Industrial Engineering Letters
ISSN 2224-6096 (Paper) ISSN 2225-0581 (online)
Vol.6, No.2, 2016


# Product Lifecycle Engineering and Management a Life Line for SMEs in Nigeria: An Appraisal

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**Abstract**
In this 21st century and beyond characterized with rapid development change in technology and innovations, organizations must relentlessly improve their product processes and systems, if they hope to outperform their competitors and maintain relevancy. Invariably, every product has 'life', starting with the design/development, followed by resource extraction, production, use/consumption, and end-of-life activities. However,, Product Lifecycle Engineering and Management (PLM), represents a very important approach for achieving a more sustainable paradigm of work and life, a more sustainable product development, manufacturing, use and dismissal. It is remarkable to note that SMEs account for 97% of all businesses in Nigeria, employs 50% of Nigeria's workforce, and produce 50% of Nigeria's industrial output, but most of these companies (SMEs) are short-lived. The sustainability of these companies and their products' lifecycle has become imperative in order to increase their contributions towards economic, social, political, environmental, and technological development of the Nigeria nation. This paper therefore, shows that effective and efficient PLM will inevitably play a vital and unprecedented role in creating sustainable product environment for SMEs in Africa and most especially fast growing economy like Nigeria.
**Keywords:** Lifecycle, Management, Sustainability, SMEs, ICT Solution, Product Life, Development

## 1 INTRODUCTION

Managing product's lifecycle cannot be feasible without referencing the engineering design and development of various tools and components that make up this ICT solution. Product lifecycle engineering in this context will be treated as an integration of all the business solution softwares (such as; CAD, CAM, ERP, SCM, PDM, etc.) into one system known as Product Lifecycle Management (PLM) at each stage of the product lifecycle.

In this age of rapid developmental change, organizations must relentlessly improve their product processes and systems if they hope to out perform their competitors. In normal course of a product's life, there are several factors which can and do affect the product's future in the market such as changes in the customer's needs, technological innovations, competition and other aspects of marketing environment (Alabar, 2012). In like manner, as the complexity and variety of products increase to satisfy increasingly sophiscated customers, so does the need for knowledge and expertise for developing products. Co-located and monolithic design teams can no longer effectively manage the product development efforts in its entirety. In order to avoid lengthy product development cycles, higher development costs and quality problems, collaboration across distributed and multidisciplinary design teams has become a necessity (Farhad and Deba, 2005).

Rapidly, changing technology is creating short market windows for technology companies. Product complexities due to embedded and installed software are increasing the need to manage software development as part of product development. Along with globalization and aggressive pricing, these challenges are placing intense pressures to optimize new product development from discovery to development, from commercialization to retirement (Grieves, 2006).

According to Tumay (2011), when technology platform and product features are not aligned with customer needs, products are late to market and costs are higher than anticipated. When product development and management activities are not collaborative, the timing of new product launch or retirement of declining product is off resulting in lost market share or profit. Today's' knowledge –intensive product development environment requires a computational frame work which effectively enables capture, representation, retrieval and reuse of product knowledge. This is where the phenomenon of product life cycle management (PLM) comes into play.

However, aggressive innovation by competing firms is leading to more complex products. This in turn requires specialist teams to handle different activities in product lifecycles, concept design, engineering analysis, tooling development, manufacturing planning, part manufacture, product assembly, delivery, service and

disposal. These teams need to work with each other concurrently, to optimize the product with respect to various life cycle issues, and to launch the product early in the market. Concurrent engineering is actually difficult to practice when the specialist teams are located in different parts of the world or a particular country, an increasing trend with globalization (Ravi, 2013). The solution to this problem lies in connecting the team members through a digital communication network and providing them with appropriate software programs to create, analyze and modify a virtual model of the product. The model and results are stored in digital form in a central or distributed server and accessible to all team members over a Local Area Network (LAN) or internet. This approach to product development is referred to as collaborative Product Lifecycle Engineering; its framework is shown in Fig 1.


Fig. 1: Collaborative Product Lifecycle Engineering Framework

Product lifecycle management (PLM) due to its recent application and importance has being defined in many ways. Jensen and Remmen (2004) defined PLM as the application of life-cycle thinking to modern business practice, with an aim to manage the total life cycle of an organization's product and services towards more sustainable consumption and production. It is an integrated framework of concepts and techniques to address environmental, economic, technological and social aspects of products, services, and organizations (Hunkeler et al in SETAC, 2004). Grieves, (2006) puts PLM as an integrated, information-driven approach comprised of people, processes/practices, and technology, to all aspect of a product's life, from its design through manufacture, deployment and maintenance-culminating in the product's removal from service and final disposal. In simple terms, PLM is a business strategy for creating a product-centric environment, rooted in Computer Aided Design (CAD) and Product Data Management (PDM) systems and aimed at connecting various product stakeholders over the entire lifecycle of the product from concept to retirement (Joshi and Dutta, 2004). As a technology solution, it establishes a set of tools and technologies that provide a shared platform for collaboration among product stakeholders and streamlines the flow of information along all the stages of product life cycle. But, what makes PLM district from many other technology solutions is not its states-of-the-art tools; instead it is the establishment of a sustainable corporate strategy via product lifecycle management.

Every product has a "life", starting with the design/development of the product, followed by resource extraction, production (production of materials, as well as manufacturing/provision of the production), use/consumption, and finally end-of-life activities (collecting/sorting, reuse, recycling, and waste disposal). All activities or processes, in a product's life result in environmental impacts due to consumption of resources, emissions of substance into the natural environment, and other environmental exchanges (e.g. radiation) (Rebitzer, et al 2004).

This gives rise to the importance of sustainability in the development of consumer products and services. From the semantics of the word, sustainability is a quality that permits to preserve, to keep, to maintain something. In recent past, the term sustainability was mainly environmentally-oriented i.e. as the quality to sustain the environment (Duque-Ciceri et al, 2009). However, in recent literatures, sustainability is defined with three dimensions of; environmental, social, and economical, also with addition of a forth one, technology (IMS, 2007).

Therefore, achieving "sustainable development requires methods and tools to help quantify and compare the environment impacts of producing goods and services (products) in the society. The Earth Summit in Rio 1992 that introduced Agenda 21 perhaps marks the start of sustainable development in business to meet the challenges of the 21$^{st}$ century. This led to formation of bodies like the World Business Council for Sustainability Development (WBCSD) a business action for sustainable development that promotes sustainable development among business community. These bodies promote sustainable business culture among companies integrating economic, social, and environmental framework in their operation. The rapid adoption of sustainable

business in many companies has provided opportunity to develop closer collaboration with government communities and other stakeholders (Amiolemen and Adegbite, 2010). Adegbite (2009) in his work however, evaluated the application of sustainable development principle among business organizations in Nigeria.

## 2 REVIEWING LITERATURES

### *2.1 Product Life Cycle (PLC) or Life Cycle*

Wells et al (1995) put product life cycle (PLC) as an important tool for analysis and planning of the marketing mix activity. Theodore Levitt introduced the concept in an article in the Harvard Business Review in 1965. It is based on a metaphor that treats products as people and assumes they are born (introduced), develop (grow), age mature, and die (decline). Going by the work of Morden (1991), the product life cycle represents recognition of the fact that most products will only have a finite market life - be it short as in the case of fashion goods or long as in the case of certain types of industrial equipment. Kotler (2000) sees the concept as implying the following.

(a) That a product has a limited life, which is to say that a product may not to go on in perpetuity except definite ways are formed to reinvent the product to re-establish its relevance.
(b) The product sale passes or undergoes different stages with each stage posing its own challenges and problems.
(c) Profit also rise and fall at different stages in the life of the product.
(d) These products require different marketing, financial, manufacturing, purchasing and personal strategies or assistance at different stages from the marketing people so as to maximize the benefits or potentials open to the product.

According to Bearden et al (1998), demonstrated the following stages for the product life cycle, thus;

(a) Introduction stage (b) Growth stage
(c) Maturity state and (d) Decline stage

These stages are represented graphically in Fig 2.

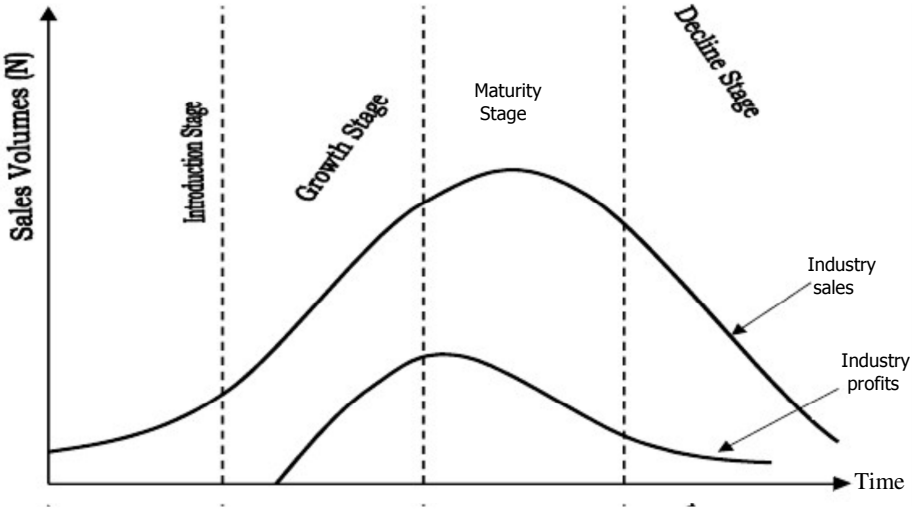



Fig. 2: The Product Lifecycle Stages

*2.1.1 Introduction Stage:* The introduction stage of the product life cycle occurs when a production is first introduced to its intended target market. At this stage, sales grow slowly, and profit is minimal. Buyers are unsure about the product and it is not stocked by all distributors. The product is adapted as customers provide feedback. If purchasers are satisfied with the product, its reputation will spread and it will enter the growth stage.
*2.1.2 Growth Stage:* This stage is marked by a rapid climb in the sales of the product especially the early adopter like the product and the middle class majority is beginning to start patronizing the product. New competitors enter the market with different product versions arising from the increasing number of potential customers.
*2.1.3 Maturity Stage:* No product or market can grow forever, eventually all the significant uses will have been developed. The sales curve will flatten and the market or product will have reached maturity. Profit peaks, and then begins to decline, reflecting intensified competition, especially on price. Demand is also fairly stable at this point in time with no sudden upsurges or downward dip in the sales of the product.
*2.1.4 Decline Stage:* This is the period when sales continue a strong downward drift and profits erode rapidly toward the zero point. The decline may be slow or rapid (Alabar, 2012).

### 2.2 Brief History/Evolution of Product Lifecycle Engineering and Management

In the earthly 1980s, engineering design entered a new era with the advent of Computer Aided Design (CAD) systems. CAD systems enabled the creation of a geometric model of the product in the computer, to be reused

and manipulated by the designer as needed. Each new CAD system provided more/better features and functions than earlier ones. In parallel with the development of Computer-Aided Design, Manufacture and Engineering (CAD/CAM/CAE) tools, Product Data Management (PDM) systems appeared during 1980s to control and manage the product information created by various information authoring tools (Hayes and Pisano, 1994).

Later, the PDM solutions were supplemented with new functionalities like; change management, document management, workflow management and project management that promised concurrent engineering and stream-lined product development processes within the enterprise. However, PDM had two major constraints (a) they had a limited scope, in terms of data as they are limited to engineering information like geometric models, BOM (Bill of Material) and FEA (Finite Element Analysis) models (b) working with PDM systems was not always easy and usually required an engineering technical background. In the 1990s PDM vendors began offering systems with web-enabled front-end together with more powerful and user-friendly visualization tools to broaden the user base. Due to the universal, inexpensive and ubiquitous nature of the internet, the web-based PDM systems became more accessible throughout the extended enterprise. Nevertheless, their core functionalities remained focused on managing engineering documents, hence inadequate to support all tasks in the management of a product data throughout its lifecycle (Lee, 1999).

Almost concurrent with the evolution of PDM systems, the first wave of enterprise applications such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM) and Supply Chain Management (SCM) were introduced. These were aimed at further streamlining and improving the manufacture's business practice. However, PDM systems could not provide the necessary support for ERP/CRM/SCM (unlike CAD/CAM/CAE) simple because the internal piping of PDM systems are designed specifically for handling engineering data (Stark, 2004; Grieves, 2009).

Product Lifecycle Management and Engineering (PLM) concept came later in the 1990s with the aim of moving beyond engineering aspects of a product and providing a shared platform for the creation, organization and dissemination of product related information (cradle to grave) across the extended enterprise (Saaksvouri and Immonen, 2008; Bernard and Tichkiewitch, 2008). PLM seeks to extend the reach of PDM beyond design and manufacturing into other areas like marketing, sale and after sale service, and at the same time addresses all the stakeholders of the product throughout its lifecycle business processes and product development processes. PLM also seeks to fill the gap between enterprise business processes and product development processes. In addition, PLM has one major identifier: it is all about knowledge management". Unlike PDM, systems which focus on managing data, PLM, at its core is a process which supports capture, organization reuse of knowledge throughout the product lifecycle.

### 2.3 Product Lifecycle-Engineering and Management (PLM)

Product lifecycle engineering solution is well known in the ICT market, even if unlike other technology solutions PLM is not a point solution or an off-the-shelf tool. Instead, it is grounded in the philosophy of connectedness of knowledge and seeks to provide "the right information at the right time,, in the right context". PLM is physically enabled by the integration of a variety of enterprise software applications, like Computer Aided Design (CAD) tools, Product Data Management (PDM) platforms, Enterprise Resource Planning (ERP) and Supply Chain Management (SCM) solutions (Terzi et al, 2007). Such a term "life cycle" generally indicates the whole set of phases which could be recognized as independent stages to be passed/followed/performed by a product, from "its cradle to its grave". According to Kiritsis et al (2003), product lifecycle consists of three main phases (Fig 3).

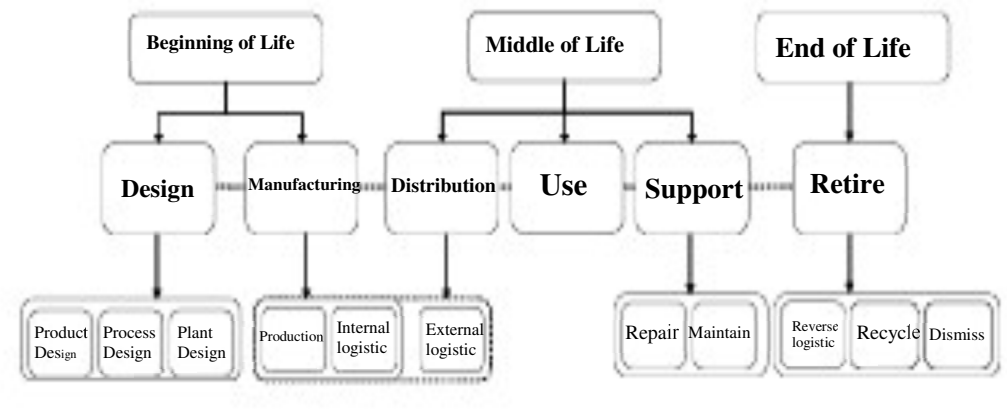



Fig. 3: Reference model for product lifecycle phases

*2.3.1 Beginning of Life (BOL):* This consists of design and management. Design is a multi level phase, since it comprises product, process and plant design. Today's knowledge - intensive product development (PLM IWG, 2007) requires a computational framework that enables the capture, representation, retrieval and reuse of product and process knowledge. Manufacturing means production of the artefacts and related plant internal logistics. At this stage, product information has to be shared along the production chain, to be synchronized with future updates.
*2.3.2 Middle of Life (MOL):* This includes distribution (external logistic), use and support, (in terms of repair and maintenance). In its life, a product passes from the company's hand to service suppliers (e.g. transportation suppliers, but also after-sales assistance suppliers), to arrive in the customer's hands. These passages could happen many and many times in reiterative ways. Product usage data are to be collected, transformed and used for various purposes in the service chain. For example, data on product behavior during the usage phase can be fed-back in BOL and used for design development improvement.
*2.3.3 End-of-Life (EOL):* This is where products are retired-actually recollected in the company's hands (reverse logistic) in order to be recycled (disassembled, remanufactured, reused etc) or disposed. Recycling and dismissal activities require and provide useful information on product components, materials and resource from/to the design and manufacturing stages. Recycling is a process to change (waster) materials (Figs. 4a-c) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower green house gas emissions as compared to plastic production (Zimring, 2005).

Nevertheless, PLM concept is certainly a question of data visualization and transformation where ICT plays a fundamental role. PLM also comprises of two other levels: processes (where data flow among actors/resource with relative competences, inside and outside an organization) and methodologies (practice and techniques adopted along the processes, using and generating product data). These three elements (ICT, Processes and Methodologies) are the fundamentals of the PLM concept, evolving along the lifecycle phases of the product as depicted in Fig. 5.


Fig. 4(a): Early sorting of recyclable materials: glass and plastic bottles

Fig. 4(b): A recycling point with separate containers for paper, plastics and differently colored glass.

Fig. 4(c): Bales of crushed steel ready for transport to the smelter.

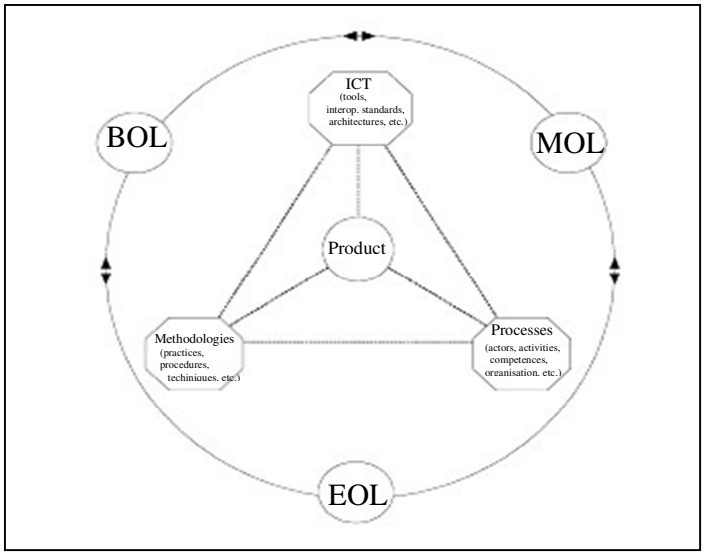



Fig. 5: Three elements of Product Lifecycle Management

**2.4 Product Lifecycle Engineering and Sustainable Development**

One of the most used definitions of sustainable development is the one given in 1987 by Brundtland Commission as "the development that meets the need of present without compromising the ability of future generations to meet their own needs" (UN Commission 1987). From the basics, engineering is a key driver of human development. Looking at the role of technology based human development which is leveraging on a large collaboration from many individual disciplines. Hence Sustainable Engineering can be defined as the way of applying engineering for sustainability purposes (Duque-Ciceri et al, 2009). Sustainable Engineering can be seen (Fig.6) as a layer of engineering oriented approaches, methods and tools crossing the four pillars of social (society), Economy, Environment and Technology for achieving sustainability oriented results.

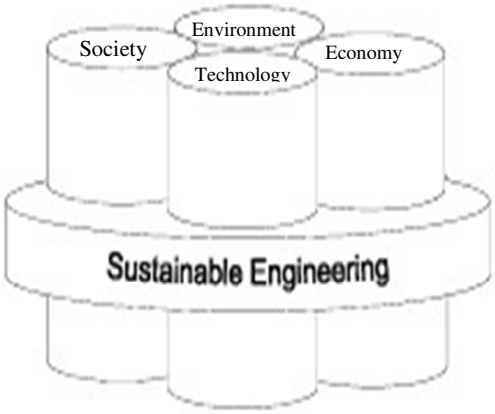



Fig. 6: Dimensions of Sustainable Engineering

Subsequently, sustainable manufacturing is defined as the application of scientific knowledge to design and implement of products, materials, systems, processes, etc, that take into account constraints coming from the 4 pillars of sustainability to develop solutions for the design, operational and organizational activities related to products, processes and services in the manufacturing sector. Sustainable development therefore, poses a challenge to industry to produce higher levels of output using lower levels of input and generating less waste (Egun, 2012). Deloitte and Touche (1992) indicated the concept of sustainable development requires organizations to develop a culture that emphasizes employee participation, continuous learning and improvement.

Sustainability in the context of the product lifecycle can be seen as an optimization of all activities belonging to the product lifecycle; a more sustainable development could be reached managing efficiently processes and information Seliger (2004) epitomized. During BOL, PLM can support a sustainable product development providing a common system in which the relevant product information is stored, managed and

actually retrieved by the applicable lifecycle phases. The PLM system can be used to store and manage relevant information regarding resources (such as energy and renewables, ground and soil, water etc) and materials (such as hazardous substances, waste and recycling etc). In fact, a life cycle approach to sustainability (Joshi and Dutta, 2004) means to evaluate a product/service beginning with material extraction, continuing with manufacturing and use, and ending with recycling and disposal.

In terms of evolution of PLM for sustainable manufacturing, there is an urgent need to identify and retrieve decades-old product information for delivering service and sustainability along the product lifecycle. As mentioned, sooner or later in each industrial sector, it will not be enough for product manufacturers simply to design their products for disposal and recycling: manufacturers will be responsible for the actual disposal and recycling, till the end of the life of their artifacts.

## 3. SMALL AND MEDIUM ENTERPRISE: THE NIGERIAN CONTEXT

The historical background of small and medium enterprises (SMEs) in Nigeria can be traced back to 1946 when the essential paper No. 24 of 1945 on ten-year plan of development and welfare of Nigerian 1946 was presented. SME is an all time necessity; it was there at the beginning, it has gained prominence today and will increase its importance tomorrow. This is simply dictated by the development needs of the Nigerian society (Aremu and Adeyemi, 2011). The SME industry is seen as a key to Nigeria's growth and alleviation of poverty and unemployment in the country. Therefore promotion of such enterprises in developing economic like Nigeria is of paramount importance since it brings about a great distribution of income and wealth, economic self-reliance, entrepreneurial development, employment and hosts of other positive economic uplifting factors (Aremu, 2004).

Countries do not use the same definition for classifying their SME sector, nor does a universal definition, appear to be necessary (Henschel, 2009; Altman et al, 2008; Aremu and Adeyemi, 2011). These differences are from country to country, industry to industry, school to school and author to author (Fatai, 2010). According to United Nations Environment Programme (UNEP) 2003, while some countries prefer to categorize small enterprise into three, that is, micro, small and medium or very small, small and medium, some others adopt two categories of small and medium. Hence, authors from different countries have come-up with different definitions of SMEs based on the classification used in their countries and the guidelines approved by their governments. European Union (EU) submits that micro firms are those which employ less than 10 employees, and with an annual turnover of about 2 million Euros, small firms employ less than 50 employees, and with about 10 million Euros as their annual turnover, while medium sized firms employ less than 250 employees with an annual turnover of 43 million Euros (UNEP, 2003). However, in South Africa, small enterprises are categorized into four namely; micro, very small, small and medium enterprises (Smith and Watkins, 2012). Table 1, summaries some of the definitions used in Nigeria (Yusuf and Damson, 2013).

**Table 1: Definitions of SMEs in Nigeria**

| Author | Year | No. of Employees | Capital Employed/Asset |
|---|---|---|---|
| The Small Scale Industries Association of Nigeria | 1973 | Not more than 50 | N60,000 (Pre-Sap Value) |
| The third National Development Plan | 1975-1980 | Less than 10 | N600,000 |
| The Federal Government | 1980 | Nil | N150,000 |
| The Centre for Management Development (CMD) | 1982 | 50 Full time workers | Nil |
| The Central Bank of Nigeria | 1995 | Nil | Less than N500,000 |
| Ogundele | 2000 | 5 | N5000 |
| The Federal Ministry of Commerce and Inductries | 2003 | Not more than 50 | N250,000 |

Nevertheless, writing the Nigerian context, the best way to capture the definition as posited by National Economic Summit Group (NESG), (2002) is based on the nature of business and magnitude. For instant, road-side artisans, petty-traders pure/bottled water producers, bakers, local fabricators (regard as micro enterprises) should constitute part of SMEs.

Policymakers world over have the positioned small and medium enterprises (SMEs) as the ideal way to increase sustainable development in any country (Mbizi, Hove and Kakava, 2013). In Nigeria, there is a general believe that the desired employment generation in the country can be achieved through development of small and medium enterprises (Awosika, 1997; Schmitz. 1995; Guru, 2004). Also, recent studies have established the fact that SMEs are keys to the growth and development of economies. Ojukwu (2006) puts it that SMEs provide the cornerstones on which any country's economic growth and stability rests. The Nigerian Business Life (2003), Szabo (1998), Stokes (1998) and the Organization for Economic Co-operation and Development (OECD) (2006) support the argument that SMEs form the backbone of all economies. As concurred by Twist (2000) cited in

Ojukwu (2006), that SMEs represent more than 99% of all employers, employ 51% of private-sector workers, provide about 75% of new jobs of the private sector output and represent 96% of goods exported.

However, Nigeria has an estimate population of seventeen million SMEs (Aganga cited in Adeloye, 2012), representing over 80% of the total number of firms in Nigeria and employ over 31 million Nigerian or about 75% of the total workforce. Aganga further noted that SMEs' contribution to the GDP in Nigeria is relatively low as a result of the major is relatively low as a result of the major constraints in the operating environmental (Adeloye, 2005). Such constraints include; insecurity, corruption and poor infrastructure (Kauffmann 2005).

### 3.1 SMEs and Nigeria's Economic Development.

Emphatically, SMEs have a number of significant contributions roles to the economic growth and development of Nigeria. SMEs also participate actively in the mobilization of natural resources and reduce supply on the labour market (Ogechukwu, 2011). In affirmation, Ariyo (2008) posits that SMEs account for 97% of all businesses in Nigeria employs 50% of Nigeria's workforce and produce 50% of Nigeria's industrial output. Nowduri (2012) reiterates that SMEs enhance the distribution of economic growth in a decentrized and more equitable manner eliminating concentrated areas of population and enable equitable distribution of wealth among the populace in an emerging economy. Some of the role/contributions of SMEs to Nigerian economic growth are summarizes below (Yusuf and Damson, 2013).

1. Sound development of SMEs has positive implications for improved standard of living of the people, and it generators foreign exchange for further development of the economy.
2. SMEs proliferation has increased the level of economic and social development particularly in the rural areas. They can survive on rudiment industrial infrastructures, hence easily located in rural areas and become major facilitators for industrial dispersed and rural development and thus help in mitigating the rural-urban drift.
3. SMEs are sources of employment generation: this is because more jobs per unit of investment capital and per unit of energy consumed are created worldwide by SMEs than large-scale enterprises, providing employment to a lot of unemployment Nigerians.
4. SMEs provide a training avenue for the creation of local entrepreneurs in several areas of economic activities.
5. Citing SMEs in rural areas help to improve rural infrastructures and standard of living of the rural people.
6. SMEs act as catalysts to large enterprises through the supply of raw materials, goods and parts to them.
7. SMEs have minimized the pressure and dependence on government and large companies by job-seekers for salaried employment.
8. They provide opportunities for the development of local skill and technological acquisition. Examples are "the Japan of Nigeria" with reference to Nnewi industrial prowess and "the Aba made" syndrome.

### 3.2 Problems of SMEs Sustainable Development

Despite the efforts of government and other stakeholders to achieve economic growth and development through sustainable SMEs, most small firms are short-lived. (Aremu and Laraba, 2011; Yusuf and Damsu, 2013). According to Utomi (2008) cited in Ifekwem et al (2011), few of the early wealthy families (SMEs owners) have been able to sustain wealth past one generation, many of the ventures have failed rather than change ownership. It is obvious that most large public firms in some countries started as SMEs, but the case of Nigeria could not be treated as such, where only about five to ten percent (5% to 10%) of SME companies survive, thrive and grow to maturity. Key among the factors contributing to premature death of SMEs in Nigeria include; insufficient capital, lack of focus, inadequate market research, over-concentrations on one or two markets for finished products, lack of succession plan, inexperience, lack of proper book keeping, irregular power supply, infrastructural inadequacies (Water, roads etc), lack of proper to separate business and family to personal finances, lack of business strategy, inability to distinguish between revenue and profit, inability to procure right plant and machinery, inability to engage or employ the right caliber of staff, cut-throat competitions (Basil, 2005).

However, several factors have been identified to be responsible for the poor implementation of sustainable development policies by small/medium business organization in Nigeria. These factors are summarily discussed below with a view to anticipate necessary improvement towards sustainable cooperation as defined by Dunphy et al (2003).

*3.2.1 Employee Awareness:* It is observed that although most SMEs in Nigeria claim to do business in a sustainable way, the awareness among employees is low. The role of employees in any business can never be under estimated. As the principle of sustainable development is evolving in industrial organization in Nigeria, there is need for employers to effectively ensure that sustainable development policies, adopted by organizations are also enshrined in the employees' codes of conduct. Constant training and awareness campaign (on ICT related solutions such as PLM tools), from top management to lower level of the organization are also important.

*3.2.2 Inadequate Knowledge Base on Sustainable Strategy:* From recent studies, it is evident that majority of SMEs in Nigeria lack the knowledge on how to implement principles of sustainable business compare to those in

the United Kingdom and United States. The result of recent survey showed that the banking and telecommunication companies, which are categorized and large enterprises in Nigeria lack explicit knowledge of Triple Bottom Line concept by John Elkington (1997) and Eco-efficiency concept of World Business Council for Sustainable Development (WBCSD, 1996). Subsequently, it is glaring that SMEs in Nigeria will not fare any good.

*3.2.3 Organization Ignorance:* Most SMEs even some large enterprises in Nigeria adopt a subjective approach to their sustainable policy rather than a holistic approach. They view corporate social responsibility as a sustainable policy factored on entertainment and sponsorship. For instance, MTN Nigeria adopted a subjective development (i.e. education, small scale business development, and healthcare development) without focus on environmental health. But, this is quite unlike MTN South Africa, where it engages in waste re-use, recycle, and minimizing energy usage in its operations to reduce operational cost.

*3.2.4 Lack of Experts in the Field:* The overall implementation of any form of policy or agenda within an organization either public or private requires the services of experts in that field. To this extent, it is imperative for tertiary institutions in Nigeria to start training sustainable /environmental managers and computer literate engineers who can implement a well co-ordinated sustainable development policy and product lifestyle engineering tools for SMEs and large corporations in Nigeria.

*3.2.5 Government Role/Policy:* The role played by government both nationally and internationally in implementing sustainable development policy is very critical to the impact the policy will have on the society. Based on evidence, the federal government of Nigeria approach towards sustainable development and her general plan to facilitate business organizations to embark on sustainable programme is poor. Nigerian government also have not provided detailed information on nation strategy and indicators for sustainable development that can serve as a building block for SMEs and large enterprises (UNCSD 2009).

With justice done to the list of problems and factors affecting SMEs, how then can a sustainable SME be achieved in Nigeria?

## 4 SUSTAINABLE SME AND PRODUCT LIFECYCLE ENGINEERING AND MANAGEMENT (PLM) TOOLS

Cim-data (2003) defined PLM as a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life -integrating people, processes, business system, and information. The actual definitions of PLM (Stark, 2004; Terzi, 2005) focus on the product data, but do not include the processes management option. Small and Medium enterprises have special needs and limited resources. PLM concept brings complete solutions designed specifically for them; solutions that help them respond better to their customers' needs (Gecevska et al, 2010).

SMEs need a product lifestyle management solution designed from the ground-up, one that is pre-configured with the industry's best practices, and offers fast and affordable deployment. Fully integrated PLM solutions are designed to provide what small and medium enterprises need to maximize their innovative strategy, and easily scale to meet their needs tomorrow (sustainable). One producer of that type of PLM software solutions is Siemens PLM software (Siemens PLM, 2009). It helps mid-sized manufacturing companies to transform their process of innovation by applying pre-configured best practices to everyday engineering tasks and processes. SMEs using PLM software benefit from.

i. Securing their corporate design data while facilitating access by authorized personnel.
ii. A more successful more from 2D to 3D.
iii. Increasing their design reuse, facilitated by a powerful and flexible search capability.
iv. Streamlining their engineering process with simple review and release workflow and effective change management.
v. Error reduction through more effective collaboration between their departments and the elimination of mistake manual hand offs to manufacturing.
vi. Rapid deployment of a full-featured product data management (PDM) solution.
vii. Low total cost of ownership.

### 4.1 Effective Product Lifecycle Management

Effective product lifecycle management (PLM ) is extremely complex for most consumer goods and services companies, requiring them to integrate many internal and external resources and capabilities, not all of which they control directly. These external participants and influences include innovators and new product development agencies that feed product ideas to the research and development (R & D) team, as well as widely distributed partners in a global supply chain or manufacturing operation (Accenture, 2010).

Effective product lifecycle management should span the whole lifecycle, from product ideation and market research to product retirement. Yet ensuring this holistic treatment requires the cooperation of many

functions: research, marketing, sales and manufacturing and participants including retailers and supply chain partners. There are companies that supply software to support the PLM process. That software itself is just a tool and cannot make many contributions if the PLM process is not defined first and understood by its users whom it should contribute to at the end (Kecojevic et al. 2010).

Setting up an effective and efficient PLM with the SME organization is a process and a project itself. Selected operations that should be managed as a part of the PLM across the SME business would be:

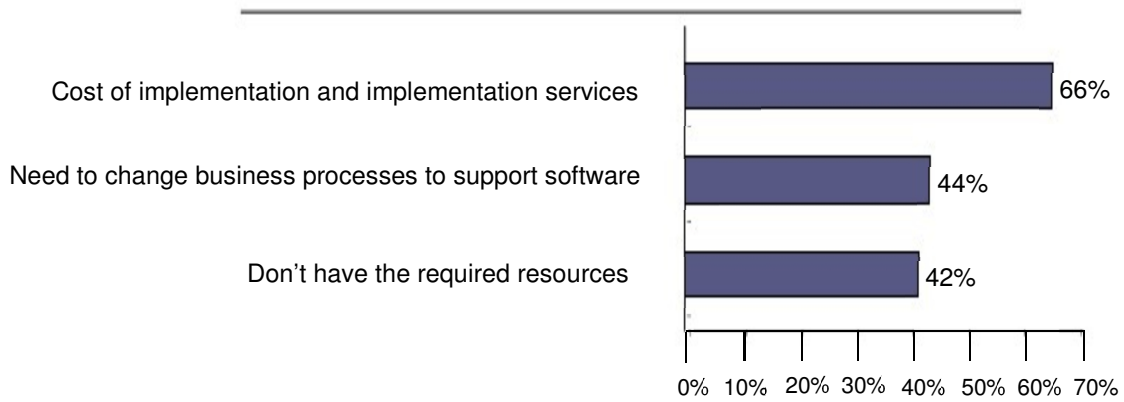
a. Customer relationship management (CRM) system for managing customer record.
b. Enterprise resource planning (ERP) system for managing financial records.
c. Supply chain management (SCM) system for managing supplier support.
d. Human resource management (HRM) system to manage the employee record.
e. Requirement management (RM) system for managing of requirements.
f. Project management (PM) system for managing capabilities, provide project scheduling, tracking, and resource management while the change management is driving the execution of these project via the process workflows and part/document management capabilities.
g. Product data management (PDM) system for managing product data and workflows (Pol et al., 2008).

In addition, to establish effective and efficient PLM, the first-step would be to understand and analyze the company's way of work, organizational structure, roles and responsibilities within the organization. Each of the PLM operational systems should be defined to specify who is contributing to the system, how the information is shared and responsible person appointed for each of the systems. However, it is not necessary that all those operation systems are integrated within one software tool, and usually for SMEs they won't be, while on the other side, large enterprises might need to adopt available software and tools to their specific needs.

**4.2 SMEs Unique Challenges with PLM**

In response to increasing complexity and strategic activities for profitable growth, many SMEs are planning to improve product innovation, product development, and engineering processes with PLM technologies. SMEs face challenges when considering or implementing PLM, however, that are unique to smaller-sized organization (Fig 7). In fact, more than two-third of the SMEs in Nigeria mentioned the cost of a software package and knowledge as a challenge to adopting PLM solutions. Their concern also was focused on successfully incorporating the solution into the business (Brown, 2006).

**Figure 7: PLM Adoption Challenges for SMEs**




These unique challenge SMEs face with the implementation of PLM solution is summarily discussed thus:

*4.2.1 Cost Implementation:* Implementations of enterprise software solutions require acceptance and adoption (i.e. regular use by the business in order to provide value). For a successful adoption, SMEs must assess their business processes, identify the changes to be targeted and the solutions to be deployed and train users to take advantage of them. However, the cost of implementation may become a barrier if solutions are too complex, require significant configuring, entail software modifications, or force companies to rethink business processes from scratch.

*4.2.2 Need to Change Business Processes:* The greater the changes to business processes, the more effort required for training, documentations, and user acceptance. Often, SMEs must create a balance: changing processes that enable a business advantage. Actually, no company should expect to achieve significant benefits without enacting change, many companies feel that must conform to the business process built into the software.

*4.2.3 Lack of Knowledge Base:* SMEs may approve funding for software and implementation, but then face roadblock in assembling the appropriate project team. Making business-knowledgeable employees available to

help craft the new processes and determine how to use the software is important to ensure that new processes fit the business. While, functional talent may be hard to commit to projects, SMEs may also lack the depth in technical resolution required to implement a new solution.

### 4.3 PLM Towards a Sustainable SME

Sustainability in the context of the product lifecycle can be seen as an optimization of all the activities belonging to the product lifecycle: a more sustainable development could be reached managing effectively processes and information. A lifecycle approach to a sustainable SME means to evaluate a product or service beginning with material extraction, continuing with manufacturing and use, and ending with recycling and disposal. This information generation and sharing can be housed by PLM in terms of providing the place to be created, to be stored, to be processed and to be properly allocated.

In terms of evolution of PLM for sustainable manufacturing for SMEs there is an urgent need to identify and retrieve decade-old product information for delivering service and sustainability along the product lifecycle. Sooner or later in the SME sector and other industrial sector, it will not be enough for product manufacturers simply to design their products for disposal and recycling. Rather, manufacturers will be responsible for the actual disposal and recycling, fill the end of the life of their artifacts (Giavic and Lukman, 2007).

### 4.4. Benefits and Business Values of PLM to SMEs

According to Aberdem Group Benchmark research (2006), many SMEs are responding to the product innovation challenge by proactive focusing on product related processes by planning for PLM solutions. They have achieved significant improvement, including increased revenues (19%), reduced product cost (17%) and decreased product development cost (16%) recorded remarkable improvements in the following areas (Fig 8);

a. Control over product and related project development and program execution.
b. Accelerate product launch – bringing innovative and quality products to market ahead of competitors, enables strategic differentiation and high profit margins through premium pricing.
c. Increase profitable growth and extend lifecycle returns – coherent platform and PLM strategy provides agility and speed for delivering new product versions and options to diverse global market.
d. Reduce operational costs - Concurrent product/production process design, virtual product development, part reuse and elimination of rework, drives down design and development costs.
e. Reduce business risks – requirement, traceability detailed documentation of the product/process history, shared product/process knowledge enables adherence and responsiveness to changing compliance and safety regulations, product liability claims, supply chain sustainability. (Tumay, 2011; Lindenthal, 2006).

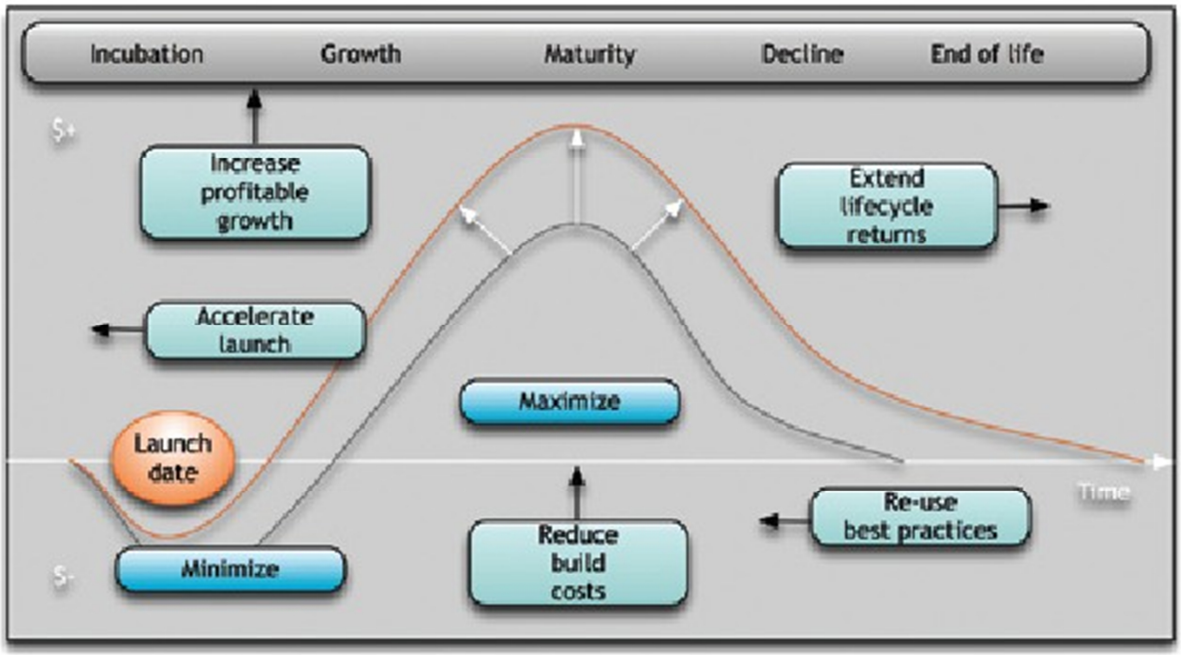



Fig. 8: Benefits and Business values of PLM to SMEs

### 4.5. Actions Recommended for SMEs in Nigeria

The following recommendations are intended to help small to medium-sized manufacturers in Nigeria and their counterparts world over to take action and size opportunity that PLM provides to improve, product innovation, product development, and engineering processes to improve corporate level and sustainable business performance (Aberdeen Group, 2006). SMEs specifically should take these actions in order to compete and win in the global environment;

i. Educate themselves on PLM including the implications of PLM outside of departmental and company boundaries, for example, with supply chain partners.
ii. Pick the right starting point by starting with a tangible business problem that they can solve and implementing a solution targeted to solve that problem as a foundation on which to build their full PLM solution.
iii. Look for PLM solutions that provide templates to common business processes and best practices and modify them if necessary, so they do not need to rethink every business process in an attempt to improve it.
iv. Seek solutions that fit their industry, through specialized solution or industry templates. Softwares that provide a better fit with the business can better support businesses processes, leading to more rapid adoption by users.
v. Include organizational process and performance measurement considerations in their PLM strategy in addition to technology considerations.
vi. Consider hosted or software-as-a-service solutions to reduce the technical barriers to PLM adoption. The implementation approaches can reduce the resource requirements from internal technical resources, which may already be stretched in many smaller businesses.
vii. Take advantage of the PLM opportunity to achieve tangible improvements. SMEs that do not adopt PLM will be at a competitive disadvantage.

### 4.6 CONCLUSION

Product Lifecycle Engineering and Management (PLM) represents a very important approach for achieving a more sustainable paradigm of work and life, a more sustainable product development, manufacturing , use and dismissal. Invariably, sustainability has a social responsibility impact, but its attainment is matter of practical implementations. Sustainability can be achieved through lifecycle, while retaining quality of product and services. It is obvious that optimization and quality of product related processes are strongly based on the use of information, which is what PLM solution provides in its database at every stage of the product's life. Hence, SMEs need to manage the product lifecycle and keep track of the information flow within all of the lifecycle phases of the product or services. However, the top SME challenges to PLM adoption in Nigeria are; the cost of implementation, the need to change business processes, and lack of internal resources available for the project. The truth is that PLM product offerings that help smaller companies achieve the available benefits are emerging, leading to increased adoption by SMEs in Nigeria and mostly developed countries. Therefore, achieving value requires more than just PLM software but also requires efforts to transform the organization and business processes, in combination with the underlying supporting technology. Finally, this paper shows that effective and efficient PLM will inevitably play a vital and unprecedented role in creating a sustainable product environment for SMEs in Africa and most especially fast growing economy like Nigeria.

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