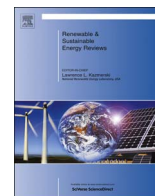




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## Renewable and Sustainable Energy Reviews

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## Renewable energy development in rural areas of Iran

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## ABSTRACT

Iran's energy system is extremely dependent on fossil fuels which, in turn, have led to problems such as fossil fuels depletion, social, economic and environmental damage and territorial imbalance. The country should therefore design a sustainable energy system based on clean energy as well as renewable energy. Accordingly, and given that Iran's rural areas suffer from the unsustainable energy system, it is necessary to integrate renewable energy into comprehensive development programs in general, and into rural development programs, specifically. This review paper answers the following questions: Why is renewable energy important for Iran at national and rural levels? How is renewable energy related to sustainable rural development? and What are the challenges in the promotion of renewable energy technologies in Iran? The paper concludes that although renewable energy has potential for development in Iran's rural areas due to environmental, social and economic advantages, it could face some infrastructural, managerial, socio-cultural and economic challenges. Accordingly, aggressive and innovative policy making is required to meet these challenges.

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**Abbreviations:** TAVANIR, Iran Power Generation Transmission and Distribution Management Company; GHG, Green House Gas; RE, Renewable Energy; MOE, Ministry of Energy; UN General Assembly, United Nations General Assembly; RETs, Renewable Energy Technologies; R&D, Research and development; RES, Renewable Energy Systems; EU, European Union; FITs, Feed-In Tariffs; SUNA, Iran Renewable Energy Organization; CCPI, Climate Change Performance Index; MDGs, Millennium Development Goals; DG, Distributed Generation

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## 1. Introduction

Nowadays, global energy systems are highly reliant on fossil fuels. However, in spite of strong economic development emanating from the energy system in the last century, fossil fuel depletion, environmental damage and territorial imbalances [77] have led to a global shift toward clean energy. As Fig. 1 shows, the total global investments in clean energy increased from \$54 billion in 2004 to \$269 billion in 2012 and the total new global investments in renewable energy increased from \$40 billion in 2004 to \$244 billion in 2012 (Fig. 2). According to the International Energy Agency [38] the utilization of renewable energy<sup>1</sup> will triple between 2008 and 2035. Also, it is anticipated that the share in renewable electricity production in Middle Eastern regions - the heart of the world's fossil fuel reserves- will amount to 16% in 2035 [38].

In Iran, unsustainable energy supplies and use coupled with an unreliable and unsecure energy system have had a demanding and lasting impact on economic, social and environmental development [31]. Hence, the country should act in line with the global approach and consider renewable energy, as well as endeavor to restructure and redesign the existing energy systems. Such an approach is imperative, because Iran, as a developing country, is experiencing serious challenges such as the depletion of fossil resources and territorial imbalances that highlight a need to design a sustainable energy pattern based on clean energy. It is therefore necessary to integrate renewable energy into development programs; specifically in rural areas where rural development programs dramatically suffer from unsustainable energy systems despite those areas being among the most important areas in Iran's economy. According to the Statistical Center of Iran (2011), 29% of the country's population live in rural areas and produce about 11% of the country's GDP. These areas are also contribute to 23% of the country's employment and 80% of the food supply [4].

According to TAVANIR, about 5.5% of households in villages in Iran's rural areas with less than 20 households still do not have electricity [21]. Also, the average annual cost of energy for rural households and its share in total household expenditure is higher than in urban households [20]. However, it seems that unsuitable access to energy resources and its destructive impacts have inevitably led to some negative consequences; such as deforestation, soil erosion, low soil productivity, the increasing emission of GHG and the spread of various human diseases due to traditional energy systems. Bearing such consequences in mind, the present study was conducted to: (i) investigate factors that necessitate the development of renewable energies at national and rural levels, (ii) link renewable energy to sustainable rural development, and

(iii) explore challenges to promote renewable energy technologies in Iran.

## 2. The necessity of renewable energy development in Iran

A review of literature reveals that at national levels, renewable energy development is at least entangled with four key categories as follows: (i) energy consumption, (ii) status of power plants, transmission and distribution grid, (iii) heavy fossil fuel costs, and (iv) the great potential of renewable energy.

Each category includes several factors that are discussed more in the following details.

### 2.1. Energy consumption

Fossil energy carriers provide more than 97% of the energy in Iran (Fig. 3). The country suffers from undesirable levels energy consumption. As far as energy systems are concerned, even goal-oriented subsidies and increasing energy carriers' prices have not motivated a reduction in energy consumption. According to the Majlis (Iranian Parliament) Research Center [47], both targeted subsidies and rising energy prices have not had significant influence in reducing energy consumption in either urban or rural areas. The amount of energy consumption in Iran is so unbridled that per capita energy consumption in the country is 68% higher than the global average consumption; i.e. fourteen times higher than Japan, five times higher than India and Pakistan [21].

The sustainability of the energy system could be investigated through macroeconomic energy indicators such as the average annual energy consumption, energy intensity, etc. According to Energy Balances [21], Iran is ranked 13th in the world with regard to the average annual energy consumption which equals to 155 million tons of crude oil. In the country, from 2000 to 2010, the residential and commercial sectors have long been the country's largest energy<sup>2</sup> user (40%) followed by the transport and industrial sectors with an average of respectively 28% and 20% in the same period [8]. This shows that Iran is facing serious challenges regarding the optimal utilization of hydrocarbon resources, raising the concern about imbalanced energy use and unsustainable energy systems that can lead to unsustainable development. This, in turn, affects different aspects of social, economic and environmental development including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues.

In Iran, energy intensity defined as the amount of energy used to produce a dollar's worth of economic output (or conversely, the amount of economic output that can be generated by one standardized unit of energy [21] is, on average, seventeen times higher than in Japan, four times higher than in Canada, three and a half

<sup>1</sup> The IEA's definition of renewable energy sources includes energy generated from solar, wind, biomass, the renewable fraction of municipal waste, geothermal sources, hydropower, tidal, wave resources, biofuels [37].

<sup>2</sup> Including oil, gas, coal and biomass energy.

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