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Analysis of Engineering Dynamics and Carbon Footprint Reduction Potential of Fuel-less Generator

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Abstract

Carbon dioxide is one the major precursor of climate change. The largest source of carbon emission is electricity generation from fossil fuel based power generators. It accounts for 31% of the total carbon emission globally. As the world clamor for cleaner source of energy generation, fuel les generator can serve as an alternative source of electricity generation for households. This paper analyzed the engineering dynamics and carbon foot print reduction potential of fuel less generator. The paper examined the design and construction of fuel less generator. Analyzed the engineering principles and intricacies of fuelless generator. Carbon footprint from household usage of conventional fossil fuel electricity has been also analyzed. The findings revealed that fuel les generator is powered by DC battery and the battery contuse to charge itself as the generator operates and therefore it is self-sustaining. Total pollution of Nigeria as at 2023 was 229.5 Million. Average of size of Nigeria house hold (HS) is 5.06 people. Number of households in Nigeria (NHH) from the analysis s 45.36 million. Number of Nigeria household that use gasoline generator to generate electricity for domestic use (NHG) is 18,142,292.4901Million. Average quantity of gasoline used by Nigeria household daily (QGNH) for electricity generation is 5 Littre per day and Quantity of CO_2 emission (CO_2EMg) per year of petrol (in tonnes of CO_2) by Nigeria household from electricity generation is 208,273,517.79kg per year.(208273.52 metric tons per year. Therefore if household substitute fossil fuel generator with fuel less generator Nigeria will record 208273.52 metric tons of carbon footprint reduction yearly.

Keywords: Analysis, Engineering Dynamics, Carbon, Footprint, Fuel Less and Generator

1.0 Background

The task of engineers globally is to find solutions to real life problems. Hence engineering is the application of scientific knowledge, skills and creativity to solve human problems. The products of engineering make things easier and life comfortable. The United States Engineering Council for Professional Development (USECPD) defined engineering as the application of scientific principles to design or develop structures, machines, apparatus or manufacturing process. All these are aimed at making life easy and comfortable for humans existence.

Engineering dynamics is aspect of engineering that deals with relationship between force and motion. The knowledge of engineering dynamics is applied in the development of machines that make work easy or generate energy for human use. Engineering dynamics can be applied to provide solution in the area of climate change by reducing carbon footprint from electricity through fuel less generators

In recent times, there has being global clamor for the reduction of carbon footprint from human activities most especially through the use of cleaner or green energy. Carbon dioxide and other greenhouse gases in the atmosphere warm the earth planet, thereby causing climate change. Human activities have raised the atmospheric carbon dioxide content by 50% in less than 200 years according to the National Aeronautics and Space Administration (NASA 2024). Fossil fuel combustion is by far the major contributor to climate change. It accounts for over 75% of global greenhouse gas emissions and nearly 90% of all carbon dioxide emissions according to the United Nations Climate Action (UNCA, 2024).

The effects of climate change are harmful and can be disastrous to the environment and human existence. The effects include; hotter temperatures, More severe storms, increased drought, a warming and rising ocean, loss of biodiversity, food scarcity or shortage more health risk, poverty and human displacement. Courtney (2024) reported that climate change is the earth's greatest existential threat. The report further states that, if we don't limit greenhouse gas emissions from burning of fossil fuels, the consequences of rising global temperature include massive crop and fishery collapse, the disappearance of hundreds of thousands of species and entire communities becoming uninhabitable.

The largest source of carbon emission is electricity generation from fossil fuel based power generators. It accounts for 31% of the total carbon emission globally. In the United States alone, about 0.81 pounds of CO2 is emitted per Kilowatt hour of electricity generated from fossil fuel. As at 2023, carbon emissions from the power sector in Nigeria was 21.3 million metric tons of carbon dioxide equivalent (Sasu, 2024)

The world is passing through a period of unpredictable and extreme weather conditions (Climate Change). Climate Change otherwise known as Global warming is an environmental problem with multifaceted impacts of varying dimension. This means the world is experiencing an increase in

the daily average temperature of the earth's atmosphere. This phenomenon is scientifically known as Global warming or climate change.

Climate change mitigation or our ability to reverse climate change and undo its wide spread effects depends largely on successful enactments of policies that encourages or promote deep cuts on carbon pollution or carbon footprint (Courtney, 2024). During the United Nations (UN, 2021) conference COP26, on climate change held in Glasgow UK, agreement was reached via the representatives of over 197 countries that attended, to move towards reducing dependence on coal and fossil fuel sources. One of the key reasons is to create energy systems that protect and improve climate and health (WHO, 2021; Hunter., Salzman and Zaeike, 2021.) The aim of this paper therefore, is to provide an analysis of the engineering dynamics of fuel less generator and its carbon footprint reduction potential.

2.0 LITERATURE REVIEW

2.1 Conceptual review

In discussing this important subject, it pertinent to review some very important concepts that relates to the subject for our clear understanding and significance of this paper.

I. **Engineering dynamics**.

It is a branch of engineering that deals with the motion of rigid body under the influence of a force. The study of dynamics is divided into two subdivisions. Kinematics and kinetics. Kinematics deals with study of moving body without considering the force responsible for the movement or generated as a result of the motion. While Kinetics deals with action of force on bodies and the resulting motion. The basis of solid or rigid body in motion is the Newton's second law of motion which states that "A body of mass m acted upon by a force F, will experience an acceleration (Movement) a that has the same direction as the force and magnitude that is directly proportional to the force" However, when it comes to electricity and motion, Fleming's left hand rule and Fleming right hand rule are the important and applicable rules in magnetism and electromagnetism as a simple way of working out the direction of an electric current in electric generator or the direction of motion in an electric motor. Flemings rules however, do not determine the magnitude, but they only show the direction of the three important parameters (magnetic field, current and force) when the direction of the other two parameters is known. Fleming's rules build on the Faraday's law of electromagnetic induction which states that "When a conductor moves through a magnetic field, an electric current is induced in it". Fleming's right hand rule is used to determine the direction of the induced current. The right hand riles states that "If we arranges our thumb, forefinger and the middle finger of the right hand perpendicular to each other, then the direction of the motion of the conductor in relation to the magnetic field, the forefinger points in the direction of the magnetic field and the middle finger points towards the direction of the induced current". While the left hand rule stats that "When a current carrying conductor is placed in an external magnetic field, the conductor experiences a force perpendicular to both the field and the current flow's direction".

Therefore, Fleming's left hand rule is used to determine the direction of the force acting on the current carrying conductor placed in a magnetic field.

II. Carbon footprint

Carbon footprint refers to the amount of carbon dioxide emission from human activities. It is calculated by adding up all the carbon emissions from a product, event, persons or organizations. Carbon footprint is usually reported in tons of emissions. It includes direction emissions from driving a car and indirection emissions like energy used to produce goods. The term carbon footprint emanated from the idea of ecological footprint, which was developed in the 1990s. The term was later popularized by the oil and gas company BP in the early 2000s. Williams Rees (1992) an ecologist published an academic paper that used the term ecological footprint for the first time. Then in 1999, the British Broad Casting Corporation (BBC) Magazine vegetarian food magazine used the concept of carbon footprint for the first time. In 2003, BP launched an advertising campaign to encourage people to calculate their carbon footprint. In 2004, BP then hired an advertising firm (Ogilvy & Mather) to create the idea of a carbon footprint with sole purpose to shift focus away from the impact of large corporations and onto individuals' responsibility. The whole essence of the concept of carbon footprint is to determine how our collective human activities are contributing to climate change through carbon emission. According to the United nations Framework Convention on Climate Change, Carbon footprint is a change in climate attributed directly or indirectly to human activities that alters the composition of the world's atmosphere, UNFCCC, (1992) Cited in Lawrence (2008)

III. Greenhouse gases

Greenhouse gases retain the radiant energy (heat) provided to earth by the Sun in a process known as the greenhouse effect. Greenhouse gases occur naturally, and without them the planet would be too cold to sustain life. However, human activities are introducing more and more amount of these gases into the atmosphere (). For example, the burning of fossil fuel such as gasoline, diesel, coal for energy generation to power domestic residence, industrial factories and for transportation is increasing the levels of carbon dioxide, nitrous oxide and sulphur oxide which are powerful greenhouse gases in the atmosphere. Greenhouse gas emission is a key factor that has been identified to be responsible for climate change. Greenhouse gases include Carbon dioxide (Co_2), Methane (CH_4), Nitrous Oxide, Synthetic Chemicals such as chlorofluorocarbons (CFCs), ,hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

IV. Climate change

The world is passing through a period of unpredictable and extreme weather conditions (Climate Change). Climate Change otherwise known as Global warming is an environmental problem with multifaceted impacts of varying dimension. This means the

world is experiencing an increase in the daily average temperature of the earth's atmosphere. This phenomenon is scientifically known as Global warming or climate change. Climate Change or Global Warming is the measurable increases in the average temperature of earth's atmosphere, oceans, and landmasses. It is the believe of Scientists that the earth is currently facing a period of rapid warming brought on by rising levels of heat-trapping gases, known as greenhouse gases, in the atmosphere. This period of rapid warming of the earth, seas, oceans and atmosphere is what we refer to as climate change era.

V. Cleaner energy

Clean energy refers to nergy that doe not pollute the environment and usually come from sources that nevers runs out or get depleted. Their by product have no a minimal effect on the environment Clean energy include solar and wind power energy. This energy are considered clean because they do not produce carbon dioxide which has been identified as one the major causes of climate change. Because the emission of greenhouse gases from the burning of fossil fuel, there seems to be a consensus all over the world on the need to shift from conventional energy sources to cleaner energy. Analyst opine that a shift to cleaner energy will take time, technological development and political will, but is possible and doable. For instance, the United States (US) energy Information Administration reported that the electric power sector accounted for about 39% of total U.S. renewable energy consumption in 2023, and about 21% of total U.S. electricity generation was from renewable energy sources. (USEIA, 2024)

VI. Fuel less generator

As the world grapples with the effect of climate change occasioned by greenhouse gasses emission, there is the clamor for green and cleaner energy sources. These are energy sources that do not produce greenhouse gases such as carbon dioxide and nitrogen oxide. They do not pollute the environment. Fuel less energy as an example of clean energy. It does no produce greenhouse gas in its operation. Fuel less generator is a device that generates electricity without using fuel, such as gasoline, diesel or gas. They are powered by a battery that drives a Direct Current (DC) Motor which turns an alternator to produce electricity. According to the alternative energy company directory), Fuel less generator is a new source of power that is completely safe, free and efficient (Altenergymag, 2024)

VII. Environmental cost

Pollution of the environment causes harm or damage to the environmental that can be quantified in monetary terms. Such quantification in term of monetary cost is refer to as environmental cost. Therefore put, environmental cost is the cost associated with the damage to the environment caused by human activities. These costs include the cost of cleaning up pollution, restoration of damaged ecosystems and cost of mitigation of climate change according to the IGI Global publishing (2025)

3.0 METHOD

3.1 Design and construction of fuel less generator

The design and construction of a fuel less generator consist of the following components.

12v battery, DC electric motor, connector rod, alternator, voltage stabilizer, electric motor control panel. Schematic diagram of a fuelless Generator is presented in Fig 3.1

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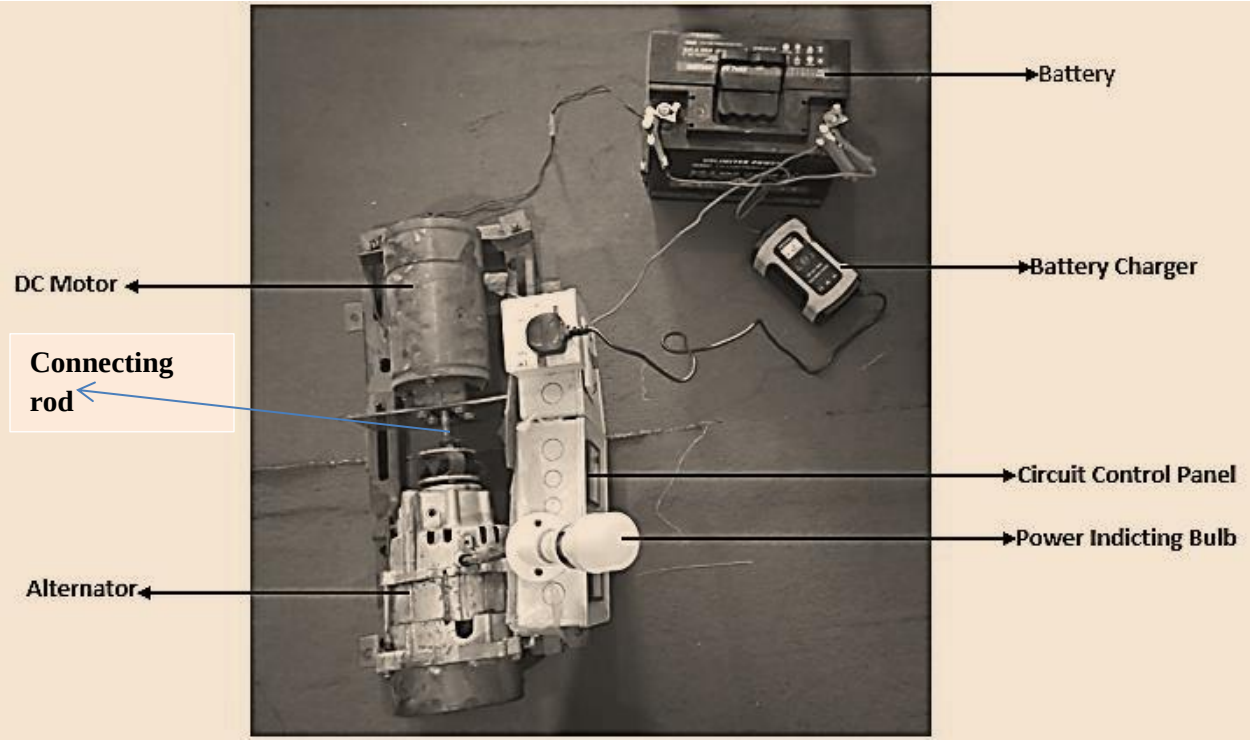

Fig3.1: Fuel less Generator with Battery Charger. Source (Tunji et al., 2023)

The battery is used to power the motor, as the electric current from the battery enters the motor through a wire winding. The electric current in the wire winding interact with the electric field in the motor to generate a twisting or a turning force called torque. The torque applied a turning effect on the shaft of the electric motor which brings about the rotation. The rotationary motion of the electric motor is further transmitted to the alternator through a connector rod. The alternator then converts the mechanical energy of the electric motor to electric energy. The electric current from the alternator is pass through a voltage regulator or stabilizer that helps to step up and stabilize the output voltage. The output current from the regulator is used power electric appliances and also

charge the battery through a charging device and thereby making the fuel less generator a self-sustaining system. Generator without the need of fossil fuel

3.2 The Engineering dynamics of fuel less generator

The Torque which cause the rotation of the DC motor shaft about its axis is the product of the electric force applied and the radius at right angle to which the force acts. This is represent by the equation

$T = F \times R$ (3.1)

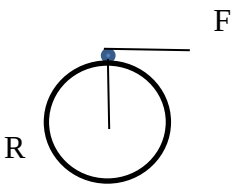

Fig 3.2: schematic diagram of the relation between force and the radius of the electric motor armature

Where F is the force acting on the circumference of the armature of the motor and R the radius of the armature.

When the armature of the DC MOTOR rotates under the influence of of the driving torque, the armature conductors the magnetic field and thereby generate an electromotive force E.M.F. this electromotive force acts in opposite direction to the voltage applied and it is therefore known as the back or counter E.M.F denoted by E_b. The electric work done in overcoming and causing electric current to flow against the E_b is converted into mechanical energy developed in the armature. Therefore the energy conversion in D.C motor is only made possible by the production of the back E.M.F.

The net voltage in the armature is thus represented by the equation

$V_a = V - E_b$ (3.2)

If R_a is the electric resistance of the armature circuit then the current in the armature is represented by the equation

$I_a = \frac{V - Eb}{Ra}$ (3.3)

Therefore $V = E_b + I_a R_a$ (3.4)

Power generated by a D.C motor is represented by the equation

$VI_a = E_b I_a + I^2_a R_a$ (3.5)

Where VI_a = the electric power supplied to the armature (armature input)

E_bI_a = Power developed by the armature (armature output)

$I^2_aR_a$ = electric power wasted in the armature (armature cu loss)

Therefore small (about 5%) of the armature input is wasted and only the remaining portion which is E_bI_a is actually converted into mechanical power within the armature.

The maximum power P_m developed by electric motor is E_bI_a

$$P_m = VI_a - I^2_aR_a \quad (3.6)$$

the torque which is available at the motor shaft to turn the alternator is is known as the shaft torque and is represented by T_{sh}

part of the total torque developed at the armature of a motor is loss in overcoming the resistance of iron and frictional losses in the iron. the frictional loss torque is given the equation

$$Ta - T_{sh} \times 9.55 \times \frac{Iron\ and\ friction\ loss}{N} \quad (3.7)$$

Where N is the number of revolution per minute (r.p.m)

Efficiency (**ɳ**) of the electric motor in generating electric power for useful work is represented by the equation

$$\eta = \frac{output}{input} \times 100 = \frac{Output}{output+losses} \times 100 \quad (3.8)$$

Secondary battery charging time can be determine by Electrical technology equation as shown bellow

$$T = \frac{AhA}{A} \quad (3.9)$$

Where Ah is Ampere per hour and A is current in Ampere
Based on the charging current given, the formula can be used to compute the needed to fully the charge a battery to keep the generator in continues operation.

3.3 Analysis of carbon footprint reduction by the use of fuel less generator

Carbon dioxide emission from the use of fossil fuel to generate electricity for domestic use and small business may seem very small but when considered holistically, it will amount to a significant cumulative amoun, Nigeria, Africa most populous country produces less grid electricity for public use hence many household depend on gasoline electricity generator to produce their own energy need. This has resulted to spending of considerable amount of money to purchase, repair, maintain portable and industrial electricity generators since it has become the most common alternative for households, businesses and industries.

$$CO_2EMg = QP \times EF \quad (3.10)$$

Where CO_2EMg is the Quantity of CO_2 emission per year of petrol (in tonnes of CO_2)

Qg is the quantity of gasoline (in litres per year)

EF is the CO_2 emission factor (2.296kgCO_2/l) as adopted from Malik and Srivastava

According to report by (Stears and Sterling) cited in Punch news paperJuly, 2022. 40% of Nigerian household use generators and spend $14bn on fuel annually. 6.8 hours of is self supplied by generators. Data from Nigeria Midstream and Downstream Petroleum Regulatory Authority cited in Punch news paper 27th October, 2024) indicated that fuel consumption dropped from 60 million to 4.5 million litres per day as at August, 2024

As at July 2024, the population of Nigeria was estimated to be around 229.5 million. Nigeria is the most populous country in Africa and sixth in the world. The average household size in Nigeria is 5.06 (Doris, 2024)

From the above statistics the number of households in Nigeria is computed using equation

$$NHH = \frac{TP}{HS} \qquad (3.11)$$

Where NHH is Number of household

TP population of Nigeria

HS is Household size

$$NHH = \frac{229500,000000}{5.06} = 45.36M$$

Therefore Number of Nigeria household that use generator to generate electricity for domestic use

$$NHG = 40/100 \text{ X } 45.36m \frac{40 \ x \ 45.36M}{100} = 18,142,292.4901$$

Where NHG is number of Nigeria household that use generator

The average quantity of gasoline use by Nigeria household (QGNH) daily is 5litre.

Therefore the Quantity of CO_2 emission (CO_2EMg) per year of petrol (in tonnes of CO_2) by Nigeria household is 18142292.49 X 5 X 2.296kgCO2

= 208,273517.79kg

From the above analysis therefore, substituting fuel less generator for the conventional gasoline generator used by household to generate electricity for domestic use will reduce Nigeria carbon footprint by 208,273,517.79kg per year.

4.0 RESULTS AND DISCUSSION

4.1 Results

The results of the evaluation of the various parameters for the quantification of carbon footprint from domestic electric power generation through gasoline by Nigeria households per year are presented in Table 4.1.

Table 4.1: Results of evaluation of parameters for determination carbon footprint rom household domestic power generation in Nigeria.

S/N	ITEM	QUANTITY
1	CO_2 emission factor **(EF)**	**2.296kgCO_2/l**
2	Total population of Nigeria **(TP)**	**229.5 Million**
3	Average of Nigeria house hold size **(HS)**	**5.06 persons**
4	Number of households in Nigeria **(NHH)**	**45.36 Million**
5	Number of Nigeria household that use generator to generate electricity for domestic use **(NHG)**	**18,142,292.4901**
6	Average quantity of gasoline used by Nigeria household daily (QGNH)	**5Litre**
7	Quantity of CO_2 emission (CO_2EMg) per year of petrol (in tonnes of CO_2) by Nigeria household	**208,273,517.79kg per year**

4. 2 Discussions

As the world grapples with the effect of climate change occasioned by greenhouse gasses emission, there is the clamor for green and cleaner energy sources. Fuel less generator provides a veritable alternative for domestic power generation as a clean and greener energy for the mitigation of climate change. This study has analyzed the engineering dynamics and the carbon footprint reduction potential of fuel less generator. The study reveals that in the fuel less generator battery is used to power a DC Motor which convert the electric energy from the battery into mechanical energy. The mechanical from the Motor is further converted to electric energy via connecting rod or belt that connect the motor and an alternator. Force behind the rotation of the armature and shaft of the motor is analyzed as the torque. The force that is loss in the armature of the motor is also analyzed as the back e.m.f. From the gross current the output of the fuel less generator and the energy efficiency is also determined from the engineering evaluation. The Results of the evaluation of parameters for the determination of carbon footprint reduction potential if household use fuel less generator rather the conventional fossil fuel electricity generator are presented in Table 4.1. data on Carbon emission factor, (EF) total population of Nigeria (TP) as at July 2024, size of Nigeria household(NHH) were collected from secondary sources. These data were used the analysis. The results presented in Table 4.1 show that CO_2EMg is the Quantity of CO_2 emission per year of petrol (in tonnes of CO_2) is (2.296kgCO_2/l) as adopted from Malik and Srivastava.

Total pollution of Nigeria is 229.5 Million. Average of size of Nigeria house hold (HS) is 5.06 people. Number of households in Nigeria (NHH) is 45.36 million. Number of Nigeria household that use gasoline generator to generate electricity for domestic use (NHG) is 18,142,292.4901Million. Average quantity of gasoline used by Nigeria household daily (QGNH) for electricity generation is 5 Litre per day and Quantity of CO_2 emission (CO_2EMg) per year of petrol (in tonnes of CO_2) by Nigeria household from electricity generation is 208,273,517.79kg per year. Therefore household use of fuel ess generator for generation of domestic electric power has the potential to reduce Nigeria carbon footprint by 208,273,517.79kg yearly (208,273.52 metric tons per year). Online literature reports show that as at 2022, Nigeria carbon dioxide emission s were 122,750,410 tons at estimated population of 223150,896. That translates 0.56 tons of carbon emission per person A study by (Chijoke, *et al*., 2022) to investigate the carbon dioxide emissions emanating from the consumption of fossil fuels for the generation of electricity for the running of business and administrative activities in Federal University of Technology Owerri (FUTO), emission of carbon dioxide from diesel and gasoline generator was estimated at 1460.20tons of carbon per annum within the institute, with diesel generators accounting for 59% and gasoline generators accounting for 41% of the total carbon emission. Similar study by Ologun and Wara (2014) cited in Chijoke et al., 2022) also showed that annual carbon emission from power generating sets in Federal University of Agriculture, Abeokuta (FUNAAB) is about 1365 tons of carbon per annum. While in Abia State Polytechnic Aba (ASPA) total carbon emission from power generating set was estimated to be 77 tons of carbon per annum as reported by (Igbokwe, et al., 2018).

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The world is experiencing of period of extreme and unpredictable weather conditions and patterns otherwise known as climate change. This is characterize by increase in average atmospheric temperature over the earth. The effects of climate change are harmful and can be disastrous to the environment and human existence. The effects include; hotter temperatures, More severe storms, increased drought, a warming and rising ocean, loss of biodiversity, food scarcity or shortage more health risk, poverty and human displacement. Available literature reveals that climate change is the earth's greatest existential threat. Climate change is cause by increase in greenhouse gases or heat trapping gases concentration in the atmosphere, of which carbon dioxide is the chief of them. The largest source of carbon emission is electricity generation from fossil fuel based power generators. It accounts for 31% of the total carbon emission globally. Climate change mitigation or our ability to reverse climate change and undo its wide spread effects depends largely on successful enactments of policies that encourages or promote deep cuts on carbon pollution or carbon footprint. The analysis of engineering dynamics and carbon footprint reduction potential of fuel less generator has been undertaken in this study. The study reveals that adoption of fuel less generator by household for domestic electricity has the potential to reduce Nigeria carbon footprint by 208,273,517.79kg yearly (208,273.52 metric tons per year)

5.2 Recommendations

Based on the findings of this study, it is recommended that:

The production of fuel less generator in Nigeria is still at a pilot scale and it is proving successful so far. Hence government should train more engineers and technologist with view to optimizing the production and efficiency of homemade fuel less generators.

As the federal government is giving much attention and emphasis on the Presidential Compress Natural Gas Initiative (PCNGI) aimed at reducing transportation cost in Nigeria, similar scheme or program should be established to carter for mass production of fuel less generator at lower cost in Nigeria.

Individuals and households should go for fuel less generator as an alternative to the conventional fossil fuel generator in order to reduce carbon footprint from domestic electric power generation.

There should be vigorous public enlightenment campaign on the effectiveness of fuel less generator and its environmental and economic benefits or advantages.

State Governments should establish fuel less generator assembly factories in their various states as deliberate and strategic step towards mitigating climate change

REFERENCES

Altenergymag, (2024). The next phase in power management. www.altenergymag.com

Chijoke M. Amakom., Oluwasogo A. Ogungbenro and Joseph Okoye (2022). Annual Carbon Footprint from Local Electricity Generation in Federal University of Technology, Oweri, Imo State, Nigeria. Accessed online at https://journals.sagepub.com.

.Courtney Lindwall (2024). What are the effects of Climate Changr? Data, Reports & resource guide of the Natural Resources Defense Council (nrdc). Accessed online at www.nrdc.org/stories

Doris Dokua Sasu (2024). Population of Nigeria in selected years between 1950 and 2024. *Society demographics*. Accessed online www.statista.com/statistics/1122838/population

Doris Dokua Sasu (2024). Carbon emissions from electricity generation in Nigeria 2000 2023accessed online at www.statista.com/stat

Fleming's left hand rule and Fleming's right hand rule, retrieved from www.byjus.com/physics on the 17th February 2025

Igbokwe EE, Okparaku VI, Igbokwe KK Isu j, Ndukwe PU (2018). Estimation of carbon footprint from fuels (gasoline and diesel) as an instrument of attenuating climate change:

Case study of Abia State Polytechnic, Aba, Abia State, Nigeria. *Int Res J Eng Tech*. 2018; 5:26 – 34

IGI global publishing (2025). What is environmental costs retrieved online on the 17th February 2025 from www.igi-global.com.dio

Imoleayo Oyedeyi (2024). Fuel consumption: 10,000 marketers may shut down over massive drop, high cost. Punch News paper, 27th October, 2024. Accessed online on 3rd February, 2025

Lawrence Boisson De Chazournes (2008).United Nations Framework Convention on Climate Change. United Nations Audiovisual Library of International Law available at. www.un.org/law/avl

Malik KT. And Srivastava P (2019). Calculation of carbon footprints in semi urban areas of Jammu, J&K (India). *Environ Conser J 20: 333- 38*

NASA (2024). Carbon Dioxide latest mneasurements; December 2024. Accessed online at www.climate.nasa.gov/

Okechukwu Nnodim (2022). 40% Nigerian households use generators, spend $14bn on fuel Report. Punch news paper of 3rd July, 2022. Available online at www.punchng.com/40

Ologun OO, Wara, ST (2014). Carbon footprint evaluation and reduction as a climate change mitigation tool- case study of Federal University of Agriculture Abeokuta, Ogun State, Nigeria. *Int J Renew Energy Res*. 2014; 4:179-180

Tunji John Erinle., Ayodeji Babatunde Falana and Ogooluwa Tunji Oladipupo (2023). Design and Fabrication of an Environmentally Friendly Generator Harnessing Electric Motor and Alternator for Pollution-Free Power Generation. 1st International Conference of Engineering and Earth Sciences (ICEES)-2023 *Climate and Environmental Changes: Emerging Advances in Engineering and Earth Sciences Management. Volume 1, Issue 1*

United Nations (2024). Causes and effects of Climate Change www.un.org/en/climate

United States Energy Information Administration (2024). How much carbon dioxide is produced per Kilowatthour of electricity. www.eia.gov

United States Energy Information Administration (2024). Renewable energy explained. www.eia.gov/energyex

World Nuclear Association (2024). Carbon dioxide emission from electricity. Energy and Environment. www.world.nuclear.org