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STATUS OF RENEWABLE ENERGY SOURCES IN IRAN

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ABSTRACT
There is a great deal of international concern for energies problems in developing countries, with regards to the renewable form of energies is highly suitable for developing countries e.g. sun, wind etc. renewable energies sources are becoming attractive solutions for clean and sustainable energy needs for Islamic Republic of Iran. Renewable energy is being used for electricity production and it has direct usage in Iran. The use of renewable energy in recent years has reached a remarkable edge. The continuous research for an alternative power source due to the perceived scarcity of fuel fossils is its driving force. It has become even more popular as the cost of fossil fuel which continues to rise. Its application was proven to be most economical, as most systems in individual uses requires but a few kilowatt of power. Iran has substantial human and material resources to renew its energy supply and to co-ordinate the transition to a sustainable energy system. There are good situation for the profitable use of wind energy and also hydro power energy as well as a perfect setting for the use of solar energy. However, a change of the energy system requires that existing deficiencies and obstacles will be worked out and discussed in a clear, frank and dependable manner. The present high levels of subsidization of energy prices prevent a market growth in favor of energy competence technologies and renewable energy sources. This paper focuses on various aspects of renewable energy sources with references to Iran and it shall be highly useful to planners, administrators and researchers.

Keywords: Renewable Energy, Sustainable Energy System,

INTRODUCTION

By 2030 growing economies will have turn into the major emitters of CO2. Shifting public and private sector investment in those countries towards a more sustainable expansion pathway is therefore a major worldwide policy purpose. The growth of renewable energy and energy efficiency, collectively known as clean energy, is seen to be a key area by which emissions can be decreased. This would help mostly the energy supply sector progress from its fossil-fuel dependence for energy production. Much interest has been given to the public support needs for adaptation in developing countries. Yet, similar support challenges exist for alleviation, where it is recognized that the private sector will probable play a dominant role in new investments and financial flows (Birel, 2009).

International renewable energy markets have grown-up enormously in the past decade. Few citizens realize that some forms of renewable energy have turn out to be huge business. This development has been driven most importantly by supportive national and local policies, many of which have impressively overcome the barricades that continue to put renewable energy at a competitive disadvantage to fossil fuels. Aggressive technology developments and cost reductions, good market information, growing consciousness of global climate change, local environmental concerns, and rural development needs in the poorest countries have also been significant drivers of this development. To put these numbers in some outlook, yearly investment in conventional power creation is on the order of $100-150 billion (matching in rough numbers to an aggregate expansion rate of 2.5%). So renewables' $17 billion yearly investment is highly important even though installed renewable energy capacity—about 100 Gigawatts (GW)—still makes up only 3% of universal installed power generation capacity (Martinot, 2004). This paper reviews Iran renewable energy policy, Iran renewable energy Investment opportunities and Iran renewable energy technology have been discussed in this paper.

IRAN'S RENEWABLE ENERGY POLICY

Iran is known as the second major oil production member in Organization of Petrol Export Country (OPEC) with production near 3.5 million barrel oil per day and accounts for approximately 5% of international oil outputs. Also, Iran contains an estimated 812 Trillion Cubic Feet (TFC) in proven natural gas reserves, surpassed only by Russia in the world (EIA, 2007). 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. Presently, 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. The biggest environmental issues consequently Iran presently faces are air pollution and carbon emission s. Iran's energy-related carbon emission has been on a steady increase as 240% was added over the past 18 years. The International Energy Agency (IEA) projects world energy require 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 . Today, the problems of energy are considered as topic conversations 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 difficulties such as limitations on fossil sources and environmental effects made by using fossil energies has attracted some attention (Karegara, A.Zahediaa, Ohis, taleghanibb, & Khalaji, 2002).

Iran has substantial human and material resources to renew its energy supply and to co-ordinate the transition to a sustainable energy system. Furthermore, Iran has a high amount of renewable energy sources: there are good situation for the profitable use of wind energy, very good opportunities for the addition of water power use as well as a perfect setting for the use of solar energy. However, a change of the energy system requires that existing deficiencies and obstacles will be worked out and discussed in a clear, frank and dependable manner. The present high levels of subsidization of energy prices prevent a market growth in favor of energy competence technologies and renewable energy sources.

These quite serious problems want a community debate to sensitize the Iranian people and the political representatives in order to look for solutions. Luckily, a public debate on these issues was initiated in 2004, for the first time, in the parliament as well as in the media. Many experts and politicians criticized the energy subsidization policy of the government and plead for more targeted subsidies for low-income families and parts of the industry instead of a general subsidization of energy prices. The Iranian Energy Efficiency Organization (SABA) developed a programme that expected at increasing energy competence. Other institutions in the energy sector such as the energy ministry discussed alternatives to the present form of energy consumption. The municipality of Tehran developed ambitious plans to officially stop the development of wasteful car fleet in Tehran. These and other steps are positive signals that indicate a increasing awareness for a structural change in the energy system in Iran. In fact, Iran has substantial human and material resources that allow it to manage the change towards sustainable energy productions and consumption models so improving the living situation of the Iranian people through the decrease of pollutants but also yielding economic benefits (Abbaspour, 2005).

INVESTMENT OPPORTUNITIES ON IRAN'S RENEWABLE ENERGY

Iran's diverse geography is well suited to a varied and wide use of renewable energy sources: hydro and geothermal in the western and northern regions, wind in the southern and eastern plains, and solar energy in the southern and central regions (Table 1).

Table 1: Potential for new renewable energy sources in Iran

Technology	Potential	Projected capacity 2030
Wind Energy	6,500Mwe	2,000 Mwe
Biomass	22,000 MWth	N/A
Geothermal Energy	1,000 MWe	260 Mwe

IEA, 2005; WUPPERTAL INSTITUT, 2006.

Until now this prospective has remained limited to a modest boost in the use of hydroelectricity; otherwise there are no plans for a major investment in renewable energy at present. Since the electricity acquire price from renewable energy sources has been newly increased, it is an advantageous market for renewable energy. The electricity id purchased during a Power Purchase Agreement (PPA) signed with Iran Renewable Energy Organization (IREO) which is the administrative arm of Ministry of Power, for a 20-year period under Take or Pay scheme backed by Letter of Credit. Existing imbalance in supply and demand for electricity in Iran has led to special blackouts in some parts of the country during current times. Considering the significance of electricity in the economy and daily life, the government has given top priority to power generation projects. All foreign investment in Iran is covered by Foreign Investment Promotion (www.investiniran.ir) against political risks (Karbassi, Abdulia, & Abdollahzadeh, 2007).

Hydroelectricity:

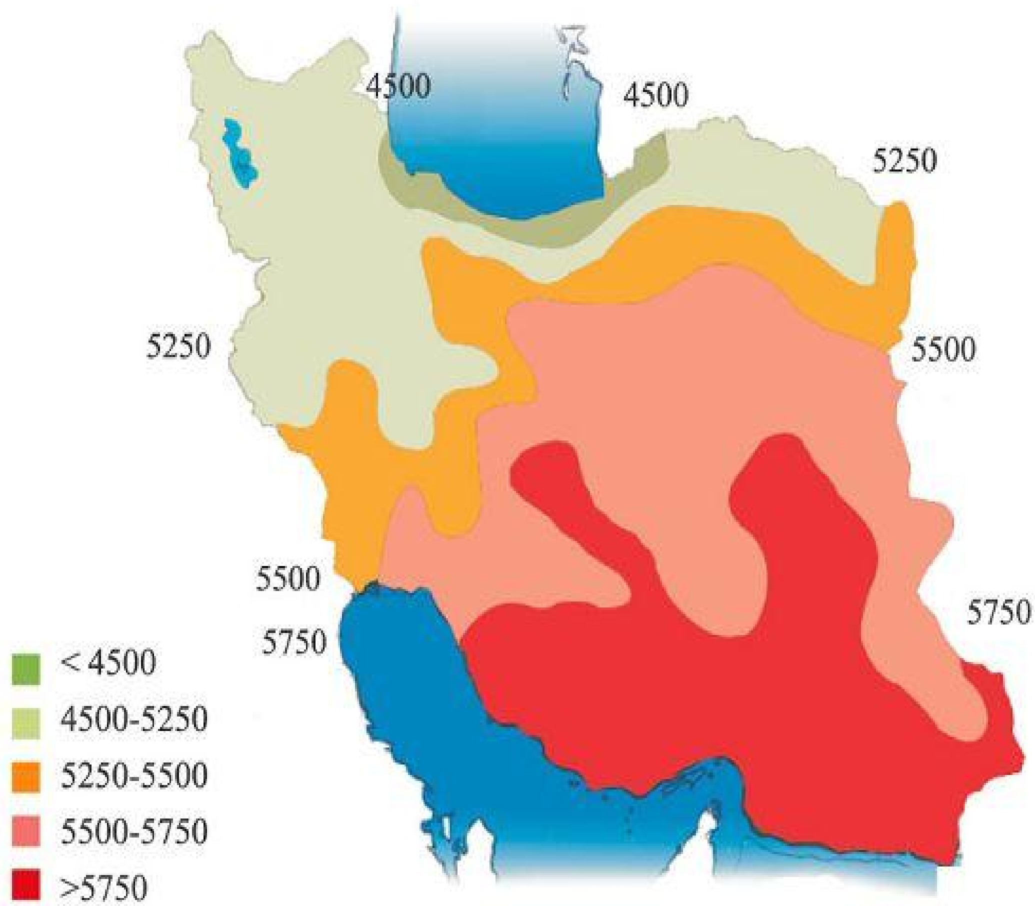
In Iran's modest renewable energy story to date, hydroelectricity is the famous exception. Iran is obviously investing important resources in its growth. The country has an expected potential for hydroelectric power generation of between 23 and 42GW. In 2003 Iran generated 11,098GWh of hydroelectricity. By 2007 the seven hydroelectric power plants being constructed should be generating over 8GW of electricity – more power than all Iran's other power generation projects at present being developed combined. With additional expansion planned, the government hopes to be generating 14GW by hydroelectric power by 2021 (representing 20% of Iran's projected electrical capacity) (Ingram & Spagnuolo, 2008).

Solar:

The prospective for solar electricity generation in Iran is almost unlimited. Iran is just outside the tropic of Capricorn and much of the country experiences high levels of solar energy, a daily average of between 5.0 and 5.4 kW h/m in the south of the country This gives a power generating ability of approximately 0.5kW /m of solar paneling, or 500MW /km (see Figure1).

The deserts of Iran occupy a quarter of the entire land area; if only one per cent of the desert area was covered by solar PV collectors, the energy acquired would be five times more than the existing annual electricity consumption in Iran. Mostly suitable areas for solar thermal power plants have been selected for future construction at Yazd, Fars, Esfahan and Kerman. The first Iranian Solar Thermal Power Plant is due to be constructed at Yazd. With enough investment and a serious commitment, the potential is vast. Solar thermal systems on the roofs of buildings have a lot of virtues, not least that more primitive proposes can be installed with economical and freely available plumbing components with limited expertise, and provide important return in energy savings. A study of the economic feasibility for household solar water heating systems around Iran was published in 2000, but the technology remains unexpectedly underutilized. The total cost of installing a full domestic solar central heating and hot water system in Iran is expected at 80m Rials (roughly $9,000). If all the public buildings in Iran were fitted with solar panels, the cost could be as little as 45,000 Rials/m2 (Geyer, 2009).

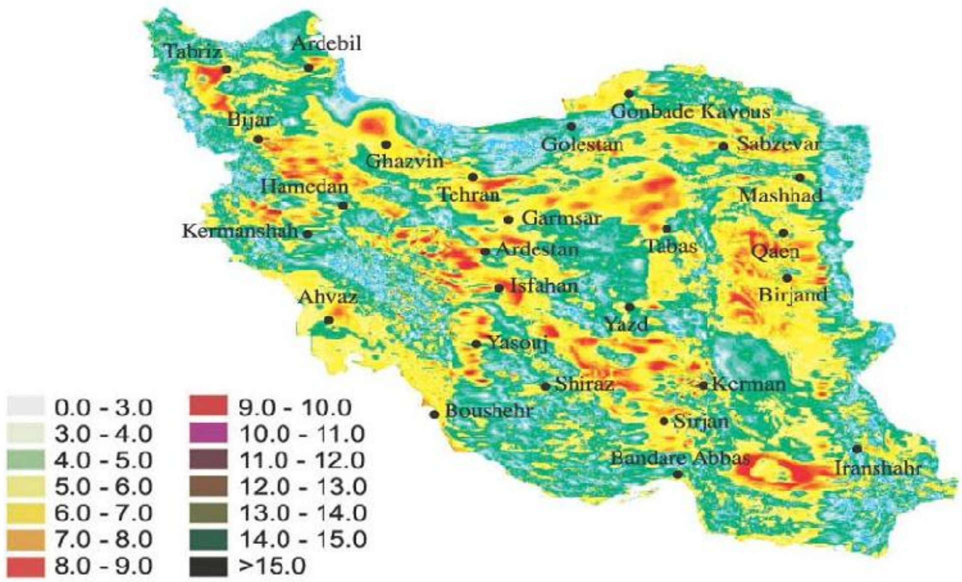
Figure 1: Solar Radiation in Iran (*www.helio-international.org/reports/pdfs/**Iran**-EN)*



Wind, Biogas and Geothermal

Iran's potential for wind energy is expected to be around 20,000 MW power (See Figure2). So far a very small part of that capacity has been utilized, creating a huge available market. Wind energy for electricity generation and water pumps holds a big deal of guarantee in the east of Iran. The wind potential has been studied in 45 investigational sites.Each year Iranian people produces 15m tonnes of community waste and 4.6bn m of urban and industrial dirt (with a collection and burial cost of $225m). Biogas technology presents a significant energy potential. Indeed, the use of biogas in Iran has gradually grown over the last 30 years but its potential remains largely unexploited. Biogas is a by-product of the domestic waste stream, and does not require complex high-technology for its extraction. Iran has large geothermal potential. It has been estimated that Azarbaijan, Damavand, Meshikin-shahr and Sabalan could produce 7.5GW of electric power. Geothermal exploration was started in Iran by Ente Nazional per l'Energia Elettrica of Italy (ENEL) and the Ministry of Energy 35 years ago in 1975. After the establishment of the Electric Power Research Center (EPRC) and the Renewable Energy Organization of Iran (SANA) 1990, a new round of exploration activities began. In 1995, SANA started to explore other sites for geothermal potential (Ghobadiana, Najafia, Rahimia, & Yusaf, 2009).

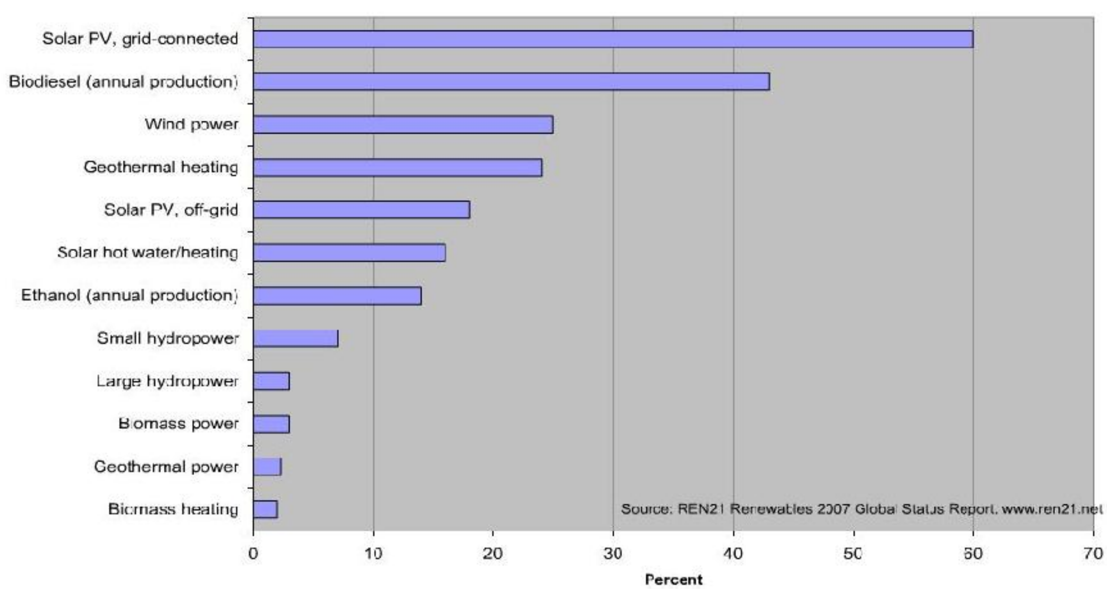
Figure 2: Map of Iran Wind Potential at 80m above the Ground Level
(www.helio-international.org/reports/pdfs/**Iran**-EN*)*



IRAN'S RENEWABLE ENERGY TECHNOLOGIES

Renewable energy technologies, mainly hydropower, solar thermal, traditional biomass and wind, are well established in world markets (or are fast establishing themselves, e.g. photovoltaic), and have established industries and infrastructures (see Figure 3. Average Annual Growth Rates of Renewable Energy Capacity). Other renewables are fast becoming competitive in expanding markets, and some have already become the lowest cost opportunity for stand-alone and off-grid requests. The investment costs for many renewable energy technologies have been divided over the last decade and are estimated to halve again over the next decade. The following part describes the main technologies, including a review of their key attributes and the value they bring to the energy system.

Figure 3. Average Annual Growth Rates of Renewable Energy Capacity, 2002–2006



Wind Energy Technology

Wind energy is measured one of the most hopeful technologies for electricity generation. Its recent deployment has been one of the fastest growing renewable technologies worldwide. Technical progresses over the past two decades, united with new marketing, have expanded capacity from around 2,000 MW in 1990 to 121,181 MW by 2008 and out of which 27'261 MW were added in 2008. Wind turbines are seen to be gradually more competitive with conventional generating sources. They can be used as individual turbines or combined in wind farms. They can supply into electricity grids (either from large wind farms or individual producers) or used in stand-alone, off-grid applications. Costs have come down significantly over the past decade and are now considered commercially viable in many situations.

Wind turbine systems can be stand-alone or for grid-based electricity. Wind turbines come in a variety of sizes that can be as small as a few kilowatts, although the normal new turbine is over 500 kW with a growing number exceeding 1 MW. Turbines have recently been getting larger as importance in wind farms increases. However, in some parts of the IEA region, small turbines for individuals are becoming more popular. They are important in inaccessible regions, including islands and cold climates. Landowners can also make money by leasing land for wind farms. Using wind turbines for mechanical pumping for irrigation and watering cattle is particularly important in developing countries.

In 2008, Iran generated 85 megawatts of electricity from wind power, being ranked 30th in the world. Wind power in Iran has been experiencing a development in wind generation in current years, and has a plan to significantly increase wind generation each year. Iran is the only center producing wind turbines in the Middle East. In 2006, Iran generated 45 megawatts of electricity from wind power (ranked 30th in the world). This was a 40% increase over 32 megawatts in 2005. Total wind generation in 2004 was 25 megawatts out of 33,000 megawatts total electrical generation capacity for the country. In 2008, Iran's wind power plants in Manjil (Gilan province) and Binaloud (in Khorasan Razavi province) produce 128,000 megawatts of electricity per year. Iran is a member of the Global Wind Energy Council (Krupp & Earth, 2008).

The government of Iran has recently accepted to increase the purchase tariff for electricity generated by renewable energies from an average of 620 rial (6.3 USD cents) per Kwh to 1241 rial (12.65 USD cents), a hundred percent increase. In addition, during last few years, Iran's Ministry of Power has made significant strides to develop the essential legal and financial infrastructures required for development in wind power sector in Iran. The arrangement of these two major factors along with many other advantage points found has significantly improved the forecast for investment in this field. The electricity is purchased through a Power Purchase Agreement (PPA) signed with Iran Renewable Energy Organization (IREO) which is the executive arm of Ministry of Power, for a 20-year period under Take or Pay scheme backed by Letter of Credit. Present imbalance in supply and demand for electricity in Iran has led to occasional blackouts in some parts of the country during recent times. Considering the importance of electricity in the economy and daily life, the government has given top priority to power generation projects. Some of the most important projects being implemented in the country in the field of wind energy are the Manjil and Paskulan, Rudbar, Harzovil, Siyahpush, and Binalud wind power plants. In addition the country's wind atlas is being drawn up and a 60-MW wind power plant is being constructed (Moj, 2008).

Solar Thermal Heating and Cooling Energy Technology

Solar thermal technologies, which supply hot water and heating for residential, commercial and industrial end users have a long history of commercial purpose. Several million hot water systems have already been sold worldwide. They have been used widely in building design and hot water heating, which are considered the easiest and most direct applications of solar energy. Solar space heating systems can be either water systems or air heating systems. The technologies are well developed for many of the applications, although more cost declines to improve competitiveness are still being accomplished. They are measured cost valuable in countries with favorable climates, for example those under 40 degrees latitude, and increasingly there are new applications that are also cost effective above 40 degrees latitude. Expansion in the installation of new systems is strong, expected at between 10 and 30 per cent per year, depending on the country anxious. Solar thermal systems have verified popular for a variety of special-purpose markets, e.g. for heating swimming pools, where there are between 1 and 2 million m2 of collectors installed worldwide. Solar thermal systems provide hot water or cooling in hotels and other service areas such as hospitals where hot water consumption is high (Melanie, 2008).

One of the major benefits of solar thermal systems is that there are no discharges. This is particularly beneficial for solar cooking as it avoids covered air pollution, a main health concern in developing countries. Solar cooking is also significant in areas where there is growing scarcity of firewood or other opportunities. However, one of the limits of solar cookers is that they can only supplement, and not fully replace, other cooking systems. It is expected that they save a third to a half of conventional fuel used for cooking Solar systems can be installed in most types of buildings throughout the world and they can easily be installed during renewal of existing buildings. Solar desalination is significant because around 30,000 square kilometres of land are taken out of use yearly due to salt levels in the ground being too high. Solar region heating can be an attractive way of supplying solar heat to existing region heating systems. An improvement is that they can be combined with other sources of energy. By including seasonal storage, as much as 50-70 per cent of the heat can be supplied by solar energy in countries with sensible climates (Dincer & Rosen, 2001).

The Shiraz solar power plant in Iran boasts a modest 250 KW energy production ability. It's a solar thermal plant that uses parabolic mirrored troughs to gather sunlight. The mirrors focus the sunlight in an intense ray on a tube that runs the length of the array of mirrors. Inside the tube, a liquid insulated by a vacuum transfers the heat of the mirrors to a traditional generator, where it's used to produce steam and produce electricity. Placing a financial worth on renewable resources makes sunny Iran rich in solar energy potential. Iran took its first footstep toward the large level recognition of that prospective with the installation of its first solar energy plant. The plant was constructed with domestic materials and labour in Shiraz, the Fars province. This solar thermal plant joins some 4,075 small scale solar thermal installations throughout

Iran–3,781 residential solar water heaters and 294 public baths heated with solar thermal energy (Williams, 2008).

Hydropower Energy Technology

Hydropower is the majority grown-up form of renewable energy and accounts for an important share of electricity generation in the world. It is mostly used for base load generation and can be used for peak power production. Hydropower represented about 18 per cent of world electricity production in 1997. Most hydropower comes from huge hydro dams (greater than 10 MW). In 1997, only around 3.5 per cent of hydroelectricity came from small hydro plants. However, growing focus on the prospective and advantages of small hydropower has led to increasing interest to refine the technology and cut site costs. Hydropower is mainly used for electricity production. Hydroelectricity causes no direct emissions; it is easy to fast adjust the amount of power produced in reaction to shifts in demand. When power is not needed, huge amounts of energy can be stored in high-level reservoirs, in so-called pumped storage. This can enhancement intermittent power produced from other renewables, such as wind or solar. Hydropower operates effectively in regulated as well as in de-regulated markets, such as in the Nordic region (Koch, 2002).

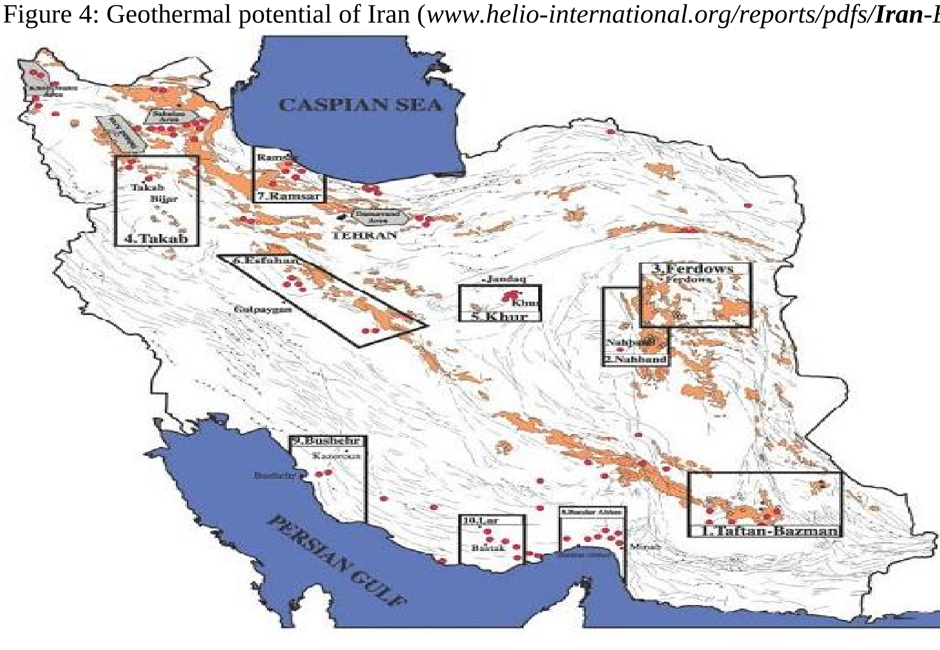
There are some disadvantages because hydro dams can influence water flow, fish spawning patterns and flood substantial areas of land. Initial construction costs of large hydro can be a obstacle. These difficulties have often made big hydro schemes controversial. Electricity production can be affected during periods of reduced or drought precipitation but these factors are often expected and thus practically well managed. Subsidiary benefits can include recreation, flood controls and irrigation. Because of the range of hydro system capacities, they can be sized according to the accessible resources as well as the needs of the consumer (Welcomme & Marmulla, 2008). Small hydro is a plain technique that is easy to preserve and is well suited for distributed or stand-alone production.

Iran has been focused on meeting higher require mainly through growing combined-cycle and hydroelectric power. However, a severe drought during late 2007 and early 2008 unfavorably affected Iran's hydroelectric production, leaving water reservoirs emptied during the summer peak require season, resulting in a drop of nearly 70 percent in hydroelectricity power generation. This has brought into question Iran's aptitude to complete its domestic power compulsions, let alone its export obligations (Marcon, 2007). Therefore, as of late 2007 some 85 water dams were under construction.

Geothermal Power and Heat Energy Technology

Geothermal is used for power generation or space heating. Electricity generation by geothermal is a baseload technology, and can be a low-cost opportunity if the hot water or steam resource is at high temperature and close to the earth's surface. With more than 70 years of commercial application, the technology is well established and commercially feasible. The use of geothermal is expanding, increasing between 1975 and 1995 by around 9 per cent per year (for electricity production) and 6 per cent per year (for direct use). Over 46 countries are at present exploiting geothermal power and heat wherewithal. The largest capacity gains through the 1990s were in the Philippines and Indonesia but they still trail the United States in total installed capacity. The use of heat pumps is becoming more accepted in countries such as the United States. Emissions can result from geothermal production, including carbon dioxide and hydrogen sulphide, but they are measured to be much lower than emissions from fossil fuels. Brines can be produced in sedimentary basins, which are re-injected into the reservoir (Kose, 2007).

Figure 4: Geothermal potential of Iran (*www.helio-international.org/reports/pdfs/**Iran**-EN)*



Interest in geothermal energy originated in Iran when James R. McNitt, a United Nations geothermal expert, visited the country in December 1974. In 1975, a contract among the Ministry of Energy, ENEL (Entes Nazionale per L'Energia Elettrica) of Italy and TB (Tehran Berkeley) of Iran was signed for geothermal exploration in the north-western part of Iran. In 1983, the result of investigations defined Sabalan, Damavand, Khoy-Maku and Sahand regions as four prospected geothermal sites in north-western Iran. From 1996 to 1999, a countrywide geothermal energy resource exploration project was carried out by Renewable Energy Organization of Iran (SUNA) and 10 more potential areas were indicated additionally. Geothermal potential site selection using Geographic Information System (GIS) was carried out in Kyushu University in 2007. The results indicated 8.8% of Iran as prospected geothermal areas in 18 fields. Sabalan as a first priority of geothermal potential regions was selected for detailed explorations. Since 1995, surface exploration and feasibility studies have been carried out and five promising areas were defined (See Figure 4: Geothermal potential of Iran. Among those prospective areas. Northwest Sabalan geothermal filed was defined for detailed exploration to justify exploration drilling and to estimate the reservoir characteristics and capacity. From 2002 to 2004, three deep exploration wells were drilled for evaluation of subsurface geological conditions, geothermal reservoir assessment and response simulation. Two of the wells were successful and a maximum temperature of 240 °C at a depth of 3197 m was recorded. As a result of the reservoir simulation, a 55-MW power plant is projected to be installed in the Sabalan field as a first in geothermal power generation. To supply the required steam for the geothermal power plant (GPP) 17 deep production and reinjection wells are planned to be drilled in 2009 (Younes, Hossein, Ryuichi, & Sachio, 2009).

CONCLUSIONS

Renewable energy today provides a plentiful array of technologies to keep happy a wide range of energy needs. For those technologies that are previously commercially available, the markets are practically robust. While the overall share of renewable energy has not changed meaningfully in the collection, the technologies are competing in an increasingly dynamic energy environment and are learning to compete well. While acknowledging that those renewable energy with great future prospective still require considerable R&D, it is worth noting that they have previously established to be theoretically feasible. Given that renewable energies are needed to build a diversified, sustainable and secure energy system in the long term, these R&D efforts should be sustained and even improved.

Ecological and geographical characteristic of Iran is well suited to a diverse and extensive use of renewable energy sources. Also, demographic diverstity (Large population in scattered and remote areas with different climates) dictates the application of all the sources of renewable energy in iran for a better and equitable access to energy. Development of renewable energy, on one hand, provides more diverse energy resources besides the dominant fossil fuels and promotes exports capacity of oil and gas. On the other hand, it helps to better meet the growing energy needs addressing environmental concerns and sustainability issues, especially reduction of greenhouse gas emissions.

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