International Journal of Engineering Technology and ManagementSciences
Website: ijetms.in Issue: 3 Volume No.6 May – 2022
DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

Comparative Analysis of Coal, Fuel oil and Natural gas for Cement Production

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Abstract— This study is a comparative analysis of the use of coal, fuel oil and natural gas cement production that marks their physical and chemical properties, costs and availability, impact on the environment and human health. In seven cents manufacturing industries in Nigeria. Based on the research analysis, it appears that between these Three (3) oil, petroleum is currently expensive even though it is available, while coal once natural gas is cheap, but coal is not available due to the closure of Nigerian coal mine. In terms of environment and health, coal oil and petrol pose a significant risk gas in the environment also cause additional health problems to cover the employee however natural gas slowly releases these harmful gases into the environment and causes little health problems for employees. Research therefore shows that natural gas is at the forefront gasoline because it is cheaper, more easily available and creates fewer problems nature.

***Keywords*—** **Coal, Fuel oil, Natural gas, Cement, Crude oil.**

I. INTRODUCTION

1.1 BACKGROUND OF STUDY

The ability to do work or produce heat is a typical definition of energy. Normally, heat is produced by the combustion of a fuel (i.e., a substance that contains internal energy which upon burning generates heat).

Today's energy system is heavily reliant on fossil fuels, with coal, oil, and natural gas accounting for around 80% of global primary energy demand. Fuels are the primary source of energy for most sectors, including the cement industry. However, the energy source chosen must fulfil the diverse needs of many countries while also enhancing each country's protection against previous energy crises. The selection/choice of fuel type depends on various factors such as environmental pollution, ease in processing, storage and handling, availability, and cost of the fuel. Coal, fuel oil and natural gas are the most used energy carrier in cement industries.

The following is a breakdown of the energy used in cement production: -

- 92.7% for pyro-processing
- 5.4% for finishing grinding and
- 1.9% for raw grinding

The amount of greenhouse gases (GHG) emitted, the cost of cement, and the quality of the cement produced all influence the fuel choice. This research work will help in selecting the best fuel and techniques to be used to attain a high-quality product at a lower cost with lesser green house gas emission to the environment.

1.2 STATEMENT OF PROBLEM

In cement manufacture, a comparison of coal, fuel oil, and natural gas is used to determine the best fuel. The following issue emerges while comparing various fuels: -

- Understanding of coal, fuel oil, and natural gas physiochemical characteristics.

DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

• Understanding of the greenhouse gases (GHG) emitted by each of these fuels, as well as their levels of emission and consequences on the environment and human health (esp. Cement workers).
• Knowledge of coal, fuel oil, and natural gas prices and availability.

1.3 AIMS AND OBJECTIVES OF STUDY

The aims of this research work is to:-
• Learn about the physical and chemical properties of coal, oil, and natural gas.
• Learn about the greenhouse gases (GHG) released, their impact on the environment and human health, and the amount of GHG released by each fuel.
• Study coal, fuel oil and natural gas in relation to cost and availability.

1.4 SIGNIFICANCE OF THE STUDY

With today's rapid industrialization, this research will benefit the cement industry, its employees, the environment, and society. For cement manufacture, it will use a cost-effective and less dangerous fuel and processes. It will also aid in the selection of techniques/fuels that will reduce greenhouse gas (GHG) emissions from the cement industry to the environment. These pollutants generate acid rain, smog, and other conditions that can cause cancer in humans and destroy plant life. In terms of infrastructure development, a cost-effective fuel for production will lower

the cost of cement, stimulating the construction of buildings and the government's development of roads, bridges, and other construction-related projects. This research will also provide students in chemical engineering and other related fields with an understanding of these fuels, including their various environmental implications, characteristics, and fuel selection when combustion is required.

1.5 SCOPE AND LIMITATION

The goal of the research is to look at the costs, storage and handling, availability, product quality, and environmental impact of coal, fuel oil, and natural gas in cement manufacture.

II. LITERATURE REVIEW

2.1 ENERGY SOURCE

Fuels are the world's most essential energy source. Fuel accounts for over 80% of total energy use. (Kul, 2001). For industry, fuels are the primary source of energy. Coal, fuel oil, and natural gas are all referred to as fossil fuels. Coal and natural gas are used in their natural state, while petroleum must be refined and distilled before it can be used.

2.1.0 Coal

Coal is the most common fossil fuel on the earth, with a global recoverable reserve estimated to be 216 years. Coal provides 26% of global primary energy needs and generates 41% of the world’s electrification. For the year 2030, coal is expected to generate 38% of global electricity. (World coal institute report, 2005) Countries heavily dependent on coal for electric generation includes; China (78%), Israel (71%), Morocco (69%), USA (50%), South Africa (93%), Australia (80%) and Poland (93%). Coal is mostly organic in origin and is created by the partial breakdown of vegetable matter. It is a complex organic natural product that has evolved over millions of years from precursor components. Coal is thought to have formed in the absence of oxygen over geological time, favouring the production of a highly carbonaceous product by the loss of oxygen and hydrogen from the initial compounds. Coal is a dark, flammable material made from plants that grow mostly in wetland areas through a process known as coalification. 2003 (World Coal Institute).In these damp conditions, layers of fallen plant material collected and partially decomposed to form peat, a spongy, gritty substance. This substance was compacted over time by sand and mud, then heated by the earth to become coal. Coal is classified as sedimentary rock by some geologists. Carbon, hydrogen, oxygen, and nitrogen are the main components of coal.

DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

Types of Coal

The degree of change a coal undergoes as it matures from peat to anthracite – known as coalification – has a significant impact on the coal's physical and chemical qualities and is referred to as the coal's rank.

1. Low-rank coals, such as lignite and sub-bituminous coals, are softer, more friable, and have a drab, earthy appearance. They have a low energy content due to their high moisture content and low carbon content.

2. Higher-rank coals are typically harder and stronger, with a black, glossy shine. They are higher in carbon, lower in moisture, and produce more energy.

Coal Classification

Coal is divided into numerous categories based on the amount of carbon it contains and its heating value. The heating value of coal is expressed in British Thermal Unit per pound (BTU/Ib) or Joules per kilogram (J/kg).

Coal is classified into three major types namely: -

1. Anthracite is the earliest coal in terms of geology. It's a hard coal made mostly of carbon with very little volatile matter and very little moisture. With a heating value of 13,600 BTUs (31,634.96 J/kg), it is the hardest and most expensive coal. It is composed of 92-95% carbon.

2. Bituminous coal is the most developed and common type of coal. It comprises roughly 85% carbon and has a thermal value of approximately 11,250–14,350BTUs (26,168.6–33,379.54 J/kg). Subbituminous coal contains around 78% carbon and has a heating value of 9,300 BTUs (21,632.73J/kg).

3. Lignite is the youngest coal from geological perspective. It is a soft coal with a high volatile matter and moisture content and a low fixed carbon content (70% carbon). It produces around 7,000 BTUs (16,282.7 J/kg) of heat.

There is no clear difference between them, thus coal is classed as semi-anthracite, semi-bituminous, and sub-bituminous.

TYPES OF NIGERIAN COAL DEPOSITS

Nigerian coal deposits are of three types.

- Bituminous
- Sub-bituminous
- Lignite

Low sulphur, ash, and moisture content are notable qualities, whereas heating values are high. These characteristics make them ideal for fuelling coal-fired power plants, and they have a high potential to contribute considerably to the nation's energy mix. Coal reserves can be found in roughly 15 states in Nigeria. The Anambra basin coal deposit, in the south-east, considered to have the largest and most viable coal resources.Lafia Obi, Inyi (Enugu state), Afrikpo (Ebonyi state), and Gombe are some of the other notable coal deposits (Gombe state).

The following qualities of coal underlie its widespread use and make it an appealing component of many countries' energy mix:

- **Availability**: commercial reserves of coal in different parts of the world means that exploiting indigenous coal resources or importing coal economically are practical options for most countries.
- **Useability**: - coal is relatively easy and safe to handle and store, thereby enhancing its usefulness in mitigating both physical and commercial risks.
- **Affordability**: - coal is a low cost option in most markets, and therefore it can play an important role in supporting economic development in developing countries.

DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

Preparation of Coal

After mining, the coal is frequently subjected to some sort of preparation or physical treatment. The preparation of coal before feeding it into the boiler is critical for good combustion.

Large and irregular coal lumps might lead to the following issues:

1.Low furnace temperature and poor combustion conditions

2. Increased stack loss due to increased excess air.

3. An increase in unburned ash.

4. Inefficient thermal efficiency.

(a) Sizing of Coal

One of the most important aspects of ensuring optimal combustion is proper coal size. Coal sizing that is unique to the type of fire system helps in even burning, lower ash losses, and improved combustion efficiency. Crushing and grinding coal reduces its size. For smaller units, especially those that are stoker fired, pre-crushed coal can be cost effective. Crushing is limited to a top size of 6 or 4mm in a coal handling system.

The devices most used for crushing are:

• The rotary breaker
• The roll crusher and
• The hammer mills.

Screening the coal before to crushing is required to ensure that only large coal is sent to the crusher.

The following are recommended coal crushing practises:

1. Using a screen to separate fines and small particles to avoid additional fine generation during crushing.

2. The use of a magnetic separator to extract iron particles from coal that could damage the crusher.

Table 2.1: Proper size of coal for various types of firing system.

S. No.	Types of Firing System	Size (mm)
1	Hand Firing (a) Natural draft (b) Forced draft	 25-75 25-40
2	Stoker Firing (a) Chain grate i) Natural draft ii) Forced draft (b) Spreader Stoker	 25-40 15-25 15-25
3	Pulverized Fuel Fired	75% below 75 microns
4	Fluidized bed boiler	< 10 mm

(b) Conditioning of Coal

Because of segregation effects, coal fines cause complications in combustion. By conditioning coal with water, particles separation from larger coal pieces can be greatly minimised. Due to the surface tension of water, tiny particles attach to larger lumps, preventing fines from falling through grate bars or being swept away by the furnace blow. When tempering the coal, it's important to make sure that the moisture addition is equal and done in a moving or falling stream of coal. Wetting coal can reduce the proportion of unburned carbon and the surplus air level
required for combustion if the percentage of particles in the coal is very high.

Table 2.2: Extent of Wetting: Fines Vs Surface Moisture in Coal.

S. No.	Fines (%)	Surface Moisture (%)
1.	10 - 15	4 - 5
2.	15 - 20	5 - 6
3.	20 - 25	6 - 7
4.	25 - 30	7 - 8

(c) Blending of Coal

In the situation of excessive fines in coal lots, it is best to blend the mostly lumped coal with the excessive fines containing lots. Coal blending may thus help to keep the number of fines in the coal being burned to less than 25%. Combining different types of coal may also aid in providing a consistent coal feed to the boiler.

Uses of coal

Coal is one of the cheapest and most important sources of fuel responsible for about 41% of electricity production worldwide. Coal is an essential raw material and fuel for important global industries like steel and cement. Different qualities of coal are used for different purposes; example coking coal with higher carbon percentage is used in steel production. Thermal coal is used in creation of electricity.

a) Electricity production:- Coal is mainly used as fuel to generate electricity through the process of combustion. Steam coal known as thermal coal is used in power stations to generate electricity.

b) Steel production:- Steel industry is the second largest user of coal after electricity industry. Coal in an essential raw material along with iron in the production of steel which is one of the useful metal products used by man today.

Coking coal is a solid carbonaceous residue made from bituminous coal with low ash and low sulphur. Metallurgical coke is used as fuel to melt iron in the furnace. This cast iron which is produced is additional refined to make steel.

c) Cement industry:- Coal is used as energy source in the industry. Huge amount of energy is required to produce cement. Kilns usually burn coal in the form of powder and by-product generated from burning coal in coal- fired power plant such as fly ash, bottom ash, boiler slag and flue gas desulphurization gypsum are also used to replace cement in concrete.

d) Paper industry and aluminium:- Both industries require large amount of fuel and energy. The price and availability of coal is an significant factor in the growth of these industries.

e) Chemical and pharma industry:- Several chemical products can be produced from the by-products of coal. Chemicals such as creosote oil, naphthalene, phenol, and benzene are made from refined coal tar. Thousands of items contain coal or coal by-products, including soap, aspirins, solvents, dyes, polymers, and fibres like rayon and nylon.

f) Coal gas and coal liquid s transport fuel:- Current transportation industry does not make much use of coal as fuel. However, the increasing cost of oil gas and liquid which can be used to power vehicles, ships etc.

2.1.1 FUEL OIL

Fuel oil is a portion obtained from petroleum distillation, either as a distillate or a residue. Generally speaking, fuel oil is any liquid petroleum product that is burned in a furnace for the generation of heat or used in an engine for the generation of power. Fuel oil is created of long hydrocarbon chains, particularly alkanes, cycloalkanes, and aromatics. The term fuel oil is used to indicate the hardest commercial fuel that can be obtained from crude oil, heavier than gasoline and naphtha. Fuel oil is categorized into six classes, according to its boiling temperature, composition, and purpose. In terms of industrial use of fuel especially in cement kiln firing, heavy fuel oil or low pour fuel oil (LPFO). The long residue obtained from the air distillation column is known as heavy oil. Heavy fuel oil is primarily used to generate electricity, to power big marine and other vessels, and to fire boilers and furnaces in industry, particularly in the cement, pulp, and paper industries.

2.12 NATURAL GAS

Natural gas is a fossil fuel like oil and coal thus it is essentially the remains of plants, animals and microorganisms that lived millions and millions of years ago. Over the years, natural gas has secured its vital role in every aspect of the world development, particularly its role to replace coal and oil. Due to its different qualities from other types of petroleum, natural gas has been well accepted as the energy for the world of today and tomorrow. Nowadays, the public do not only need the energy for their livings but most of all, they also want a superior choice for environment. Natural gas is a mixture of many hydrocarbons' gas known in scientific names i.e. methane, ethane, propane, and butane. Over 70% of natural gas is produced by methane, the major component. Natural gas is a high calorific value fuel involving no storage facilities. It mixes with air easily and does not produce smoke or dust. It has no sulphur content and is lighter than air and disperses into air easily in case of leak. It is colourless and odourless but due to security reasons, a commercial odorant known as mercaptan is added to allow users to detect the gas.

Industrial Utilization of Natural Gas

Manufacture of pulp and paper, metals, chemicals, stone, clay, glass, and to process certain foods are various fields in which natural gas is effectively consumed. Gas is also used to treat waste materials, for burning, drying, dehumidification, heating and cooling, and CO generation. It is also an appropriate chemical feedstock for the petrochemical industry. Natural gas has a large number of industrial uses, including providing the base ingredients for such varied products as plastic, fertilizer, antifreeze, and fabrics. In fact, industry is the largest consumer of natural gas, reporting for 43% of natural gas use across all sectors. Natural gas is the second most used energy resource in industry, trailing behind only electricity.

Power Generation

Natural gas is more efficient than other fossil fuel power plants and produces less pollutants. Natural gas has become the preferred fuel for new power plants because of economic, environmental, and technological changes.

There are two ways to use natural gas as a vehicle fuel: -

As compressed natural gas (CNG) and

As liquefied natural gas (LNG).

Cars/ vehicles using natural gas are estimated to emit 20% less green house gases than gasoline or diesel cars.

2.2 CEMENT

Cement is the general term given to the powdered material which initially have plastic flow when mixed with water or other liquid but has the property of setting to a hard solid structure in several hours with varying degree of strength and bonding properties Cement production is a capital-intensive activity and requires complex plants that are costly to install and maintain. Cement, a common and essential constituent of mortar and concrete, serves as the most common and widely used building material in the world.

2.2.0 Cement Manufacturing Process

1. Quarry

The majority of plants rely on a local quarry for limestone. The most common combination is limestone (for calcium) plus much smaller quantities of clay and sand (for silica, alum, iron). Other sources such as mill scale, shale, bauxite, and fly ash are brought in from outside sources when necessary.

2. Proportioning, Blending, and Grinding

Raw materials are analysed in the plant laboratory, blended in the proper proportion and then finely ground. Plants grind the raw materials with heavy wheel type rollers that crush these materials into powder against a rotating table. After grinding, the material is now ready for the kiln or pre-heater, depending on plant type.

3. Pre-heating

The pre-heater tower supports a series of vertical cyclone chambers through which the raw materials pass on their way to the kiln. To save energy, modern cement plants pre heat the materials before they enter the kiln Hot exit gases from the kiln rise more than 200 feet, heating the raw materials as they spin through the cyclones.

4. Kiln

Raw materials now enter the huge rotating furnace called a kiln, which is the heart of the cement making process- a horizontally sloped steel cylinder, lined with fire brick, turning from about one to three revolutions per minute. A kiln is often the world's largest moving piece of industrial equipment.. The raw material enters the kiln at the upper end and slides/tumbles down the kiln

Website: ijetms.in Issue: 3 Volume No.6 May – 2022
DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

through progressively hotter zones towards the flame. At the lower end of the kiln, fuels such as powdered coal and natural gas feed a flame that reaches 1870ºC (3400ºF) – one third of the temperature of the earth's surface.
This is the hottest part of the apparatus and the raw materials reach about 2700ºF (1480ºC) and become partially molten.

5. Calcination

Intense heat triggers chemical and physical changes. Expressed at its simplest, these series of chemical reactions convert the calcium and silicon oxides into calcium silicates, cement's primary constituent, through a process known as calcination. The source ingredients appear as a new substance at the lower end of the kiln; red-hot particles known as clinker.

6. Clinker Cooler and Finish Grinding

The clinker falls out onto a grate that is cooled by forced air. The clinker is ready to be processed into the grey powder known as Portland cement once it has cooled.
Re-circulate: to save energy, heat recovered from this cooling process is circulated back through to the kiln or pre-heater tower back through to the kiln or pre-heater tower.

7. Ball-mill and Finish Grinding

A ball mill grinds the clinker (a horizontal steel tube filled with steel balls). The steel balls tumble and crush the clinker as the tube rotates, resulting in a superfine powder known as Portland cement. Because the cement is so thin, it will readily pass through a water-holding filter. To manage the set, a small amount of gypsum is added during the final grinding. Gypsum is a mineral that prevents the powder from hardening once it has been mixed with water and makes it mouldable before use.

8. Bagging and Shipping

Silos: From the grinding mills, the cement is conveyed to storage tower where it shipped. Transportation: Mostly cement is shipped in bulk by trucks, rail, or barges. Bagging: A small percentage of the cement is bagged for customers who need only small amounts or for special uses such as making mortar. Mostly cement is shipped to ready-mixed concrete producers. There it is combined with water, sand, and gravel to make concrete delivered in the familiar trucks with revolving drums. Cement is also used for a wide variety of pre-cast concrete products.

There are four (4) main process paths for the manufacturing of cement namely:-
a) Dry process: **-** The raw materials are ground and dried to raw meal in the form of a flow- able powder. The dry raw meal is fed to the pre-heater or proclaimer kiln or, more rarely, to a long dry kiln.
b) Semi-dry process: **-** Before being fired, dry raw food is filled with water and put into a rate pre-heater or a long kiln with crosses.
c) Semi-wet process: **-** Filter presses are used to dewater the slurry first. For raw meal production, the filter cake is squeezed into chunks and supplied to a grate pre-heater or directly to a filter cake dryer.
d) Wet process: **-** The raw materials (often with high moisture content) are ground in water to form pump-able slurry. The slurry is also fed directly into the kiln or first to slurry drier.
The choice of process is to a large amount determined by the state of the raw materials (dry or wet). Wet processes are more energy consuming, and thus most expensive. Plants that use semidry methods are more likely to switch to dry tools when they need to expand or improve. Plants using wet or semiwet processes normally only have access to moist raw materials. The dry process consumes less energy and runs at a lower cost. Currently, the production technology employed most is the dry process technology.

Factors affecting production quality are:

• The composition of limestone.
• Particle size
• Degree of calcining/ burnability
• Degree of homogeneity.

2.2.1 Major Characteristics of Cement Industry

• **Homogenous Product**:- Because of its homogeneity status, cement is regarded a standard product. All types of cement are considered homogeneous when they are perfect substitutes and consumers perceive no actual or real distinctions between the products produced by different enterprises. In the cement sector, price is the only means of competition; if Company A lowers its price to gain market share, Company B may follow suit to keep its clients.

• **Capital Intensive**:- Because of the high cost of building a cement factory, it is one of the most capital-intensive businesses in the world. Long time periods are thus required before investments can be recovered, and plant adjustments must be carefully planned and take into account the industry's long-term nature. Because of the development of advanced automated technology and continuous material handling devices, the cement industry has a low labour intensity. The cement industry provides 58,000 direct jobs in Europe, however a modern plant typically employs less than 150 workers.

• **High Energy Usage**:- Cement manufacture involves a significant level of fuel use from the beginning to the end. Depending on the cement variety and the procedure employed, each tonne of cement takes 60 to 130 kilogramme of fuel oil or its equivalent, and about 105 KWh of electricity, which equals expensive costs.

• **Heavy Material Input and Output**:- Cement manufacture requires the use of heavy materials such as limestone; transportation of limestone as a significant raw material in cement production is difficult, which is why cement plants are placed near limestone deposits. The completed product, cement, is also very heavy and requires a significant amount of transportation, which affects cement prices.

2.2.2 Energy challenge in the industry

The high cost of cement manufacture is a global phenomenon, due to the massive amounts of energy consumed throughout the manufacturing process. Power (electricity) is necessary to run the equipment, and fuel (LPFO, coal, and natural gas) is required to fire the kilns. Depending on the cement variety and process used, each tonne of cement requires 60-130kg of fuel oil or its equivalent, as well as roughly 105kwh of energy.

Cement producers in Nigeria continue to have difficulties with energy supply. Manufacturers' annual power demand is projected to be 25000/30000 MW, however the Power Holding Corporation of Nigeria (PHCN) only generates about one-tenth of this need. During the first half of 2008, irregularities in energy supplies slowed production and resulted in the loss of production days in some cement factories. Manufacturers must generate alternative power to maintain or enhance manufacturing output, raising production costs, and reducing profitability. The cost of sales to turnover ratio is 60 percent on a five-year average basis (up from 80-90 percent in the early 2000s), owing primarily to technical advancements. (AIS Research, Annual Reports of Corporations) Moreover, cement producers confront two challenges: rising fuel prices and supply limitations.

Diesel and LPFO prices have risen by more than 100 percent in the previous three years, while terrorist activity in Nigeria's oil-rich Niger Delta region continues to stymie natural gas delivery. As a result, numerous manufacturing plants have seen their production output and profitability collapse. Cement businesses are addressing this issue in a variety of ways. For example, as a cheaper and more reliable alternative to limited fuel oil (LPFO), AshakaCem shifted to coal as a fuel source and initiated a coal-mining activity. This is projected to lower its overall energy expenditures and ensure long-term supply. It also began refurbishing roller presses to reduce cement grinding power consumption and improve cement mill efficiency. Lafarge WAPCO is also installing gas-fired power plants to reduce energy costs and ensure power availability to its facilities. Natural gas is one of the more efficient energy sources for Nigerian cement manufacture, despite its inconsistent availability.

2.2.3 Demand for cement

The task of estimating cement demand is difficult. The ideal method is to estimate demand based on actual consumption. The demand for cement is driven by construction activity powered by an economy's growth and development, as well as government, corporate, and private developers' continuing investment in the creation of both residential and commercial estates. Cement usage in Nigeria has recently increased significantly. Nigeria is a developing country with potential for growth in a variety of economic and social sectors. With the acceleration of rural–urban migration, urbanization process has become a serious concern. The situation has put further on already stressed social infrastructure, such as roads, housing, and other social overhead capital. As a result, cement is in high demand.

Website: ijetms.in Issue: 3 Volume No.6 May – 2022
DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

In terms of infrastructure development, the government is currently collaborating with the private sector to build roads, bridges, flyovers, and other construction-related projects. Cement consumption is increasing because of these projects.

2.2.4 Emissions from cement manufacturing

In terms of the key environmental issues of energy use and emissions to the air, clinker burning is the most critical phase of the cement manufacturing process. Clinker production consumes up to 90% of the total energy used in cement manufacturing. Nitrogen oxides (NOx), sulphur dioxide (SOX), carbon dioxide (CO_2), and dust are other important environmental emissions.
Cement manufacturing plants emit the following pollutants:
• Dust (stack emission and fugitives' source)
• Gaseous atmospheric emission (NOx, SOx, COx, VOC etc)
• Other emissions (noise and vibration, odour, process waste water, production waste etc)
• Waste from plant maintenance, such as waste oil from equipment lubrication, and waste from research and laboratories.
Dust and gaseous atmospheric emission during operation of the cement plant are the main pollutant Dust is produced throughout the cement making process. The dust generation is basically from the stack of various sections like crusher, raw mill, kiln system, clinker cooler, cement mill and packing plant. These are known as process dust or point stack source. While dust arising from material handling, storage and transportation etc. is known as fugitive source. Fugitive dust emission can arise during the storage and handling of materials and solid fuels and from road surface. The emission of odour may be mainly traced to emission from the burning of sulphur containing fuel and/or use of sulphur containing raw material.

Green House Gas (GHG) Emissions

Cement manufacture is a high-energy process that emits greenhouse gases from both fuel burning and the chemical calcination process that occurs during clinker synthesis. As a result, the global cement sector contributes significantly to anthropogenic GHG emissions (Soares, 2006). Practically all fuel is used during pyro processing during the production of the clinker. The pyro process removes water from the raw meal, calcines the limestone at temperatures between 900 and 1000°C and finally clinker the kiln material at about 1500 °C. The number of gases emitted during this process is influenced by the type of fuel used (coal, fuel oil, natural gas). The emission of NOx, SOx, CO_2, etc. occurs during the production of clinker. The following are the primary environmental concerns that the cement manufacturing business faces:
• Release of air of oxides of Nitrogen (NOx), Sulphur oxide (SOx), particulates and Carbon-dioxide (CO_2.)
• Resources, particularly core raw materials and fossil fuels, are used.
• Generation of waste
Nitrogen oxide (NOx) is formed during fuel combustion by oxidation of the molecular nitrogen of the combustion air as well as the nitrogen compounds in the fuels and raw materials. NOx formation is an inevitable consequence of the high temperature combustion process, with a smaller contribution resulting from the chemical composition of the fuels and raw materials.
Sulphur oxide (SOx) is formed during fuel combustion, releases of SO_2 in the burning zone of the kiln (from sulphates, e.g., $CaSO_4$) and oxidation of pyrite/marcasite (sulphide) and organic sulphur in the preheater or in the kiln inlet. Sulphur entering the kiln system through raw materials and fuels is largely captured in the kiln products. However, sulphur contained in raw materials as sulphides (or organic sulphur compounds) is easily volatilized at low temperatures (i.e.,400- 600°C) and may lead to considerable SOx emissions in the stack.Due to the dominant use of carbon intensive fuels, e.g., coal, in clinker making, the cement industry is a major emitter of CO_2 emissions The clinker-making process releases CO_2 due to the calcining process, in addition to energy usage. The cement sector is responsible for 5% of total global CO_2 emissions.

The overall CO_2 emissions from the cement manufacturing process are primarily determined by:
• Combustion of fuel and
• Calcination of limestone in raw mix ($CaCO_3$ Cao + CO_2)
• Types of manufacturing processes (dry/wet)

DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

Thus, Carbon dioxide emissions in cement manufacturing come directly from combustion of fossil fuels and from calcining the limestone in the raw mix.

Emissions of carbon dioxide can be reduced by:
• Enhancement of the process's energy efficiency
• Changing to a more energy-saving method (e.g., from wet to dry process)
• Low-carbon fuels are being used to replace high-carbon fuels.
• The flue gases are depleted of CO2.

The combustion of fossil fuels emits toxic pollutants into the atmosphere, which have an impact on the greenhouse effect as well as direct human health issues. Major emissions of NOx, SOx, CO2, and particulate matter are the primary source of environmental pollution, leading in an increase in ozone levels in the lower atmosphere, acid rain, and global warming. Effect of pollutants on human beings includes CO causes heart disease, strokes, pneumonia, tuberculosis and congestion of brain and lungs. SOx cause Acute respiratory infection (chronic pulmonary or cardiac disorders). and NOx causes Chronic respiratory infection. Emissions such as SOx and NOx contributes to the formation of smog's and acid rain.

2.3 Conceptual framework

Independent variables **Dependent variable**

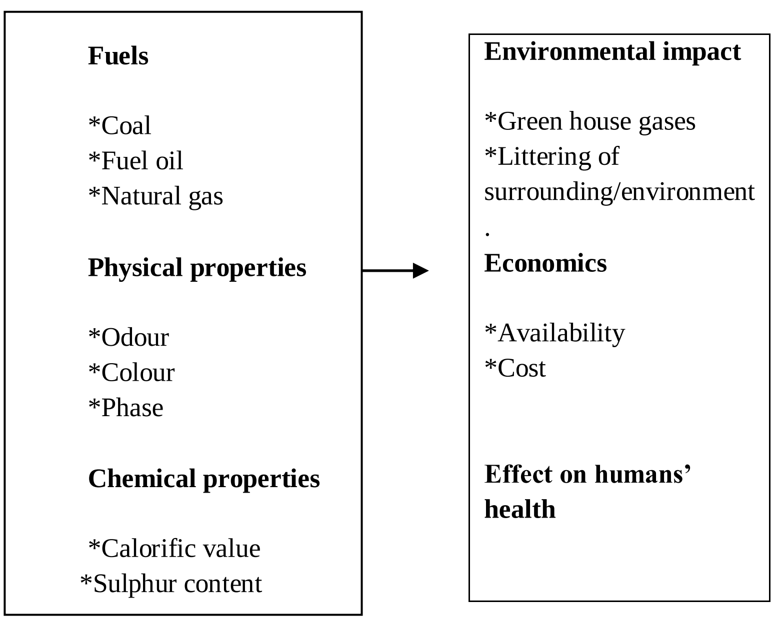

Fig 2.2: -The schematic diagram of the study.

III. RESEARCH METHODOLOGY

3.1 RESEARCH METHOD

The methods or strategies used to find, select, process, and analyse information about a topic are referred to as research methodology.

In conducting this research, the researcher employed the collecting and analysing data using particularly the cross-sectional design of data collection was administered to study subjects in the normal state of life to assess their responses about specific variables under study.

3.2 RESEARCH ANALYSIS

We can create all questions list which can be determine that which source is the best for cement production. That includes environmental impact such as green house gas and

Economics that include availability, cost, and effects on human's health.

We can research all aspects of Coal, Fuel oil, Natural gas and finalized the best fossil fuel from this for cement production.

IV. ANALYSIS OF DATA

This chapter presents the data that were collected and analysed to proffer solutions to the statement of problems.

1. Describe the fuel in terms of colour, odour, and phase.

Table 4.1: Physical Properties of Fuels

Criteria	Coal	Natural gas	Fuel oil
Color	Black	Colorless	Black
Odor	Odorless	Odorless	Pungent odor
Phase	Solid	Gaseous	Liquid

Table 4.1 shows the physical properties of coal, fuel oil and natural gas basically on the fuel's colour, odour and phase. The table shows that coal is a black, odourless and solid fuel, fuel oil is a black liquid fuel with a pungent smell and natural gas is an odourless, colourless, gaseous fuel

2. What are the chemical properties of these fuels?

2(a). What is the level of calorific value of the fuel?

Table 4.2(a); The level of calorific value in coal, fuel oil and natural gas.

Fuels	Calorific value	Recommendation
Coal	5700 kcal/kg	Low
Fuel oil	9520 kcal/kg	Moderate
Natural gas	12500 kcal/kg	High

This table shows the mean deviation for Natural gas calorific value level is high, while that of fuel oil and coal are low and moderate respectively.

International Journal of Engineering Technology and ManagementSciences
Website: ijetms.in Issue: 3 Volume No.6 May – 2022
DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

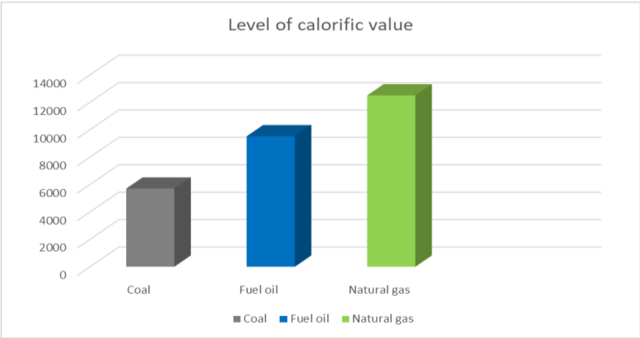

Fig 4.1:- The level of calorific value in coal, fuel oil and natural gas.

2(b). What is the level of sulphur contained in the fuel?

Table 4.2(b): The level of sulphur contained in coal, fuel oil and natural gas

Fuels	level of Sulphur	Recommendation
Coal	0.2% to 5%	High
Fuel oil	3.5%	Moderate
Natural gas	1%	Low

This table shows that the sulphur content in coal and fuel oil is Moderate while that of natural gas is low.

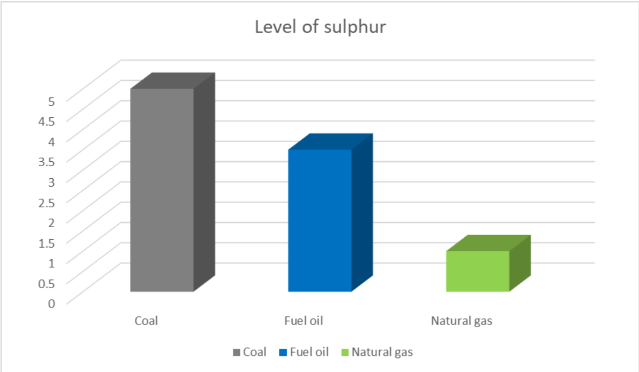

Fig 4.2: **-** The level of sulphur contained in coal, fuel oil and natural gas

3.Which of this fuel is most economical?

3(a). How availability of the fuel?

Coal is abundant Over 1.06 trillion tonnes of known coal reserves exist around the world. This suggests that there is enough coal to last us 132 years at current production rates. The United States, Russia, China, Australia, and India have the most reserves.

Fuel oil as a result, OPEC's proved oil reserves have increased to 1,189.80 billion barrels. According to current estimates, OPEC Member Countries own 79.4 percent of the world's proven oil reserves, with the Middle East accounting for 64.5 percent of OPEC total reserves.

Natural gas are 6,923 trillion cubic feet (Tcf) of proven gas reserves in the world as of 2017. The world's proven reserves are equal to 52.3 times yearly consumption. This means it has 52 years of gas left in it (at current consumption levels and excluding unproven reserves).

Table 4.3(a) The level of availability of coal, fuel oil and natural gas.

Fuels	level of availability
Coal	Low
Fuel oil	High
Natural gas	High

From the table above, coal is low in availability, but fuel oil and natural gas are high in availability.

3b. How Prices is the fuel?

Table 4.3(b) The prices of coal, fuel oil and natural gas

Fuels	Price	Recommendation
Coal	₹ 30/ Kg	Low
Fuel oil	₹ 109.29 per litre for petrol	High
Natural gas	Rs 59.01 per kg for CNG	Moderate

From the table above, the price of coal is low, fuel oil price is very high and Natural gas price is moderate.

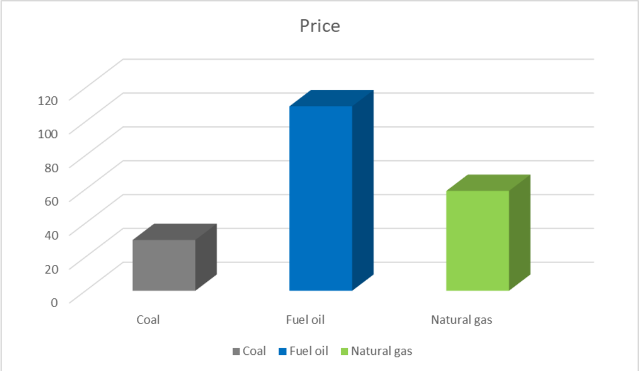

Fig 4.3:- The prices of coal, fuel oil and natural gas

4.The level of difficulties encountered in processing the fuel.
Coal and Natural gas are used in their natural forms, but Petroleum (Fuel oil) requires distillation and refinement to give useable fuel.
Fuel oil, in general, passes through several stages of exploration before reaching end users or dealers. The whole well-to-consumer supply chain for petroleum products is commonly divided into three primary segments:
Upstream operations: This is where the preliminary stages begin. It entails the discovery of crude oil resources and the subsequent production of crude oil.
Midstream activities: These include crude oil transportation to refineries and crude oil refinement into commercial products.
Downstream activities: These activities also include the retail end of the petroleum business.

International Journal of Engineering Technology and ManagementSciences
Website: ijetms.in Issue: 3 Volume No.6 May – 2022
DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

Table 4.4: The level of difficulties encountered in processing coal, fuel oil and natural gas

Fuels	level of difficulties
Coal	Low
Fuel oil	High
Natural gas	Low

This table shows that coal and natural are low difficult in processing, but fuel oil happens to be more difficult in processing.

5. The level of Green house gases emission from coal, fuel oil and natural gas.
The level of CO_2 emission from the fuel.

Table 4.5: The emission level of Carbon dioxides (CO_2) from coal, fuel oil and natural gas.

Fuels	Emission level	Recommendation
Coal	228.6 pounds	High
Fuel oil	161.3 pounds	Moderate
Natural gas	117.0 pounds	Low

Table 4.5 shows that Natural gas emits low level of Carbon dioxide to the environment other than fuel oil and coal.

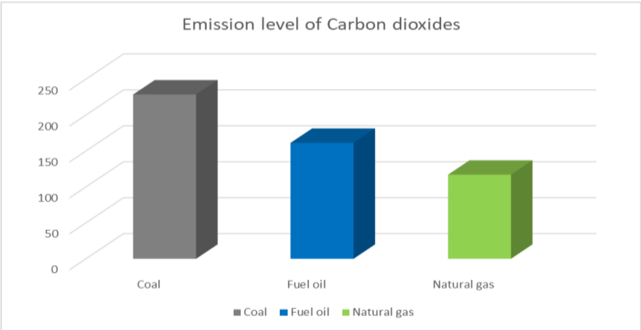

Fig 4.4: - The emission level of Carbon dioxides from coal, fuel oil and natural gas.

V. SUMMARY

Based on the findings, it has been discovered during study that coal is an odourless, black solid fuel with high calorific value and sulphur content, fuel oil is a black liquid fuel with pungent smell, low calorific value and high sulphur content and natural gas is an odourless, colourless gaseous fuel with a moderate calorific value and low sulphur content.

Also, green house gases mostly emitted during the combustion of coal, fuel oil and natural gas includes Nitrogen oxides (NOx), Sulphur oxides (SOx), carbon dioxide (CO_2), and carbon monoxide (CO). The level of these green house gases emission is high in combustion of coal and fuel oil but low in natural gas combustion.

Green house gases are pollution and environmental danger. These pollutant causes heart disease, pneumonia, congestion of the brain and lungs, chronic pulmonary or cardiac disorders, chronic respiratory infections, etc. in humans. The use of coal and fuel oil highly exposes cement workers to some of these diseases while natural gas exposes cement workers to these diseases at a low level. Finally in terms of cost and availability, coal is highly economical but is low in availability. Fuel oil is lowly economical but highly available and natural gas is highly economical with high availability.

DOI:10.46647/ijetms.2022.v06i03.015 ISSN: 2581-4621

VI. CONCLUSION

In conclusion, from the analysis of the work, coal is one of the fossil fuels used in the production of cement. It is the cheapest amongst the three-fuel used in production of cement, but it is not available due to the closing down of Nigeria's coal mine and it poses too much threat to the environment and human's health.

Fuel oil is one of the fuels used in cement production, it is available but as at now it is the most expensive fuel used in Nigerian cement industries and it also poses high threat to the environment and human health.

Then Natural gas is available, cheap and emits lesser green house gases to the environment, thereby, lowering its effect on human health.

VII. RECOMMENDATION

Energy sources have direct impact on the market price of cement, environment, and human health. Natural gas which happens to be a cheap, available and most environment friendly energy source compared to coal and fuel oil is recommended to cut down energy costs, guarantee power supply to the power plant and minimizes the emission threat caused by cement industries to the environment.

Also, since coal is also cheap though not available due to no coal mine at work, it uses can be possible only if the industries embark on a coal – mining project, this is expected to reduce the overall energy cost.

In terms of environmental and health impact, the exhausted gases can be made to pass through an air pollution control device such as Bio-scraper, Bio-filter, Electrostatic precipitators, Cyclone, Wet/Dry scrubber etc. The adoption of modern technology machineries would also be a forward step to diminishing green house gas emission from industries, eliminating the dust emitted from the factory chimneys and producing suitable environmental situation.

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