Capacity Factor



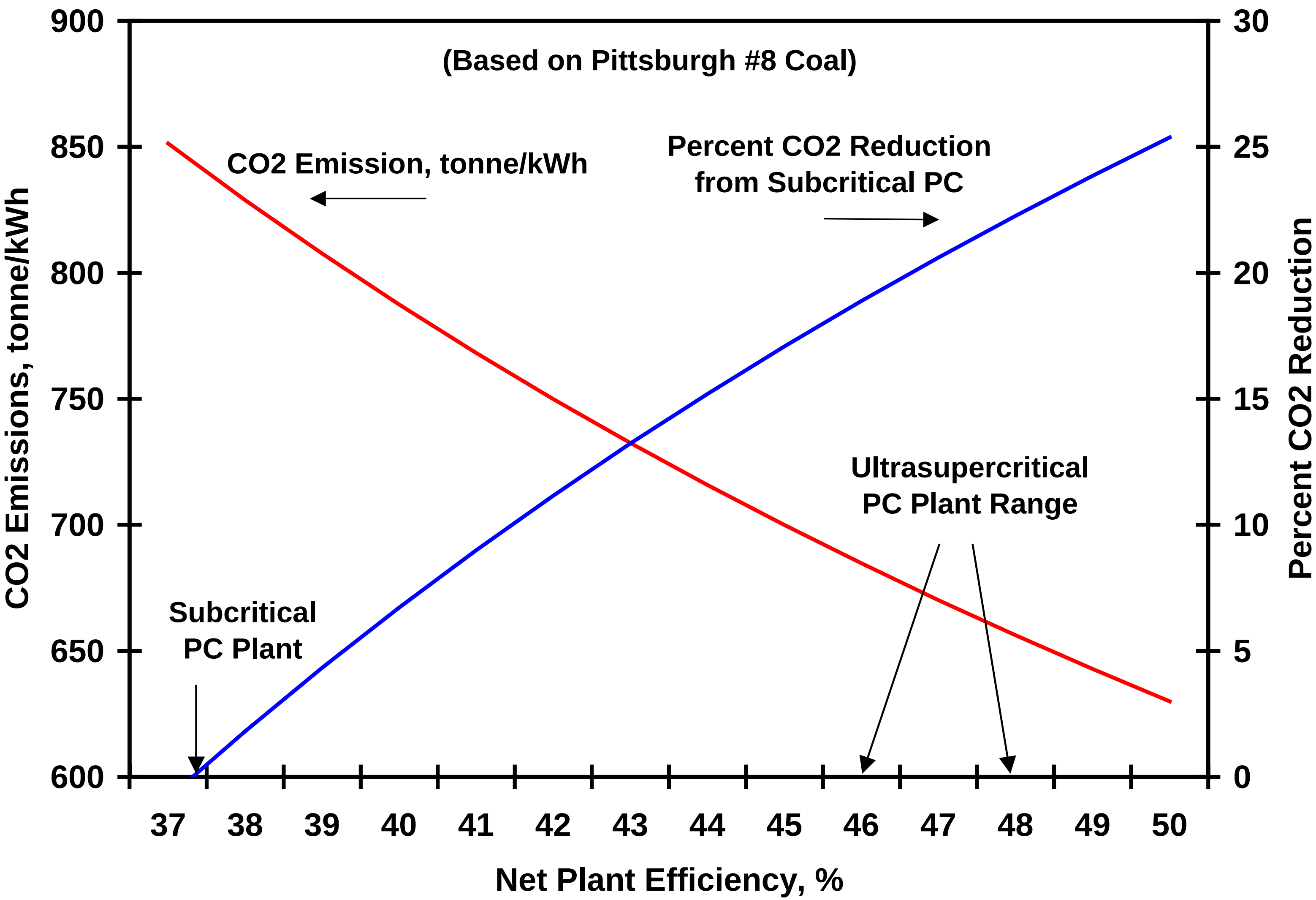
Breakeven Total Plant Cost and Fuel Cost - Sensitivity to Heat Rate (30 yr life)



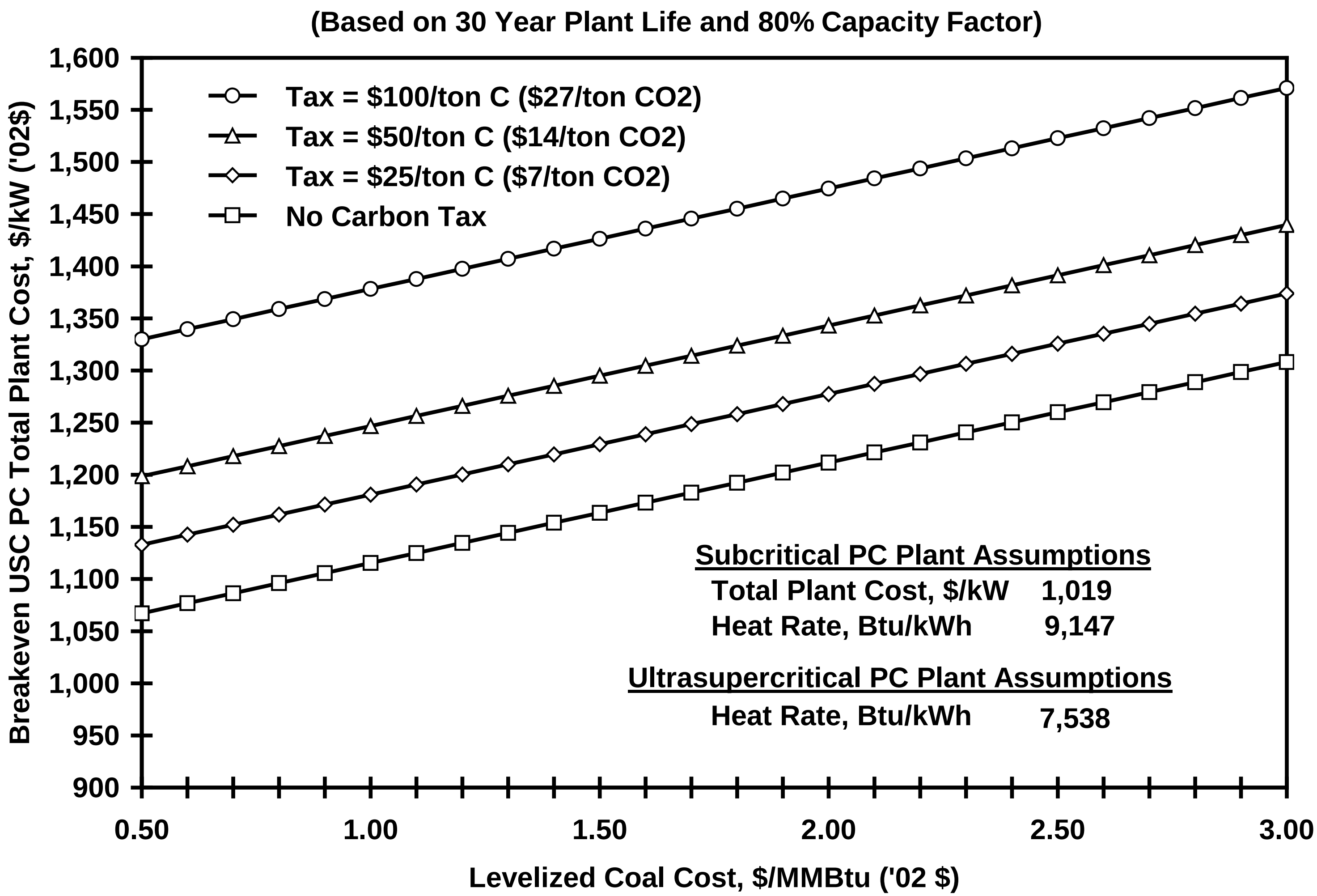
Breakeven Total Plant Cost and Fuel Cost - 20 vs 30 Year Life



Carbon Dioxide Emission Reduction from Increasing Efficiency



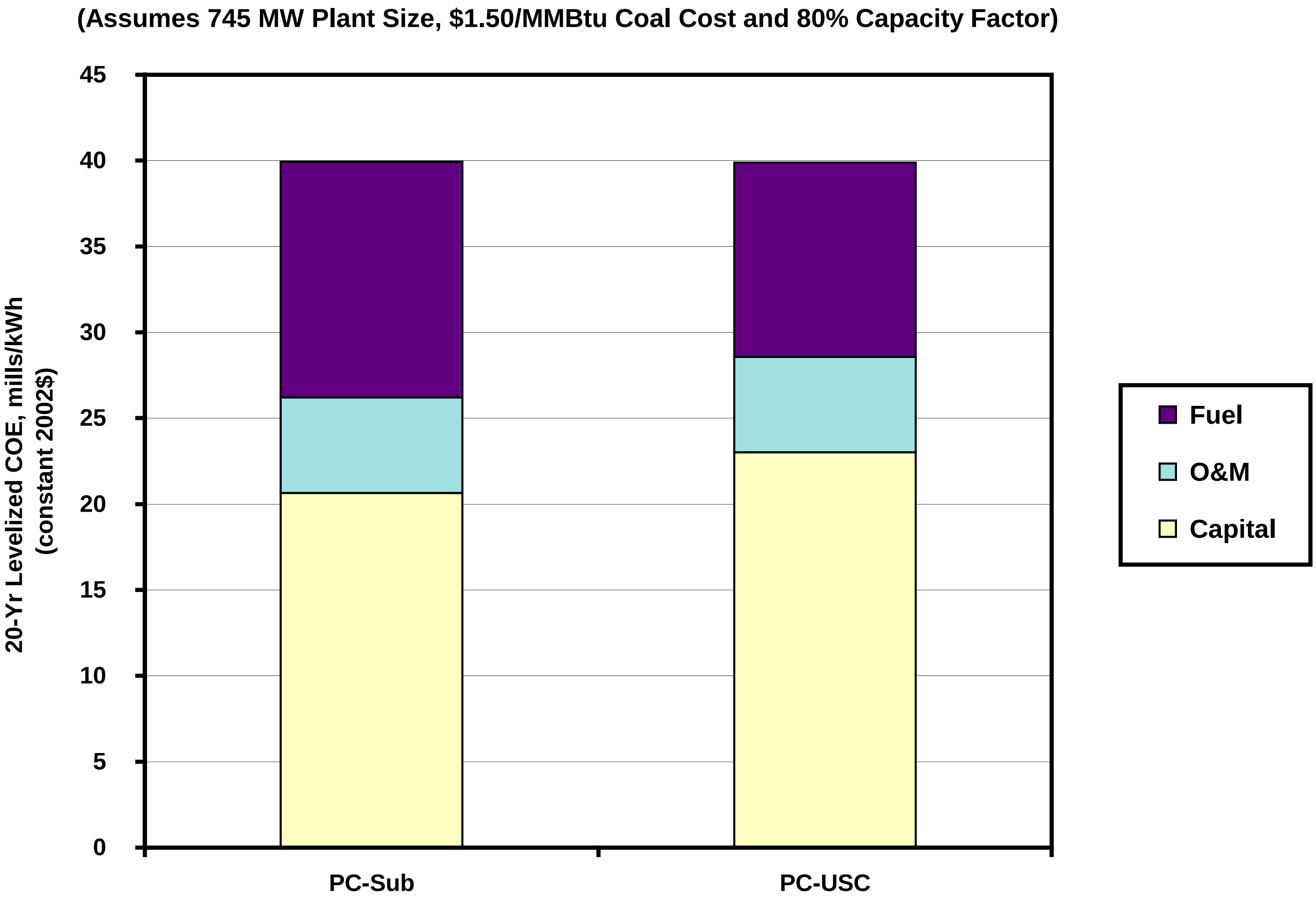
Breakeven Total Plant Cost and Fuel Cost - Impact of Potential Carbon Tax



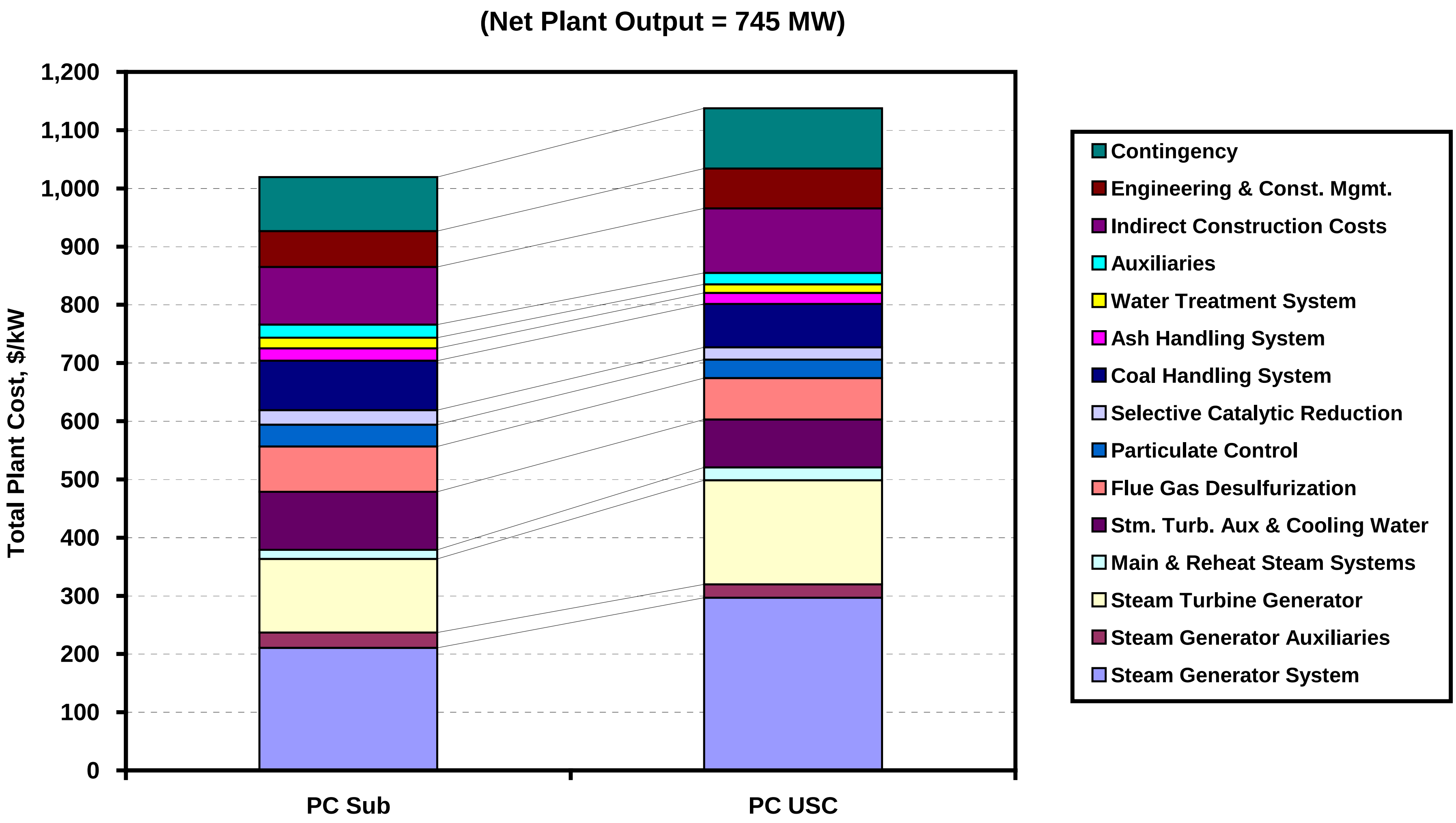
Economic Analysis Assumptions

Plant Life	20	Years
Capacity Factor	80	%
Coal Cost	1.50	$/MMBtu
Carbon Tax	0	$/ton C
Net Plant Output	745.5	MW
Subcritical Plant Heat Rate	9,147	Btu/kWh
USC Plant Heat Rate	7,538	Btu/kWh
Subcritical Plant Total Plant Cost	1,019	$/kW
Allowable USC Total Plant Cost	1,138	$/kW

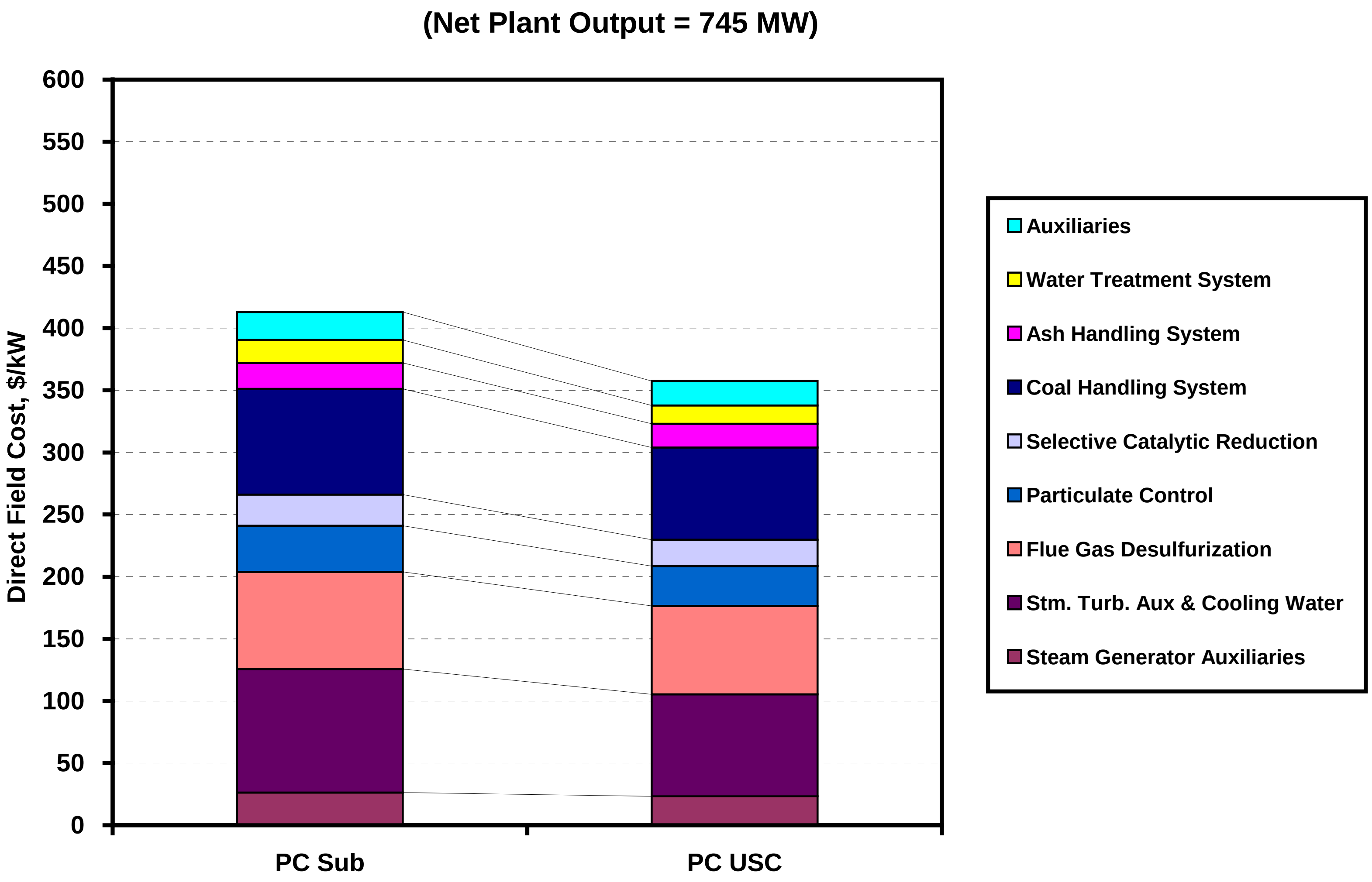
Levelized Cost of Electricity Comparison



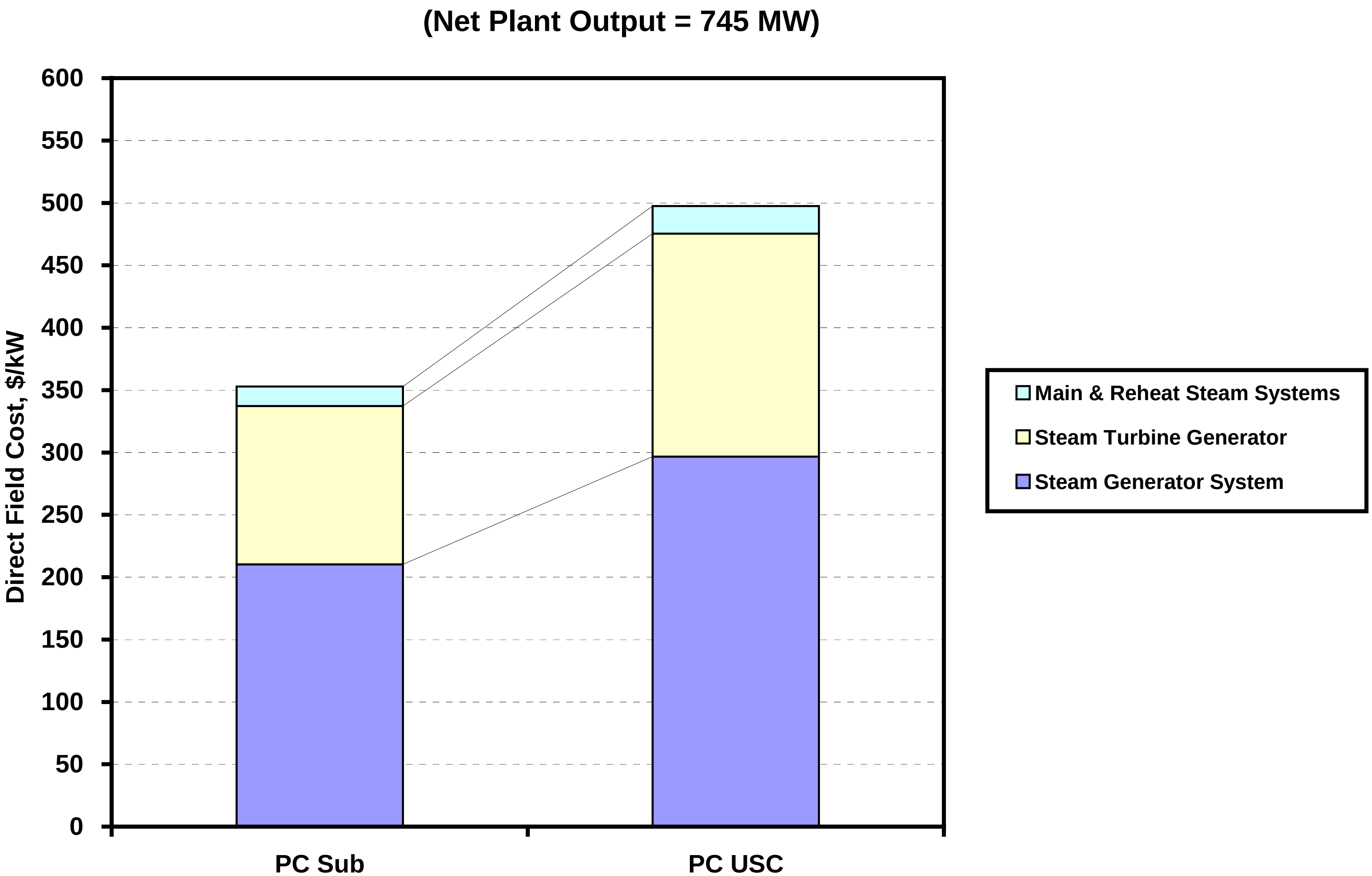
Capital Cost for Subcritical vs USC Plants
($/kW basis)



Direct Field Cost for BOP Systems
($/kW basis)



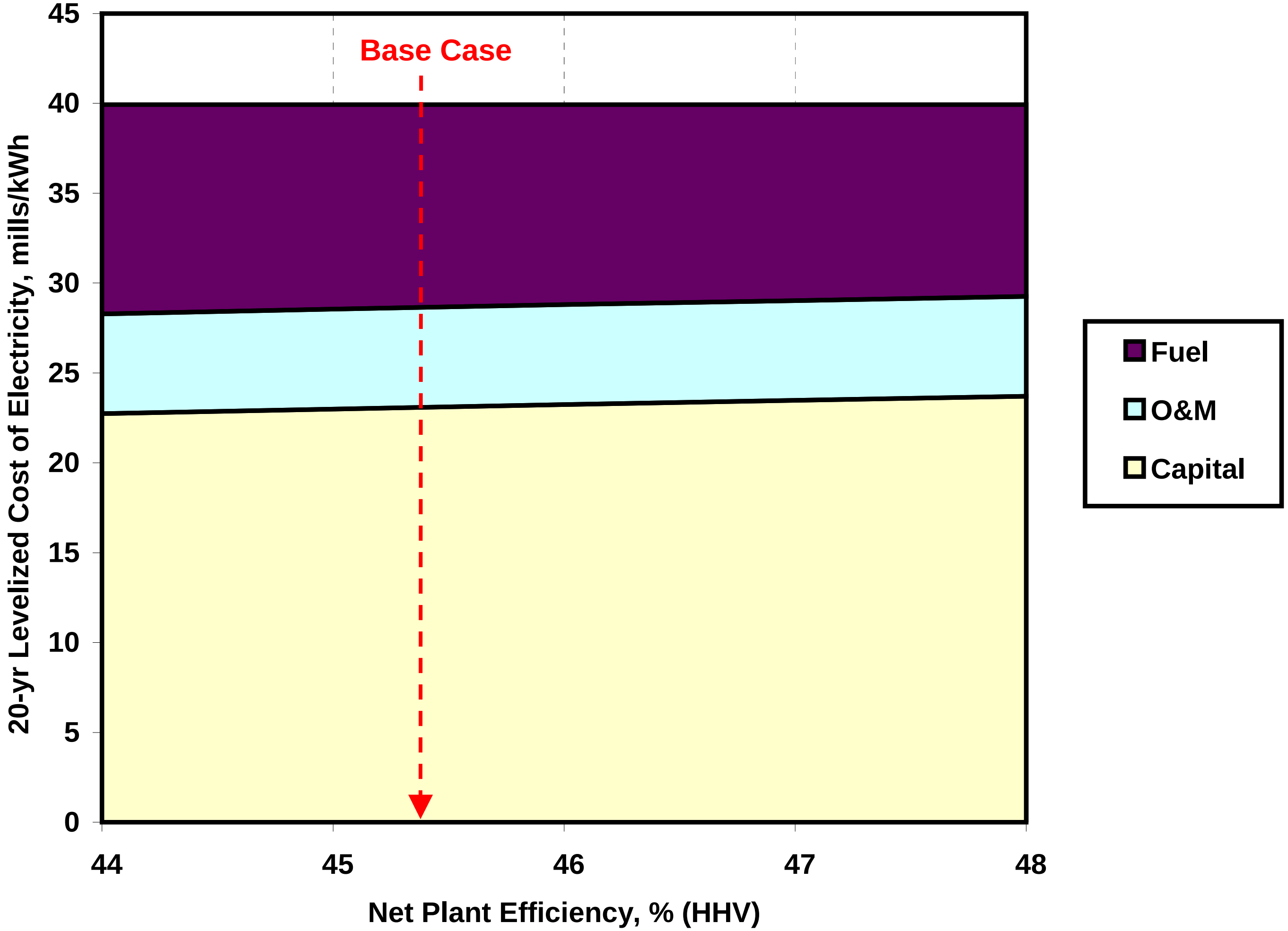
Allowable Direct Field Cost for Boiler & Steam Turbine ($/kW basis)



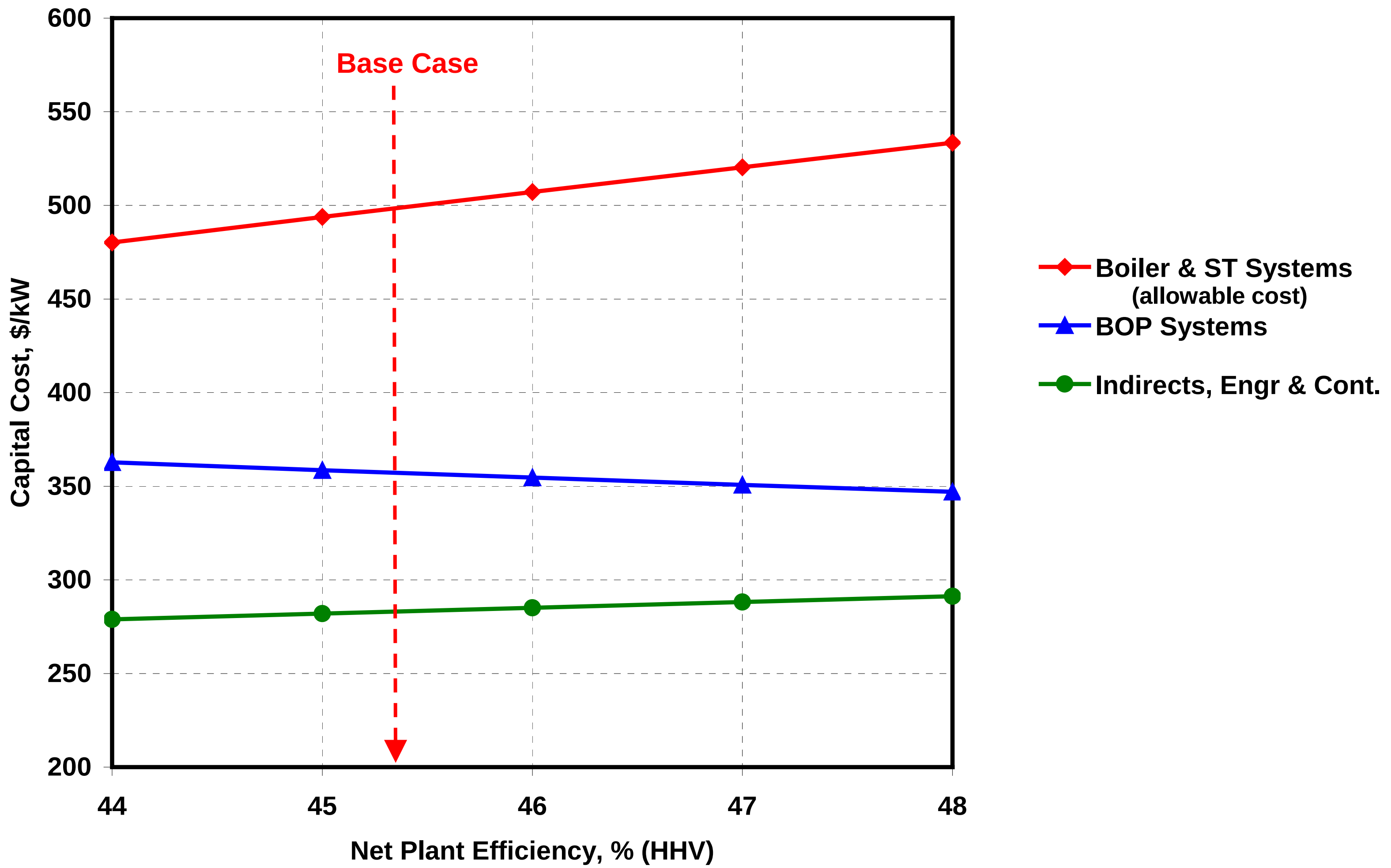
Conclusions – Base Case

- If the USC plant heat rate is 7,538 Btu/kWh (45.3% efficiency), then the USC Total Plant Cost can be 11.6% higher at the same cost of electricity as a conventional subcritical PC Plant
  - Based on EPRI TAG financial parameters, 20 year plant life, 80% capacity factor, and a coal cost of $1.50/MMBtu
- Improved efficiency leads to 13.4% lower USC BOP cost
  - Smaller coal handling, pollution control, and other BOP costs for the same net plant output
- USC Boiler/Steam Turbine cost can be 41% higher

Sensitivity to USC Plant Efficiency



Sensitivity to USC Plant Efficiency (cont.)



Conclusions – Sensitivity Cases

- If the USC plant efficiency can be improved to 48%, then the USC Total Plant Cost can be 15% higher at the same cost of electricity as a conventional subcritical PC Plant
- 48% USC efficiency leads to 16% lower USC pollution control and BOP cost
  - Emissions are reduced by over 23%
- USC Boiler/Steam Turbine cost can be 50% higher
- For each efficiency point increase:
  - USC Boiler/ST Cost can increase ~$14/kW,
  - or ~ 3.8% increase over the subcritical boiler/ST cost