ISSN 2063-5346

Section A-Research paper

Carbon Foot Print Assessment of Power Plants: Paving the Way for Renewable Energy Sources in India

Ekta Tamrakar[1, *], Ruchira[2], R.N. Patel[3],Arun Kumar[4]and Raunak kumar Tamrakar[5]

Department of Electronics and Telecommunication,Bhilai Institute of Technology, Durg, C.G,India [1,4]

Department of Electrical and Electronics Engineering, Amity UniversityUttar Pradesh, Noida, India [2]

Department of Electrical Engineering, National Institute of Technology, Raipur, C.G., India[3]

Department of Applied Physics, Bhilai Institute of Technology (Seth Balkrishan Memorial), Near Bhilai House, Durg (C.G.) Pin-491001, India[5]

*Corresponding Author: ektatamrakar@gmail.com

ABSTRACT

The total amount of carbon dioxide and its equivalents released as a result of various human activities is known as the carbon footprint (CF). A carbon footprint is a measure of the environmental impact of human activities in terms of greenhouse gas emissions. The concept of a carbon footprint is closely tied to climate change and environmental sustainability.Power generation is a major contributor to greenhouse gas emissions, primarily carbon dioxide (CO_2), which is a leading driver of climate change. India is world's third largest emitter of green house gases. In this paper, a study is conducted on the carbon footprint assessment from the different sources of power generation used in Uttar Pradesh.This research focuses mostly on CO_2 emissions using the installed capacity and load factor of power plants. The estimation indicates that Uttar Pradesh emits 39,383 megatons of CO_2 annually. The generation of electricity is responsible for 35.5% of total CO_2 emissions, followed by power plants. Thermal power plants release the most CO_2 in Uttar Pradesh, followed by nuclear, hydroelectric, and solar power plants. The ratio of annual carbon storage to annual carbon emission, or carbon status, is calculated for each power plant.This analysis will help us to adopt energy efficient technologies and switching to renewable energy sources.

Keywords: Carbon Footprint (CF), Greenhouse gas (GHG) emissions, carbon storage, climate change in Uttar Pradesh, carbon capture, renewable energy.

1. INTRODUCTION

India is the world's third largest emitter of greenhouse gases (GHGs), after China and the US. A carbon footprint refers to the total amount of greenhouse gases, primarily carbon dioxide (CO_2) and other carbon compounds, that are emitted directly or indirectly by an individual, organization, event, product, or activity over a specific period of time. The carbon footprint is typically expressed in units of carbon dioxide equivalent (CO2e), which is a standard measure used to account for the different global warming potentials of various greenhouse gases.Carbon footprints can arise from a wide range of human activities and processes, including energy production and consumption, transportation, industrial manufacturing, agriculture, and more. These activities release greenhouse gases into the atmosphere,

ISSN 2063-5346

contributing to the greenhouse effect and global warming. Carbon footprints can be assessed at different levels of scope. Scope 1 covers the direct emissions. These are emissions directly produced by an entity, such as emissions from on-site combustion of fossil fuels for heating or transportation. Scope 2 refers to the indirect emissions associated with the consumption of purchased electricity, heat, or steam, often referred to as "energy-related emissions". Last but not least, Scope 3 encompass a wide range of emissions that occur in the supply chain of a product or service, including raw material extraction, production, transportation, and end-of-life disposal. Scope 3 emissions are often the largest portion of an organization's carbon footprint. Carbon footprints are typically calculated by assessing the emissions associated with each relevant activity or source. This involves estimating the amount of greenhouse gases emitted and converting them into CO2e units based on their global warming potential.

The increased emissions of greenhouse gases from numerous sources in recent years have raised considerable concerns about global warming. The average world temperature is predicted to rise by (1.4 to 5.8) ºC by the year 2100. Carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons are the main contributors to the greenhouse effect. Each gas makes the following contributions to the greenhouse effect: CO_2 accounts for 55%, CFCs for 24%, CH4 for 15%, and N_2O for 6% [1]. One of the main greenhouse gases, carbon dioxide (CO_2), which is mostly to blame for global warming, accounts for a sizeable share of all emissions.
CO_2 emissions are mostly caused by industrial operations such as power plants, oil refineries, fertilizer, cement, and steel mills. The main energy sources for power generation are fossil fuels such as coal, oil, and natural gas, which will continue to generate power due to enormous reserves and affordability. The use of coal in electricity generation is predicted to expand in the twenty-first century as well. Fossil fuel combustion accounts for around 98 percent of CO_2 emissions, with coal combustion accounting for 30–40 percent of global CO_2 emissions.

The majority of electricity is generated by coal-fired power plants, which emit the most CO_2 per kilowatt hour. According to data on CO_2 emissions and energy production from various sources, coal-fired power plants produce the majority of the nation's CO_2 emissions [2].In order to safeguard a sustainable environment, it is crucial to do research on coal-fired power plants with the goal of lowering CO_2 emissions as well as Sulphur oxide, Nitrogen oxide, and other particles. This is because coal is still utilized to generate electricity. Therefore, lowering CO_2 emissions from power plants is essential to lowering atmospheric CO_2 levels.

The primary aim of this study is to construct a model that may be utilised for the purpose of examining the emission of carbon dioxide emissions. The study examines the influence of human activities and climate factors on the release of carbon dioxide (CO2) emissions from power plants located in the region of Uttar Pradesh (U.P) [3].This study enhances the comprehension of various processes and utilises the acquired knowledge to estimate the emissions of greenhouse gases attributed to different types of power plants, including thermal, nuclear, hydro, and solar power plants. Moreover, this work has conducted a comparative analysis of the contributions made by various power plants. For instance, the inclusion of the percentage of emissions attributed to power plants, in conjunction with the strategies employed to mitigate carbon emissions from such facilities, is incorporated.

2. CARBON FOOTPRINT

The whole set of green house gas emissions created by an organisation, event, product, or ind ividual has traditionally been defined as a carbon footprint. The total amount of greenhouse gases produced to support direct and indirect human activity; usually expressed as equivalent tonnes of carbon dioxide. Our carbon footprint is the total amount of carbon dioxide that our

ISSN 2063-5346

actions over a specific time period emit. A carbon footprint is typically computed over the course of one year. Gases that absorb and emit infrared are referred to as greenhouse gases. The most prevalent greenhouse gas in the earth's atmosphere and the main contributor to global warming is carbon dioxide, usually known as CO_2. Methane and ozone are examples of other greenhouse gases that may be emitted as a result of your actions. These greenhouse gases are usually factored into carbon footprint calculations. There are two types of carbon footprint namely Primary carbon footprint and Secondary carbon footprint. Primary Carbon Footprints are those that are directly related to the way we consume fossil fuels. This category encompasses our various modes of transportation, including train, road, and air. It also includes the usage of electricity for energy derived from coal and natural gas. Consumption of water is also a vital component.Secondary Carbon Footprint encompasses the emissions that occur from our indirect relationship with the aforementioned topic, such as when we buy garments that are transported from a far. Their secondary carbon footprint includes emissions from both their manufacture and transportation.The secondary carbon footprint considers the timing and likelihood of natural disintegration as well as what happens to these objects after we stop using them. (Plastic items score low in this category.) It also includes the products' ability to be recycled.Technically it is divided into two distinct categories. These categories are:

- **Product Carbon Footprint (PCF)**
- **Corporate Carbon Footprint (CCF)**

(a) Product Carbon Footprint:

Secondary Carbon Footprint encompasses the emissions that occur from our indirect relationship with the aforementioned topic, such as when we buy garments that are transported from afar. Their production and transportation emissions are included in their secondary carbon footprint.The secondary carbon footprint takes into account what happens to these items when we no longer use them, including the time and likelihood of natural breakdown. (Plastic items score low in this category). It also includes the products' ability to be recycled.

(b) Corporate Carbon Footprint:

As it takes into account the complete company and calculates carbon emissions for the entire setup, corporate carbon footprint covers a much wider range of operations. It is an exhaustive accounting of the company's carbon liability, starting with the manufacture of each of its products and concluding with their disposal.All of the company's operations, including product transportation, business travel, total energy use, and recycling practices, are included in the carbon footprint calculation. There are many other factors to take into account in addition to the previously mentioned ones.

Several standards are taken into consideration when calculating total carbon emissions. The GHG Protocol and a few ISO Standards related to carbon emissions are examples of this.

There are many sources of carbon emissions such as transportation, electric vehicle, all products-based industries, power plants, fossil fuel. All the human activities such as the burning of oil, coal and gas, as well as deforestation also came under this category. The work presented here mainly focuses on carbon emission from different power plants in Uttar Pradesh (U.P).In U.P, the power is generated through mainly four sources: Thermal, Nuclear, Hydro, Renewable power plants as shown in Fig.1. The particular plants which are used for the analysis under each power source category are tabulated in Table 1. Assessing the carbon footprint of different power plants involves several key parameters and factors that can vary depending on the type of power generation technology used. Some of the critical parameters and factors to consider when assessing the carbon footprint of different power plants are type of fuel, energy efficiency, emission factors, carbon capture and storage, plant capacity [5]. The next section explains the carbon footprint evaluation from different sources.

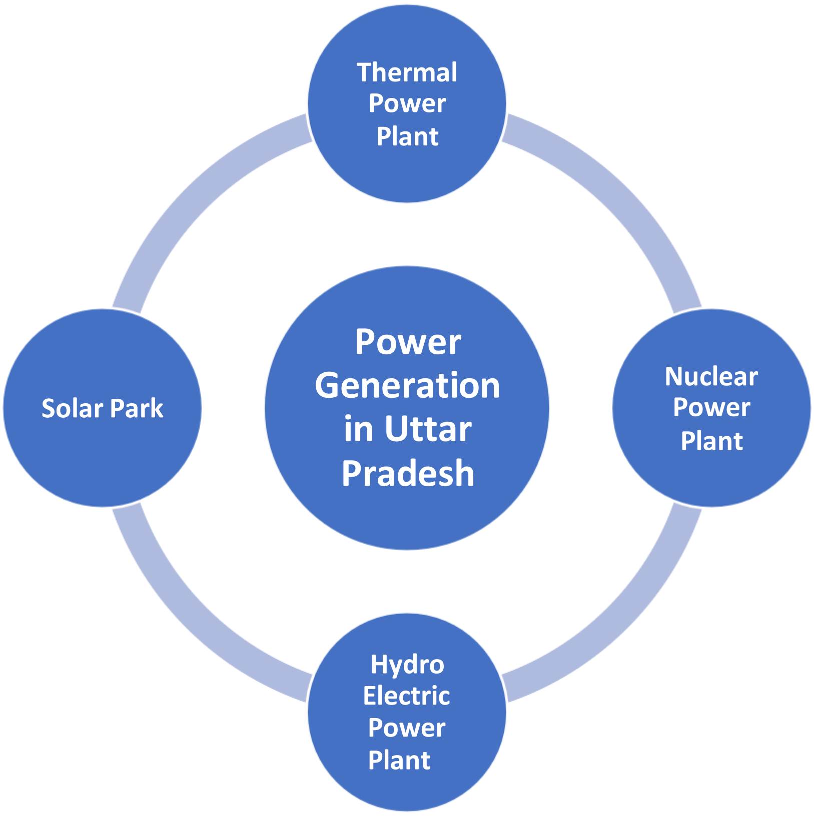

Fig: 1 Power Generation in Uttar Pradesh

Table 1: Power Plants used for Analysis

Thermal Power Plant	**Nuclear Power Plant**	**Hydroelectric Power Plant**	**Solar Park (600 MW)**
Anpara (2630 MW)	Narora Atomic Power Plant (440 MW)	Obra Hydroelectricity Power Plant (99MW)	
Obra (1094MW)		Sumera Hydroelectricity Power Plant (2000MW)	
Parichha (1140)			
Harduganj (610 MW)			

Table 1 shows different power plants used for analysis.

ISSN 2063-5346

3. CARBON FOOT PRINT ASSESSMENT FOR THERMAL POWER PLANTS

Assessing the carbon footprint of different power plants involves several key parameters and factors that can vary depending on the type of power generation technology used. Some of the critical parameters and factors to consider when assessing the carbon footprint of different power plants are type of fuel, energy efficiency, emission factors, carbon capture and storage, plant capacity [5].

3.1 CO_2 Emission's parameter for Thermal Power Plant:

The carbon dioxide (CO2) emissions from a thermal power plant primarily depend on various factors, including the quality of fuel, the efficiency of the plant, and the installed capacity and load factor of plant. These parameters and factors that influence CO2 emissions from thermal power plants are discussed below:

(a) Quality of Coal:

Coal, which produces 97.5 percent of the state of Uttar Pradesh's total electricity, is an easily accessible source of energy. For the foreseeable future, Uttar Pradesh's abundant low-sulfur, low-grade (high-ash) coal will be a significant source of energy. However, a major portion of the emissions from the industrial sector are brought on by the coal-based thermal power sector in Uttar Pradesh. Burning coal results in the production of carbon dioxide (CO_2), a major greenhouse gas (GHG) that contributes to climate change. To maintain stable greenhouse gas levels in the future, Carbon Capture and Sequestration (CCS) and other CO_2 mitigation strategies may be necessary [6]. The performance of the plant (plant efficiency, net electricity generation, CO_2 emissions), as well as the cost of energy production, are all influenced by the quality of the coal used in the production of electricity. It would also have an impact on CCS' overall performance and cost.

(b)Installed capacity & load factor of plant:

The Power Generation capacity of a specific plant is referred to as its installed capacity. It is often measured in megawatts (or sometimes in gigawatts). It is important to note that not all potential can be converted into capacity, and that overall capacity does not result in the same quantity of generation due to production losses. Power Plants have the capacity to generate a specific amount of electricity at a given moment, but if they are offline (e.g., for maintenance or refueling), they are not really producing electricity. Particularly from Thermal Power Plant in U.P it contributes 5474 MW [7].

The ratio of energy used in a specific time period to the amount that would have been used if the power had been left on during peak demand is known as the load factor. It is a useful indicator for describing the features of electricity usage across time.

(c) Efficiency of a Machine:

Efficiency has long been seen as a "no regrets" element of climate policy since it offers a financially viable energy supply even in the absence of legislation or goals for greenhouse gas reduction. Therefore, lowering CO_2 emissions related to energy use is just one advantage of a technology that is economical. Efficiency is seen as having at least two important advantages in the context of climate change: (1) delaying the rise in energy consumption to

ISSN 2063-5346

give non-emitting supply technologies time to cut average emission rates; and (2) lowering the cost of reaching CO_2 emission reduction targets.
More difficult than determining energy efficiency potential, quantifying the relationship between energy efficiency and CO_2 emissions has mostly been studied within long-term, global frameworks. Efficiency has an indirect impact on CO_2 emissions in electricity systems due to the fact that electricity generation facilities emit CO_2, depending on variables like the hourly load shape impact of efficiency measures and the marginal carbon emissions rate for the affected power system at a given hour. Studies usually employ nationally or regionally averaged emission data.

3.2 Procedure for calculation

(a) Anpara Power Plant:

CO_2 emission rate for thermal power plant = 2249 lbs/Mwh = 2249/2000 = 1.1245 tons /Mwh

Installed Capacity = 2630 MW

Load Factor = 0.74

We know that load factor of power plant is the ratio of Average demand and the installed capacity

Load Factor = Average demand ÷ Installed Capacity.
0.74 = average demand ÷2630
Average demand = 0.74 × 2630
Average demand = 1964.2 MW
Annual Generation = 1964.2 ×24 ×365 = 17,048,712 Mwh / year
Annual CO_2 Emission = 17,048,712 × 1.1245 tons/year
Annual emission = 19,171,276.644 tons/year
= 19 Megatons/year.

Similarly, calculations are done for Obra, Parichha and Harduaganj power plants and are tabulated in Table 2. Fig. 2 shows generating statistics of Thermal Plant in last four years.

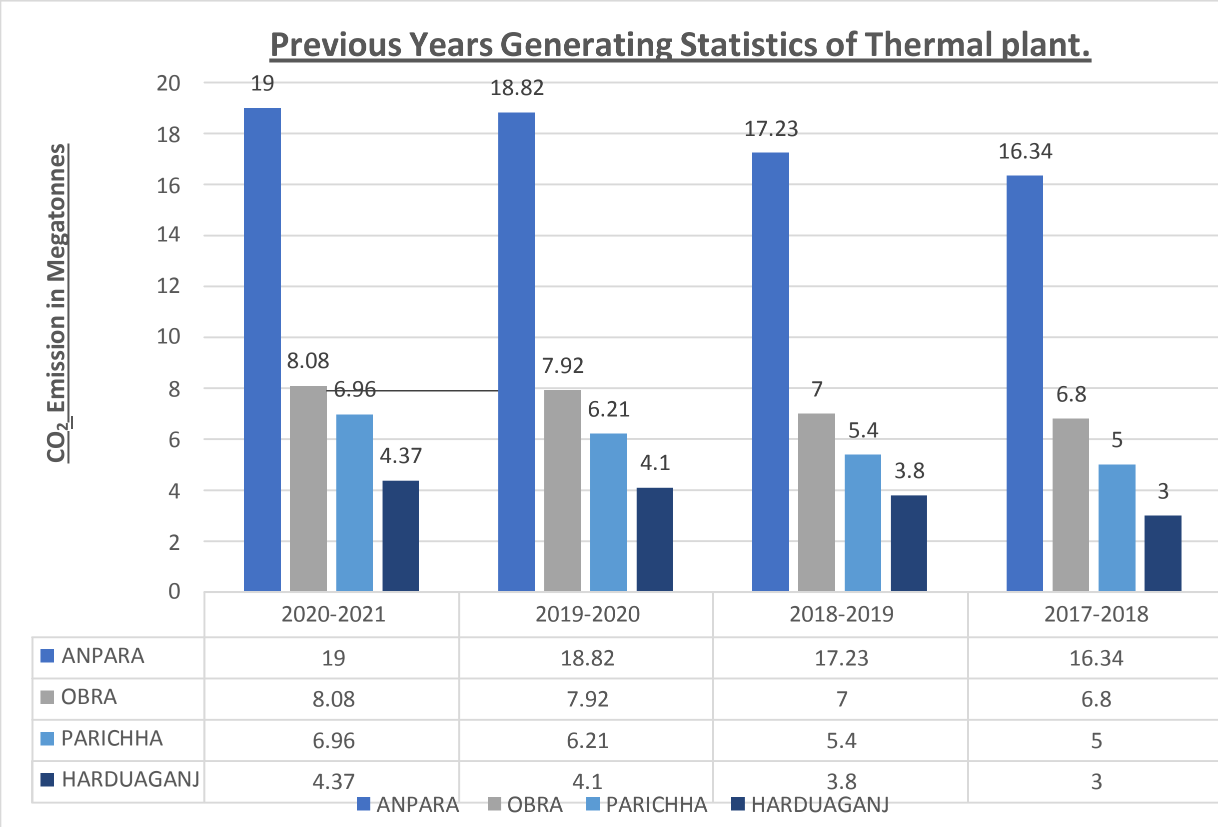

Fig: 2 Generating Statistics of Thermal Plant

Table: 2 Thermal Power Plant

S.NO.	**Power plants**	**Installed capacity (MW)**	**Load factor**	**Annual Generation (Mw-h)**	**CO_2Emission rate (tons/Mwah)**	**CO_2 Annual emission (Mtons/year)**
1	Anpara	2630	0.74	17,048,712	1.1245	19
2	Obra	1094	0.75	7,187580	1.1245	8.08
3	Parichha	1140	0.62	6,191,568	1.1245	6.96
4	Harduganj	610	0.73	3,900,828	1.1245	4.37

ISSN 2063-5346

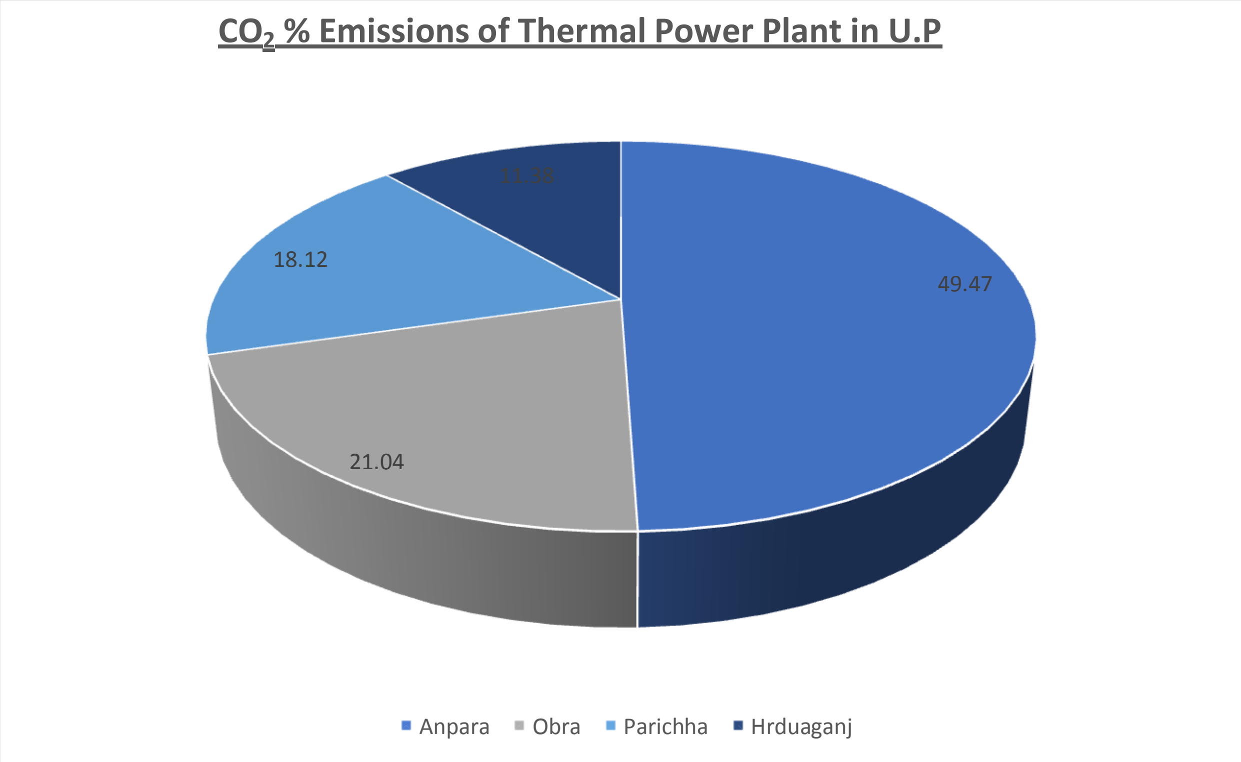

Fig:3 CO_2 % Emissions of Thermal Power Plant in Uttar Pradesh

Fig. 3 Shows CO_2 % Emissions of Thermal Power Plant in Uttar Pradesh.

3.3 Techniques implemented mainly for CO_2 reduction

A coal-fired power station is a thermal power plant that produces electricity through the combustion of coal. Numerous energy sources, such as fossil fuels, nuclear fission, and renewable energy sources, can be used to produce electricity. Three units typically make up a pulverized coal (PC) combustion power plant [8].

(a) Boiler Block**:** In this main unit where coal and air are burned to produce high-pressure steam.
(b) Generator Block:It includes the cooling water, condenser, and steam turbine.
(c) Flue Gas Clean Up Block:To reduce precipitation emissions, this device purges particulate matter and other pollutants from flue gas (ESP) utilizing wet lime or water for flue gas desulfurization (FGD). Depending on the kind of coal used, this machine can reduce emissions by 95 to 99 percent.

3.4 Carbon Capture And Storage (CCS) Technologies:

Either biological CO_2 uptake or a reduction in CO_2 emissions from sources should be used to reduce atmospheric CO_2 emissions in order to avert significant climate change. Reducing fossil fuel consumption, expanding energy production from non-fossil fuel sources like solar, wind, biomass, and nuclear energy, and adopting large-scale carbon capture and storage (CCS) technologies are a few methods for lowering CO_2 emissions from stationary sources. In CCS systems, CO_2 is extracted from the flue gas of any source and used in other processes or stored in a safe location, like an underground storage facility or the ocean. Only the reduction/capture of CO_2 from flue gas among the three stages of CCS technology will be

ISSN 2063-5346

examined in this study (capture, transport, and storage).There are many CO_2 collection technologies on the market today, some of which have already achieved commercial success while others are still being developed. There are mainly three pathways to reduce CO_2 emissions: pre - combustion, post - combustion and during - combustion. All these methods are discussed below.

A. Pre-Combustion CO_2 Capture:

Figure 4 shows how pre-combustion processes gasify CO_2 and other pollutants like NOx and SOx before combustion.This process removes CO2 from industrial sources before fuels like coal, oil, or gas are burned to produce energy. Fuel is initially converted into synthesis gas, which contains hydrogen and carbon monoxide, during the pre-combustion process (CO). This CO reacts with the water to create CO_2, which is then compressed for storage and transportation after being separated from hydrogen. The leftover hydrogen is then burned to provide energy [9]. By using this method, CO_2 emissions can be cut by 90 to 95 %. The category of pre-combustion technology includes pre-combustion technologies. Currently, this technology is used in oil refineries, but its application in power plants is limited. Electricity is produced and power plant emissions are decreased using the Integrated Gasification Combined Cycle (IGCC) and Fluidized Bed Combustion (FBC) technologies, respectively.

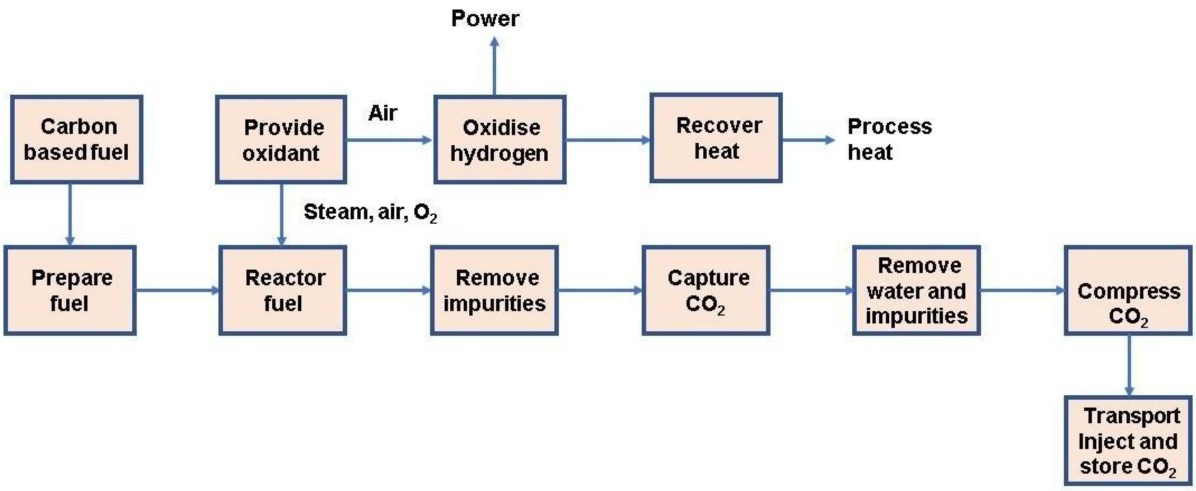

Fig: 4 Pre – Combustion CO_2 Capture

B. During Combustion CO_2 Capture:

In the case of oxy-fuel combustion, CO_2 is dispersed during combustion, resulting in a flue gas stream largely made up of CO_2 and H_2O.This procedure is basic, necessitating only compression and chilling steps. This process is mostly used to remove CO_2 from glass, aluminum, and steel furnaces, but it is still an emerging technology in power generation, with numerous large-scale pilot projects planned or in development.

By burning coal with oxygen (nearly pure oxygen >95 %) as opposed to air, CO_2 is collected. Flue gas is created, and it has a high CO_2 and water vapour content. By using a cooling technique, it is simple to separate these two flue gas constituents. The water is then condensed, producing a CO_2-rich gas stream. This oxyfuel technique allows for the complete removal of CO_2 from the flue gas. Figures 6 and 7 show how to use oxyfuel. The biggest drawback of this technique is that it uses electricity from the power plant to extract oxygen from the air [10]. CCS consumes a large quantity of energy. This extra energy comes from the process of creating power, which reduces the amount of electricity produced or increases the amount of energy needed to produce the same amount of electricity (electricity). The energy used for CCS is referred to as an energy penalty since it raises the long-term cost of producing power. By more readily separating oxygen from air, chemical looping combustion technology, which is currently being developed, can solve this problem. This technique is seen in Figure 5.

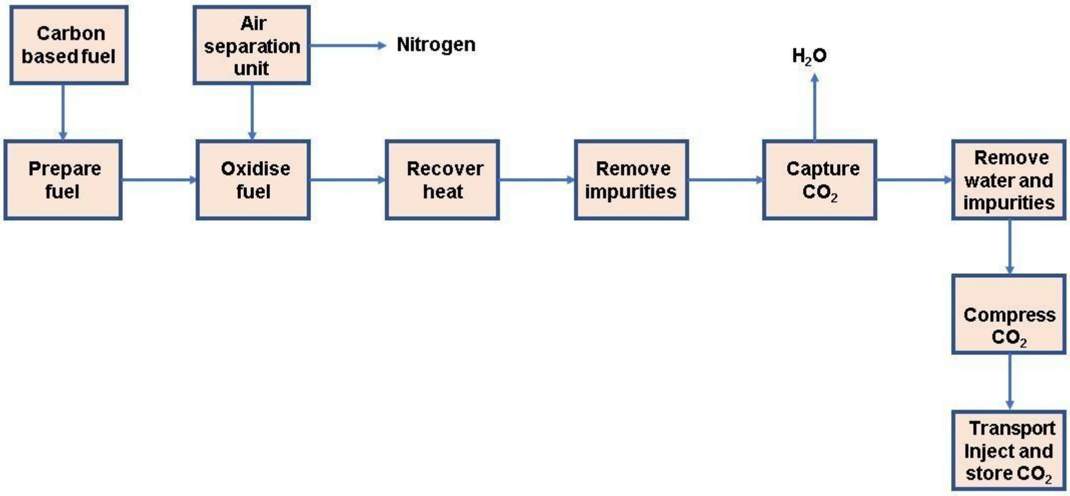

Fig: 5 During- Combustion CO_2 Capture

C. Post Combustion Co₂ Capture:

With post combustion technology, carbon dioxide from the combustion is eliminated.Post-combustion CO_2 collection takes place in power plants after the air and fuel are burned to produce electricity, but before the resulting exhaust gas hits the stack. The benefit of post-combustion CO_2 capture technology is that it is easily adaptable to existing plants; all that is needed is the installation of the necessary capturing equipment. A streamlined illustration of CO_2 capture following burning is shown in Figure 7. After burning, a variety of CO_2 collecting systems are available. The most common post-combustion process is chemical absorption utilizing amine solvents [11]. Membranes, the PSA (pressure swing adsorption) method, and mineral carbonation procedures are some of the other post-combustion CO_2 collection systems. This process is shown in Fig. 6.

ISSN 2063-5346

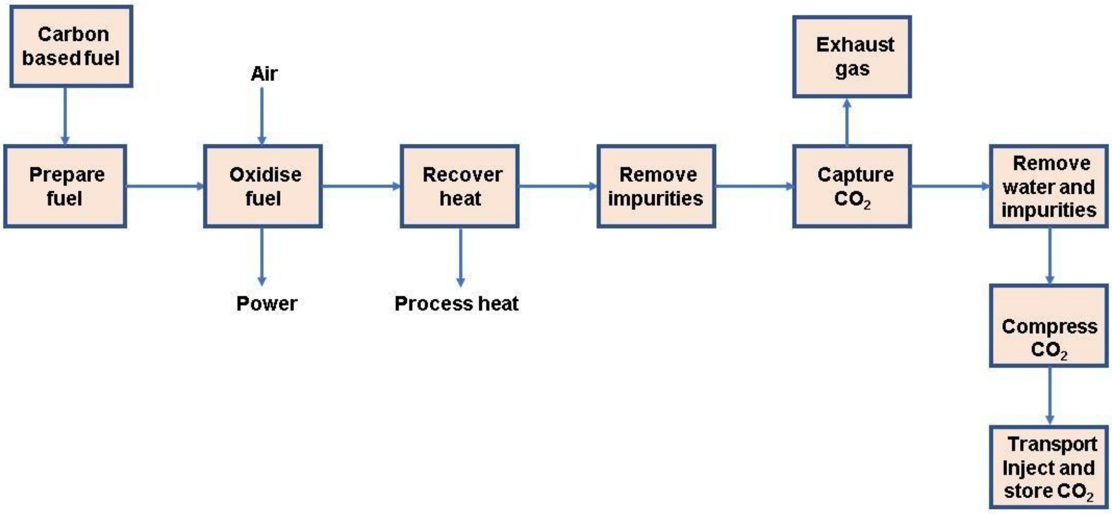

Fig: 6 Post Combustion CO_2 Capture

4. CARBON FOOT PRINT ASSESSMENT FORNUCLEAR POWER PLANT

Some nuclear lobbyists even argue that nuclear power plants do not emit carbon dioxide when generating electricity. However, this is not true. When a plant produces power, carbon dioxide is emitted.

4.1 Narora Atomic Power Plant On the basis of unit, Narora Atomic Power Plant (NAPS) sub divided in 2 parts (1 unit &2unit), but both run at same capacity 220 MW each [12].

Pressurized Heavy Water Reactor (PHWR)

A. 1-unit calculation for carbon emission:

Installed Capacity = 220 MW

Load Factor = 0.92

Load Factor = average demand ÷ installed Capacity

0.92 = average demand ÷ 220 MW

Average demand = 0.92 × 220 = 202.4 MW

Annual Generation = 202.4 ×24 × 365 = 1,773,024 MWh / year

Electricity from nuclear power plant emits = 140 gm CO_2 /KW h

= 0.14 kg CO_2 /KW h = 0.00014 tones Co_2 /KW h = 0.14 tones CO_2 /MWh

Annual Emission of CO_2 = 1,773,024 × 0.14 tones/year

= 248,223.36 tones /year= 0.248 Mega tones /year

ISSN 2063-5346

B. 2-unit calculation for carbon emission:

Installed Capacity = 220 MW

Load Factor = 0.91

Load Factor = average demand ÷ installed Capacity

0.91 = average demand ÷ 220 MW

Average demand = 0.91 × 220 = 200.2 MW

Annual Generation = 200.2 × 24 × 365 = 1,753,752 Mw-h / year

Electricity from nuclear power plant emits = 140 gm CO_2 /KW-h = 0.14 kg CO_2 /KW-h

= 0.00014 tones Co_2 /KW-h =0.14 tones CO_2 / MWh

Annual Emission of CO_2 = 1,753,752 × 0.14 tones/year

= 245,525.28 tones /year = 0.25 Mega tones /year

The Total CO_2 Emission from NAPS in U.P = (0.248 + 0.245) Mega tones/year = 0.93 Mega tones/year

CO_2 Emission calculations for nuclear power plant are shown in Table 3

Table 3: Nuclear Power Plant

Sr. NO	Units	Reactor Type	Capacity Installed (MW)	Load Factor	Annual Generation (MWh)	Emission Rate (tons/MWh)	CO_2 Annual Emission (Megatons /Year))
1	1	PHWR	220	0.92	1,773,024	0.14	0.248
2	2	PHWR	220	0.91	1,753,752	0.14	0.245

Percentage CO_2 emissions in NAPS in Uttar Pradesh is shown in Fig. 7. Generation statistics of NAPS of last five years is shown in Fig. 8.

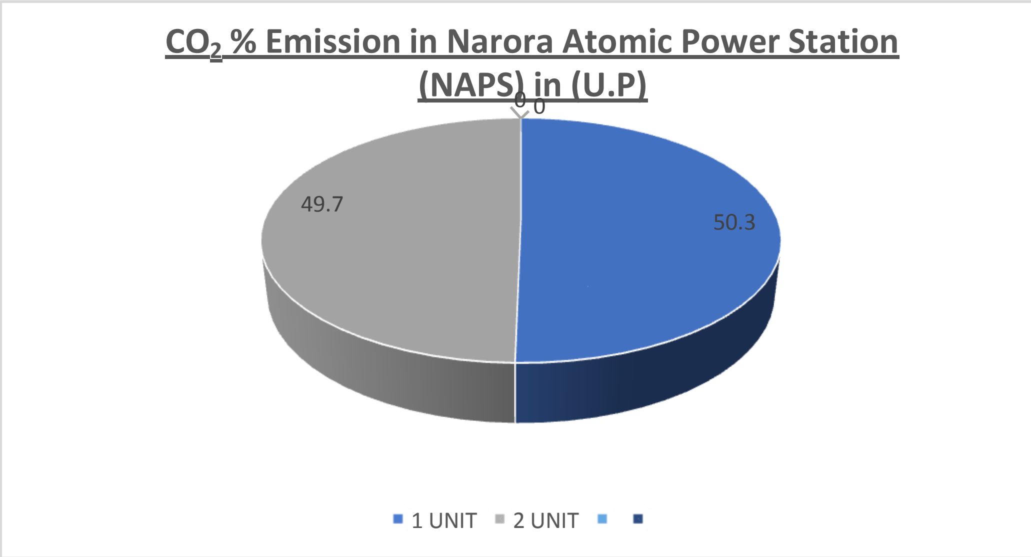

Fig:7 CO_2 % Emission in NAPS in Uttar Pradesh

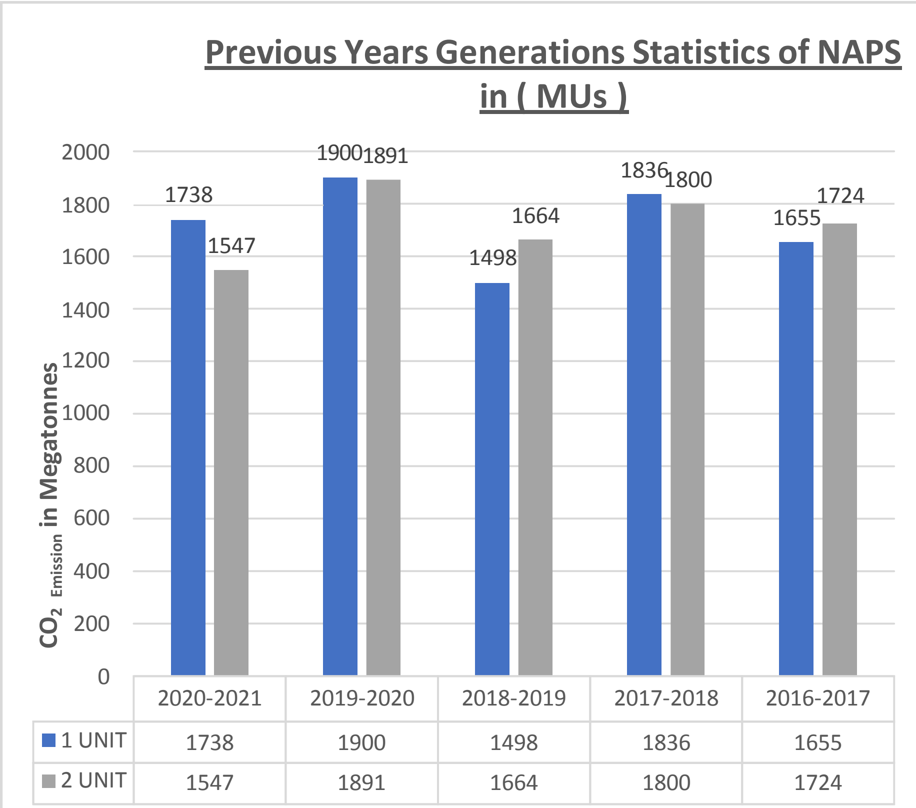

Fig:8 Generations Statistics of NAPS

4.2 Parameters for CO_2 Emission

The complete plant life cycle as well as the raw energy output must be taken into account when calculating the amount of CO_2 being released. This involves the construction, operation, maintenance, decommissioning, and dismantling of a nuclear power plant's reactor. Uranium recovery from the Earth's crust, uranium extraction from ores, uranium

ISSN 2063-5346

enrichment and chemical treatment, transportation, and used nuclear fuel disposal are all equally important [13].

4.3 Ways to reduce CO_2 Emission

1. They believe the most effective way to prevent global warming is to prioritize efficiency rather than aggressively expanding nuclear power plants since the opportunities for efficiency increases are so enticing.
2. Regardless of how much nuclear or renewable energy is developed, decreasing the rise in energy use is essential for lowering emissions. The selection of a renewable energy source was said to require caution.
3. There are options that are more practical, affordable, and socially and environmentally sustainable. Nuclear power should be replaced by effective combined-cycle gas as a move away from fossil fuels to produce baseload power.An integrated combination of nuclear, renewable energy, hydrogen, and energy efficiency initiatives is necessary and unavoidable.

5. CARBON FOOT PRINT ASSESSMENT FORHYDRO POWER PLANT:

Hydro power plant basically produced electricity with the help of running water, falling from certain height rotate the turbine, thus produces electricity. There are few Hydro power plant in Uttar Pradesh (U.P). For our research we have picked up two Hydro power plants namely: “Obra Hydroelectricity Power Plant (99 MW) &Sumera Hydroelectricity Power Plant (2000 MW)”.

5.1 Calculations for CO_2 Emissions:

Obra Hydroelectricity Power Plant (OHPP) :

Installed Capacity = 99 MW

Load Factor = 0.90

Load Factor = average demand ÷ installed Capacity

0.90 = average demand ÷ 99 MW

Average demand = 0.90 × 99 = 89.1 MW

Annual Generation = 89.1 × 24 × 365 = 780,516 MWh / year

Electricity from hydro power plant emits = 18.5 gm CO_2 /KW-h

= 0.0185 kg CO_2 /KW-h = 0.0000185 tones Co_2 /KW-h = 0.0185 tons CO_2/ MWh

Annual Emission of CO_2 = 780,516 × 0.0185 tones/year

= 14,439.546 tones /year

ISSN 2063-5346

= 0.014 Mega tones /year.

Similarly, calculations are done for Sumera Hydroelectricity Power Plant (SHPP) and are tabulated in Table 4. Fig. 9 shows percentage CO_2 emission from hydro power plant in UP. Fig. 10 shows Generating Statistics of Hydro Power Plant.

Table 4: Hydro Power Plant

S.No.	Power plants	Installed capacity (MW)	Load factor	Annual Generation (MWh)	CO_2Emission rate (tons/Mwh)	CO_2 Annual emission (Mtons/year)
1	OHPP	99	0.90	780,516	0.0185	0.014
2	SHPP	2000	0.92	16,118,400	0.0185	0.298

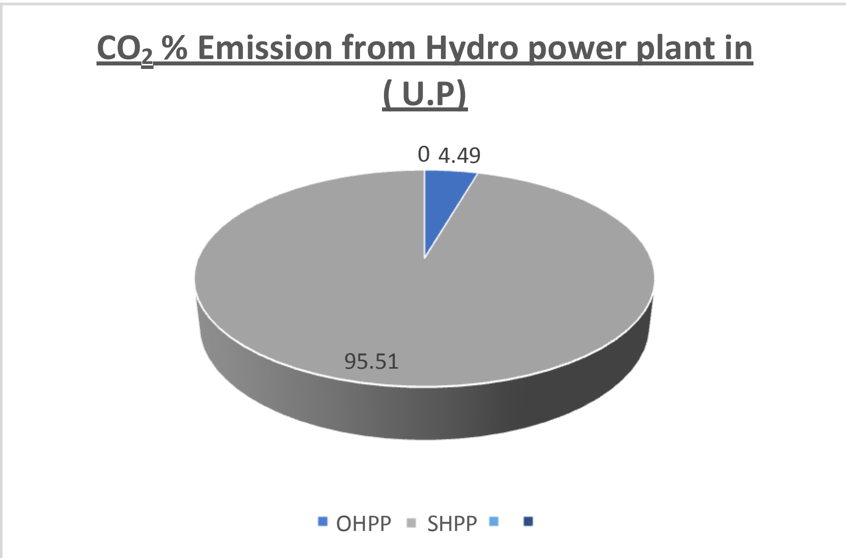

Fig: 9 CO_2 % Emission from Hydro Power Plant in (U.P)

ISSN 2063-5346

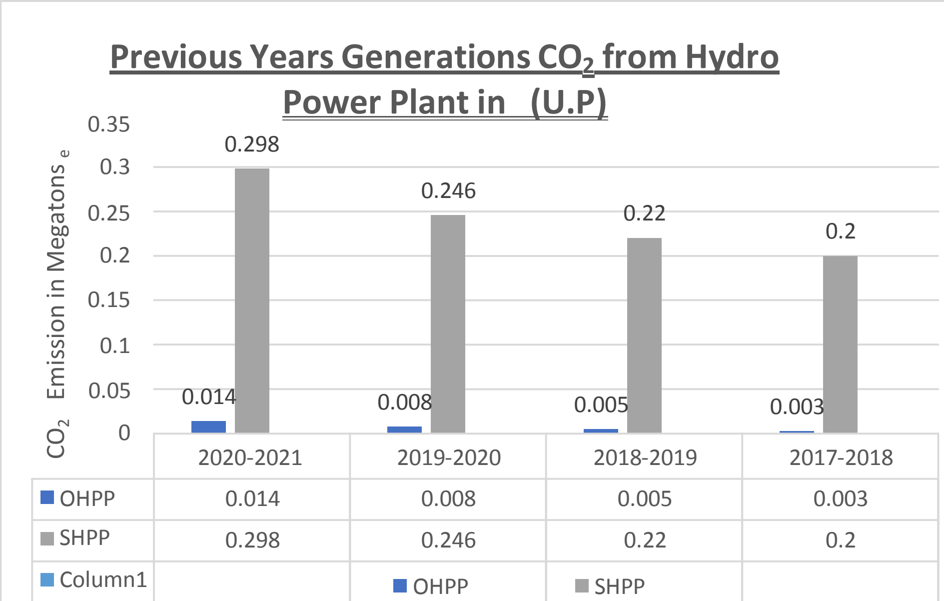

Fig: 10 Generating Statistics of Hydro Power Plant

5.2 Carbon Emission's Parameter:

Other than plant's Installed Capacity and load factor, it also depends on others factor for calculating CO_2 Emission.

(a) Construction: The term "construction" refers to the emissions produced during the production of materials, transportation, and plant stages necessary to build the dam and other related infrastructure, which are calculated based on the consumption of materials and energy as well as the associated emission factors [14].

(b) Efficiency: Efficiency of machine or its parts also contribute to the carbon emission, because if efficiency is high then it's generated more amount of energy and thus produces more CO_2 emissions.

(c) Decomposition of flooded organic materials: Under certain conditions, a reservoir generated by a hydropower dam will emit CO_2 emissions as a result of the breakdown of flooded organic matter; nevertheless, a reservoir can also function as a carbon sink: absorption of more emission than emission.

5.3 Ways to Reduce CO_2 Emission

Redeveloping, Repowering and Upgrading Existing Hydropower plant: Many of the hydroelectric plants in the U.P. are somewhat old. While dam structures might still be in good shape, other equipment eventually ages and needs to be replaced. When that happens (or even before), installing new, more potent and efficient turbines, generators, and transformers might be more economical. As a result, it would be feasible to increase the electrical production of older hydropower plants in a cost-effective manner without increasing their reservoir size or dam height. In terms of greenhouse gas emissions, this could be a desirable trade-off. Small dams occasionally have top-of-dam extensions that slightly increase reservoir depth but also boost hydraulic head and controllability as well as the absolute output for a given water flow. In order to maximize the river's overall production, utilities that run many dams on a single river system generally go to great lengths to coordinate turbine and dam operations.

6 CARBON FOOTPRINT ASSESSMENT FOR SOLAR POWER PLANT

A solar power plant absorbs and concentrates sunlight to generate the high-temperature heat required to produce electricity. All solar thermal power plant systems contain solar energy collectors with two primary components: reflectors (mirrors) that gather and concentrate sunlight on the receiver, and a receiver used to generate steam. A turbine converts steam into mechanical energy, which is then transformed into electricity.Solar park of 600 MW installed capacity from U.P state is included in the work.Solar Park (600 MW) is established in different region of U.P. These are jalaun, etah, Mirzapur, Prayagraj and Jhansi district.

6.1 Calculation for CO_2 Emission:

Installed Capacity = 600 MW

Load Factor = 0.80

Load Factor = average demand ÷ installed Capacity

0.80 = average demand ÷ 600 MW

Average demand = 0.80 × 600 = 480 MW

Annual Generation = × 480 × 24 × 365 = 4,204,800 Mw-h / year

Electricity from solar plant emits = 40 gm CO_2 /KW-h

= 0.04 kg CO_2 /KW-h = 0.00004 tones Co_2 /KW-h =0.04 tones CO_2 / MWh

Annual Emission of CO_2 = 4,204,800 × 0.04 tones/year

= 168,192 tones /year = 0.168 Mega tones /year.

Total CO_2 emission calculations are shown in Table 5. Comparison for CO_2 emissions for different power plant in U.P is shown in Table 6. Fig. 11 Shows percentage of total installed capacity

Table 5: Solar Power Plant

S.No.	Power plants	Installed capacity (MW)	Load factor	Annual Generation (MW-h)	CO2 Emission rate (tons/MWh)	Co_2 Annual emission(M tons/year)
1	Solar Park	600	0.80	4,204,800	0.04	0.168

Table 6: Comparison between Different Power Plants in U.P

S.NO	Power Plant	Installed capacity (MW)	Annual Generation (Mw-h)	CO2 Emission rate (tons/MWh)	CO_2 Annual emission (M tons/year)
1	Thermal	5474	34,328,688	1.1245	38.41
2	Nuclear	440	3,526,776	0.14	0.493
3	Hydro	2,099	16,898,916	0.0185	0.312
4	Solar	600	4,204,800	0.04	0.168

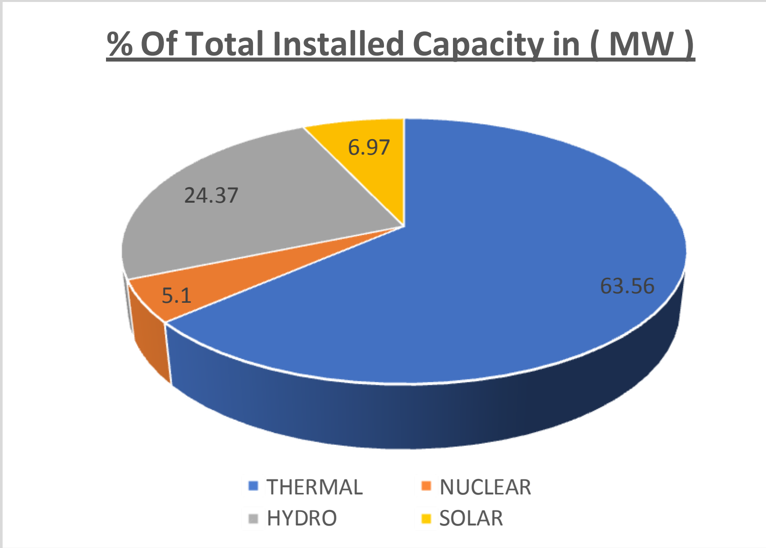

Fig: 11 Percentage of Total Installed Capacity in (MW)

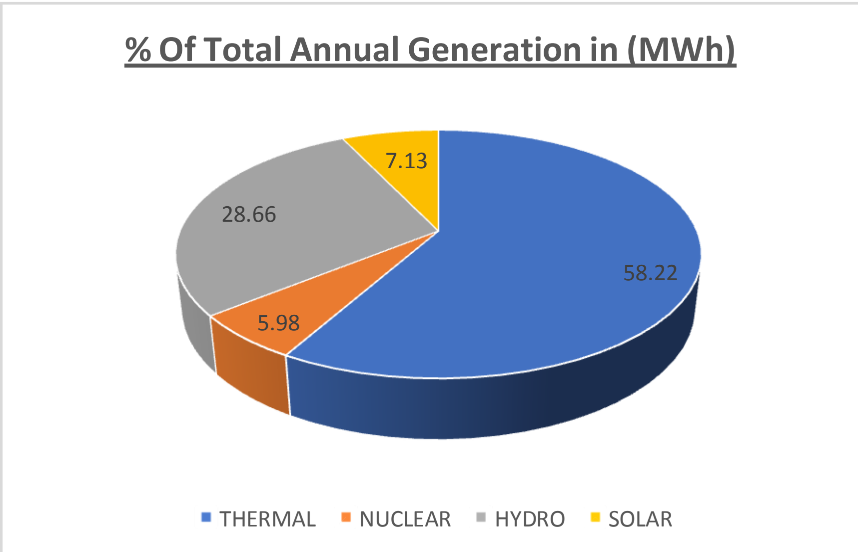

Fig: 12 Percentageof Total Annual Generation in (MWh)

Fig. 12 shows Percentageof Total Annual Generation in (MWh) and percentage of Total Annual CO_2 Emission in Mtones/year from all Power Plants in Uttar Pradesh are shown in Fig. 13.

ISSN 2063-5346

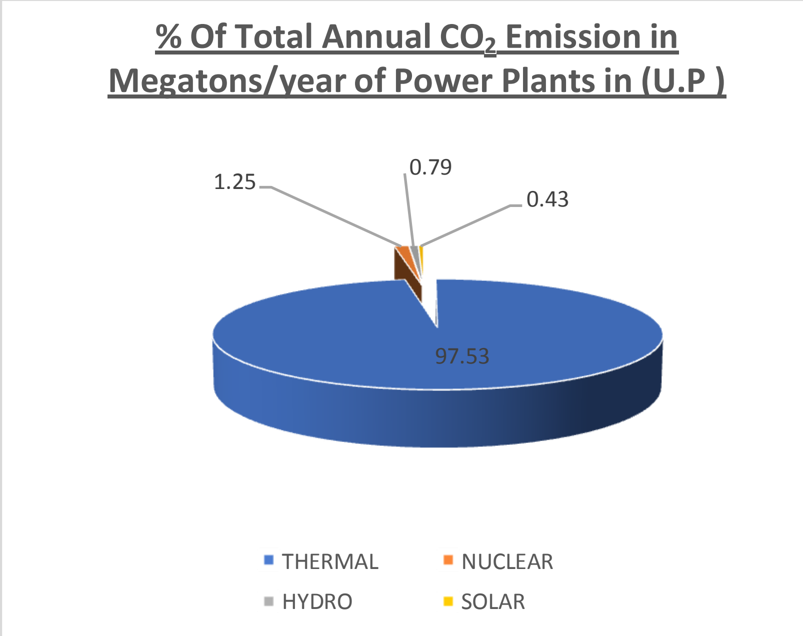

Fig:13 Percentage of Total Annual CO_2 Emission in Mtonnes/year from all Power Plants in Uttar Pradesh.

7 CONCLUSION

The carbon foot print study is the basis of low carbon research. Reducing carbon footprints is a key component of broader sustainability goals, which aim to minimize environmental impacts and promote sustainable practices to mitigate climate change.It helps in analysis of how much greenhouse gases is producing per day or per year by different sectors like power plants, transportation, industries, etc. Power plants from U.P state are selected for analysis.
Thermal power plants are the backbone of the U.P electrical supply system, generating 58.22 % of power among all power plants in U.P. Even if more natural gas-fueled combined cycle power plants and renewable power-generation facilities are created, coal-fired power plants will still produce a large amount of electric electricity. Fossil fuel supplies are finite, and renewable energy sources, primarily hydro-power plants, account for just for 28.66 % of total e-power generation in the Uttar Pradesh. Solar power plants generate 8 % of this energy whereasnuclear and solar power plants generating in all 13.12%. Thermal powerplant currently emit a significant portion of total carbon dioxide. Out of 100% of CO_2emission, 97.53% emissions are only from Thermal, and rest 2.47 % includes hydro, nuclear and solarpowerplants. This CO_2 emissions report per year in Megatons is being utilized by organizations to count themselves and their products. Strict actions must be taken by the government to make sure that emissions should be reduced at any cost. Power plants must run their machine according to their set rate of emission by the government. Penalty needs to pay by those who cross the barrier limit of CO_2 Emissions. The govt. should try to make upcoming project more on renewable source to produce energy rather than non- renewable sources of energy. Re-developing, re-powering and upgrading machine's parts will not make 0 % CO_2emission but definitely it will reduce it.

In conclusion, assessing the carbon footprint of power generation sources is essential for sustainable development, as it helps reduce greenhouse gas emissions, mitigate climate change, improve environmental and health outcomes, create economic opportunities, and

ISSN 2063-5346

promote energy security. It enables informed decision-making and the transition to cleaner, more sustainable energy systems that benefit both current and future generations.

REFRENCES

1. Nuclear power and the environment - U.S. Energy Information Administration (EIA)

2. Welcome to Uttar Pradesh RajyaVidyutUtpadan Nigam Limited, Government of Uttar Pradesh, India. / Anpara Thermal Power Station (upenergy.in)

3. Moazzem, S., Rasul, M.G., Khan, M.M.K. "A Review on Technologies for Reducing CO_2 Emission from Coal Fired Power Plants" In Thermal Power Plants, edited by Mohammad Rasul. London: IntechOpen, 2012. 10.5772/31876

4. Nuclear power and the environment - U.S. Energy Information Administration (EIA)

5. Solar Park - Uttar Pradesh New and Renewable Energy Development Agency (upneda.org.in)

6. Uttar Pradesh JalVidyut Nigam Limited (upjvn.org)

7. Narora Atomic Power Station (NAPS) | Facilities | NTI

8. Welcome to Uttar Pradesh RajyaVidyutUtpadan Nigam Limited, Government of Uttar Pradesh, India. / Anpara Thermal Power Station (uprvunl.org)

9. Welcome to Uttar Pradesh RajyaVidyutUtpadan Nigam Limited, Government of Uttar Pradesh, India. / Obra Thermal Power Station (uprvunl.org)

10. Welcome to Uttar Pradesh RajyaVidyutUtpadan Nigam Limited, Government of Uttar Pradesh, India. / Parichha Thermal Power Station (uprvunl.org)

11. Welcome to Uttar Pradesh RajyaVidyutUtpadan Nigam Limited, Government of Uttar Pradesh, India. / Harduaganj Thermal Power Station (uprvunl.org)

12. Visuvasam, D.; Selvaraj, P.; Sekar, S., “Influence of Coal Properties on Particulate emission control in Thermal Power Plants in India”. Proceedings in Second International Conference on Clean Coal Technologies for our Future (CCT 2005), 2005, Sardinia, Italy.

13. DebrupaChakraborty, Carbon Footprint Analysis of a Selected Indian Power Plant, Subramanian SenthilkannanMuthu, Environmental Carbon Footprints, Butterworth-Heinemann,2018, Pages 141-160, ISBN 9780128128497, https://doi.org/10.1016/B978-0-12-812849-7.00006-4.

14. Zhi-jieGai, Jian-gang Zhaoand Gang Zhang” Typical calculation and analysis of carbon emissions in thermal power plants”, IOP Conference Series: Earth and Environmental Science, Volume 128, 3rd International Conference on Energy Equipment Science and Engineering (ICEESE 2017) 28–31 December 2017, Beijing, China