

CARBON DIOXIDE EMISSION REDUCTION STRATEGIES FOR COAL FIRED ELECTRICITY GENERATION

S. Renuka, M.A.R.M. Fernando and A. Atputharajah

*Department of Electrical & Electronic Engineering, Faculty of Engineering,
University of Peradeniya*

Introduction

For the past few decades, the demand for electricity supply in Sri Lanka has increased many folds due to globalization, industrialization and urbanization [1]. To cater to this demand, natural resources for power generation is far below adequate, hence resorting to an alternative is a must. The government of Sri Lanka has determined to resort to thermal generation utilizing coal firing to meet the growing demand for electricity. After the completion of the projects at Puttalam and Trincomalee, undertaken by the Ceylon Electricity Board (C.E.B.), a firm energy of 1400 MW is expected to be connected to the National Grid; further C.E.B. has also decided to increase its thermal power generation annually by 300 MW coal fired power generation [1]. Though supplementing the needs of electricity by coal firing is recommended, the emission of Carbon Dioxide (CO₂) to the atmosphere has also to be taken into account.

In this analysis only CO₂ emission is considered being well aware that there are other gaseous by products with global warming potential. Concentrating mainly on CO₂ emission will impart a clear idea of the impact of the carbon foot print therefore it will help to take firm steps to reduce its impacts on the

environment. These steps have to be analyzed with the impacts of capital cost, energy penalty and percentage of CO₂ emission reduction.

The main objective of this research paper is to test the feasibility of different CO₂ emission reduction techniques and compare their performance with each other. This paper explicitly deals with the benefits and the drawbacks of CO₂ Capture and Storage (CCS), Co-firing biomass with coal and improved plant efficiency. In this study, a most suitable method is proposed to C.E.B. for its coal fired power generation. Of all the devices mentioned above to reduce CO₂ emission, nuclear fission thermal generation is the best option which completely eliminates the CO₂ emission, however this is not economically feasible to Sri Lanka.

Methodology

Carbon footprint of a power plant is linked with its life cycle. This analysis deals with the carbon emission during the fuel combustion only. As a first step Carbon Emission Factor (EF) for the pulverized coal used in Sri Lankan coal power generation was determined by the tier3 methodological approach given in "2006 IPCC Guidelines for estimating emissions from fossil fuel combustion". Subsequently falling in-line with above results, the total

amount of CO₂ emission for the forthcoming half a decade was determined to show the gradual increase in CO₂ emission with the commitment of coal fired power generation. Then a sample calculation was done for a proposed 900MW pulverised coal fired thermal power plant at Norachcholai, Puttalam based on various strategies involved in reduction of CO₂ emission.

Results and Discussion

All the results presented here and the calculations pertaining to them are purely based on the data obtained from the Long-term Generation Expansion Plan 2009- 2022, of C.E.B and on the basic assumption that coal power plants are used only for base load production. Estimates of the annual CO₂ production from coal power generation is as shown below.

Of the four mitigatory measures of CO₂ reduction, only two environmentally friendly options; CCS, Co-firing biomass with coal could be adopted in Sri Lanka. The remaining two methods viz; adopting thermal power generation by nuclear fission method and improving plant efficiency resorting to retroffing more advanced components are uneconomical to Sri Lanka and as such are not considered in this approach.

Co firing with bio mass

Biomass shall be considered as a CO₂ neutral fuel. Even though co firing reduces CO₂ emission drastically, there are many technical problems in its usage such as fuel preparation, handling and storage, milling and feeding, different combustion behaviour, possible decreases in overall efficiency, deposit formation and ash utilization [2].

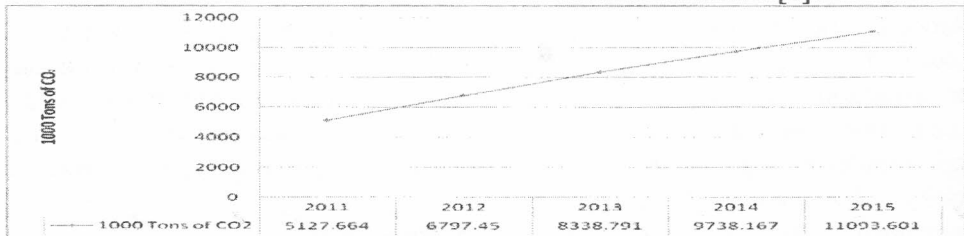


Fig.1. Estimated Annual CO₂ Emissions Due to Coal Power Plant

Table 1: Sample Calculation for 3X300 Mw Coal Fired Power Plant, Puttalam

Description of Parameter	Base	With CCS	With Bio-mass Co-firing		
			10%	30%	50%
Cost of electricity (Rs/kWh)	10.81	15.76	12.98	17.31	21.64
CO ₂ emissions to atm (kg/s)	264.42	26.4	237.98	185.09	132.21
Net output (MW)	900	720	900	900	900
CO ₂ emissions (kg/kWh)	1.06	0.132	0.95	0.74	0.529

Carbon Capture and Storage (CCS)

The implementation of CCS technology for high capacity plants is in the dormant stage and still being debated considering that it is effectively used for small capacity plants due to energy penalty in the system. Leakage and long-term storage are also most contentious areas of liability as very low leakage rates could undermine any climate mitigation effect [3].

The results of the analysis involving cost of electricity, CO₂ emission and net power output, utilizing the various techniques are comparatively given in Table 1. In the co firing arrangement, increase in the percentage of biomass will definitely reduce the percentage of CO₂ emission while increasing the operating cost. In comparison CCS technology while reducing the CO₂ emission simultaneously reduces the net output energy.

References

Long-term Generation Expansion Plan 2009-2022, Transmission & Generation Planning Branch, Transmission Division, C.E.B. Sri Lanka. Dec.2008[1].

CO₂ Capture, Reuse, and Storage Technologies for Mitigating Global Climate Change, a White Paper, Final Report, DOE Order No. DE-AF22-96PC01257 [2].

IEA Clean Coal centre, Fuels for biomass co-firing, Rohan Fernando, CCC/102, ISBN 92-9029-418-3, October 2005[3].

Conclusion

It is clear that there is today no credible pathway towards stringent GHG. stabilization targets without reducing the CO₂ emission from coal fired power plants. The two techniques i.e. Carbon Capture and Storage (CCS) and Co-firing coal with biomass reinforce each other in terms of benefits of CO₂ emission reduction, local air quality and energy security of the supply. However, the usage of biomass increases the total production cost whereas CCS technology reduces the net output power. Despite, the high cost involved in implementing these two measures may impose a burden on the consumers. Hence it is suggested; "A proper combination of CCS and Co-firing biomass with coal will be a positive approach while answering the growing energy demand and the reduction of CO₂ emission".

Computing the solar vector" Solar Energy Vol. 70, No. 5, pp. 431-441, Elsevier Science Ltd.

Tomas Matuska Ph.D,Ing. Vidimir Zmrhal PhD/CTU in Prague, Kelektor 2.2 Software package, Ing., Faculty of mech Eng, Enviornent Eng , Technicka 4 , Crech Republic.