

Thermo-economic feasibility of a hybrid wind turbine/PV/gas generator energy system for application in a residential complex in Tehran, Iran

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Abstract

The randomness of generated power by renewable energy resources has led experts in this field to provide sustained and permanent load supply with hybrid renewable energy systems (HRESs). This study investigates the modeling of an off-grid HRES based on the wind turbine/photovoltaic/gas generator for supplying the consumption of a residential complex in Tehran (capital of Iran). To this end, the HOMER software has been implemented. After calculations, the capital cost and cost of energy of each component are estimated in different HRES models. In addition, parameters such as power generation, emissions, and thermo-economic analysis of different models of the hybrid system have been investigated. Two models of optimum HRES (based on the lowest net present cost [NPC]), with and without wind turbines, were compared. According to the results, the fuel consumption and emissions caused by the operation of the gas generator will decrease by 53% as a result of using a wind turbine despite an 8% increase in NPC. This is an important achievement regarding high air pollution in Tehran. Based on the results, using a gas generator instead of a diesel generator leads to an 18% decrease in NPC. Additionally, in comparison to using a gas generator only, using the hybrid system leads to a 43% reduction in NPC.

KEYWORDS

gas generator, HOMER software, hybrid renewable energy system, photovoltaic, thermo-economics, wind turbine

1 | INTRODUCTION

The growing demand for energy throughout the world, the depleting fossil fuel resources and the increasing environmental pollution caused by greenhouse gas emissions have instigated a global passion for using renewable energy systems (RESs).^{1,2} The main problem with the use of these types of energy resources is their fluctuating and uncontrolled energy production rate.³⁻⁵ In this regard, the volatility of power production would be inevitable.^{6,7} This greatly reduces the reliability of off-grid power generation systems.⁷ The emergence of new technologies has allowed using a hybrid energy system along with a generator to

provide the required load at the lowest possible cost. In newer methods, power generators (e.g., diesel, gas, or microturbine generator) are used in combination with RESs. Hybrid technology combines multiple energy resources such as renewable energy, generators, and energy storage systems to increase the reliability of energy production and stabilize the output power.^{4,8,9} Generally, to select an optimal hybrid model, the system assessment should be based on two important factors, namely reliability, and cost-effectiveness. To have an economical and efficient operation, it is vital to select the optimal capacity of system components, ensuring that the maximum efficiency of hybrid systems can be achieved with minimal net present cost (NPC).