Energy Use and Sustainable Development: Evidence from the Industrial Sector in Nigeria.

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Abstract

The substantial growth rate of world industrial energy use along with increase in environmental problems have prompted responses aimed at reduction in the use or enhancing energy efficiency especially in the industries. While energy-use is increasing in many developing countries, the imperatives to enhance energy efficiency in industries have received little attention. This gives rise to the question: if energy efficiency pays, why is it not happening in developing countries? This paper provides insights into this question with firm level evidence-based information from the industrial sector in Nigeria.

Information was obtained from a sample of Nigerian manufacturing companies located in Lagos state (the commercial capital of the country) across four sectoral groupings, namely food, textile, iron and steel, and others. From each sectoral group, the sample firms ranged from small, through medium to large scale enterprises. Sampled firms were asked to give information on energy-use, efficiency and especially investment in energy efficiency and management. On the spot visits were made to each firm's location, in-depth interviews were conducted and production facilities inspected. Inferences were drawn from observations and the narratives recorded during the interviews.

Pertinent outcomes from the study were (i) the general level of information in Nigeria on energy efficiency was low; (ii) few companies have adequate awareness and knowledge about implementing energy efficiency projects; (iii) most companies have never carried out an external energy audit to determine areas where efficiency can be enhanced; (iv) most companies need active policy on identifying and repairing leakages such as air, heat and steam, through a combination of internal and external energy audit; (v) the relative low price of fuel in Nigeria, combined with the high investment costs of machines resulted in long payback period for investments in energy efficiency; (vi) despite the major problem of energy supply facing the companies, a number of them have no clear information on energy efficiency options; and (vii) finance for investment in energy efficiency not readily available either from retained earnings or bank loans due mainly to financial crisis. The key policy challenge is the need to address the subsisting paradox where companies pay fine for polluting the environment with generators but are not rewarded for greening the environment with energy efficient machines/processes. The paper therefore recommends the need for incentives or subsidies on investments in energy efficiency.

Keywords: Energy-use, Energy efficiency, Sustainable development, Industrial sector, Nigeria.

I. Introduction

Like capital, labour and knowledge, energy is one of the main factors affecting economic development. In fact, world industrial energy-use grew substantially over the last decades especially in the developed economies. The significant growth rate of world industrial energy-use concomitant with increase in environmental problems have prompted responses aimed at reducing energy-use or enhancing energy efficiency especially in the industries.

The focus and emphasis on energy-use efficiency practices in the industrial sector is hinged on three reasons. First, is the fact that the industrial sector represents more than one third of both global primary energy-use and energy-related carbon dioxide emissions (Price *et al.*, 2006; IEA, 2004; Ross, 1997). In developing countries, the portion of the energy supply consumed by the industrial sector is frequently in excess of 50% and can create tension between economic development goals and a constrained energy supply (McKane, *et.al*, 2006). The second is that policymakers frequently overlook the opportunities presented by industrial energy efficiency to have a significant impact on climate change mitigation, security of energy supply, and sustainability. The industrial sector is extremely diverse and includes a wide-range of activities. This sector is particularly energy intensive, as it requires energy to extract natural resources, convert them into raw materials and manufacture finished products. The common perception holds that energy efficiency of the industrial sector is too complex to be addressed through public policy and, further, that industrial facilities will achieve energy efficiency through the competitive pressures of the marketplace (McKane, *et.al,* 2006). The third reason is that countries with an emerging and rapidly expanding industrial infrastructure have a particular opportunity which they must seize, to increase their competitiveness by applying energy-efficient best practices from the outset in new industrial facilities.

. Notably, while energy-use is increasing in many developing countries, the imperatives to enhance energy efficiency in industries have received little attention. This gives rise to the question: if energy efficiency pays, why is it not happening in developing countries? This paper provides insights into this question with firm level evidence-based information from the industrial sector in Nigeria. The aim is to inform policy towards promoting energy-use efficiency practices in the industrial sector.

The rest of the study is organised into four sections. The next section provides the theoretical insights. Section III dwells on the methods and materials for the study. The discussion of findings is presented in section IV. Section V summaries and concludes.

II. Theoretical Insights

The exploration of the theoretical literature is divided into two parts. The first part presents conceptual clarifications on key concepts of energy, energy use efficiency and sustainable development. The second part explores the link between energy use efficiency and sustainable development.

2.1 Conceptual Clarifications

2.1.1 Energy

Energy is the potential for providing useful work or heat stored in the finite resources of the earth." Technically, it refers to the capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Electrical energy is usually measured in kilowatt hours, while heat energy is usually measured in British thermal units (Btu). The basic and generally notion of energy is that it is any source of usable power. Power is the energy or motive force by which a physical system or machine is operated which could be electrical and/or mechanical. The essence is to assist or replace human toil.

There are two forms of energy sources, renewable and non-renewable. The most common definition of renewable energy sources is an energy resource that is replaced by a natural process at a rate that is equal to or faster than the rate at which that resource is being consumed. Renewable energy is a subset of sustainable energy. It includes biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action (see International Energy Agency Glossary)[1]. A non-renewable energy source is a natural energy source in limited supply. While this may be plentiful, it cannot be produced at all or as quickly as consumed. In addition to being limited, not only the burning but also the extractions have dire consequences to our environment.

Typical examples of non-renewable energy sources include: (i) Petroleum, also known as crude oil, a naturally occurring toxic combustible liquid, primarily made up of hydrocarbons. Petroleum is the result of partial decay of living organisms occurring in the rock strata of certain geological formations; (ii) Coal- a combustible black or brownish-black sedimentary rock formed from fossilised plants. It consists of amorphous carbon with various organic and some inorganic compounds and is normally occurring in rock strata in layers or veins called coal beds; (iii) Natural gas is a combustible mixture of hydrocarbon gases that occurs with petroleum deposits consisting primarily of methane. It is found with other fossil fuels and in coal beds and is created by the decay of methanogenic organisms in marshes, bogs, and landfills. Lower temperatures are likely to produce more petroleum, and higher temperatures are likely to produce more natural gas; and (iv) Nuclear power- produced by controlled nuclear fission (splitting atoms). In most cases, nuclear power plants use nuclear fission reactions to heat water, using the steam to produce electricity. Uranium, specifically, uranium -235, is one of the few elements easily fissioned.

2.1.2 Energy-use Efficiency

Energy efficiency is a term used in different ways, depending on the context and possibly on the person using it. But it is more commonly understood to mean the utilisation of energy in the most cost effective manner to carry out a manufacturing process or provide a service whereby energy waste is minimised and the overall consumption of primary energy resources is reduced. In other words, energy efficient practices or systems will seek to use less energy while conducting any

[1] http://www.eia.gov/tools/glossary/index.cfm

energy-dependent activity; and at the same time, the corresponding (negative) environmental impacts of energy consumption are minimised. The Aspen Institute Centre for Business Education (2009) puts it more succinctly by defining energy efficiency as the ability to generate the same economic output with less energy input.

Industrial energy efficiency – or conversely, energy intensity, defined as the amount of energy used to produce one unit of a commodity – is determined by the type of processes used to produce the commodity, the vintage of the equipment used, and the efficiency of production, including operating conditions (McKane, *et.al,* 2006). Energy intensity varies between products, industrial facilities, and countries depending upon these factors. The objective of an energy efficient industrial system is analogous to "just in time" manufacturing—to provide the appropriate level of service needed to support the production process, to have a backup plan to address emergencies, and to keep the entire system well-maintained and well-matched to production needs over time.

There are many benefits of increased energy efficiency. These can broadly be categorised into financial/economic, environmental and social benefits. The relative importance of each of these benefits depends on the actual situation in a given country or area, including for example the prices of different types of energy, the cost of energy efficiency measures and equipment, the tax regime and the current levels of energy efficiency already being achieved. For private companies, the most important benefits of higher energy efficiency will be linked to the financial benefits of lower costs for running the business. This applies to typical manufacturing companies as well as to energy suppliers such as electricity generating plants and oil refineries. The drivers for improving industrial energy efficiency include the desire to reduce overall costs of production in order to maintain competitiveness, reducing vulnerability to rapidly increasing energy prices and price spikes, responding to regulatory requirements for cleaner production (including air quality, solid waste, and greenhouse gas emissions), and meeting consumer demand for greener, more environmentally-friendly products (McKane, *et.al,* 2006). Opportunities to improve industrial energy efficiency are found throughout the industrial sector (De Beer *et al.*, 2001; ECCP, 2001; IPCC, 2001) via executing energy efficient projects. However, unless an industrial facility is made aware of the potential for energy efficiency, none of these factors has significance. Oftentimes, facility managers have no knowledge of these opportunities. (IIEC and ECEE, 1998).

An energy efficiency project is an initiative undertaken to improve the efficiency of energy-use in a commercial, industrial, institutional or residential facility. The incremental costs of high efficiency equipment and related engineering services are recovered from savings on the energy bill. Examples of energy efficiency projects include replacing standard equipment with high efficiency equipment, applying energy-efficient design principles in a new facility or renovation, and improving operations and maintenance to better manage and track energy-use (IIEC and ECEE, 1998). Investments in energy efficiency can provide *additional* economic value by preserving the resource base and (especially combined with pollution prevention technologies) mitigating environmental problems. Improvements in energy efficiency can produce direct environmental benefits in a number of ways, not only reducing pollution but also delaying the need to develop new fuel resources. In addition, energy efficiency improvements can considerably reduce the cost of pollution abatement. Industrial, commercial and consumer equipment today can be as much as 80% more efficient than equipment installed just twenty years ago. For example, improved efficiency in any power plant can produce significant reductions in CO_2 emissions. Typically, a 1% point gain in efficiency reduces CO_2 output by 2% (ICC, undated)

There are also a number of barriers to adoption of energy-efficient technologies, including willingness to invest, information and transaction costs, profitability barriers, lack of skilled personnel (Worrell *et al.*, 1996), and slow capital stock turnover. The decision-making process regarding investments in energy-efficient technologies is shaped by firm rules, corporate culture, and the company's perception of its level of energy efficiency. A survey of 300 firms in The Netherlands reveals that most firms view themselves as energy efficient even when profitable improvements are available (Velthuijsen, 1995).

Lack of knowledge or the limited ability of industrial commodity producers to research and evaluate information on energy-efficient technologies and practices is another barrier. In addition, there is often a shortage of trained technical personnel that understand energy efficiency investment opportunities. Uncertainties related to energy prices or capital availability can lead to the use of stringent investment criteria and high hurdle rates for energy efficiency investments that are higher than the cost of capital to the firm (DeCanio, 1993). Capital rationing is often used within firms as an allocation means for investments, especially for large investments such as many energy efficiency projects.

The relatively slow rate at which industrial capital stock turns over can prove to be a barrier to adoption of energy efficiency improvement since new stock is typically more energy efficient than existing facilities. For example, an evaluation of electric arc furnaces used for steel-making in the United States of America found that electricity use was reduced by 0.7% per year between 1990 and 2002 because of the difference in energy intensity between retired facilities and facilities constructed during this period (Worrell and Biermans, 2005).

Another barrier is the perceived risk involved with adopting new technology since reliability and maintenance of product quality are extremely important to commodity producers. Industrial systems continue to offer substantial opportunities for energy efficiency due to a series of reinforcing barriers that are primarily institutional and behavioural, rather than technical. As with sector-based barriers, the organisational culture is extremely important.

First, as previously mentioned, industrial systems are usually not designed with operational efficiency in mind. Optimising systems for energy efficiency is not taught to engineers and designers at university- it is learned through experience. Systems are designed to maintain reliability at the lowest first cost investment, despite the fact that operating costs are often 80% or more of the life cycle cost of the equipment. As a result, basic design factors such as pipe size may be too small to optimise performance, and too expensive to resize – requiring a work-around approach to do the best optimisation project possible. This emphasis on reliability is further reinforced for facility plant engineers, who are typically evaluated on their ability to avoid disruptions and constraints in production processes, not energy efficient operation. Equipment suppliers also have little incentive to promote more energy efficient system operation, since commissions increase when equipment size is scaled upward. Educating a customer to choose a more efficient approach requires extra time and skill and risks alienating the customer by bringing current practices into question.

Second, once the importance of optimising a system and identifying system optimisation projects is understood, plant engineering and operations staff frequently experience difficulty in achieving management support. The reasons for this are many but central among them are two: a) a management focuses on production as the core activity, not energy efficiency; and b) lack of management understanding of operational costs and equipment life cycle cost. Industrial managers are rarely drawn from the ranks of facilities operators- they come from production and often have little understanding of supporting industrial systems. This situation is further exacerbated by the existence of a budgetary disconnect in industrial facility management between capital projects (including equipment purchases) and operating expenses. Operational budgets are typically separated from capital budgets in industrial organisations, so that energy-use, usually the single largest element of system equipment life cycle cost, does not influence purchase. Without energy-efficient procurement practices, lowest cost purchase of elements in the distribution system such as tool quick-connects and steam or condensate drain traps can result in ongoing energy losses that could be avoided through a small premium at initial purchase.

Third, as a further complication, experience has shown that most optimised industrial systems lose their initial efficiency gains over time due to personnel and production changes. Capital rationing is often used within firms as an allocation means for investments, especially for small investments such as many energy efficiency ones.

Yet, changing how energy is managed by implementing an organisation-wide energy management programme is one of the most successful and cost-effective ways to bring about energy efficiency improvement. Several countries have developed energy management standards and practices as an effective industrial energy efficiency policy mechanism. Among a number of management systems currently used by industrial facilities across most sectors to maintain and improve production quality, the International Standards Organisation (ISO) is the most acceptable framework for industrial energy efficiency. The ISO is a preferred framework because it has been widely adopted in many countries, is used internationally as a trade facilitation mechanism, is already accepted as a principal source for standards related to the performance of energy-consuming industrial equipment, and has a well-established system of independent auditors to assure compliance and maintain certification. This is perhaps because the ISO includes both the quality management programme (ISO 9001:2000) and the environmental management programme (ISO 14001) which can share a single auditing system. Energy efficiency audits or assessments involve collecting data on all of the major energy consuming processes and equipment in a plant as well as documenting specific technologies used in the production process and identifying opportunities for energy efficiency improvement throughout the plant (McKane, *et.al*, 2006).

In the final analysis, the key to effective industrial energy efficiency policy is consistency, transparency, engagement of the industry in programme design and implementation, and, most importantly, allowance for flexibility of industry response. When these criteria are met, industry has shown that it can exceed expectations as a source of reduction in energy-use and corresponding Green House Gas (GHG) emissions while continuing to prosper and grow (Thiruchelvam,*et.al*, 2003).

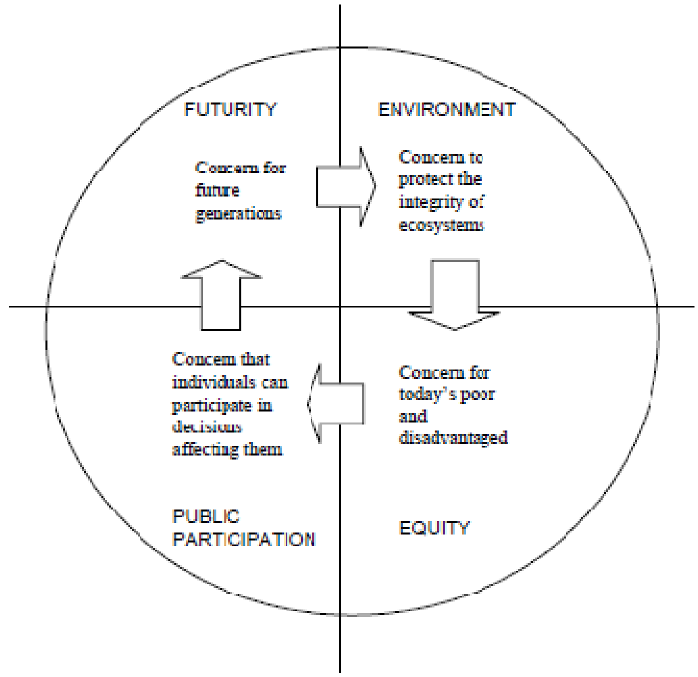
2.1.3 Sustainable Development.

Sustainable development as a concept emerged in the 1980s as a result of international and local debates which focused on environment and development in such way that they are not seen to be mutually exclusive. In other words environment and development are increasingly being seen as two sides of the same coin: if the environment is not well-managed, development will not be sustainable in the long-term. At the same time, protecting the environment at the expense of meeting people's basic needs is also considered unacceptable. According to Redclift (1992) and Beckerman (1994) sustainable development is a broad term that is general and vague, and it is often criticised because it means different things to different people. Thus, the term "sustainable development" has been defined in many different ways.

The most commonly accepted definition is that given by the World Commission on Environment and Development, commonly known as the Brundtland Report or Our Common Future (WCED, 1987) where sustainable development is defined as "a development which meets the needs of the present without compromising the ability of future generations to meet their own needs". The World Conservation Union (IUCN), the United Nations Environmental Programme (UNEP) and the World Wide Fund for Nature (WWF) (1991) define sustainable development as "improving the quality of life while living within the carrying capacity of supporting ecosystems". This definition focuses on the ability of ecological systems to cope with development, and states that there are limits that need to be considered in the natural environment, if we are not to suffer environmental degradation as a result of poor development and planning practices. As if to underscores this, sustainable development was defined by UNIDO (1998) as being about integrating economic, social and ecological concerns in decision-making

Palmer, *et al*, (1996) identify four key principles towards achieving sustainable development, namely: futurity, ecological integrity, social justice and public participation. The inter-connectedness of these four principles is captured in Figure 1.

Figure 1: The Inter-relationship among the Principles Underlying Sustainable Development



Source: Palmer, et al, (1996)

The summary of the message and/or policy lessons from Figure 1 is that sustainable development is only achievable by meeting the needs of present generations, particularly those that are marginalised and impoverished, through wise development and planning while maintaining the healthy functioning of natural systems and involving stakeholders in decisions regarding areas or regions that they have an interest in, in order to avoid exploiting the resource base or damaging the earth's life support systems to the extent that future generations cannot support their needs or have access to a reasonable quality of life. The Brundtland Report (1987) listed seven conditions that would need to be met in order to support these principles of sustainable development. These are: (i) a responsive political decision-making process; (ii) an economic system that does not generate the same resource demands as the present system; (iii) a responsive social system that redistributes the costs and benefits of unequal development; (iv) a system of production which is sensitive to the carrying capacity of the ecological system; (v) innovative developments in technology that enable better uses of resources; (vi) a global alliance to support sustainable development initiatives; and (vii) a responsive, flexible system of governance that enables public participation in decision-making.

2.2 The Link between Energy use Efficiency and Sustainable Development

Energy is related to the multidimensional aspects of sustainable development: the economic social and environmental perspectives. Adequate and affordable energy supplies have been key to economic development and the transition from subsistence agricultural economies to modern industrial and service-oriented societies. Energy is central to improved social and economic well-being, and is indispensable to most industrial and commercial wealth generation. It is key to relieving poverty, improving human welfare and raising living standards. But no matter how essential it may be for development, energy is only a means to an end. The end is good health, high living standards, a sustainable economy and a clean environment. No form of energy — coal, solar, nuclear, wind or any other — is good or bad in itself, and each is only valuable in as far as it can deliver this end (IAEA, 2005).

The important connection between energy and sustainable development concerns the environmental dimension in terms of the relationship between energy extraction, processing and use, and environmental quality. There is no energy production or conversion technology without risk or without waste. Somewhere along all energy chains — from resource extraction to the provision of energy services — pollutants are produced, emitted or disposed of, often with severe health and environmental impacts. Even if a technology does not emit harmful substances at the point of use, emissions and wastes may be associated with its manufacture or other parts of its life cycle. Combustion of fossil fuels is chiefly responsible for urban air pollution, regional acidification and the risk of human-induced climate change (IAEA, 2005). This link is now well-established in the literature and is increasingly recognised in policy circles (IPCC, 2001). Atmospheric releases from fossil fuel energy-systems comprise 64% of global anthropogenic carbon dioxide emissions from 1850 to 1990 (Marland *et al*., 2002; Houghton and Hackler, 2001), 89% of global anthropogenic sulfur emissions from 1850 to 1990 (Lefohn and Husar, 1999), and 17% of global anthropogenic methane emissions from 1860 to 1994 (Stern and Kaufmann, 1996). Fossil energy combustion also releases significant quantities of nitrogen oxide; in the US, 23% of such emissions are from energy use (EIA, 2001). Power generation using fossil fuels, especially coal, is a principal source of trace heavy metals such as mercury, selenium and arsenic. These emissions drive a range of global and regional environmental changes, including global climate change, acid deposition and urban smog.

The requisite of sustainable development is that the production and use of energy should not endanger the quality of life of current and future generations and should not exceed the carrying capacity of ecosystems. Of all the measures that will contribute to meeting this requisite and/or of challenge of sustainable development and limiting climate change, one obvious solution is to use energy more efficiently. That means consuming less energy to produce goods and services, environmental-friendly new behaviours and working methods, coupled with the use of new technologies that offer better energy performance (Total,2007)). Energy-use efficiency is the fastest, cheapest, cleanest way to address these challenges. The efficient use of energy and supplies that are reliable, affordable and less-polluting are widely acknowledged as important and even indispensable components of sustainable development (WCED, 1987; and Goldemberg and Johansson, 1995).

The ability to use the full range of market-based energy and energy technology resources, along with cleaner technologies and fuel systems will help drive the innovation needed to optimise business and societal activities within the framework of sustainable development.

III. Methods and Materials

This study sought to make case for the adoption of industrial energy efficient technologies and practices in developing countries in general, and Nigeria in particular. In this regard, we performed a case study of selected manufacturing companies. Information was obtained from a sample of 13 Nigerian manufacturing companies located in Lagos state (the commercial capital of the country) across four sectoral groupings namely food (4), textile (4), iron and steel (2), and others (3). From each sectoral group, the sampled firms ranged from small, through medium to large scale enterprises. Sampled firms were probed for information about energy-use, energy efficiency and especially investment in energy efficiency and management. And in collecting the required information, we specifically ask questions and sought information in respect of the followings: level of information on energy efficiency; awareness and knowledge about implementing energy efficiency projects; conduct of external energy audit to discover areas where efficiency can be enhanced; existence of active policy on identifying and repairing leakages such as air, heat and steam, through a combination of both internal and external energy audit; investments in energy efficiency; possession of clear information on energy efficiency options; and availability of funds for investment in energy efficiency projects. On the spot visits were made to each of the selected firms, interviews were conducted and production facilities inspected. Inferences were drawn from observations and the narratives recorded during the interviews.

3.2. Sampled Company Information and Main Products

3.2.1 Food Sector

Four manufacturing companies were sampled under the food sector. They are a large manufacturer of food products, a large industrial conglomerate, and a medium-size beverage producing company as well as a large brewing company. The conglomerate’s activities span flour milling, pasta manufacturing, fertiliser blending, bags and other packaging materials manufacturing and agricultural business. For this interview, we visited only the flour milling factory.

3.2.2 Textile

Four companies were also sampled in the textile sector. One of the oldest of them established in 1970s manufactures quality sacks to support the industrial and agricultural market sectors of the Nigerian economy. Currently, this company has a capacity of 30million sacks per month, used to package powder and granular industrial products (Cement, Fertiliser, Flour, Sugar, Salt, Detergent, etc) and open market products (Shopping Bags, Agricultural products etc). Also, additional products such as webbing (Webby), sewing yarns, small cases (Trabag) and flexible intermediates bulk containers (Jumbo bags) have been added to the company's product portfolio. The second firm is a small scale textile company. The main production is the embroidering of laces which takes place in a newly constructed production factory. The company has diversified its production by adding a small plastic factory where plastic tubes are extruded. The third firm produces clothes and fabrics. The company produces 50.000 m^3 of fabrics a day, sold in the local market. The fourth is a large textile company. The company uses 100% Nigerian cotton to spin and weave for the printing and dyeing sector. The main products of the company are wax print, fancy print and dyed cloth. The company employs over 3000 employees and the turnover last year was around 50 million euro. It exports to other Western African countries.

3.2.3 Iron and Steel

There are two companies in this group. The main activity of the first company in this group involves melting scrap metals into billets and rolling them into various sizes of iron rods. The company has about 430 employees and all the end products are sold within Nigeria. The company is 80% owned by a foreign company. The second company commenced production with Aluminium Kitchenware about the time of independence and over the years expanded its operations, investments and commitments in Nigeria. The company's products range encompass Patterned and Stucco Coils, Colour Coated Coils, Roofing Sheets, Cookware, Extruded Profiles and Flexible Packaging. The aluminium mill is being run by foreigners and is part of an international mother company, based in Europe and active worldwide.

3.2.4 Others

Under the group of others, there are three companies. The first is a paper milling company incorporated in the early 1970s as the first paper converter company in Nigeria to manufacture and market top quality paper products. The company provides a wide range of standard and customised stationery solutions to corporate organisations and the commercial stationery market. In contrast to its name, the company does not have a paper mill but focuses on printing activities. The second is a small scale producer of safety glass. The core process is to make glass stronger and suitable for use in architecture and automobile industry. It has a tempering line for hardening the glass and a lamination line for laminating the glass. The company employs about 120 workers and has a turnover of around 550.000 euro. The third is also a small company. The company is active in the fabrication and assembling of light fittings, fixtures and accessories. The company has a flexible production line, mainly focused on the assemblage of product. Most of the parts needed for assemblage are imported from China but the company is able to fabricate metal frames itself. For finishing the products the company has an own powder coating machine, the temperature within this process is around 200 degrees celcius. The company is planning to set up an assembling line for compact fluorescent lamps. The main market for the product is Nigeria but the products are also exported to other Western African countries. The current turnover is around $1 mln/year.

IV. Discussion of Findings

The discussion of the findings of the study is organised around the major focus of the visits made to the firms' production facilities and the interviews conducted. The focus include energy use and generation within the company, level of information on energy efficiency; awareness and knowledge about implementing energy efficiency projects; conduct of external energy audit to discover areas where efficiency can be enhanced; existence of active policy on identifying and repairing leakages through energy audit; investments in energy efficiency; possession of clear information on energy efficiency options; and availability of funds for investment in energy efficiency projects. The findings on each of these sub-themes are summarised and reported in Table 1b, (generated from Table 1a in the appendix) which shows the proportion of sampled firms in each of the four subsectors covered that meet the basic expected requirements in relation to energy use, energy efficiency and especially investment in energy efficiency and management.

Table 1b: Percentage Distribution of the Sampled Firms Energy-use Efficiency and Management Practices Profile across Subsectors.

Assessment Criteria/Sub-Sector	Food	Textile	Iron & Steel	Others	Total
Energy Generation by self	100.0	100.0	100.0	100.0	100.0
Level of information on energy efficiency	25.0	25.0	0.00	0.00	15.4
Awareness and knowledge about implementing energy efficiency projects	75.0	50.0	0.00	0.00	38.5
Conduct of external energy audit to discover areas where efficiency can be enhanced.	25.0	25.0	0.00	0.00	15.4
Existence of active policy on identifying and repairing leakages	25.0	25.0	0.00	0.00	15.4
Investments in energy efficiency	50.0	75.0	0.00	0.00	38.5
Possession of clear information on energy efficiency options	25.0	0.00	0.00	0.00	7.7
Availability of funds for investment in energy efficiency projects.	50.0	75.0	0.00	0.00	38.5

Note: The total column is derived by dividing the number of firms across sub-sectors that meet each requirement by the total number of sampled companies.
Source: Generated from Table 1a.

4.1 Energy-use and Generation within the Company

In the food subsector, all companies sampled (100%) use energy for creating steam, cooling, and milling, as well as for electricity. Nearly all the companies generate their own electricity and about 80% of them are not connected to the national grid because the supply from the national grid is unstable, and any supply disruption during the production process could result in huge loss to the companies. For example, the only company that had connection to the national grid gets 2 to 3 mega watts from this source, while its generates 33 mega watts from its eleven diesel and seven gas generators.

The situation is similar in the textile and other subsectors, most companies sampled generate their electricity. One of the companies in the textile subgroup that relies on the supply from the Power Holding Company of Nigeria (PHCN), states that when there is no supply from the national grid, it uses about 90, 000 liters of heavy fuel LPFO per day and pays PHCN 60,000 million naira per month. Therefore, the cost of energy to the companies in all the sub groups is very high. This is mainly because they generate their power, with additional costs associated (fuel, maintenance and depreciation). In all, energy cost takes 20% to 40% of total costs in the sampled companies. In fact, in one of the companies, a labour-intensive firm, electricity cost is twice the cost of labour which is about 18% of total costs. In all the companies the share of energy costs to total costs remains very significant. Firms, whose processes can tolerate power disruptions, connect to the national grid. Available electricity from this source is cheap, for example, energy cost from the national grid is around 10 to 12 naira/kWh; but some companies spend as much as 40 naira/kWh for independent production.

4.2 Level of Information on Energy Efficiency.

The level of information on energy efficiency among the firms is generally low. In the food subsector, only one firm, representing about 25 per cent, reportedly incorporates energy efficiency considerations into its energy usage and monitors energy-use regularly. It installed kWh measuring devices on all distribution point and on a daily basis records the data. The data is used for calculating loses in the distribution network. Also, the efficiency of the generators is continuously monitored. The other three firms' primary focus is on being able to generate enough power to meet energy demand but actively searching for energy efficiency improvement possibilities and/or options.

In the textiles companies, only one out of the four also constituting just 25 per cent, had adequate information on the levels of its energy efficiency while the other three have low information on their level of energy efficiency. The first company on itself and the group of companies to which it belongs, through information collected on the level of energy-use efficiency, changed from diesel to gas generators some five years ago, and was therefore able to reduce emissions. The three other companies with low information on the levels of their energy efficiency, however, recognise the importance of good information on their energy efficiency as a way towards reducing their energy consumption as well as reducing costs.

The two iron and steel companies (i.e. 100 %) also have low information on their energy efficiency. One of the company (constituting 50 %) has information on the relative energy intensive process of different furnaces in its plant but little or no information on loses in the distribution system and the efficiency of the different generators used in production. The second company reportedly monitors gas at different sectors in the plant, used for analysing trends and indentifying opportunities for energy reduction. However, there was no record kept for this.

One hundred per cent of the companies that constitute the group of other firms (and all of them small in size) realise the importance of adequate information on energy efficiency through monitoring within the company but mentioned that the companies have not been able to do it. What they do and which has semblance to information on energy efficiency is keeping track of energy costs on a daily basis (mainly on fuel costs).

4.3 Awareness and knowledge about implementing energy efficiency projects

A firm is considered being aware and having knowledge about implementing energy efficient projects, if it is able to identify specific projects that could result in energy-use efficiency/reduction in its company and explain the nature of the projects. Of the 13 companies sampled, only one of them belonging to the food sector is considered to have high level awareness and knowledge. This one firm represents about 25 % and 8% of the firms belonging to the food subsector and total sampled firms, respectively. Four others, two in the food sector (constituting 50%) and two in the textile sector (also constituting 50%), respectively possess a level of awareness and knowledge-base that we considered moderate. All the remaining companies, belonging to the iron and steel (100 %) and the group of others (100%), are considered to be of low awareness and knowledge given the quality of their information on projects identification and explanations on their respective nature.

4.4 Conduct of external energy audit to discover areas where efficiency can be enhanced.

As indicated under the section on theoretical insights, energy efficiency audits or assessments involve collecting data on all of the major energy consuming processes and equipment in a plant as well as documenting specific technologies used in the production process and identifying opportunities for energy efficiency improvement throughout the plant. Our findings reveal that only two companies, one from the food sector (representing 25%) and the other from the textile group (also representing 25%), had at any time conducted external energy audit to discover areas where efficiency can be enhanced. It is instructive to note that it is the same companies with awareness and knowledge on energy efficiency projects, though at high and moderate levels, respectively that had conducted external energy audit to determine areas where efficiency can be enhanced. This therefore, suggests that there is a positive link between external energy audit and the level of awareness and knowledge in implementing energy efficiency projects in firms. Expressed more precisely, external energy audit increases firms' awareness and knowledge of implementing energy efficiency projects.

4.5 Existence of active policy on identifying and repairing leakages through energy audit

The enquiry on the existence of an active policy on identifying and repairing leakages through energy audit, particularly internal audit, is to assess the extent of the commitment of the companies to good energy use and management practices. Quite in line with the pattern of previous findings, only two of the companies representing about 15 % of the total sampled firms reportedly have active policy on identifying and repairing leakages through energy audit. The first of the two which is of the food sector, is the same company that has adequate information on the levels of its energy efficiency, high level awareness and knowledge about implementing energy efficiency projects, and had conducted external energy audit to discover areas where efficiency can be enhanced. The second company is a textile company. According to the company, the necessity for an active policy on identifying and repairing leakages through energy audit, which essentially is internal, is because the machine park of the company is very old. The remaining eleven sampled companies, constituting about 85%, as at the time of the study have no active energy policy.

However, these companies disclosed being aware of the environmental impact of their processes and are standing open for assistance for greening their firms and environment.

4.6 Investments in energy efficiency

Investment in energy efficiency projects is absent in most of the sampled firms. Eight companies amounting to about 62% do not have concrete investment examples for energy reduction. Their inability or apathy towards investment in energy efficiency projects was linked to the relative low price of fuel in Nigeria, combined with the high investment costs for machines which result in longer payback period for investments in energy efficiency. Evidence of concrete investment examples were, however, observed in the remaining five companies (representing about 38% of the total sample) –two of the food sector companies (50%) and three textile companies (75%). But only one company had investments informed by awareness and knowledge about implementing energy efficiency projects, conducted of external energy audit and possessed active policy on identifying and repairing leakages. Thus, the machine park of the company is up to date. The newest technology in packaging is adopted, though has an old factory but with new equipment. The oldest machines are not more than five years old and the company is that company which scored high in most previous areas. Table 2 in the appendix provides more detail on energy efficiency investment in the sampled companies.

4.7 Possession of clear information on energy efficiency options

Only one of the companies which represent about 8% of the total sampled firms and 25% of food sub-sector firms, shows clear evidence of possessing clear information on energy efficiency options. The major factor that has perhaps assisted the company in possessing clear information on energy efficiency options is the external audit it had conducted, and which must have enabled it to have the data base of its energy consumption, wastages, environmental impacts and the opportunities for energy efficiency improvement options. The others are just exploring and experimenting with options, but are not willing to align with indentified options for energy reduction and share best practices as well as invest in energy saving and costs reduction technologies.

4.8 Availability of funds for investment in energy efficiency projects.

Only five companies, constituting about 38% of the total sampled companies reportedly have funds to invest in energy efficiency projects. The five companies instructively were those that were earlier indicated in subsection 4.6 to have concrete investment examples for energy reduction and had invested in energy efficient projects in one form or another. For these companies, their investments in energy efficiency projects were solely internally financed. The rest eight which constitute the majority (62%) associated their inability to invest in energy efficiency projects to the lack of funds from both internal and external sources. The capital costs for the projects were according to these firms too high to be financed by internally generated funds. In addition, the payback time for the investment was longer than five year, not acceptable to most of the companies. Availability of external funds was also reportedly constrained by the fact the banks do not consider investment in energy efficiency projects attractive enough.

V. Highlights of Policy Implications from the Study

From the findings of the study discussed above, a number of important policy implications are implicit. These include:

- Electricity from the national grid is heavily subsidised and does not give incentive for energy efficiency investment;
- High energy cost has adversely affected employment situation in the industry. Retrenchment of workers/reduction in number of shifts is always an easier way of reducing cost than other options such as energy efficiency;
- Energy reduction is another substitute for job reduction and both companies and government as well as development partners should be actively engaged in industrial energy efficiency options in developing countries;

- In some of the companies' plants, many machines are very old and thus do not meet the highest energy efficiency standard;
- In some companies, lots of heat energy is generated as by-products but are not being reused at other parts of the plants but simply thrown away;
- National benchmarks for energy consumption in the various industrial processes are not available;
- Some of the companies expressed the need for external consulting, auditing and advice on energy efficiency opportunities;
- Possibility of joint production of power by companies is there but such independent power generation depends on reliable gas supply and competitive energy prices;
- Need for case studies and concrete measures which can be followed by companies to become more energy efficient. In other words, technological advice on energy efficient options will be very useful;
- The need to help in developing cases for small and medium scale power plants and providing information about industrial energy-use;
- Finance for investment in energy efficiency not readily available either from retained earnings or bank loans due mainly to the financial crisis; and
- Need for incentives or subsidies on investments in energy efficiency. Since companies pay fine for polluting the environment with generators, they should be rewarded for greening the environment with energy efficient machines/processes.

VI. Summary and Conclusion

It has been observed that though energy efficiency pays, it is not operationalised in developing countries. To facilitate understanding and the resolve of this puzzle, this paper has provided firm level evidence-based information on energy use and energy efficiency management practices from the industrial sector in Nigeria. The objective being to make case for the adoption of industrial energy efficient technologies and practices in developing countries in general and Nigeria in particularly. In this regard, we performed a case study of selected manufacturing companies. Information was obtained from a sample of 13 Nigerian manufacturing companies located in Lagos state (the commercial capital of the country) across four sectoral groupings, namely; food (4), textile (4), iron and steel (2), and others (3). From each sectoral group, the sampled firms ranged from small, through medium to large scale enterprises. Sampled firms were probed for information about energy use, energy efficiency and especially investment in energy efficiency and management. On the spot visits were made to the each firm's location, interviews conducted and production facilities inspected. Inferences were drawn from observations and the narratives recorded during the interviews.

Pertinent outcomes from the study were (i) the general level of information in Nigeria on energy efficiency was low; (ii) very few companies have adequate awareness and knowledge about implementing energy efficiency projects; (iii) most companies have never carried out an external energy audit to determine areas where efficiency can be enhanced; (iv) most companies need active policy on identifying and repairing leakages such as air, heat and steam, through a combination of internal and external energy audit; (v) the relative low price of fuel in Nigeria, combined with the high investment costs for machines result in long payback period for investments in energy efficiency; (vi) despite the major problem of energy supply facing the companies, a number of them have no clear information on energy efficiency options; and (vii) finance for investment in energy efficiency not readily available either from retained earnings or bank loans due mainly to the financial crisis.

The key policy challenge is the need to address the subsisting paradox where companies pay fine for polluting the environment with generators but are not rewarded for greening the environment with energy efficient machines/processes. The paper therefore recommends the need for incentives or subsidies on investments in energy efficiency.

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Appendix

Table 1a: Summary Statistics on the Energy Use Efficiency and Management Practices among the Sampled Firms.

	Food				**Textile**				**Iron& Steel**		**Others**		
	1	2	3	4	1	2	3	4	1	2	1	2	3
Energy Generation by self	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Level of information on energy efficiency	Adequate	Low	Low	Low	Adequate	Low	Low	Low	Low	Low	Low	Low	Low
Awareness and knowledge about implementing energy efficiency projects	High	Low	Moderate	Moderate	Moderate	Low	Moderate	Low	Low	Low	Low	Low	Low
Conduct of external energy audit to discover areas where efficiency can be enhanced.	Yes	No	No	No	No	No	Yes	No	No	No	No	No	No
Existence of active policy on identifying and repairing leakages**:- air, heat, steam, etc., through a combination of both internal and external energy audit**	Yes	No	No	No	No	No	Yes	No	No	No	No	No	No
Investments in energy efficiency	Yes	No	No	Yes	Yes	No	Yes	Yes	No	No	No	No	No
Possession of clear information on energy efficiency options	Yes	No	No	No	No	No	No	No	No	No	No	No	No
Availability of funds for investment in energy efficiency projects.	Yes	No	No	Yes	Yes	No	Yes	Yes	No	No	No	No	No

Source: Field Survey, 2010

Table 2: Project Examples of Energy Efficiency Investment in sampled Companies

	Project Example	
Sector	**Currently in place**	**Planned**
Food	• A company currently investing in gas generators bought two gas engines (1800 KW each). These are used along with diesel generators. • The company is also overhauling electricity distribution system by changing to 11000 Volts network that results in less voltage drop outs and reduce the loses in the network. • Last year the installation of bi-fuel boilers was completed, which increases efficiency, reduces energy costs and increases energy security. The initial investment costs for this project was 100.000 euro, the payback time for this project was around 1 year. • Currently another company in this sub-sector is into installing a more efficient air compressor. This project has a saving potential of around 20% in electricity use. • The same company, for example, installed a new chiller system for cooling water that doubled output and halved the energy requirements. • We built a new brew house, which is according to the latest technology. As a result the heat requirement of the brew house dropped with 40%. • Another example involves the compression process of Ammonia. We compress ammonia gas and then condensate it for usage as cooling medium. During the compression, the ammonia picks up all kinds of impurities. A simple equipment of not more than 5000 euro, was installed that filters impurities out of the system. As a result the efficiency of the compressor went up by 5% and the electricity use dropped by 10%. The payback time for this investment was less than 1 year!”	• On the long run these gas generators should replace the diesel generators. • But before the company can do this, it first has to build a gas pipeline that costs about 1 million US dollars. It is expected that this investment pays back in two years because gas is much cheaper than diesel for the company.
Textile	• A company invested in energy efficiency by changing chilling system, because the energy consumption of the old system was too high. • A textile company has changed the process of fabrics bleaching from the open bath that is heated by direct steam injection to a new method for heating the bleaching fluid by means of a heat exchanger. The losses of the steam and the running time of the boiler are both reduced in the new system saving 30-40% of energy.	• A company in this sub-sector is planning to channel and use the exhaust fumes of the gas generators, in the boiler system and heat the water. In this way it can reduce around 20% of its energy needs for creating hot water and steam.
Iron and Steel	No concrete project	None
Others	None currently	A collective plan through the Nigerian Manufacturers Association to build a 3 Mega watt power plant in some selected clusters to substitute the small generators used by the companies.