Supporting Information

Carbon capture and mineralization in Singapore: preliminary environmental impacts and costs via LCA

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Life cycle inventory data

The air emissions from the NGCC power plant are taken from Tan et. al.[1]. Supplementary data are extracted from Jeramillo et. al.[2]. The CO_2 recovery process considered is amine scrubbing utilizing monoethanolamine. The energy penalty for an NGCC power plant is 16% with CO_2 recovery rates of 90% [3]. Heat energy demands for amine scrubbing of CO_2 from power plant flue gas can be as high as 3570 MJ/tonne CO_2 [4]. The amine scrubbing process technology details can be found in McKee[5].

The adoption of the carbon capture technology will affect the amount of NOx emissions per MWh from the NGCC power plant flue gas. This is because the energy penalty imposed on the power plant requires additional combustion of natural gas for every MWh delivered to the used. However, SOx emissions

(which will be very small for natural gas firing) are expected to be reduced as the sulfur compounds may react with the amine solvent. As for PM emissions, it was reported that there are hardly any changes in the emission levels with and without any post combustion capture installed[6, 7] .

The total energy required for mineral mining activities, including crushing and packaging, is estimated to be 62.3 MJ/tonne mineral[8,9]. The amount of CO_2 emissions emitted due to energy use for mining minerals in Western Australia is estimated from CARMA[10], which is 0.176 kg CO_2 per MJ. Other emissions (NOx, SOx, PM) are taken from EcoInvent[11]. The inventory data is compiled in **Table 1a.**

Freight shipment emissions and energy needed (0.095 MJ/tonne-km) are estimated with the use of GaBi life cycle engineering[12]. They are shown in **Table 1b**. The distance from Western Australia to Singapore is 3986 kilometers (from port to port by sea).

EDIP 2003: Normalization

All environmental impact methods are carried out according to EDIP 2003[13]. The normalized values for both global warming and energy use are taken from EIA[14, 15]. The values for acidification and human toxicity to air (due to dust emissions) are from the EDIP. They are compiled in **Table 1c.**

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Table 1a. Compiled list of air emissions

kg pollutants per MWh from NGCC power plant w/o capture (with capture)		kg pollutants /kg mineral mined (unless described otherwise)	
CO_2	380 (126)	CO_2	0.176 kg/MJ
NOx	0.65 (0.76)	NOx	1.16×10^{-6}
SOx	0.054 (0.011)	SOx	1.77×10^{-7}
PM	0.0055 (0.0055)	PM	0.000112

Table 1b. Pollution from shipment

kg pollutants per 1 tonne-km	
CO_2	0.00675
NOx	9.49×10^{-5}
SOx	1.61×10^{-4}
PM	5.45×10^{-6}

Table 1c. Normalized values

Environmental impacts	Normalized values
Global warming (total kg CO_2)	8700 kg CO_2/capita
Energy (MJ total)	502416 MJ/capita
Acidification (m^2/UES)	2200 m^2/UES/capita (EDIP 2003)
Human Toxicity to Air (m^3/kg air)	4.87×10^7 m^3/kg/capita (EDIP 2003)