## ENGINEERING EDUCATION AND SUSTAINABLE DEVELOPMENT

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Engineering Education has in the recent past undergone a major transformation across the world in highlighting *Outcomes-based Education* and is driven by corresponding Accreditation imperatives. The National Board of Accreditation Graduate Attribute # 7 on *Environment and Sustainability* prescribes the need to "u*nderstand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development".*

While the importance of *Sustainability* is gaining in importance, there is no generally accepted definition of the term. Those who support the concept disagree in its precise meaning; while those who do not support it, agree that it has no meaning at all! There is also no widely recognized way to *measure* it.

*The Imperatives of Sustainable Development*: There is no alternative to Sustainable Development; it is already too late; we need to stop current trends; we need to do things differently, and to do different things. Over millennia, we have moved from survival economy and lifestyles to consumption economy and lifestyles. We need to move from consumption economy and lifestyles to conservation and preservation economy and lifestyles.

There are many dimensions of Sustainable Development: Each alphabet opens up opportunities and possibilities. For example, with the letter *E we*have Energy, Education, Environment, Efficiency, Ecology, Emissions, Economy, Employment , Equity, Engineering, Earth, Ethics, etc. With the letter *R,* we have Reduce, Re-use, Recycle, Renewable Energy, Resources – Exploitation, Conservation, etc.

*Concepts of Sustainability and Sustainable Development*: The pioneering definition of Sustainable Development is from *The Brundtland Report*, 1987: Sustainable Development meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Other definitions include: Living within 'the carrying capacity' of the Environment; Realization that the biosphere is both for us and for our descendants. A very popular expression is: "We have not inherited the Earth from our parents; we have only borrowed it from our children". Sustainable Development is an inter-generational concept, seeking equity over time, and minimization of disparities between generations.

Since the present standard of living is low in most emerging economies, people aspire for a higher standard. Sustainable Development cautions that there are limits to such growth: Due to: finite stock of resources (both energy & materials); pollution of the environment; exploding populations; escalating aspirations; and conflicting interests.

Human Survival and Development depend on two crucial factors:

- Population control; and
- Successful Management of the world's natural resources.

"No development plans will be expected to bear fruit unless efforts are made simultaneously to contain population", concluded M S Swaminathan Committee recently.

SOME LAWS GOVERNING SUSTAINABLE DEVELOPMENT

Summary of the *Three Laws of Thermodynamics*:

All energy conversion processes are governed by the Laws of Thermodynamics.The following popular presentation of the three Laws brings out the hopelessness of the energy situation formankind:

- First Law :You can't win ; you can only break even.
- Second Law :You can break even only at the absolute zero (Carnot efficiency is 100% at $T_2 = 0$)
- Third Law :You cannot reach the absolute zero.
- Conclusion :You can neither win nor break even !

*The Fundamental Law of Energy Use:*

"Unless the ratio of benefit to cost, measured in units of energy, is greater than 1:1, the potential resource will fail to become an actual resource." This Law defines energy resources, and provides the standard that all potential energy resources and energy technologies must meet. For example, food, fossil fuels, fissile fuels, etc are economic sources of energy only if they can be obtained at an energy / work cost that does not exceed the energy or work benefit obtained from them.

Thus, the following have little meaning in terms of energy resources:

- estimates of crude oil in the ground
- calculation of earth's total energy content
- solar insolation intercepted by the earth.

The moment that more energy is required to find, extract, process, transport and use a barrel of oil, than can be obtained from it, or in exchange for it, there will be no more potential reserves of petroleum. *Technological* feasibility neither equals nor forecasts *economic* feasibility.

*Some Environmental Principles*

In addition to the general principles of Sustainable Development, the Engineering Council identifies four key *Principles of Environmental Protection, impinging* upon Engineers' concerns:

- *The Prevention Principle :*is based on the universal concept of Prevention being better than Cure. This Principle accords priority to anticipating and preventing pollution and environmental harm.
- *The Precautionary Principle :* This requires that "where there are significant risks to the Environment, precautionary action should be taken to limit the use of potentially dangerous materials, or the spread of potentially dangerous pollutants, even where scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it".
- *The Polluter-Pays Principle:* This Principle requires the producer of any environmental damage to meet the financial costs of that damage. In law, an "avoidance cost" approach is employed, which requires the State to set standards, and the Polluter to meet compliance costs.
- *The Principle of Integration:* This concerns the need for integration of environmental consideration into all areas of decision-making, so that measures taken to improve environmental quality in one area are not undermined by unforeseen side-effects, or contradicted by action taken in another area.

TWO CONCLUSIONS OF WORLD ENERGYCONFERENCE (1989)

These two conclusions are as valid today as they were then.

1. *"Fossil fuels will continue to meet most of the world's growing energy demand".*

The implications of this conclusion are: World energy demand is bound to increase monotonically due both to increase in population and more energy-intensive lifestyles. Most of this energy demand will be met by fossil fuels. This conclusion underscores the inevitability of our dependence on fossil fuels, and the need for us to use them rationally.

2. "*The economical rational use of our energy resources is essential for protecting the environment".*

This establishes the nexus between Energy and Environment. Modern living depends on the use of energy resources, and all energy use is accompanied by environmental degradation. Higher efficiency of energy use has the twin benefits of slower resource depletion and reduced pollution.

THE FOUR LAWS OF ECOLOGY

In order to survive on the earth, human beings require the stable, continuing existence of an appropriate environment, which encompasses a thin skin of air, water and soil. Barry Commoner has enunciated four Laws of Ecology that highlight the scope of this science of planetary housekeeping:

*I Law :Everything is connected to everything else :*The ecosystem consists of multiple interconnected parts, which interact with each other. The feedback characteristics of ecosystems result inamplification and intensification of several processes.

*II Law :Everything must go somewhere*:In nature, there is no such thing as “waste”; nothing can be expected to “go away”.

*III Law :Nature knows best :*Modern technology aims to “improve on nature”.This law holds, however, that any major man-made change in a natural system is likely to be detrimental to that system.

*IV Law :There is no such thing as a free lunch :*In ecology, as in economics, this law is intended to warn that every gain is won at some cost. In a way, this law embodies the previous three laws. Because the global system is a connected whole, anything extracted from it by human effort must be paid for; payment of the price cannot be avoided, it can only be delayed.

UN DECADE OF EDUCATION FOR SUSTAINABLE DEVELOPMENT (2005-2014)

The overall goal of the UN Decade of Education for Sustainable Development (DESD) is to integrate the principles, values and practices of sustainable development into all aspects of education and learning. This educational effort is expected to encourage changes in behaviour that will create a more sustainable future in terms of environmental integrity, economic viability and a just society for present and future generations.

Implementing the mission involves: promoting and improving quality education; reorienting educational programmes; building public understanding and awareness; and providing practical training.

Kofi Annan, the former Secretary General of the United Nations has said: *"Our biggest challenge in this new century is to take an idea that seems abstract– sustainable development –and turn it into a reality for all the world’s people."*

Several distinctive Generic Sustainability Competences have been identified:

- Competence to think in a forward-looking manner, to deal with uncertainty, and with predictions, expectations and plans for the future.
- Competence to work in an interdisciplinary manner.
- Competence to see interconnections, interdependencies and relationships.

- Competence to achieve open-minded perception, trans-cultural understanding and cooperation.
- Participatory competence.
- Planning and implementation competence.
- Ability to feel empathy, sympathy and solidarity.
- Competence to motivate oneself and others.
- Competence to reflect in a distanced manner on individual and cultural concepts.

GRAND CHALLENGES IDENTIFIED BY INAE

Corresponding to the 14 Grand Challenges proposed by the National Academy of Engineering (US), our Indian National Academy of Engineering has identified ten Important technology domains and milestones, which have implications for Engineering Education for Sustainable Development:

1. Energy Harvesting and Energy Security
2. Sustainable Healthcare
3. River Science and Water Resources
4. Sustainable, Green and Smart Cities
5. Manufacturing Engineering
6. Nano science and Nanotechnology
7. Computer and Information Science
8. Agro-Bio-Nano Technology
9. Outreach and Mass Education Program
10. Advanced Materials