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Iran's achievements in renewable energy during fourth development program in comparison with global trend

Payam Nejat [a], Abdul Kasir Morsoni [c], Fatemeh Jomehzadeh [a], Hamid Behzad [b], Mohamad Saeed Vesali [c], M.Z.Abd. Majid [a,*]

[a] Faculty of Civil Engineering, University Technology Malaysia, UTM-Skudai, Malaysia
[b] Department of Electronic, Shahrood University of Technology, Shahrood, Iran
[c] Department of Electronic, Ferdowsi University of Mashhad, Mashhad, Iran

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ABSTRACT

Since the beginning of the last century, energy affairs have always been taken into global consideration due to their effects on economies, policies, security and the environment. Fossil fuels have been the first recourse for global energy supply needs (80% of total energy consumption); nonetheless, owing to the production of greenhouse gases, they are gradually being replaced with renewable energy resources. In addition, renewable energy resources are perpetual, unlike fossil fuels, which may be exhausted in less than one century. From 2005 to 2010 (coinciding with Iran's fourth development program), renewable energy resources enjoyed a double-digit global growth rate as a result of environmentally friendly perception and a reduction in equipment price. Some policies and strategies were globally adopted to support renewable energy resources (Feed-In-Tariff, subsidies, etc.). Iran began utilizing renewable resources from the early 1990s and set targets and policies for renewable energy resource utilization in the fourth development program. However, Iran's trend has not aligned with global trends, and it appears that its enormous fossil fuel reserves overshadow the growth of renewable energy resources in the country. In this paper, the status, achievements and policies of Iran during the fourth development program will be discussed and compared with global trends.

Contents

* Corresponding author. Tel.: +60 197536100; fax: +60 7 5566157.
E-mail addresses: jomehzadeh@live.utm.my (F. Jomehzadeh), vesali202@gmail.com (M. Saeed Vesali), hamidbehza@gmail.com (H. Behzad), Akasir@gmail.com (A.K. Morsoni), mzaimi@utm.my (M.Z.Abd. Majid).

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1. Introduction

Nowadays energy plays a significant role in the global economy, as well as in security and politics. Every nation must tend to the sources, policies and environmental aspects of their energy affairs in order to achieve developmental targets [1–3]. Apart from global population and economic growth, energy consumption has considerably increased worldwide, from the equivalent of 6630 million tons of oil in the early 1980s to 11,295 million tons in 2008 [4,5]. Since the 2008 global economic crisis, the growth of energy consumption has revived at a 5.4% annual rate [6]. There are estimates that show certain fossil fuels, such as crude oil and natural gas related to members of the Organization of Petroleum Exporting Countries (OPEC), will be exhausted in 79 and 131 years, respectively [7] and that average depletion times for world fossil fuel reserves such as of oil, coal and gas are approximately 35, 107 and 37 years, respectively [8,9]. In addition, fossil fuels are the primary cause of greenhouse gas emissions, which are currently the most perilous threat to the environment [10–12]. Total global carbon dioxide emissions in 2010 were more than 33.1 gigatons—33% more than in 2000 (24.8 gigatons) [13,14].

Because carbon-based fuels will be nearing their end and they are the primary source of greenhouse gas emissions, attention has been drawn to renewable energy resources like solar, wind, geothermal and hydropower, which are perpetual, infinite and offer negligible (indirect) CO_2 production [15]. Today's worldwide share of renewable energy may not be considerable (18% of global energy consumption; see Fig. 1) [16], but its growth rate is notable—over 20% in the past 5 years (except hydro and geothermal energy).

Nearly half of the 194 GW of electric energy added to world capacity in 2010 was due to renewable energy resources, and almost 20% of global electricity generation in that year was related to different types of renewable resources (Fig. 2).

In 2010, 118 nations provided policies and targets in the employment of renewable energy—twice more than in 2005. Some policies, such as Feed-In-Tariff, subsidies, grants and taxes, have been defined and employed to support the development of renewable energy plans worldwide [18–21].The global growth rate of renewable energy between 2005 and 2010 (coinciding with the fourth development program of Iran) was 49% in solar PV, 27% in wind power, 4% in geothermal, and 3% in hydro power (Fig. 3).

In addition, the total global investment in renewable energy considerably increased from $22 billion US in 2004 to $211 billion US in 2010 (Fig. 4) [6,22].

Iran, as a developing country with a population of more than 70 million, had a total energy consumption equivalent to 1164 million barrels of oil (including oil, gas, coal and other resources) in 2009 [23]. The total expenses of Iran's energy consumption in 2007 reached US $47.8 billion, whereas in 2000 it was US $32 billion; at this rate, it may surpass US $157 billion by 2020 [24].

Apart from enormous fossil fuel consumption, Iran also suffers from greenhouse gas emissions and their environmental impacts (producing 558 million tons—1.7% worldwide). Since Iran has great potential in renewable resources, more attention is being paid to replace fossil fuels with renewable energy [25].

1.1. Fossil fuel resources of Iran

Iran currently enjoys 78 oil fields, of which 62 are onshore; the remaining fields are offshore. The total crude oil reserves were 151.17 billion barrels in 2010, and it has been estimated that the remaining lifespan of Iran's oil is approximately 94 years. Iran is considered as the third largest oil reserve holder in the world after Saudi Arabia and Venezuela [26]. The total annual production of crude oil was 1433 million barrels in 2009, of which 800 million barrels were exported. The total natural gas reserves in that year

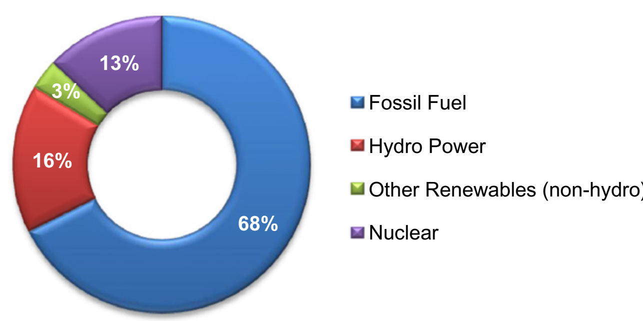

Fig. 2. Share of different sources of energy in Global Electricity Production [6].

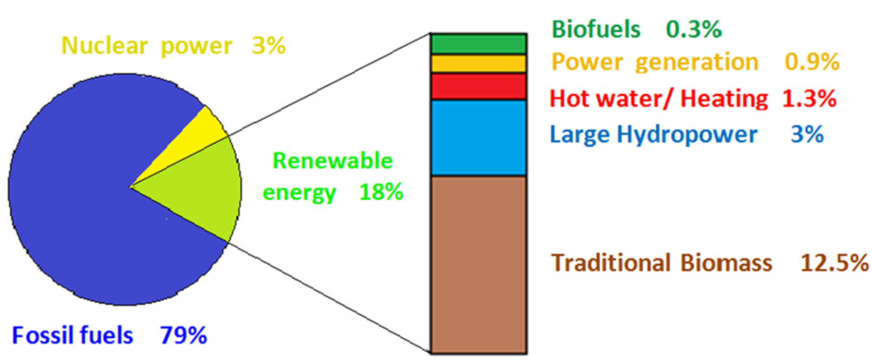

Fig. 1. Global Energy Consumption [16].

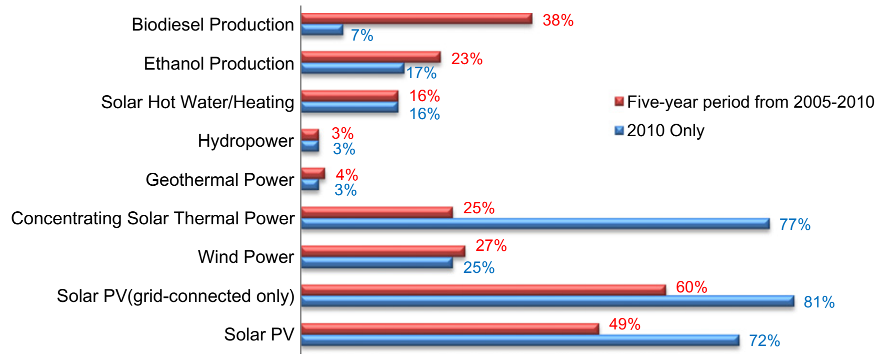

Fig. 3. Annual growth rates of renewable energy resources and biofuels production, 2005–2010 [6].

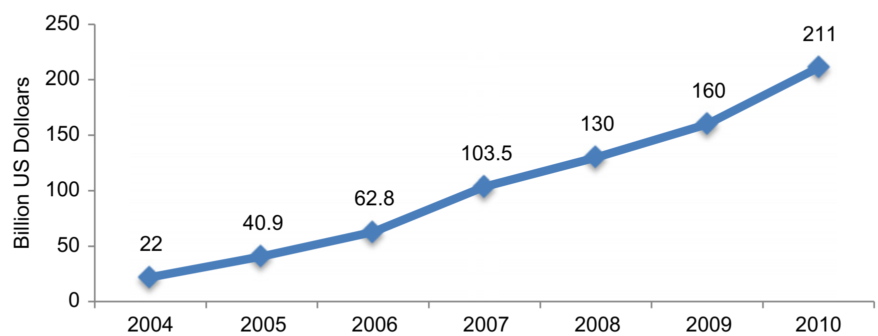

Fig. 4. New global investment in renewable energy, 2004–2010 [6].

were 33 trillion m^3 (13 trillion m^3 onshore and 20 trillion m^3 offshore).

Only Russia has greater gas reserves than Iran and the total Iranian production of natural gas in 2009 was 583 million m^3 per day. 35.1% of the total primary energy produced in Iran (equivalent to 866.2 million barrels of oil) is related to natural gas. Coal does not play a significant role in the energy mix of Iran (only 0.23% of primary energy). The measured coal reserves in Iran are 1085.8 million tons. The total extraction of coal in 2010 was equivalent to 5.8 million barrels of oil and almost all were used in iron and cement plants [5,26].

1.2. Capacity of electricity generation in Iran

The total nominal electricity capacity of Iran reached 56,182 MW at the end of the fourth development program (the actual capacity was 49,516 MW), which represents 37% growth from the commencement year of the program with 100% achievement of the program targets. During the program, the private sector share of electricity production increased fourfold (from 1213 MW to 4976 MW). Steam power stations accounted for 31.6% of electricity capacity, with the remaining capacity attributed to gas turbines (22.1%), combined cycle (28.9%), hydro power (16.3%), diesel (0.9%) and renewable resources (0.2%). The total electricity generation in 2010 was 221,372 GWh (equivalent to 131.4 million barrels of oil) [26]. Furthermore, the government planned to achieve 100 GW capacity until 2020 [27].

2. Supporting policy for renewable energy

Energy policy is a strategy employed by governments to address issues such as generation, distribution and consumption, as well as environmental and social impacts [23]. It is estimated that by the end of 2011, 118 countries provided some types of strategies and policies to support renewable resources (in 2005, only 55 countries had prepared policies). Of these nations, 96 have prepared national targets that determine the renewable energy proportion of total electricity production (on average, 10–30% over the next two decades), total primary or final energy consumption, heat production and the role of biofuels in transportation [6]. There are many types of policies implemented by different countries to assist and guarantee the growth of renewable energy including Feed-In-Tariff, Renewable Portfolio Standards, direct subsidies, grants, trading systems, rebates, pricing laws, tax exemptions, quota requirements and energy production credits or incentives. The primary goal of these methods is to decrease dependence on fossil fuels and their destructive environmental effects [28,29].

The Feed-In-Tariff (FIT) and Renewable Portfolio Standard (RPS) approaches seem to be the most popular. FIT exists at least in 61 countries around the world [30]; In FIT, a granted fee is paid for the generation of power from renewable resources (typically for each unit of electricity production over a fixed time, e.g. 20 years); this results in a risk reduction for investors in long-term new technologies [13]. Likewise, an RPS is a regulation which promotes energy production (employed in 18 countries); RPS is sometimes referred to as a Renewable Electricity Standard (RES) [30].

Increasing the share of RPS will promote competition for the renewable energy market as well as lead to lower prices for renewable energy [31]. The success of the policy relies not only on policy selection but also on policy planning, implementation and transparent, stable framework conditions. Thus, countries must select from different policies to find those that are the most adaptive with their targets, technical abilities and culture; therefore, there is no optimal worldwide method [32]; governments must continually improve and reform policies. Sweden has been the most successful in achieving targets; they were able to surpass their 2020 targets by 2010. Fig. 5 illustrates the renewable energy percentage of final energy consumption between 2005 and 2009 and targets for 2020 in selected pioneer European countries [6].

The first steps of employing renewable resources in Iran were taken in 1994, and since that time, attention to this subject has significantly increased among authorities and society. To better clarify the issue, the fourth development program proposed that 500 MW (without considering hydro power) should be supplied from renewable resources (1% of total energy consumption), with a private sector share of 270 MW [27]. In a 20-year Iranian development outlook, this share should reach 10% by 2025 [33]. In addition, a Feed-In-Tariff strategy was implemented by the Ministry of Energy, which purchases electricity from the private sector for $0.13/kWh during peak time and $0.09/kWh in non-peak time [26].

In realizing their 20-year outlook targets, the Ministry of Energy adopted the following strategies and policies in the fourth development program:

(1) supporting the private sector to operate renewable energy plants with high technology and productivity;
(2) contributing to industrial manufacturers to absorb and localize new technology related to renewable energy sources with a high level of competitiveness in the short-term, such as solar photovoltaic, and Combined Heat and Power (CHP);
(3) encouraging academic research centers to expand technologies, which will be competitive for more than 10 years;
(4) providing access to renewable energy for remote and undeveloped rural areas.

Despite these policies and efforts, only 38% of the fourth development program targets were met. The reasons for the non-realization of the fourth development program targets and policies are listed below:

2.1. Non-application of human resources in an appropriate manner

If the full potential of academic and research centers is utilized, most of the hardships related to the lack of technology, consultants, contractors and qualified supervisors will vanish. However, experts and workforce talents in renewable energy have not been completely identified in industries and universities. The designing of the Concentrated Solar Power (CSP) plant in the city of Shiraz is an appropriate model of collaboration between university and industry. However, the absence of an identified cooperation model between the private sector and governmental organizations is a fundamental defect.

2.2. Problems related to administrative and supervisory structure

A vertical organizational structure with different management layers, non-separation of duties and parallel activities appears to be the fundamental obstacles hindering the rate of project implementation. If there is an adequate separation of inter- and intra-organizational responsibilities, productivity and speed of project fulfillment will increase. As an example, Iran's renewable energy organization (SUNA) and the Renewable Committee of

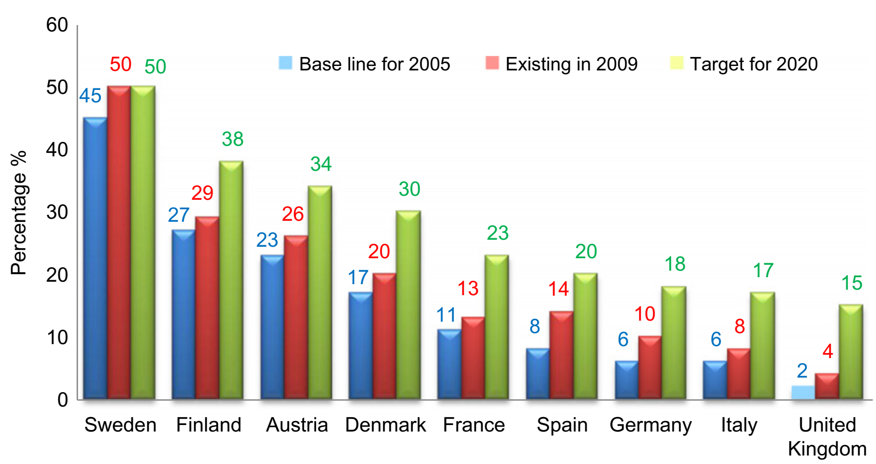

Fig. 5. Percentage of renewable energy of final energy consumption in selected pioneer European countries between 2005 and 2009 and their targets for 2020 [6].

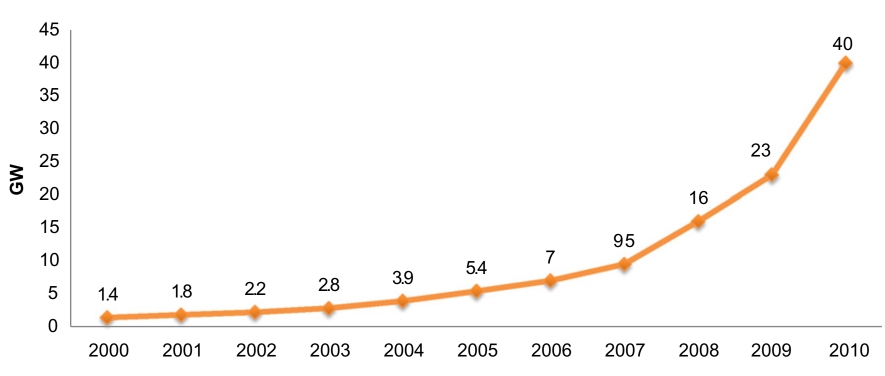

Fig. 6. Total global capacity of solar PV between 2000 and 2010 [40].

Iran (RCI) have parallel activities and duties. If their duties were accordingly separated:

- first, with a reduction of entrusted duties, the organization could more efficiently carry out its affairs;
- second, their budgets could be more appropriately allocated among projects.

2.3. Discord between identified targets and management talents

Targets should be addressed through successful management systems such as SMART (Specific, Measurable, Achievable, Realistic, and Time bonded). If obstacles such as a lack of budget or talent are justified as reasons for the non-achievement of targets, then the targets should be modified in such a way that their accomplishment can be made possible.

Moreover, the non-achievement of targets can discourage executive managers, thus diminishing their motivation. Consequently, the ability to modify and correct targets and revise the existing management system can assist in making the targets realistic as well as improve the motivation of managers and staff. These two points must be contemplated in the next development program [33].

3. Solar power

The earth receives nearly 1.8×10^8 GW from the sun—much more than the total energy requirement for all humans [34].

Solar power transforms sunlight into electricity, either directly through a Photovoltaic (PV) process or indirectly through Concentrated Solar Power (CSP) [35–37]. A CSP system utilizes lenses, mirrors and a tracing system to center a large area of sunlight into compact beams, whereas a PV system transforms light into electrical currents by means of the Photovoltaic effect [38]. Solar Photovoltaic (PV) technology was utilized in at least 100 countries worldwide in 2010. PV has the highest rate of growth for power generation among renewable resources—it achieved a 49% growth rate from 2005 to 2010 [6].

Photovoltaic projects have dramatically increased in recent years due to increased efficiency and fundamentally decreased costs, from $100/w in 1975 to approximately $1/w in 2010 [39]; this originates from an adequate supply of wafers and poly-silicon (due to the increased production capacity of China and others) [6]. Additionally, recent FIT policies have had a considerable impact on solar power growth in countries such as Germany and Italy [13].

17 GW of PV capacity were added in 2010 alone, more than two times that of 2009. Total global capacity achieved 40 GW in 2010 (in comparison with 1.4 GW in 2000) (Fig. 6).

Germany has been the global leader in solar energy employment, accounting for 17.3 GW (39% of world PV installed capacity), followed by Spain (4 GW), Italy (3.6 GW), Japan (3.6 GW) and the US (2.4 GW) in 2010 (Figs. 7 and 8). Generally speaking, Europe controls the global market of PV, accounting for more than 73% of world PV capacity [6].

The majority of worldwide PV capacity is grid-connected. In recent years, however, off-grid systems have been highly considered, particularly by developing nations for their rural and remote areas; they can have a significant impact in supplying their minimum needs of deprived people (e.g., providing clean water) [25,41,42]. While many countries have employed solar PV, only a few have employed CSP and only Spain and the US have employed Concentrating Solar Thermal Power (CSP) on a large scale, with Spain's capacity at 632 MW and the US at 509 MW in 2010 [6]. The primary reason for the lackluster CSP plans is the dramatic reduction of PV equipment prices over the last 15 years.

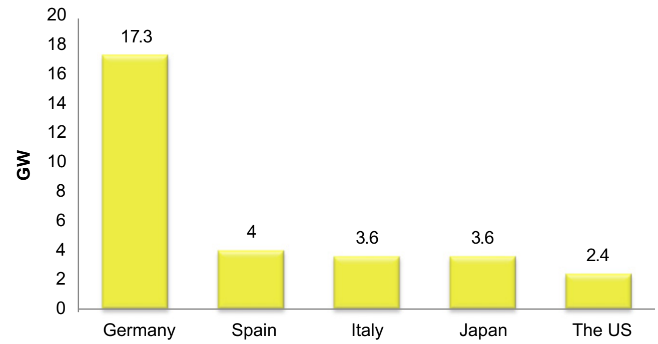

Fig. 7. Capacity of top five countries in solar PV in 2010 [6].

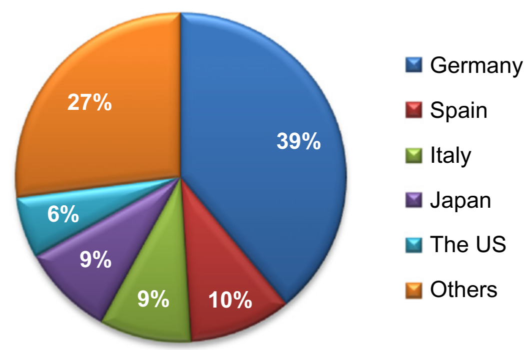

Fig. 8. Shares of pioneer countries in global PV capacity until 2010 [6].

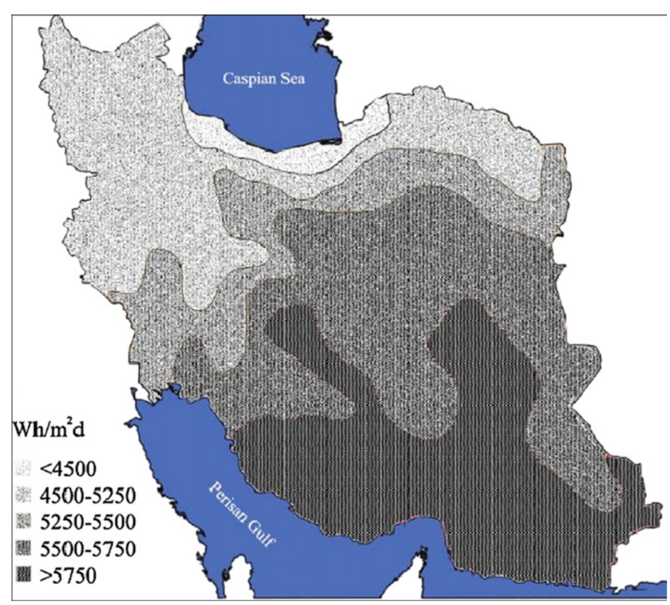

Fig. 9. Annual amounts of solar radiation in different areas of Iran [44].

3.1. Solar power in Iran

Iran is regarded as fertile area for solar energy; it should be noted that Iran enjoys an average of 300 sunny days per year [43]. The average solar energy received in the north of Iran is 2.8 kWh/m^2 per day, compared to 5.4 kWh/m^2 per day in the south and center. Moreover, the average sunshine hours are evaluated at 2800 h per year. Fig. 9 shows the amount of solar radiation in different areas of Iran.

Needless to say, the annual sunny hours escalate to 3200 h in the central desert areas of the country on account of dry and hot weather conditions [44,45]. Fig. 10 illustrates the total solar electricity generation in Iran from 1999 until 2010, and also reveals the enormous gap in Iran's potential utilization of solar energy—the production of solar energy in 2010 was a negligible 72 MWh. While PV is the only technology currently used by Iran to convert solar energy to electricity, the first CSP plant is presently under construction in city of Shiraz with a capacity of 250 kW [20]. Iran's solar power plants include Tabriz (24 kW), Sarkavire Semnan (15 kW), Darbide Yazd (12 kW) and Tehran (10 kW) [26].

4. Wind

From the distant past, wind has always absorbed mankind's heed. The first actual steps to harness wind energy trace back to 200 BC, when ancient Persians were using windmills centuries before European nations. In the 18th century, the emergence of primary wind turbines in the US with a 12 kW capacity made it possible to produce electricity from this sustainable resource [46,47].

Like other renewable resources, wind has vast worldwide access, but it has grown significantly more than other renewable resources due to being more commercialized [30]. Furthermore, wind energy has the lowest CO_2 lifecycle footprint among the other types of renewable resources [31].

Total wind capacity installed by 2010 is estimated globally at approximately 198 GW, having the greatest share among worldwide renewable resources at 63%—excluding hydro power (Fig. 11) [6].

The average growth rate of wind utilization was 27% between 2005 and 2010. Fig. 12 shows the growth and capacity of global wind power from 1996 to 2010. The primary reasons for this considerable growth are the improvement of wind turbine capacities (in some cases up to 40%) and an increase in reliability and turbine size. The turbine capacity is closely related to the area of the rotor; currently the largest turbine has a capacity of 5–6 MW with a 126 m diameter rotor [29].

To date at least 83 countries are implementing wind energy on a commercial basis. For the first time, developing countries outpaced the developed world, with China installing 18.9 GW

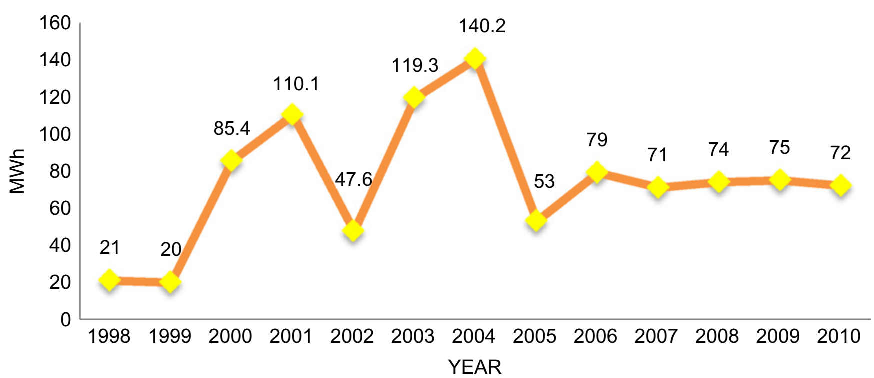

Fig. 10. Total solar electric generation in Iran from 1999 to 2010 [25,40].

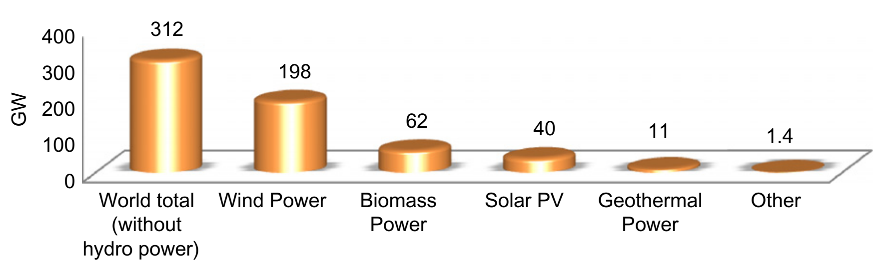

Fig. 11. Total wind capacity installed by 2010 in comparison with other renewable resources [6].

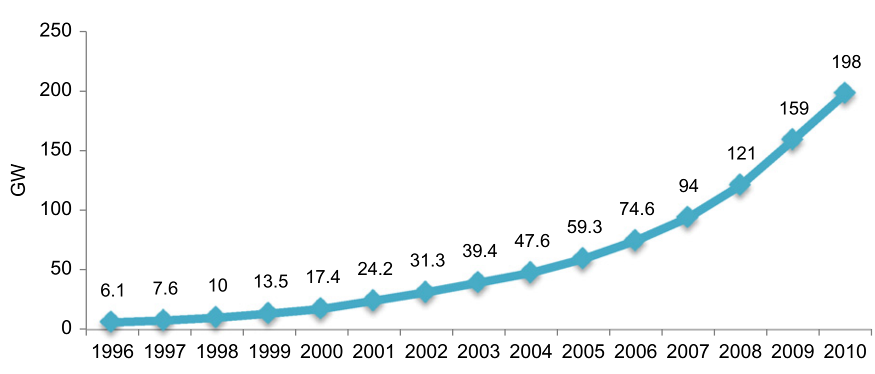

Fig. 12. Capacity of global wind power from 1996 to 2010 [49].

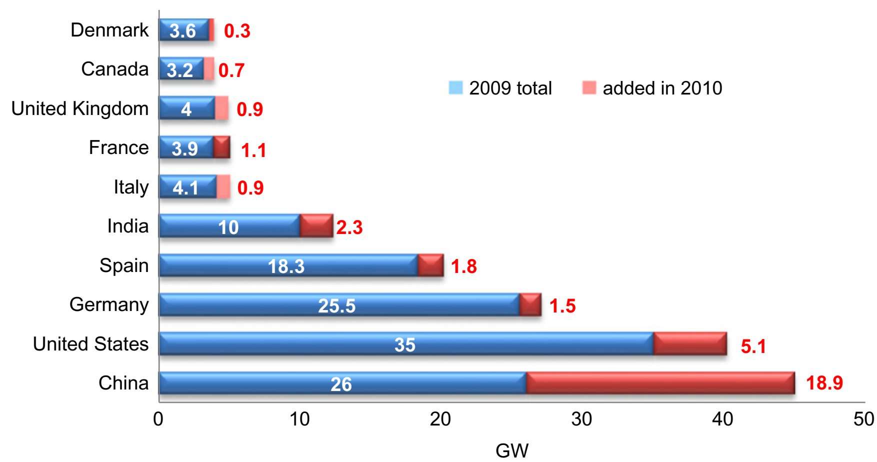

Fig. 13. Top 10 countries in utilization of wind power in 2010 [6].

Table 1
The current and future cost of selected renewable energy sources [51].

Energy technology	Present cost ($/kW)	Future cost (2020+) ($/kW)
Wind onshore	0.04_0.07	0.04
Wind offshore	0.1_0.17	0.08_0.13
Geothermal	0.04_0.07	0.04_0.07
Hydro electricity	0.04	0.04
CSP	0.11_0.15	0.1
Solar PV	>0.2	0.05_0.07
Conventional (fossil fuels)	0.07 (with social cost: 0.12)	0.08 (with social cost: 0.14)

(50% of global capacity added in 2010) and standing as the leader with a 44.9 GW total capacity [6]. China has doubled their wind electricity generation since 2005. The success of China relies on supportive policies such as their Renewable Energy Law (passed in 2005), which provided national funds, tax preferences, discounted lending and forced operators of electricity grids to buy all wind electricity [48].

Second place belongs to the US, with 40.1 GW, followed by Germany with 27 GW, Spain with 20.1 GW and India with 12.3 GW. Fig. 13 displays the top 10 countries in utilization of wind power in 2010 [49]. It is predicted that approximately 1900 GW of new capacity will be installed globally by 2030 [27,50].

The most significant reason for the remarkable growth of the wind energy market is the competitive price ($0.04 to $0.07/kW) in comparison to other resources—even fossil fuels ($0.12/kW) (Table 1). The price of wind electricity production will continue to decline (less than $0.04/kW by 2020) while the fossil fuel electricity costs will increase to $0.14/kW (including $0.06/kW for environmental costs). The majority of wind projects throughout the world have been constructed onshore due to lower prices than offshore ($0.10/kW vs. $0.17/kW) and simpler technology [51].

Although wind power is green and sustainable, it has some negative environmental aspects, including noise pollution created during turbine operation. However, this noise can be mitigated in the design phase or through acoustic insulated walls surrounding wind farms. Like other types of power plants, wind farms do generate electrical and magnetic fields which can impact telecommunications and radar systems. There are also concerns regarding visual pollution and the deaths of birds and bats due to crashes into turbine rotors [52].

4.1. *Wind energy in Iran*

Iran has an enormous opportunity to bring wind into its energy mix, with a potential capacity of 6500 MW on a commercial basis (mostly in the eastern section of the country) [53,54]. Despite its enormous talent pool and pioneering the utilization of wind in the south east of Asia (beginning in 1994), Iran's total installed capacity as of March 2010 was only 90.5 MW, with a total electricity production in 2009 of 226.8 GWh—equivalent to 0.1% of total electricity generation. However, due to supportive government policies (particularly Feed-In-Tariff) the private sector has applied for 712 MW of capacity, of which 489 MW is under construction and 223 MW is in contract preparation stage.

The primary wind power farms are listed below:

4.2. *Manjil site*

Manjil, which is located in northern Iran in Gilan province, enjoys perpetual wind flow throughout the year because of the enormous height difference compared to the Caspian Sea and the existing natural channel of the Sefidrud River. Diagrams obtained from aerology studies illustrate that wind speed is between 8 and 12 m/s, reaching a maximum of 40 m/s in summer. By the end of 2009, the total installed capacity was 60.58 MW [40,55].

4.3. *Binalood site*

Located in northeastern Iran (near Iran's second largest city of Mashhad), Binalood enjoys wind speeds of 6–8 m/s. The final capacity of the site has reached 28.4 MW; further development plans are being studied.

There are 4 other minor sites, including Dizbad in the city of Nishabur, with a capacity of 260 kW, Sahand with 10 kW and Eon with 660 kW, both in the city of Tabriz, and finally Lutak in the city of Zabol, with 660 kW. The total wind electricity production between 2006 and 2010 is displayed in Fig. 14 [26].

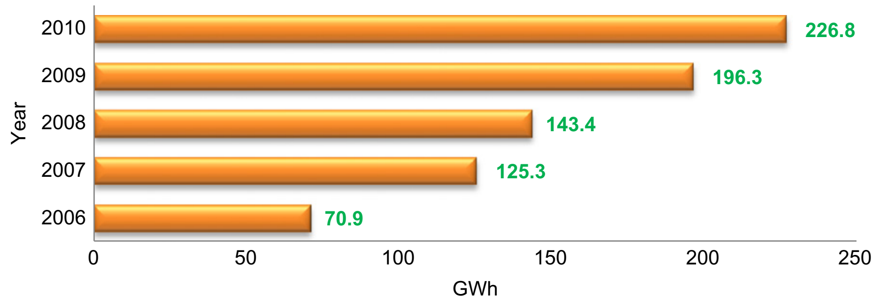

Fig. 14. Total wind electricity production between 2006 and 2010 [26].

5. Hydro power

By 2010, almost 150 countries in the world have benefited from hydropower. Among renewable energy resources, it accordingly has the widest application as well as the highest proportion (16%) of global electricity production. Conversely, its rate of growth is the lowest—3% annually in comparison to other resources. Only 30 GW capacity was installed during 2010, reaching an estimated global capacity of 1010 GW. The top countries for hydropower capacity are China (213 GW), Brazil (80.7 GW), The US (78 GW plus 20.5 GW of pumped storage), Canada (75.6 GW) and Russia (55 GW); they account for almost 52% of global installed capacity.

However, ranking these countries by electricity generation forms a different list because some countries (such as Canada) depend on hydropower for their base load supply, while others (the US) utilize hydropower to match peak electricity consumption. Asia and Latin America are the most fertile regions in the world for hydropower development.

The price of hydroelectricity appears to be more competitive than other resources, equal to $0.04/kWh (including transmission expenses) [51]. Hydro dams play other important socioeconomic roles besides electricity generation, including flood control, irrigation and public water supply [56]. Although large hydro dams have positive effects on economic development, they can also adversely affect the environment by increasing moisture in areas near a dam (which can harm the ancient sites) or changing ecological balances by affecting lakes and lagoons located downstream of a dam. As a result, the lives of people living near a dam sometimes suffer from these effects (social impacts) [57].

It can be said that although the energy produced by large hydropower plants is renewable, it is not necessarily sustainable. Due to the aforementioned problems, large hydropower plants are being reconsidered, and many countries have plans to install smaller and mini hydropower plants [25,33].

5.1. Hydro power in Iran

Hydro structures have a long history in Iran; the ancient Persians were accustomed to various methods of harnessing water for different purposes. Hydro structures in the city of Shushtar date to the 5th century BC, with two major diversion canals—one of which still supplies water to Shushtar. Moreover, ancient Persia introduced the Ghanat (aqueduct) technology to the world, creating a sustainable method for the utilization of water resources (particularly in deserts and dry regions), in contrast with deep wells, which typically threaten the sustainability of underground aquifers.

The longest Ghanat in the world exists in Iran (near the eastern city of Gonabad); it is 33,113 m long with 427 wells, and it still supplies water for that region [58]. Iran has prospered in hydro power and made significant progress in this field; at present, there are 44 hydro power plants, with a total capacity of 7704 MW, which represents 0.14% of the total electricity generation in Iran (7232 GWh). The growth rate of hydro power capacity was 27.5% in the fourth development program—9 times greater than the global average. Moreover, 7 GW is currently under construction and 21.8 GW is being studied and ready to start construction, as well as another 7.2 GW in a primary phase.

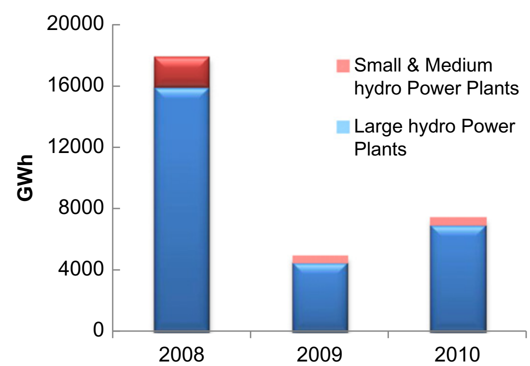

Fig. 15. The trend of hydro electricity generation between 2008 and 2010 [26].

Large hydro power plants (with capacities of more than 100 MW) account for 91.3% of Iran's hydro capacity, 8% at medium size (10–100 MW) and the remaining related to small or micro size (less than 10 MW). The trend toward constructing small and mini hydro power plants has been considered by authorities in recent years due to environmental aspects, high investments and technological hardships [25,26]. Fig. 15 reveals the pattern of hydro electricity generation between 2008 and 2010.

The tallest dam in the world is being constructed in the provinces of Chaharmahal and Bakhtiyari (in western Iran), with a height of 315 m, a 4.85 billion cubic meter water capacity and with a 2000 MW potential power capacity [26,59].

6. Geopower

Geothermal energy originates from the Earth's internal formations (20%) and the collapse of radioactive materials (80%). Utilization of geothermal energy for bathing dates back to the Paleolithic age, and in ancient Rome, geothermal energy was used for direct heating. Currently it is not only used for direct heating but also for producing electricity [60,61].

By 2010, the total installed capacity worldwide comprised 11 GW, and this resource accounted for 67.2 TWh of electricity production. By the end of 2010, at least 24 countries were employing geothermal power, and it is predicted to reach 46 countries in the next four years. The five leading countries are the US (3.1 GW), the Philippines (1.9 GW), Indonesia (1.2 GW), Mexico (near 1 GW) and Italy (0.9 GW) [6]. The current price for geothermal electricity ranges between $0.04 and $0.07/kW [51].

Table 2
Geothermal potential regions in Iran and their areas [61].

Geothermal area	Province	Area (km^2)
Sabalan	Ardebil	13,037
Damavand	Tehran	4648
Khoy-Maku	Azerbaijan-Gharbi	3257
Sahand	Azerbaijan-Sharghi	3174
Bazman	Sistan&Baloochestan	8356
Taftan	Sistan&Baloochestan	4310
Tabas-Ferdoos	Khorasan-Jonoobi	46,628
Khour	Esfahan	2334
Tekab-Hashtrood	Azerbaijan-Gharbi	4639
Mahallat-Esfahan	Esfahan-Markazi	13,648
Zanjan	Zanjan	3285
Avaj	Hamadan	4283
Kashmar	Khorasan-Markazi	7107
Ramsar	Gilan	5532
Amol	Mazandaran	1697
Baft	Kerman	11,525
Minab-Bandarabbas	Khorasan	3191
Lar-Bastak	Khorasan	4191

6.1. Direct use

The direct usage of geothermal for heating is more popular than electricity generation (51 GW_{th} thermal capacity) worldwide in 2010. The average growth rate in the last decade is 9%; in addition, approximately 78 countries are using direct geothermal. The US leads the world with 12.6 thermal GW, followed by China (9 GW_{th}), Sweden (4.5 GW_{th}), Germany (2.5 GW_{th}) and Japan (2.1 GW_{th}) [6].

6.2. Geopower in Iran

There are 18 geothermal fertile areas recognized in Iran, and 8.8% of Iran's area has been identified as geothermal potential regions [62]. Table 2 shows the geothermal potential regions in Iran and their areas [63,64]. During Iran's fourth development program, the first geothermal plant near the city of Meshkin Shahr was under construction, with an initial capacity of 55 MW, being able to increase to 200 MW and produce 410 GWh of electricity. This plant is being constructed as a Combined Heat and Power (CHP) facility [33,59].

This project has been slow in developing during the fourth development program. Although it was to be completed and installed before 2010, it has yet to be completed; it is predicted that it will be completed by the end of the fifth development program (2015) [26].

7. Biomass power

Biomass power is generally utilized to produce power or heat and is sometimes transformed to liquid fuels for transportation (ethanol and biodiesel).

The demand for biofuels, biomass fuels and their equipment has significantly risen due to policies which propose to decrease GHG emissions and promote varieties of energy resources. The current energy consumption of biomass is approximately 53 EJ worldwide. A major part of this quantity (86%) is utilized for heating, cooling and cooking, as well as for industry (three-fourths of this is traditional biomass that was directly- and inefficiently-burned), while 10.5% is used for electricity generation and 3.5% for biofuels production [32].

A global biomass electricity capacity of 62 GW was in place as of 2010. The progressive countries in this field are the US with 10.4 GW, Brazil with 7.8 GW, Germany with 4.9 GW, China with 4 GW and India with 3 GW [6].

The production of biofuels has enjoyed a growth rate of 400% from 2000 to 2009; it is assumed that this growth will continue. Global production of ethanol and biodiesel reached the equivalent of approximately 20 million barrels of oil. The US, Brazil, China, Canada and France are the leading countries in ethanol production and the US, Germany, Brazil, Argentina and France lead biodiesel production [32,65].

7.1. Iran's status

Iran enjoys great potential for biomass because of its enormous generation of agricultural, animal and municipal waste (8.8×10^6 t, 7.7×10^6 t and 3×10^6 t, respectively) [66]. Iran established two biomass power plants in two different cities (Mashhad and Shiraz) in 2009, producing biogas from the municipal garbage. The capacity of Shiraz's power plant is 7455 MWh annually, with nominal power of 1200 kW; Mashhad's capacity is 4875 MWh, with nominal power of 600 kW. Spain, the Netherlands and Germany aided Iran in establishing these power plants. In addition, 11.5 MW of capacity is under private sector construction and another 11.5 MW is in the contract preparing stage [26]. However, there is no considerable effort to produce biofuels in Iran, despite the relative potential due to the large yield of varied crops [65].

8. Conclusion

The trend toward renewable energy has accelerated, and many countries in the world are utilizing varied types of renewable resources for different purposes but mostly for electricity generation and direct heating. A majority of countries have established policies to direct, support and strengthen renewable energy application. Unlike the past, developing countries are contributing more to increase renewable energy proportion globally; for instance, China has been able to outperform developed countries in wind resources.

Although Iran, as a developing country, has employed renewable resources since the early 1990s, the growth of some resources (solar and geothermal) has not been acceptable. The notable and enormous amount of fossil fuel reserves overshadows the promotion of the renewable portions of Iran's energy basket. Appropriate policies and targets were adopted in Iran's fourth development program. Nevertheless, many of them were not achieved due to obstacles such as insufficient budgets, technical knowledge and management.

It should not be ignored that fossil fuel reserves will be exhausted in less than one century; this fact illustrates the importance of expanding renewable energy in Iran. Iran enjoys significant potential for renewable energy sources such as solar, wind, geothermal and hydro power. If a portion of oil import revenues were allocated to expand renewable energy plans, Iran will not suffer from dependence on hydrocarbon fuels and their environmental threats. With sufficient investment, Iran can play a vital role as a prominent green energy exporter.

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