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## An overview of renewable energy potential in Palestine

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## ABSTRACT

The energy sector situation in Palestine is highly different compared to other countries in the Middle East due to many reasons: non-availability of natural resources, unstable political conditions, financial crisis and high density population. Furthermore, Palestine depends on other countries for 100% of its fossil fuel imports and for 87% of its electricity imports. In addition high growth of population, increasing living standards and rapid growth of industrial have led to tremendous energy demand in Palestine in recent years. The total energy consumption per habitant in Palestine is the lowest in the region (0.79 MW h/inhabitant) and costs more than anywhere else in the Middle East countries. The primary goal of this paper is to analyze the current energy sector situation in Palestine and to highlight the status of the potential of renewable energy as an essential future energy source sector in Palestine. Regarding the main possibilities of RE, the wind speed averages (m/s) for main 5 cities were: Tubas 4.97, Salfeet 4.26, Ramallah 3.09, Hebron 2.90 and Jericho 1.32. With these data, Palestine can be considered as a country of moderate wind speeds. By the other hand, Palestine has a high solar energy potential about 3000 sunshine hours per year with a solar radiation (kW h/m<sup>2</sup>/day) for year 2013 of 8.27 in Ramallah, 7.51 in Hebron, 6.86 in Salfeet and 6.15 in Tubas. These values are encouraging to exploit the solar energy for different applications. This study highlights that the main renewable energy sources in Palestine are solar energy, wind energy and biomass, thereby the energy dependence on neighbouring countries may significantly decrease, when Palestine uses the available renewable energy sources. The renewable energies in Palestine open new perspectives for energy sector in order to prompt practices for sustainable development.

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## 1. Introduction

Energy is a continuous driving force for economic development, sustainable development, social improvements, and improved quality of life [1]. So, energy plays a significant role in economic and social development, and constitutes a major threat to the environment and sustainable development. Rapid technological developments, improvement in standards of living, and increased population density have increased the interests to use the RE resources [2]. The importance of energy for the processes of production and manufacturing is also a key element of sustainable development for this the increasing attention is going to the sources of energy that are renewable in the sense that they can be used without exhausting the source of the energy [3]. In addition, climate change issues and fossil fuel depletion are the main drivers for the recent focus on finding alternative energy resources [4]. It is well known that burning of fossil fuels (Coal, oil, and natural gas) generates pollutant harmful gases (SO<sub>2</sub>, CO, NO<sub>x</sub>, HC, and CO<sub>2</sub>) that causes environmental pollution problems [5]. The reserves of fossil fuels are limited and their large scale use is associated with environmental deterioration [6]. The use of Renewable Energies (RE's) instead of fossil fuels provides many important advantages to the developing countries, including an increase of energy services in remote, rural areas, and is associated with general improvement of economic sector, social sector and environmental issues [7]. The reliance on RE resources around the world is linked with effective approaches to sustainable development: they have a high potential to be cost efficient, not damaging the environment and designed to be suitable for local conditions [8,9]. RE technologies as clean energies continue to grow in the fields of residential, commercial, agriculture and industrial applications [10,11]. RE can help countries to meet their policy goals to secure, reliable and affordable energy, promote development and reduce energy price volatility [12]. The energy sector situation in Palestine is highly different compared to other countries in the Middle East. Palestine is divided into two geographic areas: West Bank (Including East Jerusalem) and Gaza Strip. Nowadays (2014), according to Palestinian Central Bureau of Statistics (PCBS) the population of Palestine is 4,550,368 inhabitants for an area of 6020 km<sup>2</sup>, being the population density 756 people/km<sup>2</sup>, distributed as follows: West Bank 494 people/km<sup>2</sup>, and Gaza Strip 4822 people/km<sup>2</sup>, one of the highest population density in the world. The complex geographical and administrative situation of Palestine can be seen in its administrative divisions made by the Oslo II Accord in 1995, that divided West Bank into three administrative divisions: the Areas A, B and C (See Fig. 1. So, the Areas are not contiguous. Area A indicates that full civil and security control belongs to the Palestine. Area B indicates that Palestine has civil control but security control is joint Israel and Palestine. Area C indicates that full civilian and security control is made by Israel. Approximately 60% of the land regions in the West Bank are classified as Area C. So, Israel control of these divisions therein severely hinders and affects the potential development of a traditional energy sector's infrastructure and regulations and policies, also hinders development initiatives [13]. As shown Fig. 1, there is a complex geographical distribution of these areas, e.g. there are 253 different enclosures for area B.

Palestine is facing a critical situation concerning the achievement of sustainable development. Several problems have

contributed to the continuous deterioration of the political, economic, social, and environmental conditions and hindered development initiatives. One of the main characteristics of the Palestinian situation is the political instability with direct and indirect consequences for the energy sector and the local economy. In addition, the high electric dependency on Israel can be considered as a major obstacle for economic development in the West Bank. There is no physical continuity between Gaza Strip and West Bank and East Jerusalem. Gaza's isolation presents technical and political challenges for transporting, storing and importing energy [13]. Almost all petroleum products are imported through Israeli companies. So, Israel controls energy imports into Palestine and thus prevents open trade in electricity and petroleum products between Palestine and other countries that hindered the development initiatives [14]. Abu Hamed et al. [13] found that the costs of energy are more expensive than anywhere else in the region. The national and comprehensive energy policy is still not clear, weak and fragmented institutional framework and the incomplete framework of Palestine. RE market is strongly affected by the political stability in the region, and the economic situation of the people rises the demand on energy and availability of indigenous resources. The environment of the political risk and uncertainty has inhibited investors from making large scale energy or industrial investments [13]. So, RE in Palestine can play a key role in the transition to a truly sustainable energy development sector in the long term [15]. Then, Availability, affordability and sustainability of energy supply are interlinked facets of overall energy security in Palestine [16]. The lack and need of stable conditions, reliable and sufficient energy system is one reason that Palestinian community development and economic development are curtailed even before accounting for expected population growth and economic potential [13]. The important conditions such as: economic, political, environmental, geographic, social and infrastructural make clear the necessity and advantages of RE over fossil fuels. Palestine features promising capacities in the potential use of solar, wind and biomass energies. Almost the whole country has high sunshine hours throughout the year; the total annual sunshine hours exceed 3000 h [17]. Global solar radiation is the sum of the beam or direct radiation and the diffuse solar radiation on a surface, where the former is radiation received from the sun without having been scattered by the atmosphere and the latter is radiation received from the sun after its direction has been changed by atmospheric scattering. For Palestine, the average solar resource ranges from 5.4 kW h/m<sup>2</sup>/day to 6 kW h/m<sup>2</sup>/day [18]. Photovoltaic and thermal systems (e.g. solar water heating) without concentrators use the entirety of global solar radiation, that is, both beam and diffuse radiation. However, solar concentrating systems can only use beam solar radiation [19]. This energy is very promising if it is compared to other places in the world like Spain-Madrid (4.88 kW h/m<sup>2</sup>/day) [20], USA-Denver CO (4.95 kW h/m<sup>2</sup>/day) [21], Australia -Sidney (4.64 kW h/m<sup>2</sup>/day) [22], Mexico-Gulf of Mexico (4.78 kW h/m<sup>2</sup>/day) [19]. Biomass represents an abundant carbon-neutral renewable resource for the production of bio-energy and biomaterials, and its enhanced use would address several societal needs [23]. Biomass supplies approximately 50 EJ globally, which represents approximately 10% of the global annual primary energy consumption [24]. This percentage is almost the same as the one used in Palestine, where

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