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ScienceDirect

Energy Procedia 74 (2015) 981 – 990

Energy Procedia

International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES15

Estimation of hydrogen production using wind energy in Algeria

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Abstract

In response to problems involved in the current crisis of petrol in Algeria, with the decrease in the price of the oil barrel, the rate of growth in domestic electricity demand and with an associated acceleration of global warming, as a result of significantly increased greenhouse gas (GHG) emissions, renewable energy seems today as a clean and strategic substitution for the next decades. However, the greatest obstacles which face electric energy comes from renewable energy systems are often referred to the intermittency of these sources as well as storage and transport problems, the need for their conversion into a versatile energy carrier in its use, storable, transportable and environmentally acceptable are required. Among all the candidates answering these criteria, hydrogen presents the best answer. In the present work, particular attention is paid to the production of hydrogen from wind energy. The new wind map of Algeria shows that the highest potential wind power was found in Adrar, Hassi-R'Mel and Tindouf regions. The data obtained from these locations have been analyzed using Weibull probability distribution function. The wind energy produced in these locations is exploited for hydrogen production through water electrolysis. The objective of this paper is to realize a technological platform allowing the evaluation of emergent technologies of hydrogen production from wind energy using four wind energy conversion systems of 600, 1250, 1500 and 2000 kW rated capacity. The feasibility study shows that using wind energy in the selected sites is a promising solution. It is shown that the turbine " De Wind D7" is sufficient to supply the electricity and hydrogen with a least cost and a height capacity factor. The minimum cost of hydrogen production of 1.214 $/kgH2 is obtained in Adrar.

Peer-review under responsibility of the Euro-Mediterranean Institute for Sustainable Development (EUMISD)

Keywords: Wind energy, Weibull parameters, Capacity factor, Alkaline electrolysis, Hydrogen production, Algeria;

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Peer-review under responsibility of the Euro-Mediterranean Institute for Sustainable Development (EUMISD)
doi:10.1016/j.egypro.2015.07.829

1. Introduction

Globally, the share of renewable energies in power generation is 13.2% of the power generated in the world in 2010. The majority still comes from fossil fuels such as oil (32.4%), coal (27.3%), natural gas (21.4%) and nuclear energy (5.7%) [1]. In Algeria, Oil occupies an important place in the country's economic development. The increase in oil revenues following the increase in volumes produced jointly and energy prices has allowed an average growth in GDP of 4% per year between 2001 and 2007. With assumptions of economic growth rate of 3% and a growth rate of 1.6% per year for the period 2007-2030, the rate of growth in energy demand would be between 2.8% and 4.3% per year, for the projection period it will absorb 61.5 (Mtoe) of primary energy in 2020 and 91.54 Mtoe in 2030 against 52 Mtoe in 2020 to 66.45 Mtoe in 2030, in the low scenario [2].

Within the framework of the national program of renewable energy development and energy efficiency in Algeria, an electricity company Sonelgaz carried out many projects of electricity production based on wind and solar energy to power the isolated villages and remote houses of south Algeria. These projects include the project of a wind power plant of 10 MW in Adrar, the project of solar gas hybrid power plant of 150 MW in Hassi R'mel. At present, Sonelgaz is leading the way towards the development and utilization of renewable sources of energy in the country in general and it is expected that about 22 000 MW of power generating capacity of electricity will be from renewable energy sources in 2030, of which 12 000 MW will be intended to meet the domestic electricity demand and 10 000 MW destined for export [3].

In the recent years, wind power becomes an important source of environmental-friendly energy and one of the most promising energy sources. There are several advantages to use wind energy such as the wind is a free, clean and inexhaustible energy source. Wind energy can provide suitable solutions to the global climate change and energy crisis. The utilization of wind power essentially eliminates emissions of CO_2, SO_2, NO_x and other harmful wastes as in traditional coal-fuel power plants or radioactive wastes in nuclear power plants. Wind energy dramatically reduces the dependence on fossil fuels which strengthen global energy security. According to World Wind Energy Association [4], the world wind power capacity reached 196,630 MW in 2011. The top two countries on the chart are China (44,733 MW in 2011) and the U.S (40,180 MW in 2010) [5].

There are particularity reasons to use wind energy in Algeria for electrifying remote sites which cannot be connected to the power network (mountain, deserts and isolated villages). Moreover, the use of windmills for pumping water from underground [6] in order to satisfy water needs of isolated villages. In addition, it helps to develop national industries. However, the greatest obstacles which face electric energy comes from wind energy systems are often referred to the intermittency of wind, storage and transport problems; the need for their conversion into a versatile energy carrier in its use, storable, transportable and environmentally acceptable is required. Of all the candidates answering these criteria, hydrogen presents the best answer; it is the most abundant element in the universe; it is not pollutant [7]. Hydrogen produced from renewable energy sources offers the promise of a clean and sustainable energy carrier. Hydrogen's potential production from renewable energy resources such as solar [8-10], geothermal energy [11-14], Hydrogen production from oil palms biomass as a potential source [15].

Currently hydrogen production by water electrolysis process using wind energy is regarded to have the lowest life cycle GHG emissions of all hydrogen pathways, wind energy has a low cost of electricity ($/kWh) after hydraulic power among all renewable options [16], as an example energy generation costs for solar PV systems are typically 6–18 times higher than for equivalent wind turbine systems [17].Various studies have been reported in the literature on wind energy based on hydrogen production in different countries [18-20]. In contrast, few studies are found about hydrogen production in Algeria [21].

In this work, the data were collected from different sites of Algeria are used to determine the wind hydrogen production. The various resources necessary for a viable exploitation of wind hydrogen are examined. Water electrolysis system is considered. Estimations of the production cost are carried out for different sites and different wind turbine systems. The results are discussed taking into consideration the sustainable development of the region. An approximate costs analysis, which included a total investment estimate, was performed. The cost of electricity production was also calculated for comparison purposes. Finally, the results are discussed.