Identifying Cost-Effective CO_2 Control Levels for Coal-fired Power Plant

Anand B. Rao, Chao Chen and Edward S. Rubin

Department of Engineering and Public Policy
Carnegie Mellon University
Pittsburgh, PA 15213

The Fourth National Carbon Sequestration Conference, May 2005

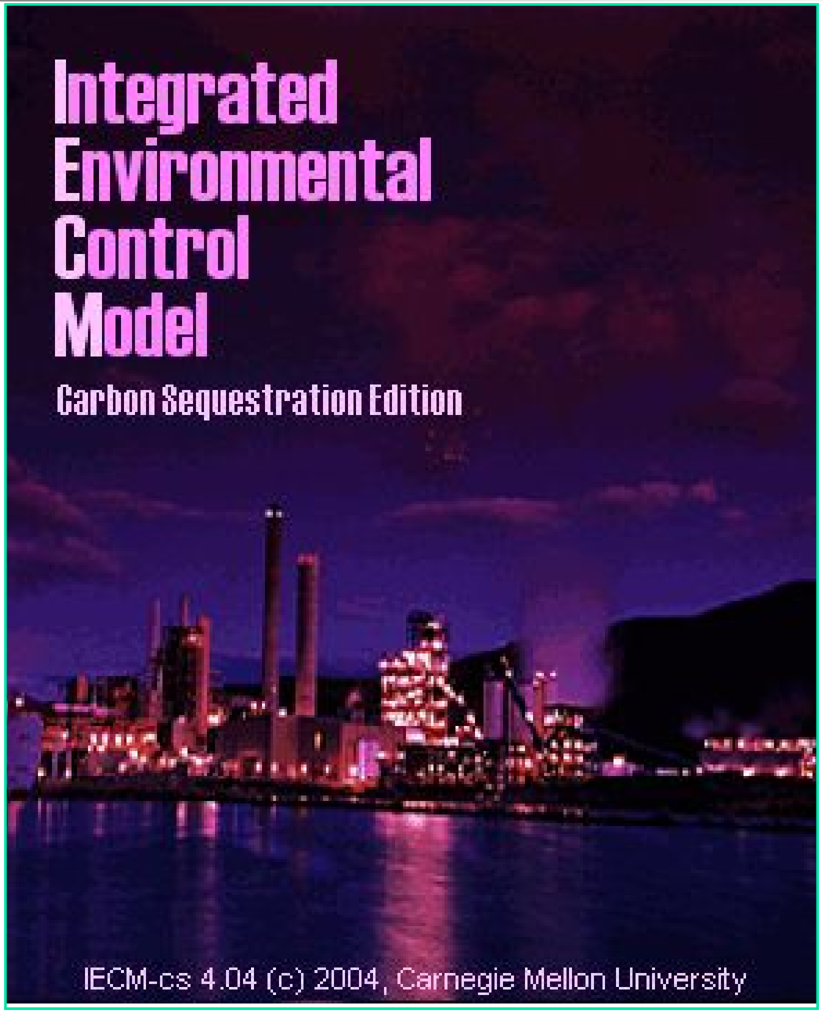
CO_2 Control Level for Coal-fired Power Plants

- Typical capture efficiency assumed in the literature:
  - PC plants: ~90% CO_2 capture (*range: 85-96*)
  - IGCC plants: ~88% CO_2 capture (*range: 85-92*)
- What is the basis for choosing a particular value?
- If lower CO_2 reduction is desired, is it more cost-effective to bypass a portion of the flue gas stream?

Factors Affecting the Cost-Effective CO_2 Control Level

- All the many factors affecting COE and CO_2 emission rate for both the *reference* and *capture* plants also influence the cost-effectiveness:
  - Type of power plant and fuel properties
  - Plant configuration, size and performance parameters
  - CO_2 capture system performance parameters
  - Assumptions about plant financing and plant capacity factor
  - Plant boundary or scope (inclusion or exclusion of post-capture CO_2 processing including compression, transport and storage)
- Use a case study to explore influence of several factors on cost-effective CO_2 control level

Cost Estimation using IECM-*cs*



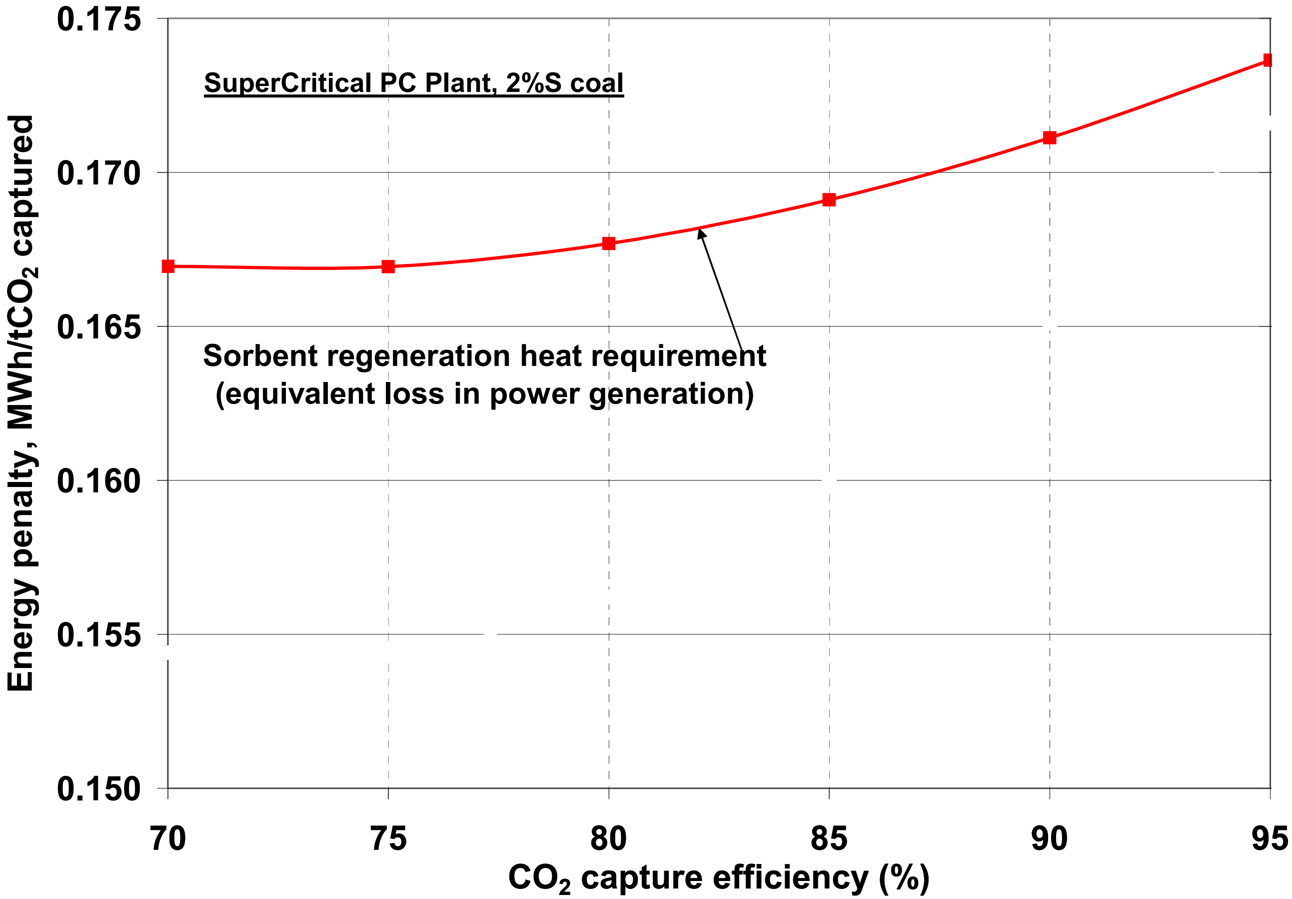
Case Study Assumptions

Parameter	PC	IGCC
Reference Plant (~1000 MW_{gross})	Supercritical	Texaco quench
Fuel Type	2%S, Bit.	2%S, Bit.
Net HHV Efficiency (%)	39.5	37.5
Capacity Factor (%)	**75**	**75**
Fuel Cost, HHV ($/GJ)	1.2	1.2
CCS Plant (~1000 MW_{gross})		
CO_2 Capture System	Amine	Shift+Selexol
CO_2 Capture (%)	70-95	70-95
Pipeline Pressure (MPa)	13.8	13.8

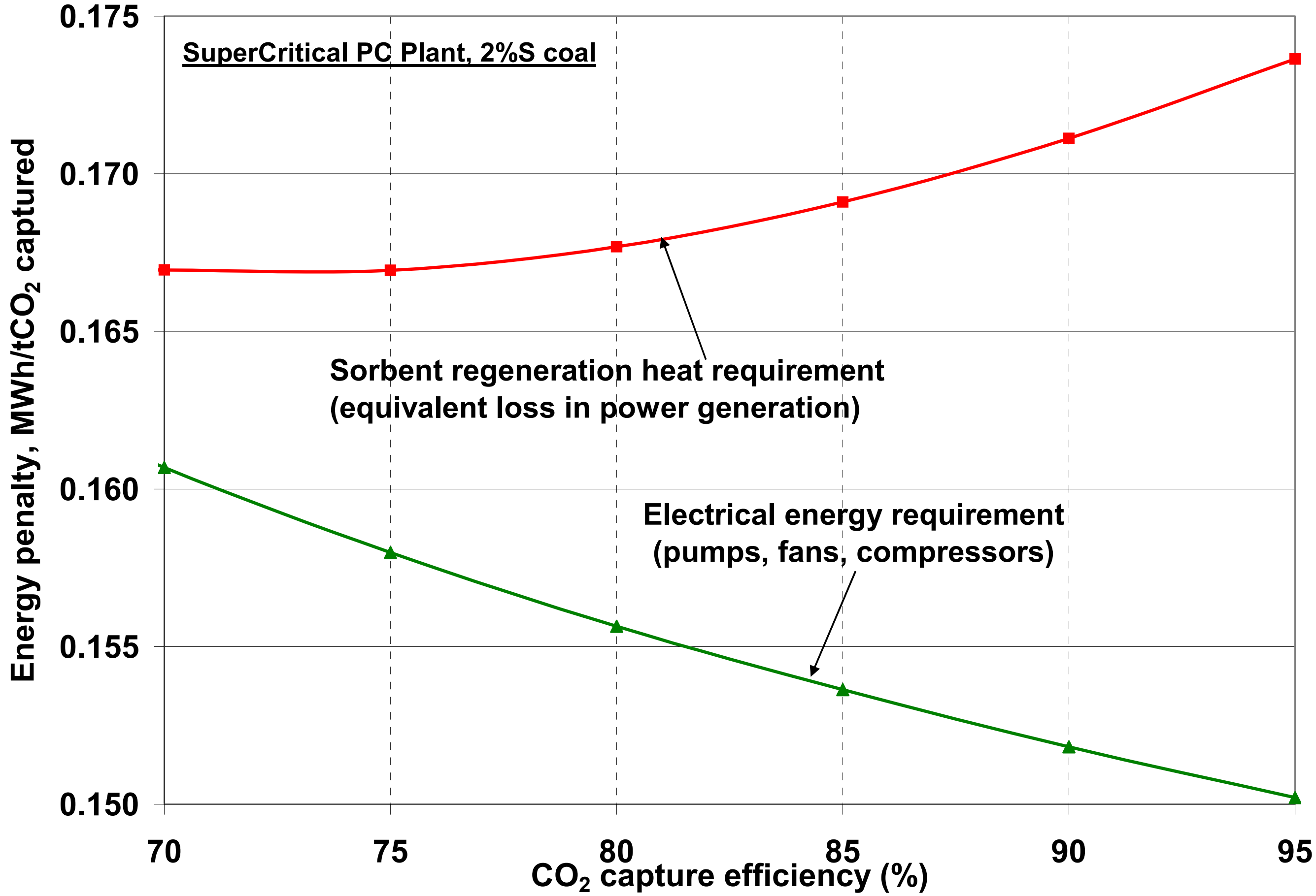
Also: fixed charge factor = 0.148; all costs in constant 2002 US$

PC + Amine-based CO_2 capture system

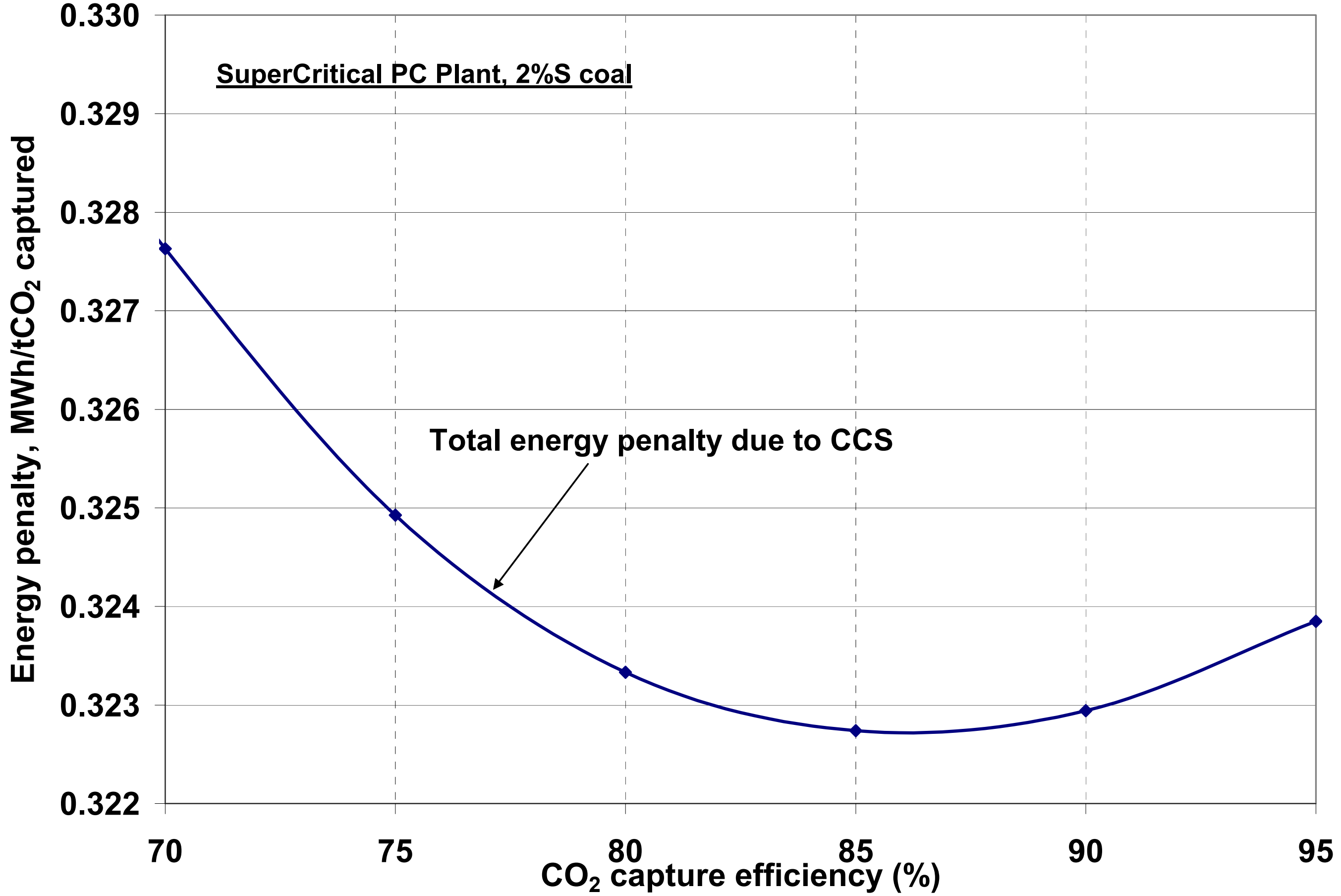
Sorbent Regeneration Energy Requirement for Amine System



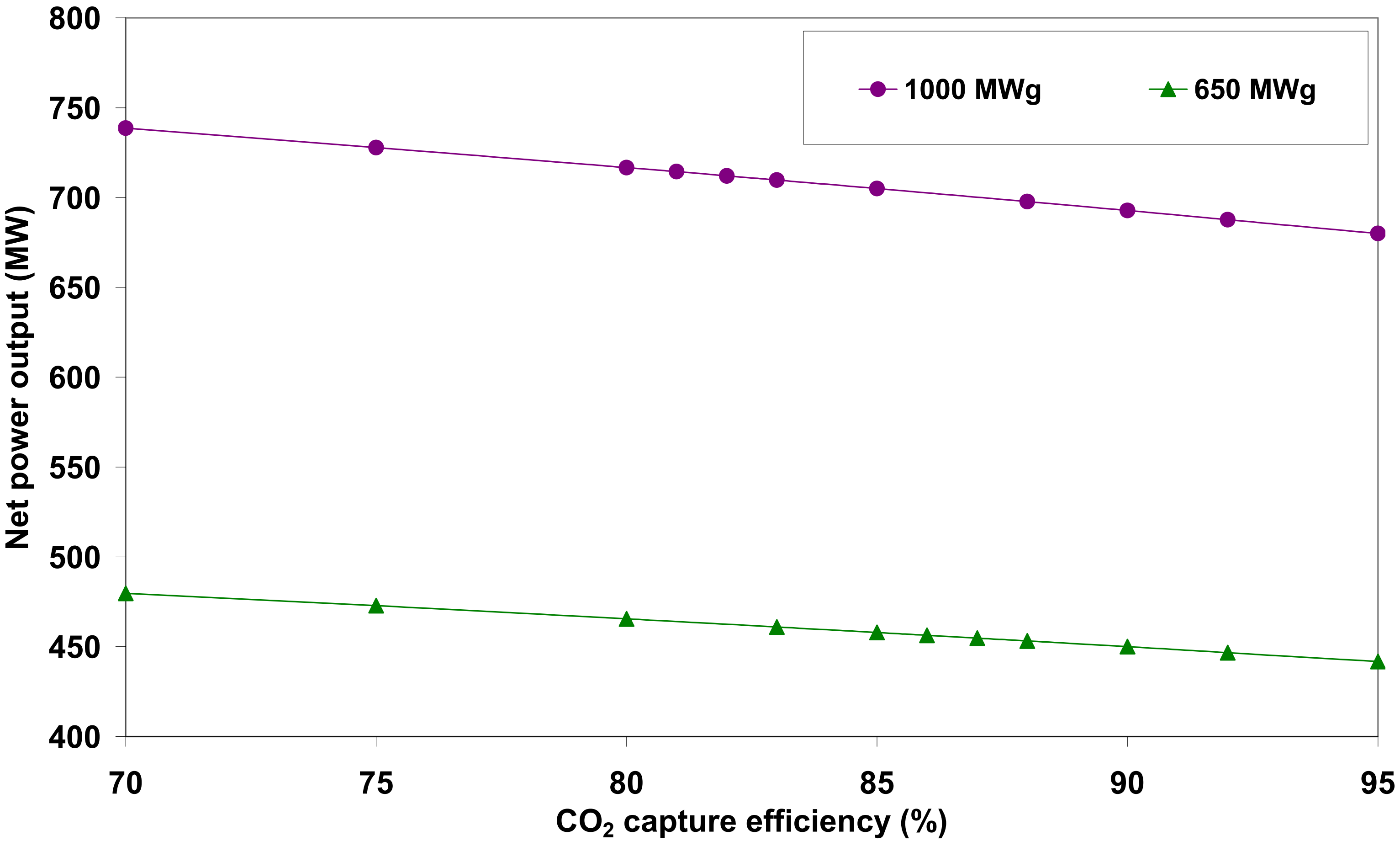
Amine System Energy Requirement



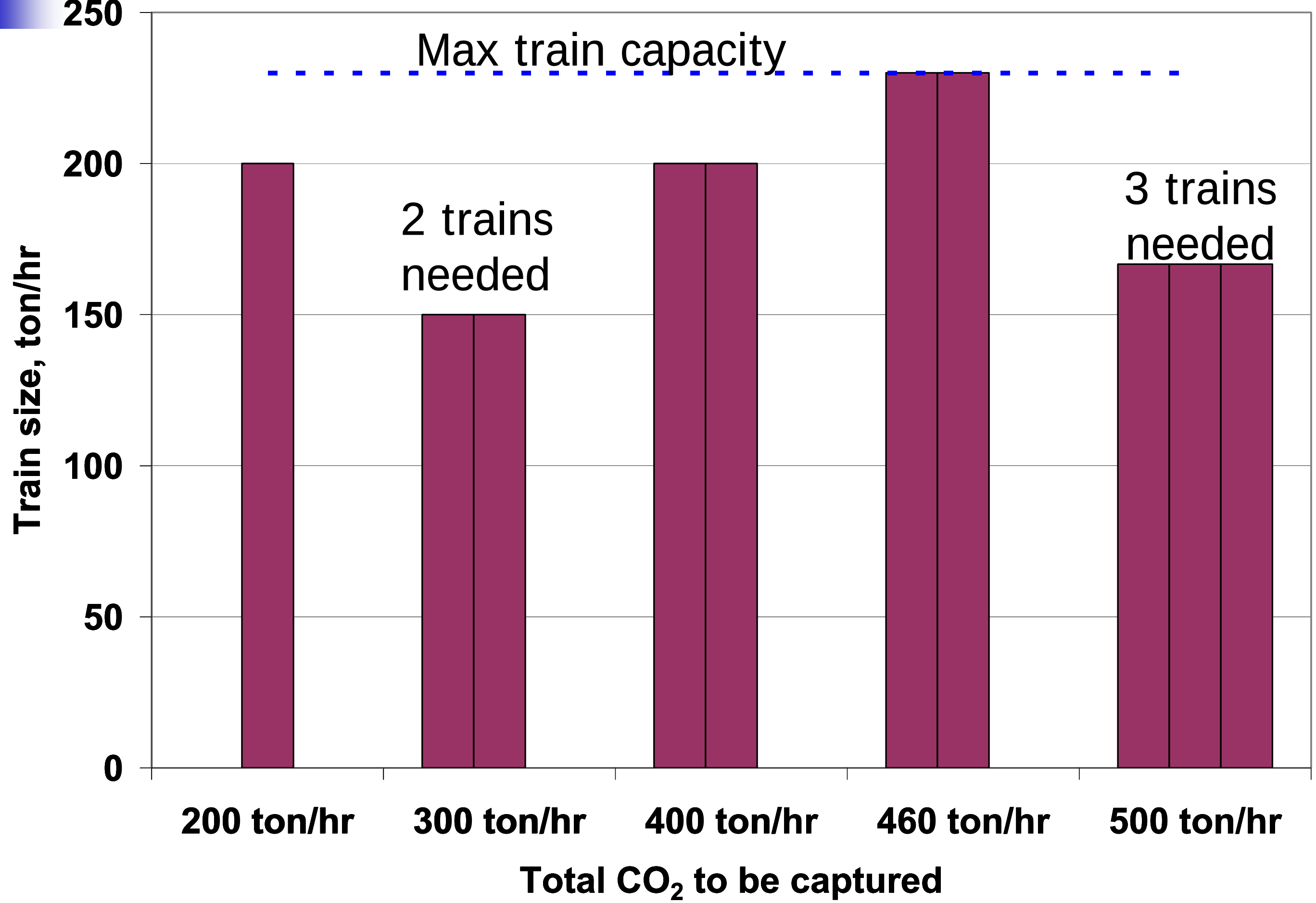
Total Energy Penalty of Amine-based CO_2 Capture System in a PC Plant



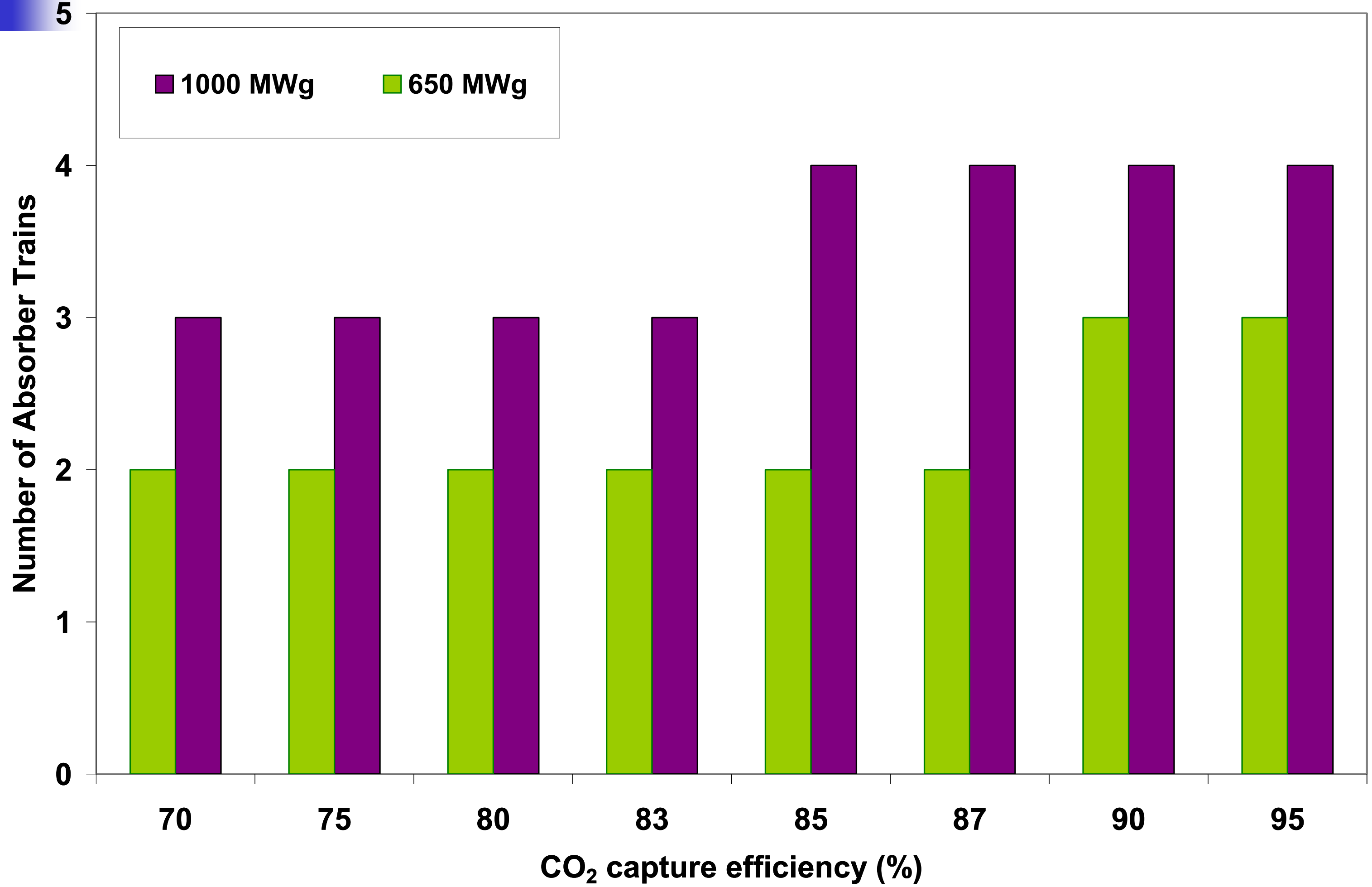
Net Power Output - PC



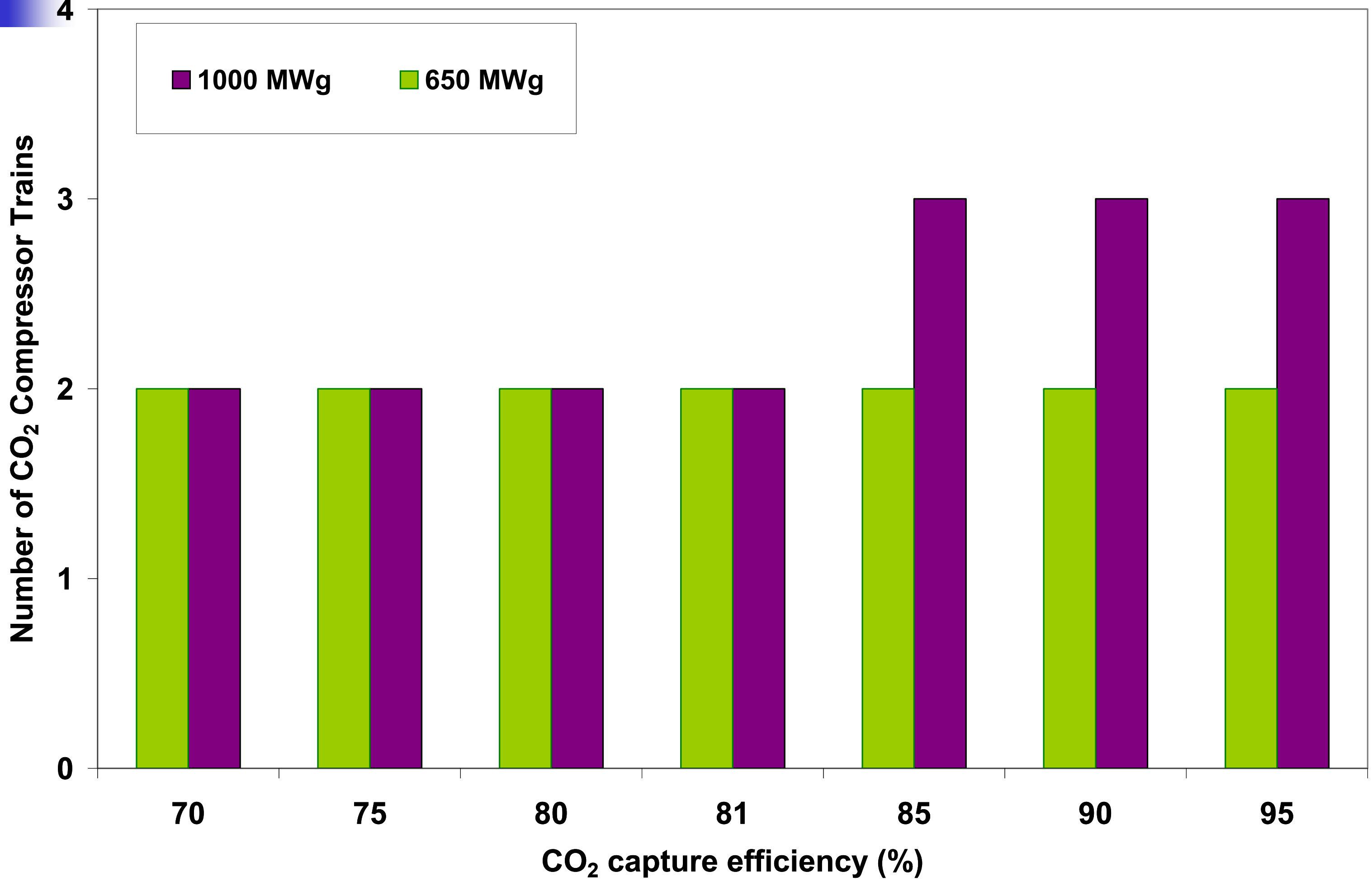
The Importance of Train Size



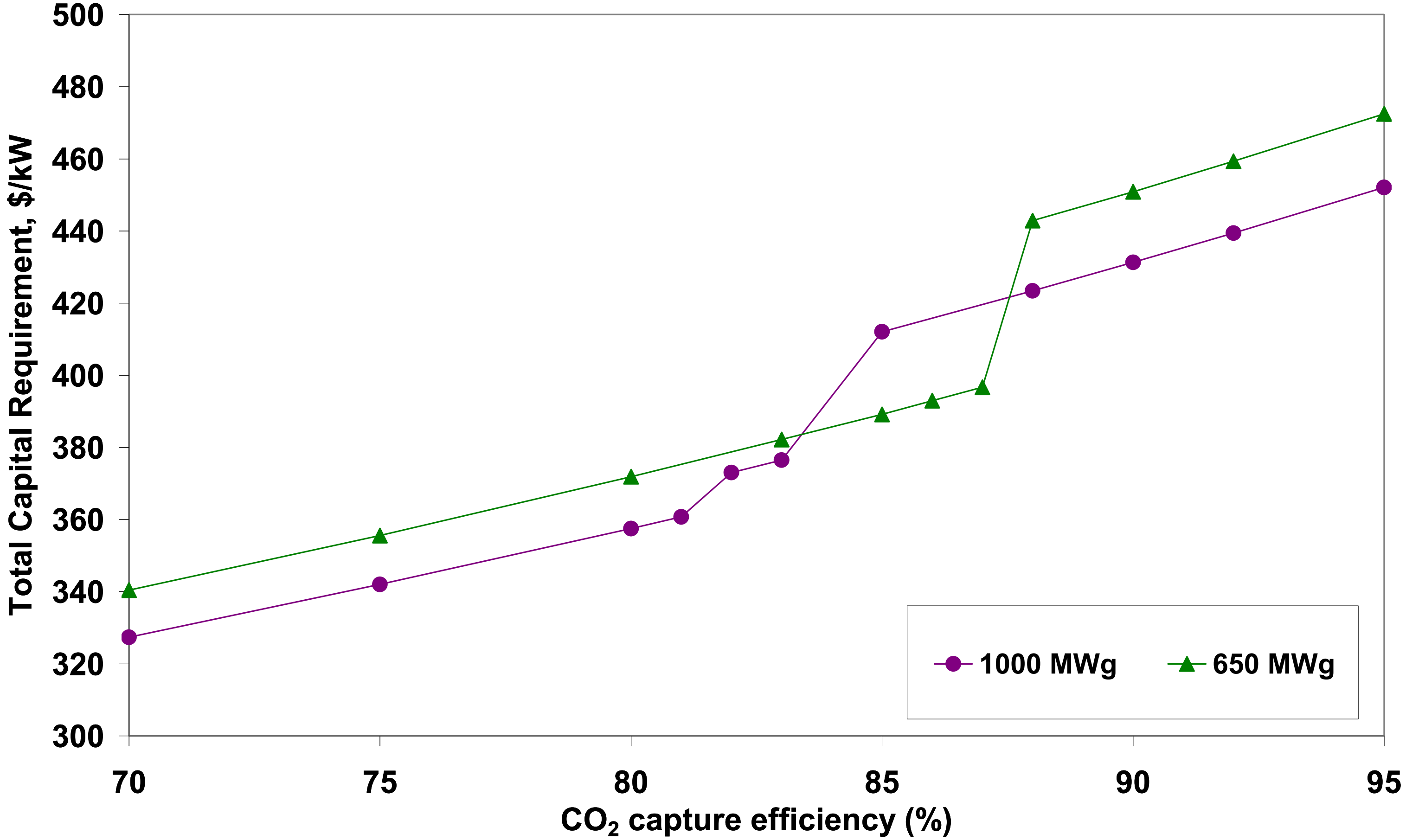
Number of Absorber Trains



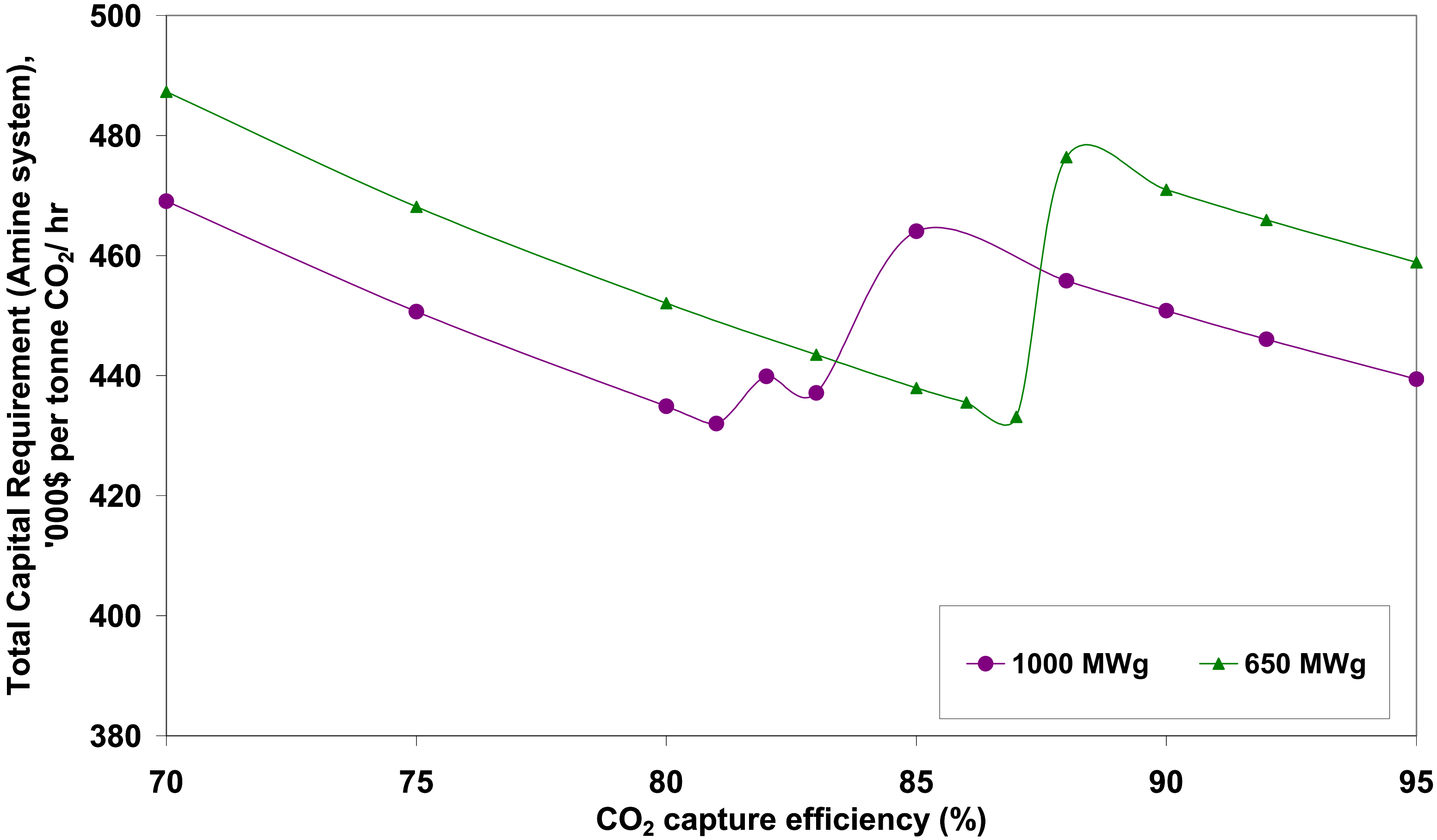
Number of Compressor Trains



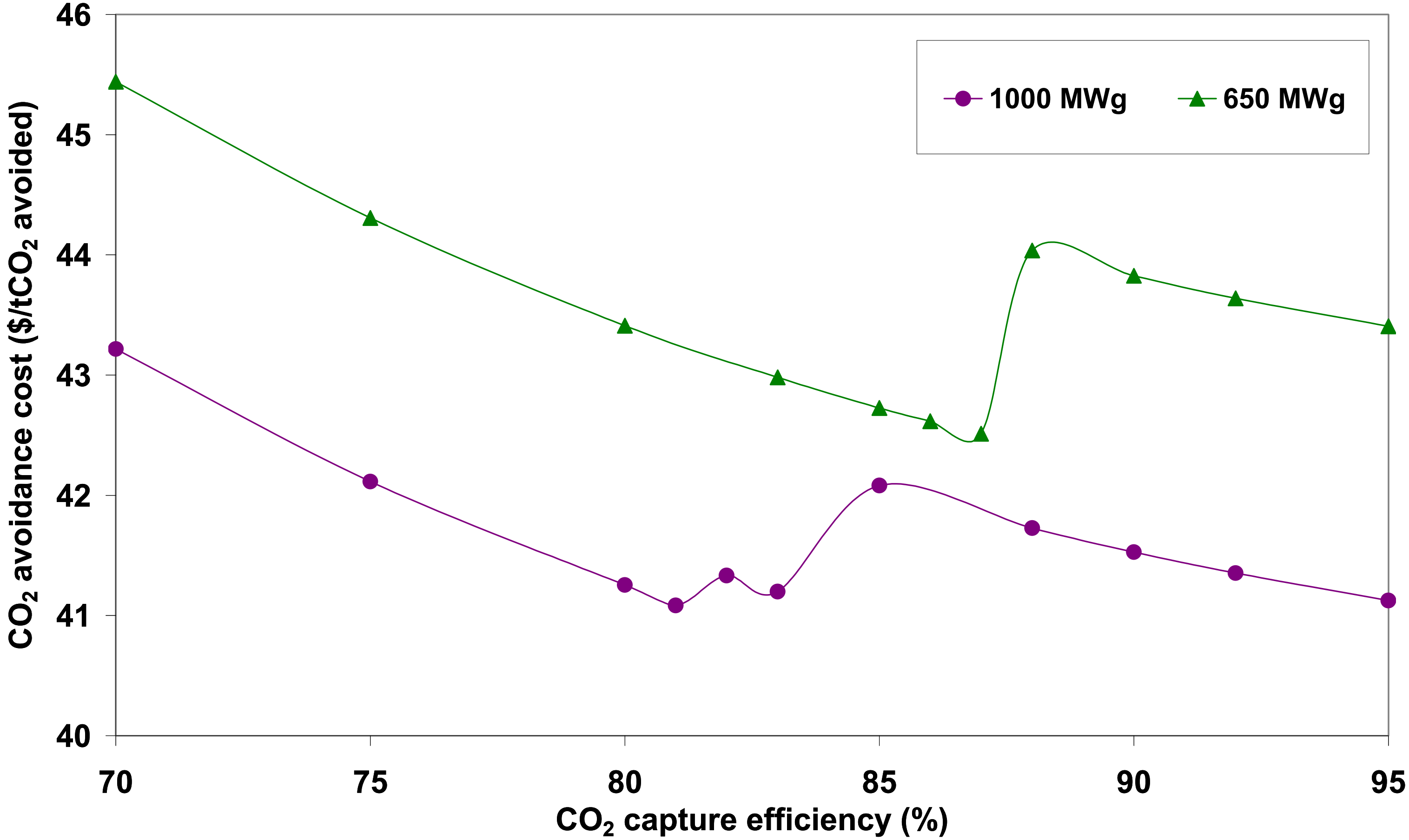
Amine System Capital Cost
(Normalized per unit power output)



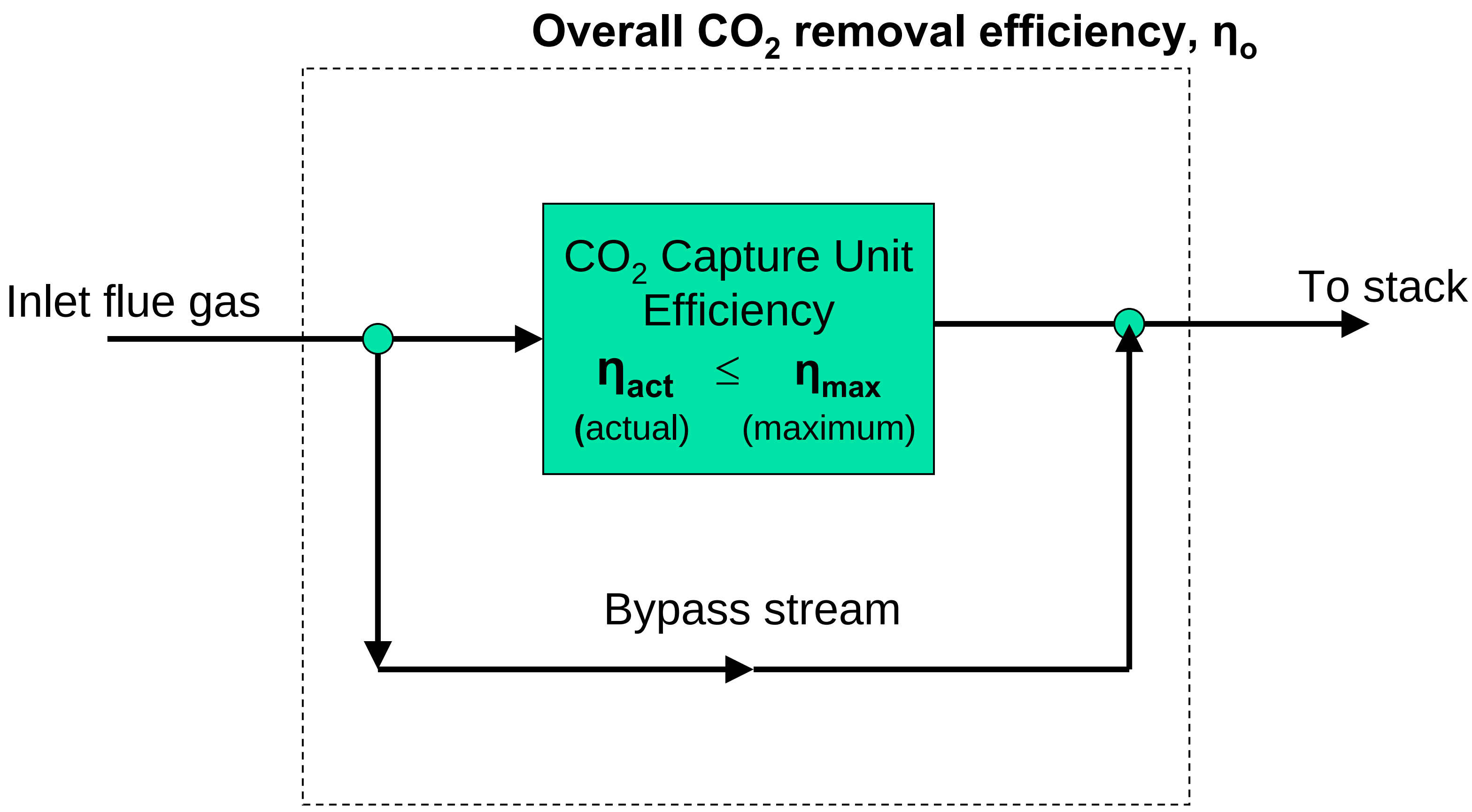
Amine System Capital Cost
(Normalized per CO_2 tonnage capacity)



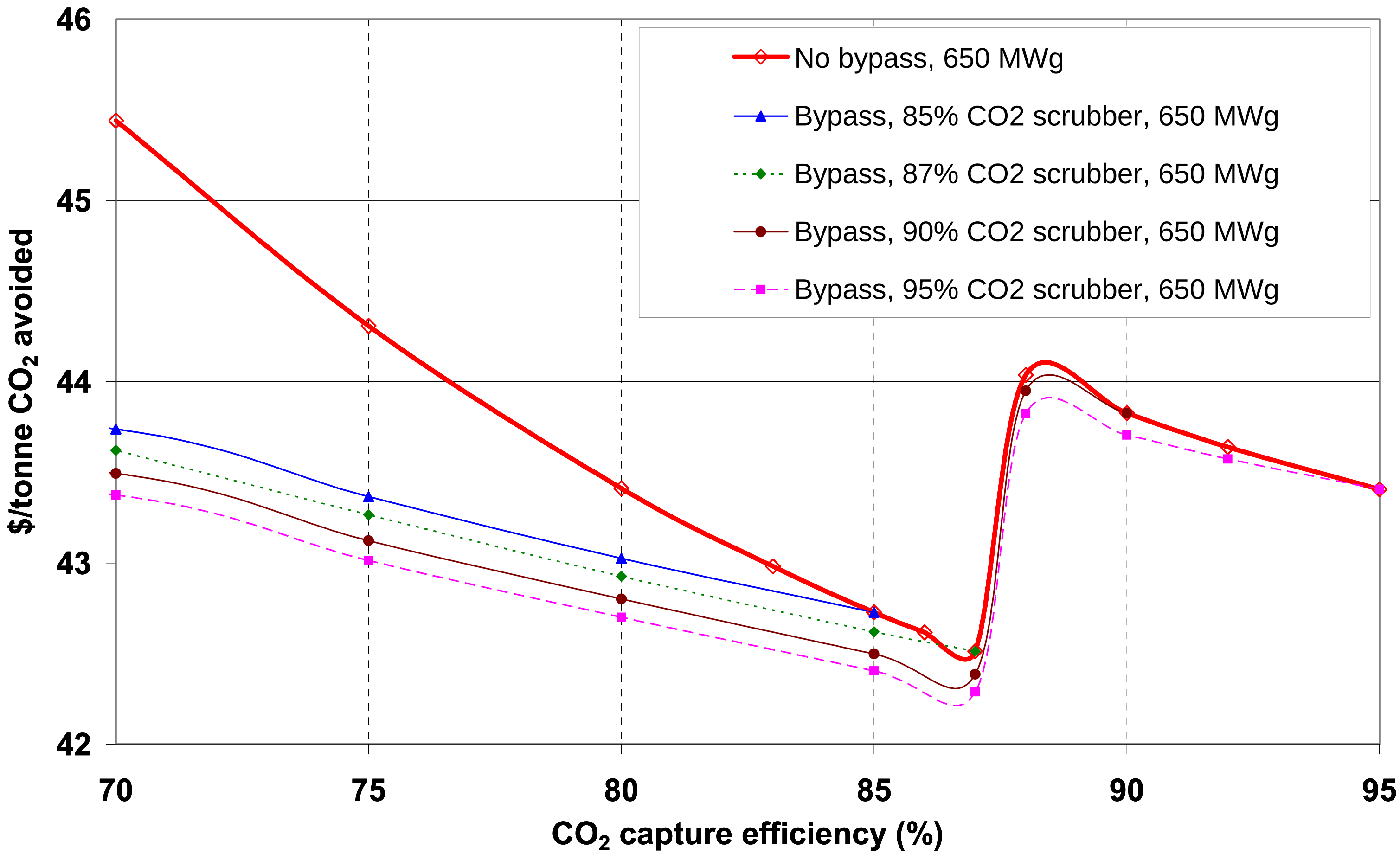
CO_2 Mitigation Cost - PC



Flue Gas Bypass Option

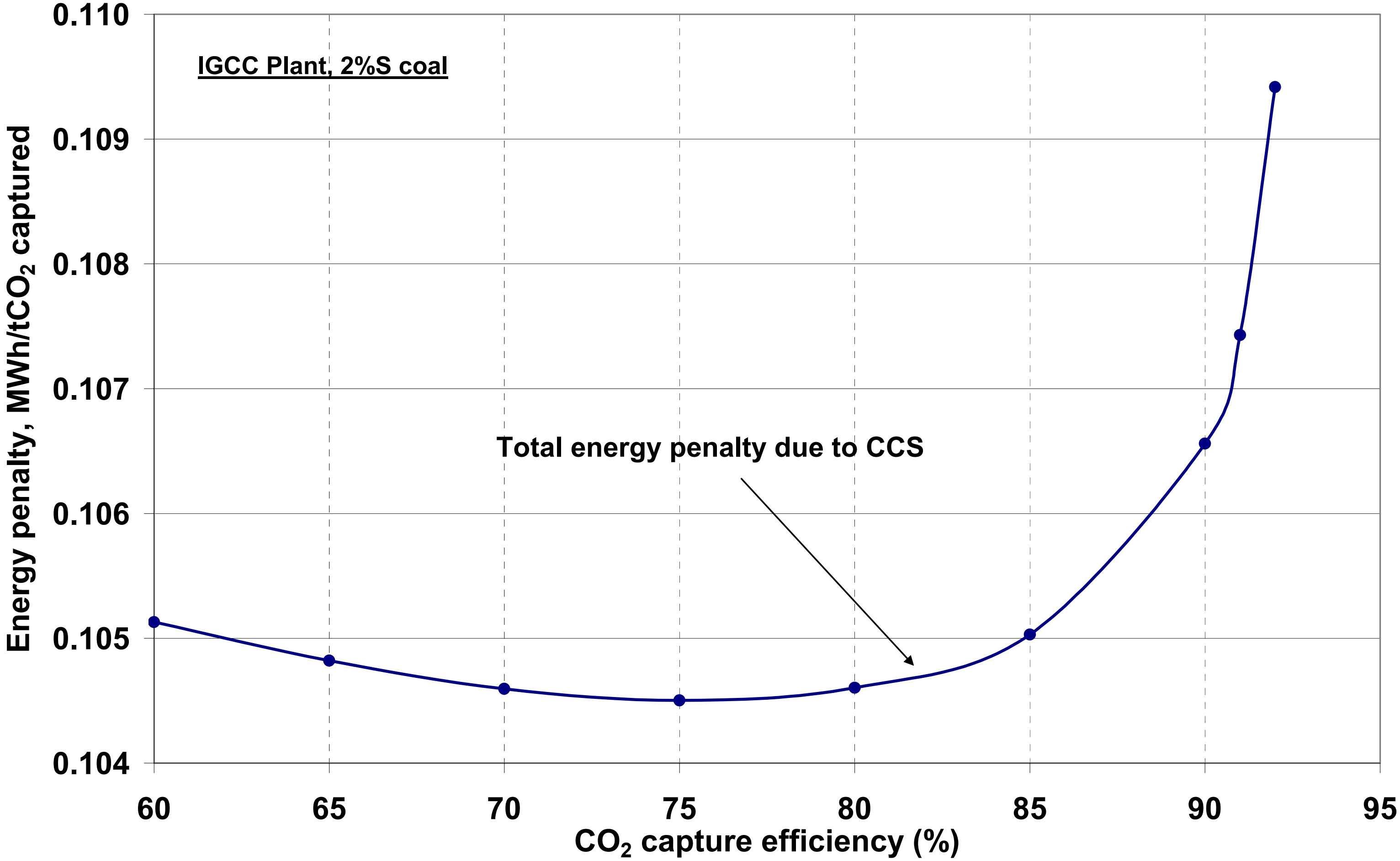


Flue Gas Bypass Results

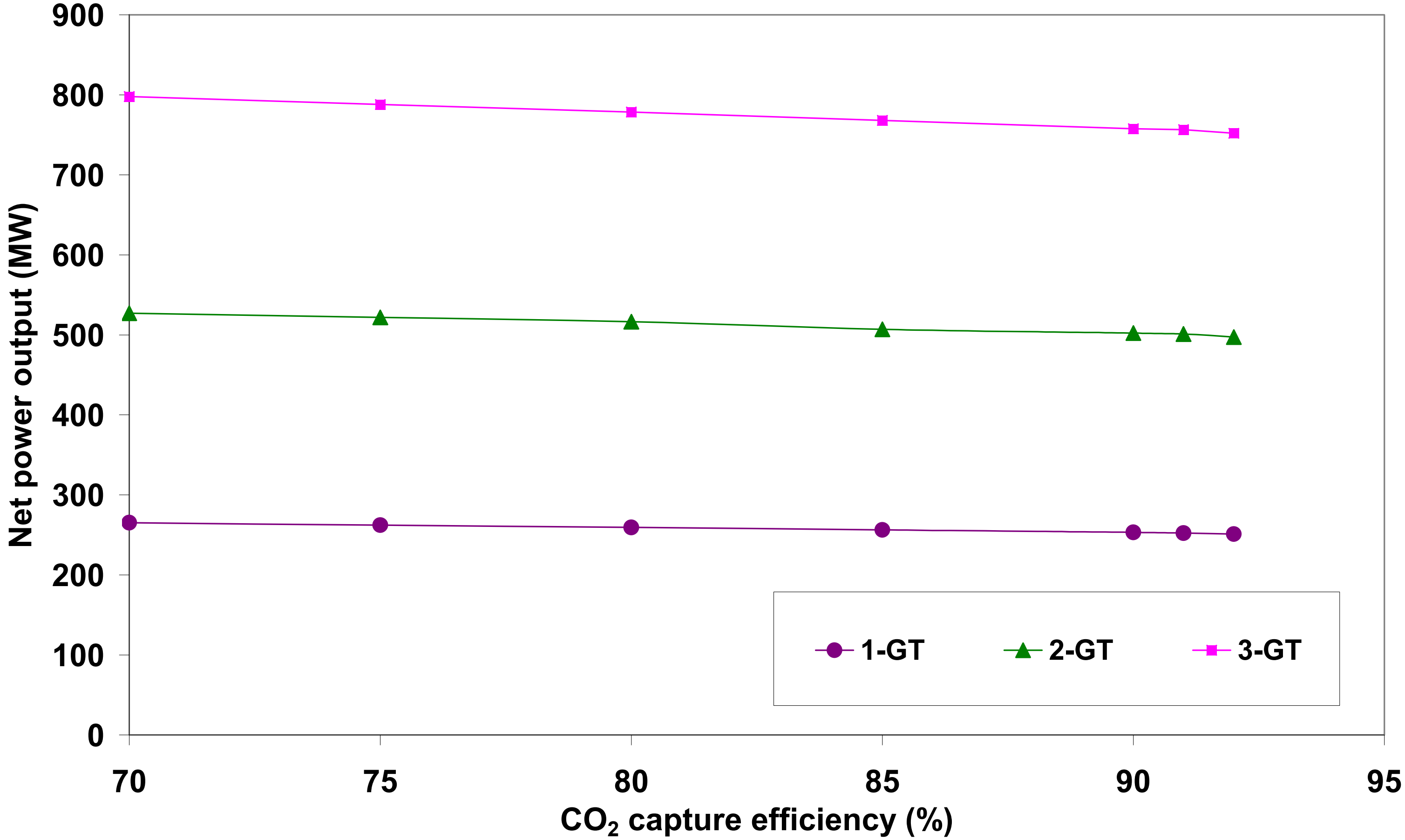


IGCC + Shift/Selexol CO_2 capture system

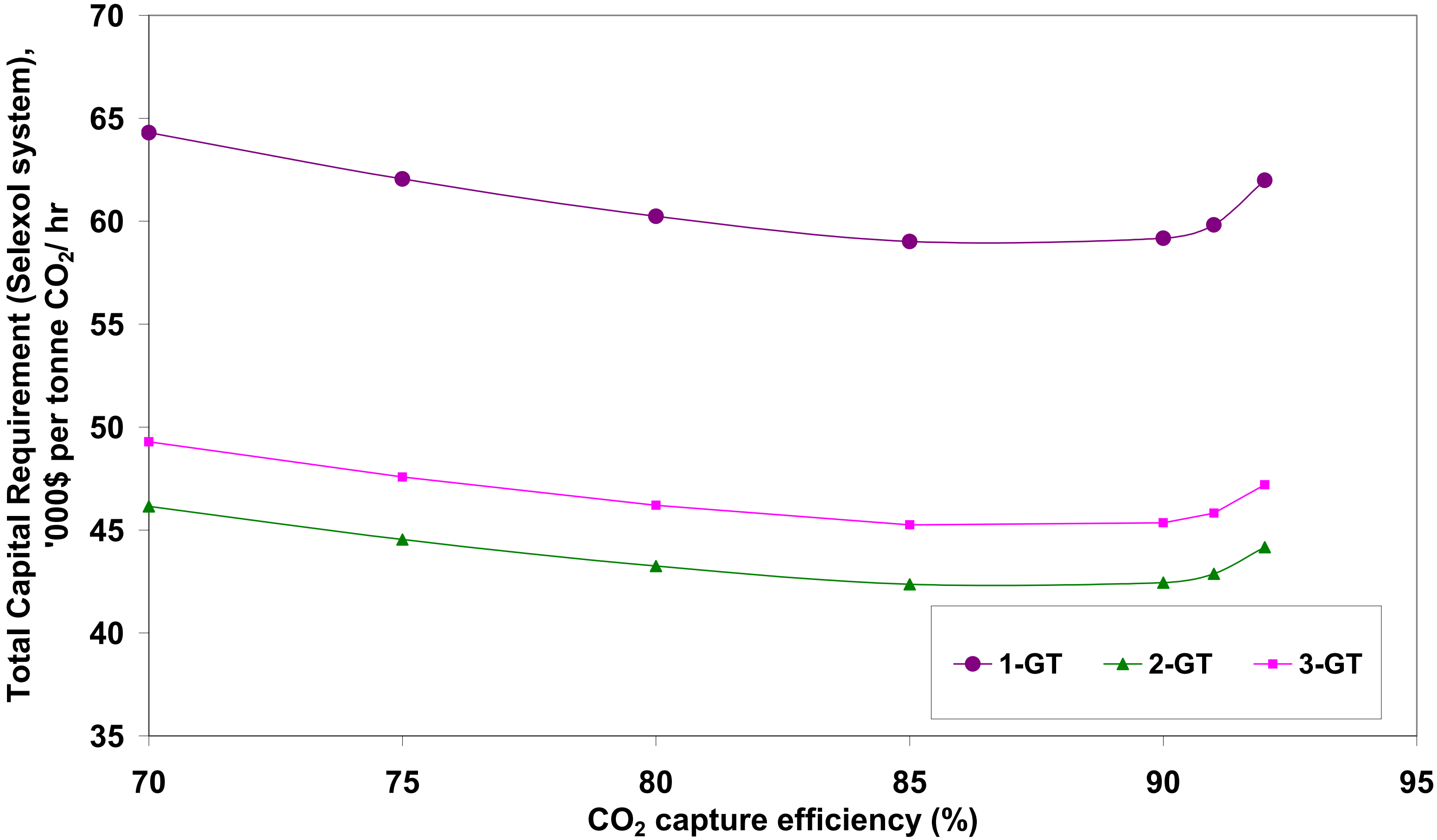
Energy Penalty of Selexol-based CO_2 Capture System in an IGCC Plant



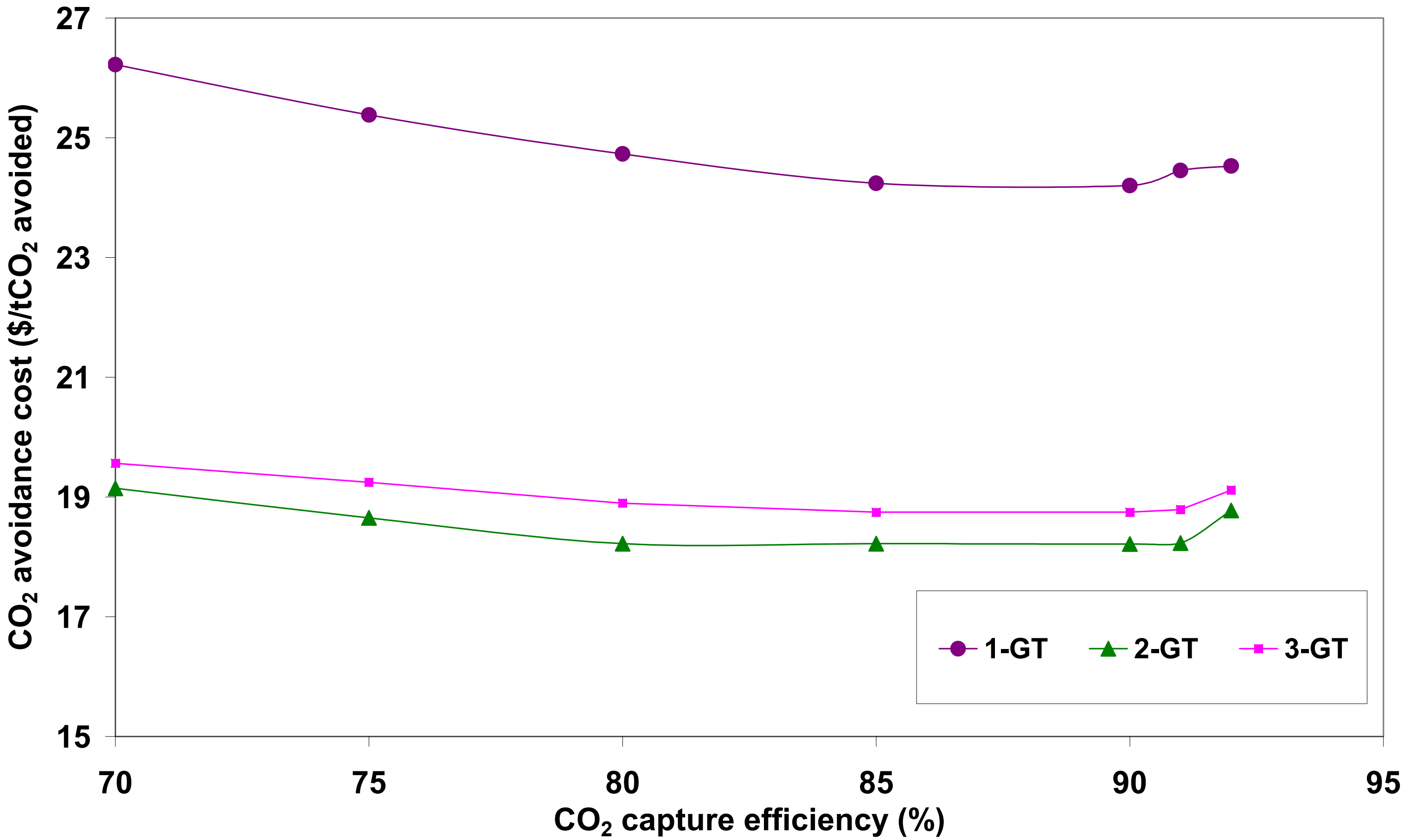
Net Power Output - IGCC



Selexol System Capital Cost
(Normalized per CO_2 tonnage capacity)



CO_2 Mitigation Cost - IGCC



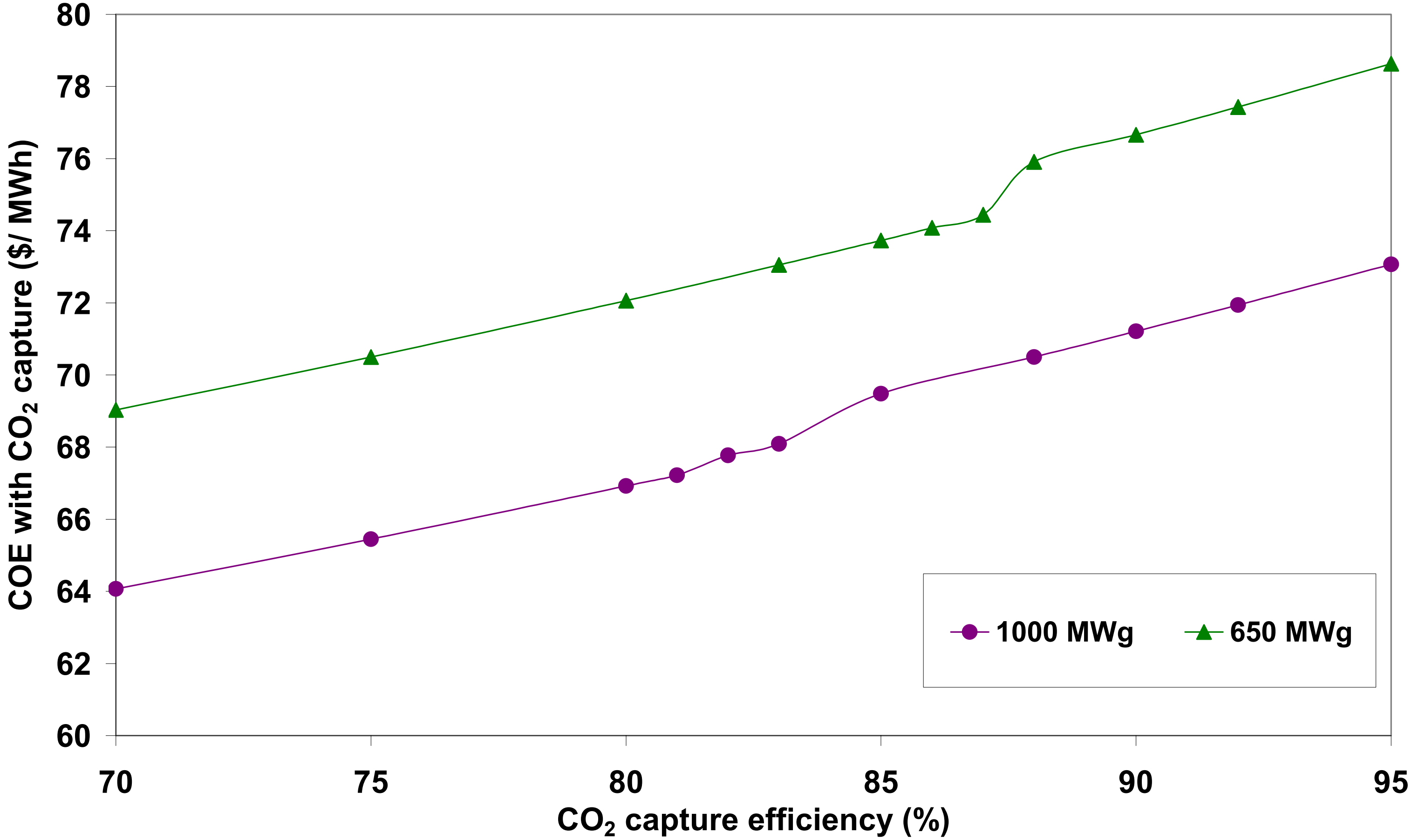
Conclusions

- The most cost-effective level of CO_2 control depends on a variety of design factors
- Although energy requirement is a key factor in the cost of CO_2 mitigation, the train size and its effect on capital cost also has a major influence on CO_2 capture economics
- If low to moderate levels of CO_2 control are desired, bypassing a portion of the flue gas can help to reduce the overall cost of CO_2 control

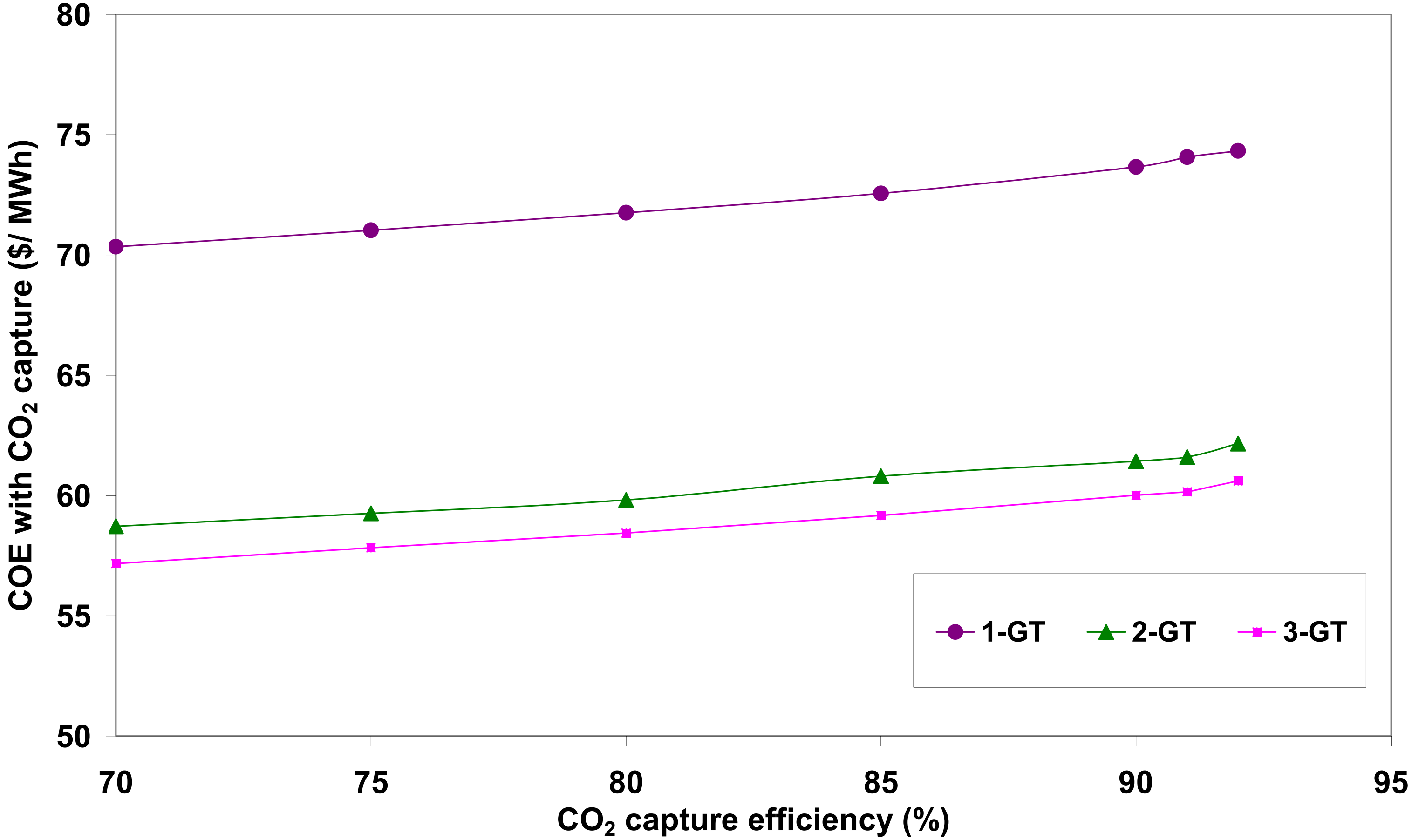
Thanks!!

Open for comments/questions

Cost of Electricity - PC



Cost of Electricity - IGCC



Breakup of Energy Penalty of CO_2 Capture