THE ROLE OF ENGINEERS IN SUSTAINABLE DEVELOPMENT

By

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*"Scientists study the world as it is, **engineers** create the world that never has been" (Theodore Von Karman)*

Abstract

Engineers are increasingly required to play a leadership role in sustainable development, overcoming global challenges, such as depletion of resources, environmental pollution, rapid population growth and damage to ecosystems. In the 20th century, engineering achievements were developed without considering their impact on social, economic, and environmental natural systems. Considering the problems facing our planet today and the problems expected to arise in the first half of the twenty-first century, engineers must revisit their mindset and adopt a new mission statement - to contribute to the building of a more sustainable, stable, and equitable world. For that to occur, engineers must adopt a completely different attitude towards natural and cultural systems and reconsider interactions between engineering disciplines, non-technical fields and the society. As we enter the twenty-first century, we must adopt a more holistic approach to engineering. This will require: (1) a major paradigm shift from control of nature to participation with nature; (2) an awareness of ecosystems, ecosystems services, and the preservation and restoration of natural capital; and (3) a new mindset of the mutual enhancement of nature and humans that embraces the principles of sustainable development.

Keywords: Engineers, sustainable development, ecosystems, environmental pollution, society, economic resources, global challenges.

1. INTRODUCTION

One of the first sources of confusion, particularly among those who are not engineers or scientists, is the distinction between ***science*** and ***engineering***. The main focus of the scientist is to develop knowledge and understanding of the physical universe. Science is the pursuit of knowledge in its purest sense without any concern to the needs (or interpreted needs) of society, whereas engineering is the combination of both. The direction of scientific research has been described by some as curiosity-based research which is not necessarily driven by the values of society. Societal values (and resulting priorities) do not necessarily define the bounds, direction or scope of scientific curiosity. Engineering connects pure science to society (Figure 1). Unlike science, in engineering the environment in which engineers plan, design, build, manufacture, maintain and operate continually changes and so the engineer must be prepared within an 'acceptable level of risk' for all possibilities and outcomes.

Engineers have contributed very largely to society, but are a misunderstood group, as their efforts are often under-appreciated. Delivery of most of the services essential to modern life such as electricity, flight, television, medical imaging, sewage networks, the telephone, water networks and railway lines are the result of engineering.

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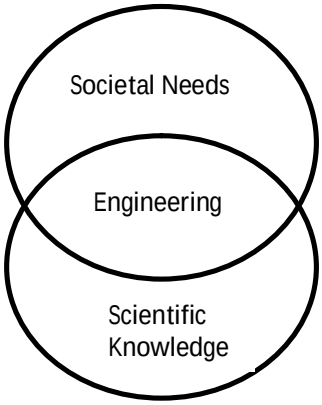

Figure 1: Relationship between societal needs, scientific knowledge and engineering.

Engineers plan, design and create the physical structure through which society lives, works and plays. Therefore in order to appreciate and understand the role of the engineer, we must examine the relationship between the engineer and society. Then, perhaps 21st century engineers can develop a sustainable world in balance with the forces of nature to combat some of the inventible global crisis if given the opportunity.

2. ENGINEERING ACHIEVEMENTS IN 20th CENTURY AND FUTURE CHALLENGES

For the past 150 years, engineering practice has been based on a paradigm of controlling nature rather than cooperating with nature. In the control-of-nature paradigm, humans and the natural world are divided, and humans adopt an oppositional, manipulative stance toward nature. Despite its drawbacks, this approach has led to remarkable engineering achievements during the nineteenth and especially twentieth centuries. For instance, civil and environmental engineers have played a critical role in improving the condition of humankind on Earth by improving sanitation, developing water resources, and developing transportation systems.

The 20th century have witnessed a great achievement in engineering technology in the field of design, information technology (IT), construction, manufacturing, robotic, advanced materials or even the engineering management techniques for problem solving. Some of the newly and enhanced technologies include:

Nuclear technologies - a new source of electric power and new capabilities in medical research and imaging as well as for unwarranted military use

Lasers and fiber optics - pulses of light from lasers are used in industrial tools, surgical devices, satellites, and other products. In communications for instance, a single fiber-optic cable can transmit tens of millions of phone calls, data files, and video images.

Petroleum and gas technologies – fuel for cars, home, and industries. Petrochemicals are used in products ranging from aspirin to zippers. Engineering in oil exploration and processing, petroleum products have an enormous impact on world economies, people, environment and politics.

Health technologies - Medical professionals have an arsenal of diagnostic and treatment equipment at their disposal. Artificial organs, replacement joints, and bio-materials are but a few of the engineered products that improve the quality of life for millions.

Imaging technologies - Imaging technologies have expanded the reach of our vision. Probing the human body, mapping ocean floors, tracking weather patterns are all the result of engineering advances in imaging technologies.

Space explorations – development of spacecraft has expanded our knowledge base, and improved our capabilities. Thousands of useful products and services have resulted from the space program, including medical devices, wireless communications, etc.

Agricultural mechanization - machinery of farms; tractors, cultivators, combines, and hundreds of others dramatically increased farm efficiency and productivity.

Electronics - provide the basis for countless innovations; CD players, TVs, and computers. From vacuum tubes to3 transistors, to integrated circuits, engineers have made electronics smaller, more powerful, and more efficient.

Aeronautics - modern air travel transport goods and people quickly around the globe, facilitating personal, cultural and commercial interaction.

Automobiles - may be the world's major transporter of people and goods, and a strong source of economic growth and stability. The automobile is a showcase of 20th century engineering ingenuity, with innovations made in design production & safety.

Electrification - powers has literally lighted the world and impacted countless areas of daily life, including food production and processing, air conditioning and heating, refrigeration, entertainment, transportation, communication, health care, and computers.

Most engineering achievements of the past were developed without consideration for their social, economic, and environmental impacts on natural systems. Not much attention was paid to minimizing the risk and scale of unplanned or undesirable perturbations in natural systems associated with the engineering systems.

The world is becoming a place in which the human population is becoming more crowded, more consuming, more polluting and more connected. There is a growing recognition that humans are altering the Earth's natural systems at all scales, from local to global at an unprecedented rate. This has raised an important issue of maintaining a balance between satisfying the needs of an exponentially increasing population and preserving the carrying capacity of our ecosystems and biological and cultural diversity. A related question is what should be done now and in the near future to ensure that the basic needs for water, sanitation, nutrition, health, safety, and meaningful work are fulfilled for all humans. These commitments ware usually defined as "Millennium Development Goals".

The increasing population is creating unprecedented demands for energy, food, land, water, transportation, materials, waste disposal, earth moving, health care, environmental cleanup, telecommunication, and infrastructure. The role of engineers will be critical in fulfilling those demands at various scales, ranging from remote small communities to large urban areas (megacities), mostly in the developing world (Cruickshank and Fenner, 2007). If engineers are not ready to fulfill such demands, who will? The emergence of large urban areas is likely to affect the future prosperity and stability of the entire world.

Considering the problems facing our planet today and the problems expected to arise in the first half of the twenty-first century, the engineering profession must revisit its mindset and adopt a new mission statement - to contribute to the building of a more sustainable, stable, and equitable world. ***"Sustainable development will be impossible without the full input by the engineering profession."*** For that to occur, engineers must adopt a completely different attitude towards natural

and cultural systems and reconsider interactions between engineering disciplines and nontechnical fields.

As we enter the twenty-first century, we must embark on a worldwide transition to a more holistic approach to engineering. This will require: (1) a major paradigm shift from control of nature to participation with nature; (2) an awareness of ecosystems, ecosystems services, and the preservation and restoration of natural capital; and (3) a new mindset of the mutual enhancement of nature and humans that embraces the principles of sustainable development.

3. ENGINEERS AND SUSTAINABLE DEVELOPMENT

Sustainability is a characteristic of a process that can be maintained at a certain level indefinitely. From an environmental stance, the term refers to potential longevity of vital human ecological support systems, such as planet's climate system, system of agriculture, industry, forestry and fisheries, and human communities in general, and the various systems on which they depend. Sustainability is an approach to decision making that considers the interconnections and impacts of economic, social and environmental factors on today's and future generations' quality of life. It is a dynamic and evolving notion, and as a process, it strives to be participatory, transparent, equitable, informed, and accountable.

Sustainable development is the process of moving human activities to a pattern that can be sustained in perpetuity. It is an approach to environmental and development issues that seek to reconcile human needs with the capacity of the planet to cope with the consequences of human activities. Sustainable development consists of the three broad themes of social, environmental and economic accountability which is said as the Triple Bottom Line concept (Elkington, 1994).Sustainable Community can be defined as a community that maintains, enhances, or improves its environmental, social, cultural, and economic resources in such a way that support current and future community members in pursuing the healthy, productive and happy lives (Figure 2).

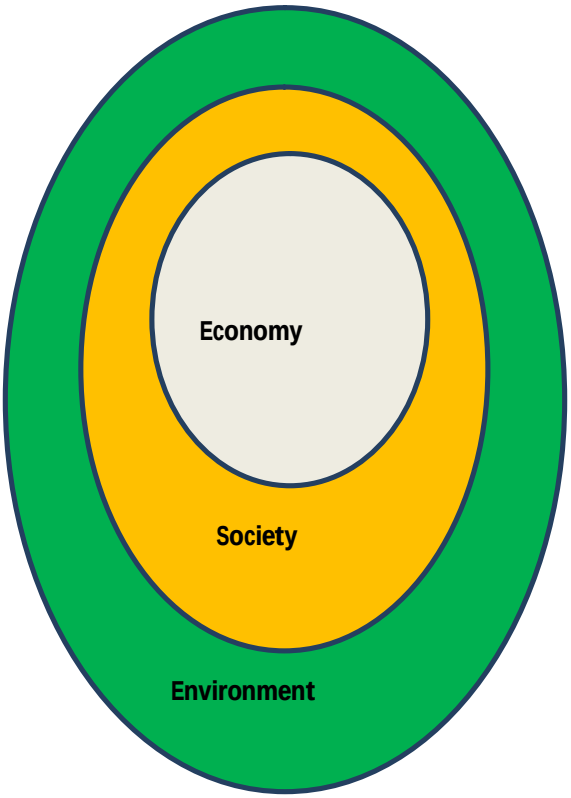

Figure 2: Triple bottom line concept of sustainable development

Professional engineers have an important and significant role to meet the sustainability. They work to enhance the welfare, health and safety, with the minimal use of natural resources and paying attention with regard to the environment and the sustainability of resources. Their work is influenced by the opportunities and challenges that bring the sustainability. Engineers are the providers of options and solutions to maximize social value and minimize environmental impact. There are some pressing challenges due to the adverse effects of environmental pollution, depletion of resources, rapid population growth and damage to ecosystems. Therefore a purely environmental approach is insufficient, and increasingly engineers are required to take a wider perspective including goals such as poverty alleviation, social justice and local and global connections.

Globalization brings important opportunities for engineers to promote change through sharing experience and good practice. The leadership and influencing role of engineers in achieving sustainability should not be underestimated. Increasingly this will be as part of multidisciplinary teams that include non-engineers work that crosses national boundaries. *The main goal of the sustainable development is to make enable all people throughout the world to satisfy their basic needs and enjoy an improved and better quality of life without compromising to the quality of life for future generations. Sustainable development stands on two concepts, needs and limitations imposed by the state of technology and the present and future demands.* The following principles have been agreed to achieve sustainable development:

- living within environmental goals
- ensuring a strong, healthy and just society
- promoting good governance
- achieving a sustainable economy
- using sound science responsibly

4. GUIDING PRINCIPLES FOR ENGINEERS TO ACHIEVE SUSTAINABILITY

Engineers should carryout their role in abroad context that encompass social, ethical, environmental and economic challenges. These six principles will guide an engineer to achieve sustainable development (Dodds and Venebles, 2005). They will help engineers meet their professional obligations to seek to achieve sustainability, and ensure that this goal is integrated into all their engineering activity.

Contribute to building a sustainable society, present and future

Engineers have a responsibility to maximize the value of their activity towards building a sustainable world. This requires an under standing of what society demands and what is achievable, and are cognition that these change overtime. They should.

- Recognize that though their activity may be local and immediate, the potential impacts of their work may be global and long-lasting
- have an understanding of other relevant social and cultural structures outside their own normal community of practice
- understand their important role in the sustainable development of communities
- recognize the impacts of an engineering project on communities, global or local, and incorporate the views and concerns of the communities

Apply professional and responsible judgment and take a leadership role

Engineering is a profession with a strong ethical dimension. Engineers have an important role in providing solutions to the problems such as poverty, under-development and environmental degradation. Therefore the professional engineers should:

- look at the broad picture
- ensure that their knowledge about sustainable development is up-to-date
- be prepared to influence the decision-maker for a project
- Identify all the issues and options to the decision-maker about a projects of that decisions are soundly based
- Identify options that take account of economic, social and environmental outcomes
- Ensure that offered solutions and options will contribute to sustainability
- Be aware that there are inherently conflicting and un-measurable aspects of sustainability

Do more than just comply with legislation and codes

In seeking sustainable solutions, complying with current legislation, codes and environmental protection regulations may not be sufficient. Therefore engineers should:

- Go beyond the minimum wherever possible, anticipating future legislation which may be stronger
- By their example, help others improve their performance
- Alert the relevant authorities if there are deficiencies in legislation and if sustainable solutions and outcomes could been dangered by regulatory change
- Use their technical expert is to drive new legislation and codes

Use resources efficiently and effectively

Engineers have as towards hip role with respect to planetary resources, and a responsibility to society to create more useful products and services with the lowest possible consumption of raw materials, water and energy. This requires them to:

- Understand that there are environmental limits and finite resources
- Reduce resource demand by using less in the first place
- Reduce waste production by being efficient with resources that are used
- Use systems and products that reduce embedded carbon, energy and water use, waste and pollution
- Adopt strategies for re-use, recycling, decommissioning and disposal of components and materials
- Minimize any adverse impacts on sustainability at the design stage

- Work to repair any damage

Seek multiple views to solve sustainability challenges

The increasing complexity of sustainability challenges means that engineers working alone cannot solve all the challenges that we face. Therefore it is important for engineers to:

- Engage with stakeholders, listening and recognizing the value of the perspectives of others, including non-specialists
- Avoid working in isolation, involving other professionals at all stages of a project
- Utilize cross-disciplinary knowledge and diverse skills
- Promote the important leadership role of the engineer in finding solutions to sustainability challenges for the benefit of society
- Seek a balanced approach

Manage risk to minimize adverse impact to people or the environment

Engineers are routinely involved in planning and managing projects where they should:

Harness their skills to minimize damage to people or the environment from engineering processes and products

Undertake a comprehensive risk assessment before a project begins

Ensure that the risk assessment includes the potential environmental, economic and social impacts, beyond the lifetime of the engineering project

Give sustainability the benefit of any doubt, adopting a precautionary approach where scientific knowledge is not conclusive

Instigate monitoring systems so that any environmental and social impacts of engineering projects are identified at an early stage

5. CONCLUSIONS

The development of the modern world has been dominated by science, engineering and technology and the role of the engineer is linked closely to the needs of society. Unfortunately engineers are either public relations shy or poor communicators of their success. As famous scientists tend to develop medicines, they appear to be viewed by society in a more philanthropic light. The term engineer used in this paper includes any professional scientist, technologist or engineer who uses her skill sets and training to develop practical real world applications.

The 21st century will be defined by some of the huge challenges now facing humanity. Among these are energy and food security, competition and scarcity of natural resources, and climate change. This year's engineering graduates will face these issues throughout their working careers. The demand for engineering skills is likely to be higher than ever before in order to deliver sustainable engineering systems, low-carbon energy technologies, and robust physical infrastructure to protect against geophysical hazards such as sea-level rise and extreme meteorological events.

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