Sources of Industrial Energy Use in the 9th Mile Area of Enugu State, Nigeria

Ogbu, S. Okonkwo[1] and Ugwoke, Agatha Chinwe[2]

[1,2]Department of Geography and Meteorology, Enugu State University of Science and Technology (ESUT), Enugu, Nigeria Email: simokogbu@gmail.com or uagathachinwe@gmail.com

Abstract

Energy is important in industrial activities because no production processes of any sort can take place without its utilization. This study examines the industrial energy sources at Udi industrial area of Enugu State, and to determine if their sources and utilization are environmentally friendly or not. Purposive sampling technique was adopted, and 32 management members (64%) of the 50 available and functional industrial plants as well as 160 employees formed the study population. The field data were collected using the methods of questionnaire, guided interview, and field observation. Data obtained were analysed using percentage, pie graph, and descriptive statistical methods. The result of the analyses reveals that the available energy sources in the area are electricity from Enugu Electricity Distribution Company (EEDC) (50.8%), installed generators in the factories (46%), and firewood (3.2%). It was found that 12.5% of the 32 industrial plants use EEDC as the only available source of energy for them in the area. They are sited at Ngwo-Uno in the East, Ameke in the North and North-West, and Nsude in the South of the area in the ratio of 1:2:1 respectively. Thus, in sourcing for energy for industrial uses in the area, there are insufficient applications of modern methods or techniques of biotechnology, biomass, wind, and solar energy sources. It is therefore, recommended for the industrialists to source and use energy sources like solar, wind, biomass, and biotechnology that are renewable in industrial activities in the area, and reduce over dependency on oil and its resources as energy sources in the study area.

Keywords: Energy, energy source, industry, industrial area and utilisation

Introduction

Global energy demand is projected to increase rapidly in coming years, with population growth and lifestyle changes in developing economies, placing ever greater demand on current energy supply grids. This may be particularly true for Africa, where economic development is directly linked to energy demand, a 1.0% growth in GDP is projected to require 0.55% increase in energy production. Moreover, Africa constitutes approximately 13.0% of the world population but consumed only 5.6% of the global energy supply as of 2001(United Nations Economic Commission for Europe (UNECE), 2016). Therefore, it is expected that African per-capita energy use (ca. 41% of the global average) is likely to increase with growing trade, changing lifestyles, and improving infrastructure. For instance, because of its inadequate access to modern energy sources such as kerosene, liquefied petroleum gas (LPG) and electricity, Sub-Saharan Africa (SSA)-with the exception of South Africa, where coal is an important fuel - has the largest proportion of its population relying on traditional biomass, mostly comprised of firewood and charcoal. SSA also represents the world's highest regional per capita wood energy consumption, with an average consumption of 0.69 m^3/year in 2011, compared with a global average of 0.27 m^3/year (Trossero, 2002 and UNECE, 2016). An estimated 93.0% of households in SSA depend on wood energy for their daily cooking needs. While firewood remains the preferred choice in rural areas, charcoal is especially popular in urban markets because of its higher energy content, ease of storage and transport, and lower smoke production compared to firewood. Charcoal is likely to become even more important in the future as fossil fuels become less attractive due to environmental and financial costs. Various case studies have reported an increase in charcoal use in SSA urban centers and this trend is expected to increase in the future, due to the absence of affordable alternatives. In more developed world as in Europe and America the trend in the use of energy is towards modern alternative sources that permit the use without much damage to environmental resources that are targeted towards environmental sustainability. Such alternative sources of industrial power are coal, Hydro-Electric Power (H.E.P.), and petroleum (oil and natural gas), wind, solar, and nuclear energy sources (Bacelona Field Study Center (BFSC), 2007; Sloagett & Woods, 2003; Asimov, 2003; and Intel Corporation, 2005). Some of these energy sources in their processes for use contribute a lot in environmental degradation and pollution, while others are environmentally friendly and impact minimally on the environment. It is on this premise that this study examined industrial energy sources in the area and their implications on the environmental sustainability.

Description of the Study Area

The study area is Udi Local Government Area of Enugu State in the South Eastern part of Nigeria. It is bounded by Enugu North and South, in the East and West by Ezeagu, North by Uzo-Uwani and Igbo-Etiti, and South by Oji-River and Awgu LGAs (Fig.1). It lies geographically between latitudes 6^0 24′ and 6^0 26′ North of Equator, and longitudes 7^0 23′ and 7^0 25′ East of Greenwich Meridian (Fig. 2). The area is a nodal environment, being found at the junctions of many roads. Such roads are Enugu to Markurdi expressway, Enugu to Onitsha dual carriageway, and subsidiary roads of Oji-River - Udi- Ngwo - Enugu road, Nsukka - Okpatu - Abor- Enugu road, Nsukka - Enugu road, and Ezeagu- Eke - 9th Mile - Enugu road. It comprises Ngwo (Ngwo-Uno and Ameke) and Nsude communities in Udi L.G.A. of Enugu state with population projected (based on the National Population Commission (NPC) (2006) recommendation of 2.83% annual increase in population for Nigeria) to 48,719 persons for 2019.

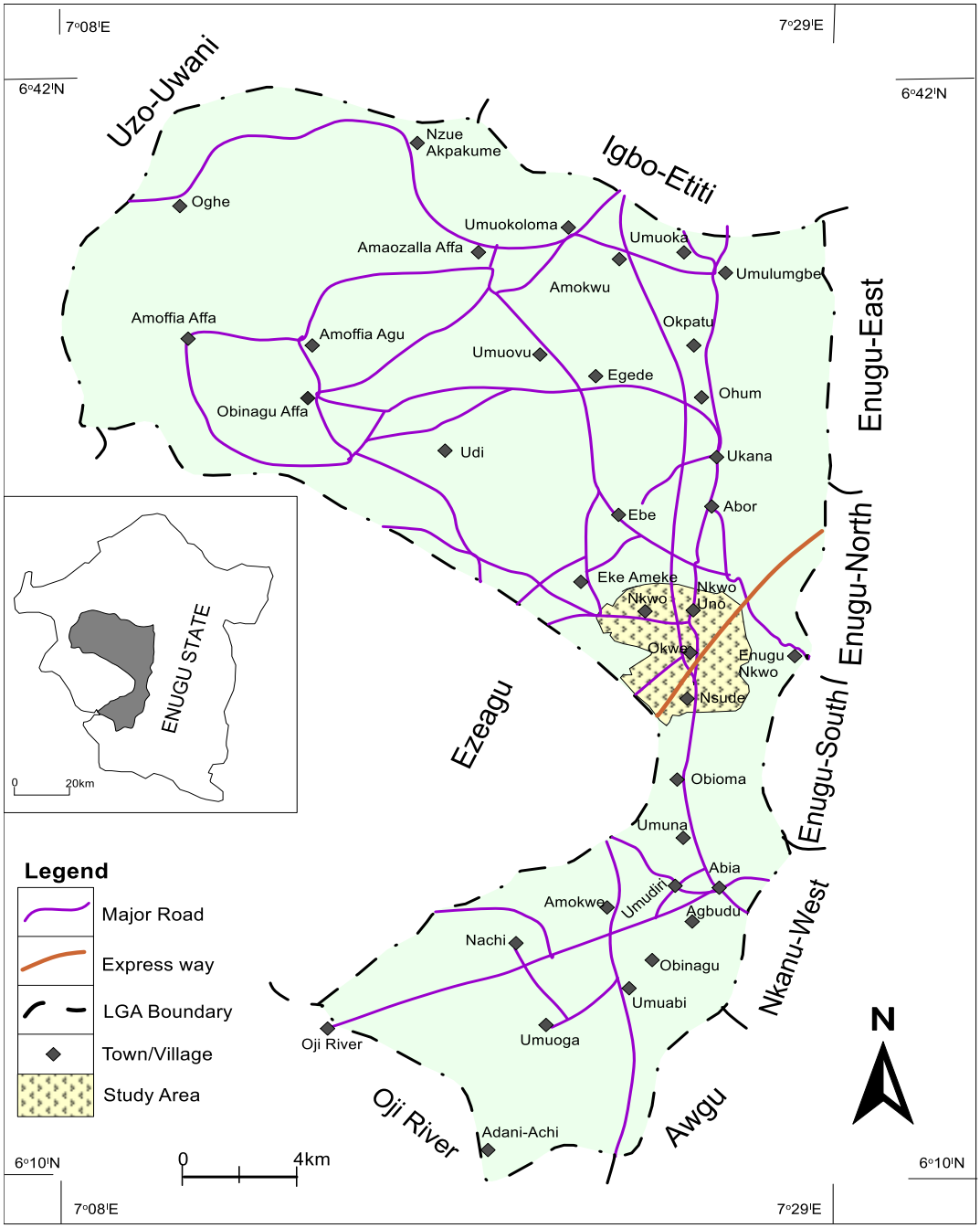

Fig. 1: Udi LGA Showing the Location of the 9th Mile Area.
(Source: Town planning office, Udi LGA, 2010)

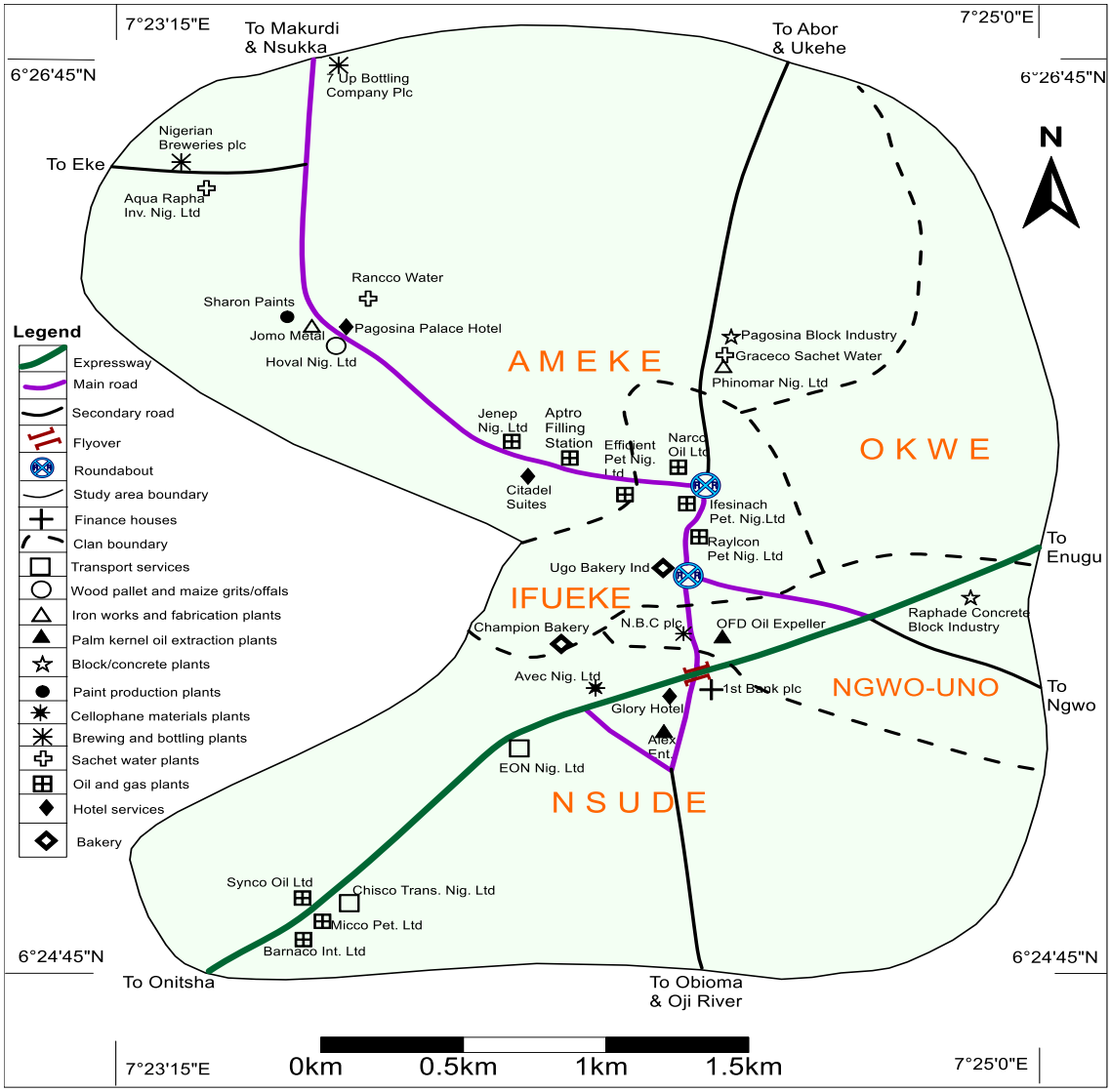

Fig. 2: The 9th Mile industrial area, and the sampled industrial plants
Source: Adopted from Ehirim (2001), and fieldwork, 2019

The relief is formed by sandstone rocks that can hold large quantities of water in the pore spaces, which is an important source of water for industrial and human uses. This explains the reason for easy access to groundwater in the area, and why bore holes are common in the area. Up to 70.0% of the vegetation cover is grass such as elephant grass *Pennisetum purpureum*, while trees found in the area include gmelina *Gmelina barborea*, palm tree *Elacis guineensis*, etc (Ozonnadi, 2007). Sand deposit used in building constructions is an important resource in the area. Furthermore, the settlers undertake a lot of petty jobs like

peasant farming, oil palm processing, roadside mechanics, block industries, carpentry, petty trading, and own business centers (Ehirim, 2001). Examples of such industries are those that exploit water resources from the environment like Aqua Rapha Investment Nig. Ltd., manufacturing industries like Avec Nig. Ltd and Ugo Bakery Industry, Transport Agents such as E.O.N. Nig. Ltd and Chisco Transport Nig. Ltd (Haulage Division), and oil and gas service providing activities of Narco Oil Nig. Ltd and Efficient Petroleum Nig. Ltd. These industries use different sources of energy in their production activities like wood, petroleum, and electricity from the national source.

Literature Review

Almost every modern industry uses some form of energy/power, although the amount/volume varies according to the nature of activity and the kind of technology applied (Trossero, 2002 and Ogbu, 2014). To Asimov (2003), energy is the ability to do work, and it is required to provide heat and as a motive force. The main sources of modern industrial energy are coal, Hydro-Electric Power (H.E.P.), and petroleum (oil and natural gas) (BFSC, 2007; Sloagett & Woods, 2003; Intel Corporation, 2005). Others are animal, wood, water, and nuclear energy sources (Asimov, 2003). In another perspective, the possibility of substituting one source of energy for another in many industries has been important in bringing about changing emphases in industrial energy sources over time. The reason given by Asimov (2003) is because of technological advancement which has progressively altered the conditions of demand for energy. This explains the reason why the effect of energy supply sources on industrial processes usefully adopted a chronological approach in sources, time, and specified uses as found on Table 1. Before the second half of 18th century, the main sources of energy were wood, wind, and water. Water provided a steady source of energy and industrial sites were near swiftly flowing streams (waterfall) (Cortright, 2001a; 2001b). Also, hydropower is an important renewable energy resource worldwide (Mussa, Teka & Ayicho, 2018). However, the major environmental effects of hydropower are flooding and consumption of large land area which destroys forest, wildlife habitat, agricultural land, and scenic lands (Concerned Scientists, 2013). Again, hydropower does not pollute the water or the air, but its facilities change the environment and affect land use, homes, and natural habitats, and its development is accompanied with environmental drawbacks-change in hydrological flow regimes, deteriorating water quality, migration corridor barriers, sedimentation, and greenhouse gas emission (Mussa, Teka & Ayicho, 2018).

Table 1: The chronicle of energy sources in industrial activities

Source	Approximate time	Specified uses
Man and Animal	Prehistoric (time before recorded history).	Transportation
Wood	Prehistoric and early historic (1880).	Domestic cooking space heating and handicraft.
Wind	Early historic period (time of known and recorded history).	Transportation
Water	Pre-historic-18th century	Handicraft, crude mills and transportation.
Coal	13th – 20th century (1920)	Domestic cooking and space hearting.
Steam power	18th-19th century	Steam engines for factories, and transportation.
Petroleum	19th (1859) – 20th century	Space heating, domestic cooking, lighting, motors for transportation.
Electricity	Late 19th – 20th century	Motors for factory machines, transportation, space heating and lighting, and domestic cooking.
Wood, coal, petroleum	Early 20th century	Generation of electricity.
Nuclear energy	2nd half of 20th century	Generation of electricity and specialized uses like manufacture of nuclear weapons.
Fossil fuels (petroleum, coal, natural gas), water power, and nuclear energy. Others are wood, solar, tidal, chemical, and geothermal energy	Late 20th and 21st centuries	Heating, lighting, cooling, transportation, smelting (reduce ore content by fusion), welding, cooking, work machines, process information, entertainment, drilling, saws, assembly lines, examine patients and perform medical tests, conduct research, production.
Fuel cells, solid and liquid wastes, hydrogen and mergnetohydro-dynamic (MHD) convert fuel directly into generators electric energy.	Future	Development of the 21st century uses especially in the areas of communication.

(Sources: Adopted from Wolfson, 2004; Catania, 2004; Udall, 2003; Ogbu, 2014).

By the time these difficulties could be overcome, coal was forming an alternative source of energy. By mid-19th century, steam power played part in manufacturing as in U.S.A. (Craft & Mulatu, 2006). Thus, steam overcame the serious limitation of water, being more reliable and within limits more mobile to become the principal reason for the growth of the great industrial concentration on the coalfields of United Kingdom (U.K.) (Estall & Buchaman, 1973).

The next important energy source is the use of wood for energy (Brito, 2007). Logs, wood chips, brush clippings and grasses all serve as woody biomass-renewable fuels suitable for producing heat and power (Sunshine, 2017) and occur in the form of fuel, such as firewood, charcoal, chips, sheets, pellets, bark, straw, biogas, black liquor, energy crops, and sawdust. The particular form used depends upon factors such as source, quantity, quality and application. Approximately 60% of the world's total wood removals from forests are used for energy purposes (Trossero, 2002). Only 30% of the wood produced in developed countries is used for energy (33% in Europe and 29% in North America). Woody biomass covers 21% to 23% of the primary energy demands of Finland and Sweden, and 14% to 16% in Estonia and Austria. Woody biomass accounts for over half of the renewable energy supply in the Nordic and Baltic states as well as in Armenia, Republic of Moldova, Serbia, Slovenia, Czech Republic, and Luxembourg (UNECE, 2016). In developing countries like Nigeria and Ruanda that amount reaches 80%. In Africa, Asia and Latin America fuel wood account for 89%, 81%, and 66% respectively of total wood consumption (UNECE, 2016).

By the mid-20th century, oil (petroleum) was being increasingly used as the main source of energy (Intel Corporation, 2005). Oil possesses advantages of transportability, easily handled in loading and discharging, less volume, higher energy value, lower cost of movement, clean and relatively convenient, and more easily controllable. However, the main effects of oil as an energy source upon industrial activity resulted from its relative mobility. Thus, power supplies in the modern world possess flexibility tendencies (more ubiquitous) since new forms of energy (electricity) were introduced and the means of transporting them were made easier and cheaper.

Another modern industrial energy source is nuclear energy which is used to produce electricity. Nuclear energy is clean, cheap, and sustainable. Moreover, it is effective at supplying energy for submarines, cancer treatments, and growing agricultural productions. This energy source is reliable, does not emit greenhouse gases and pollute water. Maehlum (2018) and Kuet (2018) added that it provides a stable base load of energy that can work synergistic with renewable energy sources such as wind, more beneficial in terms of the

climate crisis, to replace other energy harnessing methods in use today with nuclear power. But it releases harmful amounts of radiation into the environment during the process of regular use, and it requires precautions in mining and handling as revealed by Asaff (2015) and Barnard (2017). Also, nuclear waste is potentially harmful for both humans and the environment.

These various sources of energy are spatially different in both availability and usage. The more developed areas have better opportunities in sourcing and uses of energy than the less developed parts of the world. In Nigeria, energy sources are few and the technology available in the use of energy is inadequate. The main source of energy in use in industries are wood, hydro-electric power (H.E.P.), and petroleum (oil and natural gas) (Ogbu, 1998 and 2014) with petroleum dominating because the supply of electricity (only through Nigerian Electric Power Authority (NEPA), which later changed to the Power Holding Company of Nigeria (PHCN), and now to Electricity Distribution Companies of Nigeria (EDCN)) is erratic, and epileptic in supply.

These energy resources as indicated by Umar and Abubakar (2014) are classified as either renewable (flowing water, wind, geothermal, solar, hydrogen, biomass) or non-renewable (petroleum, coal, natural gas, uranium). The non-renewable energy resources account for 82% of the world's energy consumption (76% from fossil fuel and 6% from nuclear power), while the remaining 18% comes from renewable energy sources such as biomass (11%), hydropower (4.5%) and geothermal, wind and solar energy (2.5%) (Umar & Abubakar, 2014). In this sense, Helder (2015) in his study on energy sustainability explained that the better energy sources for abundant, cheap, sustainable, and available to everyone everywhere are hydropower, wind power, solar panels, and biomass. It is in line with these discussions that this study was necessitated in order to identify the energy sources and use in the study area. Also important was to determine whether the various energy sources for industrial activities in the study area are sustainable and friendly to the environment or contribute in small measure to environmental pollution and degradation.

Materials and Methods

Relevant data were collected through questionnaire, guided interviews, and field observations. Both structured and unstructured questionnaire were designed for every respondent in this study. In addition, pilot texting was conducted on Alex enterprise in order to determine whether the items were clear enough and easily understood. Guided interview which is personal contact between the interviewer and the respondents supplemented the questionnaire.

Only 32 of the 50 functional industrial plants were sampled in this study because 18 of them, for restrictions on the release of information concerning them refused to fill our questionnaire. Thus, only those industrial plants that released information pertaining to their energy sources and use were involved in this study. Also, 160 of the studied industrial workers/employees were used in this work. Five (5) employees were purposively selected from each of the 32 industrial plants. The choice of 5 employees was facilitated and informed by the fact that Alex Enterprise has only 7 employees and 5 of them were accessible to the study during the period of pilot testing. Again, the refusal of many employees to attend to the study restricted this study to only 5 employees in each of the studied industrial plants. Moreover, similar information was obtained from the management of the sampled industrial plants. Thus, they are good enough to confirm and validate information from other sources. Therefore, the study used 160 employees of the 32 industrial plants, and the management (any of director, plant/factory manager, human resources manager, and production manager) of the 32 studied industrial plants as respondents in this study. In this study, descriptive statistical technique, percentages and pie graph were used in the analyses of the field data.

Results of the Findings

The sources of energy/power in use to produce products, drive machines or to move materials and products, heat objects such as oven for baking, and for chemical and electrolytic processes as in the fabrications of machine components for the industrial plants are mainly electricity from Enugu Electricity Distribution Company (EEDC), firewood, and petroleum via generating plants installed by the studied industrial plants in the study area (Table 2). In the study area, industrial plants are all scattered in their locations along the national lines/sources of electric power. This is true because every industrial plant is hooked up with power source from EEDC as the main source, and 12.5% of the 32 industrial plants (O.F.D. Oil Expeller, Pagosina Block Industry, Alex Enterprise, and Graceco Sachet Water) have no other sources of power except EEDC (Table 2). They are located at Ngwo-Uno in the East, Ameke in the North and North-West, and Nsude in the South (Table 2) in the ratio of 1:2:1. Since these industrial plants convert one form of materials or the other to better products (manufacturing), national sources of energy/power (EEDC) are very important because of the volume of energy requirements. Therefore, EEDC is the main source of energy at the 9th Mile area of Enugu State. The spatial distributions of other industrial plants are as shown on Table 2. In addition to power from EEDC, 87.5% of the 32 industrial plants have stand-by generating plants in their factories (Table 2). The aim is to supplement and avoid erratic and epileptic power supplies from

EEDC. More so, as found on Table 2, Ugo Bakery Industry, and Champion Bakery (3.2%) have firewood as their third power sources. These two industrial plants that are located at Ifueke in the central part of the area perform similar activities of bakery and use a lot of firewood that are sourced from markets in the neighbourhoods. From this result, the modern electric oven is not yet available for use in the study area. This means that the availability of energy is very significant in industrial locations in the area. This is because every industrial plant studied is located where access to energy supply especially energy from EEDC is available.

Table 2: Sources of energy/power for industrial plants at the 9th Mile area

S/N	Industrial plant	Clan of location	Sources of energy		
			EEDC	Generator	Firewood
1	Nigerian Bottling Co. Plc	Ngwo-Uno	X	X	-
2	O.F.D. Oil Expeller	Ngwo-Uno	X	-	-
3	7up Bottling Co. Plc.	Ameke	X	X	-
4	Pagosina Block Industry	Ameke	X	-	-
5	Rancco Water	Ameke	X	X	-
6	Jomo Metal Nig. Ltd	Ameke	X	X	-
7	Aqua Rapha Invt. Nig Ltd	Ameke	X	X	-
8	Aptro Filling Station	Ameke	X	X	-
9	Ugo Bakery Industry	Nsude	X	X	X
10	Alex Enterprise	Nsude	X	-	-
11	Synco Oil Ltd	Nsude	X	X	-
12	Avec Nig. Ltd	Nsude	X	X	-
13	Hoval Nig. Ltd	Ameke	X	X	-
14	Jenep Nig. Ltd	Ameke	X	X	-
15	Barnaco Int. Ltd	Nsude	X	X	-
16	Champion Bakery	Ifueke	X	X	X
17	Narco Oil Nig. Ltd.	Ifueke	X	X	-
18	Efficient Petroleum Nig. Ltd	Ameke	X	X	-
19	Raphade Concrete Block Ind.	Ngwo-Uno	X	X	-
20	Ifesinachi Petroleum Ltd	Ifueke	X	X	-
21	Micco Petrol Ltd	Nsude	X	X	-
22	Nigerian Breweries Plc	Ameke	X	X	-
23	Phinomar Nig. Ltd	Ameke	X	X	-
24	Citadel Suites	Ameke	X	X	-
25	Pagosina Palace Hotel	Ameke	X	X	-
26	Glory Hotel	Nsude	X	X	-
27	First Bank of Nig Plc	Nsude	X	X	-
28	Sharon Paints & Chem. Co. Nig.Ltd	Ameke	X	X	-
29	Graceco Sachet Water	Ameke	X	-	-
30	ChiscoTrans Nig Ltd(Haulage Div)	Nsude	X	X	-
31	E.O.N. Nig. Ltd	Nsude	X	X	-
32	Raylcon Petroleum Nig. Ltd	Ifueke	X	X	-

Total			32	29	2
Percent			50.8%	46%	3.2%
Rank			1st	2nd	3rd

X= source of energy in use; = not source of energy in use

Source: Fieldwork, 2019

This energy source is found to be the cheapest and easily accessed in the area. Therefore, the main sources of energy for the industrial activities in the study area are only firewood, installed generating plant, and electricity from EEDC. The percentage proportion of industrial plants involved in each case is further illustrated on Fig. 3.

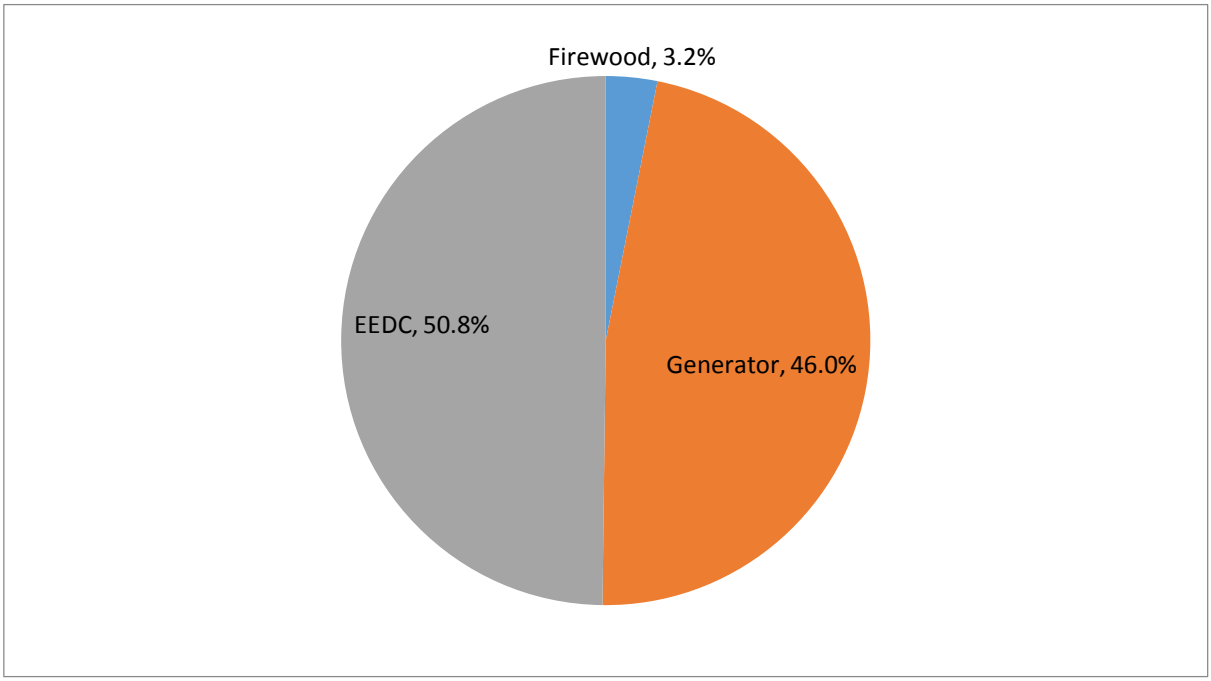

Fig. 3: Energy/power sources of the industrial plants at the 9th Mile area

Source: Fieldwork, 2019

Some of these fuels can be sourced directly from forests or indirectly as by-products from the wood processing and pulp industries, whereas others can be created from processed wood products that are recovered and repurposed at the end of their consumer life cycles. At the study area, the application of these technologies in the use of firewood as energy source is lacking, rather it is the traditional method of buying dry wood cut into sizes from open market that is used as energy source. The technologies involve the burning of residues through pellet and chips stove to produce energy; charcoal using waste materials,

production of liquid fuel by the processes of gasification, acid hydrolysis and fermentation; use of biomass energy and biotechnology; recycling; etc. which reduce the rate of dependency on the natural environment.

Conversely, the burning of firewood continues to impact negatively on health due to high emissions of carbon. Such health implications are common in respiratory and heart diseases, lung cancer, and eye irritations. Wood energy consumption contributes to deforestation, clearing of land for farming (Catalyst Forum, 2012). In addition, concentrated industrial and urban demand for firewood combined with weak regulation and control still contribute to forest degradation and deforestation. Thus, the amount of harvested firewood exceeds the annual growth rates for forest resources (Brito, 2007), while inefficient harvesting and utilization practices are prominent. This counteracts the efficient potential for firewood to be a renewable resource and calls for the establishment of a conducive framework that fosters sustainable forest production and management as unsustainable wood harvesting does not only contribute to the rising levels of carbon dioxide in the atmosphere, but threatens the local ecosystems and biodiversity (Catalyst Forum, 2012).

From the discussions, it is clear that industries in the study area like other parts of less developed economies have not been able to apply biomass, biotechnology, etc. as methods of energy sources which involve and occur inform of wood fuels such as firewood, charcoal, chips, sheets, pellets, sawdust, brush clippings, and grasses (Sunshine, 2017). It is through these technological sources that electricity especially for industrial activities is obtained as commonly found in Brazil, New Zealand, etc. The findings of UNECE (2016) show that wood energy accounts for 3.5% of the total primary energy supply (TPES) and 38.2% of the renewable energy supply (RES) in the UNECE region.

On the other hand, electricity in use by the industries in the study area is obtained from EEDC, the national source. It is sourced from a thermal power station, and has the advantages of low cost, produced everywhere in the world i.e. it is always available, its heat on production system is simple, easy mechanism, same heat can be reused, easier maintenance of power station, relatively inexpensive, and requires small space to be installed. However, the main concerns are the release of hydrogen sulfide, a gas that smells like rotten egg, the disposal of some geothermal fluids, which contain toxic materials, unlike electrical energy, it is almost impossible to transfer or store in thermal energy (Virk, 2017).

From these issues raised, it is clear that energy sources in the study area are not environmentally friendly since they cause environmental degradation of air, water, land, vegetation, and even human components. The alternative option available is the application of recycling, biomass, biotechnology, renewable, use of wind, and solar sources of energy. This is in order to reduce over dependency on environmental resources, deal with huge amount of available waste materials, and encourage environmental sustainability for achieving development goals.

Conclusion

In conclusion, the main sources of energy for the industrial activities in the study area are only firewood, installed generating plant, and electricity from EEDC. These energy sources in use in industrial activities are not friendly to the environment in the area. Therefore, the main issue in the source and use of energy by industries in the area becomes availability for sustainability in production activities without thought to their environmental effects. This means that the availability of energy is very significant in industrial locations in the area. The reason is that every industrial plant studied is located where access to energy supply especially energy from EEDC which is the cheapest and easily accessed source is available. Also, because other energy sources like charcoal, biomass, and solar are not developed in the area every industry resorted to the use generator as an alternative energy source. Thus, the better energy sources in the modern industrial activities like biomass, biotechnology, wind, and solar, etc. are not in use in the area.

Recommendation

From the results of this study, the following recommendations are made;

It is necessary for training and retraining of industrialists in the need to adopt modern methods of recycling, biomass, bio-technology in sourcing for energy in the study area. Also, the use of wind energy, water energy, solar energy, etc. that are renewable and more friendly to the environment as energy sources should be developed by both the entrepreneurs and the government and involved as industrial energy in the area. It is important for the industrialists especially those of them in bakery productions to source and involve electric oven as another source of energy in the study area. To reduce environmental pollution, there is need to discourage over reliance on the use of oil sources as major industrial energy in the study area through policy statements.

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