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Review Article

Assessing the Current Status of Renewable Energies and Their Limitations in Iran

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ABSTRACT. Innovative and more sustainable methods of supplying energy needs in the world have led to a change in the dependency model for fossil fuels, including more integrated planning and adoption of new and motivating models regarding the use of renewable energy. Today, with the reduction of fossil fuel consumption in the world, the use of renewable energy has gained an important role in the global energy mix, but according to studies, the share of renewable energy in Iran's energy mix is very small. Therefore, the present paper attempts to present all potentialities for obtaining clean energy in Iran by assessing the current state of renewable energies. The fact that, in the present time, the real value of energy carriers is not appreciated properly in Iran, on the one hand, and the lack of willingness to invest in these energies in the private sector, which may have been less protected, on the other hand, has caused the consumption level of fossil fuels to remain unchanged, which may have some disadvantages, such as environmental damage, in addition to their utilization. The authors of the paper are of the opinion that, on the one hand, by finding solutions for bank investment problems, easing restrictive laws, providing bank with guarantees by investors, as well as modifying parts of the guaranteed electricity purchase contract for accepting foreign banks to provide loans and obtain financing, and on the other hand, by facilitating the process of obtaining land permits and connecting to these power plants, Iran is not far from reaching a reasonable rank in the world. ©2020. CBIORÉ-IJRED. All rights reserved

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1. Introduction

Population growth and the progress of industry in many developing countries has led to a continuous increase in energy consumption. Projections indicate that global demand for primary energy is likely to lead to an additional growth of 37% by 2040 (International Energy Agency 2014). The destructive effects of fossil fuels on the environment and concerns about greenhouse gas emissions, global climate change, and the desire to find alternative and sustainable energy sources and the creation of potential job opportunities for future generations have led to a growing tendency to use renewable energy (Moosavi *et al.* 2018; Jahangiri and Shamsabadi 2017; Aghahosseini *et al.* 2018). The most important renewable energy sources are the solar, geothermal, biomass, landfills, wind and hydropower (Shin *et al.* 2018) and in the near future, with the advancement of energy storage technology, traditional energy sources seem to be replaced by renewable energy

sources. The share of renewable energy in the global energy mix in 2010 was 6.8% and is expected to increase to 22.5% in 2020 (Power Technology 2018).

2. The status of renewable energy in the world

Setting a new record for higher use of renewable energy capacities, high-cost reductions especially in the field of wind and photovoltaic power, as well as the separation of economic growth from carbon dioxide emissions associated with energy carriers, all illustrate the fact that a global energy transition is taking place (REN21 2018a).

70% of the net capacity added to the world's electricity by 2017 was generated by renewable energy. The photovoltaic capacity in 2017 increased from 98 GW in 2016 to 402 GW. Wind electricity, biomass, geothermal and hydropower also increased by 52, 8.1, 0.7 and 19 GW, respectively, reaching 539, 122, 12.8 and 1114 GW in 2017. These increases are shown in Fig. 1 (REN21 2018b).

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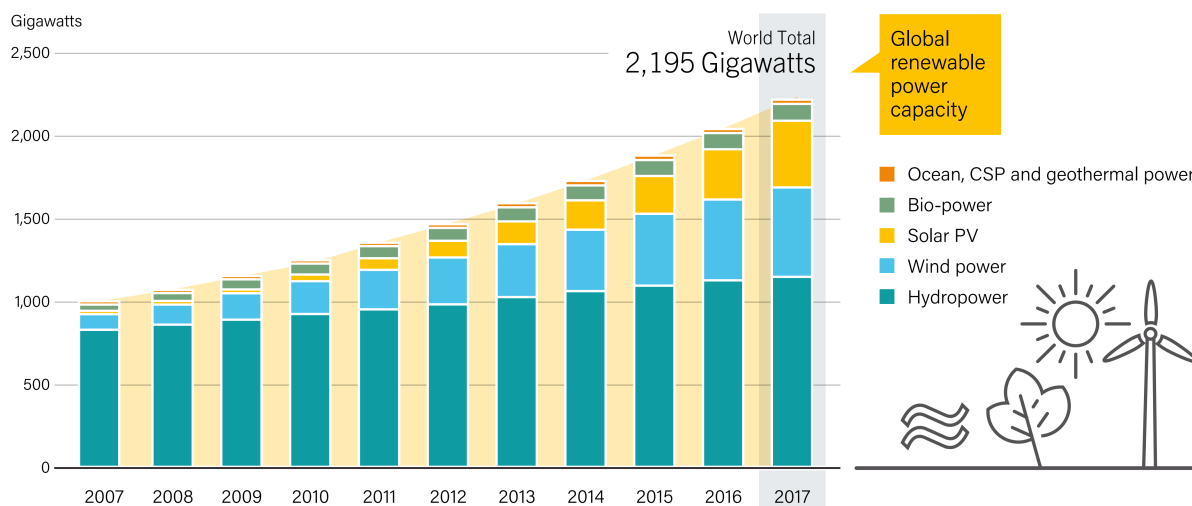


Fig. 1 Global Renewable Power Capacity, 2007-2017 (REN21 2018b).

3. Status of renewable energy use in Iran

Energy sources are the most important factors and elements of sustainable development. Having adequate energy sources is the most important factor in the economic development of industrial societies after human resources because energy is a fundamental requirement for the continuation of economic development, social welfare, improvement of the quality of life, and the social security. In recent years, most of the energy used in Iran has been supplied through fossil fuels. Due to the increase in energy consumption, Iran faces a reduction in its fossil resources, which further shows the necessity of using renewable energies in Iran (SATBA 2019a). Nowadays, Iran produces only 2% of its required energy from renewable sources that the renewable energies sector mainly includes wind, biomass, solar energy and hydropower (CMS 2016).

In Iran, from July 2009 to the end of August 2018, 2459 million kWh of energy from renewable sources was produced, of which 115 million kWh was due this August. According to reports, this amount of electricity generated from renewable energies has caused a reduction of about a million and 697 thousand tons of greenhouse gas emissions, with a share of 79 thousand tons for August of the present year. Also, this amount of renewable energy produced has reduced 698 million m³ of natural gas produced by consumption of fossil fuels in the Iran, which is one of the main sources of air pollution in the country. Meanwhile, this amount of renewable energy production has reduced the consumption of 541 million liters of water in recent years, with the share of August alone being about 25 million liters. The largest capacity for renewable energy in Iran is related to wind power plants. According to the report, 437 MW of renewable energy plants are being built in the country and the newly installed capacity of renewable energy has reached 637 MW. Renewable energy has provided employment for 43065 people directly and indirectly in the country. The study of the figures in

this section indicates that 46% of the country's renewable power plants are wind-powered, 35% solar, 15% small hydroelectric, 2% heat recovery and 2% biomass (SATBA 2018c). In Figure 4, the location of renewable power plants is specified on the map of Iran. Regarding the shape, it is clear that the provinces of Khorasan Razavi, Kerman, Isfahan and Fars are leading in the use of renewable energy. It is also clear from Figure 4 that the northern and western provinces of the country have performed very poorly in exploiting renewable energy plants and the lowest percentage of renewable energy use is in these provinces (SATBA 2018d).

According to Figure 4, 5-10 MW heat recovery units are used in Khuzestan Province. It is noteworthy that, to increase the efficiency and energy security in Iran, there is an increasing interest in using these kinds of power plants which also clean the exhaust gasses of the plant. A waste heat recovery (WHR) unit is a heat exchanger that transfers heat from process outputs at high temperature to another part of the process for the purpose of increasing efficiency (Holtec 2013). Generally, the heat dissipated from processes exits through air filtration systems, flues, or vents. Heat recovery system plays an important role in extracting heat for energy-related sectors (Zeb *et al.* 2017). WHR power plant is a way for energy optimization and saving which is capable of providing 25% of the plant's electricity demand. Furthermore, the electricity generated by a WHR power plant is green electricity which is environmental-friendly (Deniz *et al.* 2016). The following figure shows the diagram for a WHR power generation system.

According to the data released by renewable energy and energy efficiency organization (SATBA), by mid-September 2018, four companies with a total capacity of 7 MW in biomass, 7 companies with a total capacity of 16 MW in the field of hydroelectric power, 32 companies with a total capacity of 1513.4 MW in wind farms, 249 companies with a total capacity of 2611.36 MW in the solar field and 5 companies with a total capacity of 64 MW in

the field of heat loss recovery have signed guaranteed renewable energy purchase agreement in Iran. Based on these statistics, the provinces of Fars, Kerman, Yazd, Isfahan and Khorasan Razavi have the highest number of companies (SATBA 2019b).

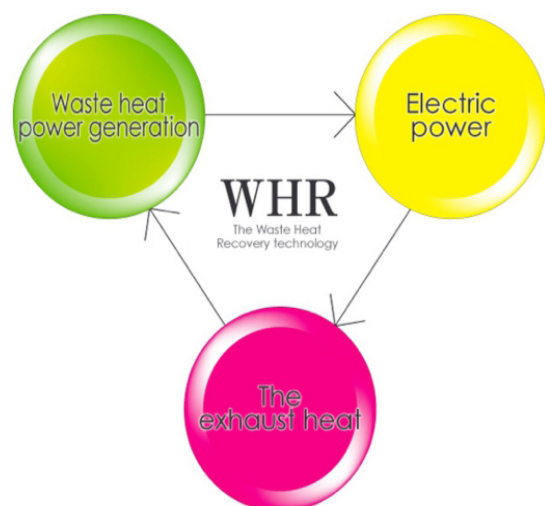


Fig. 2 Diagram of a WHR system.

For example, the potential of biomass resources in Iran is 132 million tons of oil equivalent which, given the amount of biogas usually produced from cattle manure, industries, sewage, and agricultural wastes, it can be used to produce 16146.35 million m³ of energy resulting in 323 petajoules (1015) of electricity (Ashley-Edison 2016). Iran enjoys sustainable infrastructure needed to use gas as the fuel for vehicles which facilitates the implementation of using biomass as a renewable alternative to natural gas (IRENA 2018). Despite adequate infrastructure, however, no extensive plan has been so far envisaged to use biogas in the transportation sector.

In the Ocean Power Plants sector too, according to the International Energy Agency (IEA) statistics, wave energy technologies are still in the early stages of development and more R&D is required in this area. It is predicted that by 2035 marine energy generation and the installed capacity will increase to 60 TWh and 17 GW, respectively (Khojasteh *et al.* 2018). Iran borders Persian Gulf for 1259 km, the Caspian Sea for 784 km, and Oman Gulf for 657 km (Badii 1993). Therefore, Iran enjoys a very outstanding position for utilizing the marine energy. Persian Gulf islands and Oman coastline, having 16.6 and 12.6 kW/m of average wave power respectively, are appropriate places for extracting marine energy to meet the energy demands of people residing in these deprived areas (Zabihian and Fung 2011). In a research by Majidi Nejad and colleagues (2018) aimed at preliminary evaluation of wave energy potential in coastlines of Iran and identification of potential places for using WECs, they studied 6 different sites in the Caspian Sea, Persian Gulf, and Oman sea. The obtained results indicated that the most appealing and justifiable sites were Gheshm, Anzali, and Chabahar. According to the research conducted in the Caspian Sea, the tidal phenomena are not much significant and the

potential available in the tides is considerably higher in southern areas such as Persian Gulf and Oman sea (Rashid 2012; Abbaspour and Rahimi 2011). As it could be seen in the following figure, the highest flow of water occurs near the Strait of Hormuz and Gheshm islands (Abbaspour and Rahimi 2011). Also, the 'Khoran Strait' or 'Clarence Stait' is a narrow strait that separates Gheshm Island from the Iranian mainland and it is a favorable place in terms of power generation from marine tides. Accordingly, based on a research by Soleimani *et al.* (2015) in this strait, the results indicated the feasibility of achieving a generating power of 15.8 MW by building a tidal barrage with a tidal range of 3.75 m.

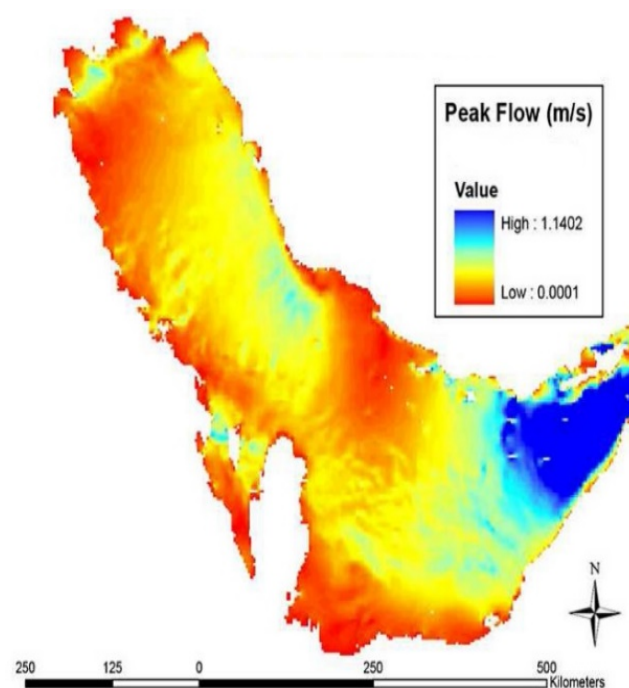


Fig. 3 Detailed information of tides in Persian Gulf and Strait of Hormuz.

3.1 Guaranteed Electricity Purchase Tariffs in Iran

In order to expand the use of renewable energy as much as possible, the basic tariff for the purchase of electricity from renewable energy plants for a period of 20 years was announced on May 8, 2016, according to the following tables (SATBA 2016). Given their power consumption, each subscriber has a branch and can, therefore, install a small or domestic or rooftop solar plant in accordance with their branch. For example, typical domestic users usually can get up to 5 kW permits unless they go to the electric utility and increase their branch share by paying for conventional charges. Smaller 20 kW plants are given to small workshops and industrial units that their branch is higher than domestic electricity. If they do not branch, they are treated like large solar power plants with lower tariffs for purchasing their electricity and they will lose more profits in the long run.

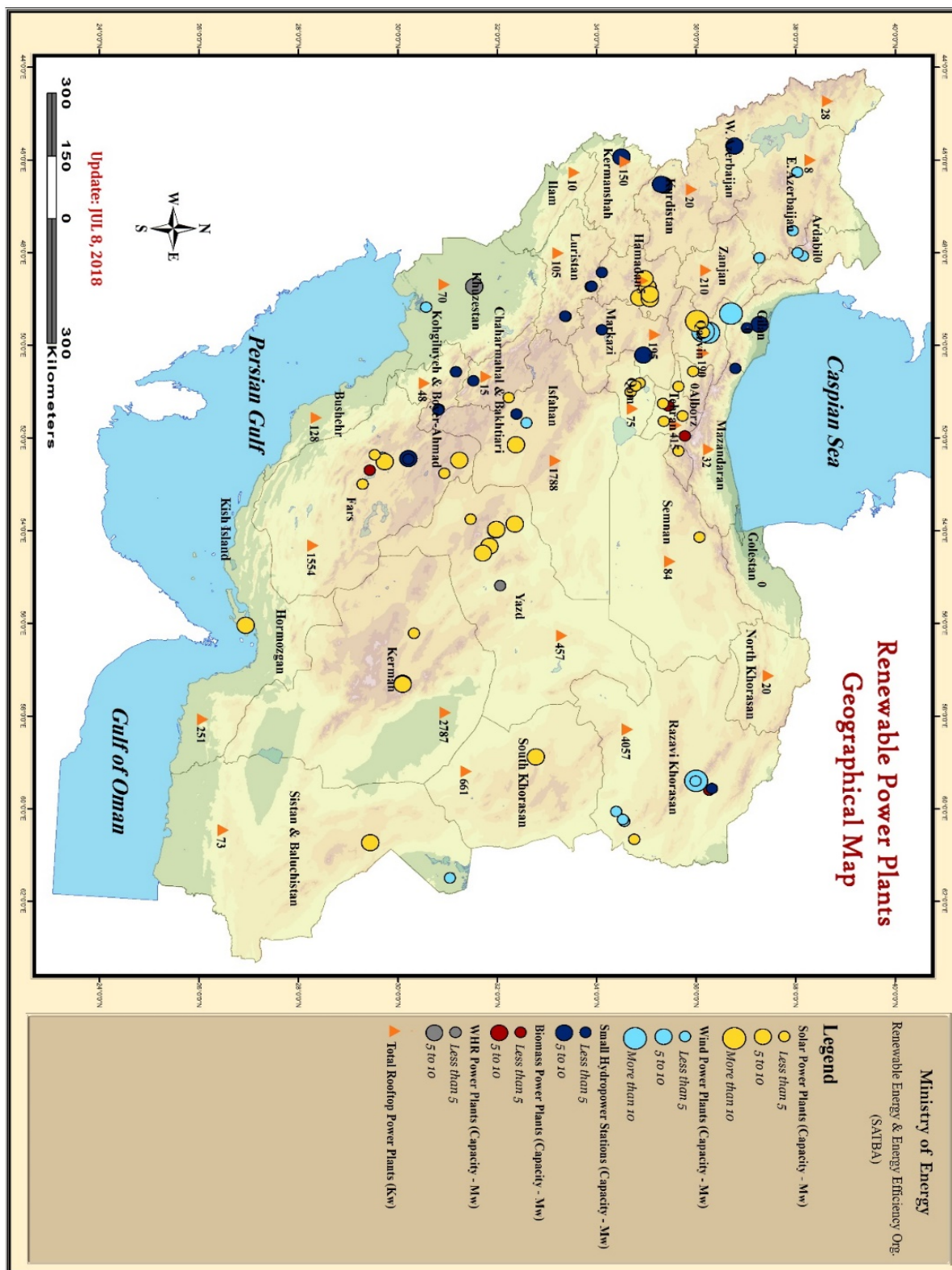


Fig. 4 Renewable Power Plants Geographical Map.

Table 1
The basic tariff for the purchase of electricity from renewable energy plants.

Row	Technology type	Guaranteed electricity purchase tariff (IRRs per kWh)	
1	Biomass	Landfill	2700
		The aerobic digestion of manure, sewage and agricultures	3500
		Incineration and waste gas storage	3700
		above 50 MW capacity	3400
2	Wind farm	With the capacity of 50 MW and less	4200
		With the capacity of 1 MW and less	5700
		above 30 MW capacity	3200
3	Solar farm	With the capacity of 30 MW and less	4000
		With the capacity of 10 MW and less	4900
		With the capacity of 100 kW and less	7000
		With the capacity of 20 kW and less	8000
4	Geothermal (including excavation and equipment)	4900	
5	Waste recycling in industrial processes	2900	
6	Small hydropower	Installation on the rivers and side facility of dams	2100
		Installation on the pipelines	1500
7	Fuel cell systems	4948	
8	Turbo expanders	1600	

3.2 Renewable Electricity Exports in Iran

Consistent with implementing the legal duties of the Ministry of Energy, in order to use the country's endowments to produce renewable electricity, create employment, generate income, increase security and develop less-developed regions, create alternative livelihoods in drought-stricken areas, and increase the country's share in supplying regional and global energy, more attention should be paid to exporting the electricity of non-governmental renewable energy plants. The applicant for the construction and export of electricity

should take steps such as obtaining electricity production and export licenses, obtaining permissions such as grid connection, the environment, and documents of ownership or land use, the conclusion of a transmission contract, the construction of a renewable power plant, the connection of the power plant to the grid and the start of operation and cooperation and coordination with the SATBA to monitor the utilization and transmission of electricity. Flowchart of the steps required to obtain a permit for the construction of a power plant and the export of renewable electricity is shown in Figure 5 (SATBA 2017).

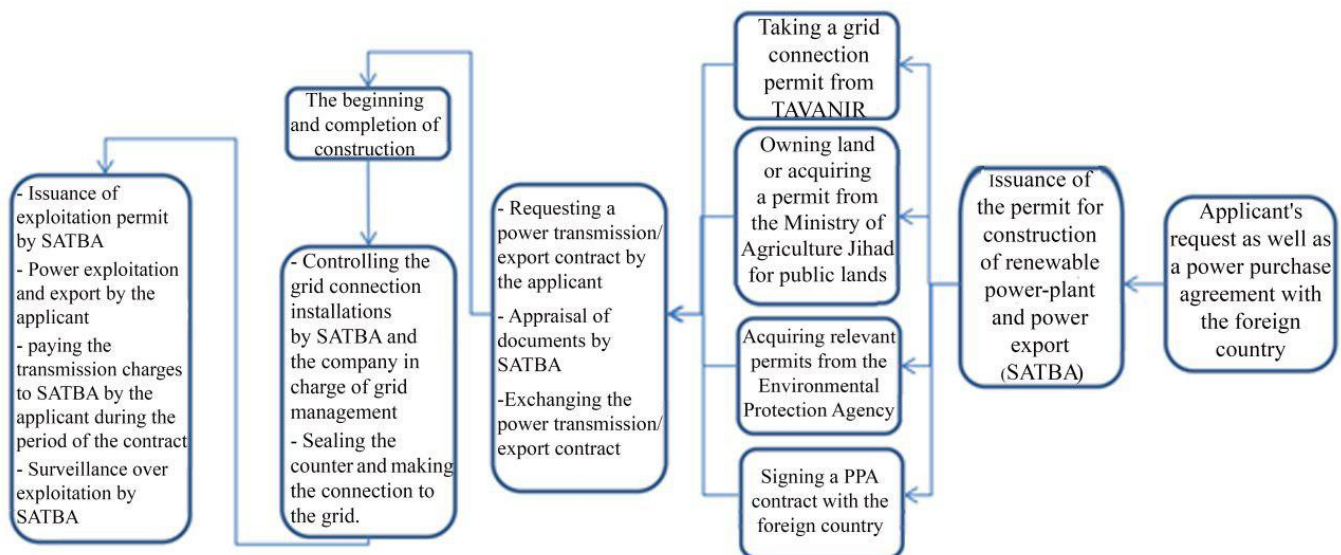


Fig. 5 Flowchart of required steps in acquiring permits for constructing a power-plant and exporting renewable power.

3.3 Renewable Energy Rural Electrification in Iran

Electrification of all the villages consisting of more than 10 households was realized in the eleventh government, and now the 12th government, in line with the Citizen's Bill of Rights, has put the electrification of villages having

less than 10 households on its agenda giving special priority to solar energy. Prioritizing solar energy for electrification of the remaining villages of less than 10 households has been considered since they are mainly in remote and impassable areas. Of course, the use of renewable energy in villages is not a new issue in the

Ministry of Energy and the Government. Of the 2,152 villages electrified in the eleventh government, renewable energies were used for 217 villages with a population of more than 2,350 households. It should be borne in mind that electricity supply to villages, especially villages in the last quarter of the gridline, has special challenges and barriers. Villages that sometimes consist of only 10 households having roads difficult to pass; these villages have a lot of dispersion, and long transmission lines are required for them. Transporting equipment to some of these villages may be carried out by helicopter, livestock or rock climbers, or even piggybacked. Electricity provision to villages is one of the "welfare and social security" aspects. In addition to electrifying villages of less than 10 households, the Ministry of Energy, in accordance with the Charter of Citizens' Rights, plans to create mobile or solar electric systems for the nomads. In Figures 6 to 9, examples of uses of solar energy are presented in villages, nomads and impassable regions of Iran (Jahangiri *et al.* 2017).

4. Restrictions on the use of renewable energy in Iran

Today, more than 45% of Spain's electricity is produced through renewable energies and Germany has exceeded 20% in this area. However, Iran has only 1% of electricity generation capacity is met by renewable energy sources, which means that, for various reasons such as low price of fossil fuels, renewable energies have been neglected. The rising prices of fossil fuels, environmental considerations, energy security, petrochemical applications, technological advances, and economic justification are some of the determinants of the future of renewable energy in Iran.



Fig. 6 Solar power in 2 villages of Koohrang in Chaharmahal and Bakhtiari province.



Fig. 7 Electricity to environmental stations.

In recent years in Iran, the need to put renewable energies in the energy mix of the country has been considered. But the lack of sufficient funding did not allow big power plants to be built, while according to the experts in this area, the whole electricity demand of the country can be provided through solar power. Such capacity has remained untapped, while power generation in Iran, including the construction and maintenance of power plants and electricity generation, annually consumes tens of billion dollars' worth of fuel and foreign exchange earnings. The existence of large oil and gas resources and the keeping the price of energy low through subsidies in Iran has made Iran, in contrast to the advanced industrialized countries, lagging behind in the field of renewable energy. One of the reasons that led to the unjustifiability of developing these power plants in Iran is their lower cost-effectiveness compared to fossil fuels. In the case of wind power electricity, the low price of fossil fuels and sanctions are the main barriers to the development of these types of power plants, and the Ministry of Energy's contract is not attractive for banks in this area.



Fig. 8 mobile solar plants for nomads.



Fig. 9 Use of solar water heater in a village in Lordegan city.

Table 2

Present works in the field of renewable energy in Iran.

Reference	The purpose of the study	Software or analysis method used	Result
(Faghani <i>et al.</i> 2018)	Determining suitable locations for installing wind turbines in 9 central provinces of Iran	Weibull distribution function	1- In the spring and summer, most parts of the center of Iran have significant potential for installing large wind turbines. 2- North-West and the northeastern part of the center of Iran are recommended for installing large wind turbines.
(Rezaei <i>et al.</i> 2018)	A desirable location for the implementation of a wind-solar hybrid power plant in Fars province	Weibull distribution function Fuzzy TOPSIS Method	Eqlid is the best option for a solar-wind power plant
(Firouzjah 2018)	Small-Scale Solar PV Potential in Iran	Financial Evaluation	The northern cities of Iran have the potential of satisfying the PV investment.
(Yousefi <i>et al.</i> 2018)	Evaluation of the feasibility of geothermal heat pumps in Iran	RETScreen software	Mashhad and Qaen are considered as cost-effective cities for Ground Source Heat Pump
(Zareei 2018)	The potential of biogas production from livestock manure and rural waste in Iran	GIS	2740 million m ³ of methane produced per year from manure and rural waste in the country
(Jahangiri <i>et al.</i> 2018)	Potential for simultaneous generation of electricity and heat from wind, solar and biomass in Zarinshahr, Iran	HOMER software	If the distance between the studied area and the national grid is more than 2.5 km, the use of the hybrid system is cost-effective.
(Mohammadi <i>et al.</i> 2018)	Development of 5 MW solar power plants in 8 cities on the southern shores of Iran.	RETScreen software	The development of PV power plants is very promising and the use of a single-axis tracking system is also the most economical option.
(Ghorbani <i>et al.</i> 2018)	Simulation of a PV-Win turbine-Battery system in Tehran	HOMER software	The levelized cost of energy for this hybrid system is 0.502\$

4.1 Legal problems of guaranteed electricity purchase

In the context of a guaranteed power purchase, PPA contracts are concluded with renewable energy producers whose electricity prices in Iran (about 13 cents per kW of electricity) are underpriced compared to today's European prices. On the other hand, in the 2017 budget, about 11000 billion Rials was devoted to purchasing electricity, which was a good opportunity for foreign investors. But there are obstacles in this regard, including the issue of guarantees and warranties for contracts that are concluded. In these contracts, various barriers in terms of contracting, capital returning and ownership must be resolved in order to make investments, and Iran must give the investors a valid government guarantee to invest in Iran. The issue of land ownership is another obstacle in this area, which should not be expensive with regard to the development of renewable energies, and actually, the cost of investment should be reduced to make these projects operational. Iran should also introduce itself as an appealing destination so that it can bring investors to Iran, and by the potential of solar and wind power and the money they can, the country can enjoy the creation of solar and wind power plants. Also, Iran's relationship with the world, brokerage issues, and foreign banking issues should be solved.

4.2 The bureaucracy of getting money in Iran

Many domestic and even foreign investors face the issue of bureaucracy and delays in receiving their dividend from the Iranian government. Therefore, this problem needs to be solved, and the government shall be a good employer in this regard so that it can make an appropriate connection with domestic and foreign investors by the timely payment of the demands of the economic activists to encourage them to invest in this field. It is important that the government can bring foreign investors in the field of renewable energy and also win the trust of domestic investors.

4.3 Investment weakness

Investments in the field of renewable energy, especially in the solar energy sector, are projected to be 5,000 MW for the next five years. But with the current rate of electricity purchases, which is equivalent to five Tomans per kW of electricity bills which is spent on renewable energies, this figure does not more than 1,500 MW. Therefore, one of the major concerns is that at present when there is a high demand of several thousand megawatts, if the conditions are provided and applicants are willing to set up power plants, then the government will not be able to pay the expensive renewable energy. Unless it plans to raise the budget by annually increasing charges by 20-30%.

4.4 Export of electricity produced by renewable energies

In the countries of North Africa, Europeans have found solutions, and with the establishment of 500 and 1000 MW solar power plants, they transmit energy with submarine cable from the Mediterranean Sea and send it to the European market. Iran can also implement such initiatives because all the desert areas have high solar power capacity and large quantities of electricity up to 10,000 to 20,000 MW can be planned for the sole purpose of exporting energy and, with collaboration of neighbouring countries, the required infrastructure can be prepared by creating a transmission line whose investment can be returned from the energy transmission program. That is, with the receipt of charges from the power transmission site, it is financed. Considering a three-hour difference in time zone between Iran and Europe, the power consumption peak in Iran has a few hours difference with European countries. That is, at peak times in Europe, Iran has passed the peak. During non-peak hours in Iran, electricity produced by solar plants during the day can be exported to European countries overnight. After that, electricity from combined cycle power-plants or other energies should be used. Therefore, electricity exports from the combination of solar energy and the combined cycle will only be economically viable for Iran when there is a three to four-hour difference between the time-zone of the source and destination countries when there is no peak traffic in Iran. That is, there should be no compulsion to sell and export electricity at peak times in Iran.

4.5 The lack of holistic for renewable energies

During low loads or at midnight, when electricity is cheaper, by exporting the solar-powered electricity, the government does not need to subsidize renewable energies as it does for domestic electricity and electricity is exported without subsidies. We have not a holistic for renewable energy as it should be in Iran and, unfortunately, no long-term program has been initiated in this area. Although mid-term programs in the field of renewable energy have been taken into consideration, it is better to consider long-term plans in the field of renewable energy so that future generations will be confronted with fewer problems.

5. Necessity of transition from a fossil fuel base to a renewable energy system

Nowadays, with the reduction of fossil fuel consumption in the world, the use of new and renewable energies plays a great role in the world energy basket. The limited availability of fossil fuels and greenhouse gas emission problems have made it more necessary for everybody to pay attention to renewable energies. Considering the desirable and appropriate potential of renewable energies in Iran, the rational development of these valuable resources seems justifiable, because in this way, it is possible to pursue the goals of sustainable development. The limitation of fossil resources, the high annual consumption of energy in Iran, the withdrawal of Iran from the oil exporters' group since the end of this

century, and, consequently, the cut off of oil export revenues, cause that, with the lack of necessary planning and progress, the development process of the country will be seriously affected.

6. Conclusion

Electricity consumption in Iran follows a periodic trend, so that in summer the load on grid in Iran is very high and at other times this load does not exist on electricity grids, which indicates a lack of balance between the intensity and the coefficient with the electric energy consumption that ultimately leads to a loss of electrical energy. Also, according to the annual load curve of 2016, there are about 300 hours of critical peak load in Iran, which will cost 10 trillion Rials with the implementation of development projects. If at this point energy consumption is not managed properly, energy supply will face difficulties. Development of competitive markets, increased transactions in the energy market, construction of privately-owned hydroelectric and renewable energy plants, development of power plants, increase in the efficiency of power plants and repair of gas turbines after running for 100,000 MW, are some of the strategies used by Ministry of Energy in Iran. Therefore, in the present work, the current status of renewable energy, guaranteed purchasing laws and regulations, and the export of renewable electricity, as well as barriers and problems with the use of these energy sources, were examined. The results showed that the highest use of renewable power plants with 81% of the total, is related to wind and solar power plants. At the same time, the authors of the paper recommend investing in solar power plants with a capacity of less than 20 kW, since they have the highest guaranteed power purchase rates.

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