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Renewable energy sources in Iran for mitigating climate change and sustainable development

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Abstract

Iran, as one of the most important contributors to greenhouse gas emissions in the Middle East and globally, holds substantial potential in aiding carbon dioxide control through an energy sector perspective. This stands as a comprehensive approach towards sustainable development and mitigating climate change impacts.
This study is based on the latest research in renewable energy and climate change in Iran. It also investigates Iran's Seventh Development Plan regarding energy and environmental aspects. This study reviews the types of renewable energy sources in Iran, their potential, the opportunities and challenges.
The total power potential of renewable energy including: solar, wind, hydroelectric, biomass and geothermal in the country is estimated to be 124 thousand megawatts. Therefore, solar energy with 71 and wind energy with 49 thousand megawatts account for more than 97% of the country's total potential in renewable electricity production. Therefore, focusing on the development of solar and wind power plants has a higher priority, and Iran ranks 133 out of 180 countries in terms of the environmental performance index. This is while the country has obtained a very poor rank of 171 in the sub-index of projected greenhouse gas emissions and the growth rate of greenhouse gas intensity. Iran, endowed with high capacities in renewable energy, can play a significant role in combating climate change and ensuring sustainable development.

Keywords: Climate change, Renewable energy, Environment, Sustainable development

1. Introduction

The world is rapidly turning into a global village due to the ever-increasing need for energy by the entire population across the globe. Statistics indicate that the demand for energy and related services is increasing in the coming years to satisfy human socio-economic development, well-being, and health (1, 2). All societies demand energy services to meet basic human needs such as health, lighting, cooking, space comfort, transportation, and communication, and they act as productive processes, highlighting the important question of whether fossil fuel energy resources can meet the global energy demand for survival and development in the coming decades. Meanwhile, concerns over global challenges associated with the rapid growth of carbon dioxide (CO2) emissions and global warming have overshadowed all planning and decision-making. Two major reasons can be cited for the development of alternative energy sources that are both clean and renewable: (1) What is used from fossil fuels today is more valuable than burning for energy; (2) The emergence of concepts and issues of sustainable development, global warming, and health problems caused by pollution (3, 4).

According to a report by the International Energy Agency, the electricity industry will experience the fastest growth in the field of renewable energy resources, which can pave the way for a sustainable future. Since the electricity industry is recognized as a major factor in global climate change, there has been much discussion about the extensive use of renewable energy resources for electricity generation worldwide (5). According to a recent assessment by the International Renewable Energy Agency, 45 million jobs could exist in the renewable energy sector by 2050. Jobs related to energy efficiency are also expected to grow by 25% over the next few years (6).

Sustainable development has become the centerpiece of recent national development policies, strategies, and programs of many countries. The United Nations General Assembly proposed a set of global Sustainable Development Goals (SDGs), which include 17 goals and 169 targets. Furthermore, an initial set of 330 indicators was introduced in March 2015 (7). Addressing climate change, providing renewable energy, food, health, and water requires globally coordinated monitoring and modeling of many factors that are socially, economically, and environmentally significant (8).

Given the high potential to help control carbon dioxide emissions from the energy sector perspective and considering the efforts of the Paris Agreement to keep the global average temperature increase below 2°C above pre-industrial levels in this century, a comprehensive approach is required to address the challenging problem of reducing total greenhouse gas levels (9). Replacing fossil fuel-based energy sources with renewable energy sources, including bioenergy, direct solar energy, geothermal energy, hydropower, wind energy, and ocean (tidal and wave) energy, will gradually help the world realize this vision. Governments, intergovernmental agencies, stakeholders, and individuals in today's world, due to the opportunities created in recent decades to replace petroleum-derived materials from fossil fuel-based energy sources with alternatives from renewable energy resources, eagerly look forward to achieving a sustainable future. The recent launch of a set of global Sustainable Development Goals helps ensure that efforts are made to mitigate climate change for the 21st century and its impacts, and a sustainable future is guaranteed and built as a legacy for future generations (10, 11).

Iran, as a developing country with an important geopolitical position in the Middle East, has large fossil resources as well as renewable energy resources. Despite the high potential of renewable energy resources, Iran faces challenges such as the depletion of fossil resources, high pollutant emissions, industrialization, and water scarcity (12, 13). Therefore, planning must be carried out so that the increasing energy demand from renewable energies instead of fossil fuels is placed on the agenda in order to simultaneously supply the required energy and take serious action to reduce the effects of climate change and achieve sustainable development. Thus, in this study, we aim to investigate the potential and trends of sustainable development with renewable energy resources and climate change mitigation, as well as its potential challenges in Iran, which we will elaborate on below.

2. Renewable energy and sustainable development in Iran

Renewable energies have a direct relationship with sustainable development through their impact on human development and economic productivity. Renewable energy resources provide opportunities in the fields of energy security, social and economic development, energy access, climate change mitigation, and reduction of environmental and health impacts (14, 15).

The share of wind and solar renewable energy from total primary energy in Iran and the world in 2000 was 0.01% and 0.09%, respectively, but the lack of attention to the development of renewable energy in Iran has caused this difference to increase, so that in 2022, the share of wind and solar renewable energy from total primary energy in the world reached 5.33%, while this figure in Iran is less than 0.16% (16, 17).

From 2009 onwards, the amount of solar and wind electricity generation has accelerated, so that in 2021, electricity generation from renewable sources was equal to 3600 terawatt-hours, which is equivalent to 16.5% of the world's total electricity generation and has surpassed the share of nuclear energy. The growth of renewable electricity has intensified in recent years, and the amount of renewable electricity generation in 2022, with a growth of 14.7%, reached 4200 terawatt-hours, which is significant (18). This means that currently, renewable electricity generation is twice that of nuclear, approximately equal to hydropower, and with this trend, it will soon equal electricity generation from gas sources. According to the EIA forecast, by 2050 (Figure 1), the amount of electricity generation will increase about 1.6 times, and electricity generation from wind and solar renewable resources will be recognized as the primary source of electricity generation with a steep slope (19).

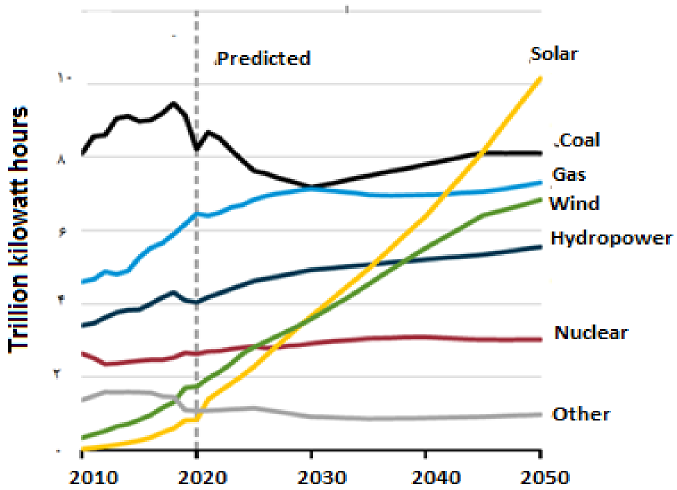

Figure 1. Forecast of electricity generation from different sources by 2050 based on EIA statistics (19).

Available resources are the most important factor in selecting the electricity generation portfolio of countries. The electricity generation portfolio in American countries is more diverse than in other countries, and although the gas sector has the largest share in them, countries such as Canada and Brazil, due to having abundant water, also have a significant role in electricity generation (blue color). In European countries, although the distribution of the electricity generation portfolio of power plants is more diverse, due to the lack of gas resources, the share of renewables is higher and reaches more than

20% (green color). Nuclear, gas, and coal-fired power plants are other sources of electricity generation in these countries. In the electricity generation portfolio of the Persian Gulf and Middle East countries, due to possessing oil and gas resources, fossil fuels (gas and oil products) have a very high share in electricity generation and reach more than 60% (yellow color). In East Asian countries such as China, Australia, India, and Indonesia, the share of coal is significant and constitutes more than 50% of the electricity generation portfolio (black color) (Figure 2) (17).

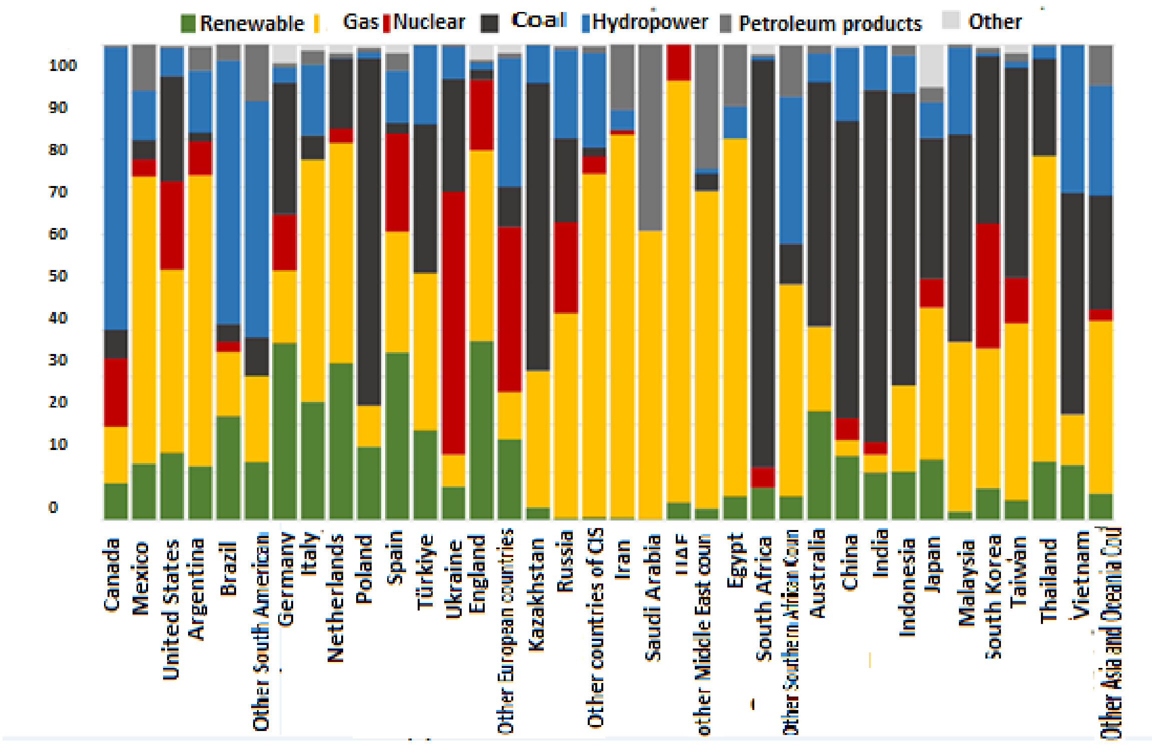

Figure 2. Share of electricity generation sources in different countries (2021) (17).

2.1. Capacity and resources of renewable energy in Iran

The total potential capacity of renewable energy, including solar, wind, hydropower, biomass, and geothermal energy in the country, is estimated at 124,000 megawatts. Accordingly, solar energy with 71,000 megawatts and wind energy with 49,000 megawatts account for more than 97% of the total existing potential of the country in renewable electricity generation (Figure 3) (17). Therefore, the focus on the development of solar and wind power plants has a higher priority. Other renewable areas such as small hydropower, biomass, and geothermal, with a share of less than 3%, have a potential of about 4,000 megawatts.

A provincial study of the renewable energy potential in the country shows that the eastern and southeastern provinces such as Sistan and Baluchestan, South Khorasan, and Razavi Khorasan, as well as Kerman province in the center of the country, have a potential of 40,000 megawatts of solar and wind renewable energy. Kerman province has the highest solar potential, and Sistan and Baluchestan province has the highest wind potential. Additionally, in the provinces of Fars, East Azerbaijan, West Azerbaijan, and Ardabil, there is potential for using geothermal energy. The highest capacity for using biomass is related to Tehran province (Figure 4) (17).

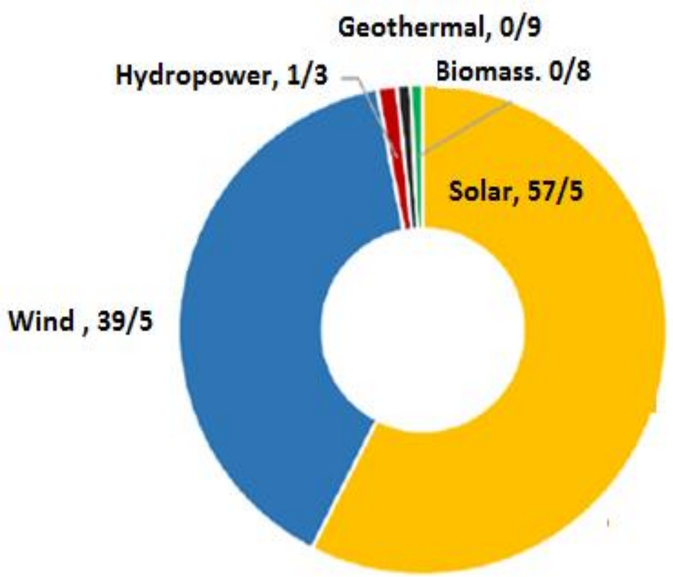

Figure 3. Share of renewable energy potential in the country by type (percentage) (20).

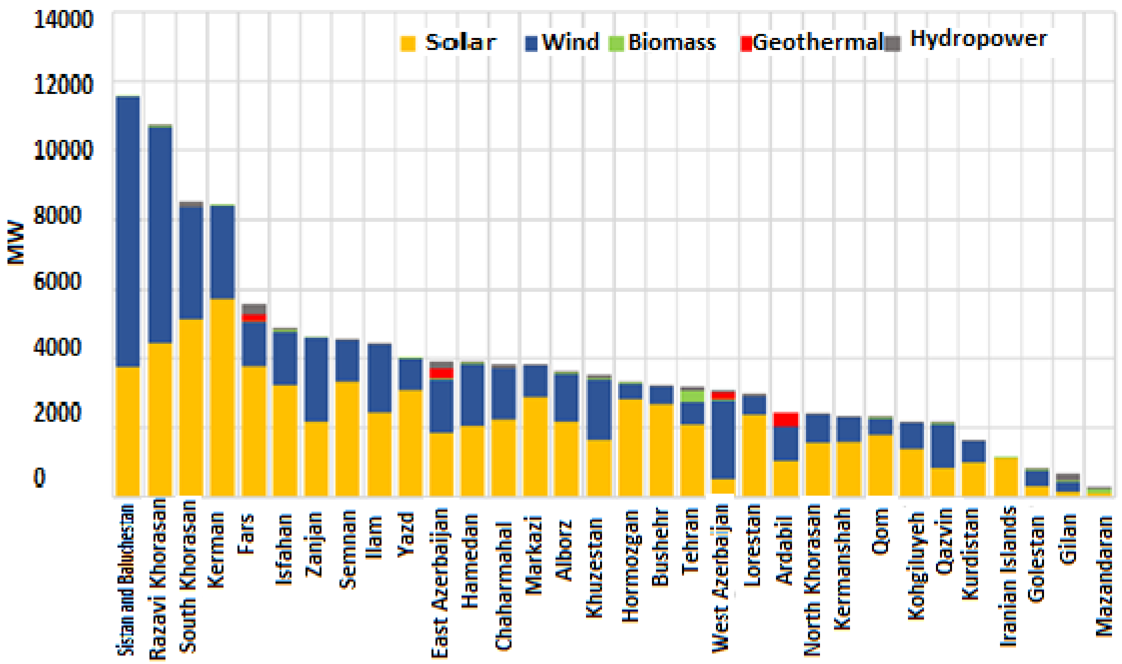

Figure 4. Renewable energy potential by province in Iran (20).

The northern provinces of the country, due to geographical conditions, have the lowest potential for renewable capacity development (17). The high potential of renewable energy in the provinces along the eastern border of Iran can be a very good opportunity for electricity export to neighboring countries, which will increase the incentive for investment in the development of solar and wind power plants in these provinces and ultimately diversify the electricity generation portfolio.

2.1.1. Solar Energy

Solar energy is a clean, renewable, and globally accessible energy. Among the regions with solar energy potential are the southwestern United States, Mediterranean countries, the Middle East and Near East, Iran, and the deserts of India, Pakistan, China, and Australia. In many parts of the world, it is possible to generate between 100 and 300 gigawatt-hours of solar electricity using solar heating technologies per square kilometer. This rate is equivalent to the amount of electricity generated annually, at average load, by conventional fossil fuel, coal, or gas power plants with a capacity of 50 megawatts (3, 21). Solar energy can be used in various ways, including energy generation using solar cells, hydrogen production using fuel cells, cold and hot air production using solar chimneys, and hot water production using solar water heaters (22). Solar energy, in addition to the advantages of renewable energies, has other benefits such as restoration of degraded lands, less concentration on the national electricity grid, improvement of water quality across the country, and expansion of remote area electricity (23).

Iran is a country rich in solar energy. The country's priority for renewable energy resources is solar energy, which averages 300 sunny days per year. The average daily sunlight in Iran, especially in the central regions, is about 5.5 to 8.5 kWh/m² (24). The technical potential for solar thermal energy is estimated at 91,000 TWh. June, July, and August are the months with the highest solar radiation, with 1050 hours, and December, January, and February have the lowest solar radiation, with 500 hours. The cumulative installed capacity of renewable energy resources is predicted to be 2.8 GW by 2030. This represents an investment of over 2.8 trillion dollars from 2010 to 2030 (25).

The central, southern, eastern, and southeastern regions of Iran, such as the provinces of Yazd, Kerman, South Khorasan, Zahedan, and Kerman, have high solar radiation throughout the year. The northern cities of the country have the highest potential for investment in photovoltaic energy (Figure 5) (26).

2.1.2. Wind Energy

Wind energy is generated by producing electrical energy from wind or airflow, which occurs naturally in the Earth's atmosphere, using windmills or wind turbines. As an alternative to fossil fuels, wind energy is abundant, renewable, widely available, and clean, emitting no greenhouse gases, requiring only a small amount of land, and playing a significant role in climate change mitigation (28).

The distribution of wind speed varies greatly in different locations. Typically, winds near the ground are used to generate electricity; winds at higher altitudes are faster and more stable, and their potential exists worldwide. In recent years, major advances have been made in the technology used to generate electricity from high-altitude winds (29). The use of wind energy in Iran dates back to windmills in 200 BC. In terms of wind energy potential, 1.3% of Iran's land (2.1 million hectares) has an average annual wind speed of 8 m/s or higher, enabling these areas to exploit this energy source (30).

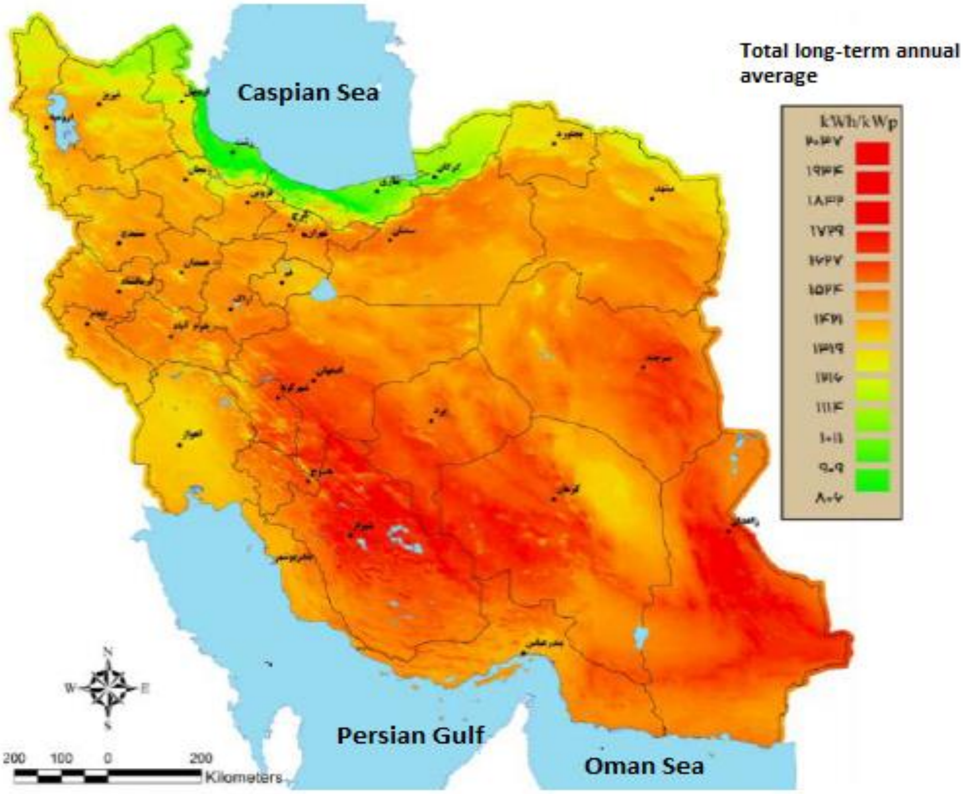

Figure 5. Thermal map of solar energy generation potential in the country (27).

Figure 6 shows the average annual wind speed at a height of 100 meters. It is noteworthy that for different average speeds, different classes of wind turbines are used, and generally, for speeds below about 6 m/s, the installation of wind turbines is not economically justified. The provinces with strong wind energy potential in the country are: Gilan, South Khorasan (especially the Duroeh and Khaf regions), Sistan and Baluchestan (especially the northern region of Zabol), Semnan, and Qazvin, where most of the country's wind power plants have been built so far (15). Zabol is the most suitable region for the deployment of large-scale wind turbines (31). The first large-scale wind turbine was installed in 1994 in Manjil, Gilan province, in two phases with generation capacities of 30 and 60 MW, which was completed in later years. In 2020, the farm's capacity reached 92.5 MW. Another wind farm is Binaloud in Razavi Khorasan province, which has a capacity of 28.2 MW (15).

2.1.3. Small-Scale Hydropower

Hydropower is an essential energy source that uses moving water from higher to lower levels, primarily to spin turbines and generate electricity. Iran, with an average rainfall of one-third of the global average, is one of the arid and semi-arid countries in the world. Accordingly, the inappropriate temporal and spatial distribution of rainfall is perhaps the most important reason for dam construction in Iran. For this reason, hydropower plants cannot be considered a reliable and stable source of electricity generation in the country, but hydropower plants play an effective role in grid frequency control.

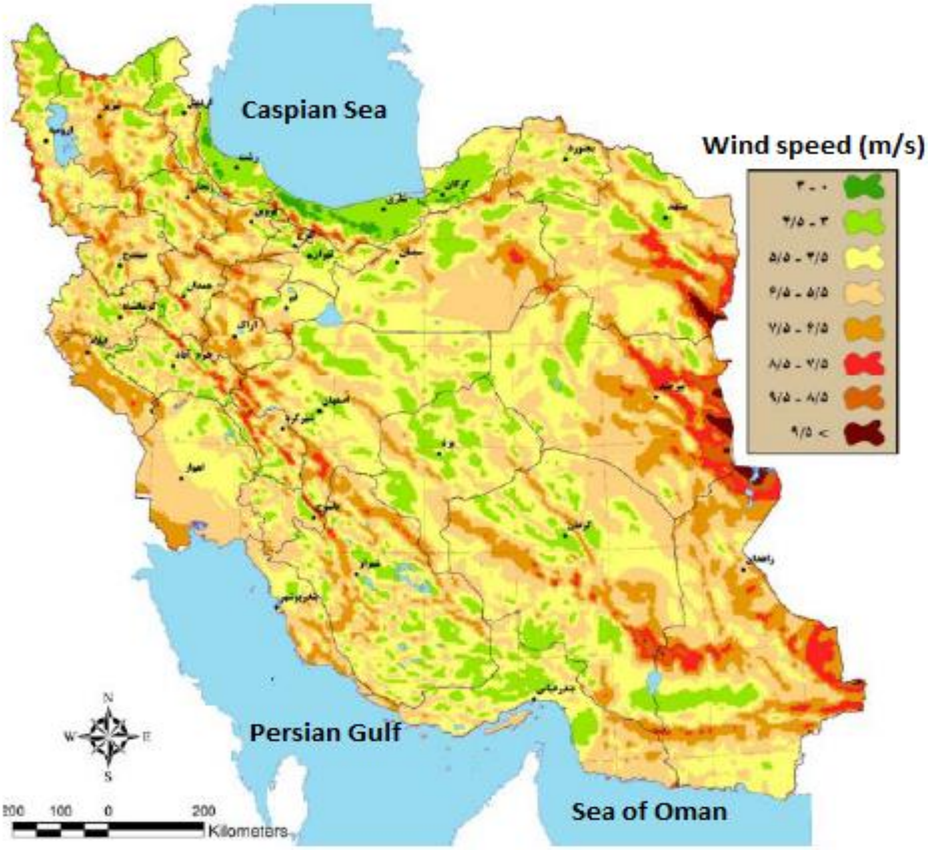

Figure 6. Average annual wind speed at a height of 100 meters (27).

Hydropower resources and potential (Figure 7) in Iran are estimated at 26,000 MW, most of which is supplied by the Karun, Karkheh, and Dez rivers. By 2017, a total of 15,329.1 GWh of hydropower had been generated, accounting for a 5% share of total electricity generated and 0.30% of the total energy supply of the country, while on a global scale, hydropower accounts for 16.6% of the total energy generated by countries (32). Since Iran is a country with abundant fossil fuels, the choice of power plant type seems to be based solely on initial investment and the availability of its primary inputs.

In 2020, about 14 small-scale hydropower plants started operating in 10 provinces of the country with a total generation capacity of 261 MW. Most of these projects are located in the northern regions and the water-rich foothills of the Zagros, including the provinces of Gilan, Mazandaran, Lorestan, and Kohgiluyeh and Boyer-Ahmad. Some researchers believe that including hydropower programs in the country's energy development plans will lead to rural economic prosperity, increase industrial and commercial activities in rural areas, and prevent rural migration to cities (33). The reason for this is the existence of very suitable areas for the construction of these power plants and their economic and social characteristics (34). Therefore, to reduce the use of fossil energy sources, the use of this type of power plant in water-rich areas is recommended, provided that environmental impact assessments are carried out realistically and decisions are made.

Hydropower does not produce greenhouse gases and is therefore often referred to as a green energy source. However, it has its advantages and disadvantages. It improves the socio-economic development of a country. But regarding social impact, it displaces many people from their homes to create it, although they receive compensation, it is not sufficient.

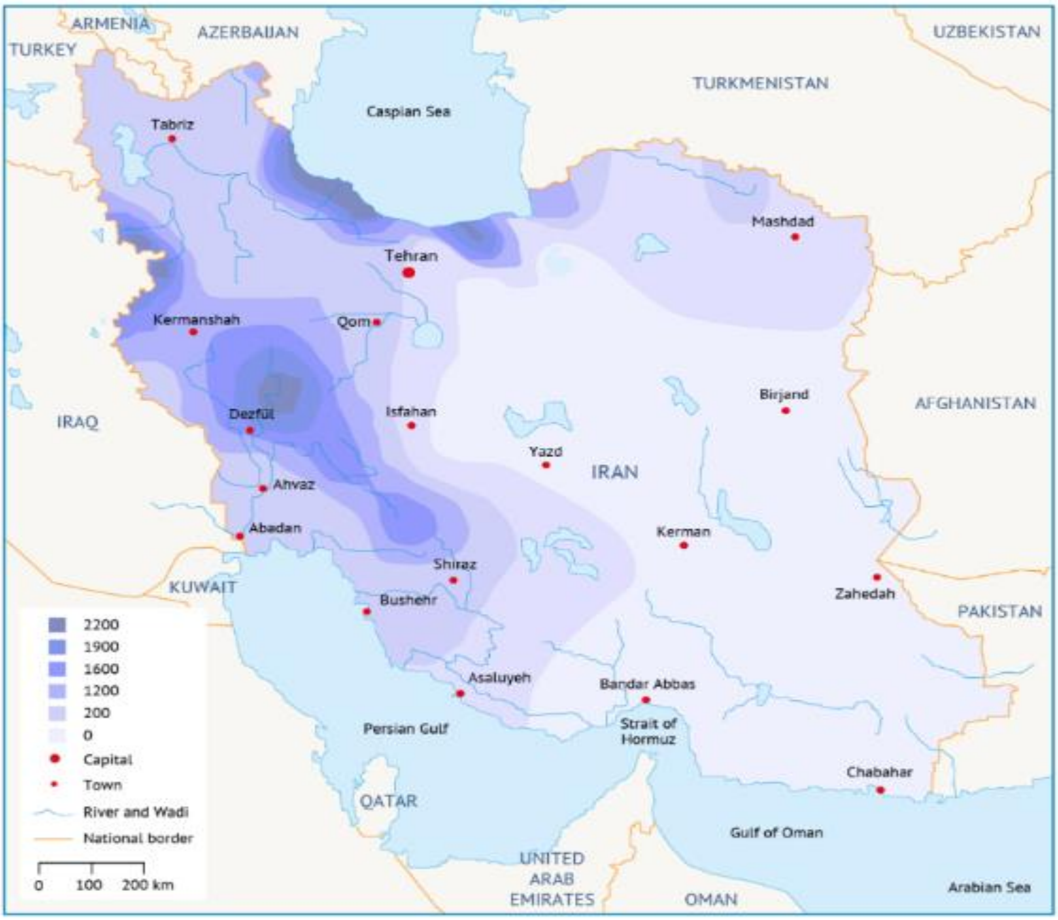

Figure 7. Map of hydropower resources in Iran (32).

The operation of sites for hydropower plants, such as reservoirs, is often artificially created and leads to flooding of the former natural environment. Furthermore, water is drained from lakes and water streams and transported through canals over long distances to pipelines and finally to turbines, which are often visible, but may also pass through tunnels created inside mountains (35, 36). Hydropower structures affect the ecology of the river body, largely by altering its hydrological characteristics and by disrupting the ecological continuity of sediment transport and fish migration through the construction of dams, dikes, and spillways. In countries where significant plants or tree cover are flooded during dam construction, methane gas may form or be released directly when plants begin to decay in the water, or when water is processed in turbines (35).

2.1.4. Biomass

Biomass is defined as all plant resources and plant residues and human biological activities that are capable of producing energy. Wood, human waste, sawdust, animal waste, food waste, and sewage are used for biomass. The process of converting biomass and other renewable resources is called biotechnology energy. This energy is mostly used for cooking, heating, lighting, and electricity generation (37).

The vast country of Iran is relatively rich in terms of biomass resources. Recently, a power plant with a nominal capacity of 650 kW has been inaugurated at the old Mashhad landfill with an initial investment of 15 billion Rials. Biogas from animal waste in Iran can be produced in the amount of 8668 million cubic meters. The producible biogas from agricultural and forest waste in Iran is 8.8 million cubic meters. Biogas from anaerobic treatment is about 200 million cubic meters. The producible biogas from large food industries in the country is estimated at 80 to 280 million cubic meters per year. By operating the anaerobic digestion process of putrescible waste, a total of 2.7 million cubic meters of biogas can be produced annually in the country. It can be seen that from the above sources alone, an average of 9 million cubic meters of biogas can be extracted annually (38, 39).

2.1.5. Energy generation from wastewater

The energy content of raw wastewater measured by bomb calorimetry is about 14.7 kJ/g COD, which is approximately 9 times the electricity requirement for its aerobic treatment (40). Considering a daily production of about 100 g COD per person, the energy content of wastewater for a city with 1 million people is estimated at about 1470 MJ per day. These estimates are made without considering the energy content of industrial wastewater, while recent calculations report the energy content in terms of chemistry to effluents as more than 153 kWh per person equivalent per year (41).

Much of the biogas produced in WWTPs (wastewater treatment plants) in the United States is flared, and only a small portion is used for heat or energy generation. This is also true in Brazil, where bioenergy production is still incipient and limited to a few treatment plants. In contrast, more than 800 WWTPs in Germany use biogas to generate electrical and thermal energy, producing 900 GWh per year of electricity and 1800 GWh per year of heat. Nearly one-quarter of the total electricity consumption of WWTPs is supplied by their own generation (42).

There is no precise information on wastewater treatment plants in Iran, and accurate calculation is not possible. Based on demographic calculations, the maximum amount of methane produced from anaerobic digestion of sewage sludge generated in the country is estimated at about 219,437.03 tons per year, and the equivalent biogas is about 337,595.43 tons per year, and the maximum electricity generation capacity is approximately 174.52 MW. Calculations show that if the country's activated sludge treatment plants are equipped with anaerobic digesters, by operating them and installing the required power plant equipment, there is a potential for electricity generation of about 44 MW. Also, considering wastewater treatment plants with anaerobic digesters, an electricity generation capacity of 22 MW is achievable (43).

2.1.6. Energy generation from waste

Energy from solid waste is primarily not an economical method of electricity generation, but the environmental benefits it can provide are the rational basis for why these power plants are established. In developing countries, including Iran, biogas production from municipal solid waste in metropolitan cities is being studied and developed (44). The average annual MSW generation in Iran is 20,232 thousand tons. The average physical properties of waste residues in Iran include organic matter (72.04), plastic (6.43), paper and cardboard (7.77), and others (13.76). The electricity generation potential based on heating value for the most populous provinces of Iran is 2171.02 MW, and Tehran province, with a generation potential of 630.2 MW, has the largest share among other provinces. The electricity generation potential from wet (degradable) MSW for the most populous provinces of Iran is 900.2 MW. Tehran province has the highest degradable potential with 307.5 MW. The electricity generation potential from dry MSW for the most populous provinces of Iran is 356.35 MW, and Tehran, Razavi Khorasan, and Khuzestan have the largest shares compared to other provinces with values of 90, 21.5, 50.2, 47, 56.8, 25.9, 44, 10.95, and 9.2 MW, respectively.

In general, the maximum power generation potential from MSW (Pmax) in Iran is 1256.45 MW. The electricity generation potential from landfill gas and the electricity generation potential from landfill waste are 262.43 and 315.05 MW, respectively (45).

2.1.7. Geothermal

Geothermal energy is naturally obtained from the Earth's interior as a source of thermal energy. The origin of heat is related to the internal structure of the planet and the physical processes occurring within it. Although heat exists in the Earth's crust in very large quantities, albeit in the deepest parts, it is unevenly distributed, rarely concentrated, and often at depths too great to be mechanically exploited (46).

Iran, due to its location along the earthquake belt and young volcanic activity, has favorable conditions for the formation of geothermal energy fields. The existence of hot springs in the country proves this claim. Therefore, geothermal energy is one of the lowest-cost renewable energy options (in terms of production cost) for Iran. The total geothermal potential of Iran for single-flash or single-phase steam cycles is about 500 MW and for binary cycle systems, which require lower reservoir temperatures, is estimated to be up to 10 times higher. However, the share of geothermal energy in the country's energy mix for the next 10 to 20 years is less than 200 MW. This is approximately the estimated potential of the Sabalan region located in the northwest of Iran, where exploratory drilling studies and resource assessment studies have been completed in this region (47). Production wells are being drilled for a five-megawatt pilot plant. Exploratory drilling has begun in three other areas: Damavand, Khoy, Maku, and Sahand, and preliminary studies are underway in 10 other areas (32).

3. Environment, sustainable development, renewable and climate change

The use of renewable energies for electricity and energy generation helps reduce greenhouse gas emissions, which leads to climate change mitigation, reduction of environmental and health effects associated with pollutants from fossil fuel sources. Also, renewable energy typically requires less water (unlike fossil fuel power plants), which can also help solve the global water resources crisis (48, 49).

Development in today's world seems meaningless without considering environmental requirements, limitations, and goals. In 2000, a summit of world leaders was held regarding the Millennium Development Goals, which was recognized as a turning point in changing the view of development from prioritizing gross national product enhancement towards sustainable development. The main goal of sustainable development is to create a balance between development and the environment. This understanding is considered as cooperation between the two aspects of economy and ecology as the basis of the sustainable development strategy. In Iran, attention to the environment has increased in development plans, especially in the sixth development plan, but the evaluation of environmental performance indicators shows that the situation is inappropriate in some indicators (Table 1) (50). According to the report of the Yale University Center for Environmental Law and Policy and the Columbia University Earth Institute Center for International Earth Science Information Network, Iran ranks 133rd out of 180 countries in terms of environmental performance index. Meanwhile, the country has obtained a very poor rank of 171 in the sub-indices of projected greenhouse gas emissions and the growth rate of greenhouse gas intensity. Also, in wetland loss, SO_2 growth rate, and black carbon growth rate, we have the first rank (51). Table 2 shows Iran's position in the environmental performance index from 2006 to 2022. The decline in Iran's rank in the 2022 assessment can be attributed to the definition of new sub-indices, especially in the air quality and climate change sectors (52).

The reality of climate change is severe among Middle Eastern countries, especially Iran. Among the Middle Eastern countries, Iran will face an average temperature increase of 2.6°C and a 35% reduction in rainfall in the coming decades. Conversely, Iran, with total greenhouse gas (GHG) emissions close to 616,741 million tons of CO_2, is the first country responsible for climate change in the Middle East and the seventh country in the world. Iran's high level of greenhouse gas emissions is dependent on significant oil and gas production and rapid urbanization. Furthermore, the increased risk of drought due to climate change in the future will threaten water and food security, especially for people living in densely populated cities, due to the additional pressure on limited freshwater resources (53, 54).

Table 1. A group of main environmental performance indicators and components of Iran in 2022 (51).

Indicators	Score	Rank	Ten-year change (%)
Health	41.9	84	6.8
PM2.5 particulate matter pollution	17.2	139	7.6
Household solid fuels	82.2	36	16.7
NOx	__	174	-4.3
SO2	7.4	169	-6
CO	6.9	169	-20.8
VOC	22	109	-4.2
Ozone	31.6	145	-1.3
CO2 growth rate	28.2	112	12.2
CH4 growth rate	20.3	154	12
Fluorinated greenhouse gas emissions growth rate	91.8	14	-1.4
Greenhouse gas intensity growth rate	9.7	171	-24.4
Projected greenhouse gas emissions	0	171	__
Greenhouse gas emissions per capita	20.1	153	-5.2
Climate change	24	159	7.8
Environmental Performance Index	34.5	133	6.9

Given the importance of diversifying energy generation sources for energy security and environmental issues, by the end of June 2023, the installed capacity of electricity generation from renewable sources in Iran reached 1,058 MW. This capacity, compared to the nominal electricity generation capacity of the country, which is 91,288 MW, has a share equivalent to 1.3%. This amount of installed renewable capacity in Iran is vastly different from the quantitative goals of the sixth five-year development plan. Although energy generation from renewable sources increased during the sixth development plan and reached 1,764,000 kW in 2022, it constitutes only about 0.5% of the country's total electricity generation. Also, in the seventh development plan, 31 issues

It also saves 1108 million liters in water consumption, creates 31,271 jobs, and attracts 143.5 trillion Rials of non-governmental investment. Meanwhile, SATBA (Renewable Energy and Energy Efficiency Organization) has 78 power plants and 1000 generators for subscribers under construction (32).

4. Challenges of non-development of renewable energy in Iran and proposals

Examining the existing laws in the field of renewable energy shows that the country has contributed to its development through three approaches: guaranteed purchase, provision of facilities, and quantitative targeting. However,

related to the environment have been identified in 7 major axes, and the analysis of environmental issues and expert opinions in this field have been considered (50).

The impact of renewable energy and electricity efficiency policies in recent years has led to the construction of 134 power plants and 4038 generators for consumers. This has resulted in the generation of 5035 million kWh of electricity, a reduction of 468 million kWh in electricity grid losses, and 3,417,000 tons of CO_2 emissions, which reduces the external effects of CO_2 emission reduction, and the non-emission of 21,300 tons of other local pollutants. Improving the energy structure and energy efficiency in Iran can significantly reduce the CO_2 emission level.

all of these have not been able to improve the status of renewable energy in the country, and the current situation is very different from the quantitative goals and programs of the country.

One of the problems of renewable energy development in the country is the lack of financial resources and lack of competitiveness with thermal power plants due to the low fuel price in thermal power plants. The Ministry of Energy secures the guaranteed purchase of renewable electricity from the proceeds of Article 5 of the Law Supporting the Electricity Industry, but with currency fluctuations and increasing costs of renewable electricity, this model cannot cover the guaranteed purchase cost of electricity. Also, renewable power plants require more investment and are less attractive for investment. On the other hand, the electricity industry faces economic imbalance problems. According to Article 6 of the Law Supporting the Electricity Industry, the country's Planning and Budget Organization must pay the necessary credit to the Ministry of Energy to cover the difference in the cost price of electricity. This situation has led to an increase in the Ministry of Energy's claims from the government, and the electricity industry has problems paying the cost of purchasing electricity from private sector power plants.

Imbalance in electricity supply and economic imbalance in the country exacerbate each other and slow down the rate of increase in renewable electricity generation capacity. The lack of financial capacity in the electricity industry due to economic imbalance has a destructive effect, and focusing on lower-cost projects with the highest generation capacity is preferred. To facilitate the move towards renewable energy, the state of economic and energy imbalance in the electricity industry must be improved, and solutions for development and investment in renewable energy must be implemented. Also, renewable energy policies must consider the interaction of factors affecting renewable energy resources and sustainability.

In addition to the mentioned issues, the non-development of renewable energy can be due to the following reasons. Long-term access to fossil fuels means that Iran relies on fossil fuels to supply energy, and this dependence limits the development of renewable energy. Energy pricing and low electricity tariffs resulting from high natural gas subsidies in Iran mean that there is no incentive for the private sector to invest in renewable energy, whose production cost is higher than other energy derivatives. A lack of initial investment exists because renewable energy power plants require more investment than thermal power plants, but there are problems in providing their initial capital. Due to uniform conventional energy prices, the private sector in Iran has no incentive to invest in renewable energies since their production cost is higher than other energy derivatives; this issue has been partially reduced by the Targeted Subsidies Law, but it is still not sufficient. Subsidy reform in Iran is one of the most important aspects of the economic transformation plan, where this change in the subsidy provision process is paid to the people in cash by gradually removing subsidies from various sectors, and the remaining income is allocated to construction and cultural projects. There is a weakness of technology transfer infrastructure, as the required infrastructure for transferring renewable energy to consumption points has not been sufficiently developed, which can cause problems in the distribution of renewable energy and reduce its efficiency.

A lack of adequate budget allocation means that adequate budget allocation to research and development sectors in the field of renewable energy and support for innovative and clean projects is not done sufficiently in Iran, which can slow down the development rate of renewable technologies. Ensuring environmental security to protect the environment and reduce environmental pollution is among the challenges of renewable energy development in Iran. Finally, the existing policy and regulatory frameworks in the field of renewable energies need to be reviewed and updated to benefit from the experiences of other countries.

Conclusion

The reality is that climate change is severe among Middle Eastern countries, especially Iran. Iran's transition to renewable energy sources is closely related to sustainable development. By diversifying energy sources and reducing greenhouse gas emissions, Iran can contribute to global sustainability goals. This transition involves not only the adoption of renewable technologies but also a change in the energy system, international cooperation, and mechanisms such as the Clean Development Mechanism (CDM) to mitigate climate change and promote sustainable development. However, examining the conditions and the decline of Iran's position in the world based on environmental performance indicators confirms the failure of existing laws in the field of renewable energy, although attention to it in the country's seventh development plan recognizes the special position of renewable energies in achieving sustainable development and reducing the effects of climate change. Nevertheless, all of these have not been able to improve the status of renewable energy in the country so far, and the current situation is very different from the quantitative goals and programs of the country. Therefore, to succeed in adapting to and mitigating the effects of climate change, it is necessary to develop a national climate change adaptation program and implement practical and effective policies by the country's authorities.

Declaration

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