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Mega-watt-hour consumption for vehicle production in Nigeria

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ABSTRACT

Energy supply from the grid is grossly inadequate and the rising cost per kWh is a challenge for the declining industrial operations, particularly the automobile sector of a developing economy. Mega-Watt-Hour consumption per product is a critical indicator of developmental status. The energy supply and utilization characteristic of vehicle manufacturing in Nigeria was assessed. The leading car manufacturer electricity situation on energy consumption from grid and self generation for 11 years was evaluated as a case in reference. The study involved analysis of secondary data that was instructional to the exploratory design for primary data collation and analysis. The results obtained were synthesized and graphically presented using Micro-Soft Excel program. The study established a power demand of 3.48MW and average annual consumption of 4,883.10MWh in the company. Also, 30.19% of consumed energy was met from self generation using diesel generators in agreement with national indicators. An average specific electrical energy consumption of 1.26MWh per Sedan vehicle was established for the normal production years. Electrical energy demand for the future can be projected there-from.

Keywords: Automobile Plant, Energy Generation, Electricity Consumption, Mega-Watt-Hour per Car.

INTRODUCTION

Energy resources, supply, availability and consumption are very important indicators for the technological and socio-economic development of every nation. Of the different forms of energy, electrical energy is considered the highest grade of usable energy for its quality and flexibility in transmission, distribution and convertibility with minimal losses and applicability on several end-use equipments. Commonly, electric energy demand and supply gap are very wide despite the availability of vast and large quantities of energy resources in Nigeria [1]. Typically, Nigeria electricity supply started in 1896 with the supply of 60kW from generating plants to serve the capital city of Lagos. At independence in 1960, Nigeria had about 200MW. Presently, eight power stations having 6,145MW Name-plates cumulative capacity are grid connected. The review of national consumption indicates declining and skewed consumption trend with the residential sector using 55.3%, Commercial/Street light consuming 24.7% and the Industrial sector consumes 20% of the national total annual consumption of electric energy. In the industrial sector, the principal consumer is the manufacturing sub-sector that uses 18%; of which 4.90% consumption is self-generated [2]. The current national power operating capacity has average at 4,225MW against the estimated demand of 40,000MW representing 68.8% of installed capacity and 10.6% of estimated national demand [3]. This indicates industrial inadequacy, lost productivity and weakening economy.

Currently, population and urbanization has significantly widened the supply to demand gap. Other related energy challenges includes balancing the energy supply conflict with the environment with respect to pollution and global warming; and the conflict with economics in the light of employment for higher purchasing power and energy taxes for revenue against social welfare. Specifically, the manufacturing industry, especially the automotive industry and automobile subsector in particular is negatively affected by the energy demand – supply gaps and is heavily investing in self-generation due to the inadequate supply of grid electric energy. Evidently, within the auto-industry, energy unavailability directly affects vehicle production; the movement of goods and services. Consequently, it shortened working hours, reduces business profitability and creates unemployment.

The Literatures review shows that much work has been carried out on MWh per vehicle and on electric energy optimal consumption for manufacturing in the developed nations. However, study on this subject has not been done on a typical automobile factory in Sub-Sahara Africa. The specific objectives are to establish the electric energy consumption pattern in Nigerian automobile assembly factory with respect to demand and supply requirements for production; to determine MWh consumed per vehicle assembled, and to compare with global standards within normal working conditions. Also it should serve as evidence-base for stakeholder to plan in resolving the energy and operational efficiency deficiencies in a secure and environmentally friendly way. The methods, results, discussion and conclusion are as presented.

Company	**Zastava Automobili**	**Peugeot-Citreon Automobile (PSA)**	**Scania**	**General Motors (GM)**	**British Motor Works (BMW)**	**Toyota Motor Enterprise (TME)**
% MWh Reduction	**22.12%**	**10.00%**	**49.97%**	**28.86%**	**11.74%**	**20.45%**
Technique Adopted	Energy Mix and reduction of water, air consumption	Energy efficient equipment and Co-generation	Heat transfer techniques	Energy efficiency initiatives	Clean production program (Exhaust heat recovery, Powder clear Top-Coating programs).	Energy plus environment efficiency techniques

The Automobile Industry in Nigerian

The production of automobile vehicles in Nigeria started in the early 1960s at semi-knocked down levels. Six automobile assembly companies were established in the 1970s via partnership with world class auto manufacturers. These factories were geographically spread, namely: Volkswagen of Nigeria Limited (VWON) at Lagos; Peugeot Automobile Nigeria Limited (PAN) at Kaduna – this case study; Anambra Motor Manufacturing Company (ANAMCO) at Enugu; Steryer Nigeria Limited (SNL) at Bauchi; National Truck Manufacturing Company (NTM) at Kano and Leyland Nisara Limited (LNL) at Ibadan, Oyo with the total annual capacity of 108,000 cars, 56,000 commercial vehicles and 6,000 tractors. Subsequently, recession and lack of commitment to the strategic plan has shrunken the industry from 90 percent to below 10 percent capacity utilization and industrial closure of some factories [4].

Global Energy Production Trend

Globally, electric energy production both grid or self-generation supply and consumption are strong indices for industrialization and standard of living. Electric energy for major automobile manufacturing firms has been extensively studied in recent literatures to establish its current status and usage trend considering minimum environmental impact. The energy consumed to assembly a vehicle moved from wide values of 29.8MWh in 1993 to 1.42MWh in 2007 all affected by production volume [4-10] through the technique in table 1. So, the minimal MWh per car production becomes very significant parameter in the Automobile industry.

Table 1: Major Automobile factories MWh per Vehicle Reduction in percent [4-10]

In Nigeria, there is no record found on the MWh consumption per vehicle production. But macro energy demand, generation, consumption records documented was assessed.

MATERIALS AND METHODS

The methods applied are broad desk research and analysis of secondary data from literatures reviewed. Literatures read served as guide for the use of exploratory design-instrument for data primary data collection which includes discussion with major stakeholders, availability and review of relevant company-specific record diaries and

documents; and on-site inspection of facilities and electrical energy potentials within the company premises. Thus, a retrospective analysis and evaluation of prospectively collected data covering a period of 11 years using percentile and comparative method was done. The data collated were tabulated, synthesized and graphically presented using Micro-Soft Excel software. The electricity requirement, its patterns and monthly variation were surveyed. Also, self-generated electricity supply was analyzed.

RESULTS AND DISCUSSION

The Electric Energy Networks in the Automobile factory

Currently, the electric energy sources in PAN are through a 33KV line PHCN supply, dropped down to 11KV through a 33/11KV (8MVA) transformer, and 5676kW at 11KV self-owned generators installed in the Powerhouse within the company premises. The Total Electric Energy Demand is 3.84MW. The energy demand for each section on table 2 was determined by elimination method.

Table 2: Total Electric Power Demand in P.A.N.

Electricity Consumption Results

The years 2000 to 2010 electricity readings on Bulk meters from PHCN, diesel self-generators and other supply parameters were recorded on an hourly basis. The electrical energy generation, consumption, number of vehicle produced and related issues were collated and tabulated monthly and annually for 11 years. Energy generated/consumption analysis is done with respect to MWh consumption per car among other indicators are graphically presented. Typical results of year 2000 to 2010 as collated are on figures 1.

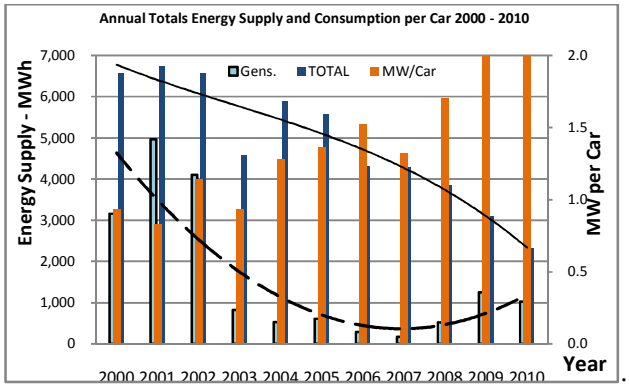

Figure1: Histogram of Annual Total Electrical Energy Consumption from PHCN 2000-2010

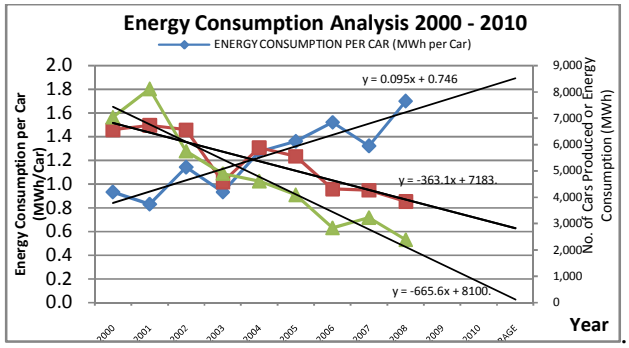

Figure 2: Graph of Energy Generated Analysis for 2000 to 2008

Total Electric Power Demand in Auto Factory is 3.48 (MW)								
Engine Room	***Paint Shop***	***Assembly Shop***	***T-Up Shop***	***Body Shop***	***Store S1/ Machine Shop***	***Store Q/Lab.***	***Commercial Block***	***Admin. Block +Others***
0.99	**1.76**	**0.19**	**0.28**	**0.37**	**0.13**	**0.04**	**0.31**	**0.20**

RESULTS AND DISCUSSION

Developing nation like Nigeria has electricity availability challenges against operational efficiency challenges for reduced consumption and cost saving in kWh in the developed nations [8-9]. In this case, the production or activity level, the availability of PHCN supply and diesel fuel, size and reliability of generators, installation-design employed in the factory determines electrical energy utilization and the pattern of consumption. When the factory is not on production due to shut-down maintenance or holiday closures, activities will be at a low, despite the functional service departments on duty, the electrical energy consumption will be near the fixed consumption level. The general rule as observed from the patterns is that the energy consumption per car increases with low production volume [5, 9-11]·

Specific Situation from 2000 to 2010

Yearly consumption from 2000 to 2010 shows declining patterns as in figure 1. The total and generators energies consumption patterns were relatively uniform. Year 2000 to 2002 has an average value of 0.97MWh per car. From 2002 to 2003, a very steep decline in the total consumption was recorded because of significant drop from the generator supply from 4105.60 to 824.94MWh. The annual consumption (2000-2010) average is 4,883.10MWh compared with GM Global consumption of 33.9 Thousand-GWh for 4.36MWh per car in 2001 [8]. The highest total consumption is 6,729.71MWh, of which 73.79% is from generators in 2001 due to PHCN unavailability. The lowest generator consumption is 174.48MWh (4.09%) in 2007.

The low generator energy consumption in 2006 to 2008 despite non-availability of PHCN supply was basically from incapable generators as a result of aging, lack of spares and inefficient operations. For example in 2007, the PHCN supply availability with weekends was higher, i.e. average was 41% compared to 33% within the weekdays. The average consumption from generators from 2000 to 2010 was 30.19%, but in 2000-2002 and 2009-2010, when generators supplies were dependable, the consumption from generators was 53.80% as three new sets of generators at capacity 1.6MW each were put to use from July, 2009. The monthly average from 2000 to 2010 is 418.38MWh. An average consumption of 1.26MWh per car was recorded for the period against Peugeot-Citroen-Automobile [6] target of 2.05 MWh/vehicle for 2012. But, Toyota attained 1.6MWh in 2005 toward the target of 1.4MWh by 2008 [10]. An unusual high value of 12.90MWh per car in 2010 was due to low volume production of 240 cars occasioned by production 307 model on trials.

For illustration, the 2002 Electrical energy consumption represents a typical situation, where the pattern is undulating except there is better availability of PHCN supply throughout the year compared to later years, which generally implies drop in the supply via generators. The highest overall consumption was in August (803.12MWh) and thereafter the consumption was 100% from Generators to the month of November. The lowest consumption of 261.80MWh was in December. An average consumption of 1.12MWh per car was recorded for the year with unusual values of 3.19 and 2.08MWh per car in January and June respectively occasioned by very low volumes production during the winter and summer holidays. The month average for year 2002 was 547.33MWh. The above is a typical year situation.

Summarily, figure 2 shows the linearized and an inverse proportionality of Mega-Watt-Hour consumed per vehicle (MWh/Car) with production volume over the years expressed in the mathematical model $y = 0.0956x + 0.7464$. Also, electricity consumption shows direct proportionality of with volume of cars produced having the equation $y = 7183.9 – 363.13x$. Hence, from these equations, the MWh/Car and the total energy requirements can be extrapolated for forecast and other planning needs for factories with similar conditions. The analysis indicates that the Load factor has an inverse relationship with cost per MWh - as the load factor decreases, the cost per MWh increases since the fixed cost and lower operating costs are distributed over fewer MWh generated. Thus impact significantly on productivity.

CONCLUSION

The energy supply and consumption of the leading automobile manufacturing firm in the most populous African country for the transportation of goods and services was assessed, data for 11 years were collated and analyzed. The values established in this paper are in conformity with the general characteristics obtained from global automobile companies in the developed countries. The automobile firm assessed has an average of 1.26MWh of energy was established to assembly a vehicle in factory during normal production years. However, this value would be decreasing with higher production volume in conformity with global trend. Also, the factory has installed capacity of 3.48MW and an average annual consumption of 4,883.10MWh. Practically, 30.19% of the total electrical energy consumed was met from diesel-driven self-generation due to inadequate supply despite the deliberate 46.2% availability of grid supply during working hours. The monthly consumption pattern is relatively sinusoidal; and the declines are at low periods during factory maintenance and holiday in the months of December-January.

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