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Understanding the Concepts of Energy and Power for Proper Sourcing, Application and Management for Farm Mechanization, Agriculture and National Economy Development in Nigeria

*[1]Simeon, P. O, [2]Jijingi, H. E
[1,2]*Department of Soil Science and Land Resources Management, Federal University Wukari, P.M.B 1020, Wukari Taraba State - Nigeria*

ABSTRACT: *In today's Nigeria, energy and power is commonly inter-changeably used, especially in the area of* ***electricity****. Now, the misconceptions have also crept into and have taken root in agricultural mechanization (both in course study and in practice) so much that they are hardly separated. Holding an improper concept will lead to wrong approach and application /utilization, control and conservation/preservation of the matter. The objective of this paper is to throw some rays of light on the thin line that separates the two concepts for better understanding, renovation of knowledge and proper application/utilization and management of energy and power in agricultural production and national development. The often neglected and mismanaged passive energy of machinery in mechanization has caused us colossal socio-economic losses. Very visible among which are exposed expanse of Land, food insecurity and agricultural and rural under-development. This present work is the outcome of an original scholarly research/inquiry based on review of relevant publications (didactic and pedagogic materials), direct observation of civil workmen involved in mortar mixing and service to bricklayers as routine occupation/job and on observed common practices in the Nigerian Energy and Farm Power sub-sectors. The result is a simple to understand exposition of the two different concepts; electricity as the technical medium in which both energy and power converge, and the implication of confusing the two concepts. The paper ends with some recommendations drawing our collective attention to necessary actions to be taken, radically and urgently, to ensure that the citizens are properly informed in practice and in studies and to get the authorities/agencies of government to the correct track for national socio-economic development.*
Keywords: *Converge, Development, Energy, Inter-changeably, Mechanization, Power.*

I. INTRODUCTION

According to Roth *et al.,* (1980) Agricultural Production is heavily dependent upon **electrical energy** to perform a multitude of task. Because of its relative importance, it is necessary that anyone connected with agricultural production have a good understanding of electricity, its potential, application, and the factors affecting its efficient use". This is not the situation presently in Nigeria in this 21st century. Itodo, (2013) is of the same realistic assessment. It is a worrisome situation, hence this paper is apt.

II. LITERATURE REVIEW

According to El-Okene (2013) the proper harnessing and coordination of all potential sources of energy on the farm should be considered from the initial stage. In the works of Simeon *et al.,* (2016) titled "Tools and Sources of Energy for Farm Force Machines: A clarification and Distinction from Simple Machines and Sources of Power for Farm Work. A Review", the authors highlighted many terms that are often improperly or incorrectly used in several teaching and learning textbooks of basic to tertiary education levels. Therein, the issue of Energy and Power came out briefly. At page 485 it is stated thus "that the inter-change usage of power and energy is inappropriate and there seems to be some elements of confusion of the content/concepts of power and energy. The question falling out here is whether power and energy means the same thing. If not, the question is whether they have a converging point and if they do, at what point and in which technical situation/process do they?" It was the opinion of the authors that the treatment of the concepts of energy and power in detail in that work was not feasible due to often limited volume of Journal Articles. Consequently thereto, the authors are following with this present work as **complement** (the completing part).

Though the unit of measurement of energy and power is the same:- Joule or Watt (1 Watt = 1joule/second), the exercise of power is a function of dissipation/consumption/expenditure of certain amount of energy over a certain period (length of time) in the course of doing work. Effort-Time function in exercise of power can have more than two peaks of output if human beings and work animals (Tamed big size four legged animals) are involved due to sluggish start, pace acceleration and stabilization, fall in output and break for intake of re-energising meal followed by another slow re-start, acceleration, stabilization and thereafter decline due to increasing fatigue with length of time/duration of work until the end of the fixed time.

While James Watt is the father of the concept of "Horse power", Michael Faraday is the father of the concept of **Electrolysis** and **Electricity**. Electricity has both chemical and physical natures involving electrons discharge, ionization and creation of energy wave and the force that move the electrons from the negative to the positive end/head/terminal of wire or electrode. The physical nature permits its transportation from place of generation to place of need which could be enormous distance apart. On the contrary, to what distance can power be transported from source to place of use? Certainly nowhere near the distance of electrical energy/electricity. This is a clear separation between electricity (electrical energy) and power despite their same unit of measurement, Joule or Watt. It is more proper or correct to say Electricity Company of Nigeria (ECN) than saying Power Holding Company of Nigeria (PHCN). Also, it is more correct to say National Electric Energy Authority (NEEA) than saying National Electric Power Authority (NEPA).

According to Abbott (1980), "it is noticed that **heat** is involved as a step in practically all the various **energy transfers** which lead to the production of that **most useful** of all forms of energy, namely **electricity**. Our present concept of energy and its measurement arose out of a search for an understanding of what it was that make things hot. In physics, the word heat is the name **given to energy** in the process of transfer from one body to another as the result of temperature deference between them. **Once heat has been transferred to a body or substance, it ceases to be heat and instead becomes internal molecular energy.** From the results of his experiments, Joule came to the conclusion that the water at the bottom of a waterfall ought to be slightly warmer than that at the top and that at the top of the fall, the water possesses potential energy which becomes transferred to internal molecular energy as it descends. Part of this kinetic energy becomes transferred to internal molecular energy when the motion of the water is arrested at the bottom of the fall".

Furthermore, Roth *et al* (1980) stated that "electricity is composed of positive (+) and negative (-) charges which cause **potentials (forces),** since like charges repel and unlike charges attract. The atoms that make up matter have negative (-) charges (electrons) that can be made to move from one atom to another. Thus, in a wire that has a (+) charge on one end and a (-) charge on the other, there is a general movement of electrons from atom to atom and from the (-) end towards the (+) ends. This more or less continuous flow of electrons from (-) to (+) leads to the general definition of **"electricity as the flow of electrons from atom to atom in a conductor"**. The flow is called **current** while the force that causes electrons to flow is called **potential difference** (or simply potential) since the potential energy of one end is different from the potential energy of the other end. This potential difference is called **electromotive force or voltage**, and it is measured in **Volts** which is the amount of **work** involved in moving an electrical charge from one point to another. The greater the voltage the greater the current flow". They added that by the definition of **power as the rate of doing work** and **energy as the capacity to do work**, it is obvious that work is done in electricity when the electromotive force (electrical potential) causes electrons to move within conductor (flow of current)

"P = E × I

Where $P = Power\ in\ Watts\ (W)$
$E = Voltage, in\ Volt\ (V)$
$I = Current, in\ ampere\ (amp)$"

Therefore, electricity is a technical situation/process in which energy **and power converged**. However, while there is work done and exercise of power within the wire or conductor, the output is **energy** which is harnessed by electric motor engine to do work, such as shelling of maize with maize Sheller; rice milling machine, grinding machine, winnowing machine, water pumping engines/water lifting pumps, etc. But the work done and the power exercised within the wire or conductor is not farm work and **the resultant output of electrical wires/conductors is electrical energy**, which is transformed in electrical devices to generate heat, spark and fire, pressure, etc that cause motor to run.

On the other hand, the concept of Horse Power (hp) was the result of James Watt attempt to establish a way to rate the power developed by his steam engine (Roth *et al.*, 1980). Furthermore, James Watt was stated to have observed "the hauling of coal out of mines by horses and concluded that one horse could raise about 166.6 kilogram (367 pounds) of coal out of a mine at a walking speed of about 0.305 metre (1 foot) per second. He said this would amount to 3,048.8 metres/kilogram (22,000 foot - pounds) of work per minute. However, for

reasons that are not entirely clear, Watt decided to make **1 (one) horsepower** equivalent to 50 % more work per minute than he observed at the mines. Thus, he established that one (1) horse power would be equivalent to 4,573 metre –kilogram (33,000 foot-pounds) of work per minute or 76.20 metres-kilogram (550 foot-pounds) of work per second.

$$\text{Horse power (hp)} = \frac{D \times F}{T \times 4{,}573}$$

Where:

$$D = Distance\ in\ metre$$
$$F = Force\ in\ kiogram$$
$$T = Time, in\ minute$$

A man who can load six (6) 25 kg bales onto a truck platform 1.5 metre high in one (1) minute would have developed:

$$hp = \frac{1.5m \times 6 \times 25}{1min \times 4{,}573} = 0.049$$

A tractor pulling a draft load of 500kg while traveling at 80 metres per minute would have developed:

$$hp = \frac{80m \times 500kg}{1min \times 4573} = 8.745$$

This is **drawbar horsepower** since it is the horse power that would be required at the drawbar of a tractor to pull an implement. The horse power developed by an engine or by rotating shaft is determined little differently and it is called **Brake or Shaft Horse Power**.

$$hp = \frac{Torque \times rpm}{K} = \frac{T_o \times rpm}{K}$$

Where:

$$Torque\ (T_o) = the\ torque\ on\ a\ shaft\ expressed\ in\ kg.meter$$
$$rpm = the\ number\ of\ revolutions\ per\ minute\ made\ by\ the\ shaft$$
$$K = a\ constant$$

III. MATERIALS AND METHOD

Firstly, this work is the outcome of an original scholarly research/inquiry based on review of publications to find out simple and clear ways of separating the concepts of energy and power and to find out any situation and/or technical medium in which energy and power converge inseparably. For this cause, didactic and pedagogic publications were used.

Secondly, a construction site in Benin City, Edo state in Nigeria (Fig. 1) was visited and personal observation of activities and measurements were carried out in an attempt to understand the reason James Watt added 50 % value to the original value he observed with the horses in the coal mine. Six (6) civil workmen involved in mixing and serving mortar to nine (9) bricklayers and working for a duration of six (6) hours. They were observed in three (3) groups 1, 2 and 3 for three different days. Each group was made up of two (2) mixers/servers and three (3) bricklayers. The workmen were experienced routine manual labour givers in the activity they were carrying out. They were healthy 1.35 – 1.50 metres tall and weighed 75 – 90 kg.

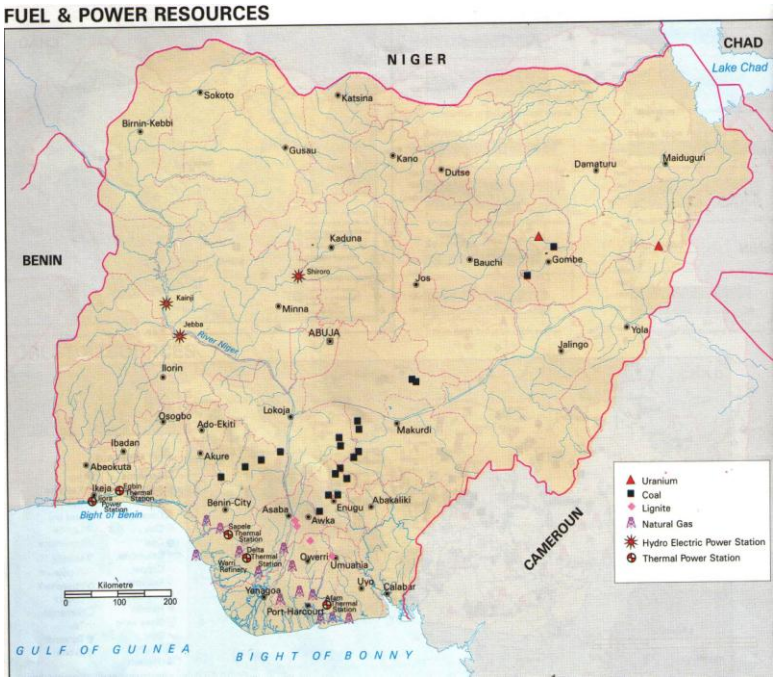

Figure 1: Map of Nigeria Showing Benin City

IV. RESULT AND DISCUSSION

The citation from Roth *et al.*, (1980) puts the concept of power in a very clear simple understanding form, and in summary power as the rate of doing work can be written as an equation:

$$Power = \frac{Work}{Time} = \frac{Distance \times Force}{Time}$$

$$\Rightarrow P = \frac{W}{T} = \frac{D \times F}{T}$$

And the above equation is where energy and power converged in electricity where we have distances continuously moved by electrons from the negative ends of conductors/wires by electromotive forces towards the positive ends and also from atom to atom and certainly, the completion of these movements take some times. But this is not to say that the output from electric conductors/wires is power. Rather, it is energy that is used to fire electric motor after transformation.

Recalling Abbott (1980), "**Energy**: Energy is the capacity to do work and anything which is able to do work is said to possess energy. The World we live in provides energy in many different forms of which **the most important has been chemical** energy. The utilization of the latent chemical energy in coal, oil and gas released in the forms of heat to drive steam turbines and internal combustion engines has been a major factor in the development of modern civilization. Many of the material comforts which we enjoy today come from the use of **electric energy**. The first **electricity generating plants were powered by coal fired steam engines**. "Hydro – electric" means production of **electricity by generators driven by water turbines**. Windmills which transfer the **energy of the wind** to mechanical energy in **machinery** have long been **in use for work**".

The observation of the six (6) manual labour men involved in mixing and service of mortar to nine (9) bricklayers using spades and headpans shows a work output of sluggish start (A – B) which gained momentum after the initial thirty (30) minutes at point (B - C) and rising to a peak at the hour (one hour) mark (C) stabilizing for about two and half (2 ½) hours at this level ($C_1 – C_2$). This was followed by a gradual decline which to them (workmen) was a call to refreshment. Work suspended and all men took usual meal and water. 20 – 30 minutes lasted the break ($D_1 – D_2$) and work resumed sluggishly and rising to a peak of about 92 % and stabilizing therein ($E_1 – E_2$) for about sixty (60) minutes and another gradual decline ($E_2 – F$) setting in till the end of the sixth (6^{th}) hour (F) of work (which is the duration of a day's work).

There were no clear differences in work performance in each of the three days. Consequently, the result of day 2 is presented in Table 1 and Fig. 2 below.

Table 1: Effort and Pace of work by the workmen in percentage (%) of maximum they attained

S/No	Length of Time (Minutes)	Group output and pace in % (efforts in percentage of maximum)			Average for the three groups.
		1	2	3	
1	2	3	4	5	6
01	0 - 30	60 – 80	60 - 80	50 - 70	56 – 77
02	31 - 60	80 – 100	80 - 100	70 – 100	77 – 100
03	60 –180	100	100	100	100
04	181 - 200	90 – 80	90 - 80	90 - 80	90 – 80
05	201 - 220	Break for meal and slight rest			92 – 92
06	221 - 240	92	92	92	92
07	241 – 300	92	92	92	92
08	301 - 360	70 – 40	70 - 40	60 - 40	67 - 40
09	360	40	40	40	40

Source: Personal observations and readings.

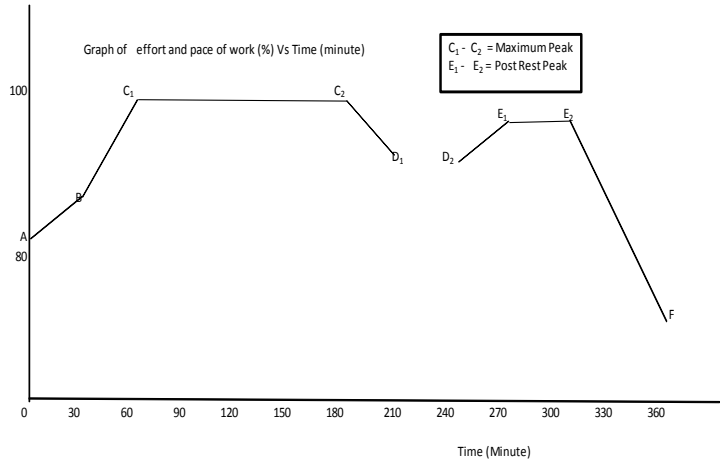

Figure 2: Effort and Pace of work by the workmen in percentage (%) of maximum they attained

From Fig. 2 above, there were observable four (4) peaks, namely B, C, D and E. The start point being "A". It could be seen that output during the sluggish start (A – B) was higher than the output and pace at the dead end of the working six (6) hours. The only explanation for this is **fatigue** which sets in as the duration of work lengthened and this is explained by fall in power output due to depleting energy reserve. The fact that the men fed themselves apparently to re-energize after about three and half (3½) hours did not help their wear out and the fatigue.

This result brought us (the authors) close to the postulation that James Watt while looking for means to rate the power of his engine and deciding to observe horses hauling coal in a coal mine must have conscientiously observed decline in output due to fatigue by the horses. And comparing his engine with the horses, he must have known that the engine's output will not be affected/influenced by fatigue once the engine is running without damage/break down and there is a stable source of energy. Hence he decided to make up for the lost production by fatigue liable horses by adding fifty percent (50 %) of what he observed as work done by each "horse power" from 22,000 foot-pound per minute to 33,000 foot-pound per minute to 4,425 metre-kilogram per minute, which has reminded the unit of power evaluation till today though the concept of Watt and its units has been introduced with 1hp (one Horse Power) equal to 735 Watts and one Watt (1W) equal to one Joule per second (IJ/S) which is one kilogram force load moving a distance of one metre in a time of one second.

$$1hp = 735W\ (or\ 0.735KW) = 76.16m - kg/s = 457m.kg/minute$$

$$1W = \frac{1Nm}{s} = \frac{1J}{s} = 1kjf.m^2/s^2$$

According to Oladipo *et al.*, (2013) "Energy is fundamental to sustenance of life in present day energy based society. Every activity towards the satisfaction of human needs and which are indices of development is dependent directly or indirectly on energy. The energy sector therefore is very strategic part of any national economy. The **energy shortages** have affected Nigerian economy as almost all manufacturing and industrial organizations rely on generators which use fossil fuel to augment electricity production. **Power sector** challenges in Nigeria include inadequate **power generation**, transmission and distribution capacities and obsolete infrastructure resulting in high losses and low access to electricity (the authors cited Kupolokun and

Mohammed, 2009)". **"The inadequacy of the power sector". "The National Technical working Group on energy for power and energy industry".** All these as stated by the cited authors are the reflections of the confusion between the concept of energy and concept of power in the Nigerian educational and national economic sectors.

When we talk of power capacity in Nigeria, we correctly ought to be talking about available workforce coming from human beings, big size tamed four (4) legged animals (draught animals) and machinery (Machines and engines) that are in the production and service sectors. Electricity (electrical energy) cannot connote either power or source of power. Any submission on power that removes the three (3) sources listed above is inadequate and must be radically corrected.

The implications of holding wrong concepts of energy and power are the following:

1. Inappropriate planning and budgeting, including misappropriation of fund and efforts.
2. Wrong target and goal, hence emptiness as the result, that is, non-realization of purpose/objective.
3. Economic setback and failure from socio-political angle of the programme or project.
4. The above three (3) maladies lead to failures in agricultural mechanization where energy and power management take pivot role for success.
5. The failure of farm mechanization means agricultural development cannot be realized, hence peasant agriculture will continue to be the order of the day.
6. The failure to develop agriculture means the rural population and the communities (over 70% of which thrive on peasant agriculture) cannot be developed. This implies that socio-economic life would remain below poverty level (subsistence production that is not even adequate qualitatively for the farming family and only meager resources to purchase goods and produce/products not gotten from the family farms).
7. Issue 1 – 6 above will collectively create a backward national socio-economic situation with food and raw materials insecurity, and where the country cannot earn foreign exchange from non-agricultural resources to import needed materials, there is certainly economic crisis, hunger and all kindly of vices for survival by the fittest.

''All agricultural machines require sources of energy to work. Existing post-harvest machines, irrigation pumps etc. cannot be used on farms in remote rural locations because of the unavailability of electricity to power the electrical motors that drive them. This has made mechanization of primary processing of cereal crops almost zero in Nigeria. Agricultural Engineers specializing in farm power and machinery have the duty to provide sources of energy for agricultural machines for their use anywhere. Consequently the profession requires distinctive pre-requisite competence in energy use and application on one hand and a deep knowledge of developing and using agricultural machine on the other hand. Surely the energy for the remote rural locations is the inexhaustible renewable energy (RE) of solar, wind and biofuels. The in depth teaching and demonstration of the use of the REs is a mandatory knowledge for the Agricultural Engineers in this century'' (Itodo, 2013).

V. CONCLUSION

In Nigeria generally, energy and power sources are ill planned, ill financed and ill managed, more so by the greedy, corrupt and often ill-trained or not at all trained persons gallivanting or masquerading as movers and shakers in this vital sector of national economy, hence the worrisome failures are not surprising and will continue to worsen if the much needed radical re-orientation/re-focusing change is not urgently brought about.

This is why this paper is apt. In farm (agricultural) production electricity is only a source of energy and the power sources are only Human Animal/Beings, Tamed Big Size 4-legged Animals and Mechanical Aggregates (engines + machines).

VI. RECOMMENDATIONS

1. When we are talking of "Power" sector development for national economic growth and development, we should be looking at:

a. Educational and skill development of the populace (the workforce therein) for the requisite competence and professionalism to confront emerging challenges, solve existing problems and for innovations.

b. Development of draught animals in aspect of number, size, strength, feed utilization, resistance to the factors capable of making them ineffective and inefficient (thus uneconomical to use) in exploitation for works.

c. Development and growth of machines; engines and mechanical facilities/installations in regard to numbers available and accessible (including affordability), ease of exploitation and management that will enhance the productivity of the human and draught animals labour, enhance expansive and intensive production (that is industrial production) in all seasons (wet and dry seasons in agriculture in the tropical and subtropical regions), enhancement of quality produce and products and other forms of output, and above all that will enhance great economic returns and sustainable production activities in a guaranteed healthy and secured environment for the present and the future.

2. On the other hand, when we talk of **"Energy Sector"** development for national economic growth and development we should be looking at electricity generation and distribution for easy accessibility where needed for production especially industries and farms and not in luxury homes where the few that have looted the resources of the country abode as it is presently in Nigeria. We should be looking at the development of solar energy, fossil fuel resources, wind current, flowing waters (whether of rivers, streams or/and of gully erosion), biological fuel resources (bio-mass, bio-gas, fire wood, etc.), atomic energy sources, etc. The energy sector and power sector must be separately sourced, planned and managed by appropriately qualified and competent professionals for any meaningful progress and realization of objective for national socio-economic growth and development and not the present worrisome situation in Nigeria, which is a far cry from the standard and practice required. The misconception and confusion which have been the barn of under-development of the country need to be urgently and radically dealt with.

3. The Ministry of Petroleum Resources should be re-organized and named **Ministry of Energy Resources.** It should have the mandate to handle all matters of renewable and non-renewable energy sources development (petroleum/ crude oil, gas, coal, electricity and flowing waters, sunlight, wind / air mass, bio-mass and bio-gas, radioactive substances/atoms etc.)

4. The Ministry of Mines and Power should be scrapped while the Ministry of Labour and Productivity should be re-organized and renamed **Ministry of Labour, Productivity and Power Development**. It should be charged with dishing out policies and promoting Programmes that will brings about Labour efficiency and high level of productivity through:-

a. Availability of highly skill, competent and professional human workforce.
b. Growth and development of quality draught animals in great numbers, including training of persons to manage such source of power and workforce. These are animal like horses, carmels, donkeys, bull-cattle and others (domesticated and yet to be domesticated) together with their necessary accessories for attachment and/or engagement to implements and for control as well.
c. Growth and development of abundance of appropriate (standard and environmental friendly) engines and machines for production, that is, promoting high degree of mechanization of production activities in Nigeria by ensuring the availability and accessibility of mechanical installations, engines and machines to human workforce to ensure greater power in their hands for higher and better output and also to draught animals for better service delivery.

5. Proper education and passage of the correct information using all possible means and media (existing and new creations) in diverse languages easily understood in the different segments of the community to support the official English language for communication. This is most urgently needed in our science and technology based tertiary institutions of study, that is, universities, colleges and institutes, technological/engineering oriented research centres, secondary education levels, etc.

6. Government should forget about quota system and nepotism to engage only **competent** specialist and not just/mere degree/diploma holders to manage the vital technical sector like the energy and power (mechanization/force machines) sectors because no nation in the world has been able to develop and improve the socio-economic life style of the citizens without proper and very efficient service delivery in the two (2) major/very vital and development bedrock/foundation.

7. Energy and mechanization (power) must be available and accessible (affordability and efficient distribution) where, when and how required for stable ever-growing production in **agriculture (in particular) and national economy (in general)**.

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