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Renewable energy management and market in Iran: A holistic review on current state and future demands

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ABSTRACT

There are abundant renewable energy sources in Iran such as wind, solar, geothermal, biomass. However, Iran is fully dependent on fossil fuels for industrial, residential and transportation sectors. It results in the country to be in top 10 producers of greenhouse gases (GHGs) into the atmosphere. GHGs can be controlled by incorporating renewable sources to produce energy. Therefore, renewable energy resources are becoming more attractive to develop sustainable energy development in Iran. However, the transformation from traditional fossil fuel infrastructures to advanced renewable technologies needs many considerations, such as strategic and core planning. In this regard, this paper covers the current state of Iran's energy market focusing on both fossil fuels and renewable energy resources. A general review is offered over the renewable energy production status in Iran and the production potentials. Finally, in conclusion, a comparisons are made over the current state, plans and also potential opportunities of Iran over each sort of energy production.

1. Introduction

Iran (Islamic Republic of Iran) is located in the West Asia, surrounded by Caspian Sea, Azerbaijan, Turkmenistan, Armenia, Pakistan, Afghanistan, Iraq, Persian Gulf, Oman Gulf and Turkey. The country owns total area of 1.65 million km^2, and a population over 80 millions people including 49.6% females and 50.6% males [1]. The population is distributed mainly in cities with urban citizen number of ca 54 million. Generally, Iran has a hot, dry climate characterized by long summers and short, cold winters. ran is one of the largest economies in the Middle East and North Africa (MENA) with an estimated gross domestic production (GDP) in 2015 of $393.7 billion [2]. Iran's economy is characterized by a large hydrocarbon sector, small-scale agriculture and services sectors, and a noticeable state presence in manufacturing and financial services [3]. Although there are many great resources of income holistically, urbanization and balanced population distribution have drawn Iran into many challenges and dilemmas such as environmental hazards and seasonal drought [4–6].

As one of the rapid developing countries in West Asia, Iran's government seek the country to become a developed nation in the near future. To realise this vision, economic growth has to propel from being an agricultural- and commodity-based ecosystem to a manufacturing and service-based one. On the other hand, both its population and economy are expanding each year, so its energy demand increases correspondingly. This increasing demand should be accompanied by sustainable development in the economy and raising welfare of the Iranians [7,8]. Fossil-based energy sources, and in particular oil and natural gas, have been the major contributing fuels for the power sector in Iran, while the economic enhancement and societal advancements are appurtenant reliable energy sources. The challenging issue is how to achieve sustainability, i.e. to ensure the security and reliability of energy supply while taking the environmental consequences of energy production into account. Globally, the power generation has been a major contributor of GHG emissions [9], as most electricity generating plants use fossil fuels. In Iran, GHG emissions increased rapidly in the past few decades, [2,10], while the country has committed to the Kyoto Protocol [11], and has a vision to implement low-carbon economy and to reduce GHG emissions. Therefore, it is essential for the country to intensify the applications of renewable energy resources. It is worth mentioning that there is an enormous potential for using renewable energies and power production from renewable energy sources in Iran,

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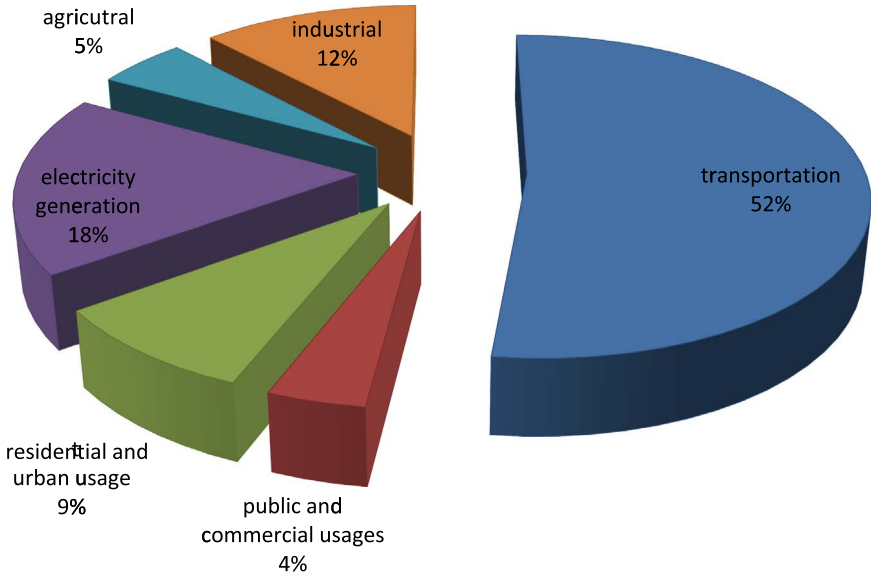

Fig. 1. Various energy consuming sectors and their related shares form Iran's total energy consumption (adopted from [30]).

and it had a positive trend in the last decade.

The aim of this study is to clarify the extent of non-renewable and renewable energies in Iran, and potentials of sustainable energy carrier. A brief review over Iran's energy market covering both non-renewable and renewable energy carriers is first performed. Furthermore, the limitations of developing renewable and sustainable energy carriers (RSE) are discussed to reach to a lower GHGs emissions.

2. Iran's current state of energy

Different aspects of Iran's energy market is covered in previous studies [4,12–17]. The country's energy consumption passed 1493.21 million barrels oil equivalent per year, which places Iran among the fast-developing countries [12]. Residential and commercial sectors, transportation, industrial sector and agricultural activities are the first four and major energy-consuming sectors in Iran. Currently, the largest energy demand is in transportation sector (Fig. 1). The government tried to increase the shares of alternative energy resources in the energy carrier mix by reducing the share of crude oil from 54% in 2001 to 44% in 2008. However, it resulted in practice to higher share of natural gas, that is still a fossil fuel [18].

There are four major energy carriers in Iran as crude oil, natural gas, coal and hydropower. Even though there are considerable coal resources, there is no significant supply for coal-based energy industries in the overall energy mix of Iran.

2.1. Crude oil

Iran owns 28 operating fields of crude oil and natural gas. To be more specific, 18 fields contain specifically crude oil, and four field contain gas resources. The remaining others field have both crude oil and natural gas. Many of the fields have not been explored yet. In fact, there are more than 102 oil fields and 205 oil reservoirs identified in Iran, from which only a small share are in operation [19]. Meanwhile, some of the oil and gas fields are shared with other neighbors that extract more oil and gas than Iran does. Iraq takes advantage of the shared resources two times more than Iran. There are even reservoirs shared with Qatar, of which, despite the neighbor, Iran has not started to extract hydrocarbons yet. Another fact is that current extraction technologies are rather old. Only 25% of accessible crude oil could be extracted with the aforementioned technology and enhanced facilities and techniques such as gas injection are crucial for higher production rates [19]. Table 1 summarizes the amount of crude oil handled by Iran.

Table 1
Different crude oil extraction and refinery companies in Iran and their working capacity.

	Company name	Production capacity (thousand barrels per day)
Crude oil extraction companies	Manategh e nafatkhiz jonub	3075
	Falatghare Iran	706
	Manategh emarkazi (onshore)	151
	Arvandan	84
Refinery companies	Abadan	350
	Bandar Aabbas	320
	Tehran	220
	Isfehan	200
	Arak	150
	Tabriz	110
	Shiraz	40
	Lavan	20
	Kermanshah	15

It is worth mentioning that even there exist great infrastructures and the country stands on the fourth stage among the oil producing countries, the demands for the energy carriers are not satisfied yet which has turned Iran into an importer of processed petroleum products and exporter of raw crude oil. Another influencing factor for Iran is the depletion in crude oil production due to the prolonged operation age of the mature wells and consequently lowered wells' pressure [20].

2.2. Natural gas

The government of Iran had a strategy to increase the share of natural gas in domestic energy mix and increase the export of crude oil [19]. It resulted in consumption of natural gas to meet an annual growth of 10.7% since 2000 [21]. Being the second producer of world's natural gas, Iran plays an important role in the field. Six available liquefied natural gas (LNG) plants are all fed with reserves owned by Pars Jonoobi field. Unlike some of the industrialized countries, Iran does not rely on coal as the main fuel due to the fact that coal involves in only 0.21% of energy consumption in the country. Main reserves considered are located in Yazd and Kerman provinces producing more than 64% of the country's coal. Based on modelling the energy