

Sustainable Product Design: A Review

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Abstract

With the increasing demand of product it become essential to consider sustainability aspects of product design The integration of sustainability into all aspects of product design cycle provides an opportunity to reduce a product's negative impact on society, environment and economy. There are three issues on which sustainability works that is society, environment and economy. We must integrate the idea of sustainable design into the process of product design in order to achieve sustainable development of environment, society and economy. The main objective of sustainable product design is to reduce or minimise the use of conventional or non-renewable resources. Hence, this paper gives an overview of the concept of Sustainable Product Design.

Keywords

Sustainability, Life Cycle Assessment, Carbon Credit, Green Production

I. Introduction

With the advancement of society, people begin to pay more attention to the adverse effects of resources and energy on social environment. So there should be the requirement of Sustainable product design that links society, economy and environment as a whole. The concept of sustainable design evolves from sustainable development at the early stage and it is an important aspect of humanity to respond to global environmental changes at present. It modulate traditional design and eco-design into new sustainable design that is based on the concept of sustainability. It does not harm future generations to meet their demand while meeting needs of present generation, for the purpose of achieving the balance of environment, society and economy and maintaining sustained and coordinated development of human society. Sustainable design involves the concepts of human life, work, production, energy, urbanization, transportation, communication and economy. It redesigns to make up the negative role which development of science and technology brought to on the basis of such thinking. With the increasing demand of product it become essential to consider sustainability aspectsof product designThe integration of sustainability into all aspects of product design cycle provides an way to reduce a product's negative impact on society, economy and environment. So, there are three issues on which sustainability works that is society, environment and economy. Sustainable product design examine the environmental and social considerations in the earliest stages of the product development process to minimize negative environmental and social impacts throughout the product's life cycle and to comply with the principles of economic, social and ecological sustainability.

II. Sustainability

The most often-quoted definition of Sustainable Development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs [1-2]. Sustainability is the capacity to maintain. Sustainability is the potential for long-term maintenance of well beings involving economic, ecological, political and cultural dimensions. Three

critical components in promoting sustainable development are economic growth, social equity and environmental sustainability [8]. Sustainability can defined in terms of 3 E's- Environment, social equity and economy as shown in fig. 1.

A. Economic

An economically sustainable system must be able to produce goods and services on a continuing basis, to maintain manageable levels of government and external debt, and to avoid extreme sectorial imbalances which damage agricultural or industrial production [14].

B. Environmental

An environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions, and depleting non-renewable resources only to the extent that investment is made in adequate substitutes. This includes maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources [16].

C. Social

A socially sustainable system must achieve distributional equity, adequate provision of social services including health and education, gender equity, and political accountability and participation.

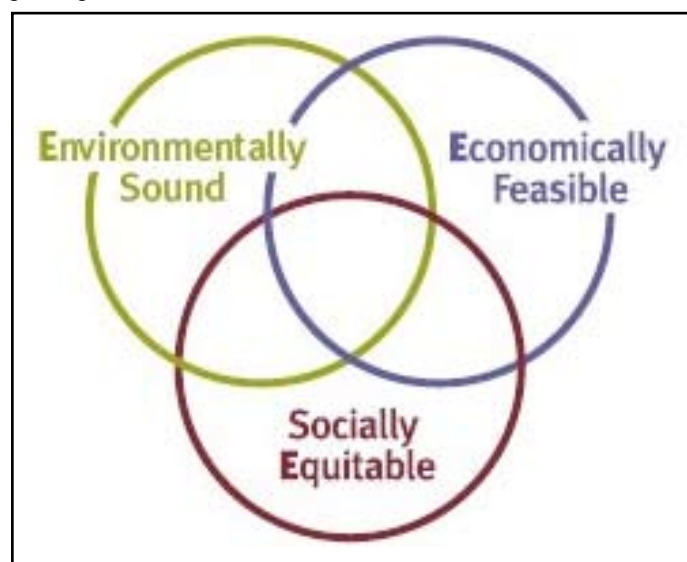


Fig. 1: The Three E's of Sustainability: Environment, Social Equity, and Economy

The concept of sustainable development raises the issue of whether present life-styles are acceptable and whether there is any reason to pass them on to the next generation. Because intergenerational equity must go hand in hand with intra-generational equity, a major restructuring of the world's income and consumption patterns may be a necessary precondition for any viable strategy of sustainable development. Sustainability, then, is more than limits on population or restraint in consumption—though these are

important. It means that in our choice of goods and technologies we must be oriented to the requirements of ecosystem integrity and species diversity. The advantages of sustainable product is that they use less energy, fewer limited resources, increase production, do not deplete natural resources, do not pollute the environment and can be reused or recycled at the end of their useful life [3].

III. Life Cycle Assessment

Life-cycle assessment (LCA, cradle-to-grave analysis) is a technique to analyse environmental impacts associated with all the stages of a product's life from initial-to-final (i.e., from raw material extraction to the final disposal of the product involving processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling) [4]. LCA demonstrates the environmental, social, and economic benefits of products over their full life cycle, from raw materials extraction to final disposition. LCA is a tool to analyse the various effects of a product or service on environment. It is a standardized method that provides the decision making process by helping government to define a policy for public. It has certain cons that it is geographical dependent i.e. results changes with change in area and analysis of whole parameters is needed to prepare a data. To analyse and minimize the impact of product design on environment from whole activities (initial to final process) of product design, LCA should be used which will help in achieving carbon credits. Carbon Credits provide an efficient way to reduce the greenhouse gas emissions by monetizing the reduction in emissions [5, 18]. To protect ourselves, our economy, our society and our land from the adverse effects of climate change, we have to reduce emissions of carbon dioxide and other greenhouse gases. So, Life cycle assessment is a very important factor of sustainable product design described in fig. 2.

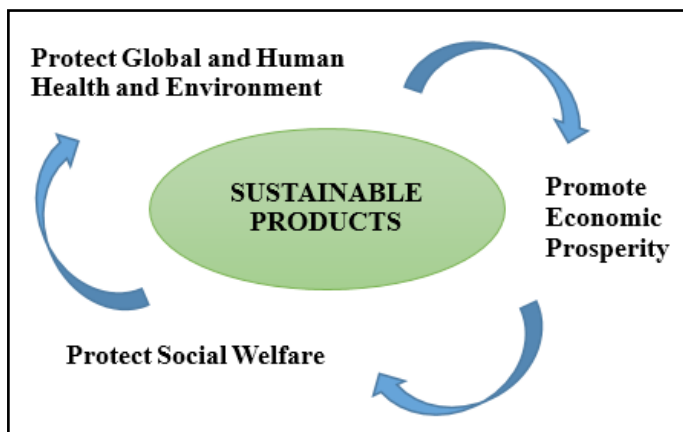


Fig. 2: Sustainability: Environment, Social Equity, and Economy

IV. Sustainable Product Design

Sustainable products are those products providing environmental, social and economic benefits while protecting public health, welfare, and environment over their full life cycle, from the extraction of raw materials to final disposition. It is the technique to design a product to comply with the principles of social, economic and environmental sustainability [6]. Sustainable product design can encapsulate the selection of materials, use of resources, production requirements and planning for the final disposition (that may be either recycling, reuse, remanufacturing, or disposal) of a product. It provides the opportunity to incorporate green and socially responsible attributes into a product. It examines the environmental and social considerations in the earliest stages of the

product development process to minimize negative environmental and social impacts throughout the product's life cycle and to comply with the principles of economic, social and environmental sustainability. In the sustainable product design it is also possible to eliminate the disposal phase of a product's life cycle by introducing the concept of reuse or recycling. It eliminates product's "end of life" by considering that materials formerly considered waste will either have the potential to biodegrade naturally or restore the soil, or by fully recycled into high quality materials to create other useful products.

Implementing sustainability in the product design can provide numerous benefits to a company as the focus is on resource efficiencies that can reduce costs and often shorten production time. Sustainable product design sometimes requires bringing diverse functional groups to the design table for the first time, sustainable product design efforts can also drive other product and process innovation.

A. Green Production

Green Production is introduced to address wasted resources in production to increase productivity, drive down costs and deduct impact on environment and socio-economy. It is one aspect of the green design process for the product. It is focused on continuous improvement, recognizing that reducing environmental and social impact is a circular process that begins and ends and begins again with the inquiry into how to make products of better quality, using fewer resources, and creating less or no waste in the process. Hazardous waste can be minimized at product design stage [7]. According to international consulting firm Deloitte, there are six sources of waste a business should address:

1. Over-production: Producing more products than you can sell leads to waste from the raw materials, energy and water used to make the products, and recycling or landfill waste when those products spoil or become obsolete before they can be sold.
2. Inventory: Look for the excess packaging used for stored products, the potential for damage when products are being stored, the replacement of products in process, and the wasted energy required to heat/cool inventory space.
3. Transportation and motion: Look for opportunities to reduce energy, emissions, and spills during product transport.
4. Defects: Look to reduce defects as they are a waste of raw materials, energy and water used in their manufacture. Defects also require the extra effort of recycling or landfilling to dispose of them, and additional energy, water and labour to rework materials into new products.
5. Over-processing: Look to reduce over-processing of products, where more raw materials, energy, water, and waste are used and emissions created per product than necessary.
6. Waiting: Look for spoilage or component damage when products are waiting to be finished, and the energy consumed during downtime

B. Greening Product Design

The highest criteria of green design are as follows: consider recycling fully, reduce the waste, increase product durability, the material's fitness, be easy to decompose and assemble, save energy source and select the least polluting material, guarantee staff safety and so on [7]. These are the following aspects that should be taken into account while designing a product with the aim of sustainability [9-10].

1. Product lifespan: Increment in product 'lifespan improve its durability and increase its value with reducing waste and thus reducing its negative impacts on society, economy and environment.
2. Material choices: Examine the availability of green materials to substitute for traditional and conventional materials. This may include creating a remanufactured product out of high quality used parts, sourcing materials with higher recycled content, or substituting a greener or non-toxic material. The renewable or non-conventional resources should be chosen that has less environmental impact and easily available with plenty amount. Shift to renewables, some of which are already cost effective, can enhance sustainable energy supply, and can reduce local pollution and greenhouse gas emissions.
3. Recyclability: Investigate the end of a product's life that makes products easier and safer to reuse and recycle into component parts [11, 15].

V. Need of Sustainable Product

As the sustainability defined in terms of three factors i.e. environment, social equity and economy, it is very essential to maintain balance between all these factors. With the concept of sustainability in product design it is essential to consider social factors of production [19-20]. The health and safety of the workplace, the protection of basic human rights of employees, including the absence of discrimination, shared benefits of economic growth, community development and stakeholder engagement are some of the key social issues over which businesses are stepping up their responsibilities. In any product development process, there are a number of social considerations to take into account, including the opportunity of using the production process to generate a positive social impact. Therefore, we must integrate the idea of sustainable design into the process of product design in order to achieve sustainable development of environment, society and economy. In other words, we must follow the idea of sustainable design at the source of product design in order to effectively guarantee to follow the idea of sustainable design in the process of later detailed design and production-manufacture in product design and avoid unnecessary troubles [12]. Designers should follow sustainable development strategy and the idea of sustainable design, so that all efforts made to promote technological development can't damage to the natural environment, and even can help to improve the speed of automatic replying of the natural environment. Such design purpose will be conducive to sustainable development of human society and make more conceptual design to succeed. Energy efficiency can also increase profits by reducing costs [13, 17].

Sustainable design and production allows business to incorporate environmental and social attributes into product's design while meeting the growing environmental requirements of customer base and thus reducing costs. Understanding the importance of the idea of sustainable design in many aspects from the source of product design, shortening the disparity of product conceptual design and demands of users, changes in the market, avoiding causing the waste of time and funds of amending when products put into production, and prompting product design to join the tide of the idea of sustainable design in order to achieve a sustainable development of environment, society and economy.

VI. Conclusion

To safeguard the interests of future generations, Sustainable Development is must. In order to achieve environmental sustainability and energy optimization, mass awareness is

needed. Product designers are facing energy challenges and are starting scrutinizing their responsibilities towards environmental problems by conducting life cycle assessment techniques. The use of sustainable or non-conventional product make the less impact on environment and sustain it for the long time. The goals of sustainable design are reducing or minimizing the use of non-renewable resources, managing renewable resources, Sustainable design should be an evolution and extension of traditional design approach.

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