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QUANTIFICATION OF CARBON DIOXIDE EMISSIONS FROM DIESEL-POWERED ELECTRICITY GENERATOR USING THE IPCC FUEL CONSUMPTION-BASED EMISSION FACTOR METHOD

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ABSTRACT

The widespread use of diesel-powered generators as alternative electricity sources in higher institutions across developing countries has increased significantly due to unreliable public power supply. While these generators ensure energy availability, they are major contributors to greenhouse gas emissions, particularly carbon dioxide (CO_2). This study evaluated the annual CO_2 emissions from diesel-powered generators at the Federal University of Technology, Owerri (FUTO), Nigeria. Primary data, including generator specifications, annual fuel consumption, and operating hours, were collected from various buildings and offices across the campus. The fuel consumption-based emission factor method was adopted using the Intergovernmental Panel on Climate Change (IPCC) emission factor of 2.68 kg CO_2/L of diesel. Results revealed an estimated annual diesel consumption of 581,882.7 litres, corresponding to a total CO_2 emission of 1,559.4 tonnes per annum. The analysis further showed that emission levels were strongly influenced by generator operating hours and utilization patterns rather than generator capacity alone. These findings provide valuable baseline data for institutional carbon footprint assessment and sustainable energy planning. The study recommends transitioning to renewable energy resources through the deployment of hybrid microgrids integrating solar photovoltaic systems, battery energy storage, and other renewable technologies to reduce dependence on diesel generators and support the achievement of net-zero carbon emissions in tertiary institutions.

KEYWORDS: Diesel-Powered Generators; Carbon emissions; Emission factor; Fuel Consumption; Carbon footprint.

I. INTRODUCTION

Energy demand in developing countries like Nigeria is increasing due to urbanization and industrialization, and this growth is expected to continue with further industrial expansion.[1] Energy is a key factor in the socio-economic life and development of any nation.[2,3] When energy supply falls short to meet the energy demand, it becomes a problem, restricting socio-economic activities, limiting economic growth, and adversely affecting the quality of life.[4] The inadequate and insufficient supply of energy from Nigeria's power sector has been a prevalent issue for years. This unreliable supply of energy from the Nigerian power sector has caused many citizens to lose confidence in the system, leading to self-generation of electric power through the use of backup power sources in order to meet their energy needs. For decades, diesel-powered generators have played a critical role in providing emergency backup electricity.[5] The increase in the need for backup power has led to a corresponding increase in the number of diesel generators. According to[6], Nigerians spend $14 billion on generator and fuel. Despite the benefit as a backup power supply, gaseous emissions from diesel engines are a major environmental concern. The emissions from these diesel-powered generators contribute significantly to increased health risks[7], climate change and global warning, also the noise pollution are disturbing and unpleasant.[8] Hence the need for the carbon footprint present in these diesel generators to be calculated to ascertain their emissions.

A diesel generator is a device used to generate electricity in many parts of the world, especially in developing countries. It is made up of a diesel engine, a generator and various ancillary devices. The main function of Diesel engine generators (DEGs) is to supply electrical power for commercial, industrial and residential consumers during blackouts; they serve as emergency sources of power. It is worthy to note that these diesel generators are reliable, fuel efficient, high torque engines, easy to repair, inexpensive to operate and highly durable, which supply power to many of the world's trucks, buses, off-road vehicles and generators. However, many of these diesel-powered generators are being installed swiftly without strict compliance with the state guidelines, as the emphasis is largely on providing reliable back up power during both scheduled and unexpected outages. The emissions from these diesel-powered generators are not environmentally friendly because of their grave effects on human health, global warming and air quality. Emission is a broad term used to describe harmful gases and particles that are released into the air from various sources. The toxic emissions from diesel powered generators include but are not limited to Carbon monoxide (CO), Carbon dioxide (CO_2), nitrogen oxide (NOx), and unburned hydrocarbons (HC) and particulate matter (PM).[5,9] DEGs release harmful pollutants such as particulate matter (PM) and Nitrogen oxides (NOx), which, according to experts, negatively impact human health and contribute to environmental issues including acid rain, ground-level ozone formation, and decreased visibility. Diesel engine exhausts are recognized as a significant contributor to air pollution. CO, CO_2[10], total organic compounds, oxides of Nitrogen, and particulates (including both non-visible and visible emissions) are the primary exhausted gases (pollutants) from internal combustion engines. These emissions from diesel powered generators cause harm to our environment. This ugly development poses a threat to the UN's SDG7, which aims to ensure access to affordable, reliable, sustainable and modern energy for all. According to the World Bank and partner agencies, Nigeria faces the largest electricity deficit globally, with approximately 86.8 million citizens lacking a grid connection.[11] However, the usage of generators keeps on increasing all over the country due to the laxity of the government to put effective measures to the menace of power supply.

Previous studies have examined the role of diesel-powered generators as backup power source, the different forms of carbon emissions, the methods employed for their estimation, the resulting environmental impacts, and strategies for their mitigation[5] noted that persistent inadequacy of energy from Nigeria's power sector has undermined public confidence, leading to widespread reliance on diesel engine generators for self-generated electricity to meet energy needs[12] noted that Nigeria, despite being the most populous country in Africa, generates less grid electricity than the Republic of Ireland with less than 6 million. Consequently, more than half of the population lacks access to electricity, which has resulted in substantial expenditure on the purchase, repair and maintenance of both partial and industrial generators which serve as primary alternative power supply. The inability of the utility electricity providers to ensure reliable electricity has led to widespread reliance on generators, making Nigerians frequent users of private power generators across the globe.[5] These diesel-powered generators release harmful substances into the environment: Carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), and particulate matter. Owing to the fact that these generators are not 100% efficient, they tend to produce emissions through their exhaust pipes during the combustion of diesel. The combustion of conventional diesel fuel significantly contributes to the emission of particulate matter and greenhouse gases, particularly carbon dioxide (CO_2) and nitrogen oxide (NOx).[13],[5], using emission factors and yearly fuel consumption data found the total emissions of 1,460.20 tons per year, with diesel generators contributing approximately 58.95% of this total, significantly more than petrol generators (~31%).[4] in their study, took measurements from 105 diesel generators in Ogun State; results showed high pollutant concentrations: CO_2 ranged from 501 to 5805 ppm and particulate matter (PM2.5) ranged from 221 to 492 $\mu g/m^3$, both significantly above recommended and safe limits.[14] analyzed raw exhaust emissions from industrial generators and reported that diesel-powered generators exhibited higher CO_2 emissions (76.1%) and NOx levels (739 ppm).

While several studies have investigated emissions from diesel-powered generators in Nigeria, relatively little emphasis has been placed on location-specific analyses within tertiary institutions. Existing research largely focuses on national or urban-scale assessments, resulting in limited empirical evidence on campus-level generator usage, fuel consumption patterns, and related carbon emissions. Notably, comprehensive studies addressing the Federal University of Technology, Owerri (FUTO) remain scarce, despite the institution’s substantial energy demand and heavy dependence on diesel generators caused by unreliable grid electricity. The lack of localized emission data hinders informed decision-making and the formulation of effective, institution-specific mitigation strategies.

This study assesses CO_2 emissions resulting from the use of diesel-powered generators within the Federal University of Technology, Owerri (FUTO) environment. Specifically, the study seeks to identify and classify the types of diesel generators operating on campus, estimate their carbon emissions using appropriate emission calculation methods, analyze the percentage contribution of different campus zones to overall emissions, and provide location-specific recommendations for reducing generator-related carbon emissions at FUTO.

II. MODELS OF DIESEL ENGINES

Diesel engines come in a variety of models shaped by their physical size and the type of combustion cycle they operate on (number of strokes). These two factors influence where an engine is used, its power output, efficiency, and cost-effectiveness. Size classifications range from small light-duty engines to massive industrial powerplants, while stroke cycle types divide models into two-stroke and four-stroke engines, each with unique operational characteristics. Understanding these models helps in selecting the right engine for applications from small generators to marine propulsion and heavy-duty machinery.

Classification of Diesel Engines by Size

Diesel engines are commonly classified by size, which is closely related to their power output, physical dimensions, cylinder configuration, and intended application. This classification broadly divides diesel engines into small, medium, and large categories. Size influences not only the engine's mechanical design but also its fuel consumption rate, emission profile, installation requirements, and operational role. In power generation and industrial applications, this classification is essential for matching engine capacity with load demand and duty cycle.

Small Diesel Engines

Small diesel engines are typically single-cylinder or low multi-cylinder engines with power outputs ranging from a few kilowatts up to approximately 150–200 kW. These engines are compact, lightweight, and relatively simple in design. They are widely used in portable and standby generators, agricultural machinery, water pumps, and small construction equipment. Due to their size, they are easier to install and maintain, making them suitable for decentralized power supply, especially in regions with unreliable grid electricity.

Small diesel engines generally operate at higher rotational speeds and are predominantly four-stroke engines to ensure better fuel efficiency, smoother operation, and lower emissions. However, their limited size restricts their ability to handle continuous heavy loads, and prolonged operation at high capacity can lead to increased wear. Despite this, they remain popular due to their low initial cost and operational flexibility.

Plate 1: A small-sized diesel engine Generator.[15]

Medium-Sized Diesel Engines

Medium diesel engines fall within a power range of approximately 200 kW to 750 kW, although classifications may vary slightly across manufacturers. These engines are usually multi-cylinder (4–12 cylinders) and are designed for continuous or prime power operation. They are commonly used in industrial facilities, hospitals, universities, commercial buildings, marine auxiliary systems, and medium-scale power plants.

Compared to small engines, medium diesel engines offer better thermal efficiency, higher durability, and improved load-handling capability. They often incorporate advanced cooling systems, turbocharging, and electronic fuel injection to improve performance and reduce emissions. Their balance between size, efficiency, and reliability makes them a preferred choice for institutions and industries requiring stable and sustained power supply.

Plate 2: Medium-sized Diesel-Powered Generator.[16]

Large Diesel Engines

Large diesel engines are high-power machines, typically producing above 750 kW and extending to several megawatts. These engines are massive in physical size, often weighing hundreds of tons, and are used in marine propulsion, locomotives, large industrial plants, and grid-connected power stations. Many large diesel engines are designed for base-load or continuous operation, running for long periods with minimal shutdown.

Large diesel engines may operate as two-stroke or four-stroke systems, depending on application. Two-stroke designs dominate in marine and large-scale power generation due to their high power-to-size ratio and ability to deliver enormous torque at low speeds. Although these engines have higher capital costs and complex installation requirements, they offer exceptional efficiency, longevity, and fuel flexibility, including the use of heavy fuel oils.

Plate 3: Large-sized Diesel-Powered Generator.[17]

Classification by Stroke

Diesel engines are further classified by the number of piston strokes per power cycle: two-stroke and four-stroke engines.

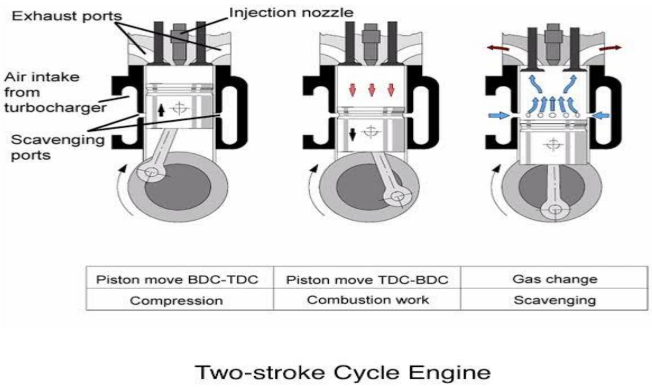
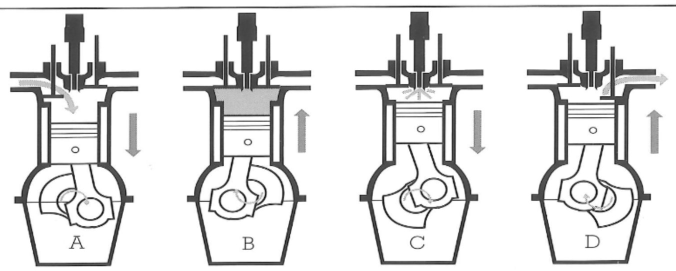


Plate 4: Two stroke diesel engine cycle.[18]



Four-stroke diesel cycle
A. Induction. Piston descends, inlet valve opens and air is drawn into the cylinder.
B. Compression. Piston rises. The air is compressed and heated to around 700^{0}C. Near the top of the stroke a fine spray of diesel is injected into the cylinder.
C. Power. The air/diesel mixture is ignited by the hot air and the piston is driven down.
D. Exhaust. Exhaust valve opens and the spent gases are expelled.

Plate 5: Four stroke diesel engine cycle.[19]

A two-stroke engine completes a full engine cycle in two piston movements (one crankshaft revolution), with intake and exhaust phases combined into each stroke. These engines are simpler and often have a high power-to-weight ratio but can be less fuel efficient and produce more emissions. By contrast, four-stroke engines complete their cycle in four piston movements (two crankshaft revolutions). They are more efficient, have better fuel economy, and lower emissions because each phase (intake, compression, power, exhaust) happens separately. Two-stroke diesel models are often used in very large industrial and marine engines. Four-stroke models are the norm in smaller industrial, agricultural, and vehicle engines due to their efficiency and lower operating costs.

Four-stroke engines generally offer lower lifecycle costs because they burn fuel more efficiently and require less maintenance over time. Two-stroke engines may have higher specific power output but usually incur higher fuel and maintenance costs due to greater wear and emissions control needs.

Advantages of Diesel Engines

Diesel engines have several distinctive properties that make them suitable for a wide range of heavy-duty applications. They operate at higher compression ratios than petrol engines, which leads to greater thermal efficiency, often converting more fuel energy into usable mechanical energy. This results in better fuel economy, particularly under load. Diesel engines also produce high torque at low RPM, making them ideal for industrial vehicles, heavy machinery, and generators. Their lack of spark ignition systems means fewer ignition components and higher reliability in harsh environments. Additionally, diesels are durable and long-lasting, with robust components designed to withstand high pressures and long operating hours. Their construction contributes to a long service life and lower long-term operational costs in high-usage contexts.

Emissions of Diesel Engines

Despite their advantages, diesel engines have emission challenges. During combustion, they tend to produce higher levels of nitrogen oxides (NO_x) and particulate matter (PM) compared to petrol engines. These pollutants contribute to smog and respiratory issues and have driven stricter emissions regulations worldwide. Diesel engine manufacturers now use technologies such as exhaust gas recirculation (EGR), diesel particulate filters (DPFs), and selective catalytic reduction (SCR) to reduce harmful emissions and meet environmental standards.

Comparison with Petrol Engine Emissions

When comparing diesel and petrol engines, the emission profiles differ significantly. Petrol engines generally produce lower NO_x and PM emissions than diesel engines because of their spark-ignition combustion and lighter fuel. However, petrol engines often emit higher carbon monoxide (CO) and hydrocarbons (HC) due to incomplete combustion at certain operating conditions. Diesel's higher compression ratios improve fuel efficiency but traditionally generate more NO_x and soot; modern emission control systems have narrowed this gap, yet diesel engines still require advanced after-treatment systems to meet today's clean-air standards.

III. QUANTIFYING CARBON EMISSIONS FROM DIESEL ENGINE

Diesel-powered generators are commonly used as backup and primary power source to areas facing unreliable power supply. While they ensure power reliability, their operations release emissions into the environment, especially, Carbon dioxide which contributes significantly to climate change. Therefore, there is need to quantify these emissions in order to know their impacts on the environment, compliance to regulatory framework and the development of strategies to mitigate the emissions.

There are various methods of quantifying carbon emissions from Diesel-powered generators. They include.

a. **Fuel-Consumption Based Model:** This is the most common approach used in Quantifying Carbon emissions. Here, we estimate carbon emissions based on the quantity of fuel consumed over a given period. It involves measuring the fuel in Litres and multiplying by a standard emission factor of 2.68.

CO_2 Emissions = F.C x E.F (1)

Where, F.C = Fuel Consumed and E.F = Emission Factor,

Typical emission factor for diesel: 2.68kg CO_2 per liter of diesel

b. **Power Output-Based Method:** In this method, emission estimation is done relative to the electrical power generated. Generator output power is measured in kW, the total operating hours is recorded, generated energy is calculated in kWh, then multiplied by a CO_2 emission factor per kWh.

CO_2 Emissions= Energy generated (kWh) x E.F (2)

Typical values: 0.6-0.9 kg CO_2/kWh for diesel generators (depending on load factor)

c. **Direct Emission Measurement Method:** The direct emission measurement method estimates carbon emissions from diesel-powered generators by monitoring the exhaust gases as the generator is running. Using tools such as portable emission monitoring systems (PEMS) or non-dispersive infrared (NDIR) gas analyzers, this method allows the concentration of carbon dioxide (CO_2) in the exhaust to be measured directly. By relating these measurements to the exhaust flow rate and the length of time the generator operates, the actual emission rate can be determined. This approach reflects real operating conditions and provides a more realistic picture of the generator’s environmental impact.

d. **Life Cycle Assessment Method:** The life cycle assessment (LCA) method estimates carbon emissions from diesel-powered generators by looking beyond emissions produced during operation alone. Instead, it considers the entire life span of the generator, including emissions from fuel extraction, refining, transportation, manufacturing, operation, maintenance, and eventual disposal. By capturing both direct and indirect emissions, this approach offers a broader and more realistic understanding of the generator’s overall environmental impact. However, because LCA requires extensive data and detailed analysis, it is better suited for comparative studies and long-term energy planning than for rapid emission estimation.

IV. DATA COLLECTION

The study was conducted at the Federal University of Technology Owerri located in Owerri, Imo state Nigeria. The study covered a 12-month period from January 2025 to December 2025 capturing both academic session and vacation periods to account for seasonal variations in generator use and fuel consumption. Primary data collection involved physical inspection and enumeration of diesel generators on campus, recording of generator specifications including make, model and rated capacity in kVA, collection of fuel consumption records and operating hour logs from utility departments and generator operators.

Table 1 provides a detailed listing of diesel generators across various buildings within the school environment, specifying their manufacturers, model types, and power ratings. It also indicates the number of units at each location and summarizes the total power capacity for each building.

Table 1: Inventory and Specifications of Diesel Generators across FUTO Study Areas.

S/N	BUILDING	MODEL NAME	MANUFACTURER	CAPACITY	NO. OF UNITS	TOTAL CAPACITY
1	FUTO Library	SP200	Perkins	200kVA	1	200kVA
2	FUTO E-Library	C110DC	Cummins	110kVA	1	110kVA
3	FUTO Guest House	CAT DE65GC	Mantrac	65kVA	2	130kVA
4	Communication Mast I	SP20	Mikano	20kVA	1	20kVA
5	NDDC Hostel	P500-3	FG Wilson	500kVA	1	500kVA
6	Tetfund Hostel	C550DC	Cummins	550kVA	1	500kVA
7	Petroleum Eng. Building	SP500	Mikano	500kVA	1	500kVA
8	ICT FUTO	C110DC	Cummins	110kVA	1	110kVA
9	Microfinance Bank	C110DC P220-3	Cummins FG Wilson	110kVA 110kVA	1 1	110kVA 110kVA
10	Workshop 3	SP100 C550DC	Mikano Cummins	110kVA 550kVA	1 1	110kVA 550kVA
11	CESPESS	C110DC	Cummins	110kVA	3	330kVA
12	ACE-FUELS	P220-3	FG Wilson	220kVA	1	220kVA
13	General Hostels	P550-3	FG Wilson	550kVA	1	550kVA
14	FUTOWA	SP30	Mikano	30kVA	1	30kVA
15	Communication Mast II	SP20	Mikano	20kVA	2	40kVA
16	Communication Mast III	DE50	Mantrac CAT	50kVA	2	100kVA

CARBON EMISSION CALCULATION

Fuel Consumption-Based Method is used for this work as it reflects the actual relationship between quantities of fuel consumed by the generators and the equivalent emissions. For engineering research focused on local diesel generator sets, an emission factor of 2.68 kg CO_2/L is the standard under the Intergovernmental Panel on Climate Change (IPPC).

The calculation follows equation 1.

CO_2 Emissions (kg) = Fuel Consumed (L) × Emission Factor (kg CO_2/L)

Where.

Fuel Consumed = Total diesel purchased and consumed by each generator over the study period

Emission Factor = 2.68 kg CO_2/L of diesel (IPCC default value for diesel combustion)

Our study selected this method as the primary approach due to direct relation with actual fuel consumption, simplicity and availability of reliable fuel purchase records.

V. RESULTS AND DISCUSSIONS

The estimated annual diesel fuel consumption across the sixteen selected buildings within the Federal University of Technology, Owerri (FUTO), was 581,882.7 litres, resulting in a total estimated annual carbon dioxide (CO_2) emission of 1,559,445.6 kg CO_2, equivalent to 1,559.4 tonnes of CO_2 per annum (Table 2). This is close to the result of 1365 tons gotten by[20] in their studies at the Federal University of Agriculture, Abeokuta (FUNAAB), though higher than the 773 tons recorded by[21] at the Abia State Polytechnic, Aba (ASPA). This high emission highlights the environmental burden associated with the widespread dependence on diesel-powered generators due to the unreliable public electricity supply. Similar campus-scale assessments by[5] also reported that extensive reliance on diesel generators constitutes a major source of institutional carbon emissions.

The results presented in Tables 2 and 3 show that annual fuel consumption and CO_2 emissions varied considerably among buildings and generator capacities, largely because of differences in operating hours rather than generator size alone. Administrative buildings and offices generally operate generators only during official working hours and therefore recorded relatively lower annual fuel consumption. In contrast, hostel facilities require electricity throughout the night to support residential activities, resulting in longer daily operating hours and increased fuel consumption. Likewise, the communication masts operate almost continuously to maintain uninterrupted telecommunication services, explaining their relatively high fuel usage despite their smaller generator capacities. These findings indicate that generator duty cycle is a major determinant of annual carbon emissions. Similar observations were reported by[4], who found that longer operating durations of off-grid diesel generators significantly increased fuel consumption and exhaust emissions irrespective of generator size.

Table 2: Estimated Annual Fuel Consumption and Carbon Dioxide (CO_2) Emissions.

S/N	Building	Annual Fuel Consumption (Litres/year)	CO2 Emission (Kg CO_2/year)
1	FUTO Library	38,402	102,917.36
2	FUTO E-Library	21,121.1	56,604.55
3	FUTO Guest House	20,400	54,672
4	Communication Mast I	18,980	50,866.4
5	NDDC Hostel	41,145	110,268.6
6	Tetfund Hostel	45,259	121,294.12
7	Petroleum Eng. Building	39,750	106,530
8	ICT FUTO	24,138.1	64,690.1
9	Microfinance Bank	42,242.2	113,209.1
10	Workshop 3	73,350	196,578
11	CESPESS	45,259.5	121,295.5
12	ACE-FUELS	30,173	80,863.6
13	General Hostels	30,173	80,863.6
14	FUTOWA	6,330	16,968.4
15	Communication Mast II	37,960	101,732.8
16	Communication Mast III	67,500	180,900
		Total = 581,882.7 (litres/year)	Total = Total = 1,559,445.6 (Kg CO_2/year) (1,559.4 Tons of CO_2 per annum)

Table 3: Annual Fuel Consumption and CO_2 Emissions by Generator Capacity.

S/N	Capacity (KVA)	Annual Fuel Consumption (Litres/year)	CO2 Emission (Kg CO2/year)
1	20	56,940	152,599.2
2	30	6,330	16,964.4
3	50	94,900	254,332
4	65	20,400	54,672
5	100	22,100	59,228
6	110	114,656.9	307,280.5
7	200	38,402	102,917.4
8	220	48,276.9	129,382
9	500	80,895	216,798.6
10	550	98981.9	265,271.5
		Total = 581,882.7 (Litres/year)	Total = 1,559,445.6 (Kg CO_2/year)

Figure 6 illustrates the annual fuel consumption according to generator capacity. The 110 kVA category recorded the highest fuel consumption despite not being the largest generator size. This can be attributed to the fact that four 110 kVA generator units are distributed across several high-demand facilities within the university, resulting in a much higher cumulative operating duration than other capacities. Conversely, the 30 kVA category contributed the least fuel consumption because only a single unit was installed (FUTOWA), with comparatively limited operating hours. Similar trends were observed by[5], who reported that cumulative emissions were influenced more by the number of installed generator units and their utilization patterns than by rated generator capacity alone. Similarly, the trend observed in Figure 7 closely follows that of Figure 6 because carbon dioxide emission is directly proportional to diesel fuel consumption according to the IPCC emission factor of 2.68 kg CO_2 per litre of diesel. Consequently, generator capacities that consumed more diesel produced correspondingly higher CO_2 emissions. Comparable findings were reported by[1], who demonstrated that greenhouse gas emissions from diesel-powered backup systems increase proportionally with fuel consumption in hybrid energy systems.

Figure 8 shows the distribution of annual CO_2 emissions across the various buildings. Workshop 3 emerged as the highest-emitting facility because it houses heavy laboratory equipment and high-power electrical machines that require larger-capacity diesel generators and prolonged operating periods during practical sessions. The high electrical demand of workshop laboratories therefore translated directly into increased diesel consumption and carbon emissions.

The ranking presented in Figure 9 identifies Workshop 3, Communication Mast III, and CESPESS as the three highest carbon-emitting facilities. Workshop 3 ranked first because of its combination of a 550 kVA and a 110 kVA generator supplying energy-intensive inductive laboratory equipment. Communication Mast III recorded high emissions due to its continuous operational requirement throughout the year, while CESPESS ranked among the highest because it operates three 110 kVA generator units, significantly increasing cumulative fuel consumption and emissions.

Lastly, a strong positive linear relationship between the annual fuel consumption and annual CO_2 emissions is seen in figure. This relationship is expected because the emission estimation employed the IPCC fuel-consumption approach, where CO_2 emission is obtained directly by multiplying fuel consumption by a constant emission factor. Consequently, buildings consuming larger quantities of diesel invariably produced higher annual carbon emissions. Similar linear relationships between diesel consumption and CO_2 emissions have been reported[5], confirming that fuel consumption remains one of the most reliable predictors of carbon emissions from diesel-powered generators.

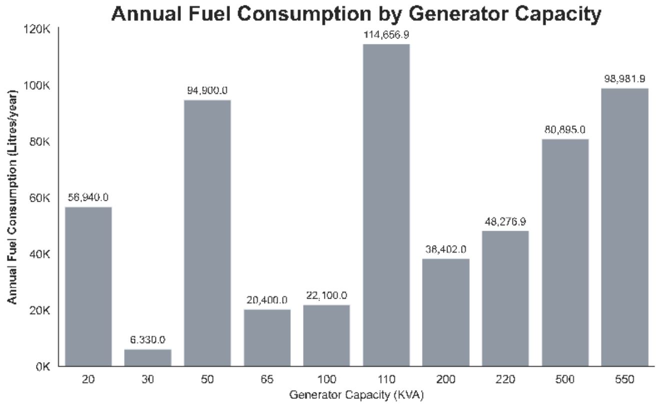


Fig. 1: Annual Fuel Consumption by Generator Capacity.

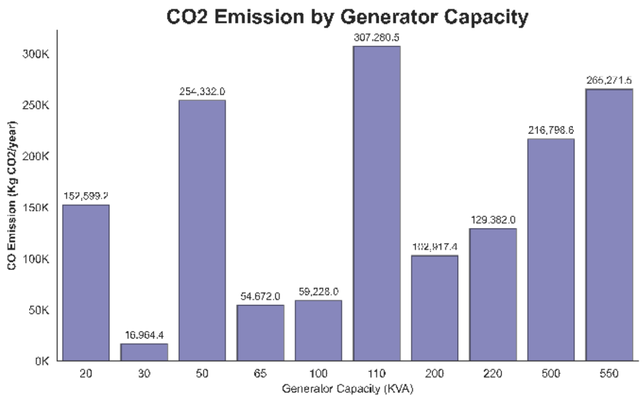


Fig. 2: Annual CO_2 Emission by Generator Capacity.

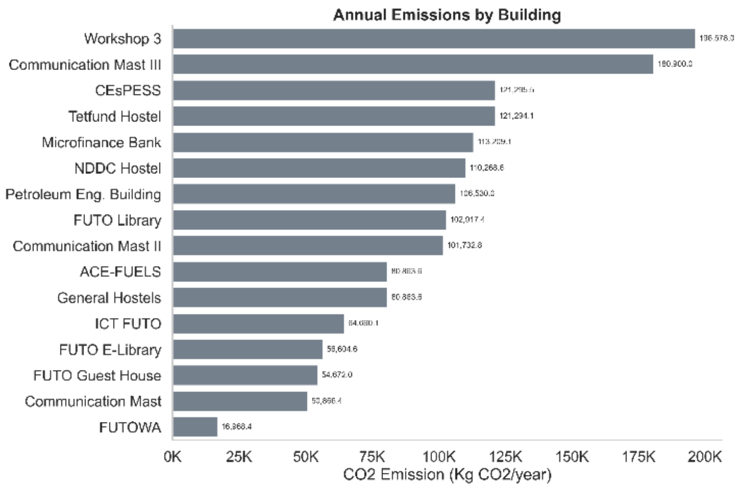


Fig. 3: Annual CO_2 Emissions by Building.

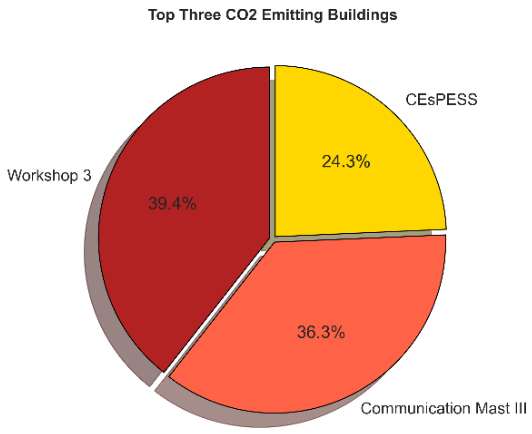


Fig. 4: Top Three CO_2-Emitting Buildings.

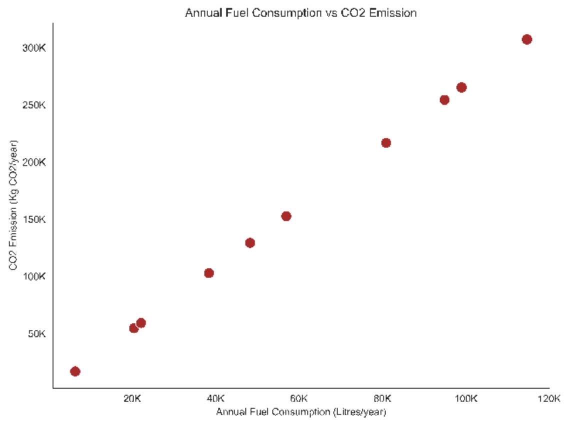


Fig. 5: Relationship Between Annual Fuel Consumption and CO_2 Emission.

VI. CONCLUSION

This study evaluated the carbon dioxide (CO_2) emissions associated with diesel-powered generators across selected buildings at the Federal University of Technology, Owerri (FUTO), using the fuel consumption-based emission estimation method. The results showed that the generators consumed a total of 581,882.7 litres of diesel annually, resulting in an estimated 1,559.4 tonnes of CO_2 emissions per year, highlighting the significant environmental impact of the University's dependence on diesel-powered electricity generation. The analysis further revealed that annual fuel consumption and CO_2 emissions were strongly influenced by generator operating hours, installed capacity, and the nature of electricity demand within each facility. Buildings with continuous or high-energy operations, such as Workshop 3, Communication Mast III, and CESPESS, contributed the largest share of emissions, while smaller facilities with limited operating schedules recorded considerably lower emissions. Furthermore, a direct linear relationship was established between fuel consumption and CO_2 emissions, confirming that increased diesel usage invariably results in higher carbon emissions. The findings provide valuable baseline data for institutional energy planning and underscore the need for cleaner and more sustainable energy alternatives, such as solar photovoltaic systems and other renewable energy technologies, to reduce greenhouse gas emissions and improve environmental sustainability within the university.

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