

WIND AND SOLAR ENERGY DEVELOPMENTS IN IRAN

H. Kazemi Karegar^{a,b}, A.Zahedi^a, V. Ohi^a, G. taleghani^b and M. Khalaji^b

^aDepartment of Electrical & Computer Systems Engineering, PO Box 35, Monash University, Victoria 3800

^bCentre of Renewable Energy Research and Application, North Amir Abad, Tehran/Iran

Abstract

This paper presents the potential for wind and solar energy in Iran and shows how much electric energy is now produced by renewable power plants compared to steam and gas. The importance of renewable energy effects on Iran's environment and economy is also discussed and the issue of the contribution of renewable energy for producing electricity in the future will be shown. Also this paper highlights the ability of Iran to manufacture the components of the wind turbine and solar system locally, and its effect on the price of wind turbine and solar energy.

Key Words: Renewable Energy, Wind Turbine, Solar Energy

1. INTRODUCTION

Iran is known as the second largest oil production member in Organization of Petrol Export Country (OPEC) with production near 3.5 million barrel oil per day and accounts for roughly 5% of global oil outputs. Also, Iran contains an estimated 812 Trillion Cubic Feet (TFC) in proven natural gas reserves, surpassed only by Russia in the world [1].

Electric power generation installed in Iran is about 32.5 Giga Watts (GW) with more than 87% being from thermal natural gas fired power plant. Currently, Iran has five small nuclear reactors used for peaceful purposes. Nuclear and renewable energy will enable Iran to export more gas and oil and increase its revenue, since 80% of Iran's revenue is based on oil and gas export [2].

The biggest environmental issues consequently Iran currently faces are air pollution and carbon emissions. Iran's energy-related carbon emission has been on a steady increase as 240% was added over the past 18 years [3]. The International Energy Agency (IEA) projects world energy demand will grow by 66% and CO₂ emission by 69% between 1995 and 2020, unless new policies are put in place to curb energy use and greenhouse gas emission [4].

Today, the problems of energy are considered as topic discussions around the world and a brief look at energy consumption shows that the progress of a country is directly related to it. Nowadays, most of the world's energy is provided by fossil sources, but some problems such as limitations on fossil sources and environmental effects made by using fossil energies has attracted some attention [5].

2. RENEWABLE ENERGY MOTIVATION IN IRAN

The necessity of renewable energy in Iran can be categorized in two main issues: a) Environmental pollution and b) More oil and gas export.

As mentioned before, the most important environmental problem that Iran faces is air pollution. Since 1980, carbon emission in Iran has increased 240% from 33.1 million metric tons to 79.4 million metric tons in 1998 [3] and is still climbing and has reached 138.6 million metric tons. Fig. 1 shows the carbon emission in Iran from 1980 to 2001.

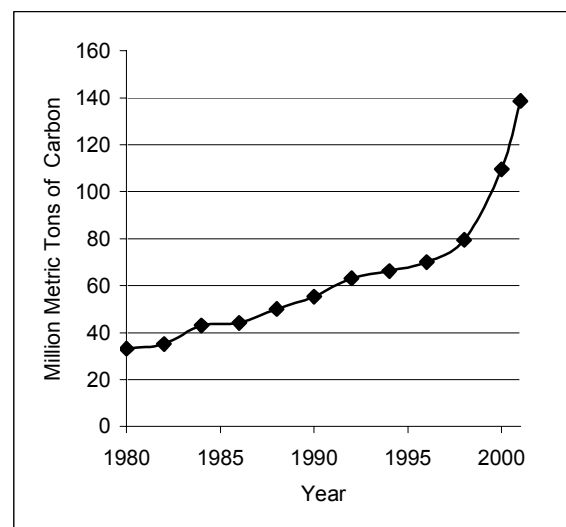


Fig. 1. Iran's Carbon Emission, 1980-2001

As can be seen, carbon emission has rapidly raised from 79.4 million metric tons in 1998 to 138.6 million metric tons in 2001. There are six major source pollutants in Iran, power plants, houses, industries, commercial and agriculture. Fig. 2 shows the contribution of each type in carbon emission.

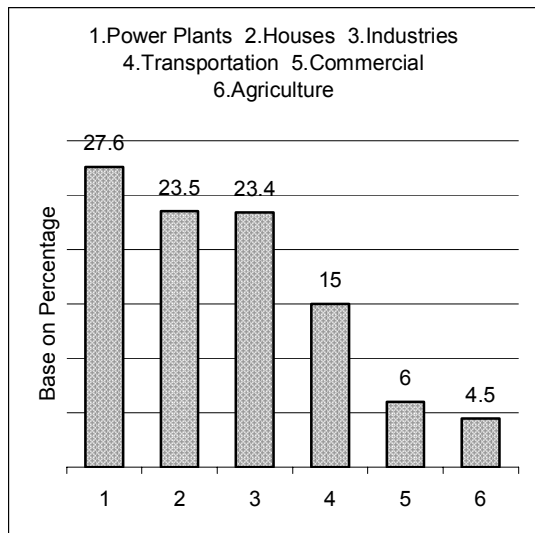


Fig. 2. The contribution of each Pollutant Base on Percentage

Fig. 2 shows that the power plants are the most significant pollutant source at 27.6%. The annual electric production in Iran is 121.6 billion kWh in which 37.5 million metric tons carbon is emitted by power plants [3].

With the nominal installed capacity of 32.5 GW, Iran ranks 21st in the world, but first one among developing nations, followed closely by Turkey [6].

MOE have planned to add an additional 13 GW by the end of 2002, and the government is also planning to increase installed capacity to around 96 GW or 350 billion kWh by 2020 [2]. If all power plants to be installed by 2020 generate electricity using of fossil fuels, they will produce 107.9-million metric tons carbon per year.

Another issue that motivates the use of renewable energy in Iran is the price of fuel for producing electric energy, and exportation, since 80% Iran's revenue is based on oil and gas exportation. A brief look at the oil usage shows that 1.2 million barrels of oil are consumed within the country, and only 2.3 million barrels of oil are exported [1]. The price of electricity and fossil fuel inside the country is much lower than the actual prices around the world. Therefore the government is paying to subsidize electric energy production. The traditional source of fuel for the power plants in Iran had been oil, but it has changed. Now 87% of the electricity is produced by gas, however, 3000 million US\$ are paid as subsidize for the production of 121.6 billion kWh electric energy per year.

Table (1) shows that the price for electric energy production in Iran is 0.035 US\$/kWh by gas and 0.059US\$/kWh by oil,

but the real price in the Iranian market is about 0.00625 US\$/kWh. Therefore, Iran's government pays 3874.4 million US\$ as subsidize or alternatively, 3874.4 million US\$ is deducted from Iran's revenue.

In addition, the harmful effects of fossil fuels such as air pollution, changes in rainfall and climate, force the government to think about the need for renewable energy seriously.

Table (1) The Contribution of Gas and Oil in Production of Electric Energy

Fuel Type	Share in Electric Energy Production (%)	Electric Energy Produced (Billion kWh per Year)	Fuel Price (US\$)	Cost Production (Million US\$)
Gas	87	105.792	0.035	3701.7
Oil	13	15.808	0.059	932.7
Total	100	121.6	-----	4634.4

3. WIND FARMS IN IRAN

The most important aspect of wind energy in Iran is to produce electricity. The potential of wind energy obtained from 26 meteorological sites through Iran and estimated by two organizations, Centre of Renewable Energy Research and Application (CRERA) and MOE, has been set at about 6500 MW

Iran's first experience in installing and using modern wind turbines dates back to 1994. Two sets of 500 kW NORD-TANK wind turbines were installed in MANJIL and ROODBAR. They produced more than 1.8 million kWh per year. These two sites are in the north of Iran, 250 km from Tehran, the capital of Iran. The average wind speed is 15 m/s for 3700 hours per year in ROODBAR, and 13 m/s for 3400 hours per year in MANJIL. After this successful experience, in 1996 the contract for 27 wind turbines was signed and they were installed by 1999 in MANJIL, ROODBAR and HARZEVIL. HARZEVIL is the third wind farm site near to MANJIL. Fig. 3 and Fig. 4 show these three sites in Iran.

Fig. 3 shows the two sites, MANJIL and HARZEVIL. These two sites are 7 km apart at different altitude. MANJIL is about 800 meters above sea level and HARZEVIL is about 500 meters higher. There are 21 installed wind turbines in MANJIL, 1*500 kW, 5*550 kW and 15*300 kW. The output voltage of the 300 kW turbines is 0.4 kV, but it is 0.69 kV for the 500 kW and the 550 kW. All the turbines are connected to a higher voltage level, 20 kV, by step up transformers

In HARZEVIL there is capacity for the installation of 21 wind turbines, 300 kW, 550 or 660 kW. But until now only two turbines have been erected, the rest will be done during the next few years. Both sites, MANJIL and HARZEVIL,

are connected to 20/63 kV substations. These substations produce more stability for wind farms.

All of the wind turbines are grid-connected, asynchronous type and fully controlled and monitored by fiber optic telecommunication systems.

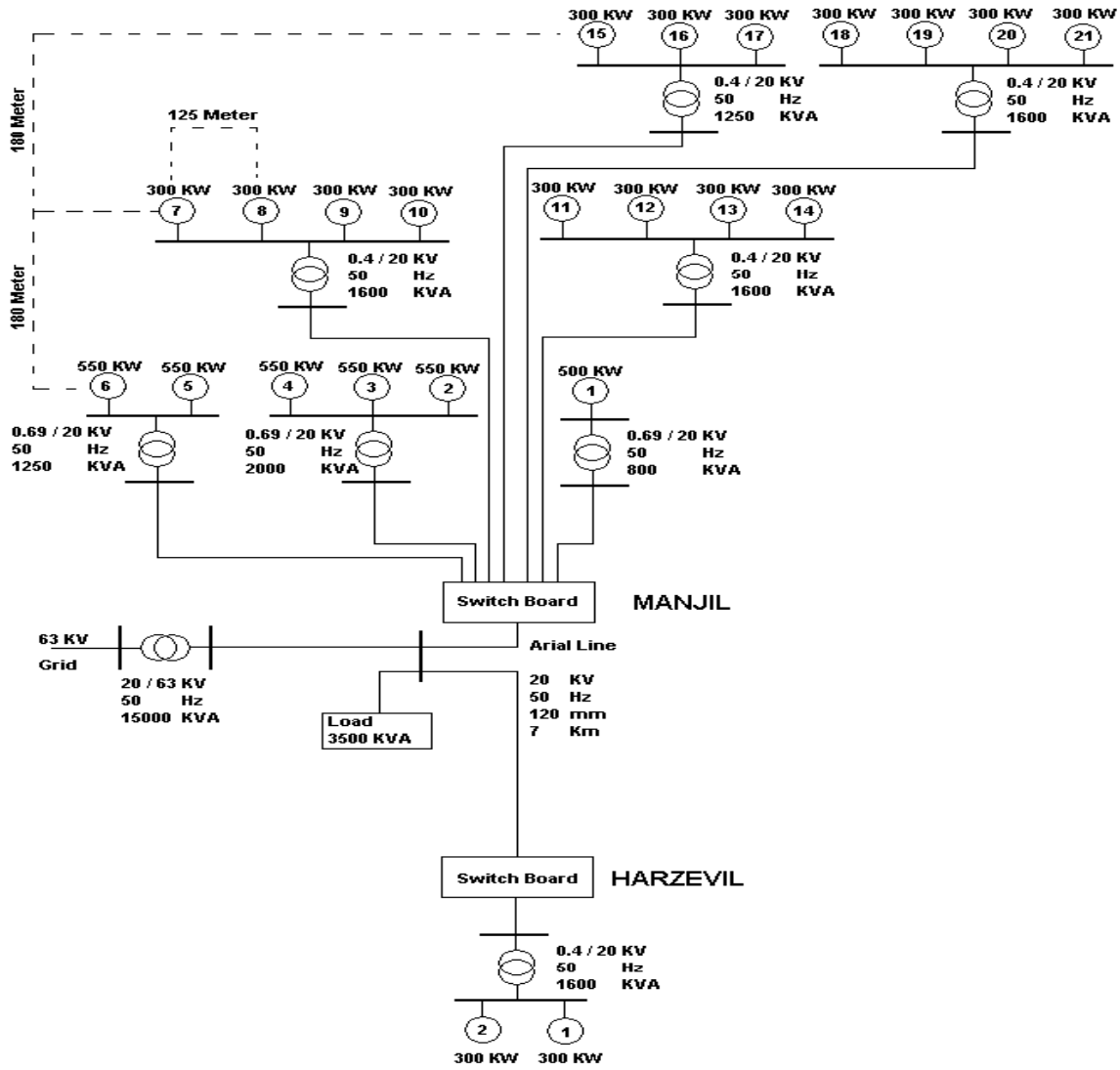


Fig. 3. MANJIL and HARZEVIL wind farm in Iran

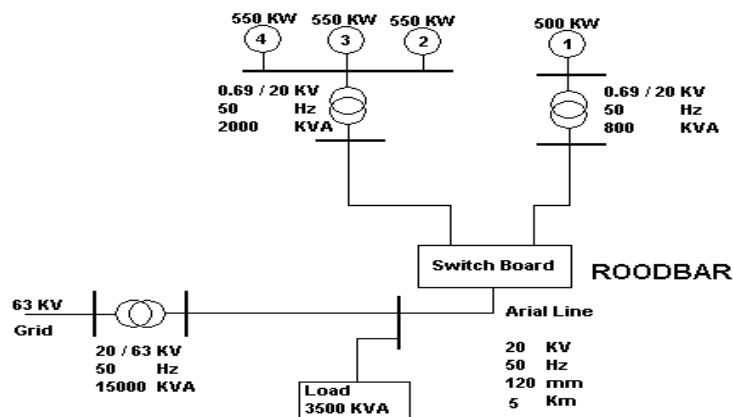


Fig. 3. ROODBAR wind farm in Iran

Fig. 4 shows 1*500 kW and 3*550 kW wind turbines in ROODBAR, and like the MANJIL site, it is connected to the grid.

The wind farms are connected to the grid at 63 kV and transfers any surplus energy to external consumers. When the wind farm is in service or there is insufficient wind, energy can also be imported to the local consumers via the 63 kV connection.

Fig. 3 and Fig. 4 show that the total installed capacity of wind turbines in Iran is 10.5 MW. This makes Iran the 28th largest out of the 46 countries in the world that have installed wind farms.

The percentage of wind farms compared to other power plants is shown in Fig. 5.

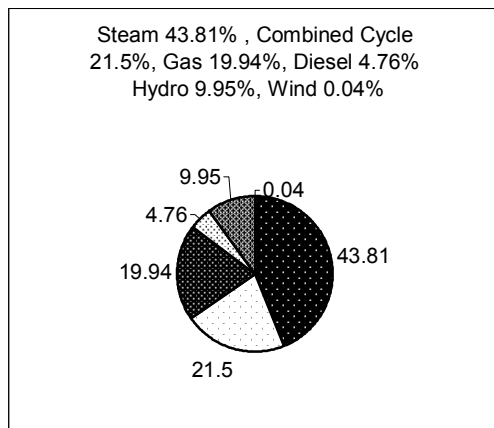


Fig. 5. The production of energy generated in Iran

Fig. 5 shows that the contribution of wind turbines in the production of electric energy is very low, only 0.04 percent, whereas fossil fuel power plants are 89.91%.

The total energy produced since 1994 is about 134.6 GWh, which is shown in table (2). Assuming that the price of electric energy is 0.038 US\$ per kWh on average, then the revenue of the wind energy is 5.1 million US\$ and has prevented the emission of 4.18 million metric tons carbon.

Table (2) shows that all of the 27 turbines in Iran, except two, were made by NEG-MICON. Installation of these wind turbines took 5 years, from 1994 to 1998, but 90.4% were completed during 1996 to 1998. Fig. 6 shows how much wind turbine capacity was installed from 1994 to 1998.

Wind turbines have another affect on industry in Iran, because Iranian industries have the ability to make seven components of wind turbine within the country. These components are: rubber cable, tower, main shaft, nacelle, hub and yaw system. In addition some research is being carried out on making generators, blades and power panels through joint ventures. This ability reduces the price of wind

turbines to about 537.5 US\$/kW, which is less than the world price of wind turbines.

Amendments ratified in parliament two years ago obligate MOE to buy produced electric energy by private investors, including renewable energy, at world market prices.

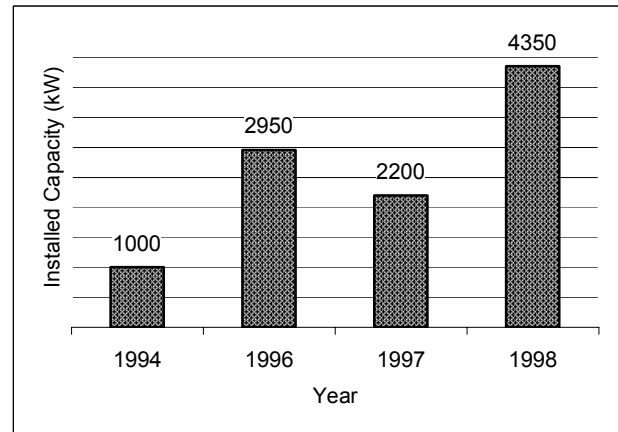


Fig. 6 Installation of Wind Turbine in Iran, 1996-1998

Table (2): Wind turbine in Iran

Site	No.	Manufacture	Year	Size (kW)	Production (kWh)
Manjil	1	NORD-TANK	1994	500	123543101
	2	NEG-MICON	1997	550	5927308
	3	NEG-MICON	1997	550	5449972
	4	NEG-MICON	1997	550	4673184
	5	NEG-MICON	1997	550	5087129
	6	NEG-MICON	1996	550	6048802
	7	NEG-MICON	1996	300	4186575
	8	NEG-MICON	1996	300	4392930
	9	NEG-MICON	1996	300	4477013
	10	NEG-MICON	1996	300	3868216
	11	NEG-MICON	1996	300	4624573
	12	NEG-MICON	1996	300	5054637
	13	NEG-MICON	1996	300	4833509
	14	NEG-MICON	1996	300	3747066
	15	NEG-MICON	1998	300	3545834
	16	NEG-MICON	1998	300	2675029
	17	NEG-MICON	1998	300	2867122
	18	NEG-MICON	1998	300	3821132
	19	NEG-MICON	1998	300	3002350
	20	NEG-MICON	1998	300	3869586
	21	NEG-MICON	1998	300	3788864
Roodbar	1	NORD-TANK	1994	500	14217435
	2	NEG-MICON	1998	550	6226583
	3	NEG-MICON	1998	550	6446298
	4	NEG-MICON	1998	550	6020263
Harzevil	1	NEG-MICON	1998	300	2386049
	2	NEG-MICON	1998	300	988071
Total	27			10500	134580840

4. SOLAR ENERGY IN IRAN

The average solar radiation for the whole of Iran is about 19.23 Mega joules per square meter, and it is even higher in the central part of Iran. The variation of radiation varies from 2.8 kWh/m² in the south-east part to 5.4 kWh/m² in central region. The calculations show that the amount of useful solar radiation hours in Iran exceeds 2800 hours per year.

For this reason, the first Photovoltaic (PV) site, with capacity of 5 kW DC was established in the central region of Iran in Doorbid village Yazd in 1993. Following this, in 1998, the second photovoltaic site with 27 kW AC capacity was installed in Hosseinian and Moalleman villages in Semnan 450 Km inland from Tehran. The capacity of these power plants has recently increased to 10 kW AC and 92 kW AC respectively.

The power plant installed at Doorbid, works independently from the grid system, while the one installed at Hosseinian and Moalleman, is connected to grid. It is worth mentioning that all equipment of these sites is made in Iran. Table (3) shows a list of PV projects that have been conducted in Iran.

Table (3) Solar projects in Iran

Project	Place	Start Year	Capacity (kW)	Agency
PV Site	Yazd	1993	10	CRERA
PV Site	Semnan	1998	92	CRERA
PV Site	Khorasan	1998	3.5	MOE
PV Pump	Tehran	1996	3.5	CRERA
PV Pump	Tehran	1998	3.5	MOE

As can be seen from table (3), using solar energy to produce electricity in Iran is not very popular and the price of these type of sites is relatively high at about 3500 US\$/kW. But there are some projects designed to use solar energy combined with thermal power plant to produce electric energy. These projects were under consideration since 1999 and will be explained in more detail in the next section.

5. FUTURE OF WIND AND SOLAR ENERGY IN IRAN

Initially, Iran planned to install 13000 MW of additional capacity by the end of 2002, but it seems unlikely. A realistic outcome is the addition of 8600 MW by the end of 2002, of which 3700 MW will be realised through hydroelectric power plants. With regards to the 6-8% growth in the electric energy demand in Iran, 5000 MW capacities should be installed each year, eventuating in the installation of 23600MW by 2005.

The government has projected an installed capacity of about 96000 MW or 350 billion kWh by the 2020. The Future of

wind and solar energy in Iran at 2005 is shown in table (4) and table (5).

Table (4): Future Wind Energy Projects in Iran

Project	Turbine Type
3.3 MW	300 kW
5.5 MW	550 kW
6 MW	660 kW
25 MW	660 kW
60 MW	660 kW
100 MW	660 kW

Table (5) Future Solar Energy Projects in Iran

Project	Capacity
Solar Power Plant (Combined-Taleghan)	250 kW
Solar Power Plants (Combined-Yazd)	100 MW
Central receiver system	1000 kW

Table (4) shows that a total of 199.8 MW of wind farm will be installed in Iran by a 2005, of which, 10*550 kW and 11*300 kW are going to be installed by 2003. It is worth mentioning that Global Environmental Facility (GEF) supports the 25 MW project and the 100 MW project is supported by the government as a joint venture with VESTAS to build blades and generators within Iran.

Table (5) shows that 101.25 MW of solar energy projects with combined cycle steam power plants will be erected in Iran.

If it is assumed that 23600 MW will be added to the capacity of Iran by 2005, then 1.7% of it will be renewable energy. Included in this calculation is a 100 MW geothermal site that has been added. The contribution of each source for producing future energy in Iran is shown in Fig. 7.

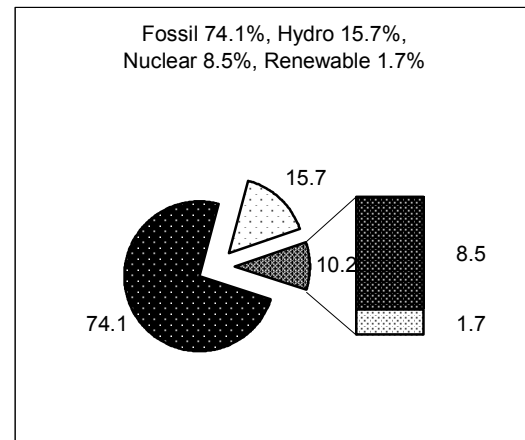


Fig.7 The contribution of various power plants to future energy in Iran

Fig. 7 shows that 8.5% of increased electric energy will be supplied by nuclear, 15.7% by Hydro, 74.1% by fossil and 1.7% by wind, solar and geothermal power plants.

6. CONCLUSION

The potential of wind and solar energy is about 6500 MW and 19.23 mega joules per square meter in Iran. From 1994 to 1998, 10.5 MW of wind turbines have been installed and more than 134.6 GWh electricity has been produced by them. By this amount of production, wind turbines have prevented 4.18 million metric tons of emission of carbon around the world and 5.1 million US\$ has been added to the revenue of Iran. In addition, because of the ability of Iran to make some parts of wind turbine, the price has dropped to 537.5 US/kW for a nominal 550 kW type. By 2005, 23600 MW of total installed generation will be added, 1.7% of it will be based on renewable energy power plants consisting of wind, solar and geothermal sources.

7. REFERENCES

- [1] Energy Information Administration, "Iran energy oil information", Feb. 2000.
- [2] Energy, "Power Projects and Services Market in Iran", Energy-Iran-Profile, Feb. 2001.
- [3] Energy Information Administration, "Environmental issues", Feb. 2000.
- [4] Energy Information Administration, "World energy prospects to 2020", Feb. 2000.
- [5] BTM Consultant, "International Wind Energy Developments", ASP-Denmark, 2000.
- [6] Windicator," Wind power monthly", Feb. 2002.