



Renewable energy sources for electricity generation in Mexico: A review



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ABSTRACT

Renewable energy projects have been launched throughout Mexico in order to deliver clean and affordable energy worldwide. The aims of this research are: (i) to know the current status of electricity generation through solar, wind, biomass, geothermal, and hydropower in Mexico, (ii) to determine the renewable energy potential in Mexico and its generation schemes, and (iii) to analyze the social and environmental challenges that these technologies are going to face in Mexico. This paper highlights for the first time a comprehensive review of the current status of renewable energy projects for electricity generation in Mexico and the potential impact of these technologies in the social and environmental areas. The results presented are based on a critical review of the energy policy and regulation, as well as statistical data on electricity generation in Mexico. It was found that in Mexico 62 GW h/year were generated by solar photovoltaic technology of which 49 GW h/year were produced by 6 private projects and 13 GW h/year by 2 generating plants of the Federal Electricity Commission (CFE). There is a proven potential to generate 16,351 GW h/year through solar energy. Although the proven potential for wind power generation in Mexico is 19,805 GW h/year, wind power is exploited by onshore technology, with a generation of 7675 GW h/year of which the CFE produced 220 GW h/year through 3 generating plants, while 27 private producers generated 7455 GW h/year. In Mexico, the main renewable technologies used to generate electricity are hydropower, onshore wind farms, and geothermal. Mexico has a great potential to generate electricity from renewable sources, however the government must encourage its use through the appropriate mechanisms in order to achieve its proposed goals of generating 35% of total electricity from clean sources by 2025, improve the social welfare, and shape a sustainable future.

1. Introduction

The use of energy plays a key role in economic development and welfare of a nation [1,2], nevertheless overuse of natural resources, both renewable and non-renewable, not only threatens this development but also affects issues such as environment, human health and economic progress. For instance, the world energy consumption has increased 18% between 2005 and 2014 and is expected to increase 35% by 2035 [3,4].

The world consumption of primary energy in 2014 was 12,928.4 Million tonnes oil equivalent (Mtoe), based mainly on fossil fuels. Oil, natural gas and coal are the major fuels for primary energy production. In the case of Mexico, main fuels for primary energy in 2014 were, oil 45%, followed by natural gas 40% and coal 8% [3]. Regarding to electricity generation in Mexico, Fig. 1 shows that 57% of energy is generated by

natural gas, 12.9% is generated by hydroelectric, and 11.1% is generated by coal. Renewable energies generate only 3% of electricity. Consequently, the use of electricity from renewable sources in Mexico is very low and there is an increase in power demand of 3.4% annually [5]. The Mexican government wants to reverse the situation achieving the goal of generating 35% of electricity from renewable sources by 2025 [6–8]. It has to invest in research and development, as well as in the search for mechanisms to encourage the deployment of renewable energy, since the deployment of the technology is based on the cumulative investment in research and development [9]. In this regard Garcia-Heller et al. [10] carried out a forecast study to estimate the investment costs by using some type of solar and wind technologies, and thus achieve the objective mentioned above i.e. to generate 35% of electricity from renewable sources by 2025. Actions should also be aimed at a more moderate use of energy in order to achieve sustainability [11].

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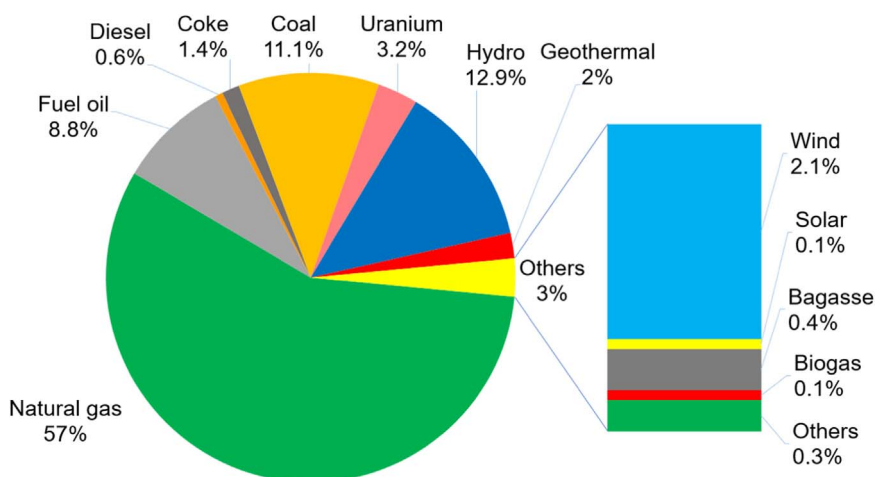


Fig. 1. Sources for electricity generation in Mexico 2014. Adapted from [5].

In Mexico, the Secretariat of Energy (SENER) is responsible for the national energy policy, particularly the planning of the Mexican electricity system [5]. The agency responsible for generating electricity and provide electric service throughout the country is the Federal Electricity Commission (CFE). CFE is a productive state enterprise under a competitive regime and can participate in the various market activities through subsidiaries and affiliates. Although the Article 27 of the Mexican Constitution stipulates that the planning and control of the national electricity system, as well as the transmission and distribution of electricity, corresponds exclusively to the nation, it is allowed for the state to enter into contracts with private parties to carry out the financing, maintenance, management, operation and expansion of infrastructure needed to provide the public service of transmission and distribution of electricity [12]. The Regulatory Energy Commission (CRE) is a decentralized body of the SENER with technical and operational autonomy and is responsible for regulating natural gas industries and electricity in Mexico. This organization grants permits for the generation, sale and distribution of electricity from private producers, and it also assesses and implements the fares regulation. Despite the subsidy that the Mexican government use to minimize the cost of energy, it represents 0.75% of Gross Domestic Product (GDP) [13], average electricity rates are 25% higher than in the U.S. even with the subsidy included [12], this due to high prices of fuel oil, which is widely used in Mexico to generate electricity. Additionally, the electricity subsidy in Mexico has increased more than three times in the period from 1995 to 2000, it almost doubled from 2000 to 2005, and from 2005 until 2014 the electricity subsidy has risen very few [14], representing 1.4 billion dollars [15]. The amount used to subsidize conventional electricity could be used to support the development of renewable energy, since its potential in Mexico for electricity generation is high. It is estimated that the proven potential for power generation through solar, wind and biomass is 16,351, 19,805 and 2396 GW h/year, respectively [16].

This paper highlights for the first time a comprehensive review of the current status of renewable energy projects for electricity generation in Mexico and the potential impact of these technologies in the social and environmental areas. Most of the reviewed scientific literature focuses on the technical aspects of renewable energy but, in the case of our research, we presented some implications that renewable energy sources (RES) cause in the social and environmental areas. In order to generate a true social benefit, it is necessary the growth and development of the national industry of renewable energy technologies. Additionally, the government and the national companies have to take into account the development of appropriate mechanisms to protect people from unfair lease contracts and promote better working

conditions. It is also necessary to establish the public policies that help preserve the environment, customs, and traditions of the communities i.e. a deployment of renewable energy projects in order to preserve the balance of human communities should be launched, while the environmental health and social welfare have to be also considered. The aims of this research are as follows: i) to know the current status of electricity generation through solar, wind, geothermal, hydropower and biomass in Mexico, ii) to determine the renewable energy potential in Mexico and its generation schemes, and iii) to analyze the social and environmental challenges that these technologies are going to face in Mexico.

2. Methodology

2.1. Literature review

2.1.1. Similar studies

In this review, we cover all the studies in regards to our topic since 2000–2016 so that we performed a literature review with studies in Mexico. The search was conducted in "Web of Science" while we refined results in 'Document Types' to include only 'REVIEW' articles. The search yielded 16 articles and a critical analysis of the literature found was performed, the findings are discussed in the following sections.

2.1.2. Research and development

A literature review was made on the scientific literature focused on renewable energy research and development in Mexico. The search was conducted in the database "Web of Science" while the results were refined by restricting the search field 'Countries/Territories' to Mexico. This research yielded 102 papers. After that we did a manual analysis to set the relevant papers that met the established search topic which are discussed in the following sections.

2.2. Status and potential

To identify the current status of electricity generation using RES in Mexico, we performed a search on inventories and databases of government and private agencies with jurisdiction in the area of renewable energies. To estimate the potential for power generation through solar, wind, biomass, geothermal and hydropower in Mexico, we made an analysis of information in the INERE and CRE, we also critically analyzed the information from the recently scientific literature about the potential generation from renewable sources in Mexico.

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