

Green energy strategies for sustainable development

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Abstract

In this study we propose some green energy strategies for sustainable development. In this regard, seven green energy strategies are taken into consideration to determine the sectoral, technological, and application impact ratios. Based on these ratios, we derive a new parameter as the green energy impact ratio. In addition, the green energy-based sustainability ratio is obtained by depending upon the green energy impact ratio, and the green energy utilization ratio that is calculated using actual energy data taken from literature. In order to verify these parameters, three cases are considered. Consequently, it can be considered that the sectoral impact ratio is more important and should be kept constant as much as possible in a green energy policy implementation. Moreover, the green energy-based sustainability ratio increases with an increase of technological, sectoral, and application impact ratios. This means that all negative effects on the industrial, technological, sectoral and social developments partially and/or completely decrease throughout the transition and utilization to and of green energy and technologies when possible sustainable energy strategies are preferred and applied. Thus, the sustainable energy strategies can make an important contribution to the economies of the countries where green energy (e.g., wind, solar, tidal, biomass) is abundantly produced. Therefore, the investment in green energy supply and progress should be encouraged by governments and other authorities for a green energy replacement of fossil fuels for more environmentally benign and sustainable future.

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1. Introduction

Energy is a key factor in discussions of economic, social and environmental dimensions of sustainable development (Dincer, 1999). A different type of energy is fossil-based energy, which generally includes coal, petroleum, natural gas, etc. Another type is green energy. As is known, fossil energy sources are not renewable. In order to explain and find out the requirement of sustainable energy strategies for green energy supply and progress, the main negative effects of fossil fuels should be first introduced.

Fossil fuels have caused some major human health and human welfare problems, due to their extensive use in various industrial non-industrial sectors. Such problems are detailed elsewhere (Barreto et al., 2003; Bockris, 2003; Dincer, 2000). In reality, the main source of these problems is seen as the extensive use of fossil-based technologies and strategies only by human beings to govern the societies, countries, in short, the whole world, throughout centuries. We have reached a level that is not tolerable anymore. The urgent need in this regard is to develop green energy strategies for sustainable future without any negative environmental and societal impacts. Here, we should define green energy! It can be defined as the energy source, which has zero or minimum environmental impact, as more environmentally benign and more sustainable, and produced from solar, hydro, biomass, wind, geothermal, etc. This type of green energy reduces the negative effects of fossil

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energy resources and the overall emissions from electricity generation, decreases the greenhouse gases, gives an opportunity to take an active role in improving the environment, and meets the clean energy demand for both industrial and non-industrial applications. Considering the benefits of green energy, sustainability of green energy supply and progress is assumed to be a key element in the interactions between nature and society. Sustainable development requires a supply of energy resources that is sustainably available at reasonable cost and causes no or minimal negative societal impacts. Clearly, energy resources such as fossil fuels are finite and thus lack the characteristics needed for sustainability, while others such as green energy sources are sustainable over the relatively long term (Dincer and Rosen, 2004). Particularly, low-priced green energy is the most essential means for increasing the sustainable technological development and industrial productivity as well as people's living standard in a society. Therefore, permanent and effective sustainable green energy strategies should be put forward to increase the use of green energy sources and technologies (Midilli et al., 2004a, b). From the literature review, it is noticed that some researchers have contributed to the sustainable development aspects of various energy sources and applications (e.g., Palmer-Jones and Jackson, 1997; Weinberg, 1997; Suganthi and Samuel, 2000; Brown et al., 2001; Brown, 2001; Dell and Rand, 2001; Momirlan and Veziroglu, 2002, 2005; Afgan and Carvalho, 2004; Dincer and Rosen, 2004; Wustenhagen and Bilharz, 2004; Midilli et al., 2005a–c; Dincer and Rosen, 2005; Clark et al., 2005; Gilg et al., 2005; Cannon et al., 2005; Tsoutsos and Stamboulis, 2005; Marechal et al., 2005; Nijland, 2005; Halasz et al., 2005; Goldemberg, 2005; Hughes and Johnston, 2005). However, no studies on the green energy strategies for sustainable development have appeared in the open literature. In fact, this was the motivation behind this original work. Therefore, this paper essentially aims to develop some key green energy strategies for sustainable future and to derive some key parameters like green energy impact ratio and the green energy-based sustainability ratio. As differing from other studies, this work will also:

- help understand main concepts and issues about green energy use and sustainability aspects,
- develop relations between green energy use and sustainability development,
- encourage the strategic use and conservation of the green energy sources,
- provide the methods for energy security, implementation and development,
- increase the motivation on the implementation of green energy strategies for better energy supply,
- give an idea to reduce the negative environmental impacts by considering the possible green energy strategies, and
- form a scientific platform to discuss the possible green energy strategies for sectoral use.

For the above listed outcomes, we propose seven possible green energy strategies and develop new parameters on the technological, sectoral and application impact ratios for sustainable development.

2. Analysis

Here we present some key steps in the analysis and model development which are expected to accelerate the use of green energy technologies and implementation of green energy strategies, as follows:

- main basis,
- green energy and sustainability,
- essential factors,
- green energy applications,
- key strategies,
- parametric description,
- general assumptions, and
- model development.

2.1. Main basis

In order to develop green energy strategies for sustainable development, we need to build upon a logical/systematic framework as the main basis of this study. In a recent study, Dincer and Rosen (2005) have outlined the essential factors impacting sustainable development and their interdependences. They introduced the sustainable development as the confluence of energy and resources sustainability, economic sustainability, environmental sustainability, and social sustainability and discussed their interrelations, as shown in Fig. 1. Dincer and Rosen's work is taken as the main basis of this analysis and model development.

It is obvious that a cost-effective and stable energy supply is the prerequisite for social and economic development in industrial and non-industrial sectors. Indeed, energy is essential to human welfare and quality of life. However, energy production and consumption generate significant environmental problems (at global, regional and local levels) that can have serious consequences and even put at risk the long-term sustainability of the planet's ecosystems. The relationship between energy consumption and production and sustainability is, therefore, complex (Balocco and Grazzini, 2000; Dincer and Rosen, 2005). Here we consider sustainable development to involve four key factors in Fig. 1 as presented by Dincer and Rosen, (2005), namely environmental, economic, social, and energy and resource sustainability. In this regard, the relationship between green energy and sustainability will

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