POLICY NOTE

Electricity Sector in India

Electricity plays an indispensable role for the economic growth of a country, as it caters to multiple facets of the economy – from a small household in a rural village to a large manufacturing industry. In developing countries like India, due to the versatility and growing demand, electricity growth has outpaced economic growth in recent times. In fact electricity use as a share of overall energy use has increased over time, as societies modernise and become wealthier[1] . India is the world's third largest producer and fourth largest consumer of electricity[2]. The total installed capacity (including non-utilities) as on 31 March 2016 was 349.2 Gigawatts (GW) and the total generation was 1351.97 Terawatt hours (TWh)[3]. Industries are the major consumers of electricity contributing to 44.11% of the total share followed by domestic (22.93%) and agriculture sector (17.81%). Per capita electricity consumption of India crossed the thousand mark in 2014-15 at 1010 kWh, growing at 5.3% CAGR over 2005. Due to increasing population, urbanisation and energy access, electricity consumption is expected to grow further.

The utility based electricity generation capacity grew at 9.1% CAGR and non-utility based electricity generation capacity grew at 9.3% CAGR over the period 2005-13. Coal has dominated the electricity generation in India with 74.79% of the gross electrical energy generation in the country, followed by hydro (11.57%) and renewable energy sources (6.59%).

Historical Greenhouse Gas Emissions from Electricity Sector

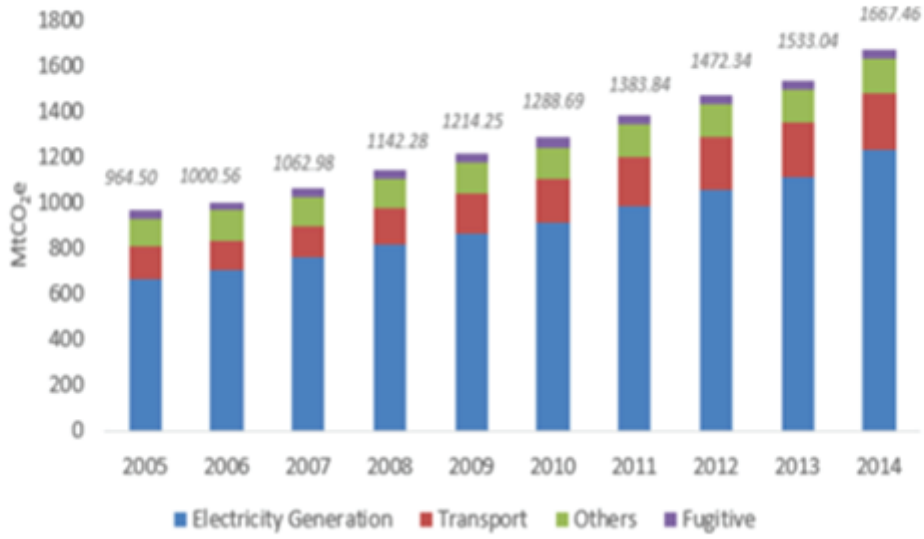
Electricity generation is the highest source of greenhouse gas emissions accounting for more than 40% of the total emissions as per official inventories[4]. Carbon dioxide (CO_2) emissions constitute 99% of the total emissions in this category. The emissions from electricity sector are calculated by multiplying fuel-wise activity demand by their respective Net Calorific Values (NCV) and gas specific Emission Factors (EF). The formula used to calculate Greenhouse gas emissions is described below:

$$Emissions_{Gas} = Activity\ Data_{Fuel} \times NCV_{Fuel} \times EF_{Gas}$$

The emissions in the electricity sector have grown at a rate of 7% CAGR during the period 2005-14. The graph below illustrates contribution of different sectors to emissions from energy sector.

Emissions from utilities grew at 6% CAGR, whereas non-utilities/captive power plant emissions grew at 11% CAGR over 2005-14. The higher growth rate in captive generation can be attributed to the National Electricity Policy 2005 which freely permitted captive generation. There has been an increasing trend of emissions from coal and lignite based power plants. In contrast, a decreasing trend of emissions

Figure 1: Historic emissions from Energy sector



1. https://twas.org/sites/default/files/sustainenergyreport.pdf
2. http://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-electricity.pdf
3. CEA General Review 2016
4. MOEFCC. (2015). India: First Biennial Update Report to the United Nations Framework Convention on Climate Change. New Delhi: Government of India.

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Table 1: Fuel wise emissions from Electricity Generation (in $MtCO_2e$)

Fuel	2005	2014	CAGR
Coal	583.3	1154.7	7.9%
Furnace Oil	3.6	1.4	-9.6%
LDO/HSD	1.6	0.7	-9.1%
LSHS/ HHS	2.3	0.7	-11.9%
Natural gas	36.6	30.6	-2.0%
Lignite	24.1	33.4	3.7%
Naphtha	2.4	1.3	-6.2%
Diesel	12.8	10.0	-2.7%
Total Electricity Generation	**666.7**	**1233.0**	**7.1%**

was seen in the power plants using gas, naptha, furnace oil, diesel and Low Sulphur Heavy Stock (LSHS)/Hot Heavy Stock (HHS). Emissions from different fuels used in electricity generation between 2005 and 2014 is summarised below.

Emissions from solid fuels, i.e. coal and lignite constitutes about 96% of the total emissions from electricity generation sector and there has been an increasing trend of coal based emissions (7.9% CAGR) over the years 2005-14. However, owing to the limited application of liquid fuels in thermal power plants, there has been a decline in emissions from gaseous and liquid fuels.

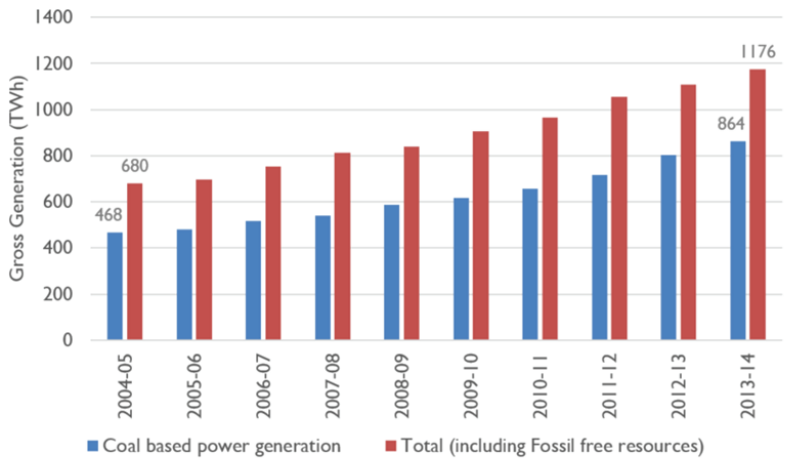
Policies and Strategies towards decarbonisation

Despite the increased adoption of Renewable Energy (RE) based power generation, coal has continued to dominate the electricity generation mix (refer figure 2). Developmental aspirations (24/7 Electricity for All) coupled with increase in demand for electricity from various sectors (Agriculture, Buildings, Industry and Transport), and policies towards economic development has led to the indomitable role of coal, which till recently was the most accessible and affordable source. However, owing to improved efficiency in newly introduced technologies such as super-critical boilers for thermal power generation, emissions from coal based power generation is expected to gradually reduce in the coming years.

The Electricity Act 2003 was enacted to transform power sector in India and provides for measures conducive to the development of power sector in the country. Under this Act, electricity generation was de-licensed and captive generation was freely permitted.

The National Electricity Policy in 2005 provided the sector with policy impetus to decarbonise and grow – it aimed to provide reliable and quality electricity supply to all in an efficient manner, at affordable prices. Following this, in 2011 it was reported that

Figure 2: Share of coal based power generation



nearly 200 GW of coal and gas based plants were given environmental clearances from the Ministry of Environment and Forests and around 500 GW more were in the pipeline – much higher than the policy mandates. In 2016, after reviewing clearances and projects, CEA announced that several proposed plants were scrapped due to project financing, coal linkage delays while some failed to receive clearances.

As per the CEA's National Electricity Plan 2016, the the projects underway total to a capacity addition of 101.6 GW by 2022, of which 86.2 GW (85%) will be realised from coal based power plants. Around 39% of this coal based capacity addition will be met by super-critical technology. Other recent announcements from the government include ambitious targets for both coal mining, renewable energy targets, improving net heat rate of existing plants through renovation and modernisation programme, in addition to process changes in boiler and turbine systems. Furthermore, policies focussing on (a) phasing out older plants (>25 years) from the existing stock and switching them into super critical boilers[5] and (b) implementation of emission standards for thermal power plants, will improve efficiency and reduce the average emission factor of power generation.

The coal production is expected to reach one billion tonnes by 2020[6] and the renewable energy target is set at 175 GW capacity by 2022[7] . On the other hand, the government has also doubled the coal tax (Clean Environment Cess) to Rs 400 per tonne of coal and proceeds from this tax have been channelled to set up National Clean Energy and Environment Fund (NCEEF)[8] .

According to a recent amendment in New Coal Distribution Policy, the upward limit of coal consumption has been revised to 10,000 tonnes as compared to the previous limit of 4,200 tonnes for the consumers[9] . This policy action, coupled with coal production target is set to increase coal consumption in India- thus the emissions from coal. Power sector (utilities and non-utilities) consumed 62% of the total non-coking coal produced in India for the year 2014-15[10] . The one billion tonnes target of coal production could potentially add 1427 million tonnes carbon dioxide equivalent ($MtCO_2e$) emissions from power sector[11] . Other policy initiatives like revision in fuel supply agreement for improving Plant Load Factor (PLF) and minimise coal shortages via new e-auctions will also add to the rationale for planned increase in domestic coal production.

The total CO_2 emissions for the year 2021-22(electricity demand 1748 TWh) and 2026-27(2335 TWh) are estimated at 983 million tonnes and 1165 Million tonnes respectively[12] . The report estimates that 6.073 $MtCO_2e$ has been avoided during 2015-16 due to commissioning of super-critical technology based coal power plants and 268 $MtCO_2e$ emission will be avoided annually by the end of the year 2021-22 owing to increased use of renewable energy sources.

India's Nationally Determined Contribution (NDC) projects 2499 TWh of electricity demand in 2030. It aspires to achieve 40% of cumulative electricity generation capacity by fossil free energy resources by 2030. CSTEP's 'Quality of Life for All' report examined the Sustainable Development (SD) scenario under the light of various government policies such as National Solar Mission, National Mission for Enhanced Energy Efficiency, 24/ 7 Electricity Access , Deendayal Upadhyaya Gram Jyoti Yojana, RE capacity targets and policy instruments and INDCs[13] . The potential reduction in GHG emissions due to RE generation and reduction in Transmission & Distribution (T&D) losses is estimated to be 707 $MtCO_2e$ by 2030 under the SD scenario[14].

Various initiatives undertaken by Government of India such as improving efficiency of thermal power plants, implementation of strict environmental norms, retiring old and inefficient thermal power plants and Perform Achieve and Trade (PAT) scheme and adoption can help reduce greenhouse gas emission from Electricity Generation sector. There is also a need for robust sector wise greenhouse gases emission inventory so that the ambitions set by the

5. http://www.indiainfoline.com/article/news-top-story/super-critical-power-plants-power-ministry-to-phase-out-old-power-plants-117031600358_1.html
6. http://coal.nic.in/content/roadmap-enhancement-coal-production-one-billion-tonnes-cil-0
7. http://niti.gov.in/writereaddata/files/writereaddata/files/document_publication/report-175-GW-RE.pdf
8. http://doe.gov.in/sites/default/files/NCEF%20Brief_post_BE_2017-18.pdf
9. http://coal.nic.in/sites/upload_files/coal/files/curentnotices/270916ncdp_0.pdf
10. http://coal.nic.in/sites/upload_files/coal/files/coalupload/chap6AnnualReport1516en.pdf
11. Assuming a same share of coal consumption (62.27%) between utilities and non-utilities in power sector in 2014-15 and 2021-22; and Global warming potential for methane (21)
12. http://www.cea.nic.in/reports/committee/nep/nep_dec.pdf
13. Considers 44% fossil free installed capacity for electricity generation
14. http://niti.gov.in/writereaddata/files/document_publication/58fc41cccff9acf678dea2ffa24f8f28.pdf

government can be realised effectively and priority sectors can be identified.

Drivers for Emission Reduction

Drivers to accelerate the decarbonisation rate of power generation sector include:

a. Fuel switch: Increased the utilisation of natural gas and clean coal (coal beneficiation) are two levers for decarbonising existing plethora of thermal power plants. Shifting from coal to natural gas based power generation will require retrofitting procedures that can be linked with the government's RNM (Retrofitting and Modernisation) programme. By implementing coal beneficiation process, the absolute quantity of coal required to generate a unit of electricity reduces by 0.05 kg, on average. This further influences the overall quantity of coal combusted in boiler to generate heat.

b. Technology adoption: Pulverised Coal (PC) boiler technology is predominantly used in Indian power plants. Increasing the share of super-critical boilers in the existing and new stock will help reduce the emissions footprint of power sector; however, shifting from pulverised coal boiler to Fluidised Bed Combustion (FBC) boiler may yield better efficiency, especially in non-utilities sector given the limitations in scalability. Further, process changes within the boiler and turbines[15] may improve heat rate, and reduce changes in station heat rate to within 7% of design heat rate. Other advantages like import fuel independency and reduction in ash-generation can act as associated benefits of switching technologies from PC boiler to FBC boiler in non-utilities.

c. Fossil-free Sources: Given the price drops in solar based power generation, in addition to natural availability of solar and wind resources, 'coal' is not a cheap resource for electricity generation. However, owing to interruptive nature of RE, other fossil-free sources such as hydro and nuclear may yield positive results towards decarbonising the power sector.

d. Policy thrust: Several policies (refer earlier section) have been implemented in the past decade towards realising the potential of emissions reduction. In addition, policies towards disincentivising coal procurement (increase in cess tax) also play a crucial role in influencing the decision of end-user. Further, state governments have placed strict regulations towards reduction of coal footprint in their State Action Plan on Climate Change (SAPCC) targets. Innovative business models and financial incentives towards decentralised RE generation and micro grids is necessary to further reduce the net emission intensity of electricity moving forward.

Authors: Murali Ramakrishnan Ananthakumar & Yeshika Malik
For more information contact cpe@cstep.in

15. http://shaktifoundation.in/wp-content/uploads/2014/02/Whitepaper-Thermal-Power-FINAL.pdf