Journal of Cleaner Production 71 (2014) 1–10

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Editorial

Sustainability engineering for the future

Keywords:
Sustainability
Futuristic engineering
Assessment of transition to sustainable societies
Social improvements
Economics for sustainable societies
Governmental policies for sustainable societies

A B S T R A C T

This Special Volume of the Journal of Cleaner Production focuses on the "Sustainability Engineering for the Future". It highlights the roles of present and future engineers and provides guidelines and insights on how sustainability can be embedded systematically into all dimensions of engineering. Gone are the days when engineers only focus on technical and economic feasibility of a system design. The challenges of global warming brought about by widespread environmental pollution, resource depletion, rising human population, and multiple threats to food, water and energy securities require a paradigm shift in engineering thinking and ways to find and test solutions. The evolving engineering paradigm increasingly calls for engineers to consider the whole spectrum of sustainability i.e. from the economic, environmental, social and time dimensions. A selection of papers presented in the 6th International Conference of Process Systems Engineering Asia (PSE Asia) held in Kuala Lumpur, Malaysia from 25th to 27th June 2013 is included in this Special Volume.
The papers in this volume focus upon:

(i) Important considerations for the planning and development of sustainable products;
(ii) Models and methods designed to support sustainable planning and management;
(iii) Effective sustainability assessment tools and the needs for new ones;
(iv) New approaches for improved resource management;
(v) Illustrative future, sustainable technologies;
(vi) Ways policies will play significant roles in promoting implementation of sustainable engineering approaches.

The collection of papers as designed to provide guidelines for present and future engineers, researchers, academicians and policy makers for ways to improve current and future trends in engineering to help catalyse the transition to truly sustainable societies with improved quality of life.

1. Introduction

'*Engineers of the future*,' will face bigger and more demanding challenges. Whereas, '*engineers of the past*,' mainly focussed upon the technical and economic feasibilities of systems design, '*engineers of the future*,' will have the responsibility to address the entire spectrum of sustainability aspects, including the economic, environmental, social and multi-generational dimensions. Engineers, together with other members of society much increasingly address the rapidly evolving challenges of global warming are causing or will cause in areas of widespread environmental pollution, resource depletion, rising human populations, and increasingly severe threats of food, water and energy securities.

These are some of the urgently needed dimensions for transforming the engineering profession onto a much more proactive, holistic and dynamic profession, which goes far beyond what it is presently. Consequently, instead of only focussing upon the design or improvement of a product or process, the paradigm for 'sustainable engineering' requires dynamic, holistic, integrative analyses of present and future product life cycles, entire supply chains and the eco-systems upon which truly sustainable societies are totally dependent. Consequently, '*Engineers of the future*,' have to be more innovative, creative and engaged in seeking to ensure that the products/processes/systems they design and use will enhance present and future sustainable societal lifestyles.

More than ten years ago, Bakshi and Fiksel (2003) already presented the following framework for engineers who wish to contribute positively toward societal sustainability:

> "*A sustainable product or process is one that constrains resource consumption and waste generation to an acceptable level, makes a positive contribution to the satisfaction of human needs, and provides enduring economic value to the business enterprise.*"
>
> Bakshi and Fiksel (2003).

http://dx.doi.org/10.1016/j.jclepro.2014.03.013
0959-6526/

This and related statements clearly imply the need for more holistic, integrative and preventative approaches to societal evolution. There are many issues, which present and future engineers have to consider. In this Special Volume, the following needs for change are addressed:

(i) What are the main issues to be considered during the development of a sustainable product, process or system?
(ii) What are the barriers to incorporation and implementation of sustainability into engineering, in reality?
(iii) What are the roles for governments in promoting and supporting the transition to truly sustainable engineering?
(iv) What are effective and efficient ways to develop test and apply methods, which are simpler, easy-to-use and easy-to-interpret, so that they are utilized effectively for effecting 'real' improvements on the journey toward more sustainable societies?
(v) How can information technologies be harnessed to help to support and to accelerate the transition to more sustainable societies?
(vi) How can 'truly sustainable resource management,' be integrated into planning and implementation of sustainable societal development plans?
(vii) What should engineering education and research focus upon so as to help to prepare future engineers who are able to help societies become sustainable?

The selected papers from the 6th International Conference on Process Systems Engineering Asia (PSE Asia) held in Kuala Lumpur, Malaysia, June 25–27, 2013 are included in this special volume to provide guidelines on how sustainability can be more effectively embedded into engineering courses, curricula and practices so that 'real progress' can and will be made toward sustainable societies.

The PSE Asia conference theme, "Engineering Sustainable Process Systems", brought together more than 300 engineers, scientists, researchers, practitioners, policy-makers and educators from more than 30 countries from six continents. They discussed the urgent societal challenges and planned ways to help to ensure security of food, energy, water and environmental sustainability. They also focussed upon the urgent need for engineers to catalyse 'real changes' in ways of preventing and solving the societal problems of the present and those that are anticipated in the future.

The articles of this Special Volume include three, sustainability orientated, contributions selected to expand its scope beyond the papers presented at the conference.

2. An overview of papers in this Special Volume

The future sustainability engineering directions addressed in this Special Volume are divided into the following six categorises of papers:

(i) The first group discusses the important considerations for the development of more sustainable products.
(ii) The second group focuses on various models and methods, which have been developed to aid sustainable planning and management. Various examples for regional and technological planning are illustrated.
(iii) The third group provides a comprehensive assessment of the sustainability assessment tools and highlights the needs for new tools for the future.
(iv) The fourth group addresses how improved resource management must be incorporated into truly sustainable societal development.
(v) The fifth group provides examples of future, more sustainable technologies.
(vi) The last group provides a review of ways policies can/should play pivotal roles in promoting implementation of sustainable and holistic engineering approaches to help make the transition to sustainable societies.

2.1. Sustainable production

The first paper of this group is titled, "Review of evolution, technology and sustainability assessment of biofuel production," by Liew, Hassim and Ng from Malaysia (Liew et al., 2014). The authors reviewed the evolution, technology and sustainability assessment of biofuel production. Biofuels are seen as potentially valuable energy sources to replace fossil fuels since they are renewable and can help to reduce the societal carbon footprint. However the nitrogen footprint of such sources has to also be considered (Čuček at al., 2013). Biofuels have evolved from the first to the fourth generation. Different technologies are needed and are used for each generation of bio-fuels as summarized in the following paragraph:

a. The first generation of biofuels are primarily derived from food crops and are mainly used to produce biodiesel and bioethanol. The technologies involved in their production are based upon trans-esterification for biodiesel production and fermentation for bioethanol production.
b. The second-generation biofuels are based on lignocellulosic biomass and the biomass conversion technologies involve thermochemical and biological processes.
c. The third generation biofuels are or will be mainly derived from algae or microalgae. Algae are easy to produce since they do not require extensive land areas; therefore, they do not compete for land needed for producing human food and animal feed. Nevertheless, the efficiency of algal harvesting and extraction technologies are currently inadequate to achieve economic viability, especially within the current, heavily subsidized, fossil carbon-oriented societies.
d. The fourth generation biofuels will be fossil carbon-negative biofuel. The crops will be genetically modified to be able to absorb more CO_2. The biomass resulting from the crops will then be converted into efficient and clean fuels such as bio-gasoline or bio-hydrogen. Any CO_2 generation will be captured and sequestrated. However, research on generation of these types of biofuels is still very new and limited.

There are strengths and weaknesses in all four types of biofuels, which require much more research to improve the technical, environmental, economic and social impacts.

The economic, environmental and social aspects must be much more adequately assessed for their potential to contribute to 'sustainable' biofuels production. Techno-economic analyses have been performed under various scenarios affecting biofuel production e.g. oil prices, extreme weather, variation in subsidies, changes of governmental policies, new technologies, new social values, etc. It was found that the main economic barriers for biofuel commercialisation are the high capital and feedstock costs, among other factors. Liew et al. (2014) reviewed safety, health and environmental (SHE) assessment tools for biofuel production. They concluded that the majority of the studies were focused on the environment, while fewer addressed the safety and health dimensions. It was believed that biofuels could potentially help to mitigate greenhouse gas emissions and their consequent effects. The authors highlighted the need for a