

Engineers' Obligations towards Sustainable Environment

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Abstract— The earth is being over populated day by day. Accordingly, it is failing to provide basic needs to all the populations of the current world since it has the limited natural resources. Thus, sustainable development comes into scientists' consideration to run the earth smoothly. As engineers are the important body of the society, they have responsibilities and obligations to the society especially to the environment. In this paper, engineers' role from ethical perspective is briefly mentioned with respect to society, economy and environment. To make the environment sustainable, basic components like air, water, land etc. of the environment need to be kept safe and secured that can be done by the proper engineering planning. In that regards the engineers' obligations and responsibilities are also highlighted in this paper. Energy shortage is one of the critical issues that can be minimized by engineers' wise planning. Climate change is another phenomenon of the current world that the inhabitants are experiencing regularly. The most environmental facts are related to construction engineering. So, engineers' responsibilities to make the environment sustainable are explicated in this paper.

Keywords—sustainable environment; engineers' obligations; ethics; ethics of engineers; sustainability; responsibilities; engineering and environment

INTRODUCTION

Engineering plays a vital role in human, economic, social and cultural development to achieve United Nation (UN) millennium development goals, especially environmental sustainable development. Sustainable development is the challenge to meeting current human needs from natural resources, industrial products, energy, food, transportation, shelter and effective waste management while conserving and enhancing earth's environmental quality. This challenging issue is trying to be met by engineering knowledge and modern technologies. Sustainable development is not only the demand for the current world but also necessity for the next generation that can be achievable by professional engineers. Engineers should strive to enhance the quality of biophysical

and socioeconomic urban environment and also to promote the principles of sustainable development. Engineers have the obligations to the society to seek the opportunities to work for the enhancement of health, safety and the social welfare of both local and global community through the practice of sustainable development. Since public health and safety is fully dependent on engineering judgments, assessments of risk, decisions and practices incorporated into structures, machines, products, processes and devices, they should be responsible and accountable to their assigned duty. Thus, engineers should follow the rules and regulation imposed by local and global community.

ENGINEERING AND SUSTAINABILITY

Engineering is the professional art of applied science for the optimum conversion of natural resources to the uses of humankind [1]. In another way it can be said that Engineering is the application of mathematics and science by which the sources of energy in nature and the properties of matter are made useful to the people [1]. Engineers solve the problems based on mathematics and logic to make human life easy and comfortable. To solve a problem they have to consider many factors that is imposed by legislated authority. Besides that they also put into consideration for sustainable development for designing an goods and products.

Sustainability, as defined in the Brundtland report [2] is, Humanity has the ability to make development as sustainable by ensuring the needs of the present demands without compromising any power or ability of future generations to meet their own needs. Based on this report several actions have been taken to enhance sustainable development in last two decades. It also has been recognized that many of the practices and lifestyles of modern society, particularly but not exclusively industrialized society, simply cannot be maintained indefinitely. We are exceeding the capacity and capability of the flora to provide many of the resources that we

use and to accommodate our emissions, while many of the planet's inhabitants cannot meet even their most basic needs. Recognizing the needs for live within constraints and ensuring more fairness in access to limited resources, are the main problems that lies at the heart of the concepts of sustainability and sustainable development. It is something new in human history that the planet is full and we have no new geographical horizons to move to. Consistent with social, economical and environmental aspects of sustainability, sustainable building is one of the rapidly growing practices in new construction and development area in the world as the movement of green development has been acquired and adopted by engineers, designers and builders. Life-cycle analysis shows evidence that sustainable design and building makes good economical sense with regard to environmental impact. It is anticipated that this kind of trend will continue to propel and accelerate, as most of the countries are planning to shift to green technology. Furthermore, individual owners are intent upon raising the standards of existing buildings and structures with the green renovation to lift them up to the sustainable state of specifications.

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 [3]. It is useful to represent the constraints of the sustainable development, in the form of a simple Venn diagram shown in the figure 1.

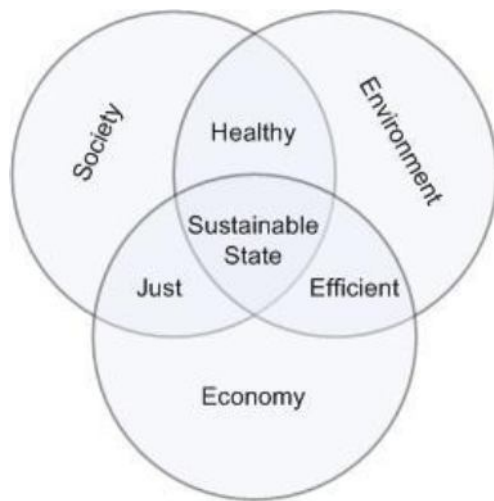


Figure 6. Components of a sustainable environment [3].

Society, environment and economy are the three basic essential parts for human being to live in. To live healthy in the society good environment is needed. Figure 1 indicates the

interconnectedness of a healthy society, economy, and environment. It is clear that sustainable state is economically efficient, environmentally healthy and socially justified in all aspects.

Law and Ethics are the fundamental way that deals with the meaningfulness of life. So this term can be included as another component of the sustainable environment. Inspiring with the Triple Bottom Line concept, a new idea can be generated where the Law and Ethics is considered as another and valuable component of the sustainable environment. This thought is visualized through another Venn diagram as shown in the figure 2.

There is no conflict with the state named as Healthy and Efficient as stated in the Triple Bottom Line concept. A society will be a moral society only if the ethical values are established and they will be more acceptable and reliable. Economy having the ethical values is sensible which means the state is intellectually and intuitively perceived through sound judgment. The state of the society having interaction with only Environment and their Ethical values can be defined as Unstable state because if economy falls down, society will collapse. Wisdom can be defined as the ability of applying knowledge, experiences, understanding, common senses and insights which is possible if the Economy having Ethics is stable for the Society. The quality of doing right and productive while avoiding the wrong is the Virtue which can be established with the combination of Economy and Ethics having the proper knowledge and understanding to the Environment. Society and their Environment with efficient Economy make a state which can be defined as Sound State. But in a comprehensive matter the Sustainable Environment is a state which is environmentally healthy, economically efficient, socially moral and ethically sensible.



Figure 7. Sustainable environment and its relation with four components.

PROFESSIONAL ETHICS OF ENGINEERS

In the discipline of philosophy, ethics covers the study of the actions that a responsible individual ought to select, the values that an honorable individual ought to espouse and the character that a virtuous individual ought to have. For instance, everyone ought to be honest, fair, kind, civil, respectful and trustworthy. Besides these common obligations that everyone takes part, the professionals have additional obligations that arise from the responsibilities of their professional work and their relationships with employers, clients, other professionals and the general public. Professionals have some special obligations because of their specialization, knowledge and skills and they are granted licenses by the public to use their knowledge and skills to affect the lives of their clients significantly.

Codes of ethics for engineers state that they should hold paramount for the safety, health, and welfare of the public, above other obligations to clients and employers. This commitment to the public good echoes the public commitments of other professions: medicine is committed to human health, law to justice. But engineering and engineering societies have provided little guidance on prioritizing the public good, except in extreme cases such as whistle-blowing. When an engineer finds an immediate threat to the safety of the public, the engineer must notify appropriate authorities. If this threat is not handled and practiced within the organization, the engineers are expected to raise the flag or blow the whistle.

SOCIAL RESPONSIBILITIES OF ENGINEERS

Engineers are the valuable part of the society and they have responsibilities to it. This requires the engineers to make the determined efforts in discovering all of the relevant facts concerning the design, development, deployment and every possible outcome of the choices available that may positively and negatively affect the society and the citizenry. People are fully dependent on their designed products and goods that should be robust, safe, reliable, economically feasible and environmentally sustainable. There are few principles of Engineering for the Sustainable Development [2] which are,

- Looking beyond the locality and the immediate future.
- Being innovational and creative.
- Seeking a balanced solution.
- Seeking engagement from all stakeholders.
- Making sure about the knowledge of needs and wants.
- Planning and managing effectively and efficiently.
- Giving sustainability with the benefits of any doubt.
- Adopting a holistic like, cradle to grave approach.

- Doing right things with the right decisions.
- Beware to the cost reductions that masquerade as value engineering.
- Practicing what engineers preach.
- Ensuring the safety and wellbeing to the public.
- Ensuring that society's funds and resources concerning technology are well used.
- Refusing work on a particular project or for a particular company.
- Speaking out publicly in contrast to a proposed project.
- Remonstrating the illegality or wrong-doing.
- Providing the protections for the whistleblowers.
- Individual and organizational concern about any engineering projects and its impact on the society.
- Contributing one's services to worthy, non-profit groups and projects.
- Engineering schools' commitment for educating future engineers about their social and moral responsibilities.
- Commitment of risk assessment experts to ethical risk or safety assessments
- Promoting the ethical development actively and use of technologies.
- Voluntarily assume the job of education to the public about valuable consequences of different technical and scientific developments.
- Commitment of engineers in designing and developing sustainable technologies
- Providing expert advice to non experts.
- Taking part in democratic procedures for technology decision making and policy management.
- Social activities of engineers in public interest.
- Explicit care and concern about technology's impact on Nature and the Environment
- Following the principles of sustainable development while thinking about any technical and engineering designs.
- Honoring the precautionary principles to take any steps in engineering designs.

In engineering design, engineers have to practice social responsibility by applying factors of safety to their designs and products.

THE ROLE OF ENGINEERS IN SUSTAINABILITY

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 [9].

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 because of the adverse effects of environmental pollution, depletion of resources, rapid population growth and damage to ecosystems. A purely and environment friendly approach is insufficient and increasingly engineers are required to take a wider perspective including 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 and through work that crosses national boundaries.

The main goal of the sustainable development is to make enable the people throughout the world to meet and satisfy their basic needs and enjoy a 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 social organization on the environment's ability to meet present and future demands [4]. In a recent conference, the following principles have been agreed to achieve sustainable development [5],

- living within the environmental goals,
- ensuring a healthy, strong and justified society,
- promoting well governance,
- achieving a sustainable and efficient economy,
- using well science responsibly.

Engineers have a responsibility to maximize the value of their activity to build a sustainable world. This requires an understanding about the demands of society, achievable goal and recognition of the changes over time. They should,

- understand the important potential role for engineering,

- understand about the environmental limits and finite resources,
- reduce the demand of resources by using less in the first place,
- reduce waste production by being effective to the resources that are used,
- use systems and products which reduce embedded carbon, energy and water use, waste and pollution, etc.
- adopt the full life cycle assessment as a normal practice including the supply chain,
- adopt strategies such as reusing, recycling, decommissioning and disposal of components and materials,
- minimize any adverse impacts on sustainability at the design stage,
- work to make any reparation of any damages,
- harness their skills to minimize damage to people or the environment from engineering processes and products,
- undertake a comprehensive risk assessment at the beginning of a project,
- ensure that the risk assessment includes the potential environmental with economical and social impacts, beyond the lifespan of the engineering project, design or product,
- recognize the potential long-term aspect of risk,
- give sustainability and the benefit of any doubt, adopting a precautionary approach where scientific knowledge is not conclusive,
- establish the monitoring systems so that any environmental, social and economical impacts of engineering projects can be identified at an early stage.

ENGINEERS' RESPONSIBILITIES TOWARDS ENVIRONMENT

Scientific research continues to provide information about the links between human health and environmental quality. Essential components of life are air, water and food, which provide potential pathways for contaminants to affect our health. Exposure to pollutants through the contamination of air, water and soil has been linked with various health conditions such as cancer, cardiac and respiratory illness, reproductive problems and birth defects, allergic reactions, nervous system disorders, hypersensitivity and decreased diseases resistance [6].

Air Pollution

Air pollution is a great threat for our sustainable environment. So, the engineers in every country of the world should try to,

- Reduce emissions of sulphur dioxide, nitrogen oxide, carbon dioxide and mercury through regulatory programs according to established targets and time frames.
- Participate in national and international initiatives that address trans-boundary air issues.
- Work to meet national standards for two primary components of smog: ground level ozone and particulate matter.
- Develop air-shed management plans and work with large industrial facilities to monitor transport and deposition from major sources.

Water Pollution

Safe drinking water is another challenge for many developing countries where engineers in the world can contribute much in this issue. So, engineers should do the followings,

- Work with agriculture and fisheries sectors to address their water quality and quantity issues,
- Develop a framework for protection of water sources and aquatic habitat that builds on the drinking water strategy,
- Consult with the Municipal Public Works Association of relevant country when developing guidelines, standards and regulations for municipal water and wastewater issues,
- Use a government-wide approach to water issues through the Interdepartmental Drinking Water Management Committee,
- Expand, modify and upgrade the ambient water monitoring system with proper maintenance,
- Work with the Department of Health on issues related to contaminants in drinking water,
- Work with municipal and domestic partners to address the wastewater issues,
- Provide funding support to municipalities for their water and wastewater infrastructure programs, and for land use planning in water supply areas.

Land Pollution

Hazardous substances in water, air, and soil pose significant health risks. The relative government is committed

to minimize the environmental impacts of such materials and protecting country's health. In this regard engineers will,

- Promote pollution prevention in efficient way,
- Apply risk-based management approaches to focus efforts where they are most needed,
- Modernize existing regulations controlling hazardous substances and eliminating regulatory duplication,
- Promote effective use, storage, treatment, and disposal of hazardous substances,
- Apply the "polluter pays" principle to users of hazardous substances,
- Promote stewardship by producers to encourage proper lifecycle management of hazardous substances,
- Work with other jurisdictions to improve rehabilitation of contaminated sites and promote sustainable redevelopment,
- Promote early detection and response to land quality issues through legislated requirements for mandatory reporting of site contamination.

CLIMATE CHANGE AND ENGINEERS OBLIGATION

Climate change is one of the current phenomenons of the world. The models of climate change predict rising sea-levels, shifting rainfall patterns, altered growing seasons and more frequent and severe weather disturbances within a century. Climate change will have environmental and economic impacts for many countries in the world as well as it also welcomes some new diseases. The substances are responsible for climate changes are green house gases where carbon dioxide is the main substance. This carbon dioxide is generated by human beings for our luxurious lifestyle. However, we are not concerned about the disaster of climate change. Some impacts of climate change over the world are increasing droughts, heavy precipitation events and flooding as well as decreases drinking and freshwater supplies and availability [6]. Moreover, it increases the intensity and frequency of typhoons hurricanes, tsunami and tornados, especially in the low lying area of the world due to the rising of the sea level. It also affects on our ecosystems for long time. It destroys our animals and plants, increases wildfires, flooding, and drought. Similarly it also decreases forest coverage, expanding arid lands, and other similar changes. It helps ocean acidification and coral reef bleaching and exotic, invasive plants and animals. Climate change reduces crop yields shifts growing zones increases hunger and malnutrition and declines fish yields. On our health it has sever affects which cannot be imagined easily. It increases deaths due to floods, heat and cold waves, storms, fires, and drought. It changes in the distribution of certain infectious diseases, including malaria, cardio-respiratory, diarrhea and

malnutrition. All of these problems we cannot solve in a single day but we can mitigate and minimize most of the problems by the helps of engineers in engineering approach, and thus engineers are obligated to the sustainable development.

ENERGY SHORTAGE AND ENGINEERING SOLUTION

Nowadays, we are facing problems for the unavailable energy sources where energy is the key for development. To provide available energy to be demanded by the population of the world is very difficult and sometimes it's not possible for some places. However, to ensure possible energy we are making our environment more polluted and risky. The burning of various fossil fuels such as coal, oil and natural gas, for generating electricity will release greenhouse gases and other pollutants into the environment and will impose the harmful impacts to the Earth and Mankind [7]. In contrast to the fossil fuels, renewable energy, as the name suggests, exists perpetually and in abundant quantity in the environment. Renewable energy is ready to be harnessed, inexhaustible, and more importantly, it is a clean alternative to fossil fuels. Renewable energy can be defined as energy which is derived from natural process and is replenished constantly [8].

Many countries are already switching to renewable energy. Apart from looking for clean energy sources from the environmental point of view, the search for new energy sources as substitutes for fossil fuels is another reason providing such drive. With a projected world population of 10 billion by the year 2050 [8], the increasing global energy demand will propel a more rapid depletion of the world's fossil fuel reserves. Such possible tightening of energy supplies in the future will inevitably result in an upsurge of fuel and electricity prices. In this regard engineers can play an important role to develop new ideas for sustainable development. Typical renewable energy sources include sun, water, wood, wind, biomass, geothermal, ocean tides and wasted materials.

IMPORTANT AREAS OF SUSTAINABILITY

Construction Area

To make this planet sustainable some areas should be given highest priority for consideration. Construction development is the most important issue as it is related to everyone's daily life. Construction engineers need to be careful to design buildings, industries, roads and highways efficiently considering greening technology. The concept of sustainability to build and construct any structure must focus not only to the limited resources but also to the energy and on the procedure to reduce the impacts on the environment and technical issues, materials, building components, construction technologies and design concepts related to the energy but also ethics, values and humanity of the occupants of buildings. Developers, clients, owners and investors should have important and effective interaction in disseminating

sustainable construction, since they represent the demand of the building sector. Planning system should be amended in order to promote sustainable development. Individual car use should be reduced and public transport system should be increased with more comforts especially with due consideration to old aged and invalids. Working at home and combining office and living space must be increased. More open and free spaces and green areas are must be envisaged. The improving of standards and quality should be viewed as a global objective having the aim of raising the longevity, safety and multiple use of buildings. As far as construction is concerned, the rules, standards, and certification schemes for sustainability and Eco compatibility should be introduced in to the design activity.

THE ROLE OF CONSTRUCTION AND DEVELOPMENT ENGINEERS

Constructions engineers must possess an initiative in Eco-efficiency to consider setting a target of achieving a tenfold improvement in production in the long term with some possible fourfold that increase in the next two decades.

- Fresh water should be given as the highest priority. A strategic approach has to be reached to preserve, protect and supply fresh water.
- Safe substitute for toxic chemicals should be developed and those technologies transferred to developing countries. Hazardous wastes, like radioactive wastes should be disposed of in the country in which they were originated.
- A fourfold leading to a tenfold should be increased for the efficient use of materials and energy.
- A major effort in reducing greenhouse gas emissions involves sustainable energy, new technology and energy efficiency.
- Support for internalization of environmental costs in energy pricing and for transfer of clean technologies to the developing countries.
- Engineers should be knowledgeable about the principles of sustainable development and be continuously trained on the current technologies on sustainable development.
- Engineers must incorporate long-term environmental impacts and costs into the analysis of alternative solutions being considered.
- Engineering responsibilities must be readdressed by incorporating sustainable development principles into the engineering codes of ethics and organizations through all over the world.

- Engineers must continuously participate in public explanation of the principles of sustainable development as relate to their profession.

Education Area

A new teaching system for engineers, potential engineers or general students must be developed introducing sustainable development into the curriculum both for undergraduate and graduate level and also for the professional skill levels. The following could be the important points in designing the new educational system.

- A platform and level of education about sustainable development and the environment.
- Integrated and interactive teaching of sustainable development and sustainable environment in every engineering course.
- A system focus.
- Accreditation requirements that encourage facilities to formulate teaching capacity in these matters.
- Eco-efficiency environmental assessment, its impact, and life cycle analysis.
- The improvement, uses and application of IT.

Area of Electronics and ICT

The present time is known as the era of information and communication technology (ICT). By the blessing of modern science and technology people are fully dependent on ICT for their daily needs. In the mean time, to supply people's demand many electrical and electronics companies are producing many products which are not reusable and recyclable and renewable that makes hazard on the earth. Day by day this hazard is increasing exponentially due to the demand of the customer for additional features of the new technology. As this is a flourishing area, the harmful impact is not seen significantly. However, all these expired electronics materials are injurious for our environment.

CONCLUSION

Sustainable development has become as an accepted orthodoxy for the global economic development and environmental protection since the ending of the twentieth century where engineers play an important role for this sustainable development and protection. Our environment is complex, made up of interacting systems of water, air, land, organic and inorganic matter and living organisms. Maintaining a healthy environment for current and future generations requires the collaboration of citizens, organizations and businesses and all levels of government. Using a balanced, coordinated approach, we can protect the health, prosperity, and environmental integrity of our communities. Individuals can conserve energy, choose

environmentally responsible products, and modify their behavior. Organizations can develop environmental management plans, reduce emissions and waste from their operations, and adopt environmentally responsible practices. The government can continue to lead by administering legislation, establishing public policy, delivering programs and services, participating in regional, national, and international environmental initiatives, and managing its own operations responsibly. However, all of these strategies mentioned in this paper are done by different level of engineers. Engineers and scientists are obligated to protect our environment in terms of inventing safe chemical substances, sustainable environment, and reusable and renewable energy resources and so on to ensure a better life for us and our future generation.

ACKNOWLEDGMENT

Authors are very much thankful to Almighty Allah. They are also grateful to their honorable parents. The authors also would like to express their gratitude to the Kulliyyah of Engineering, International Islamic University Malaysia (IIUM), Kuala Lumpur, Malaysia.

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