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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.

Keywords: Green energy; Sustainable development; Fossil fuel

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

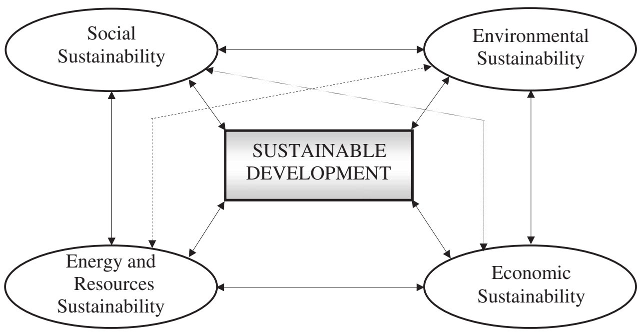

Fig. 1. Factors affecting sustainable development and their interdependences (adapted from Dincer and Rosen, 2005).

be investigated through our present model. It is clear that green energy strategies will lead to sustainable development as to be discussed below.

2.2. Green energy and sustainability

Sustainability has been called a key to the solution of current ecological, economic, and developmental problems by Dincer and Rosen (2005). For sustainable development, green energy can play an important role for meeting energy requirements in both industrial and local applications. Therefore, development and utilization of green energy strategies and technologies should be given a high priority for sustainable development in a country. The need for sustainable energy development is increasing rapidly in the world. Widespread use of green energy sources and technologies is important for achieving sustainability in the energy sectors in both developing and industrialized countries. Green energy resources and technologies are a key component of sustainable development for three main reasons (Dincer and Rosen, 2005):

- They generally cause less environmental impact than other energy sources. The variety of green energy resources provides a flexible array of options for their use.
- They cannot be depleted. If used carefully in appropriate applications, green energy resources can provide a reliable and sustainable supply of energy almost indefinitely.
- They favor system decentralization and local solutions that are somewhat independent of the national network, thus enhancing the flexibility of the system and providing economic benefits to small isolated populations. Also, the small scale of the equipment often reduces the time required from initial design to operation, providing greater adaptability in responding to unpredictable growth and/or changes in energy demand.

Thus, green energy and technologies are needed for sustainable development that ensures a minimization of global unrest. Clearly, energy resources such as fossil fuels are finite and thus lack the characteristics needed for sustainability, while others such as renewable energy sources are sustainable over the relatively long term (Dincer and Rosen, 2005). The relation between green energy and sustainability is of great significance to the developed countries as well as developing and/or less developed countries. Moreover, examining the relations between green energy sources and sustainability makes it clear that green technology is directly related to sustainable development. Therefore, attaining sustainable development requires that green energy resources also be used, and is assisted if resources are used efficiently (Rosen and Dincer, 2001). Major considerations involved in the development of green energy technologies for sustainable development as modified from Dincer and Rosen (2005) are presented in Fig. 2.

If sustainable energy strategies are effectively put into practice, the countries may maximize the benefits from the green energy sources and technologies, while minimizing the global unrest (Midilli et al., 2005a) associated with the use of fossil fuel energy sources. It expected that this initiative can contribute to development over a longer period of time, i.e., to make development more sustainable (Dincer and Rosen, 2005).

2.3. Essential factors

There are various essential parameters as outlined and detailed in Fig. 3. These factors can help in identifying

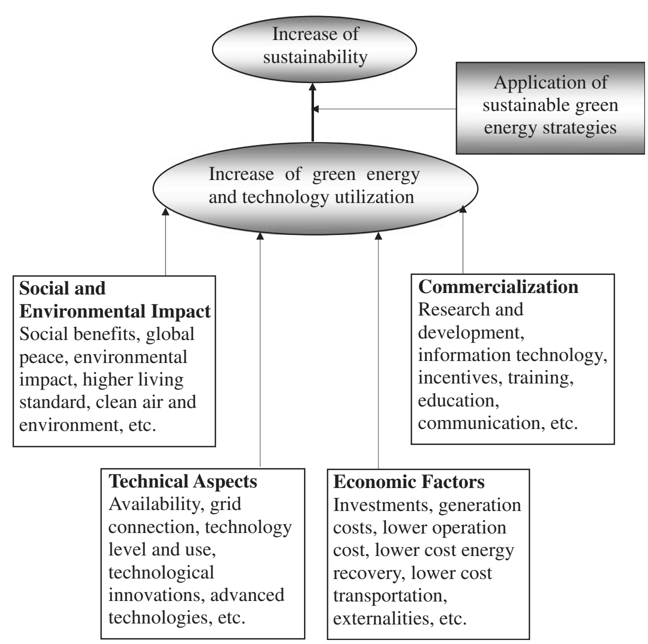

Fig. 2. Major considerations involved in the development of green energy technologies for sustainable development (modified from Dincer and Rosen, 2005).

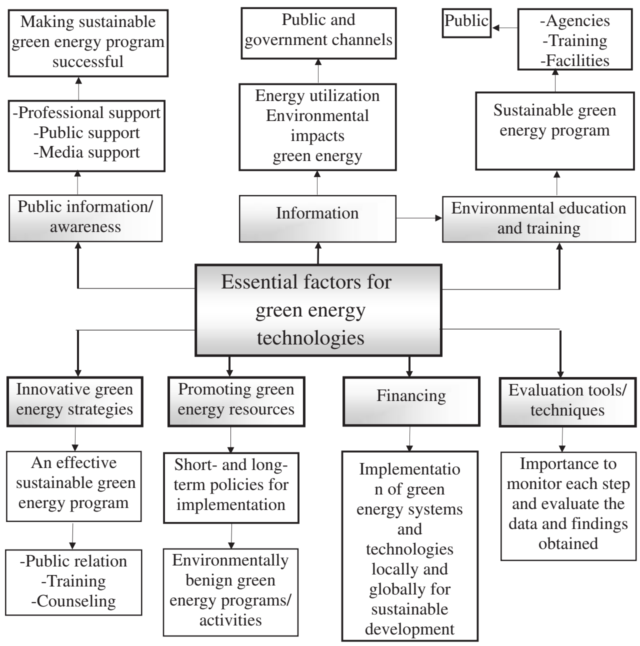

Fig. 3. Essential factors for green energy strategies and technologies.

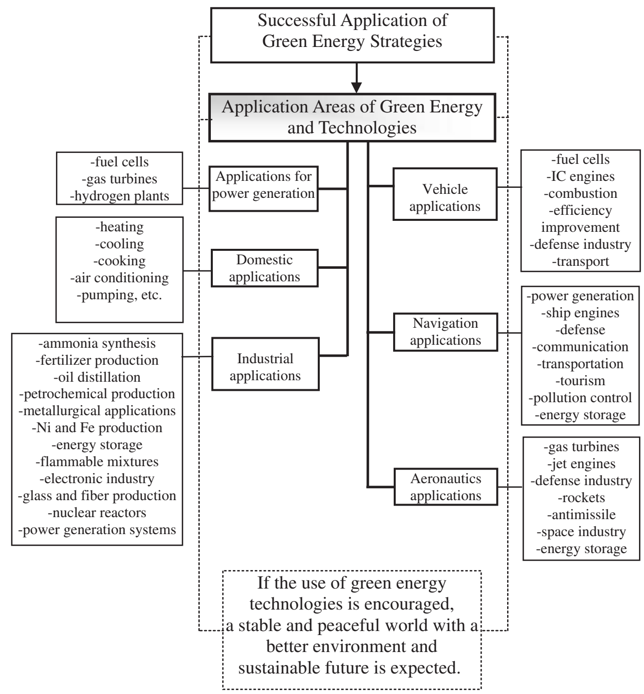

Fig. 4. Possible application fields of green energy and technologies in for sustainable development.

and achieving required green energy strategies and technologies for sustainable development. As shown in Fig. 3, green energy technologies are largely shaped by broad and powerful trends that have their roots in basic human needs. In conjunction with this, the increasing world population requires the definition and successful implementation of green energy technologies. Briefly, the important parameters and their interrelations as outlined in Fig. 3 are definitely required to carry out the best green energy program and select the most appropriate green energy technology/technologies for sustainable development.

2.4. Green energy applications

Green energy technologies are expected to play a key role in sustainable energy scenarios for future. The foremost factor that will determine the specific role of green energy and technologies will likely be energy demand. Therefore, in order to compensate the energy requirement, it will be possible to produce green energy from renewable energy sources such as hydraulic, solar, wind, geothermal, wave, biomass, etc. If so, the green energy and technologies can be utilized for many application fields as shown in Fig. 4. Thus, it can be said that green energy and technologies, which are abundantly available, can help:

- provide a more environmentally benign and more sustainable future,
- increase energy security,
- facilitate or necessitate the development of new, clean technologies,
- reduce air, water and soil pollution and the loss of forests,
- reduce energy-related illnesses and deaths,
- reduce or stop conflicts among countries regarding energy reserves, etc.

Therefore, green energy and related technologies are needed to ensure the global stability by reducing the harmful effects of the fossil-based energy consumption. Thus, importance of green energy in reducing the world problems and achieving a sustainable energy system should be emphasized considering the sustainable green energy strategies, and a transition to green energy economy should be encouraged and developed countries, in particular, should increase investments in green energy and technologies.

2.5. Key strategies

Here we present some key strategies by considering social sustainability, environmental sustainability, economic sustainability, and energy and resource sustainability that have already been illustrated in Fig. 1, and also with major considerations in Figs. 2–4. An increase in the energy consumption of a country provides a positive impact on its economic as well as social and technological developments (Dincer and Rosen, 2005). Moreover, the supply and utilization of green energy are particularly significant for sustainable green energy technologies. The most important scenario to encourage the use of green energy and promote sustainable green energy-based technologies is to supply the required incentives and interactions among the countries, scientists, researchers, societies and others (Midilli et al., 2005a; Dincer and Rosen, 2005). For the future of the countries dealing with green energy and technologies, there is a need to determine the possible sustainable green energy strategies. In order to develop and publicize the sustainable green energy technologies in a developed or less developed country, the following important green energy strategies should be taken into account:

- industrial and technological support for transition to green energy technologies,
- control of the projection and analysis of green energy sources,
- governmental and public support for green energy economy,
- production, consumption, distribution, conversion, management and marketing of green energy,
- research, development and application of sustainable green energy technologies,
- availability, productivity and reliability of green energy and technologies, and
- design and fabrication of green energy-based environmental and ecological applications.

2.6. Parametric description

Considering the above strategies, the following important parameters can be defined to derive the green energy impact ratio.

- *Sectoral impact ratio* (R_{si}) is based on the provided financial support of public, private and media sectors for transition to green energy-based technologies, and depends on the total green energy financial budget as a reference parameter.
- *Technological impact ratio* (R_{ti}) is based on the provided financial support for research and development, security and analysis of green energy-based technologies, and also depends on the total green energy financial budget as a reference parameter.
- *Practical application impact ratio* (R_{pai}) is based on the provided financial support for projection, production, conversion, marketing, distribution, management and consumption of green fuel from green energy sources, and also depends on the total green energy financial budget.

Accordingly, it should be emphasized that these parameters can be defined as the ratio of the provided financial support to the total green energy financial budget in a country. In addition, it should be always remembered that it is assumed that the financial share of each parameter is equal to 1/3 of the total green energy financial budget in a country.

2.7. General assumptions

In order to analyze the effects of sectoral, technological and practical application ratios on the green energy impact ratio and green energy-based sustainability ratio, some general assumptions are made as follows:

- There are three green energy parameters, namely technological, sectoral and practical application impact ratios, as given in the previous section, and their weights have split equally (= 1/3 of the total green energy financial budget). The values of the impact ratios of these parameters may change, but the total ratio of these parameters should equal to 1, because it is considered that the total green energy financial budget is prepared in accordance with the activities involved in the parameters.
- The practical effects of technological, sectoral and practical application impact ratios are selected as 20%, 60% and 100%, respectively.
- The total primary energy consumption, total fossil fuel consumption, total green energy consumption as indicated in (Workbook, 2005) are taken as reference parameters and evaluated in the total green energy financial budget in a country.
- Three cases including technological, sectoral and practical application impact ratios as the constant or variable parameters are considered in the parametric analysis:
  - o Case 1 includes one variable and two constant parameters (max. effect of constant parameters = 2/3 of total green energy financial budget).
  - o Case 2 includes two variables and one constant parameter (max. effect of constant parameter = 1/3 of total green energy financial budget).
  - o Case 3 includes three variables and no constant parameter.

2.8. Calculation procedure

Here we define the impact ratios as follows, after describing them above in detail:

- *Sectoral impact ratio* (R_{si})

$$R_{si} = \frac{C_{p,si}}{C_{geb}} \quad C_{p,si} < C_{geb} \quad \text{(ranging from 0 to 1/3)}, \tag{1}$$

where $C_{p,si}$ defines the provided financial supports of the public, private and media sectors for transition to green energy-based technologies; C_{geb} the total green energy financial budget in a country.

- *Technological impact ratio* (R_{ti})

$$R_{ti} = \frac{C_{p,ti}}{C_{geb}} \quad C_{p,ti} < C_{geb} \quad \text{(ranging from 0 to 1/3)}, \tag{2}$$

where $C_{p,ti}$ defines the provided financial supports for research and development, security and analysis of green energy-based technologies.

- *Practical application impact ratio* (R_{pai})

$$R_{pai} = \frac{C_{p,pai}}{C_{geb}} \quad C_{p,pai} < C_{geb} \quad \text{(ranging from 0 to 1/3)}, \tag{3}$$

where $C_{p,pai}$ defines the provided financial supports for projection, production, conversion, marketing, distribution, management and consumption of green fuel from green energy sources.

2.9. Green energy impact ratio (R_{gei})

In order to take into account the proportional effects of the sectoral, technological and practical application impact ratios on the green energy financial budget in a country, the green energy impact ratio is considered as follows, based upon Eqs. (1)–(3):

$$\begin{aligned}\text{Green Energy Impact Ratio} &= [\text{Sectoral impact ratio}] \\ &\quad + [\text{Technological impact ratio}] \\ &\quad + [\text{Practical application impact ratio}]\end{aligned} \tag{4}$$

and

$$R_{gei} = \{R_{si} + R_{ti} + R_{pai}\} \quad \text{in algebraic form.} \tag{5}$$

2.10. Green energy-based sustainability ratio (R_{ges})

Green energy-based sustainability ratio leads to the sustainable development in a country using green energy sources and technologies. It is considered that this parameter is a fuction of the green energy utilization ratio (R_{geu}) and green energy impact ratio (R_{gei}). Therefore, the green energy-based sustainability ratio can be written in algebraic form as follows:

$$R_{ges} = R_{gei} \times R_{geu} \tag{6}$$

In order to estimate the green energy-based sustainability ratio, the green energy utilization ratio should be defined as a function of fossil fuel utilization ratio (R_{ffu}). Hence, this parameter can be written as

$$R_{geu} = 1 - R_{ffu} \tag{7}$$

In Eq. (7), the fossil fuel utilization ratio should be determined by considering data for fossil fuels that are consumed in each year starting from 1965 as taken from (Workbook, 2005). Thus,

$$R_{ffu} = \frac{\text{Total fossil fuel consumption}}{\text{Total primary energy consumption}} = \frac{\sum ffc}{\sum pec} \tag{8}$$

Substituting Eq. (8) in Eq. (7), the green energy utilization ratio can be described as

$$R_{geu} = 1 - \left(\frac{\sum ffc}{\sum pec}\right) = \frac{\sum pec - \sum ffc}{\sum pec} \tag{9}$$

Thus, the green energy-based sustainability ratio can be obtained substituting Eq. (5) in Eq. (6) as follows:

$$R_{ges} = \{R_{si} + R_{ti} + R_{pai}\} \times R_{geu} \tag{10}$$

Hence, the green energy-based sustainability ratio can be written in the following form substituting Eqs. (1)–(3) and (9) in Eq. (10) as

$$R_{ges} = \left\{\left[\frac{C_{p,si}}{C_{geb}}\right] + \left[\frac{C_{p,ti}}{C_{geb}}\right] + \left[\frac{C_{p,pai}}{C_{geb}}\right]\right\} \times \left\{1 - \left(\frac{\sum ffc}{\sum pec}\right)\right\} \tag{11}$$

3. Results and discussion

In accordance with the objective of this study, the projection data are obtained using historical data of primary energy, fossil fuel and green energy consumptions. In order to emphasize the importance the green energy strategies, the variations of fossil fuel and green energy consumptions, and their utilization ratios are taken into consideration as shown in Figs. 5a–c. In addition, considering the technological impact ratio (max. value = 1/3 of the green energy financial budget), the sectoral impact ratio (max. value = 1/3 of the green energy financial budget) and the practical application impact ratio (max. value = 1/3 of the green energy financial budget), three cases are analyzed and discussed in detail as shown in Figs. 6(a–c).

Fig. 5a illustrates the variations of fossil fuel and green energy consumptions as a function of year depending on the historical data taken from Workbook (2005) and projection data. As seen in this figure, the variations of fossil fuels and green energy consumption have shown a linear increase up to 2004. It was observed that, according to the projection data for fossil fuel and green energy after 2004, the consumption of the fossil fuel sources would increase. For example, the fossil fuel consumption and the green energy consumption are expected to reach 13807.2 and 2694.9 Mtoe, respectively, by the year 2050. This increase indicates our dependence on the fossil fuels. If the increase of fossil fuel consumption continues in this manner, it is likely that the world will be affected by many negative problems caused by the use of fossil fuels. Therefore, it is expected that the green energy consumption should be increased

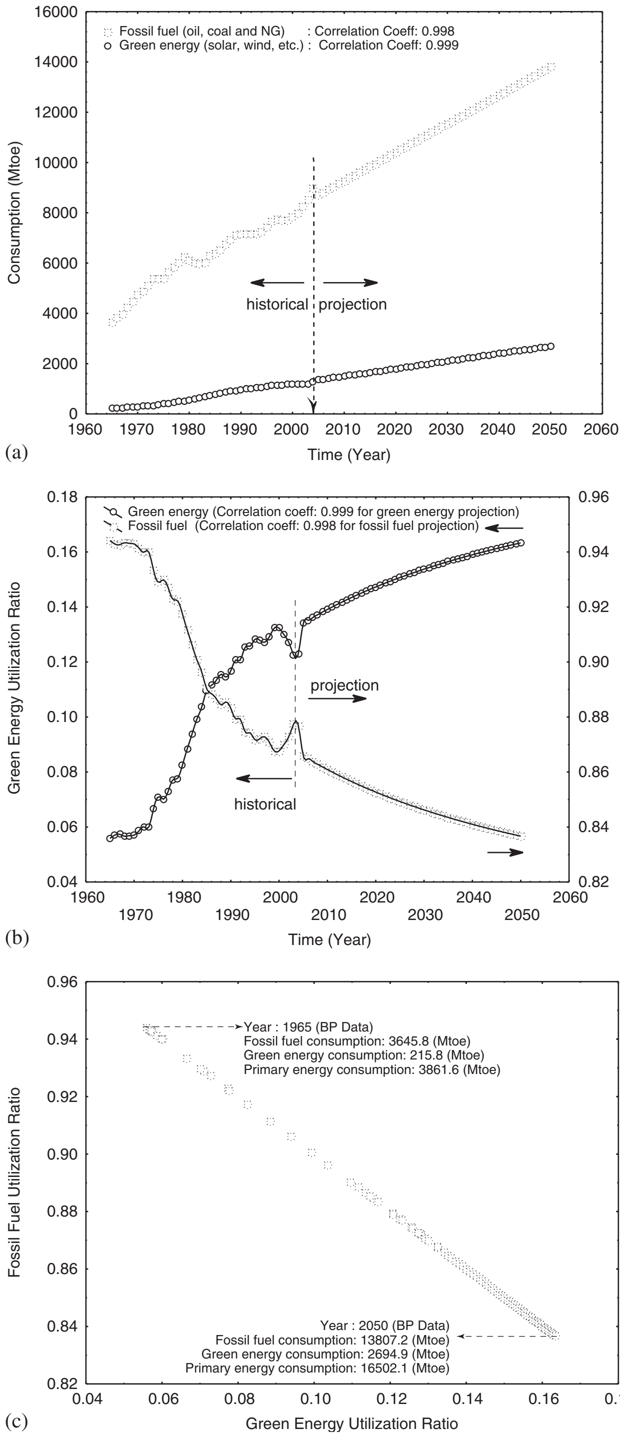

Fig. 5. (a) Actual and projected consumption of fossil fuels and green energy sources. (b) Variations of the green energy and fossil fuel utilization ratios as a function of year based on the historical data taken from Workbook (2005) and projections. (c) Fossil fuel utilization ratios versus the green energy utilization ratios.

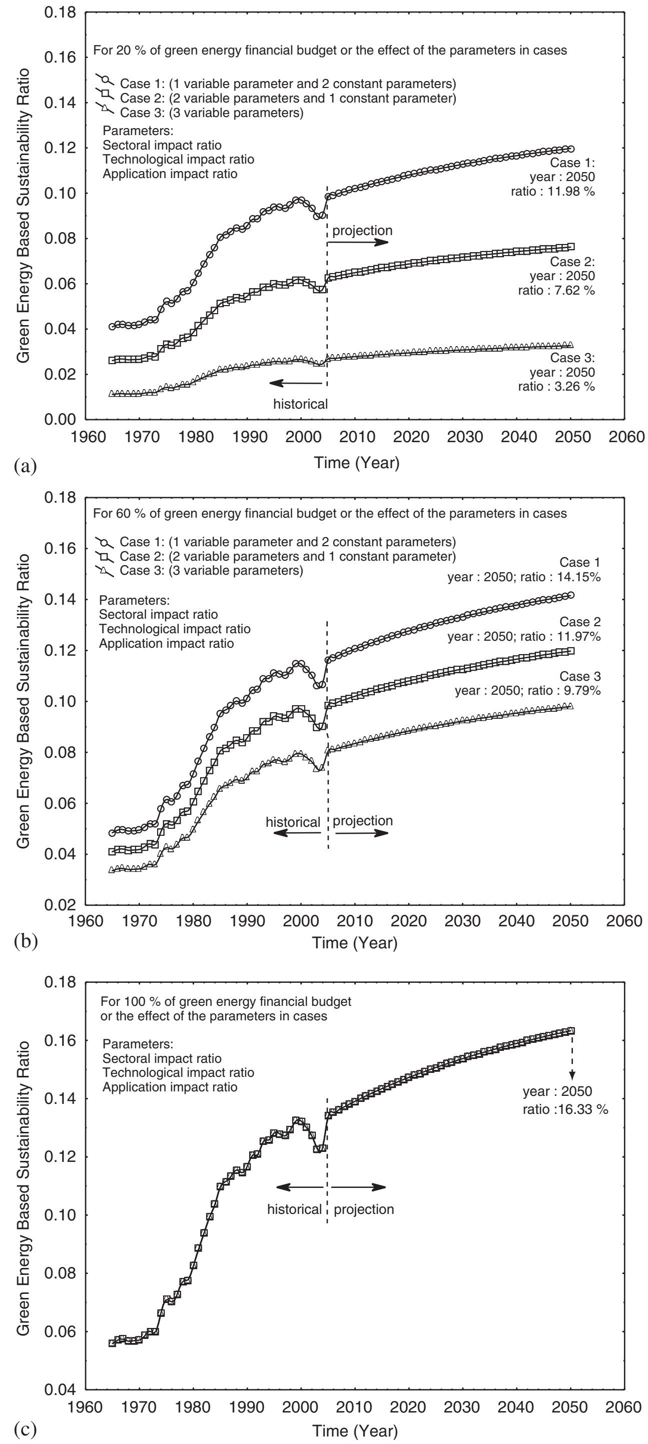

Fig. 6. (a) Variation of green energy-based sustainability ratio as a function of year, depending on 20% of green energy financial budget (or the effect of the parameters) in the cases considered. (b) Variation of green energy-based sustainability ratio as a function of year by depending on 60% of green energy financial budget (or the effect of the parameters) in the cases considered. 6c. Variation of green energy-based sustainability ratio as a function of year by depending on 100% of green energy financial budget (or the effect of the parameters) in the cases considered.

at the same trend as in Fig. 5a. In the near future, green energy will likely become increasingly important to compensate for shortages of conventional energy resources.

Table 1
Green energy impact ratios based on cases 1–3, depending on the percentages of total green energy financial budget

Effect of variable parameters (ε)			20%	40%	60%	80%	100%
Cases		Percent of total financial budget for green energy	Green energy impact ratio				
Case 1	2 constant parameters 1 variable parameter	2/3 $1 \times (1/3) \times \varepsilon$	0.733	0.80	0.867	0.933	1.00
Case 2	1 constant parameter 2 variable parameters	1/3 $2 \times (1/3) \times \varepsilon$	0.467	0.60	0.733	0.867	1.00
Case 3	3 variable parameters	$3 \times (1/3) \times \varepsilon$	0.20	0.40	0.60	0.80	1.00

Fig. 5b presents the variation of the fossil fuel and green energy utilization ratios as a function of time (i.e., year) depending on the historical data taken from Workbook (2005) and the projected data. However, Fig. 5c shows the variations of the fossil fuel utilization ratio as a function of green energy utilization ratio. As shown in these figures, the fossil fuel utilization ratio decreases depending on the rise of the year while the green energy utilization ratio increases. For example, the green energy utilization ratio was 5.59% while the fossil fuel utilization ratio was 94.41% in 1965 based upon the actual data. However, it is observed that the green energy utilization ratio increased and reached 12.31% while the fossil fuel utilization ratio decreased to 87.69% in 2004. Based on the projected data, it is expected that the green energy utilization ratio will reach almost 16.33% and the fossil fuel utilization ratio will decrease to almost 83.67% in 2050. Thus, in order to increase the green energy utilization ratio and to reduce the harmful effects resulting from the fossil fuel consumption, the green energy strategies should be put into practice for sustainable development.

First, it should be stated that one or two of the parameters that are sectoral, technological and practical application impact ratios can be selected as constant parameter(s). As shown in Table 1, a variable and two constant parameters are considered in case 1, two variables and one constant parameter are considered in case 2, and three variable parameters are considered in case 3. When case 1 is applied for green energy supply and progress, it is found that the green energy impact ratio changes between 0.733 and 1.00 depending on the percentages of the variable parameter. In case of the application of case 2, it is obtained that the green energy impact ratio varies between 0.467 and 1.00 depending on the percentages of two variable parameters. In case of the application of case 3, it is calculated that the green energy impact ratio changes from 0.20 to 1.00 depending on the percentages of three variable parameters. When we compare three cases with each other, it can be said that the highest values of green energy impact ratio are found by applying case 1, and also case 3 gives the lowest green energy impact ratios. Thus, case 1 should be selected to increase the green energy impact ratio and green energy-based sustainability ratio.

Figs. 6a–c show variation of green energy-based sustainability ratio (R_{ges}) as a function of year by depending on the percentages of green energy financial budget as 20%, 60% and 100% or the effect of the parameters in cases, respectively. The values of green energy-based sustainability ratios were calculated using Eq. (11). As shown in these figures, the values of R_{ges} increase with time based on the cases. The highest values of R_{ges} are obtained when case 1 is applied as shown in Figs. 6a–c. For example, the green energy-based sustainability ratios are estimated to be 9.8% in 2005 and 11.9% in 2050 in case of 20% of green energy financial budget; 11.6% in 2005 and 14.2% in 2050 in case of 60% of green energy financial budget; 13.4% in 2005 and 16.3% in 2050 in case of 100% of green energy financial budget.

It is important to implement green energy strategies through green energy systems and applications for sustainable future. If so, the green energy-based sustainability ratio increases, and green energy is more easily supplied, and thus, its technologies are more preferred and applied. Hence, as long as sustainable green energy strategies are increasingly applied, and the green technologies are more utilized and encouraged, the negative effects stemming from the fossil fuel utilization will decrease, and thus, the green energy-based sustainability ratio will increase. Considering the above explanations, some key expectations from the implementation of the green energy strategies for sustainable future are presented in Fig. 7.

4. Conclusions

In this study, the green energy strategies for sustainable development are investigated and hence some key parameters are developed. The effects of technological, sectoral and practical application impact ratios on green energy impact ratio and the green energy-based

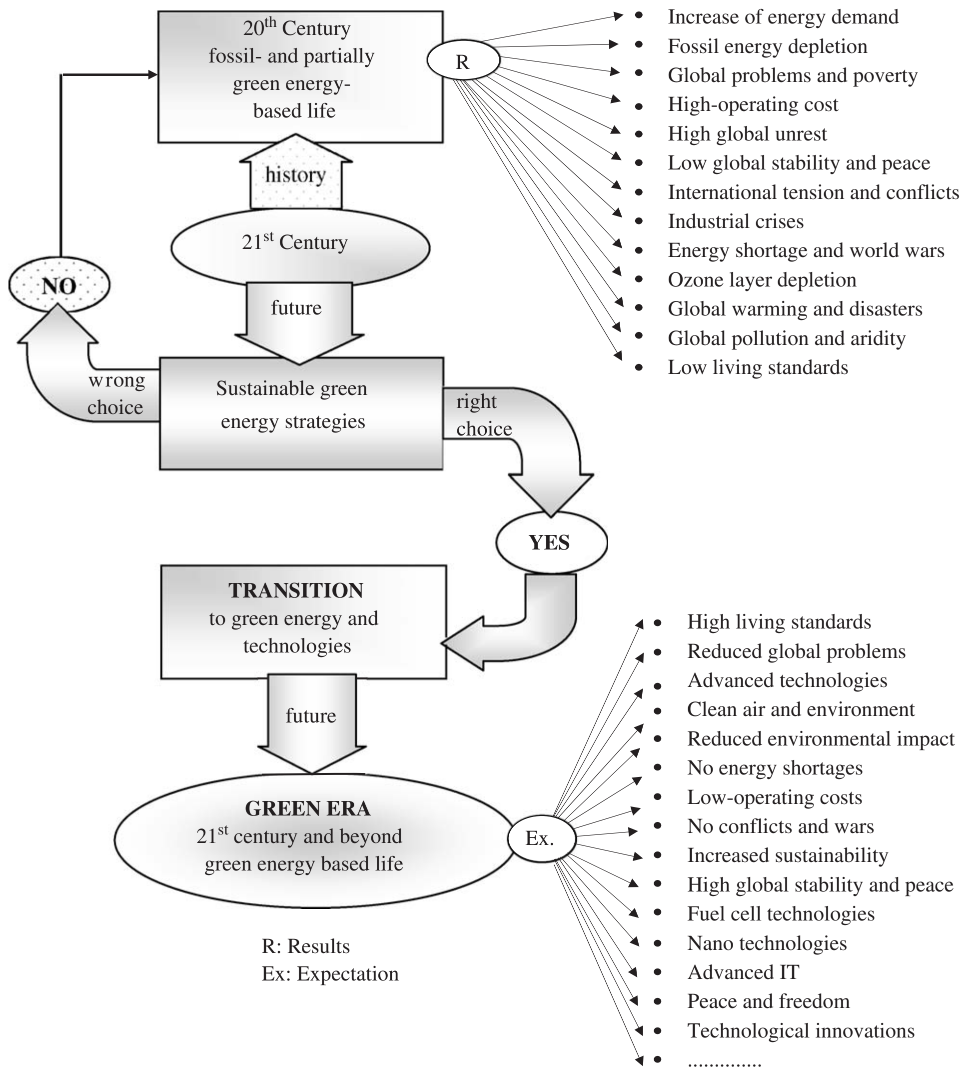

Fig. 7. Chart of green energy strategies and technologies for sustainable development.

sustainability ratio are studied thoroughly. We can then extract some important remarks as follows:

- The fossil fuel consumption and the green energy consumption are expected to reach 13807.2 and 2694.9 Mtoe, respectively, by the year 2050. This increase indicates that we will still be dependent on the fossil fuels.
- The green energy utilization ratio is estimated to be 12.31% while the fossil fuel utilization ratio is 87.69% in 2004. Based on the projected data, it expected that the green energy utilization ratio will reach almost 16.33% and the fossil fuel utilization ratio will decrease to almost 83.67% in 2050.
- If the increase of fossil fuel consumption continues in this manner, it is likely that the world will be affected by many negative problems due to the fossil fuels. More utilization of fossil fuels will harm world stability and increase local and global environmental problems, resulting in increasing global unrest. It is thus suggested that the utilization of fossil fuels should be reduced, and fossil-based technologies should be gradually converted to green energy-based technologies.
- The highest green energy impact ratio is found between 73.334% and 100% in case 1. Therefore, in order to obtain the highest green energy impact ratio in practice, the highest percentage (e.g. 100%) of the variable parameter in case 1 should be selected.
- Case 1 gives better results than cases 2 and 3. Therefore, for a higher green energy impact ratio in practice, case 1 should be applied to increase the green energy sustainability ratio depending on the green energy strategies. Moreover, case 1 gives the best results of the green energy-based sustainability ratio depending on the green energy impact ratio and green energy utilization ratio.
- Sustainable green energy strategies are definitely required to ensure the global stability by reducing

the harmful effects of the fossil-based energy consumption. So, it is suggested that the importance of green energy and technologies that probably reduce the world problems and achieve a sustainable energy system should be emphasized considering the sustainable energy strategies. Moreover, a transition to the green energy-based economy should be encouraged, and developed countries, in particular, should increase investments in green energy and technologies.

- Progress of green energy and technologies is based on the sustainable green energy strategies for future green energy scenarios. The foremost factor that will determine the specific role of green energy and technologies will likely be energy demand. In order to balance the energy demand now and in the future, it is suggested that sustainable green energy sources and technologies should be definitely taken into consideration to increase the sustainable development in a country.
- In order to develop and implement the green energy technologies and applications in a developed or less developed country, green energy strategies appear to be essential for sustainable development. It is clear that they are becoming more and more important for human beings due to global environmental problems, green energy security and supply issues, and technological innovations.
- Considering the sustainable green energy strategies, it can be concluded that the most important scenario to encourage transition to green energy and technologies, and promote green energy-based technologies is to supply the required incentives and interactions among the countries, scientists, researchers, societies and others.

In summary, green energy strategies can make an important contribution to the economies of countries where green energy is abundantly produced. Therefore, the investments in green energy supply should be, for the future of world nations, encouraged by governments and other authoritative bodies who, for strategic reasons, wish to have a green alternative to fossil fuels.

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