CAMBRIDGE CARES — CAMBRIDGE CENTRE FOR ADVANCED RESEARCH AND EDUCATION IN SINGAPORE LTD.

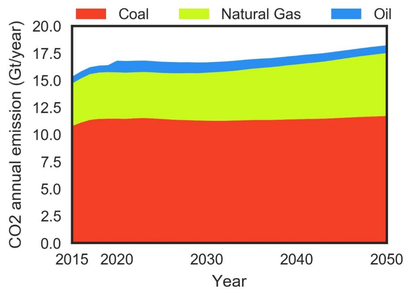
C4T

The critical role of economic assumptions in cost-effectiveness analysis of power plant CO_2 capture and storage

The work inspects the impact of key assumptions on cost-effectiveness of fossil fuel power plant CO_2 capture and storage (CCS). The generation cost of typical pulverized coal and natural gas combine cycle power plant under key parameter uncertainties are compared. We find that power plant CCS cost could vary by ± 20% when investigated parameters are at high/low end of uncertainties.

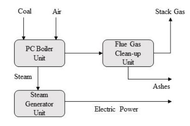
New contributions Cost-effectiveness evaluation is an important dimension of fossil fuel power plant CCS, we find that parameter assumptions could influence the plant CCS cost by up to 20% thus the cost-effectiveness results.

1 INTRODUCTION

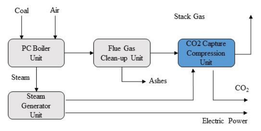


Projected annual CO_2 emission from fossil fuel power plant from 2015 to 2050 without CCS (from 15.3Gt in 2015 to 18.2Gt in 2050).

- Fossil fuel power plant is responsible for 25% worldwide CO_2 emission in 2014;
- Carbon Capture and Storage (CCS) has been identified as key technology to enable sustainable utilization of fossil fuel;
- The impact of CCS on the generation cost of fossil fuel power plant needs to be systematically inspected.

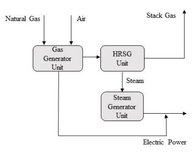


➢ PC w/o CCS

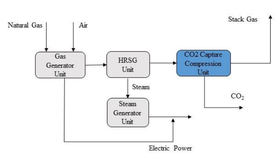


➢ PC w CCS

Process flow sheet of typical Pulverized Coal and Natural Gas Combine Cycle Power Plant with and without CCS



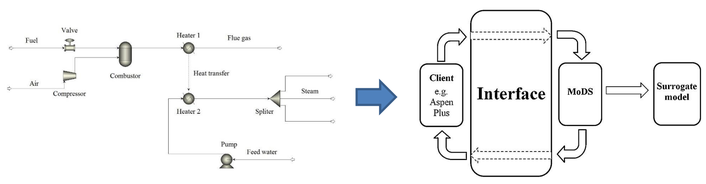
➢ NGCC w/o CCS



➢ NGCC w CCS

2 METHODOLOGY

2.1 Techno-economical modelling of power plant



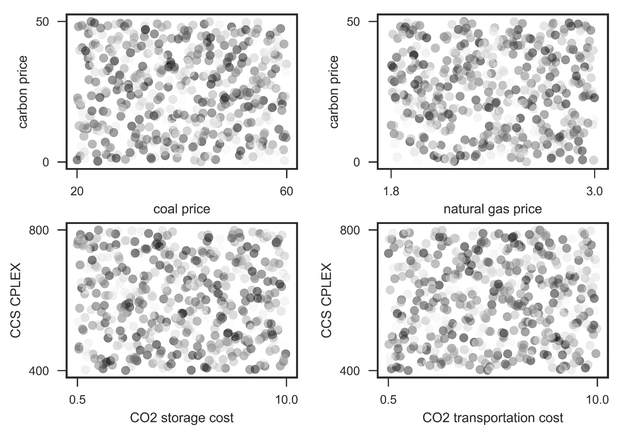
- Process flow fleet of power plant is modelled in Aspen Plus;
- Interface between Aspen and MoDS software is developed to manipulate the model inputs of Aspen;
- Techno-economic model of power plant is parametrized into surrogate model.

2.2 Single-factor sensitivity analysis

	500MW subcritical PC	500MW NGCC	Uncertainty range
Fuel price	42$/ton	2.6$/MBTU	20-60$/ton for coal; 1.8-3$/MBTU for gas
Technology learning	40%	40%	20%-90%
Carbon tax	0$/ton	0$/ton	0-50$/ton
CCS CPLEX	1200$/kW	600$/kW	700-1500$/kW for coal; 400-800$/kW for gas
CO_2 transportation cost	2.2$/ton	2.2$/ton	0.5-10$/ton
CO2 storage cost	3$/tom	3$/ton	0.5-10$/tom
Capacity factor	75%	75%	40%-90%

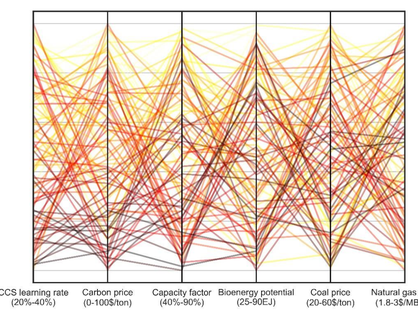
➢ Key parameter assumptions and uncertainties in the techno-economic model

2.3 Global sensitivity analysis



➢ Latin hypercube sampling method

2.4 Normalized CCS cost

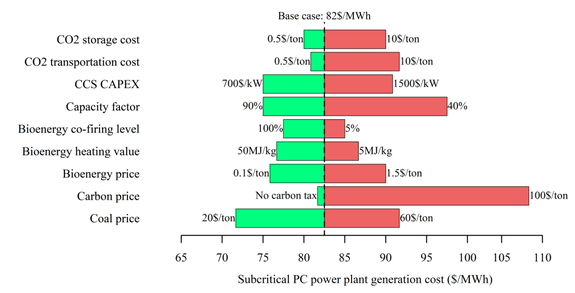


➢ Parallel coordinate plot of CCS cost;
➢ Each line represents a scenario;
➢ Colour of line represent the cost value (the darker, the higher).

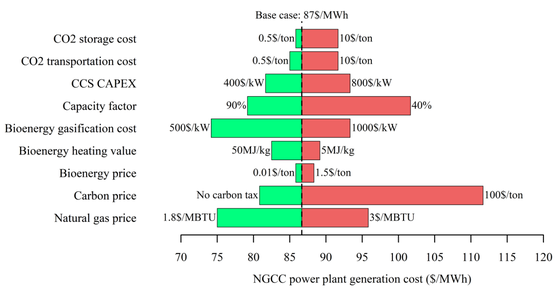
➢ Normalized CCS cost with parameter uncertainty

3 RESULTS

Change of typical PC and NGCC power plant generation cost with parameters

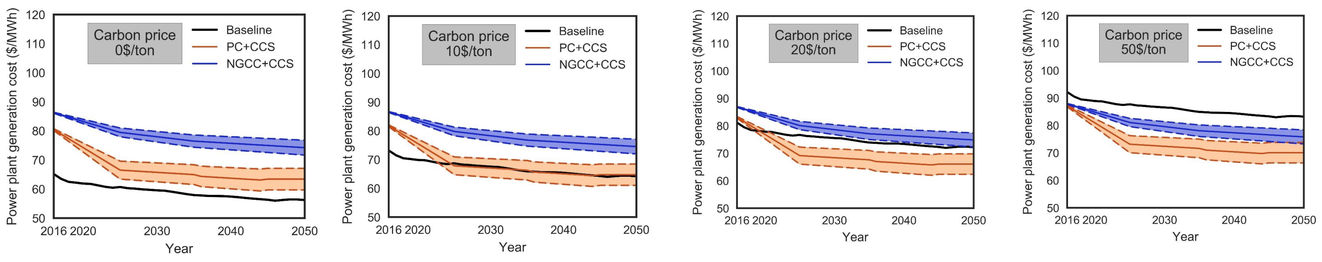


- For PC plant, parameter uncertainty could change its generation cost from 82 $/MWh to 72 $/MWh and 108 $/MWh;
- The low and high end of generation cost happens when coal price and carbon price is at the low and high end respectively.



- For NGCC plant, parameter uncertainty could change its generation cost from 87 $/MWh to 75 $/MWh and 110 $/MWh;
- The low and high end of generation cost happens when natural gas price and carbon price is at the low and high end respectively.

Impact of carbon tax and technology learning of power plant generation cost

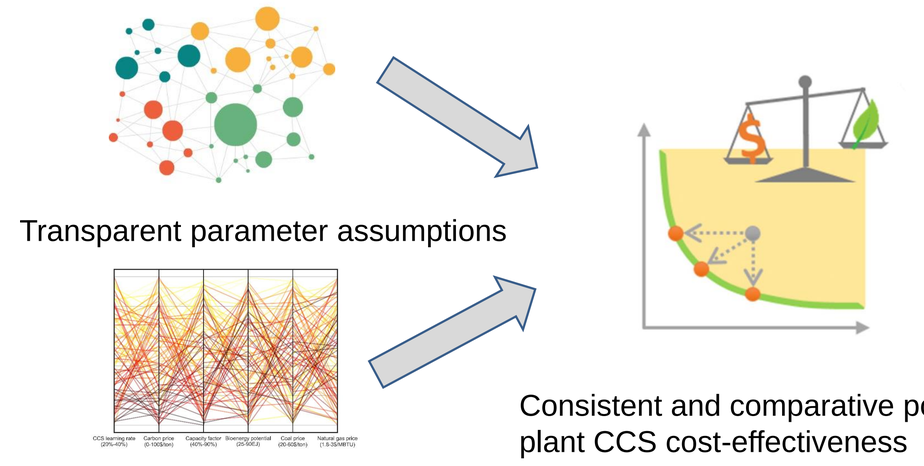


➢ 0 $/ton carbon tax ➢ 10 $/ton carbon tax ➢ 20 $/ton carbon tax ➢ 50 $/ton carbon tax

4 CONCLUSIONS AND FUTURE WORK

- Sensitivity analysis of fossil fuel power plant generation cost regarding to parameter uncertainties are conducted;
- Seven key parameters, namely fuel price, technology learning rate, carbon tax, CCS CPLEX, CO_2 transportation and storage cost, capacity factor, are investigated to inspect their impact on the plant generation cost;
- Generation cost of typical PC and NGCC power plant is sensitive to parameter uncertainties at different levels;
- Assumptions and models are equally important for cost-effectiveness evaluation.

Consistent power plant CCS cost-effectiveness evaluation framework



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CAM.CREATE C4T Cambridge Centre for Carbon Reduction in Chemical Technology