# Coal Fly Ash Production, Utilization in India

Subjects: Mineralogy

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Coal fly ash (CFA) is one of the most burning issues in the whole world due to its large amount of production in thermal power plants. Every year a million tons (MTs) of CFA are generated globally of which almost half is utilized in various forms, while the remaining half remains unused, leading to various types of pollution.

pozzolanic thermal power plants aluminum

## 1. Introduction

Energy, being one of the fundamental requisites across the globe, is essential to all significant activities such as industry, transportation, and other related fields. There was a time when energy was required only in a few sectors but, today, we cannot think of any field without energy. This energy is fulfilled by various sources like coal, nuclear, hydro, wind, and solar [1]. Historically, several economies relied heavily on energy derived from fossil fuels, but significant numbers of industrialized nations embrace cleaner energy instead. However, for a growing nation like India, wherein coal is still the primary source of energy, it will always be a major accomplishment. This is a result of India's substantial coal reserves, which impose on it a dependency on coal-fired thermal power plants (CF-TPPs) [2][3][4][5].

A nation's economic development is critically correlated with its energy usage. The national per capita income has a direct correlation with the energy demand [6]. The necessity to address the increased energy demand is due to the growing demand for energy brought on by globalization. The efficient conversion of resources into energy perhaps relies on technical prowess plus resource availability. Fossil fuels, among which coal makes up a substantial proportion, are still the major source of energy [5]. Gradually, around the whole globe, the demand for energy is increasing in the sectors like agriculture, defense, transport, etc. In addition to this, an extra burden has been put on energy due to rapid industrialization, urbanization, and the explosion of the human population [7]. In comparison to 2020, the demand for energy has increased in 2021, as in 2020, there was a decline of 4.1% due to COVID-19. As per the International Energy Agency (IEA, 2021), there was an increase in power generation in 2021 around the globe, it increased by 9% to 10,350 TWh in 2021. India is a developing country; energy plays a vital role, as its economy is predicted to develop by 8%–10% per year.

## 2. Coal as a Source of Energy in India

The largest known source of energy for the generation of electricity worldwide is coal, and its proportion is increasing. Coal-fired power plants produce more than 42% of the world's electricity [8]. The world's largest reserves of all types of coal are believed to be over 990 BTs, which is plenty for 150 years as the per current usage. Coal is by far the most prevalent and accessible fossil fuel worldwide (BGR, 2009) [6]. According to the access to coal, the Indian coal sector decided to set two objectives for the fiscal year (FY) 2021, the first of which was 1.5 BTs of income and the other was to double its output in order to fulfil the growing demand. Indian power sectors would naturally need to concentrate on having a positive influence in the near future in order to reach the FY 2021 goal. The growth of India's coal use has been supported by its investment in new CB-TPP capacity.

## 3. Status of Thermal Power Plants in India

As of now, India has over 197 coal/lignite-based thermal power plants (CB-TPPs), that generate 133 MTs of CFA (half yearly) [MT] (2021–2022). These plants generate (70–75% of the country's electricity. According to official statistics from the half-year period of 2021–2022 (half yearly), no new TPPs will be commissioned for the purpose of generating energy beyond 2027. Approximately 50,025 MW of coal-based thermal power (CB-TPP) facilities are now planned for construction in India (Coal projects 2010); (NEP 2021). This information is encouraging because it suggests that India would become a stronger superpower in terms of economics and energy. Hence, a reliable source of coal that can be supplied to CB-TPPs is required for the uninterrupted and reliable energy generation by TPPs.

By 2031–2032, the CFA generation figure could surpass 1000 MT. Despite ongoing study and improvement around CFA consumption, a significant portion, about 50% of CFA, remains underutilized each year. All three types of pollution—land, water, and air—are caused by the ongoing disposal of leftover CFA. An extensive analysis of government data on CB-TPPs revealed a yearly increase that has been happening over time, making the problem untenable. The commissioning of super TPPs will not only have a positive impact but rather the pollution generated in all forms will be a major concern for the government as well as locals.

## 4. Basic Structural and Chemical Properties of CFA

Coal is basically an organic sediment which contains several elements like H, S, N, C, and O along with a broad range of trace metal concentrations [9]. The amount of carbon in coal's constitution determines its qualitative value [10]. Coal might incorporate one or more dangerous elements, such as Arsenic, Beryllium, Boron, Cadmium, Chromium, Cobalt, Lead, Manganese, Mercury, Molybdenum, Selenium, Strontium, Thallium, and Vanadium, in either significant or minute concentrations, based on the origin [11][12][13][14][15][16]. The ignition of pulverized coal in the TPPS results in the production of CFA, a finer powdery material that resembles glass [15]. Its size is approximately in microns ranging between 0.01 to 100, and its surface is glassy heterogeneous [17][18]. CFA also contains a number of the elements found in coal, including silica, alumina, and iron, which are significant oxides, as well as minor oxides of Na, Mg, Ca, P, K, and Ti [19]. The type of coal used in TPPs to produce electricity affects CFA's Al, Si, and calcium content. The classification is essentially centered on the total amount of calcium, silicon,

and aluminum oxides; if this amount surpasses 70%, it is class F fly ash, which is made from top varieties of coal, while if it is less than 70% and contains calcium greater than 5%, it is class C fly ash. Poorer varieties of fossil fuels like peat and sub-bituminous coal are the sources of class C fly ash. One of the most notable characteristics of CFA is size-based because CFA particles have a large surface-area-to-volume ratio (SVR). Heavy metals and other elements may accumulate on their surface readily when particle size decreases [20][21].

## 5. CFA Production and Utilization in India

Annual coal production was roughly 40 MTs during 1993–1994, whereas CFA utilization was only 3% or 1 MT. Conversely, CFA usage significantly climbed from 6.64 MTs in 1996–1997 to 107.77 MTs or 60.97% during 2015–2016. One may anticipate a brighter future for thermal power stations based on total coal consumption, CFA generation, and CFA utilization by looking at these figures. Without question, one may presume a prosperous India, dominating globally relative to its stronger economy. Although coal burning provides energy, environmental pollution is a detrimental component of the process. A significant number of techniques have been developed for their effective handling and disposal. Nonetheless, the management of the CFA will continue to be a significant matter of debate. Considering the advancements in CFA-based techniques and products, CFA has been upgraded from hazardous waste to a “useful and saleable asset” [22]. Coal-fired TPPs were built in India by state-owned companies, private businesses, central agencies like the national thermal power corporation (NTPC), and others.

For electricity generation, India has a substantial coal reserve and coal-based TPPs. Different federal agencies monitor the TPP’s operation, installation, life cycle, carbon dioxide emission, CFA generation, and utilization on a regular basis. The Central Electrical Authority of India (CEA) gathers relevant information from all thermal power facilities and releases half-yearly and annual reports in the month of June and December, respectively. Therefore, according to CEA reports spanning from 2010–2011 to 2021–2022, the following data have been acquired, which are listed in **Table 1**.

**Table 1.** Progressive CFA production and utilization during the period from 1996–1997 to 2020–2022 (CEA reports December 2021/July 2022).

| S. No | Year | CFA Production (Million Tonnes) | CFA Utilization (Million Tonnes) | Percentage (%) |
|---|---|---|---|---|
| 1 | 1996–1997 | 68.88 | 6.64 | 9.63 |
| 2 | 1997–1998 | 78.06 | 8.43 | 10.80 |
| 3 | 1998–1999 | 78.99 | 9.22 | 11.68 |
| 4 | 1999–2000 | 74.03 | 8.91 | 12.03 |
| 5 | 2000–2001 | 86.29 | 13.54 | 15.70 |
| 6 | 2001–2002 | 82.81 | 15.57 | 18.80 |

| S. No | Year | CFA Production (Million Tonnes) | CFA Utilization (Million Tonnes) | Percentage (%) |
|---|---|---|---|---|
| 7 | 2002–2003 | 91.65 | 20.79 | 22.68 |
| 8 | 2003–2004 | 96.28 | 28.29 | 29.39 |
| 9 | 2004–2005 | 98.57 | 37.49 | 38.04 |
| 10 | 2005–2006 | 98.97 | 45.22 | 45.69 |
| 11 | 2006–2007 | 108.15 | 55.01 | 50.86 |
| 12 | 2007–2008 | 116.94 | 61.98 | 53.00 |
| 13 | 2008–2009 | 116.69 | 66.64 | 57.11 |
| 14 | 2009–2010 | 123.54 | 77.33 | 62.60 |
| 15 | 2010–2011 | 131.09 | 73.13 | 55.79 |
| 16 | 2011–2012 | 145.41 | 85.05 | 58.48 |
| 17 | 2012–2013 | 163.56 | 100.37 | 61.37 |
| 18 | 2013–2014 | 172.87 | 99.62 | 57.63 |
| 19 | 2014–2015 | 184.14 | 102.54 | 55.69 |
| 20 | 2015–2016 | 176.74 | 107.77 | 60.97 |
| 21 | 2016–2017 | 169.25 | 107.1 | 63.28 |
| 22 | 2017–2018 | 196.44 | 131.87 | 67.28 |
| 23 | 2018–2019 | 217.04 | 168.4 | 67.13 |
| 24 | 2019–2020 | 226.14 | 189.01 | 77.59 |
| 25 | 2020–2021 | 232.56 | 214.91 | 83.28 |
| 26 | 2021–2022 | 270.82 | 259.86 | 92.41 |
| 27 | 2022–2023 | - | - | - |

om 1996-1997 to 2021–2022 (CEA, 2022). It is indeed suspected that the increasing production of CFA is attributable to the addition of new super TPPs. Whilst increased use of CFA could be attributed to rigorous government directives, regulations, awareness, legislation, and technological advancements. The instruments aid in the assessment of CFA's comprehensive characteristics, which may also play a significant role in CFA's enhanced usage rates. The use of CFA has grown rapidly from 1996–1997 to 2021–2022, as shown in **Table 1**. Only 9.63% of CFA were used in 1996–1997, following which there was a gradual increase in the use of the different forms. Whereas the CFA utilization percentage grew to 81.65 (half yearly) per cent in 2021–2022. India's CFA usage is projected to improve in the coming time, depending on such figures. Considering the developments in technology, governmental initiatives, regulations, and public awareness, there will be no serious pollution in the form of hazardous waste in

the foreseeable future. The government estimates that between 2020 to 2025, roughly 240 and 300 MTs of CFA will be generated [23].

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