"A Study on Coal Production and Import in India"

Submitted to the School of Maritime Management, Indian Maritime University in partial fulfilment for the award of degree in

MASTER OF BUSINESS ADMINISTRATION

Submitted

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INDIAN MARITIME UNIVERSITY
(A Central University, Government of India)
SCHOOL OF MARITIME MANAGEMENT

CHENNAI CAMPUS 2023

SCHOOL OF MARITIME MANAGEMENT

INDIAN MARITIME UNIVERSITY

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Certificate

This is to certify that the project report titled **"A Study on Coal Production and Import in India"** is a bonafide work done by **Rakhi R (Reg.No:- 2103305034)** in partial fulfilment of the requirement for the award of the degree of Master of Business Administration in Indian Maritime University,

DECLARATION

I, **RAKHI R (Reg. No. 2103305034),** student of School of Maritime Management, Indian Maritime University – Chennai Campus, hereby declare that this project report titled"**A Study on Coal Production and Import in India**" submitted in partial fulfilment of the requirement for the degree of Master of Business Administration in Port and Shipping Management is my original work carried under the guidance of my project guide. It has not formed the basis for the award of any Degree/Diploma of any University/Institution. The information submitted is true and original to the best of my knowledge.

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ACKNOWLEDGEMENT

This endeavor would have been incomplete without proper assistance and guidance; hence I would like to thank and express my gratitude to all those people who have helped me in the completion of this project directly or indirectly.

I'd like to express my gratitude to **Dr. M.Sekar, Assistant Professor, School of Maritime Management, India Maritime University**, for recommending this study topic. I owe him a great debt of gratitude for his patient advice and support throughout my studies. His encouragement and inspiration, as well as his faith in my potential, enabled meto accomplish what I have so far.

I'd want to express my gratitude, Indian Maritime University, Chennai Campus, and all Professors in the Department of SMM for providing me with all of the resources I needed to complete my research and project work.

Finally, I thank all the non-teaching staff and fellows of the university my cordial regards to the employees of the organization for their kind cooperation throughout the period.

ABSTRACT

Coal production and import have been key components in India's energy sector, as the country has one of the world's largest coal deposits. This paper investigates the dynamics of coal production and import in India, including the factors that drive them, the obstacles that must be overcome, and the solutions that can be implemented to solve these challenges.

The research employs a secondary data analysis.. According to the data, coal is largely used in power generation, followed by the steel, cement, and fertiliser industries. Coal, on the other hand, is utilised in a variety of industries, including paper and pulp, chemicals, and textiles.

The research looks at the environmental impact of coal use in various industries, focusing on the numerous emissions and contaminants related with coal burning. Particulate particles, sulphur dioxide, nitrogen oxides, and greenhouse gases are among the pollutants emitted. The study also looks at the health and environmental effects of coal combustion, such as lung ailments and climate change.

. Several factors influence coal production and import in India, according to the report, including resource availability, technology and infrastructure, regulatory and policy frameworks, and environmental considerations. The report finds that the coal business in India has a number of problems, including obsolete equipment and infrastructure, environmental concerns, and policy uncertainties.

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CHAPTER 1

INTRODUCTION

1.1 Coal and its importance

Coal is a fossil fuel that is formed over millions of years through the decomposition of plant and organic matter. It is a combustible black or brownish-black sedimentary rock composed mostly of carbon and hydrocarbons. Coal is a non-renewable resource and is primarily used for generating electricity and for steel production.

Importance of Coal:

Coal has been a critical energy source for over a century, and it has played a vital role in the industrialization and economic development of many countries. Coal is a cheap and abundant resource, and its widespread availability has made it a popular choice for power generation and industrial use. Coal is a major source of electricity generation, accounting for around 38% of the world's electricity production in 2020, according to the International Energy Agency (IEA). Coal is also used extensively in the steel industry, where it is used in the production of coke, a fuel that is used in blast furnaces to produce steel.

Despite its many benefits, coal also has some significant environmental concerns associated with its use. Burning coal produces carbon dioxide, sulfur dioxide, and other harmful pollutants that contribute to air pollution and climate change. The environmental impact of coal has led to a shift towards cleaner sources of energy, such as natural gas, wind, and solar power.

Coal production is the process of mining coal from underground or open-pit mines. The process involves drilling, blasting, and removing the coal from the earth. The extracted coal is then processed and prepared for transportation and sale to different industries.The production of coal varies from country to country, depending on the availability of the resource and the demand for it. According to the IEA, the world's total coal production was 7,994 million tonnes in 2020.The top coal-producing countries in the world are China, India, the United States, Australia, and Indonesia. Together, these countries accounted for 77% of the world's coal production in 2020. China is the world's largest coal producer, accounting for nearly half of the world's coal production.

In some countries, there is a shortfall in domestic coal production, and so they import coal to meet their energy needs. The import of coal depends on the energy demand of the country and the availability of the resource in the domestic market.

The top coal-importing countries in the world are China, India, Japan, South Korea, and Taiwan. These countries accounted for 74% of the world's total coal imports in 2020. China is the world's largest coal importer, accounting for 21% of the world's total coal imports.Coal is an essential fuel source for power plants that generate electricity. Coal-fired power plants burn coal to produce steam

that drives turbines, which generate electricity. The global demand for electricity continues to grow, and coal remains one of the primary sources of electricity generation.The power sector is the largest consumer of coal globally, accounting for 60% of the world's coal consumption in 2020. The demand for coal in the power sector is driven by the growing demand for electricity, particularly in developing countries. According to the IEA, coal-fired power generation is expected to decline in developed countries, but it will continue to grow in developing countries.

The steel industry is another major consumer of coal. Coal is used in the production of coke, a fuel that is used in blast furnaces to produce steel. Coke is made by heating coal in the absence of air to remove volatile compounds and leave behind a solid fuel with a high carbon content. The global steel industry is expected to continue to grow, and coal will remain a vital input in its production

1.2 DEFINITION AND MEANING

- TWh -Terawatt-hour (TWh), a measure of electrical energy, 10^{12} watt-hours.
- FT-IR spectroscopy – Fourier transform infrared spectroscopy which the most common form of infrared spectroscopy.
- REE – Rare Earth Elements are a group of chemically similar metallic elements comprising the lanthanide series and (usually) scandium and yttrium.
- Fly Ash – finely divided residue that results from the combustion of pulverized coal.
- CCS – Carbon Capture and Storage refers to a suite of technologies that can play a drole in meeting global energy and climate goals.
- CCUS – Carbon Capture Utilisation and Storage is the process of capturing carbon dioxide emissions and either using them to make things such as building materials (utilization) or permanently storing them thousands of feet below the surface(storage)
- SCR -Selective Catalytic Reduction means converting Nitrogen oxides with the aid of a catalyst into diatomic nitrogen and water
- CIL – Coal India Limited is an Indian Central Public sector undertaking under the ownership of the Ministry of Coal, Government of India.
- SSCL- Singareni Collieries Company Limited (SCCL) is a government coal mining company jointly owned by the Government of Telangana and Government of India on a 51:49 equity basis

- ❖ CAGR - Compound annual growth rate or CAGR, is the mean annual growth rate of an investment of a specified period of time longer than one year.

1.3 RESEARCH QUESTION

Why does India import coal when it has enough?

1.4 OBJECTIVES OF THE STUDY

- To study the production and import of coal in India
- To analyse the requirement of coal in power plant
- To analyse the requirement of coal in steel industry

1.5 SCOPE OF THE STUDY

- Details about the coalfield in India and their production
- To understand the amount of coal consumption in power plant and steel industry in India
- Details regarding coal import to India

1.6 RESEARCH METHODOLOGY

The information used in this project is from various news articles and journals. 'Secondary Data' is widely used for the completion of this project.

1.7 LIMITATION

- Lack of reliability in secondary data
- Due to time constraint, primary data could not be collected

CHAPTER 2

REVIEW OF LITERATURE

India is one of the largest producers and consumers of coal in the world. The country has significant reserves of coal, with the majority of the coal production coming from state-owned Coal India Limited (CIL). The production of coal in India has been increasing steadily over the years. In 2020, India produced around 729 million tonnes of coal, which was a slight decrease from the previous year due to the COVID-19 pandemic.

Despite being a major producer of coal, India also imports a significant amount of coal to meet its growing energy demands. In 2020, India imported around 240 million tonnes of coal, which was a decrease from the previous year due to the pandemic. The majority of the imported coal comes from Indonesia, Australia, and South Africa.

India's dependence on coal for energy production has been a cause of concern for environmentalists as it is a major contributor to air pollution and greenhouse gas emissions. The government has been taking steps to reduce the country's dependence on coal and increase the share of renewable energy in its energy mix. However, given the current state of infrastructure and energy demand, it is likely that coal will continue to play a significant role in India's energy sector for the foreseeable future.

4.1 LITERATURE REVIEW

1. Coal accounts for half of India's commercial primary energy. Non-commercial biomass, on the other hand, remains an important energy source, accounting for nearly one-quarter of total primary energy. The power sector consumes the majority of India's coal (Figure 1), and coal dominates supply in terms of capacity and generation (Figures 2 and 3). India mostly uses native coal, but imports approximately 200 million tonnes of coal per year, including coking coal used in steel mills. Power plants are intended to run on a specified quality of coal—small variances may reduce efficiency, while greater differences may prevent operation. Many plants on the coast, far from coal mines, are built to run on imported coal. Imports are frequently combined with native coal to raise the average heat value—Indian coal has a high ash content and a low heat value in general. (Tongia & Gross, n.d.)

2. In India, coal-fired power stations have been a major source of air pollution and the accompanying health consequences. These plants emit a variety of pollutants into the atmosphere, including particulate matter, sulphur dioxide, nitrogen oxides, and mercury, which can have major health repercussions for neighbouring communities and the broader population. In India, the health costs of coal-fired power plants are enormous. In addition to the health expenses, coal-fired power plants have environmental costs, such as harm to ecosystems, water supplies, and the effects of climate change. To address these concerns, the Indian government has established targets for increasing the share of renewable energy in the country's energy mix, as well as rules to minimise emissions from coal-fired

power plants. However, there is still much work to be done in India to reduce the health and environmental consequences of coal-fired power plants. (Barrows et al., 2019)

3.Until today, the volume and trade relationships of the global coal trade have been increasing, which has a negative impact on both the environment and coal supply security. However, it is unknown whether it is possible to reverse this trend and reduce global coal trade competition. If this was possible,the volume and kind of coal trading would steadily dwindle. To answer this question, this research employs a complex network model to investigate the dynamic competitive interaction and intensity of the worldwide coal import trade. The results show that more competitive ties related coal imports are emerging at the global level, and the coal import competition network has shifted from a core periphery structure to a reticular one. Furthermore, the competitive intensity of the global coal trade continues to rise. (Wang et al., 2021)

4.The life cycle greenhouse gas (GHG) impacts of coal and imported gas-based power generation in the Indian context depend on several factors, including the type of fuel, the efficiency of power generation, and the emissions from upstream activities such as fuel extraction, transportation, and processing. Coal-based power generation is a major contributor to GHG emissions in India. The entire life cycle of coal, from extraction to combustion, emits significant amounts of CO2, methane, and other greenhouse gases. The emissions from coal-based power plants can be reduced through the use of more efficient technologies, such as supercritical and ultra-supercritical boilers, and through the implementation of carbon capture and storage (CCS) technologies. (Mallapragada et al., 2019)

5.The advance of renewable energy around the world has kindled hopes that coal-based energy is on the way out. Recent data, however, make it clear that growing coal consumption in India coupled with its continued use in China keeps coal-based energy at 40 percent of the world's heat and power generation. To address the consolidation of coal-based power in India, this article analyses an energy transition *to*, rather than *away from*, carbon-intensive energy over the past two decades. We term this transition *India's new coal geography*; the new coal geography comprises new ports and thermal power plants run by private-sector actors along the coastline and fuelled by imported coal. This geography runs parallel to, yet is distinct from, India's 'old' coal geography, which was based on domestic public-sector coal mining and thermal power generation. We understand the development of coastal thermal power as an outcome of long-term electrical energy shortages and significant public controversy within the old coal geography. By analysing the making of the new coal geography at a national level, and scrutinizing its localised manifestation and impact through a case study of Goa

state, we outline the significant infrastructural investment and policy work of a dispersed network of public- and private-sector actors that slowly enabled this new coal energy avatar. We argue that the enormous effort to establish India's new coal geography further entrenches the country's reliance on coal. The result is that for India, energy security is a choice between domestic and imported coal. (Oskarsson et al., 2021)

6. There is a complex relationship between the resource recovery practices of the UK concrete industry and ongoing low-carbon transitions taking place in electricity and steel. Reductions in UK coal-based electricity and primary steel production are reducing domestic availability of residues – coal ash and steels lag – that are used to replace cement in concrete; for decarbonisation purposes and to increase concrete quality. This is leading to an unusual mass-transportation of 'wastes' from the Global South to Global North. Focusing closely upon the mitigation pathways of concrete producers, we develop an inter-industry model of material flows, and a diversity of scenarios and sensitivity tests, to consider how resource recovery practices and carbon emissions of the three sectors may evolve.(Millward-Hopkins et al., 2018)

7. Surface coal mining and processing endangers residential areas' health by polluting the air and water. Coal combustion generates more nitrogen oxides, sulphur dioxide, particulate matter, and heavy metals per unit of energy than any other fuel source, endangering worldwide public health. The disposal of coal ash exposes communities to heavy metals and particle matter waste. Coal consumption in private households has the greatest impact on public health in developing countries. Across the coal continuum, people with low socioeconomic status are disproportionately affected, contributing to health disparities. Despite efforts to develop renewable energy sources, worldwide coal use has not decreased. To improve public health and avoid significant climate change implications, concentrated measures to eliminate coal as an energy source are required.(Hendryx et al., 2020)

8. The iron and steel making is considered among the biggest industries which run the world. This industry contributes around 20% of global industrial-sector energy consumption that is provided significantly by coal and coke. The fossil-based fuels are consumed largely for heat generation and reducing agents in steel production processes which leads to huge global CO2 emissions. This matter encourages to find an effective, environmentally friendly, and sustainable substitute instead of coke and coal. Recently, biochar has received lots of consideration as a possible replace since the acceptable adaptation and comparable metallurgical properties to coal and coke. However, the biomass

application in iron and steel making manufactures is currently limited and it endures strong competition with coal-based fuels. This paper investigates the key challenges affected on the steel production plant and the ability of biochar to overcome these difficulties. This work evaluates coal and coke substitution with biochar, focusing on metallurgical, technical and environmental aspects with the view of gate-to-gate analysis, from industry entry gate (input feedstocks that are coal or biochar) to exit gate (that is steel production). Moreover, the opportunities and obstacles of biochar performance in energy-intensive processes in steel production such as coke-making, sintering and blast furnace are discussed and finally, the main questions regarding the evaluation of these alternatives and their impacts on the system are answered. (Safarian, 2023)

9. Coal which is commonly called as the black gold of India contributes a major part to its commercial energy production and is widely used in the power industry to generate electricity. However, as compared to other fossil fuels, coal is more pollution intensive and the energy efficiency is very low1 . Moreover its transportation and combustion have deleterious consequences which are borne by the Indian society as well as the people around the world. A number of these effects have been investigated by Indian researchers but the indirect and far reaching impacts have not been properly dealt with. (Upgupta & Singh, 2017)

10. Fly Ash is the fine particulate residual outcome of pulverized coal burning obtained primarily from the coal-based electricity generation plants. Considering the exponential increase in population around the world, the electrical energy demand as of now is at an all-time high and coal-based power plants are responsible for satisfying major part of this demand especially in developing countries. Owing to this extra load on coal-based plants, there is a significant increase in the production of fly ash from these plants and the disposal of fly ash which is considered a deleterious product for environment is becoming a concern for everyone. In this paper, a brief review about the composition, production and utilization has been provided with special reference to India.(Yousuf et al., 2020)

11. India is one of the fastest developing countries in the world. To sustain this growth, energy and electricity demands will increase. In 2015, of the 1337 TWh produced, 916 TWh were from fossil fuels. We prepared several models of electricity demand from 2015 to 2030, based on publicly available datasets and trends. Models were tested on data from previous years and adjusted accordingly. From several scenarios, we decided to introduce two possibilities, i.e., a scenario using high energy savings in all sectors, and a scenario counting on a high industrial growth not supported

by an equal increase of electricity savings. For both cases we prepared models for extreme situations: (1) where coal- and lignite-based power plants are preferred after slow-down of a renewable energy boom, and (2) with high utilization of renewable energy supported by natural gas and nuclear energy. With GDP and population increasing at the same rate as in previous years, the unambiguous result in all scenarios is a 2 to 3-fold increase of the electricity demand by 2030. On the electricity production side, all scenarios stress the role of coal, renewables and nuclear sources. Both energy and climate policies should be prepared for such a development in advance.(Tiewsoh et al., 2019)

12. One argument for transitioning from coal to renewable energy is that it will provide local health benefits. Existing literature has demonstrated the air quality and health cobenefits that accompany climate mitigation in various regions (3–8). Several studies have analyzed the air pollution or human health impacts specifically contributed from coal-fired power generation (9–12). Studies of the health impacts of Indian electricity sector are, however, for earlier years and do not reflect the state of the art for calculating mortality impacts of particulate matter 2.5 μm (PM2.5) (Designed Research; R & Performed Research; M, 2021)

13. Coal is on the rise in India: despite the devastating impacts of the climate crisis, the awareness for land and forest-rights, and political talk of a coal phase-out. In this article, we demonstrate that despite the renewables-led rhetoric, India is in the midst of a transition to (not away from) greater use of coal in its fossil energy system and in the electricity system in particular. We investigate this paradox by combining socio-metabolic and political-ecological analysis of the Indian coal complex. Our framework integrates material and energy flow data as characterizing the Indian fossil energy transition, indicators on the development and structure of the coal in-dusty, and studies of ecological distribution conflicts around coal. The dominant claim to expansive use of coal and the competing counterclaims are indicative of underlying power relations which can also be witnessed in other countries. In India, they extend into the conflicted development of renewable energy including hydro-power, in which the land dispossession, exclusion, and injustices associated with the expansion of the coal complex are reproduced. We conclude that the current energy transition – in which coal continues to play a dominant role – is neither sustainable nor just. (Roy & Schaffartzik, 2021)

14.In 2015, at the same time as countries around the world were hammering out their positions in preparation for COP21 in Paris, global coal production declined by 2.8%. This was the largest fall since the International Energy Agency (IEA) began keeping records in 1971 and the second successive year of declining production since 13 years of constant growth had delivered the highest

ever coal production in 2013 (IEA, 2016a). It was immediately followed up with a 6.3% fall in production in 2016, confirming the trend away from coal. (Edwards, 2019)

15. India's ambitious renewable energy development targets have been warmly praised, but the other side of the coin is the phase-out of coal-based electricity generating. We presently have around 210 GW of coal-based capacity in operating, 39 GW under construction, and another 25 GW in various phases of approval where building has not yet commenced. According to this profile, approximately 200 GW of thermal capacity will still be operational by 2050, and the power sector will not achieve zero emissions until 2070! (Singh Ahluwalia & Patel, 2021)

16. Currently, global steel production is reliant on coal and capital-intensive manufacturing plants with extended economic lives. While the Paris Agreement requires global carbon neutrality by 2050-2070, with negative emissions thereafter, coal-based steel production now contributes for roughly 8% of global energy-related CO2 emissions. Its output may stabilise or perhaps fall in developed countries, but it will rise dramatically in emerging economies. Previously, the focus of CO2 reduction for steel has been on reducing moderate emissions through energy efficiency measures and investigating carbon capture and storage. However, since the cost of renewable electricity continues to fall, carbon capture and storage has failed to materialise, and more and more governments set aggressive emission reduction targets, electricity- and hydrogen-based steelmaking has gained significant traction during the last half-decade.(Arens et al., 2021)

17.Coal mining adversely affects the eco-system as a whole. On the unstable earth, the unresting mankind constantly uses a variety of resources for daily lives. Coal is recognized to have been the main source of energy in India for many decades and contributes to nearly 27 % of the world‘s commercial energy requirement. Coal is mainly mined using two methods- surface or _opencast‘ and underground mining. The geological condition determines the method of mining. Coal mining is usually associated with the degradation of natural resources and the destruction of habitat. This causes invasive species to occupy the area, thus posing a threat to biodiversity. Huge quantities of waste material are produced by several mining activities in the coal mining region. If proper care is not taken for waste disposal, mining will degrade the surrounding environment. The method of waste disposal affects land, water and air and in turns the quality of life of the people in the adjacent areas. This paper throws lights on the burning issues of coal mines and its impact on the environment. (Goswami, 2015)

18.The increasing demand for rare earth elements (REEs) for advanced technology development has elevated and to fulfill this demand, we should look for the new resource base substance with REEs. The existence of REEs in coal is in a new fancy study over the past decade. Despite its (REEs) importance, very limited studies have been carried out on methods to recover and refine the REEs in coal as well as the existence. REEs are strategic as well as non-renewable resources that are widely used in many fields. These REEs are excessively used and aggressively mined of its ores globally, which will escalate to depletion in abundance (Tang et al., 2019). REEs is a group of 15 elements, which we call the lanthanide elements (atomic numbers 57–71) and two transition metal elements, i.e. yttrium and scandium. Promethium (atomic number 61) is very rare in the earth crust and is normally considered not to exist in nature (Chen 2011; Resende and Morais 2009). Increasing applications for REEs started in the 1960s when developments in process technology allowed their purification at the commercial scale (Kronholm, Anderson, and Taylor 2013). (Modi et al., 2021)

19. The chemical composition and macro-molecular structure of coal have raised substantial interest due to their importance in the development of novel and improved coal conversion practices (Larsen et al. 1986; Marzec 2002). Coal structure is inherently complex; it varies widely in their chemical (molecular) and physical (conformational) properties, making detailed structural characterization of coal extremely difficult. Therefore, research on coal structure is still a stimulating task and continues to be pursued (Mathews and Chaffee 2012). It is well known that during coalification, the organic structure of coal consisting of heterogeneous aliphatic and aromatic compounds keep changing with aromaticity increasing from low rank to high rank coals (Oikonomopoulos et al. 2013). In our present study, three coals of Indian origin with different ranks, namely Coal A (ranked 1.26%), Coal B (ranked 1.38%) and Coal C (ranked 0.46%), were chosen for in-depth analysis. The structural features of the three different coals and their density fractions obtained through dense media separation were investigated thoroughly by petrography, swelling index and Fourier transform infrared (FT-IR) spectroscopy(Chakravarty et al., 2020)

20.Coal power generation is a primary cause of greenhouse gas (GHG) and toxic airborne emissions globally. We present a uniquely comprehensive inventory of CO2, methane, particulate matter, sulphur dioxide, nitrogen oxides, and mercury emissions for 7861 coal generating units including their supply chains. Total GHG and toxic substance emissions are largest from China, US, India, Germany and Russia (together >64% per pollutant). Overall supply chain contributions are below 19%, but exceed 75% for individual units and pollutants. Methane emissions from underground coal mining offset Chinese coal power plant efficiency advantages in comparison to India. Health impacts,

as quantified by regionalized life cycle assessment, are highest in India and parts of eastern and south-eastern Europe due to lack of modern flue gas treatment, and in China due to widespread coal power generation. Deployment of state-of-the-art flue gas treatment, driven by local emission limits, can mitigate health impacts in India and parts of Europe while it is already largely used in China and the US. Phase-out of the 10% most polluting coal power plants (by capacity) would reduce coal power GHG emissions by 16% or human health impacts by 64%, respectively.(Oberschelp et al., n.d.)

CHAPTER 3

INDUSTRY PROFILE

3.1 COAL AND ITS FEATURES

Coal is a fossil fuel that is primarily composed of carbon, along with small amounts of other elements such as sulphur, nitrogen, and oxygen. It is formed from the remains of ancient plants that have been buried and compressed over millions of years. Coal is classified into four main types based on its carbon content, with higher carbon content coal being more energy-dense and desirable for energy production. The four types of coal are lignite, sub-bituminous, bituminous, and anthracite.

Coal has been a critical source of energy for human civilization for centuries. It is primarily used for electricity generation, providing about 38% of the world's electricity in 2021. Coal is also used in other industrial processes, such as the production of steel and cement.

Coal has several features that make it an attractive energy source. It is abundant and widely available, with large reserves in many parts of the world. Coal is also relatively inexpensive compared to other forms of energy, making it an affordable option for many industries and households.

However, the use of coal also has negative environmental impacts. Coal mining can cause significant environmental damage, including deforestation, water pollution, and soil erosion. The burning of coal also generates significant greenhouse gas emissions, which contribute to climate change and air pollution, leading to respiratory diseases and other health issues.

In recent years, there has been a growing shift towards renewable energy sources such as solar and wind power. Many countries have set targets to reduce their dependence on coal and transition to cleaner forms of energy. However, coal is likely to remain an important source of energy for many countries in the foreseeable future, particularly those with large reserves of the fossil fuel.

3.2 GLOBAL AND DOMESTIC IMPORTANCE OF COAL INDUSTRY

The coal industry has played a significant role in the global economy for centuries, providing a reliable source of energy for industry, transportation, and households. The importance of coal has been particularly pronounced in countries with abundant coal reserves, such as the United States, China, Russia, India, and Australia. In this response, we will examine the importance of the coal industry in both the global context and in India.

3.2.1 Global Importance of Coal Industry:

Coal is one of the most abundant fossil fuels, and it has been a critical source of energy for the global economy for centuries. The coal industry has been a significant contributor to economic growth,

providing jobs and revenue for many countries. In 2019, the global coal industry generated approximately 7.7 billion tons of coal, with China, India, and the United States being the top producers. Despite the significant contribution of the coal industry to economic growth, it has also faced criticism due to its negative environmental impacts. Coal mining can cause significant environmental damage, including deforestation, water pollution, and soil erosion. The burning of coal also generates significant greenhouse gas emissions, which contribute to climate change and air pollution, leading to respiratory diseases and other health issues.

In recent years, there has been a growing shift towards renewable energy sources such as solar and wind power. Many countries have set targets to reduce their dependence on coal and transition to cleaner forms of energy. In the United States, for example, coal consumption has declined steadily in recent years, and renewable energy sources have become a more significant source of energy. Despite the trend towards renewable energy, coal is still an essential source of energy for many countries, particularly those with large reserves of the fossil fuel. Coal remains a reliable and affordable source of energy for many industries, and it is likely to continue playing an important role in the global economy for the foreseeable future.

3.2.2 Importance of Coal Industry in India:

India is one of the world's largest consumers and producers of coal. Coal is a significant source of energy in India, accounting for approximately 55% of the country's total primary energy consumption. The importance of coal in India can be attributed to several factors, including the country's growing energy demand, its abundance of coal reserves, and its reliance on coal for electricity generation.The coal industry has played a significant role in the Indian economy, providing employment opportunities and revenue for the government. The coal mining sector employs approximately 2.5 million people in India, and the industry has been a critical source of revenue for the government through taxes, royalties, and dividends.

Coal is a primary source of energy for electricity generation in India, and it is expected to remain so for the foreseeable future. India has set ambitious targets for expanding its renewable energy capacity, but coal is likely to remain an essential part of the country's energy mix due to its reliability and affordability. The Indian government has taken several steps in recent years to promote the growth of the coal industry. In 2015, the government launched the "Coal Mitra" portal, which allows companies to buy and sell coal online. The government has also introduced policies to encourage private investment in the coal sector, including the auction of coal blocks to private companies.

Despite the importance of coal in India's energy mix, the coal industry has faced criticism for its negative environmental impacts. Coal mining can cause significant environmental damage, including

land subsidence, soil erosion, and water pollution. The burning of coal also generates significant greenhouse gas emissions, which contribute to climate change and air pollution, leading to respiratory diseases and other health issues.

3.3 COAL IMPORT TO INDIA

India is the second-largest importer of coal in the world, after China. In 2020, India imported approximately 241 million tonnes of coal, representing a 12% increase from the previous year. The majority of coal imports come from Indonesia, followed by Australia, South Africa, and the United States.

The drivers of India's coal imports include the growing demand for electricity, the inadequate domestic supply of coal, and the increasing use of imported coal in power plants. India's electricity demand is expected to continue to grow, and coal is expected to remain an essential source of energy in the country's energy mix. However, India's domestic coal production has not kept pace with the growing demand, leading to an increase in coal imports. The import of coal has significant implications for the Indian economy. Importing coal is costly, and it puts pressure on the country's current account deficit. In 2020, India spent approximately USD 17 billion on coal imports, representing a significant drain on the country's foreign exchange reserves.

3.4 COAL PRODUCTION IN INDIA

Coal production in India is an essential component of the country's energy mix, as coal remains the primary source of electricity generation in India. In this response, we will examine the coal production in India, its challenges, and its impact on the Indian economy.

India's Coal Production:

India is the world's third-largest coal producer, after China and the United States. The country has significant coal reserves, with the estimated coal reserves being 319.02 billion tonnes as of April 2021. However, despite having significant coal reserves, India has faced challenges in meeting the growing demand for coal.

India's coal production has grown steadily in recent years, increasing from 730.4 million tonnes in 2018-19 to 729.1 million tonnes in 2019-20. The majority of coal production in India comes from state-owned companies such as Coal India Limited and Singareni Collieries Company Limited.

3.4.1 Trends and Future of Coal Production and Import

The future of coal production and import is subject to a range of factors, including economic, political, and environmental considerations. While coal remains an important source of energy, there are several trends that are likely to impact the future of coal production and import.

One of the most significant trends is the shift towards renewable energy sources. Governments and businesses around the world are increasingly investing in renewable energy technologies such as wind and solar power, which are becoming more cost-competitive with traditional fossil fuels like coal. This shift is likely to lead to a decline in demand for coal, especially in developed economies where environmental concerns are driving the adoption of clean energy.

Another trend is the increasing adoption of clean coal technologies, which aim to reduce the environmental impact of coal-fired power generation. These technologies include carbon capture and storage (CCS), which involves capturing carbon dioxide emissions from coal-fired power plants and storing them underground. While these technologies are still in the early stages of development, they have the potential to reduce the carbon footprint of coal-fired power generation and extend the life of coal as an energy source.

In addition to these trends, the future of coal production and import is also subject to political and economic considerations. In some countries, such as China and India, coal remains a critical source of energy and is likely to continue to play a significant role in the energy mix for the foreseeable future. These countries are likely to continue to rely on coal imports to meet their energy needs, especially if domestic production is insufficient to meet demand.

At the same time, the global coal market is subject to fluctuating prices and supply disruptions, which can impact the cost and availability of coal. For example, in 2020, the COVID-19 pandemic led to a decline in global coal demand and production, as countries implemented lockdowns and reduced economic activity. This led to a drop in coal prices and reduced demand for coal imports.

Looking ahead, the future of coal production and import will depend on a range of factors, including the development of renewable energy technologies, the adoption of clean coal technologies, and economic and political considerations. While coal is likely to remain an important source of energy in some parts of the world, the long-term trend is towards a reduction in coal consumption and an increasing focus on clean energy sources

3.5 COAL IMPACT ON ENVIRONMENT

Coal has significant impacts on the environment, including air, water, and land pollution, as well as climate change. Burning coal releases carbon dioxide, sulphur dioxide, nitrogen oxides, and other pollutants that contribute to air pollution and climate change.

Coal-fired power plants are a significant source of air pollution, emitting large quantities of sulphur dioxide, nitrogen oxides, and particulate matter into the air. These pollutants can cause respiratory problems and other health issues, particularly for people living near coal-fired power plants .Sulphur dioxide emissions from coal combustion can react with other compounds in the atmosphere to form acid rain, which can damage forests, lakes, and rivers. Nitrogen oxides emissions can contribute to the formation of smog, which can cause respiratory problems and reduce visibility.

Particulate matter emissions from coal combustion can also contribute to health problems, particularly for people with pre-existing respiratory issues. Fine particulate matter can penetrate deep into the lungs and cause inflammation, leading to asthma, heart disease, and other health problems.

Coal mining and processing can have significant impacts on water quality. Surface mining can result in the disruption of stream beds and the release of contaminants into nearby waterways. Coal washing, which involves the use of water to remove impurities from coal, can also result in the release of pollutants into waterways.In addition, coal-fired power plants can also contribute to water pollution. Coal-fired power plants require large quantities of water to produce steam, and the discharge of wastewater from these plants can contain pollutants such as mercury, lead, and arsenic.

Coal mining and processing can also have significant impacts on land quality. Surface mining can result in the loss of topsoil and the destruction of habitats. Underground mining can result in subsidence, the collapse of land above underground mines, which can cause damage to buildings and infrastructure.

In addition, the disposal of coal ash, a byproduct of coal combustion, can also have significant impacts on land quality. Coal ash contains contaminants such as arsenic, lead, and mercury, which can leach into the soil and groundwater if not properly stored.

Burning coal is a significant contributor to climate change, as it releases carbon dioxide, a greenhouse gas, into the atmosphere. The burning of coal is responsible for around 40% of global carbon dioxide emissions, according to the International Energy Agency (IEA).The accumulation of greenhouse gases in the atmosphere has led to a warming of the planet, resulting in changes to the climate, such as more frequent and severe heatwaves, droughts, and storms. Climate change also has significant impacts on the environment, including the loss of biodiversity, sea-level rise, and the melting of glaciers and ice caps.

There are several ways to mitigate the environmental impacts of coal. One way is to reduce coal consumption by transitioning to cleaner sources of energy, such as natural gas, wind, solar, and hydropower. Another way is to increase energy efficiency, reducing the amount of energy needed to perform a given task. Technologies such as carbon capture, utilization, and storage (CCUS) can also be used to capture carbon dioxide emissions from coal-fired power plants and store them underground. This technology is still in the early stages of development and is not yet commercially viable at scale. In addition, regulatory measures can be used to reduce the environmental impacts of coal. Regulations can limit the amount of pollutants that can be emitted from coal-fired power plants, require the proper disposal of coal ash, and mandate the use of more efficient technologies. Coal has significant impacts on the environment, including air, water, and land pollution, as well as climate.

3.6 COAL AFFECTS HUMAN HEALTH

Occupational Hazards:

Coal mining is a dangerous occupation, with the potential for accidents, injuries, and exposure to harmful substances. Miners are at risk of developing black lung disease, a condition caused by inhaling coal dust. This disease can cause chronic coughing, shortness of breath, and permanent lung damage.

In addition, miners may be exposed to other harmful substances, such as silica dust, which can cause silicosis, a respiratory disease. Miners may also be at risk of injury from falling rocks or equipment, or from explosions or fires.

Social and Economic Impacts:

The coal industry can also have significant social and economic impacts on communities. Coal mining communities may experience higher rates of poverty, unemployment, and health problems. Coal mining can also result in the displacement of communities and the loss of cultural and historical sites. In addition, the use of coal can contribute to climate change, which can have significant impacts on vulnerable communities, particularly in developing countries.

3.7 COAL IN VARIOUS INDUSTRIES

Coal has been used as a fuel and raw material in various industries for centuries. Here are some of the industries that use coal:

Power Generation: Coal is a cheap and abundant source of energy, which is why it has been the primary source of fuel for power generation for decades. Coal-fired power plants burn coal to produce steam, which drives turbines to generate electricity. Despite concerns about air pollution and climate change associated with burning coal, coal-fired power plants continue to provide a significant portion

of the world's electricity, particularly in developing countries where coal is still the most affordable and accessible fuel source. Efforts are being made to reduce the environmental impact of coal-fired power plants through the use of cleaner technologies and the shift towards renewable energy sources, but the transition away from coal is expected to take time.

Steel Production: Coal is an essential raw material in the production of steel. In the blast furnace process, coke (a form of coal) is used as a fuel to heat the furnace and provide the necessary carbon for the production of steel. Coke is created by heating coal in the absence of air, which removes impurities and creates a porous material that can be used in the blast furnace. Additionally, coal is used as a reducing agent to remove oxygen from iron ore and other metals in the blast furnace process. Without coal, the production of steel would be significantly more expensive and difficult, making it a critical component of the steel manufacturing industry.

Cement Manufacturing: Coal is an essential fuel in the cement manufacturing process. Cement production involves heating limestone and other raw materials at high temperatures to form a material called clinker. Coal is burned in a kiln to provide the heat necessary to create clinker. The heat from the combustion of coal causes the raw materials to break down chemically and react to form clinker. Additionally, coal is used as a source of carbon during the chemical reactions that occur during cement production. Carbon is required to form calcium silicates and aluminates, which are the primary components of cement. Therefore, coal is a critical fuel source for the cement industry, providing the heat and carbon needed to produce high-quality cement.

Paper Manufacturing: In the paper manufacturing process, coal is primarily used as a fuel to generate the heat needed for drying the paper. This is typically done by burning pulverized coal in a boiler to produce steam, which is then used to drive turbines that generate electricity. In addition, coal is also used as a source of carbon in the chemical reactions that occur during paper production. Specifically, coal can be used to produce black liquor, which is a by-product of the papermaking process that is used to recover chemicals and energy from wood pulp. The black liquor is burned in a recovery boiler, and the heat generated is used to produce steam and to recover chemicals such as sodium and sulphur. Overall, coal plays a significant role in the paper manufacturing process by providing both heat and chemical inputs.

Chemical Manufacturing: Coal can be converted into a variety of chemicals through a process called gasification. In this process, coal is exposed to high temperatures and pressure in the presence of oxygen and steam, which breaks down the coal into a mixture of carbon monoxide and hydrogen gas. This gas mixture, also known as syngas, can then be further processed to produce a variety of chemicals, such as methanol, ammonia, and synthetic fibers. These chemicals are used in various

applications, such as the production of plastics, fertilizers, and textiles. While the gasification process can be expensive and complex, coal remains a key raw material for the chemical industry due to its abundance and low cost.

Brick Manufacturing: Coal is used as a fuel in the brick manufacturing process because of its high calorific value and relatively low cost. During the brick-making process, coal is burned to generate heat, which is used to bake the bricks in a kiln. The high temperature of the kiln causes the clay in the bricks to vitrify, or become hard and glass-like, giving the bricks their strength and durability. Coal is also used as a source of carbon in the chemical reactions that occur during brick production. Carbon is required to reduce iron oxide, which is present in the clay, to metallic iron. The metallic iron reacts with oxygen to produce iron oxide, which forms a glassy bond between the clay particles, further strengthening the brick.

Food Processing: Coal is used as a fuel in the food processing industry due to its ability to provide a high and consistent heat source. It is primarily used in large-scale cooking and processing applications such as baking, roasting, and drying. Coal-fired ovens are commonly used in bakeries to bake bread, cakes, and pastries, while coal-fired boilers are used to cook and process food products such as meat, grains, and vegetables. However, the use of coal in the food processing industry has declined in recent years due to concerns about air pollution and the adoption of cleaner and more efficient energy sources.

Pharmaceuticals: Coal is an important source of raw materials in the pharmaceutical industry. It can be converted into a variety of chemicals such as phenol, which is used as an antiseptic and a precursor to other chemicals. Coal tar is another important product of coal that is used in the production of drugs for psoriasis, eczema, and other skin disorders. Additionally, coal-derived activated carbon is used as an absorbent in various drug formulations. The use of coal in the pharmaceutical industry highlights the versatility of this fossil fuel and its importance in various sectors of the economy.

Textile Manufacturing: Coal is an important fuel source for the textile manufacturing industry as it provides the heat necessary to dye and dry textiles. During the textile manufacturing process, coal is burned to generate steam which is used to heat water and create the necessary conditions for dyeing and drying. In addition, coal is also used as a source of carbon in the chemical reactions that occur during textile production. The carbon derived from coal is used in the production of chemicals such as carbon disulphide which is used in the manufacture of rayon, a synthetic fabric. While coal is a cheap and abundant source of energy for the textile industry, concerns about its impact on the environment and human health have led to the development of cleaner energy alternatives.

Plastics Manufacturing: Coal can be converted into various chemicals, including ethylene and propylene, which are important raw materials for the production of plastics. Ethylene is produced by cracking hydrocarbons derived from coal, and is used to make polyethylene, which is one of the most commonly used plastics in the world. Propylene can also be produced by cracking hydrocarbons derived from coal, and is used to make polypropylene, which is used in a variety of products, including food packaging, automotive parts, and textiles. The ability to convert coal into these valuable chemicals has made coal an important feedstock for the plastics industry.

3.7.1 Uses of Coal in Power Generation

Coal is one of the primary fuels used to generate electricity around the world. Coal-fired power plants produce electricity by burning coal to heat water, which creates steam. The steam drives turbines, which generate electricity.

There are several advantages to using coal for power generation. First, coal is abundant and relatively inexpensive, making it an attractive fuel source. Second, coal-fired power plants can be built at large scales, which makes them suitable for meeting the high electricity demands of urban areas and industrial centers. Finally, coal-fired power plants are reliable and can be operated continuously for long periods of time, making them a stable source of electricity.

Despite these advantages, there are also several disadvantages to using coal for power generation. The burning of coal releases large amounts of greenhouse gases into the atmosphere, including carbon dioxide, sulfur dioxide, and nitrogen oxides. These pollutants contribute to air pollution and climate change, which can have negative impacts on human health and the environment.

There are several technologies that can be used to reduce the environmental impact of coal-fired power plants. One of the most effective is the use of flue gas desulfurization (FGD) systems, which remove sulfur dioxide from the flue gas before it is released into the atmosphere. Another technology is selective catalytic reduction (SCR), which reduces nitrogen oxide emissions. In addition, carbon capture and storage (CCS) technology can be used to capture carbon dioxide emissions and store them underground. Coal-fired power plants are used to generate electricity in many countries around the world. The largest coal-producing countries, such as China, the United States, and India, are also the largest consumers of coal for power generation. Coal is also used to generate electricity in Europe, where it is still an important source of energy, particularly in countries like Germany and Poland.

In recent years, there has been a growing trend towards the use of renewable energy sources, such as wind and solar power, to generate electricity. However, coal-fired power plants are expected to continue to play an important role in meeting the world's energy demands for the foreseeable future, particularly in developing countries where electricity demand is rapidly increasing. As a result, it is

important to continue to develop and improve technologies that can reduce the environmental impact of coal-fired power plants, while also exploring new sources of renewable energy.

3.7.2 Uses of Coal in Steel Industry

Coal is a crucial raw material in the steel industry. It is used as a fuel and a reducing agent in the production of steel. The process of making steel involves reducing iron ore into metallic iron, which is then converted into steel. Coal is used in multiple stages of this process, including coking, sintering, and ironmaking.

Coking coal is used in the production of coke, which is a fuel and a reducing agent. Coke is made by heating coal at high temperatures in the absence of air. The resulting coke is a hard, porous material that is used in blast furnaces to produce iron. The coke is added to the blast furnace along with iron ore and limestone. The heat generated by burning coke reduces the iron ore to metallic iron, while the limestone helps remove impurities.

Sintering is another process used in the steel industry, which involves heating a mixture of iron ore fines, coke fines, and fluxes. The resulting sinter is a porous material that is used as a feedstock in blast furnaces. Coke is an important component in the sintering process, as it provides the necessary heat to agglomerate the iron ore fines.

In the ironmaking process, coal is used as a reducing agent to remove oxygen from the iron ore. This process is known as direct reduction. Coal is injected into the ironmaking furnace along with iron ore and fluxes. The heat generated by burning the coal reduces the iron ore to metallic iron. The resulting iron is then used to make steel. Apart from the direct use of coal in the steelmaking process, it is also used in other ancillary processes. Coal is used in the production of electricity, which is used to power the steel mills. Additionally, coal is used in the production of coke oven gas, which is used as a fuel in the mills.

The use of coal in the steel industry has several advantages. Firstly, coal is abundant and relatively cheap compared to other fuels. Secondly, the use of coal as a reducing agent in ironmaking allows for the production of high-quality steel. Thirdly, the use of coal in the steel industry creates jobs and economic opportunities in regions where coal is abundant. However, the use of coal in the steel industry also has some environmental drawbacks. The burning of coal in the steel mills results in the emission of greenhouse gases, which contribute to climate change. Additionally, coal mining and

transportation have a significant impact on the environment, including the destruction of natural habitats and the release of pollutants.

In conclusion, coal is a crucial raw material in the steel industry. It is used as a fuel and a reducing agent in the production of steel. The use of coal in the steel industry has several advantages, including its abundance and relatively low cost. However, the use of coal also has some environmental drawbacks, and efforts are underway to develop cleaner and more sustainable alternatives to coal in the steel industry.

3.7.3 Uses of Coal in Chemical Industry

Coal is used as a feedstock to produce a variety of chemicals, including ammonia, methanol, and ethylene, among others. These chemicals are used in a wide range of industries, including agriculture, pharmaceuticals, and plastics.

One of the most important chemicals produced from coal is ammonia. Ammonia is a key component in the production of fertilizers, which are essential for modern agriculture. The production of ammonia involves the reaction of nitrogen and hydrogen, which are obtained from the air and natural gas, respectively, with the help of a catalyst. Coal can also be used as a source of hydrogen, which can be obtained through a process called gasification. Gasification involves the reaction of coal with oxygen and steam to produce a mixture of gases, including hydrogen and carbon monoxide, which can be separated and used for various purposes.

Methanol is another important chemical produced from coal. Methanol is used as a feedstock to produce formaldehyde, which is used in the production of plastics, resins, and coatings. Methanol can be produced from coal through a process called gasification, which involves the reaction of coal with oxygen and steam to produce a mixture of gases, including carbon monoxide and hydrogen, which can be converted into methanol.

Ethylene is another important chemical produced from coal. Ethylene is used as a feedstock for the production of a variety of plastics, including polyethylene, which is the most widely used plastic in the world. Ethylene can be produced from coal through a process called cracking, which involves the breaking of larger hydrocarbon molecules into smaller ones. Coal-derived ethylene is typically produced in regions where natural gas, which is the primary feedstock for ethylene production, is not readily available.

In addition to ammonia, methanol, and ethylene, coal can also be used as a feedstock for the production of a variety of other chemicals, including benzene, toluene, and xylenes, which are used in the production of a variety of products, including plastics, pharmaceuticals, and synthetic fibers.

However, the use of coal as a feedstock for the chemical industry has come under scrutiny due to concerns about the environmental impact of coal mining and processing. The production of chemicals from coal typically involves significant greenhouse gas emissions, as well as other environmental impacts such as water pollution and land use change. As a result, efforts are being made to develop alternative feedstocks for the chemical industry that are more sustainable and environmentally friendly.

3.8 COAL TRANSPORTATION AND LOGISTICS

Coal transportation and logistics play a critical role in the supply chain of coal from production sites to power plants and other industries. The transportation of coal involves moving large quantities of coal over long distances, often across different modes of transport, including trucks, trains, barges, and ships.

One of the primary challenges of coal transportation is the need to move large quantities of coal quickly and efficiently. This requires an efficient logistics system that can coordinate the movement of coal across different modes of transport and minimize the time and cost of transportation. Another challenge is the environmental impact of coal transportation, which can result in emissions of greenhouse gases, air pollutants, and water pollution. To address these issues, many coal transportation companies are investing in technologies and practices to reduce their environmental impact, such as using cleaner fuels, reducing emissions from vehicles, and improving the efficiency of transport operations.

The transportation and logistics of coal are critical to the functioning of the coal industry and the wider economy. As the demand for coal continues to grow, the industry will need to continue to invest in efficient and sustainable transportation systems to ensure a reliable and affordable supply of coal to meet the needs of power plants and other industries

3.9 COAL QUALITY AND CLASSIFICATION

Coal quality refers to the physical and chemical properties of coal that affect its value and suitability for different applications. Coal quality is determined by a variety of factors, including the type of coal, its age, and the conditions under which it was formed. Coal classification is a way of categorizing coal based on its physical and chemical properties.

The most common classification system for coal is based on its rank, which is determined by the amount of heat and pressure that the coal has been subjected to over time. The four main ranks of coal, in order of increasing rank, are lignite, sub-bituminous, bituminous, and anthracite.

Lignite is the lowest rank of coal, with the lowest heating value and the highest moisture content. It is typically brown or black in color and is used primarily for power generation.

Sub-bituminous coal has a higher heating value than lignite but a lower heating value than bituminous coal. It is typically black in color and is used for power generation and industrial applications.

Bituminous coal is the most common type of coal and has a higher heating value than sub-bituminous coal. It is typically black in color and is used for power generation, steel production, and other industrial applications.

Anthracite coal is the highest rank of coal and has the highest heating value. It is typically black in color and is used for residential and industrial heating, as well as for steel production.

In addition to rank, coal is also classified based on its sulphur content, ash content, and volatile matter content. Low-sulphur coal is preferred for power generation and industrial applications, as it produces less pollution when burned. Low-ash coal is preferred for industrial applications, as it produces less waste and reduces the need for ash disposal. High-volatile matter coal is preferred for industrial applications, as it produces more heat and reduces the need for additional fuel.

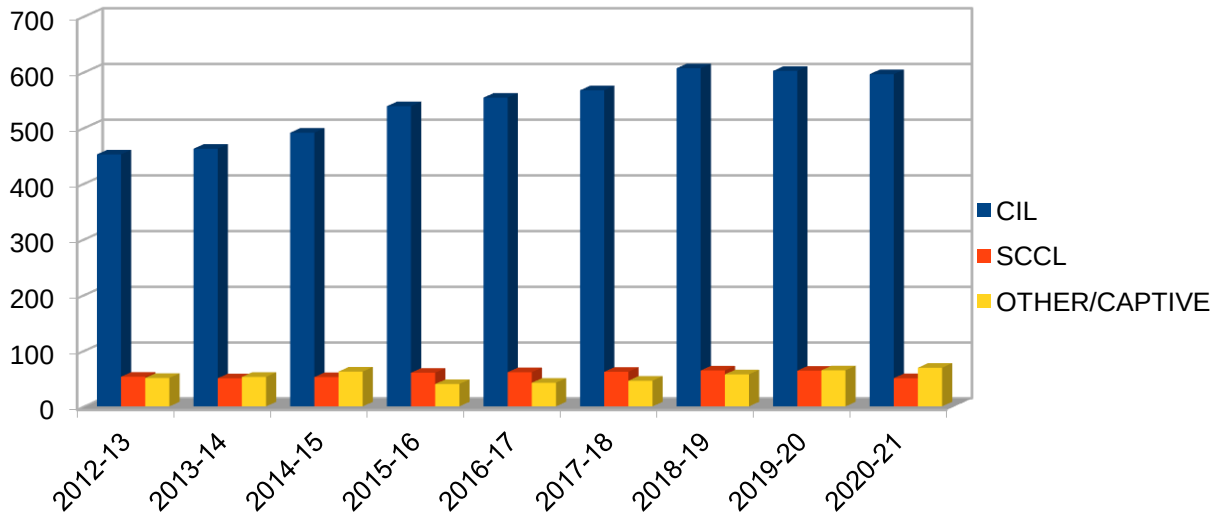
The quality and classification of coal are important factors that affect its value and suitability for different applications. By understanding the physical and chemical properties of coal, industries can choose the right type of coal for their specific needs and optimize their operations for efficiency and cost-effectiveness.

CHAPTER 4

ANALYSIS AND INTERPRETATION

Table 1 COMPANY WISE PRODUCTION OF RAW COAL DURING LAST TEN YEARS

YEAR	COMPANY			Million tonnes
	CIL	SCCL	OTHER/CAPTIVE	TOTAL
2012-13	452.20	53.19	51.01	556.40
2013-14	462.41	50.47	52.88	565.77
2014-15	491.23	52.54	62.41	609.18
2015-16	538.75	60.38	40.09	639.23
2016-17	554.14	61.34	42.39	657.87
2017-18	567.37	62.01	46.03	675.40
2018-19	606.89	64.4	57.43	728.72
2019-20	602.13	64.04	64.7	730.87
2020-21	596.22	50.58	69.29	716.08
CAGR (%)	3.12%	-0.22%	3.42%	2.85%



Source of data : Ministry of Coal

From the above figure,

- CIL has a dominant position in terms of production of coal compared to SCCL and other companies.
- There is a noticeable increase in production in the year 2018-19 that may be due to economic factors.
- The CAGR of company CIL is 3.12% whereas for SCCL it is -0.22%.
- The reasons why CIL shows a positive trend in the production of raw coal from 2012-2021 are as follows:

- Despite the trend towards renewable energy sources, demand for coal remains high in India and other emerging countries. As a result, CIL has been able to sustain and even boost production levels to satisfy rising demand.
- Expansion: CIL has undertaken a number of expansion projects, including the construction of new mines, the acquisition of mining firms, and investments in technology and equipment, all of which have resulted in a rise in production.
- Government backing: CIL is a state-owned corporation that receives government backing in India. The government has provided incentives to the corporation, including as tax breaks, allowing CIL to invest in its operations and expand output.

- SSCL has the least CAGR which denotes that there is no considerable increase in growth of production from the year 2012 to 2021 .

This may be due to the following reasons:

- Decrease in Demand: One of the primary reasons for the decline in coal production is the decrease in demand for coal due to the increased adoption of renewable energy sources like solar and wind power. As a result, the demand for coal has reduced, leading to a decrease in production.

- Environmental Concerns: The coal mining industry is associated with environmental concerns, such as air and water pollution, deforestation, and the emission of greenhouse gases. To combat these issues, many governments are imposing stricter regulations, which can lead to a decrease in production.

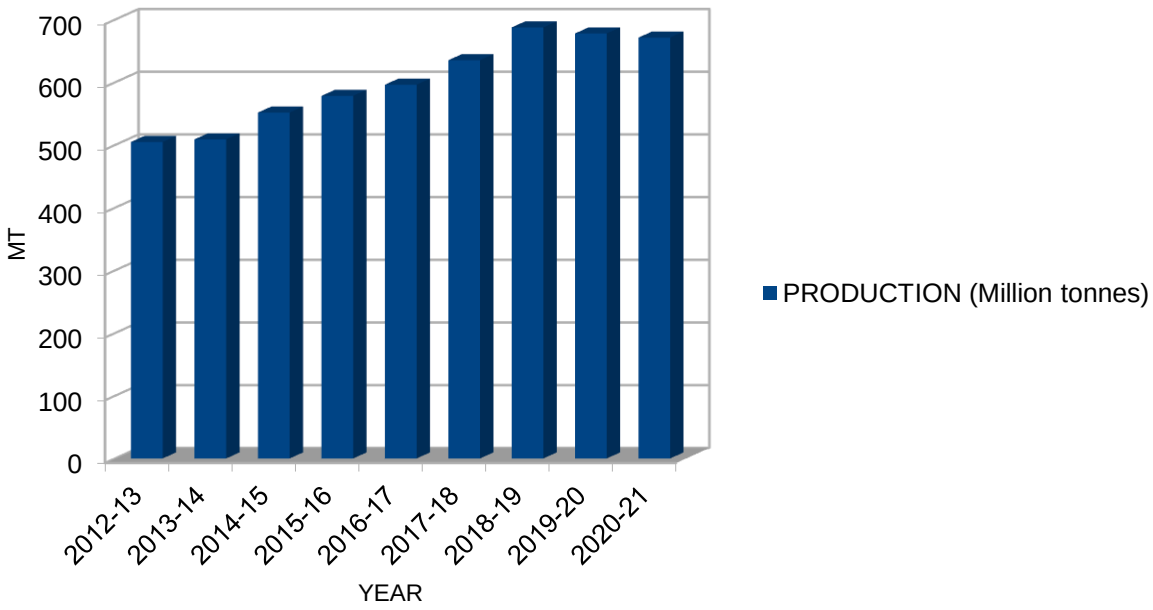
- Labor Issues: Labor disputes and strikes in the mining industry can impact production levels. These issues can be caused by wage disputes, poor working conditions, or disagreements between management and workers.

- Infrastructure Issues: The infrastructure required for coal mining, such as transportation and equipment, can deteriorate over time, leading to decreased production levels.

- The total production of raw coal from CIL, SSCL, and other companies altogether shows a CAGR of 2.85%

Table 2 PRODUCTION OF NON COKING COAL DURING LAST TEN YEARS

YEAR	PRODUCTION (Million tonnes)
2012-13	504.82
2013-14	508.947
2014-15	551.733
2015-16	578.343
2016-17	596.207
2017-18	635.252
2018-19	687.586
2019-20	677.938
2020-21	671.296
CAGR(%)	2.90%



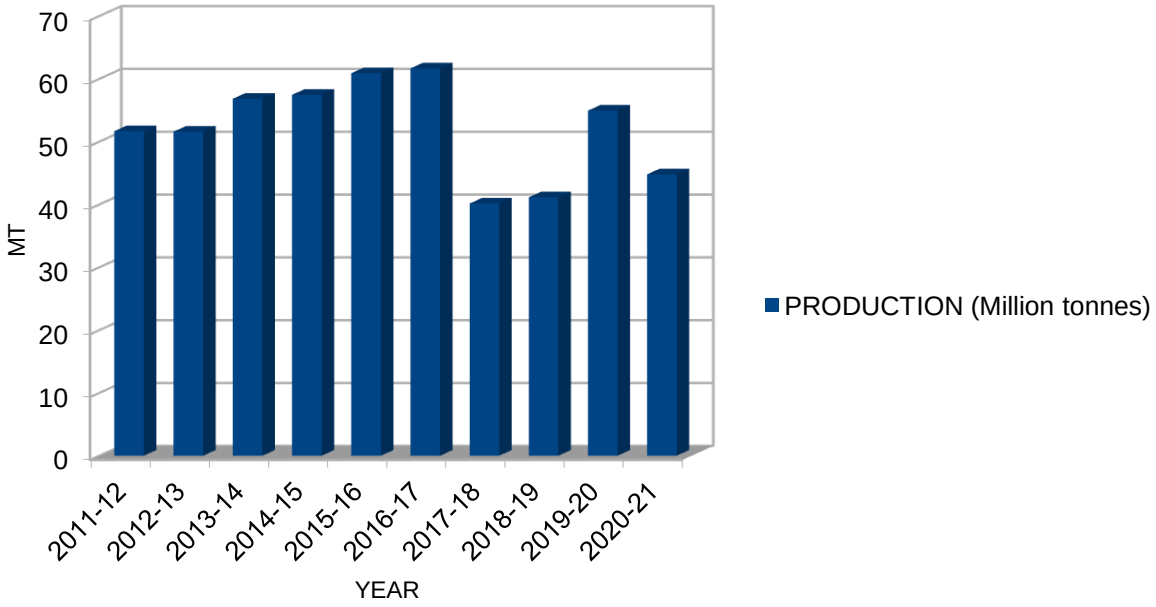
Source of data:Ministry of Coal

From the above figure,

- There has been a CAGR of 2.9% from year 2012-21.
- Production of non-coking coal has been steadily increasing for 7 years from 2012-19, mainly due to the following reasons:
  - Improvements in Technology and Infrastructure: India has made investments in the construction of new mines, the use of modern technologies, and the enhancement of coal mining infrastructure, such as transportation and equipment. These advancements have boosted the efficiency of non-coking coal mining and production, resulting in higher output.
  - Increase in foreign investment: India has also attracted international investment in the coal mining sector, which has resulted in the introduction of new technologies and enhanced operational efficiency.
- Reduction in production of non coking coal from year 2019-21 maybe due to the Covid-19 that affected world wide. Reasons for this are as follows:
  - COVID-19 Pandemic: The COVID-19 pandemic impacted the coal mining industry globally, and India was no exception. The lockdowns and restrictions imposed to contain the virus's spread disrupted mining operations, supply chains, and logistics, leading to a decrease in production.
  - Decrease in Demand: The pandemic and subsequent economic slowdown led to a decrease in demand for non-coking coal in India.
  - Environmental Concerns: To address environmental concerns related with coal mining, such as air and water pollution, deforestation, and greenhouse gas emissions, the Indian government has implemented stronger laws. These regulations have had an influence on the coal mining industry, resulting in a decline in output.
  - Coal Shortage: India faced a coal shortage in 2020 as a result of a number of causes, including disruptions in mining operations, logistics, and transportation. This scarcity reduced the output of non-coking coal.

Table 3PRODUCTION OF COKING COAL DURING LAST TEN YEAR

YEAR	PRODUCTION (Million tonnes)
2011-12	51.66
2012-13	51.582
2013-14	56.818
2014-15	57.446
2015-16	60.887
2016-17	61.661
2017-18	40.148
2018-19	41.132
2019-20	54.936
2020-21	44.787
CAGR(%)	-1.47%



Source of data : Ministry of Coal

From the above figure,

- Even though there has been a steady increase in production of coking coal from 2011-17, there has been an immense drop in year 2017-18
- The CAGR of 10 years is negative for coking coal production as stands at -1.47% due to the below mentioned reasons:
  - Transition to renewable energy: There has been an increasing global trend towards renewable energy sources in recent years. As renewable energy becomes a more appealing and realistic option, demand for coal, notably coking coal, has decreased.
  - Natural gas competition: In many regions of the world, natural gas is becoming a preferred alternative to coal. Natural gas is frequently less expensive and emits less pollutants than coal, making it an appealing option for energy production.

Table 4 YEAR WISE IMPORT OF COKING COAL TO INDIA DURING LAST TEN YEARS

Year:	Coking Coal		
	Qty.	Value(Rs)	Value($)
2012-13	35.557	378398.09	694227
2013-14	36.872	348318.65	5744.41
2014-15	43.715	337655.59	5522.77
2015-16	44.561	282519.09	4329.92
2016-17	41.644	412300.61	6138.37
2017-18	47 003	595226.36	9231.96
2018-19	51.838	720497.64	10341.90
2019-20	51.833	612668.32	8592.55
2020-21	51.198	453552.10	6125.98
2021-22	57.161	1029958.47	13786.02
CAGR (%)	5.00%	10.53%	-32.42%

From the table,

- There is a drastic increase in the import of coking coal from 2012-2022 which shows a CAGR of 5% for the 10 years.
- 2016-17 shows a decrease in import of coal unlike all other years
- The import of coking coal in terms of value (Rs) has increased steadily over the last ten years which makes a CAGR of 10.53%
- The import in terms of value ($) have steep down from 2012-2022 due to the fluctuation in exchange rate

Table 5 YEAR WISE IMPORT OFNON COKING COAL TO INDIA DURING LAST TEN YEARS

Year:	Non Coking Coal		
	Qty.	Value!Rs)	Value($)
2012-13	110.228	490056.94	9009.19
2013-14	129.985	574973.16	9536.52
2014-15	168.388	707585.71	11559.46
2015-16	159.388	577818.53	8836.58
2016-17	149.365	590772.69	8809.64
2017-18	161.245	789543.41	12247.55
2018-19	183.510	938707.26	14 171.33
2019-20	196.704	914652..23	12794.73
2020-21	164 054	706688.44	9539.41
2021-22	151.773	1257459.99	16837.79
CAGR (%)	3.22%	9.88%	6.45%

From the table,

- The import of non-coking coal has increased from 2012 to 2016 followed by a decrease in 2016-17 and then a gradual increase till 2020,which further decreased till 2022.
- However, the CAGR of coal import in terms of quantity over past ten years remains positive ie 3.22%
- The value wise (in Rs) import of non-coking coal shows a CAGR of 9.88%
- The value wise (in $) import of non-coking coal shows a CAGR of 6.45%

Table 6 YEAR WISE IMPORT OF TOTAL COAL TO INDIA DURING LAST TEN YEARS

Year:	Total Coal		
	Qty.	Value(Rs)	Value($)
2012-13	145.785	868455.02	15951.46
2013-14	166.857	923291.81	15280.93
2014-15	212.103	1045241.30	1708223
2015-16	203.949	860337.62	13166.50
2016-17	191.009	1003073.30	14948.01
2017-18	208.249	1384769.77	21479.51
2018-19	235.348	1709204.90	2451322
2019-20	248.537	1527320.55	2138728
2020-21	215.251	1160240.54	15665.39
2021-22	208.934	2287418.46	30623.81
CAGR (%)	3.67%	10.17%	6.74%

From the table,

- There was a huge increase in the import of coal in 2018-19 . This was beacause the domestic coal production in India has not been able to keep up with this demand and restriction imposed on consumption of petroleum coke.
- The total import of coal over past 10 years shows a CAGR of 3.67%
- The value wise (in Rs) import of coal shows a CAGR of 10.17%
- The value wise (in $) import of coal shows a CAGR of 6.74%
- Reduction in production of non coking coal from year 2019-21 maybe due to the Covid-19 that affected world wide

Table 7 YEAR WISE IMPORT OF COKE AND COAL PRODUCTS TO INDIA DURING LAST TEN YEARS

Year:	Coke & Coal Products		
	Qty.	Value(Rs)	Value($)
2012-13	3.081	56918.82	1044.23
2013-14	4.171	67994.89	1122.14
2014-15	3.294	43806.15	720.05
2015-16	3.072	32683.54	500.87
2016-17	4.356	54019.35	005.55
2017-18	4.585	91524.74	1419.92
2018-19	4.931	120644.85	1730.61
2019-20	2.875	60256.67	844.61
2020-21	2.457	44688.59	003.62
2021-22	2.481	80519.14	1076.97
CAGR (%)	-3.97%	3.53%	0.30%

From the table,

- The import of coke and other coal products initially show an increase from 2012 to 2014, decreased from 2014 to 2016 again increased from 2016 till 2019 and then suddenly declined for the rest years.
- The import in terms of quantity show a negative growth with a CAGR of -3.97%
- The value wise (in Rs) import shows a CAGR of 3.53%
- The value wise (in $) import shows a CAGR of 0.30%

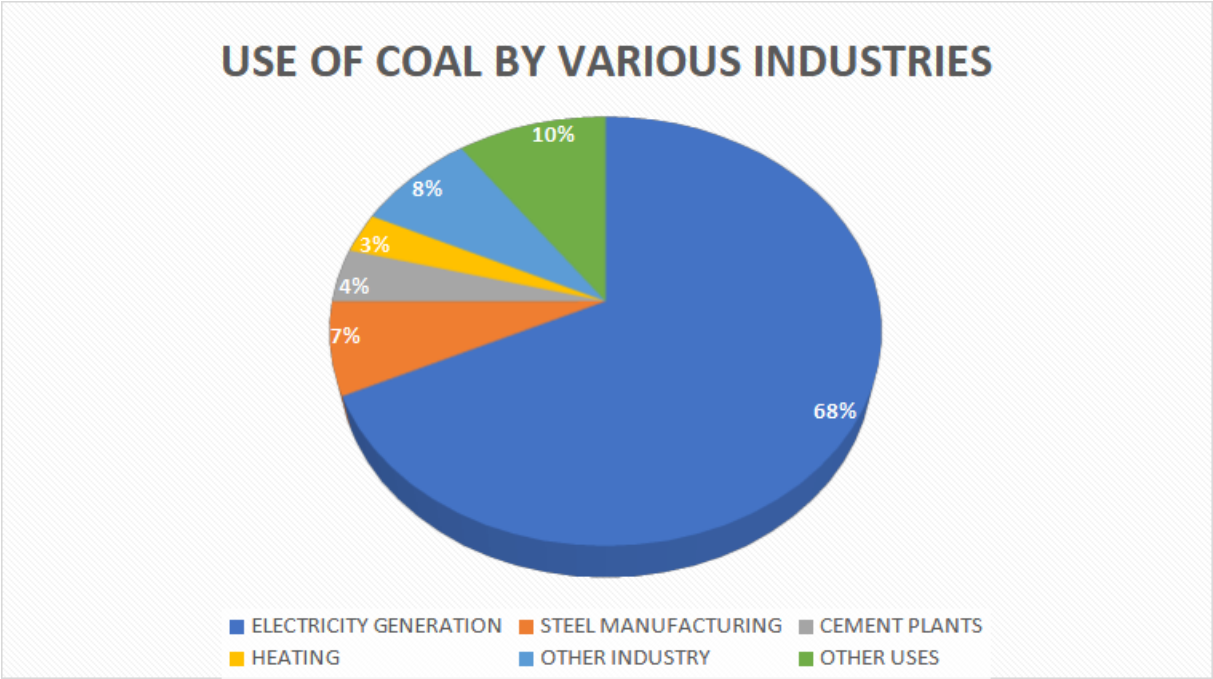


Table 8 COAL USE BY VARIOUS INDUSTRIES

VARIOUS INDUSTRIES	PERCENTAGE
ELECTRICITY GENERATION	68
STEEL MANUFACTURING	7
CEMENT PLANTS	4
HEATING	3
OTHER INDUSTRY	8
OTHER USES	10

From the figure,

- Coal is mainly used for electricity generation at 68% whereas only 3% is used for the purpose of heating.
- Steel manufacturing and cement plants use 11% combined coal.

CHAPTER-5

FINDINGS, SUGGESTION AND CONCLUSION

5.1 FINDINGS

- CIL has a dominant position in terms of production of coal compared to SCCL and other companies.
- There is a noticeable increase in production in the year 2018-19 that may be due to economic factors.
- The CAGR of company CIL is 3.12% whereas for SCCL it is -0.22%

- The total production of raw coal from CIL, SSCL, and other companies altogether shows a CAGR of 2.85
- There has been a CAGR of 2.9% from year 2012-21.
- Production of non-coking coal has been steadily increasing for 7 years from 2012-19
- Even though there has been a steady increase in production of coking coal from 2011-17, there has been an immense drop in year 2017-18
- The CAGR of 10 years is negative for coking coal production as stands at -1.47%
- There is a drastic increase in the import of coking coal from 2012-2022 which shows a CAGR of 5% for the 10 years.
- 2016-17 shows a decrease in import of coal unlike all other years
- The import of coking coal in terms of value (Rs) has increased steadily over the last ten years which makes a CAGR of 10.53%
- The import in terms of value ($) have steep down from 2012-2022 due to the fluctuation in exchange rate
- The import of non coking coal has increased from 2012 to 2016 followed by a decrease in 2016-17 and then a gradual increase till 2020,which further decreased till 2022.
- However the CAGR of coal import in terms of quantity over past ten years remains positive ie 3.22%
- The value wise(in Rs) import of non coking coal shows a CAGR of 9.88%
- The value wise (in $) import of non coking coal shows a CAGR of 6.45%
- There was a huge increase in the import of coal in 2018-19 . This was beacause the domestic coal production in India has not been able to keep up with this demand and restriction imposed on consumption of petroleum coke.
- The total import of coal over past 10 years shows a CAGR of 3.67%
- The value wise (in Rs) import of coal shows a CAGR of 10.17%
- The value wise (in $) import of coal shows a CAGR of 6.74%

- Reduction in production of non coking coal from year 2019-21 maybe due to the Covid-19 that affected world wide
- The import of coke and other coal products initially show an increase from 2012 to 2014, decreased from 2014 to 2016 again increased from 2016 till 2019 and then suddenly declined for the rest years.
- The import in terms of quantity show a negative growth with a CAGR of -3.97%
- The value wise (in Rs)import shows a CAGR of 3.53%
- The value wise (in $) import shows a CAGR of 0.30%

5.2 SUGGESTION

- India should think about diversifying its energy mix by lowering its reliance on coal and encouraging the growth of renewable energy sources including solar, wind, and hydroelectric power.
- Implementing and enforcing rigorous environmental rules on coal mining, transportation, and power generation can drastically cut demand for coal.
- Encourage sustainable mining practices by using contemporary mining technology, encouraging mine reclamation and land restoration, and putting coal miners' health and safety first.
- Exploring and developing new coal fields can assist improve output while decreasing reliance on existing coal fields.
- Mechanisation of coal mining operations can assist boost output and efficiency.
- Developing indigenous coal deposits and expanding output through initiatives such as modernization, mechanisation, and infrastructural improvement can assist minimise the demand for coal imports.
- Implementing emissions guidelines for coal-fired power plants can help reduce air pollution and improve air quality, lowering demand for coal.

5.3 CONCLUSION

India's coal import and production present a complex challenge that requires a delicate balance between meeting the energy demands of various industries and transitioning towards a more sustainable and cleaner energy future. As one of the world's largest consumers and producers of coal,

India faces significant environmental, economic, and social implications in its pursuit of energy security.

While coal has played a vital role in powering India's economic growth and meeting its energy needs, there is a growing recognition of the need to reduce its reliance on this fossil fuel. India's import of coal can help bridge the demand-supply gap and cater to the requirements of industries that heavily rely on this resource. However, it is essential to critically assess the necessity of coal imports and explore alternative energy sources to promote a sustainable and low-carbon economy.

One crucial aspect of India's energy transition is the diversification of its energy mix. By promoting renewable energy sources such as solar, wind, and hydroelectric power, India can decrease its dependence on coal. Investing in the development and deployment of these technologies can not only contribute to reducing greenhouse gas emissions but also foster job creation and energy independence. Additionally, improving energy efficiency across various sectors can significantly decrease the overall demand for coal and optimize resource utilization.

In parallel, the adoption of clean coal technologies can mitigate the environmental impact of coal-based power generation. Technologies such as supercritical and ultra-supercritical coal-fired power plants offer higher efficiency and lower emissions compared to conventional coal plants. Furthermore, investment in research and development efforts focused on clean coal technologies, including carbon capture, utilization, and storage (CCUS), can play a pivotal role in reducing the carbon footprint associated with coal use.

Strengthening environmental regulations is of utmost importance to ensure responsible coal production and utilization. Implementing and strictly enforcing stringent environmental standards and emission norms can help minimize air and water pollution, mitigate land degradation, and protect the health and well-being of local communities. Additionally, sustainable mining practices, including modern techniques, mine reclamation, and worker safety measures, should be prioritized to minimize the environmental impact of coal extraction and ensure the welfare of coal miners. Assessing the import requirements of coal is crucial for India's energy planning. A comprehensive analysis of domestic coal production capabilities, projected demand, and cost-effectiveness can help determine the necessity of coal imports. Additionally, diversifying import sources and exploring options for strategic partnerships with countries rich in cleaner coal reserves can contribute to reducing the environmental impact associated with long-distance coal transportation.

India's commitment to international collaboration and knowledge-sharing is instrumental in addressing the challenges related to coal import and production. Engaging with other countries, organizations, and forums can provide valuable insights, best practices, and technological advancements that facilitate the transition to a sustainable energy future. Learning from the experiences of countries that have successfully reduced coal dependence can inform India's policies and strategies for a smoother transition.In conclusion, India stands at a critical juncture in shaping its energy landscape. Balancing the import and production of coal requires a comprehensive approach that considers the requirements of various industries, environmental sustainability, and the well-being of its people. By embracing renewable energy sources, investing in clean coal technologies, strengthening environmental regulations, and promoting sustainable mining practices, India can pave the way for a sustainable, low-carbon future that ensures energy security, mitigates climate change, and improves the quality of life for its citizens.

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