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Review on Solar Energy Development in Tehran

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ABSTRACT. *In Iran, there are many renewable energy sources such as wind power, the sun, geothermal, biomass; though, Iran is totally dependent on fossil fuels for industrial, residential and transportation sectors. Tehran has an extremely high level of energy consumption per capita. Additionally, air pollution in Tehran is increasing every day. So, novel solar power technologies development is one of the best solutions to these problems in Tehran and other cities of Iran. In this paper, first of all, the status quo of Iran's energy such as fossil fuels and renewable energy resources is depicted. Then the solar potential energy in Iran and specifically in Tehran is described with a few case studies. Finally, in conclusion, the potential opportunities of solar energy in Iran are described.*

Keywords: Energy Resources, Solar Energy, Renewable Energy, Iran's energy, Sustainability Development,

1. INTRODUCTION

The use of solar energy dates back to the seventh century. They used solar energy for heating, cooking, lighting and etc. Greeks and Romans had architectures for the use of light and solar heating inside their buildings. Nowadays energy is known as the driving engine for economic improvement all over the world. Global energy resources are divided into three main groups of energies, including fossil energies (e.g., oil, gas, coal, etc.), nuclear energy, and renewable energies (e.g., wind, solar, geothermal, hydropower, biomass, hydrogen, ocean, etc.) [1] [2]. Considering the restricted sources of fossil fuels and nuclear energy and their rather quick decline, replacing them with new sources of energy seems to be unavoidable. Moreover, fossil fuels are hazardously related to carbon dioxide. Problems associated with fossil and nuclear energies such as pollution and environmental damages can be resolved using the unlimited renewable energies resources [3][4]. Therefore, they appear to be appropriate alternatives to both fossil fuels and nuclear energy. Nowadays Building Information Modeling (BIM) makes it possible to superimpose the multi-disciplinary information within one model [5] [6] [7] [8] [24], it provides an opportunity for conducting these analyses accurately and efficiently in comparison traditional methods.

Solar energy is among the most important renewable sources around the world, but the amount of radiation from this energy is different in various parts of the world. Studies indicate that the use of solar energy in Iran is suitable and could provide part of the energy needed by the country. According to the information provided by the New Energy Organization, Iran with annual average of more than 330 sunny days and a daily average radiation of 5.5 to 4.5 kilowatt-hours /m2 is one of the countries with high potential in the field of solar energy [9]. Also some of the scientists believe that by equipping its desert area with solar energy systems, Iran can provide energy for the wider areas of the region and activate the power supply [10].

On the other hand, Iran possesses 9% and more than 15% of the world oil and gas reserves, respectively [11]. However, owing to the population explosion, industrial development, and higher living standards, the fossil fuels domestic usage has significantly increased, leading to a situation which in the near future may cause a drastic reduction in the oil exports. The energy consumption of the country passed 1848 million barrels oil equivalent yearly. This places Iran among rapidly developing countries. Among the first four and major energy-consuming sectors in Iran are residential and commercial sectors, transportation, industrial sector and agricultural activities. But due to the low cost, availability, and abundance of fossil resources, the application of renewable energies in Iran improves very slowly.

In recent years, energy has been a strategic source impressing wars consequences, and chokes economic growth, and contaminates as well as cleans the environment. In the globalization era, the increasingly demand of countries for energy indicates that in the next century, energy will be among the major problems all over the world. This requires countries to

develop a comprehensive plan of energy. Despite having huge hydrocarbon reserves, Iran is likely to face significant energy challenges over the next few years.

2. IRAN'S ENERGY RESOURCES

Iran is an immense country located in the Middle East with an area of 1648, 195 km2. Iran is regarded as the 18th biggest country in the world with a total population of 82,011,735 in 2018 [12].

Fig -1: Iran's plan. [13]

Considering the crude oil and natural gas reserves, Iran possesses the fourth (Fig. 2) and second ranks (Fig. 3) in the world, respectively [3] [14].

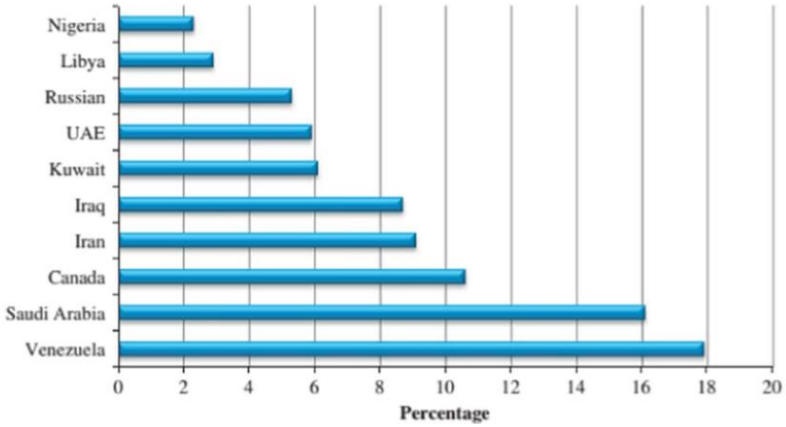

Fig -2: Top 10 oil reservoir countries. [3]

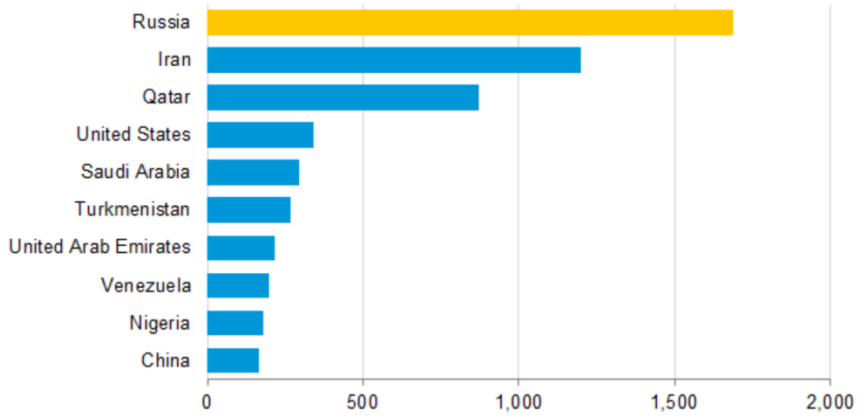

Fig -3: Top 10 gas reservoir countries. [14]

In the March 2017, electricity consumption in Iran was reported to be 241,091.00 kWh [15]. As shown in Fig.4, Iran energy consumption consists of 56.9% natural gas, 41.2% oil, 0.6% nuclear and hydro, 0.5% coal, and 0.2% bio fusils/waste.

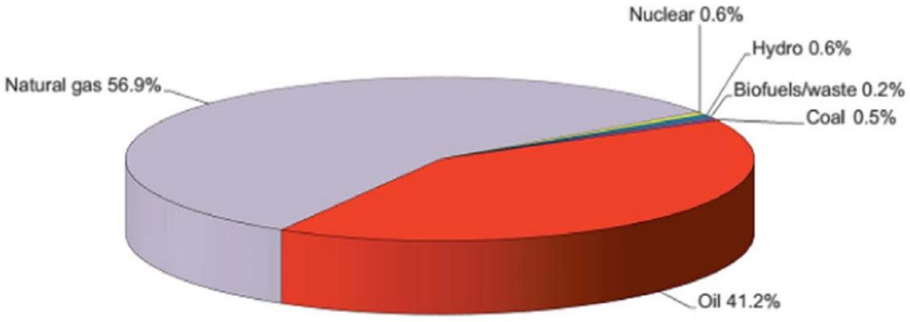

Fig -4: Iran share of total primary energy supply. [3]

According to Figure 5, in the next years, the electricity sector of Iran will expose a shortage due to an annual increase of 6% in the Iran's electricity demand, but its generating capacity development is only restricted to less than a third of that value. Various primary issues force Iran to shift from fossil energies to renewable ones, including air pollution, greenhouse gases and climate change induced by such fuels in domestic, transportation and industrial uses, and limited fossil resources which are expected to be discharged soon.

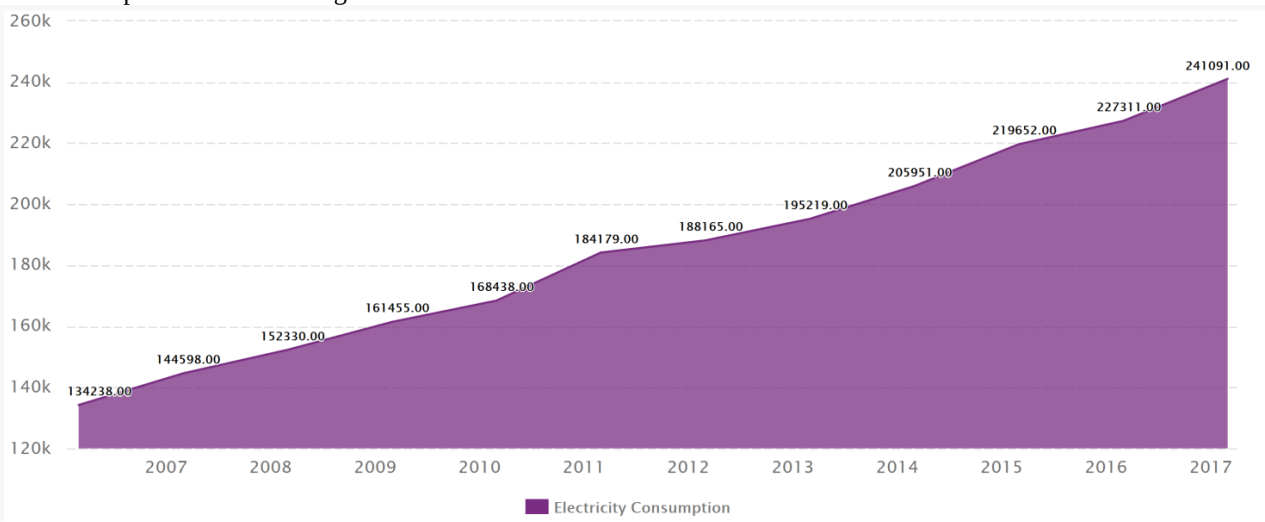

Fig -5: Iran's electricity consumption from 2006 till 2017. [15]

Currently, only 0.1% of Iran's energy is generated from renewable sources, which is very low [16]. Renewable energy is defined as energy gathered from renewable sources, which are naturally refilled on a human timescale, including solar energy, wind, rain, tides, waves, and geothermal heat. In Iran, the renewable energy sector consists mostly of wind (53.88 MW), biomass (13.56 MW), sunlight (0.51 MW) and hydropower (0.44 MW) [17]. The geography and climate of Iran are very appropriate for using renewable energy technology.

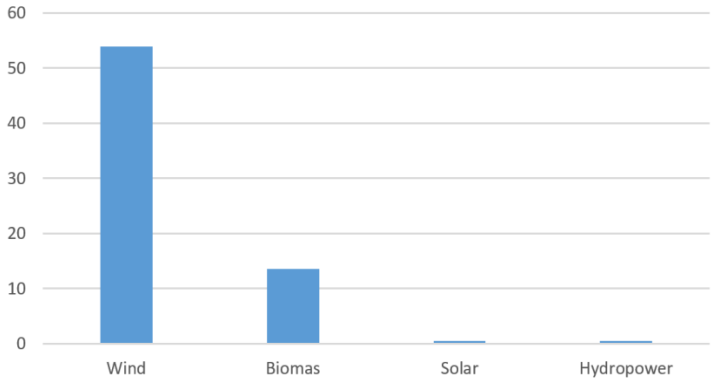

Fig -6: Iran's Electricity Consumption. [17]

2.1. Challenges facing renewable energy sector in Iran

For a variety of reasons Iran should utilize renewable and sustainable energy sources. Amongst these reasons we can refer to population growth, increased demand for energy, high potential of renewable sources, extreme air pollution, and the approved reliability and advantages of renewable energies. In spite of all these reasons, in Iran, the renewable energy sector faces several significant challenges to improve the renewable energies consumption and achieve its potential: Availability of inexpensive fossil energies like oil and gas in Iran [18].

Financing: The local Iranian banks inside the country do not offer project finance and will only give loans at very high interest rates (around 20%) [19]. Local capability: In a country where most of the energy is produced using fossil fuels, no information exists on the advantages of renewable energy, especially in rural regions [20].

Land acquirement: To acquire a public or private land is an expensive process in Iran and takes developers a lot of time [17]. Regulatory framework: The current regulations in place are not comprehensive and also they have not yet been fully tested [17]. Collaboration with other countries: Iranian companies are not able to buy technologies and tools from experienced countries in renewable energies [21].

3. SOLAR POTENTIAL ENERGY IN IRAN

Solar energy is generated as a result of nuclear fusion within the sun. As known, nothing can be compared with the energy potential of the sun. The sun's energy received by each point on the earth surface depends on its latitude and climate. Solar energy is both sustainable and renewable. Considering the depletion probability of solar energy is not necessary. Iran is situated in the world's Sun Belt and possesses an average sun radiation of about 20–30 MJ/m2 per year which is even higher in the central parts [11]. Central-south areas of Iran, including Kerman, Fars, Yazd, Kohkiluyeh va Buyer Ahmad, Chaharmahal va Bakhtiari and Hormozgan provinces experience the higher irradiation rates with the average irradiation of 5.2 to 5.4 kWh/m2/day.

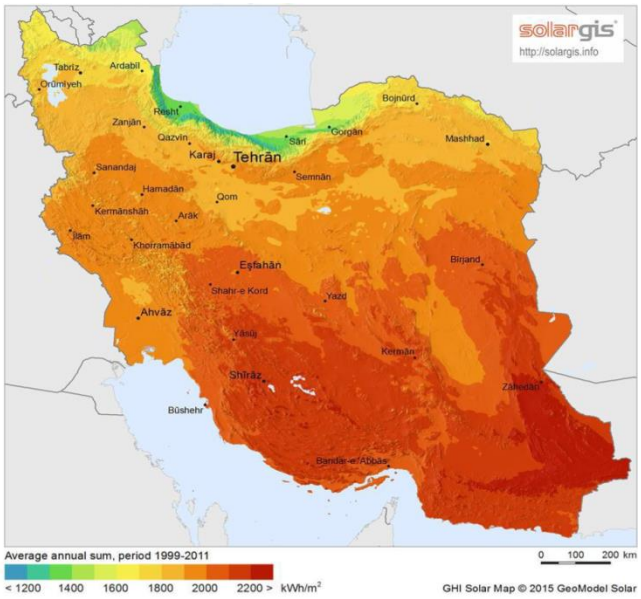

Fig -7: Atlas of solar horizontal irradiation [22]

However, owing to lack of self-cleaning mechanisms in the majority of the solar panel systems, these areas are dry and dusty lands with higher operation cost of PV systems. Solar cells or according to scientists photovoltaic (PV) cells, generate electricity from sunlight directly. PV was named after the light to electricity (photons to voltage) conversion process called PV effect.

Pricing formula and tariff rate for solar energy system in Iran is calculated as the following formula:

Tariff = Base rate*Conversion Rate* Inflation/FX Adjustment Factor* Domestic Manu* Second 10 Year Adjustment

As shown in the following table, the base rate is the agreed tariff rate over time:

Table -1: Solar farm size and base tariff prices. [22]

Solar Farm Size	Base Tariff in Rials	Base Tariff in Dollars
Above 30 MW	3,200	0.10
30 MW and Less	4,000	0.13
10 MW and Less	4,900	0.16
100 KW and Less	7,000	0.22
20 KW and Less	8,000	0.26

The conversion rate is the rate that the farm is producing energy per its capacity. The adjustment rate is a yearly mechanism that can be weighted more towards the change in the central banks EUR fx rate, or the change in the CPI rate's for inflation. Domestic Manu is an additional 30% which the government provides to the rate of the tariff. Also there will be a 30% reduction in a rate of the tariff for the second 10 years. The following process is required to develop the renewable energy project in Tehran (SUNA is Renewable Energy Organization of Iran):

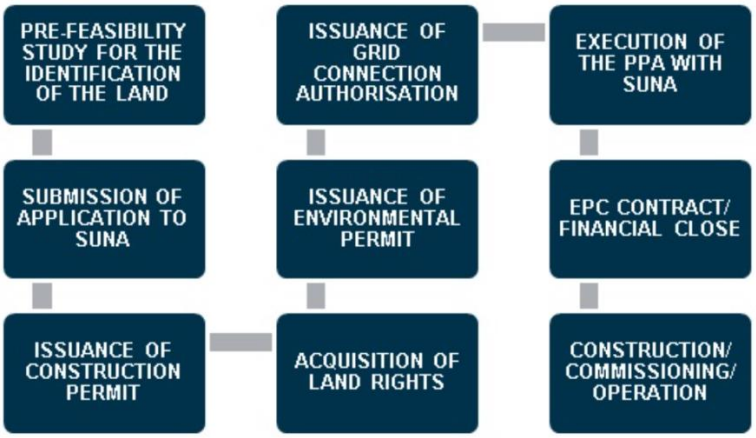

Fig -8: Process of development solar energy in Iran [9].

For solar system to be developed any organization, company, or person should follow these steps. Figure 9 shows some of the solar energy projects in Iran which have been completed:

- 10 kW Photovoltaic Power Plant at "Dorbeed" village in Yazd Province.
- 2 Photovoltaic Power Plant at "Hosseinian" and "Moalleman" village in Semnan Province with the total capacity of 92 kW.
- 250 kW Solar Power Generator in Shiraz.
- 350 units (1400m2) Solar Water Heaters.
- Some of the solar energy projects under construction include:
- 1 MW on-going Solar Power Thermal Plant in Tale- gan-Karaj.
- 45 kW grid connected P.V. in Talegan- Tehran.
- 650 units (2600m2) Solar Water Heaters for domestic use.
- Units (400m2) Solar Water Heater for village public baths.

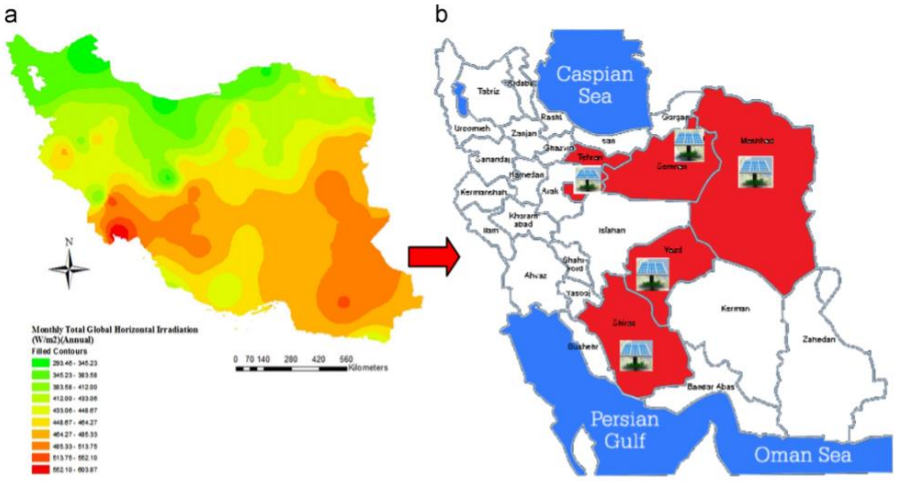

Fig -9: Some of the completed solar projects in Iran. [16]

3.1. Challenges lying ahead the solar energy sector in Iran

To get its potential, the solar energy sector in Iran faces considerable challenges, including high initial installation cost; low efficiency (about 10–20%) in most domestic solar panels (more efficient solar panels can be used at higher prices); lack of comprehensive regulation, collaboration and communication.

4. SOLAR STATUS OF TEHRAN

Tehran city, the capital of Iran with a high population is situated at an altitude of 1190.8 m from the sea level. Based on a study on Tehran province greenhouses, among input energy sources, diesel fuel consumption was found to be the highest with 49.02%–54.17% share [1]. The high amount of fossil energy use is not economically and environmentally appropriate. The yearly average solar radiation in Tehran province is 4.92 kWh m-2 day−1. Considering this great potential in Tehran, by installing solar energy systems, one can achieve economic efficiency and reduction in gas emissions.

Fig -10: Atrin Parsian 2- Tehran solar power plant. [9]

In different regions of Tehran, some of the homeowners have installed solar panels. It helps to decrease greenhouse gas emissions, reduces dependence on fossil fuel, and really helps to improve polluted weather of Tehran.

Fig -11: Solar panels of homes in downtown Tehran.

Most of the streets in Tehran still are using the traditional street lights, but in recent years, Tehran municipality and urban planning department have begun using solar street lighting.

Fig -12: Green light for Tehran streets.

In some rural areas of Tehran, people began using Solar panels. One significant benefit of solar power in rural areas is the increased availability of electricity. Also, it is better for their health because indoor air pollution from burning non-renewable energy sources like wood and coal can kill people.

Fig -13: Using solar panels in Tehran's rural areas.

5. OUTLOOK FOR SOLAR ENERGY IN TEHRAN

Nowadays renewable energy is producing about 3% of electricity in Iran but it has a growth potential of 38% by 2030. It can even be increased to 57% if energy is utilized more efficiently in various sectors [9]. According to Mohammad Behzad, the Iranian Deputy Minister of Energy, the production of solar energy in Iran requires investing $2,000 USD for every KW of electricity to be produced, and for mass production the investment amount can be decreased. Additionally, he announced the Ministry of Energy readiness to purchase energy produced by private sector using solar technologies. Driven by a projected increase in the rate of economic growth following the lifting of sanctions and a growing population, demand for power has increased in the capital of Iran-Tehran. Bringing in much more private investment, the government of Iran is now seeking to invest on its broad potential and is thus giving considerable incentives to these private investors. In recent years, Iran has concluded different solar energies project contracts with European countries like Germany and Italy.

Germans have concluded a contract with Iran to build 500 megawatts of solar projects in Tehran, including 150 MW in Kahrizak, 200 MW in Varamin and 150 MW in Malard. Iran and Italy have clinched a contract on the construction of a solar power station. The agreement for making 100-megawatt power plant was signed between Iran's Industrial Development and Renovation Organization (IDRO) and the Italian Carlo Mascar Company in Tehran on March 3, 2018. Iran's Deputy Energy Minister had recently noted that Iran plans to develop a capacity of more than 1.1 thousand megawatts in renewable sources of energy.

6. CONCLUSION AND RECOMMENDATIONS

As illustrated in Figure 8, the renewables' share of total energy production is increasing rapidly on a global scale. Due to their lower emissions compared to fossil resources, these renewable sources of energy are known to be environmental-friendly. Hence, quick replacement of fossil fuels by renewable resources is recommended by most of the recent energy polices. Emerging policies are more inclined toward renewables in the future; therefore, we will see energy mix suggested by those policies which includes a combination of both fossil and renewable resources, with the gradually increased share of the renewables over time [23].

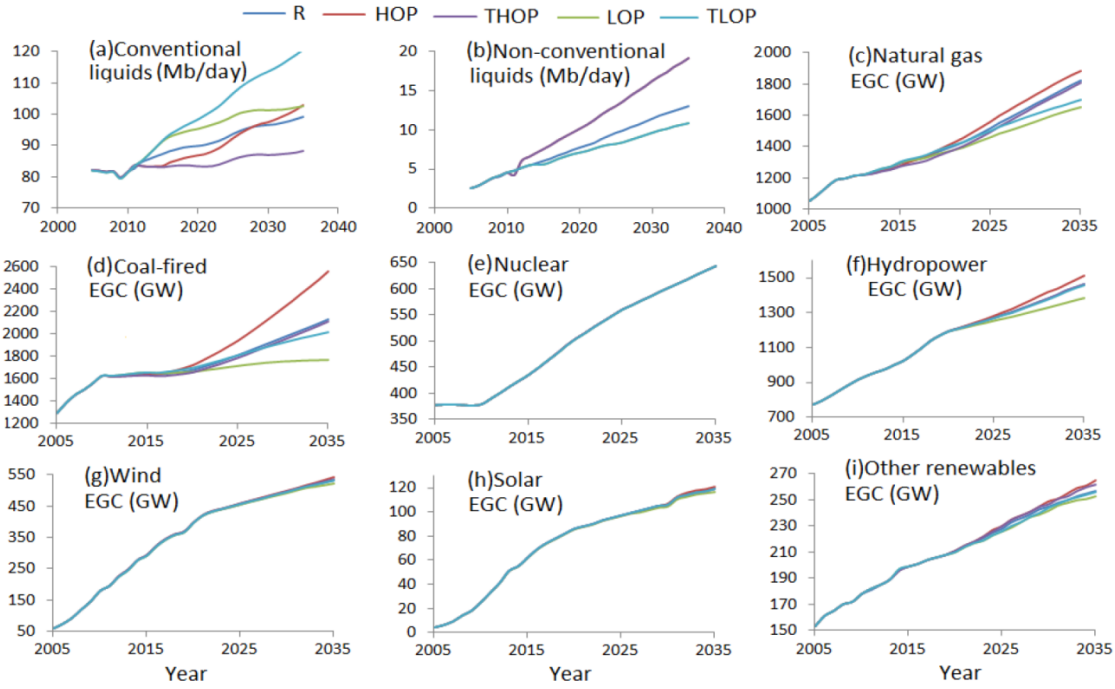

Fig -14: Energy generation capacity, 2005-2035 [23]

Due to the environmental reactions and the limited fuel reserves, the current fossil fuels-based energy model in Iran is not sustainable. Replacing this model with a different, sustainable one requires developing renewable energy sources [25]. As solar energy becomes the economically viable choice for energy production, utilities, building owners, and homeowners are seeing it as the best option for new generation. Considering solar energy, there are vast barren lands in Iran which are most days exposed to intensive solar radiation, thus there are many appropriate places to improve solar energy, including Tehran, Semnan, Shiraz, and Yazd. To put it briefly, this paper presents a review of the development potential of renewable energy in Iran. The results revealed significant potential for solar energy development in various areas of Iran, especially in Tehran. Now, the Iranian government has determined a new target in its 6th Development Plan (2018 to 2030), to be approved by parliament this year, which will consider a 7,500 MW instalment of renewable capacity. This needs to invest more than 2800 million US dollar by 2030. I believe that according to the Tehran's energy consumption and also air population the government can increase the use of solar energy systems.

Finally I recommend to:

Prepare a comprehensive energy plan and force the municipalities, building owners, homeowners, etc. to implement it;

Finance with low interest;

Invite international investors for projects;

Communicate and collaborate with countries using the latest technologies;

Advertise and create culture that values the use of solar energy among people.

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