Renewable and Sustainable Energy Reviews 66 (2016) 617–630

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Application of Artificial Intelligence Methods for Hybrid Energy System Optimization

S.M. Zahraee [a], M. Khalaji Assadi [a,*], R. Saidur [b]

[a] Department of Mechanical Engineering, Universiti Teknologi PETRONAS (UTP), Bandar Seri, Iskandar, 31750 Tronoh, Perak, Malaysia
[b] Centre of Research Excellence in Renewable Energy (CoRE-RE), King Fahd University of Petroleum and Minerals (KFUPM), Dhahran 31261, Kingdom of Saudi Arabia

ARTICLE INFO

Article history:
Received 11 September 2015
Received in revised form
9 March 2016
Accepted 13 August 2016

Keywords:
Artificial Intelligence
Hybrid Energy System
Optimization

ABSTRACT

Consciousness of the need to decrease our unnatural weather changes and of the critical increase in the costs of traditional sources of energy have motivated many nations to provide innovative energy strategies that promulgate renewable energy systems. For example, solar, wind and hydro related energies are renewable energy sources, and they are environmentally friendly with the potential for broad use. All of the load requirement conditions in comparison with single usage can provide more economical and dependable electricity, as well as environmentally friendly sources, by compounding such renewable energy sources using backup units to shape a hybrid scheme. Sizing the hybrid system elements optimally is one of the most important matters in this type of hybrid system, which could sufficiently meet all of the load demands with a minor financial investment. Although a number of studies have been performed on the optimization and sizing of hybrid renewable energy systems, this study presents a full analysis of Artificial Intelligence optimum plans in the literature, making the contribution of penetrating extensively the renewable energy aspects for improving the functioning of the systems economically.

Contents

* Corresponding author.
E-mail addresses: morteza.assadi@petronas.com.my, mkhassadi@yahoo.com (M. Khalaji Assadi).

http://dx.doi.org/10.1016/j.rser.2016.08.028
1364-0321/

1. Introduction

One of the prominent challenges that the world faces today is providing its needed energy while saving for the future simultaneously [1]. In recent times, a considerable amount of energy has been required around the world. The world depends solely on conventional energy sources, for example, coal, natural gas and crude oil [2,3]. In addition, the demand for energy use is growing every day, which, however, results in a brisk demand for the usual fossil fuels [4,5]. Whereas these sources of energy are limited and unload quickly, that in turn pressures the stability of potential generations of energy demand [6–8]. In addition, the unpredictable supply of the aforementioned sources and the negative influence on the administrative balances between energy (petroleum) exporting/importing nations warrants vital investigations on the prospects of popular means for producing energy [9]. In recent years, global warming and climate change are two main important issues in the global economy and environment, and they have a considerable effect on the insufficient accessibility and rising cost of energy [10]. The high consumption of energy in the world has already increased concerns about supply difficulties and significant environmental influences, such as global warming and climate change [11–13]. The evidence from [7,14–17] concludes that energy created by traditional energy sources causes an increase in greenhouse gas discharge, which could affect global warming. Efforts to reduce the volume of greenhouse gas emission have led to the Kyoto agreement on the global decline of greenhouse gas production. This agreement was put in place to lessen the issue and the dependence on traditional energy systems. The notion of greenhouse gas reduction is valid for both developing and developed nations [18,19]. Addressing the issues discussed above, continual potential action for sustainable improvement is required. In addition, cost-effective, consistent, and environmentally friendly energy systems are the attributes of a sustainable energy system that efficiently uses local assets and networks [20]. Therefore, renewable energy sources are positioned as one of the proficient and useful solutions [7,15]. There are different types of renewable energy structures, such as wind, solar, hydro-electric, water, ocean, biomass and geothermal energy, which have unique benefits and are suitable for applications. Currently, some countries have the potential for different types of energy resources, such as solar, wind, water, and geothermal, and in addition, many companies are developing, constructing and setting up modern and high-tech renewable energy systems. These countries attempt to lead a large network of investigators and other partners to utilize cutting-edge and advanced technologies that will provide a cost for renewable electricity generation that is competitive with traditional sources of energy. Increasing the proportions of renewable energy systems such as wind and solar have joined the grid and will impact the fossil fuel generators on the grid, which will lead to a decrease in emissions and costs for the consumers. These advantages include, for example, a reduction in the external energy confidence and a decrease in communication and conversion costs. Additionally, renewable energy sources supply an important improvement over the usual energy systems, and almost none discharge gaseous or water pollutants during their operations [20,21]. As mentioned before in this study, renewable energy systems are measured as capable power producing sources. On the other hand, a disadvantage of the specified energy selection is their irregular character and our confidence in the weather conditions. Therefore, renewable power production cannot completely control the power requirement of the load at any specific instant in time [14,22–24]. This type of difficulty is connected to the changeable character of these resources, which can be solved by assimilating resources in an appropriate hybrid blend. This approach causes an improvement in the system's effectiveness and reliability of the energy supply [7,14,25]. As a result, renewable energy access can be improved in upcoming sustainable areas [13]. Renewable energy systems present some helpful effects in several types of applications modes, which have been identified to be, for example, the costs of the systems when preventing wide-ranging consumption, assessment efforts that are focused on fast cost falls, and the ability of these systems in development [4]. Method designs should be most favorable in operations and component selection, to achieve electrical energy from renewable energy resources, which is related to hybrid system reliability and cost efficiency [26–28]. Therefore, the most advantageous sizing method is to proficiently and inexpensively use renewable energy resources [9]. Principally, the most favorable size systems are required for comprehensive analysis to give the location and control site-dependent factors, such as solar rays, wind rates, and temperatures, and their costs [14,29]. Computer-based simulation and optimization has become a preeminent technique for designing power systems; this approach involves comprehensive analysis [30]. There are some constraints in the formulation and solution of the design and optimization approach, such as the resource availability, technology, efficiency, mathematical models and other aspects. However, the advancement in computational techniques has made it easy to address optimization problems by using a number of optimization and simulation techniques. A number of simulation tools, such as HOMER (Hybrid Optimization Model of Electric Renewable), HYBRID2 (The Hybrid Power System Simulation Model), and HOGA (Hybrid Optimization using Genetic Algorithm), are used for the design and optimization of hybrid systems as well as for improving their performance. One of the main branches of computer science is Artificial Intelligence (AI), which investigates and builds intelligent software and machines. Russell and Norvig [31] explain that AI is “the investigate and framework of intelligent factors”, in which an intelligent factor performs actions that maximize the possibility of success. AI is composed of branches such as genetic algorithms (GA), particle swarm optimization (PSO), simulated annealing (SA), artificial neural networks (ANN) and hybrid models, including two or more previous branches. The effective and correct application of intelligent methods cause the development of comprehensive and useful systems with better performance or different characteristics, which cannot be obtained compared to using traditional approaches [32]. This paper aims at reviewing the literature that is related to the various optimization techniques of Artificial Intelligence Methods for Hybrid Energy Systems Optimization, such as genetic algorithms (GAs), simulated annealing (SA), and particle swarm optimization (PSO). In addition, the characteristics of all of the methods are compared together, to help researchers to use them effectively and in a cost-effective manner.

2. World energy scenario

According to the Energy Information Administration, the global energy consumption is increasing by approximately 2.3% per annum [33]. The wind generates approximately 20% of the electricity in Denmark. However, on a global scale, the electricity that is produced from the wind is less than 1%. The statistics of world energy consumption from the year 2008–2035 is expected to grow by approximately 53% [33]. Fig. 1 exhibits the high development of the universal energy requirement.

Fig. 2 shows the United State's electricity generation from fuel during the years 1990–2040. Additionally, it shows that the renewable share would be increased by a few percent; however, some sources, such as fossil fuels comprising coal and natural gas, are still increasing.

The world's economic development is surprisingly dependent