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A life cycle environmental impact assessment of natural gas combined cycle thermal power plant in Andhra Pradesh, India

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ABSTRACT

The study presents the life cycle environmental impacts of natural gas combined cycle thermal power plant in India. The CML 2001 and Eco-Indicator 99 (H) methods have been used to assess the midpoint and endpoint impacts from 'cradle to gate'. The primary data was collected by personal visits for environmental emissions, wastewater, fuel used, and technical specifications. The impacts category comprised of global warming, acidification, eutrophication, ecotoxicity, carcinogens, respiratory organics, respiratory inorganics and climate change. The study shows that upstream processes have more impacts except global warming potential if compared at mid-point stage. It is an interesting observation that ~81% of the total carcinogen impacts and ~88% of the respiratory-organics impacts in terms of disability adjusted life years are due to upstream process. This is due to the reason that during natural gas extraction, treatment and transmission, organic air emissions such as non-methane volatile organic compounds, formaldehyde and polycyclic aromatic hydrocarbons are released. Impacts on ecosystem quality are due to acidification & eutrophication together i.e. 2.27E-03 in terms of potentially disappeared fraction over a certain area and time frame (PDF × m^2 × yr) and 1.54E-03 as potentially affected fraction (PAF × m^2 × yr) due to ecotoxicity. This study shows that climate change potential contributes to 53% impacts on human health; whereas, human toxicity potential results into 47% impacts on human health.

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Acidification and eutrophication cause 60% impacts on species diversity, mainly for vascular plants and lower organisms; whereas, ecotoxicity results into 40% impacts on aquatic life.

1. Introduction

The energy sector is the major contributor to economic and industrial accomplishments as well as a pre-requisite for providing the basic human needs (Santoyo-Castelazo et al., 2011). In India, the main source of electricity generation is coal, which contributes to about ~56% of the electricity generation, whereas natural gas also contributes a significant ~10% towards electricity generation. Other sources of electricity generation in India include diesel, nuclear, hydro and other renewable sources as shown in Table 1 (CEA, 2012). Due to limited availability of coal and stringent environmental clearance requirements, the expansion of coal mining and exploration of coal is a very difficult task in current situation. The Indian coal sector is facing a substantial shortfall in the quantum of coal production that is likely to continue in future. Natural gas is a clean fuel as compared to coal and can be efficiently used in power generation in terms of overall environmental damage (Dinca et al., 2007). As the domestic coal supply i.e. lignite is generally of low grade in terms of specific calorific value, a high degree of ash content (30–50%) is generated, which has an adverse impact on the environment. Indian coal based thermal power plants require more energy for generating 1 kWh of electricity as compared to other countries such as USA (MIT, 2007). Therefore, the Government of India encourages gas based or imported coal thermal power plant in coastal regions if the indigenous coal availability is very far from the plant site. The use of gas in power-generation was initially promoted by the government on environmental considerations. As on September 30, 2012, the total installed capacity of the natural gas based power plants in India was ~18,903 MW (CEA, 2012).

According to IEA (2011), India has been importing natural gas since 2004 and the gap between natural gas extracted within the country and its demand is increasing. The main sources of natural gas

Table 1
Overview of installed generation capacity of power in India.

Region	Installed capacity (MW)–(2011–12)							
	Thermal				Nuclear	HYDRO	RES[a]	TOTAL
	COAL	GAS	DSL	TOTAL				
Northern	29,924	4671	13	34,608	1620	15,424	4438	56,089
Western	42,479	8255	17	50,752	1840	7448	8147	68,186
Southern	23,032	4963	939	28,935	1320	11,338	11,769	53,362
Eastern	22,338	190	17	2254	0	3882	411	26,838
N. Eastern	60	824	143	1027	0	1200	228	2455
Islands	–	–	70	70	0	0	6	76
All India	**117,833**	**18,903**	**1199**	**117,646**	**4780**	**39,291**	**24,998**	**207,006**
All India generation of electricity (terawatt-hour-TWh)–2011-12								
Target	712				25	112		
Actual	709				32	131		
Short fall(−)/Surplus(+)	−3				7	19		

Note: As on July 2010, the total number of thermal power stations using coal, natural gas and diesel as fuel source were 115, 42 and 13, respectively (CEA, 2012).

[a] **RES**–renewable energy sources includes small hydro project(SHP), biomass gas(BG), biomass power(BP), urban & industrial waste power(U&I), and wind energy categorized by ministry of new and renewable energy, Government of India.