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Solar Energy and its potential to advance gender- sensitive planning in rural areas

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Abstract

Iran has a very high level of per capita energy use (estimated to be 80% above other Middle East countries). That reality is primarily due to the high fossil fuel subsidies currently provided to consumers and businesses. Iran's diverse and abundant renewable energy resources have the potential to increase energy access throughout the entire country while also providing tangible benefits for isolated rural communities and particularly local women. Despite the high potential of renewable energy (RE) physical resources available in most rural areas, the implementation of RE systems remains a novel strategy. The few RE projects that have been implemented, mainly by government projects, are gender biased as they are excluding females from such projects by focusing just on males for training, financial support, and prioritizing them for job opportunities. This article uses a gender-sensitive focus to analyze the potential that RE technologies in general and solar energy initiatives in particular can have to advance human living conditions in Iran's isolated rural areas. More specifically, our analysis focuses on strategies to empower local women to harness advanced solar technologies for energy retailing, storage, and demand-side and supply chain management, which have been used in a rural project called Barekat-e-Aftab. The paper also analyses the performance and replication prospects emanating from the Barekat-e-Aftab Solar Project.

Keywords: Iran; Renewable energy; Rural areas; Solar technologies; Women empowerment

1. Introduction

The Islamic Republic of Iran has about eighty million inhabitants and has a population density of about 48.5 persons per km2 (Iran's statistical year book, 2016). The country's population has doubled in size over the last three decades. In terms of land, Iran is the eighteenth largest country in the world, with an area of 1,648,195 km2. The country is located between latitudes 24° and 40°N, and longitudes 44° and 64°E. Iran from the North shares borders with Armenia, Azerbaijan and Turkmenistan and the Caspian Sea. From the East it shares borders with Afghanistan and Pakistan and in the West with Turkey, Iraq and Kuwait, and in the South with the Persian Gulf and the Sea of Oman. Tehran is the capital city of Iran and the major ports of the country include: Anzaly, Noshahr (in the North) and Bushehr, ShahidRajai, Imam Khomeini, Abadan, Khorramshahr and Bandar Abbas (in the South). About 90% of Iran's territory is located in the Iranian plateau and is, therefore, considered mainly a mountainous country.

More than half of the country's land is mountains and highlands, 14% of country is covered by deserts (mostly in the centre and South East), and less than 14% of the total land area of the country contain lands suitable for agriculture.

Due to Iran's rapid population growth, growing urbanization rates and economic development, energy demand per capita is growing rapidly, a trend that is accelerated due to widespread government subsidies aimed at lowering the local prices of fossil fuels. (Kaygusuz K, Sarı A, 2003: 459-478, REN21,2020:32).

According to a report from the international Renewable Energy agency (IRENA) The renewable energy sector employed 9.8 million people in 2016 in the world (IRENA, Renewable Energy and Jobs – Annual Review 2016) , an increase of 1.1% over 2015 and this trend is continuing in 2017 and in 2018 this number reached to 11 million people (REN21,2020:50) . By technology, solar PV leads employment in the RE sector (36%) followed by biofuels (6% or 2.1 million jobs). RE employment remains concentrated in a handful of countries, with China, Brazil, the United States, India and members of the European Union in the lead. Asian countries' RE share remained at 60% of the global total. (REN21, 2019:5) and worldwide only 32 % of renewable energy jobs are held by women (IRENA, Renewable Energy and Jobs, Annual Review 2019:4, REN21, 2016:19)

The G7 nations have for the first time set a deadline for ending most fossil fuel subsidies, and mandating that government support for coal, oil and gas should end by 2025. (https://www.theguardian.com/environment/2016/may/27/g7-nations-pledge-to-end-fossil-fuel-subsidies-by-2025)

In 2016, the Iranian government adopted policies to support the development of domestic renewable energy supply chains. For example, under its feed-in tariff system (FIT), Iran established a 35% premium for solar and wind power plants built using domestic content (IEA PVPS, 2015, http://www.iea-pvps.org/fileadmin/dam/public/report/national/IEA-)

To reduce dependency on fossil fuels, the Iranian government is pushing for a move away from the use of hydrocarbons as a source of electricity production (Deputy Minister of Electricity and Energy, 2019: 50). This approach will free up oil and gas for export and allow electricity to be produced more cost effectively and locally. The new Iranian energy policy is to produce more products from raw oil instead of focusing solely on oil exports. Therefore, Iran's policy-makers now attribute great importance to renewable energy development (CMS, 2016: 3

In Iran, like in many other parts of the world, renewable energy provides attractive opportunities to provide new clean energy sources, protect our planet, achieving local sustainable development as well as creating local job opportunities, income generation for people and a possibility for empowering rural communities.

Rural areas in Iran represent 26% of the country's total population in 2016 (Statistical centre of Iran, 2016) and compared to urban areas rural people experience higher rates of poverty. Also, rural populations have less access to modern energy sources than urban centers. The good news is that many rural areas in Iran experience about 300 clear sunny days per year and this local source of energy can be designed to empower rural communities.

Human resource is a main and vital resource in any society, including rural areas, women in rural area contain more than half of population and therefore they are the main human resource in this area. Recently due to extension of education facility to rural areas that even covers the remote villages, women are able to enjoy from education and literacy programs. Meanwhile, due to domination of masculine approach, and gender bias planning, they are deprived from having access to modern technologies and even machinery agriculture. When, it comes to modern technical works, such as Solar Energy System, this situation even getting worse. So in this article the gender-bias solar energy project is challenged and the capacity of Solar Energy technology as a tool for empowering rural women is discussed, based on Sara Longwe empowerment theories.

2. Research Methodology

This study relies on a gender analysis approach that highlights the great potential that renewable energy in general and solar energy projects in particular have to improve people's quality of life. We also analyze key Iranian projects focused on solar energy development in local rural communities. The role that such projects can have to minimize gender gaps is analyzed based on the necessity for developing new technology, particularly solar energy system and its need to apply gender-sensitive planning in the rural areas. .

So the article is organized to answer the question that, how Iran as an oil export oriented country, is participating in reducing the Carbon emission in the world by developing Renewable Energy, particularly Solar Energy system? And how we can use RE such as solar energy systems capacity to reduce the gender disparities and empower women in rural areas?

3. Discussion and Analysis

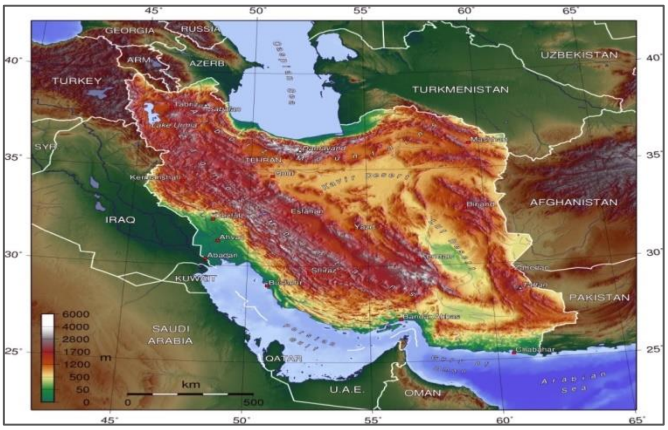
The vast geographical potential that characterizes Iran, makes the country one of the best places in the world for developing renewable energy (RE) projects. Solar initiatives, makes the development of solar energy in the country an unavoidable necessity that will be happen sooner or later, but we need to be aware of the social impact of this initiative as a modern technology particularly its effect on widening the gender gap in rural areas. In the following sections, we provide an overview of the vast Iranian RE potential and key barriers/opportunities for its development.

3.1 *Iran's Renewable Energy (RE) Potential*

Iran's geography and climate are highly suitable for a vast development of several resources. Most of Iran's land is located in a sub-tropical arid region; therefore, its climate is often dominated by clear skies and high solar radiation access.

Iran’s total area is around 1.6 million km2 with about 300 clear sunny days per year that yield solar radiation daily averages ranging 2.8 – 5.4 kWh per m2. The south and eastern part of Iran consists mostly of desert basins such as the Dasht-e Kavir, Iran's largest desert, in the north-central portion of the country, and the Dasht-e Lut, in the east.I Furthermore, in 2004 & 2005 Kavire Loot was the hottest spot in the world (https://whc.unesco.org/en/list/1505/). It is often said that the Kavir-e-Lut and Dasht-e-Kavir are impossible to cross except by the single road which runs from Yazd to Ferdows, but in recent years, heavy trucks and other vehicles have travelled over long stretches of these deserts, which contain extensive mineral deposits that include chlorides, sulphates and carbonates. The southern provinces of Iran are located on the world’s 'Sun Belt' enjoying high solar irradiation (direct nominal irradiation of up to 5.5 kWh/m² day).

In addition, mountains dominate 1/3 of Iran’s total land surface. More specifically, a series of massive, heavily eroded mountain ranges surround Iran's high interior basin, including the Caucasus, Zagros from West-North to South-East and Alborz Mountains from West to East in the Northern part of country. Iran’s landscape is dominated by rugged mountain ranges that separate various basins or plateaus from one another. Most of the country is above 460 metres above sea level, one-sixth of it over 1,980 metres high. In sharp contrast are the coastal regions outside the mountain ring. In the North, the 650 km strip along the Caspian Sea, never more than 115 km wide and frequently narrowing, falls sharply from the 3,000-metre summit to 30 metres below sea level. In the South, the land drops away from a 600-metre plateau, backed by a rugged escarpment three times as high, to meet the Persian Gulf and the Gulf of Oman (https://www.britannica.com/place/Iran/Relief.These mountains make centralized energy provision expensive and challenging and creates a natural incentive for local, de-centralized renewable energy generation (Fazelpour, et.al, 2017: 648)



Map (1) Physical Geography of Iran

Reference: NICHE GALLERY at: https://www.wpmap.org/physical-map-of-iran/detailed_physical_map_of_iran_and_iraq-jpg/

The Iranian Plateau dominates the nation, with the exception of the coasts of the Caspian Sea and Khuzestan Province. The only large plains are found along the coast of the Caspian Sea and at the northern end of the Persian Gulf. Due to its vast size and diverse geography, the country experiences a range of temperature and precipitation patterns at the same time. Iran is potentially one of the best regions in the world for solar energy and is also blessed with abundant wind and biomass resources. Although not a renewable energy, the country also has significant geothermal potential. In short, Iran is a country with a much diversified geography and highly suitable conditions for renewable energy generation.

According to figures released by the Islamic Republic News Agency (IRNA, 2018), non-renewable sources contributed in 2018 85% of the electricity generated in Iran, whereas the share of renewable energy provided 1,7 % (Moshiri, and Lechtenböhmer, 2015) in producing electricity in Iran. Meanwhile about 1.45 percent which includes 63% of it, is belong to Hydro/marine and, rest of renewable energy shares are as following:

Solar	Wind	Small hydropower plants	Bioenergy	Geothermal
45	40	13	2	2

Table (1) the share of renewable energy in electricity production

Source: IRNA(the Islamic Republic News Agency): https://www.irna.ir/photo/83528711/ 0ctober 2020

In short, 1% of Iran’s total land area could provide the entire country with renewable energy to satisfy all its current energy needs (Fadai 2007b).

3.2 *Energy production in Iran*

Iran ranks as the world's fourth–largest and second –largest reserve holder of oil and natural gas, respectively (Independent Statistics & Analysis, 2019). Iran is the second largest supplier of the Organization of Petroleum Exporting Countries (OPEC) and the world's fourth oil producer. About 70% of Iran's crude oil reserves are located onshore, with the remainder mostly located offshore in the Persian Gulf (Najafi et al, 2015). Iran also has the world's second largest natural gas reserves holder (behind Russia), and has proven reserves total 33.6 trillion cubic meters. Furthermore, Iran is the only country with such huge hydrocarbon reserves and the potential to still increase its output massively (since its current production levels are well below its maximum potential). Iran is also one of the most energy intensive countries of the world, with per capita energy consumption of 15 times that of Japan. The figure 1 shows the most of the energy used in Iran is supplied from fossil fuels (Najafi et al, 2015).

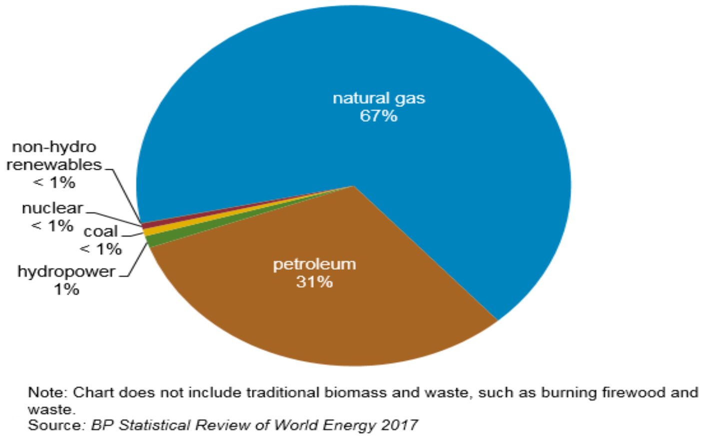


Figure 1: Iran's total primary energy consumption shared by fuel, 2017
https://www.eia.gov/international/analysis/country/IRN

Natural gas use is rapidly growing in Iran and approximately 1.6 (trillion cubic feet (Tcf) of all the gas used in the country was re-injected into oil wells for enhanced oil recovery (EOR) In addition, Iran vented and/or flared approximately 0.6 Tcf of gas in 2017 (Rystad Energy UCube, 2018). Most of the natural gas produced is consumed domestically, with Iran's consumption averaging an estimated 6.9 Tcf in 2017(Iran Oil and Gas Monthly January 2018). Also, another main reason for such rapid national demand growth can be attributed to existing national subsidies that make oil and natural gas much cheaper than elsewhere in the world. The volume of Iranian fuel subsidies extended to all its citizens has increased 42.2% year-on-year since 2018 and now is equivalent to 15.3% of Iran's GDP and 16% of total global energy subsidies, figures thatmake Iran the largest fossil fuel subsidizer in 2018, according to the International Energy Agency(Financial Tribune, July 16, 2019).

In the early 2000s, energy infrastructure throughout Iran was becoming increasingly obsolete and inefficient because of technological lags. However, by the middle of the decade, new hydroelectric, conventional coal and oil-fired stations were built, which increased the country's installed capacity by 33 gigawatts (GW).

The electricity generation capacity of the country has increased exponentially in the last 35 years and it has reached close to 80 GW and it is expected that, due to increasing demand for economic growth and the development plans of the country, total installed capacity will reach 90 GW in 2020 (ShokriKalehsar, 2019). In other words, demand for electricity is growing at around 6.5 percent per year, which if not reduced, will lead to a doubling of total electricity demand in a decade. The current rate of electricity demand is today at least 3.5 percent greater than the country's GDP growth; a fact underscoring that Iran cannot reasonably hope to sustain its current use of hydrocarbons to generate electricity nationwide without facing major ecological and supply problems (Frost & Sullivan 2015. http://ww2.frost.com/news/press-releases/iran-aggressive-growth-path-de)

Energy in Iran						
Year	Population (million)	Prim. Energy supply (mtoe)	Energy Production (mtoe)	Export (TWh)	Electricity Final Consumption (TWh)	CO_2-emission (Mt)
2004	67	156	293	1,530	139	386
2007	71	191	337	1,602	165	480
2008	72	205	338	1,429	175	487
2009	72.9	204	334	1,537	183	504
2010	73.97	204	342	1,574	196	499
2012	74.8	217	297	1,614	210	512
2013	76.42	221	298	961	217	536
2014	77.45	237	316	649	234	557
2015	78.49	237	323	-	236	553
2016	79.93	245	391	-	253	554
2017	80.67	262	423	-	270	567
Changes from 1999-2017		279.71	125	-	400.43	231.58
Mtoe = 11.63 TWh, Prim. energy includes energy losses Re:IEA Key World Energy Statistics 2018, https://www.iea.org/countries/Iran						

Table (2) the energy situation in Iran

Source: IRENA 2018

Iran's current electricity demand patterns by fuel types show an unsustainable path that needs to be addressed. The Iranian government has already tried to move away from the use of hydrocarbons as a source of electricity production and is actively moving towards sustainable energy generation (Ghorashi, 2007:1677, Ghorashi & Rahimi, 2011:730). That trend is justifiable due to sustainable development goals and the growing need to reduce national fossil fuel energy subsidies, which are depleting government resources and minimizing potential revenue generation through exports (Shokri Kalehsar, 2019).

In addition, Iran is planning to add at least 1,000 megawatts (MW) to total power-generating capacity each year through 2022 with the help of the private sector. The government is targeting the installation of more than 5,000 MW of renewable capacity by 2022, to include 4,500 MW of wind and 500 MW of solar power. (Sixth Five-Year Development Program of IRI, 2017).

Since that time, attention to the RE sector has significantly increased among Iranian authorities and society (Deputy of electricity and energy affairs 2010: 250–300). Iran is interested in attracting more foreign financial resources and technology with the aim of increasing renewables. This prompted a May 2016 Ministry of Energy announcement that drastically reduced the tariff. (Moshiri, S. And Lechtenböhmer, S., 2015:22, Shokri Kalehsar, 2019).

Earlier in 2010, Iran's government decided to develop the country's renewable energy sector by opening new renewable energy centres in the University of Tehran (the country's most prestigious and largest university) and at Sherif University (the country's most famous university in engineering after energy engineering faculty was established in 2004). Such decision signalled a new direction in energy policy for Iran and aimed at ensuring that renewable energy can become ingrained not just in universities but also in government agencies and civil society.

Iran has in place legislation obliging the Minister of Energy to increase the share of renewable energy and clean power plants as a priority of non-governmental investment (local and foreign). However, compared to the vast potential of the Iranian renewable energy market and the Iranian government's target of 5,000 MW by 2020 (as set out in the 6th Development Plan), the number of energy projects actually commissioned remains low (Watson et al, 2018).

In 2016, The Iranian government adopted policies to support the development of domestic renewable energy supply chains. In early 2017, Iran signed several agreements with more than 250 companies, mostly from Europe, to develop renewable energy and deploy solar PV and build manufacturing facilities in the post sanction era. Iran had planned to spend $60 million on solar power projects on 2018 (https://xn----ymcwegdv2llie54jykkab.com).

The international nuclear deal with different European countries provided an opportunity for their companies to sign contracts with Iran to build a solar power plant. A Norwegian company has signed a 5-year contract to build a solar power plant in the desert areas of Iran. The contract was worth 2.5 billion Euros and the plant was projected to have a capacity of 2 GW. A British company also signed a contract with Iran for the construction of a 600 MW solar power plant. The company had pledged to increase the plant's capacity to 5 GW by 2020 (Iran International News, 2019, https://iranintl.com/).

With the withdrawal of the United States from the Joint Comprehensive Plan of Action of Nuclear Deal (JCPOA) and reinstating the sanctions against Iran, all foreign companies withdrew from the Iranian energy industry. Norwegian and British companies were also forced to leave Iran. Due to that geopolitical reality, Iran faced the barriers to achieve its goal of increasing the share of renewable energy in the national energy and electricity generation mix (Ibid)

3.3. *Solar energy: Iran's new gold*

Iran's geographic solar potential is one of the best in the world and could easily power the entire country's energy needs. The country can count on frequent sunny days and enormous solar radiation in key parts of the country. The total available average annual solar radiation in Iran is about 3,080 hours; with spring providing 700 hours, summer 1050 hours, fall 830 hours and winter 500 hours (Ghoreshi and Rahimi, 2011).

In addition, in the deserts of the country, annual solar radiation is close to 3,200 hours. More specifically, the southwest and central regions of Iran are very promising for solar generation and just those regions could power the entire country's energy needs (using commercially available technologies such as photovoltaic and concentrating solar power technologies).

The most commonly used technologies for solar energy include thermal, photovoltaic and thermoelectricity systems. Flat plate solar collectors have been used for decades to heat water worldwide. Photovoltaic (PV) systems today are the most commonly used solar systems, and have a huge market potential in Iran due to the feasibility of installing them in roofs and parking lots (close to where the electricity is needed) and also in solar farms that can be easily located where solar resources are abundant and land is cheap (e.g. desert areas), (Sabetghadam Morteza, 2006). PV systems are also widely used to power satellites, telecom stations, signalling units, forest monitoring stations, fire observation systems, lighthouses and highway emergency systems. Thermoelectricity systems are becoming commercially available in many countries with similar conditions to Iran's (for example Spain and Chile).

Solar power is still used in Iran mainly for generating hot water (e.g. by using solar water heaters in rural houses and by thermal systems located in the roofs of public washrooms in the main cities). As figure 2below illustrates, Iran has the opportunity to become the first nation in the region to be powered 100% by renewable energy.

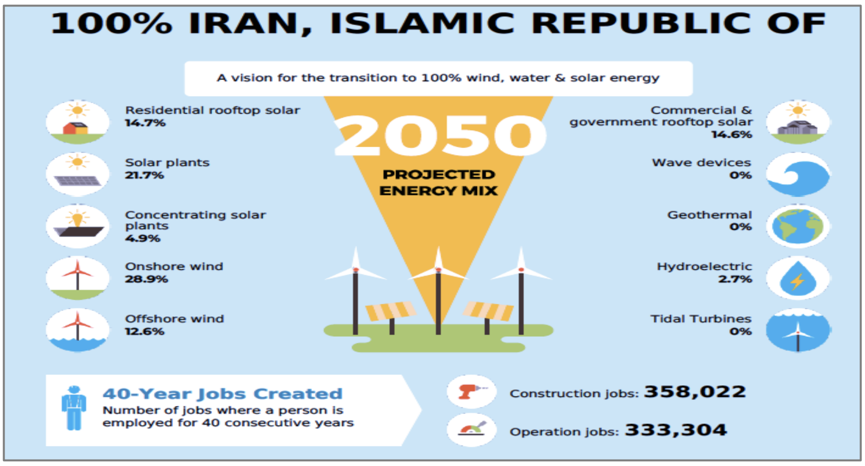


Figure 2: Iran's Golden Opportunity to become powered 100% by Renewable Energy (adapted from Solutions Project, 2020)
https://thesolutionsproject.org/wp-content/uploads/wce/country_IranIslamicRepublicof.pdf

Proactive national energy policies and effective foreign diplomacy are essential to develop new regional cooperation initiatives with neighbors that can provide Iran with the opportunity to generate abundant electricity using renewable energy for its own sustainable development and to share clean resources with neighboring countries.

4. Solar energy as a tool for rural development in Iran

As the previous section indicates, with the implementation of ambitious new policies, Iran can create a new source of local prosperity that taps into its huge solar resources and creates local security, environmental health, and abundant new local jobs. Those reasons alone justify adopting a new renewable energy policy path. However, there is a social justice argument that also needs to be considered: the current urban-rural energy access divide. Currently in Iran, almost 59 million people (about 75% of the country's total population) are living in urban centres while close to 21 million people (or 25% of the population) live in rural areas (Statistical Centre of Iran, 1956- 2016). As a contrast, please note that in the 1950s, only about 31% of Iranians lived in urban areas. The rapid growth of urban population has created in Iran an energy divide characterized by widespread urban access to electricity and fossil fuels for transportation while rural people, particularly those living in the most remote areas of the country, face limited access to the essential energy services that urban people take for granted.

In 1979, after the Islamic revolution in Iran, specific attention was given to poverty alleviation in rural areas. "Hadi[1] " projects are known as one of the most significant physical projects associated with rural development planning in Iran and begun 25 years ago. The Hadi project has changed physical, economic, social, and even cultural aspects of rural life (Hatamnia et al. 2014). Based on that project, the Ministry of Power has planned to provide electricity to all villages, but in many cases, rural areas with fewer than 20 households have been excluded from those electrification efforts. At the same time, about 92% of villages that have more than 20 households, have benefited from electrification and access to piped water. Therefore, village population size has a decisive role for Iranian rural development policy. According to the rural development strategy of Iran, most rural development plans in the country cover only the villages which have 20 households or more. So, due to that rule, 37 percent of rural villages are deprived of access to government facilities such as access to new electricity projects and other essential equipment such as piped water. To address that shortcoming, modular RE technologies (such as solar PV) can be a most suitable alternative to help develop and sustain the considerable amount of rural areas lacking electricity and clean water access.

Employment and economic opportunities are also very different in rural and urban areas Based on Iranian statistics; the predominant economic engine in rural areas is agriculture and its related activities. More specifically, the agriculture sector employs 52%, industry 24%, and services 23% of the rural labor force. In comparison in cities, employment rates are 19% in agriculture, 31% in industry and 49% in the services sector. Although the Iranian government recognizes the importance of the agriculture sector for the country as a whole, data indicates the reduction of agricultural employment trends in recent years. For example, the share of the national labor force in the agriculture sector has reduced from 18% to 17% from 2016-2017. Many factors have contributed to the reduction of agricultural activity in Iran including: drought; land fragmentation; lack of managerial and marketing skills; insufficient technical knowledge; the absence of modern machinery; poor connectivity to markets; low investment; and high-interest rates of banks.

Iran's agricultural crisis has led to a decrease in rural population size. The migration rate is higher in rural areas due to the difficulties of finding a job and the shortage of economic opportunities. Indeed imbalances in the levels of regional economic development have led to increased internal migration and the resettlement of the economically active population from disadvantaged regions to regions with better economy profiles. So, different Iranian provinces have clear disparities levels between urban and rural areas in key economic factors such as income levels, purchasing power, and development opportunities. Moreover, secondary school graduates have very little chance of finding a job in their home village. A lack of work and poor social infrastructure in rural areas contribute to migration to cities, especially by young males.

Energy supply in rural communities is an essential agenda item in the development plan of the Iranian government. That explicit focus is reported to be on rural areas that are otherwise very dependent on diesel-powered generators. Renewable energy, particularly modular solar PV systems, hold great potential to fit the energy demands of rural areas in a sustainable way to help decrease energy poverty. Renewable energy technology (RET) needs to be robust, inexpensive, and reliable to supply the energy services that are essential to provide rural areas with enough energy for agriculture, transportation, heating, and lighting.

Modular solar PV systems are the most common RET used in rural areas. For example, the Barekat Aftab Project (BAP) has been established by a partnership between Imam Khomeini Charity Committee (IKCC,a governmental organization in Iran), and Iran's Ministry of Power. The partnership aims to install PV systems (ranging between 3-5 kW) on rural households selected by IKCC to be financially supported. The program provides an opportunity for low-income people to generate income by producing electricity in rural areas. Based on the planned program, it is anticipated that after 5 years the capital invested in this project will be recuperated. Based on statements by the CEO of the Power Distribution Company behind this program, the electricity which is produced by the solar PV systems will be sold in the market at a favourable price and the government will guarantee market conditions for 20 years to help rural families involved in the program (Resalat daily newspaper, July 4, 2017).

One of the main challenges of this project is how to continue to improve it to ensure that the program continues to be productive, expand, and be cost-efficient. A key strategy to achieve those goals is to educate local people so they can be able to maintain and repair the systems. This project has been focused in the best solar

[1]Hadi translates as "Guidance"

regions in 12 provinces and has included more than 10,000 local families living in those areas. Local users will be trained to learn how to install, use, repair, and maintain the solar modules and report their performance to IKCC on a regular basis. A private company has been selected to train system owners so they can be able to install, maintain and use their solar systems. Through a final exam, trainees will receive a diploma, awarded by the professional experimental institute of Iran, and be qualified as a solar technician for rural and remote communities. Potential candidates must be male, between ages18 to 40; they require, at a minimum, a high school diploma or a technical diploma and must have done their military service as well. Unfortunately, this project is a gendered-biased project as it has excluded all the female population from participating in the training and thereby become involved in its economic and social development benefits.

5. Capacity of Solar Energy technology for rural women's empowerment

Access to technology, using it, and the ability to generating income by working with it, is an essential right for women, regardless where they live. Parallel to development of RE system as a new technology, there is a need to help end the gender technology gap and empower women and girls to create innovative solutions to advance equality in rural communities.

To better understand the relationship between a new technology such as solar energy system and women's empowerment, the theory of Sara Longwe that draws Women's Empowerment Framework, published in 1990 (March, C; Smyth, IA.; Mukhopadhyay, M, 2011) can be helpful in this regard. The basic premise is that women's development can be viewed in terms of five levels of equality: welfare, awareness, access, participation and control. As it will be shown briefly here, solar technology can bring positive changes to all this five elements.

First, in the context of welfare, it increases the standard of life by facilitate access to affordable energy and electricity, that enable them to work at night and extend their activities by feeling more safety. It also generating extra income for families, and crating new job opportunity for women in different sectors as well as in the solar energy sector including a wide range of occupation from semi-skilled to professional jobs. Because of the variation of the nature of Jobs in solar technology, and part time nature of this kind of jobs in remote areas, women are able to combine their housework with their work in solar technology market. At the same time, in process of solar energy system development, many infrastructures, particularly in communication, transportation and implementing of the energy-intensive projects will be improved and therefore it will lead to economic growth and social development and women can benefit from the advantages of solar energy system to increase their quality of life. In other words, women's welfare leads to belter standard of life for families and community members, particularly for children.

Also solar energy system can effect on women's awareness because of more communication, movement and interaction and interacting with different people and new information in this sector, it highly can engage in awareness and can facilitate women's access to the knowledge, information and know-how. It also encourages women to use technologies and tools by gaining new skills for improving their work in the technology intensive market. As a result, women will be encouraged to involve more in higher education and participate in any kind of learning programs, which can facilitate their access to information and knowledge. In one word, it generates an awareness process, among women in local communities.

At the same time, it will effect on self-confidence of women positively. Giving them more power to contribute in decision-making process in the family and in society, this is an important characteristic for controlling over their life.

Participation is another important factor in empowering women. Solar energy system activities highly linked with economic participation of women and their presence in the workforce, for not only lowering the levels of poverty among women, but also as an important step toward raising household income and encouraging economic development in communities. In addition, we can see that due to the profitable nature of solar energy system, economic participation in these activities can easily turn to a family business.

Women represent half of the population of any country and therefore not only are the subject and goal of development but also can be key agents of change (Dadvar-Khani, 2015). In Iran, as mentioned earlier, 74% of all residents live in urban areas and 26% live in rural areas (2016). In urban areas, women account for 48% of the population. While in rural areas, they account for 49%. The combined (males and female) total literacy rate in Iran is 91 %; however, the literacy rate for women in turban areas is 96% and in rural areas it is 90 % (Statistical Centre of Iran, 2016). Based on the data, it is clear that the differences between literacy rates for women living in urban and rural areas is low and indicates that rural women have the same capacity as urban women do. It shows rural women have a good talent to access technology or higher education to improve their lives in all its aspects, from social to economic in order to have better control of their personal life.

Indeed, there are more women of working age in rural areas than urban areas 7.1% and 6.2% respectively. Traditionally, rural fertility rates are higher when compared with urban areas. However, there is a decreasing trend in rural fertility rates. For example, rural fertility rates were 6.5% in 1996, and then it fell to 2.6% in 2006 and again decreased to 2.1% in 2016. Those figures show that by increasing rural development and decreasing the infertility rate, women have more opportunity and time to participate in the economic development of their family and as a whole in their society. On the other hand, all indicators of poverty are higher among Iranian rural households than urban ones, especially when compared with big cities. For example, in 2006, the Human Poverty Index (HPI) of the rural population was 21, while in the urban areas it was 12. The higher levels of rural poverty are a significant social concern in Iran.

The economic participation rate in the country is 38%, while this rate is 13%.for women and 63%for men. There are also significant differences in the women's and men's employment in the economic sectors in the rural areas: 43% of employed women in rural areas of Iran work in agriculture (which is the largest sector of employment in rural areas). Moreover, statistical data shows that employment in agriculture is a more attractive option for women than other sectors; 21% of all those employed in agriculture in 2017 are women and 17% of them are men. It is worth noting that a large proportion of the rural employed population are self-employed farmers. This is the reason why unemployment is lower in rural than in urban areas \(i.e. the unemployment rate for women is 20% and 9% for men).

Notably, there are approximately six million households located in 62,284 villages in Iran. According to official statistics, men are the heads of most farms, while, women represent less than 5% of farm owners (Dadvar-Khani, 2015). Consequently, households headed by men have higher incomes compared to households headed by women. In rural areas, women and men also tend to engage in different activities within agriculture, with most women involved in lower-paid work additional evidence of unequal gender relationships. Women are responsible for the majority of day-to-day agricultural activities including: fieldwork; collecting the harvest; milking cows; the processing of food; and also housekeeping; and budget management in a small sale. Moreover, women are more excluded than men from on-going economic reforms, because they have less access to proper information, financial resources, adequate property rights, and limited access to opportunities in the labor market.

In reality, the small farming sector in Iran faces many challenges including; a poor economic base, low productivity, and a lack of access to the inputs, knowledge and capacities that farmers need to build profitable farming businesses. Additionally, because of the gender gap rural women in Iran are not actively involved in decision-making processes. Almost in all regions, there is a lack of leadership participation by women in the local community, despite women having a decisive role in the household economy and in subsistence farming. Women remain significantly under-represented in local assemblies, accounting for only 6.3% of seats in the local Councils of all Iranian Regions.

According to Guttman (2015), 70% of Iranian university students are women who study in science and engineering and, recently they are being encouraged to get involved in start-up innovations. However, when it comes to rural areas, the gender gap becomes a more significant barrier for women’s participation. Women’s literacy rate in the rural area increased from 69% in 2011 to 73% in 2017 but, it has not lead them to get involved more often in their new social and economic development. In rural areas, particularly in agriculture region of the North of the country, women are mainly involved in traditional farm tasks such as: rice transplantation and harvesting tea leaves.

Consequently, as rural social and economic conditions are improving, due to men’s privileged access, they have more access to modern equipment and to more advanced machines than women and that technological determinism again cause more exclusion of women from the social economic fabric of society (Guttman, 2015).

To summarize, the inadequacy of current policies could be addressed by involving various interest groups in RE development plans. Women and girls contributions in rural areas are essential for the success of programs aimed at boosting the use of RETs. However, female inclusion and active engagement require encouragement by governments and a commitment by local communities themselves. Cultural and economic inclusion that hinder women from accessing RETs are challenges that can only be addressed through a broader framework supported by policy makers (Atabi, 2004). The imposition of foreign and new technologies, without involving the entire local community –including men and women—should be questioned as it will not lead to community empowerment or progress. More specifically, women’s economic empowerment is fundamental to increase social capital and economic development in urban and rural areas. To achieve that goal policy-makers and stakeholders need to:

1. Ensure that policies and programs designed to revitalize the rural economy, including energy production, technology improvement, take into account the role of women as individual contributors and as pillars of the local community.
2. Increase female participation in RET projects to provide them with the ability to control supply chains by increasing their knowledge levels and skills in related technologies. Females need to be empowered and trained to become workers/producers that can improve socio-economic levels and reduce the economic and leadership gender gap in rural areas.

3. Address local social infrastructure barriers including in school facilities, which need to be improved to incorporate the latest standards for gender equality. Also, there is a need for the provision of female-oriented financial incentives for training and additional cultural arrangements to increase women’s employment opportunities in targeted and measurable ways.
4. Enhance women’s local capacity in marketing, access to knowledge, and direct control over new technologies to increase the ability to play an active leadership role in their communities.
5. Need to increase government support of balanced gender advocacy to design policies, programs and strategies explicitly, and enhance the economic empowerment levels of women in rural areas.
6. Increase social dialogue between local authorities, businesses, and civil society to increase transparency, measure social progress, and enhance accountability in gender budgeting.

Sustainable rural development principles clearly indicate that focusing on renewable energy development is a logical strategy to achieve reliable energy access, new jobs and better quality of life in Iran. Furthermore, RE development in all rural areas of Iran can be crucial for achieving a safer environment, better living conditions, reducing labour migration from rural to urban areas, and providing new opportunities for women to be effective participants in the development process and finally it can lead to social, economic, environmental and cultural sustainable development opportunities for everyone in Iran.

At the same time, it can effect on increasing women’s access to different resources and will led to the capacity building for women which is a key factor in the process of economic empowerment. However in the absence of gender –sensitive planning, which leads to exclusion of women from the programs, introducing of the new technologies such as solar energy system, not only cannot help in empowering women, but it will lead to widening the gender gap in fabric society of rural areas.

6. Conclusion

Iran is severely reliant on energy-intensive industries and polluting fossil fuels for national economic production and export. Iran is also one of the major energy-consuming countries and primary energy intensity is worsening. These adverse conditions are linked to stagnant economic sectors in the country, which have considerable energy-intensive industry sectors; on the other hand, the Middle East energy production sector is dominated by artificially low-priced fossil fuels that present economic and environmental challenges.

Despite those challenges, Iran is an exciting new market for renewable energy, with a high demand for electricity and numerous incentives from the government to encourage a switch from hydrocarbons to renewable energy. The Iranian government hopes to launch 1,000 MW of renewable capacity per year through 2022 with the help of the private sector. The biggest challenge faced by RE developers is the bankability of new projects in Iran, which highly harmed RE development in IRAN. Also Iran's crude oil exports and production have declined since the May 2018 announcement by the United States that it would withdraw from the Joint Comprehensive Plan of Action (JCPOA) and reinstate sanctions against Iran.

Despite, decreasing population trends in rural areas, there are still millions of people living in rural areas of Iran that have huge geographic opportunities for RE development. To maximize RE development, rural projects have been focused on villages with over 20 households. Overall, project development needs to focus on less densely populated areas to ensure equality and to decrease rural poverty.

In Iran, women are usually one of the most deprived groups in rural areas. Our research shows that women are getting more isolated by rural development projects and by the introduction of new technologies and the mechanization of agriculture. Renewable energy projects need to be implemented with a clear gender focus to ensure their sustainability and more importantly to address socio-economic gender gaps that are particularly large in rural areas. Policy makers and project developers need to take steps to design measurable new initiatives that can reduce gender gaps and provide new jobs and economic opportunities targeted to empower local women. RE technology can be harnessed as a tool for empowering rural women in Iran and emphasizing that focus will lead to improved lives throughout Iran. Therefore, the gender bias project such as “Barekat – e- Aftab” should be adjusted to include both sexes in society. Solar energy System can effect on women’s empowerment from different aspects.

Based on this discussion, it is recommended that gender sensitive planning should be considered in solar energy planning especially in rural areas and local communities and due to effect of this technology; female’s entrepreneurship should be supported and extended by local government

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