Chapter

Introductory Chapter: Green Energy Systems

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1. Introduction

As one of the very crucial elements of life, energy has given huge impacts in forming the domestic and international policies of the country, raising the environmental issues, changing the social dimensions, accelerating the economic growth, etc. The study related to energy has focused mainly on finding and establishing the new and efficient ways to produce (convert), store, transport, and utilize the energy. The conventional energy system, coupled with the huge demand of energy due to industrial activities, has resulted in various social, psychological, and environmental problems. Concretely, conventional combustion of fossil energy sources has accelerated the emission of greenhouse gases (GHGs), leading to high concern on climatic issues. In order to tackle down the above problems, several research have been developed, especially related to the way to achieve greener energy systems. Dincer and Zamfirescu [1] have proposed the concept of greenization, which refers to the efforts to greenize the energy systems, including the processes and applications with high sustainability.

Some academic efforts to clearly analyze the problems also include several theoretical approaches to correlate the theories to their real implications. The intensive correlation of thermodynamics toward sustainable energy systems and environment has been studied by Hammond [2]. In addition, Bejan [3] also used the theory of entropy generation minimization in order to analyze the energy policy. Discussing the energy policy, there is a strong relationship between the exergy destruction and environmental impact. Lower exergy destruction leads to higher energy efficiency of the system; hence, the systems consumes less energy input followed by lower environmental impact, leading to the sustainability of the system.

2. Challenges in energy systems

Figure 1 shows four essential pillars related to energy issues, covering security and resilience, economy, social, and environment. In energy security, recently, the issue is not only limited to the security of supply but also includes the capability of the system to respond and recover back when any disturbance in the energy system occurs. Therefore, the security and resilience correlate strongly to both quantitative and qualitative aspects of energy. Furthermore, the economic issues cover several major points including equity, participation, economic performance, and open opportunity to the whole players. All of the entities in the system can behave as energy producers and consumers simultaneously, leading to the concept of "prosumer." The equal opportunity provided to the all players involved in the system potentially accelerate and maximize the introduction of renewable energy, as well as improve the total economic performance. The environmental issues deal

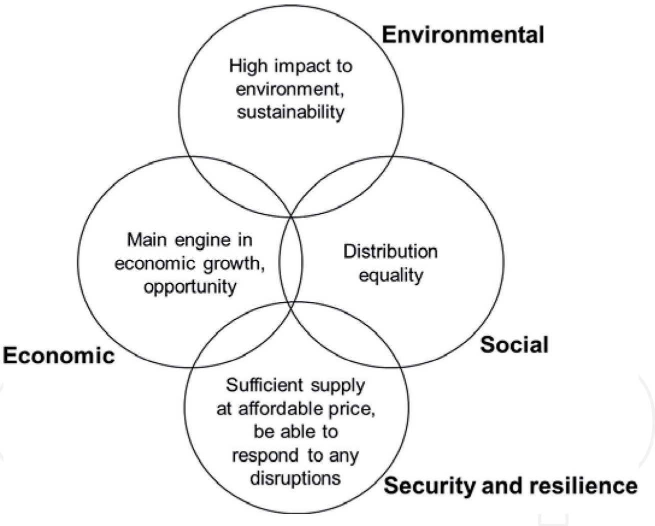

Figure 1.
Essential pillars in energy system.

strongly with some challenges to realize the green and clean energy system which give a minimum influence to the environment, as well as keep both the system and environment to be sustainable. At the last, the social issues are related strongly to the problems in equal and appropriate distribution of the energy to the consumers. Energy is very essential element in human activities; therefore, the correlation and balance of those four pillars in energy system are very important.

The transition of the energy systems from currently high- to low-carbon emitting systems has led to several socioeconomic-environmental opportunities. However, there are still many unresolved issues related to the correlation among the energy, economic growth, and social welfare. The prediction and projection of energy systems in the future, especially related to the balance of both fluctuating demand and supply, face many uncertainties, due to several parameters including social, economic, weather, climate, and technological developments.

Long-term accurate and flexible (responsive) strategies on energy will gave a strong confidence to all of the energy entities involved in the system/region. The dynamic and fast changes in energy systems have occurred time by time following the technological and social changes in the community.

3. Exergy

Energy has two different measures, which are quantity and quality. The energy quantity is the amount of energy which is supplied or consumed, while the energy quality deals with the availability/usability of energy resource to be consumed. The latter has revealed the concept of exergy. It is very strongly correlated to both the first and second laws of thermodynamics. The exergy is possibly destructed, which is different with the concept of energy as it is conserved. It strongly relates to the concept of entropy generation; however, exergy can be useful in determining the system components which are responsible for the system irreversibility [4].

The concept of exergy is very useful for economic, ecological, and sustainability measures, as its capability to describe the quality of the energy resource. The exergy analysis also includes and considers the impact of energy stream to the environment, which further influences significantly both energy and environmental policies. The exergy is a very potential indicator for the policy makers and industrial practitioners in justifying the energy system and resources [5].

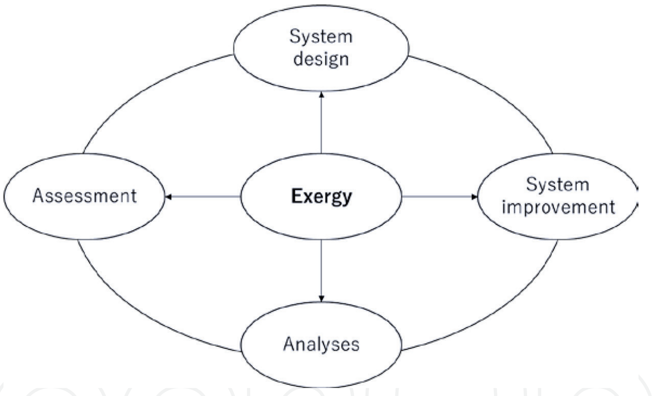

Figure 2.
The exergy concept for practical applications.

Figure 2 shows the possible utilization of exergy in practical applications. First of all, the exergy is very important to model and optimize the developed design of the processes or systems, before they are being developed and constructed. Furthermore, exergy is also convenient tool to analyze the performance of the developed system, as well as measure and predict the possible improvement points which can be performed.

The exergy of the system, Ex, is basically represented as follows:

$$Ex = S(T - T_0) - V(p - p_0) + \sum_i n_i(\mu_i - \mu_{io}) \quad (1)$$

where S, T, V, and p are entropy, temperature, volume, and pressure, respectively. In addition, n_i and μ_i are number of moles of substance i and chemical potential of substance i. From Eq. (1), it can be understood that the exergy could be zero when the system reaches the equilibrium with the surrounding environment. Practically, the exergy depends on several condition parameters, including temperature, pressure, chemical potential, electricity, magnetism, gravity, and radiation [6].

By adopting the exergy, both the quantity and quality of energy are coherently considered, resulting in the holistic approach of the energy itself. This is compatible for all cases of energy systems and all types of energy resources. Therefore, the economic and social prices of the energy systems and resources can be more clearly defined, as well as their impacts to the environment.

4. Conclusion

Development of sustainable energy system requires comprehensive knowledge, deep scenario analysis, and referable case studies. The discussion of energy requires a deep analysis of both quantitative and qualitative aspects. In addition, energy sustainability strongly imposes sustainability in other sectors, including economic, social, and environmental. The concept of exergy potentially leads to the opportunity for energy efficiency in the targeted system. The coherent understanding and application of both energy and exergy is urgently demanded. The inclusion of exergetic consideration in energy policy and practical application is strongly expected to be able to realize the sustainable and efficient energy system in the future.

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