World Academy of Science, Engineering and Technology
International Journal of Energy and Environmental Engineering
Vol:9, No:07, 2015

Achieving Net Zero Energy Building in a Hot Climate Using Integrated Photovoltaic and Parabolic Trough Collectors

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Abstract : In most existing buildings in hot climate, cooling loads lead to high primary energy consumption and consequently high CO2 emissions. These can be substantially decreased with integrated renewable energy systems. Kuwait is characterized by its dry hot long summer and short warm winter. Kuwait receives annual total radiation more than 5280 MJ/m2 with approximately 3347 h of sunshine. Solar energy systems consist of PV modules and parabolic trough collectors are considered to satisfy electricity consumption, domestic water heating, and cooling loads of an existing building. This paper presents the results of an extensive program of energy conservation and energy generation using integrated photovoltaic (PV) modules and parabolic trough collectors (PTC). The program conducted on an existing institutional building intending to convert it into a Net-Zero Energy Building (NZEB) or near net Zero Energy Building (nNZEB). The program consists of two phases; the first phase is concerned with energy auditing and energy conservation measures at minimum cost and the second phase considers the installation of photovoltaic modules and parabolic trough collectors. The 2-storey building under consideration is the Applied Sciences Department at the College of Technological Studies, Kuwait. Single effect lithium bromide water absorption chillers are implemented to provide air conditioning load to the building. A numerical model is developed to evaluate the performance of parabolic trough collectors in Kuwait climate. Transient simulation program (TRNSYS) is adapted to simulate the performance of different solar system components. In addition, a numerical model is developed to assess the environmental impacts of building integrated renewable energy systems. Results indicate that efficient energy conservation can play an important role in converting the existing buildings into NZEBs as it saves a significant portion of annual energy consumption of the building. The first phase results in an energy conservation of about 28% of the building consumption. In the second phase, the integrated PV completely covers the lighting and equipment loads of the building. On the other hand, parabolic trough collectors of optimum area of 765 m2 can satisfy a significant portion of the cooling load, i.e about73% of the total building cooling load. The annual avoided CO2 emission is evaluated at the optimum conditions to assess the environmental impacts of renewable energy systems. The total annual avoided CO2 emission is about 680 metric ton/year which confirms the environmental impacts of these systems in Kuwait.

Keywords : building integrated renewable systems, Net-Zero energy building, solar fraction, avoided CO2 emission
Conference Title : ICRET 2015 : International Conference on Renewable Energy Technology
Conference Location : Zurich, Switzerland
Conference Dates : July 29-30, 2015