The Nigerian Institution of Mechanical Engineers *a division of*
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Challenges and Contributions for Mechanical Engineering:♣

A call to the Nigerian Mechanical Engineer

by

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CHALLENGES AND CONTRIBUTIONS FOR MECHANICAL ENGINEERING

1.0 INRODUCTORY MESSAGE

It is a special pleasure and privilege for me to be here in Jos, the Plateau State capital. The Nigerian Institution of Mechanical Engineers (a division of the Nigerian society of Engineers) is particularly a good place to think about the future of one of our emblematic disciplines: Mechanical Engineering. As a Mechanical Engineer, an academic and consultant, I am very pleased to meet all of you and to share my thoughts with you. I wish to thank the organizers, (the Nigerian Institution of Mechanical Engineers (NIMechE) Jos Branch) very much for inviting me.

The title of this talk could not be more relevant in a period when we have to adapt the education and the practice of mechanical engineering to a completely different society from that of the second half of the 20th century. My attempt this morning will be to deal with three major issues:

- The new context of our society today;
- The engineering profession and its interaction with society:
  - What is the role of the mechanical engineer in the knowledge economy?
  - What are the values that a mechanical engineer should have?
  - Is it true that mechanical engineers have lost value in engineering practice?
- The main challenges that the mechanical engineering profession has to address are multidisciplinary and multicultural, what are these challenges and the way forward for Nigeria.

1.1 The 21st Century Society: a new context

Today, hardly does anyone question the series of transformations that are changing the way we live, the way we produce "things" and the way that society evolves. Three main features are present in our society today:

- ✓ Complexity – dynamic complexity
- ✓ Global interdependence – social, financial and economic Interdependence
- ✓ Huge science and technological capital stock. Scientific research has increased our knowledge and ability to understand almost

everything in an ever-wider range of scales in space and time. Today, there is enough science, enough technology to meet almost all our needs.

Looking at the world picture, the increasing integration of the different regions of the planet throughout trading and foreign investment has brought not only opportunities and growth, but also challenges and risks. As a result, our society faces four main challenges that are instrumental for the engineering profession:

- ✓ Demography: the global population explosive growth
- ✓ Tremendous disparities in wealth and in the distribution of raw materials and resources
- ✓ Changing patterns of consumption and production
- ✓ Sustainable development

Peace and welfare for all cannot be achieved unless these essential issues are properly addressed. Today, information technology allows us all to be informed of what is happening to others. There is an increasing awareness that whatever is happening in one country cannot be considered in isolation but has important implications for other countries.

In light of these challenges the engineering profession stands out as the one profession that is best prepared to address these issues. Currently, there exists sufficient knowledge to address the challenges posed by globalization and wealth disparities. All that is required is to apply this available knowledge. It is important to share and apply the right knowledge and the right technology in an **efficient** way to resolve local problems. What the world needs is engineering to be applied in specific places under specific conditions irrespective of human or political agenda. It is important to state here that the engineering policies and the mechanical engineer's profile that the world needs demand dramatic changes.

1.2 The engineering profession and its interaction with society

The process of technological innovation has become intricately linked to the globalization of the world economic system. This means that new attitudes and new approaches will be required in the practice of the engineering profession in the very near future. So far, increasing industrial development has caused the practice of mechanical engineering to be more specialized, at least in Europe.

The workload of the mechanical engineering academic programmes has been focused on their areas of specialization. But today, the engineering professionals can no longer afford to lack a sound base of knowledge and skills that are needed to solve global economic, social and ethical issues that arise in the normal engineering activity. Engineering as a whole is a global activity which is undergoing dramatic changes at an increasing rate. In practice, the original idea of an infrastructure project, for project services or for new products may be conceived by an engineer in one particular country, it may be designed in one or more countries, constructed or produced with components from many countries and operated and maintained where it is used, with international support. These factors have changed the mechanical engineering practice (Prieto, 2008).

Global problems are always complex and require the collaboration of several engineering disciplines. Think about the increasing constraints affecting mega projects. It is necessary to learn from one another and to have a close interaction. The shift from largely domestic activities to more complex international relationships demands a fresh look to the mechanical engineer. He or she must know that each country uses technology in different ways and some of them will not be ready in years to come to fully use the least demanding of these applications, even if they acquired them. So the mechanical engineer needs to have enough local and social knowledge to address local engineering issues.

Think about risk assessment, ethics and social responsibility. These should be integral component of the behaviour of the engineer, due to their deep and far reaching consequences. Gender issues and diversity should be in the conscious knowledge of the mechanical engineer. The interrelated forces of globalization and information technology are producing so much change in the curricula of engineering professionals. **Mobility, complexity and sustainability** are the grassroot challenges that any mechanical engineer must face in the next twenty years and beyond. Engineering needs, more than ever, to become a dynamic profession with a comprehensive display of skills to use technologies and to respond to the interdisciplinary reqirements of engineering projects.

The level of technological advancement in developed and developing nations is instrumental in the decision making process of any infrastructure. The world today is not divided by ideology. It is divided by technology “haves” and “have-nots”. It is divided by cheap access to telecommunication networks “haves” and “have-nots”. It is divided between those that have or do not have certain knowledge. Those are the great challenges for the mechanical engineers.

1.3 Relevance of the Mechanical Engineer

The viability and potential impact of mechanical engineering in the 21st century is clearly in evidence in the commercialization of the scientific trilogy—information, biomedicine and nanotechnology—defining the frontiers of science in the early years of the 21st century. In parallel with the profession's contributions to the solution of space, microelectronics, and biomedical "mega challenges," the vast post-World War II expansion of scientific research and the perceived socioeconomic benefit of rapid, and frequent, commercial product introduction brought to the fore the mechanical engineer's unique role in "product realization." The broad science and engineering base, as well as experiential learning of product design, characteristic of Mechanical Engineering education in the latter decades of the past century, has defined the mechanical engineer as a system and product integrator, well positioned to harness a diverse set of emerging, scale-spanning technologies to produce a constant stream of innovative products (Avram, 2008).

The scales of design and fabrication are continuing to shrink. Minimization of mass and required energy are now a common expectation in product development. "Smart" materials with embedded controllers are no longer a novelty. Thermal management and mechanics are crucial to the successful packaging and exploitation of nanoscale electronic circuits and photonic devices emerging from research laboratories. Thermodynamics underpins the application of polymerase chain reaction and self-assembly processes, key techniques in miniaturized bio-assaying and in nano fabrication, respectively. The integration of smart materials and micro-controllers, along with the application of rapid prototyping and advanced manufacturing techniques, is transforming and personalizing the biomedical industry (Maier, et al. No date).

If the growing body of new science is to yield a significant number of near-term products, the product realization process—integral to the practice of mechanical engineering—must be used to address the gulf between discovery and commercial success. In the absence of modeling techniques, failure analysis, reliability prediction, established design tools, and cost-effective manufacturing processes, the incalculable promise of info, bio, and nano technologies for improving the human condition will remain largely unrealized (Prieto, 2008).

For mankind to successfully meet the burgeoning challenges to its dominion on this earth – breathable air, potable water, plentiful energy and safety from the elements – the knowledge embodied in three millennia of mechanical engineering practice must be reapplied in the context of the 21st century. While these components of mechanical engineering knowledge can and should be integrated into the toolkits of the other branches of engineering, it is the Mechanical Engineers who are best able to place this knowledge at the service of society and product development organizations.

1.4 Contributions of the Mechanical Engineer

Imagine: the mechanical engineers are instrumental in bio-engineering, nanotechnology, mechatronics, new materials (composites) and networking technologies. Artificial intelligence is a 50 year old dream that was meant to lead to intelligent machines. These machines are already changing the way things are done atleast in the developed econmies. Imagine the revolution in food production, in genetic modification or in access to water. Imagine the revolution on transport: next generation cars will have to comply with more restrictive laws on green-house emissions and fuel economy. The market will demand cars with flexible fuel engine systems that can run on biofuels where available, or on petrol where they are not.

Think of the car models themselves. The last Tata car showed in Dehli last January is meant to be the cheapest new car on the planet (100,000 rupees, $2,500 USD, €1600, ₦300,000). This is the price of a car that results from a complex project that involved 100 suppliers and spawned 34 patent applications. The motor industry will rely on the mechanical engineers to help make the right choices: to produce significantly more fuel-efficient vehicles in a format that consumers like (Prieto, 2008).

Without any doubt the mechanical engineering curricula can no longer afford to remain as it has for the past 40 or 50 years. Multiculturalism and teamwork are essential. How are we going to acquire such competencies or get such global knowledge? One avenue that is opened to us to enrich ourselves from research and industrial experiences is an institution like ours – The Nigerian Institution of Mechanical Engineers (NIMechE) which can only be strengthened by branches nationwide. That is why I am proud to be a part of the inauguration of the Jos Branch of the NIMechE. Congratulations to us all.

2.0 THE MECHANICAL ENGINEER AND NATIONAL DEVELOPMENT: The socio-economic perspective

Engineering is a term applied to the profession in which a knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied to the efficient use of the materials and forces of nature for the benefit of man.

Mechanical Engineering is one of the broadest engineering fields. Mechanical engineers are found in virtually all industries, from aircraft and automotive to medical, energy, building, agricultural, and consumer products. They design products, machines and processes for manufacturing. They analyze, test and develop these products, machines and manufacturing processes to attain the best performance reliability within regulations to meet the cost and time limits. Virtually every aspect of life is touched by mechanical engineering; this is because if "something" moves or uses energy, a mechanical engineer was probably involved in its design and/or production.

In developing economies, population growth and poverty are closely knitted. Poverty is one of the deadliest deseases of our time that must be addressed through sustainable development initiatives. The extent and nature of poverty and its impact on marginalizing and alienating segments of the society, are difficult to measure. UNDP's Human Development Index is an attempt to compile and compare all the aspects of poverty. As the Human Development Report of 1999 shows, the extent and nature of poverty vary considerably in countries of Asia and the Pacific, and that of urban poverty varies considerably between countries, between rural and urban areas, among urban areas within a particular country, among neighbourhoods of a given urban area and even within neighbourhoods.

Part of the millennium Development goals is to eliminate poverty i.e. providing all material things needed for our daily living – food, clothing, shelter, health, environment, education and importantly leisure. As diverse as these material things are, there are certain factors which are common in their design and manufacture. In the light of these, some important challenges to the Nigerian Engineer and particularly the Nigerian Mechanical Engineer are briefly outlined. These are the areas of Design and Manufacture and Energy supply.

2.1 Engineering Design and Manufacture in Nigeria

The earliest efforts at engineering design and manufacture were based on the efforts of research institutes like FIIRO and PRODA, and the faculties of engineering of some Universities and Polytechnics. Most if not all these efforts have ended at the prototype stage. The first real commercial effort at engineering design and manufacture can be traced to Addis Engineering (Chukwujekwu, 1998).

Some Government Agencies have made some effort to get engineering design and manufacture off to a good start: The defunct Directorate of Foods, roads and rural Infrastructures (DFFRI), Raw Materials Research and Development Council and also the Nigerian Mining Corporation. Two of the greatest challenges to the Engineering design and manufacturing industry in Nigeria are the Family Economic Advancement Programme (FEAP) and the establishment of the Centre for Automotive Design and Development (CADD). The FEAP programme planned to establish about 10,000 cottage/small scale industries annually over a three year period while CADD was to produce the made in Nigeria car. These challenges were not properly tackled because:

- A fair proportion of these companies involved in the FEAP programme were manned by people with limited engineering training who cannot copy existing equipment or a prototype.
- Most of the engineering companies have limited facilities. The Nigerian Machine Tool Industry, Oshogbo is not fulfilling its mandate.
- The inability of our steel factories to produce
- Administrative bottlenecks

The basic concept is that the engineering design and manufacturing industry must be carefully nurtured if Nigeria is to make an impact in the global economy. This concept was obviously accepted by the nation when based on pressure by engineers and scientists, the National Agency for Science and Engineering Infrastructure (NASENI) was established (Chukwujekwu, 1998).

The two main challenges that must be tackled here are:

- Manpower development: Intensive training of Craftsmen, Technicians and Technologists, Draughts men and Engineers.
- Capacity building: Design and manufacture involves the following essential elements – process design, equipment design, component design, materials selection, drawing (draughtsmanship), materials supply, component manufacture, equipment assembly, equipment testing, plant assembly and installation, plant testing and final production. These are lacking in our system and as a matter of urgency needs to be properly addressed.

2.2 Energy Demand and Supply

The insufficient energy situation in Nigeria has continued to dwindle despite promises of improvement by succeeding governments. This has had a ripple effect on the economy since there is no facet of human activity that does not depend on one form of energy or the other. Consequently, the lack of consistent availability of energy has aggravated the poverty status of Nigerians.

The choice of energy systems, like any other feature of major social organization, is a product of a historical development, of prevailing social value systems and often the role of influential individuals from various layers of society: political decision-makers, industrialists or intellectual figures.

Electricity generation in Nigeria began in 1896. The Nigerian Electricity Supply Company (NESCO) commenced operations as an electric utility company in 1929 with the construction of a hydroelectric power station at *Kurra falls near Jos*. The Electricity Corporation of Nigeria (ECN) was established in 1951 while the first 132KV line was constructed in 1962 linking Ijora power station to Ibadan power station. The Niger Dams Authority (NDA) was established in 1962 with the mandate of developing the hydropower potential of the country. However, ECN and NDA were merged in 1972 to form the National Electric Power Authority (NEPA). In 1998 NEPA ceased to have an exclusive monopoly over electricity generation, transmission, distribution and sales (Sambo, 2004).

Although the installed capacity of the existing power stations is about 5801.6MW, most of the generating units have broken down as they have not been maintained as and when due. The transmission lines are radial and are overloaded. The switch gears are obsolete while power transformers have not been maintained for a long time. The distribution sub-sector is in dire need of upgrading as many of its transformers are overloaded and the overall transmission and distribution losses are in the range of 30 - 40%. When these are added to the poor payment record of consumers, collections are less than 50% of the power generated.

The present generation level of about 4,000MW on average, is much lower than the estimated demand of about 10,000MW. There is about 1,500MW of self-generation in the form of small diesel and petrol generating sets. The estimated percentage of Nigerians currently having access to electricity from Power Holding Company of Nigeria (PHCN) is about 36% (Sambo, 2004).

In the report of the National Energy Master Plan by Energy Commission of Nigeria (ECN), the estimated demand for electrical power in Nigeria for the years 2010 and 2015 and 2030 are respectively 15,000, 30,000 and 190,000MW based on our current growth rate. It is therefore necessary to fully rehabilitate the existing power stations, rehabilitate some critical transmission and distribution lines and their associated substations and add new generating, transmission and distribution capacity to the grid. The same report also suggested an electricity generation mix of Nuclear (1%), Hydro (7%), Renewables (10%), Coal (11%) and Natural gas (71%) (ECN, 2006).

This is a challenge to us all. The task at hand demands the following:

- Rehabilitating existing plants and strict adherence to both preventive and turn around maintenance schedules
- Completion of all ongoing energy related projects and fast tracking the commencement of all proposed electricity projects
- Designing and implementing a long term coordinated programme for rural electrification based on distributed decentralized generation
- Designing and implementing a long term R&D portfolio for the Electricity Supply Industry
- Sensitizing the general public on the ills of vandalizing public utility infrastructure and enforcing the existing laws of the land.

2.3 Social values and the introduction of monetary economy.

Social value systems are by no means laws of nature. They differ from one culture to another, and they change with time. They can be influenced to a substantial degree by conscious or unconscious propaganda (from teachers, advertisements, spiritual or political indoctrinators, etc.), and by willingness to imitate. However, there are a number of more fundamental social values, associated with basic needs, which are determined by the biology of human beings and thus less subject to modification. Food and shelter, an acceptable biological environment (an atmosphere with oxygen, temperatures within certain limits, etc.) and human relations are in this category.

The abbreviation LCA is used for both life-cycle analysis and for life-cycle assessment. However, they are two different concepts: life-cycle analysis is the scientific and technical analysis of impacts associated with a product or a system, while life-cycle assessment is the political evaluation based upon the analysis. The need for incorporating study of environmental impacts in all assessment work performed in our societies; from consumer product evaluation to long-term planning decisions, is increasingly being accepted.

Energy systems were among the first to be subjected to LCA, trying to identify environmental impacts and social impacts related for example to health, or in other words to include in the analysis impacts that have not traditionally been reflected in prices paid in the marketplace. This focuses on the sometimes huge difference between direct cost and the full cost, including what are termed externalities: those social costs that are not incorporated in market prices. It is seen as the role of societies (governments) to make sure that the indirect costs are not neglected in consumer choices or decision-making processes related to planning in a society. The way externalities are included will depend on the political preferences. Possible avenues range from taxation to legislative regulation.

CONCLUDING REMARKS

The technological infrastructure required for development in any society whether developed or developing depends largely on the **level of engineering development and practice** in that society. The development of engineering practice in any country depends largely on the political will of the government i.e. the willingness to challenge the citizenry with tasks which they had never attempted before. If the millennium development goals are to be achieved, if Nigeria must attain the vision 20:2020, then the challenge is to all of us as a Government and as Engineers, particularly Mechanical Engineers. It is my ardent believe that we will face these challenges headon and given all the required enabling environment and support we shall succeed. Thank you all.

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