The prioritization and feasibility study over renewable technologies using fuzzy logic: A case study for Takestan plains

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Regardless of the precious oil and gas resources, Iran is also recognized as one of the largest renewable energy potential holders in the region. Iran, as one of the world's largest oil exporters and producers of gas, plays a significant role in international energy policy. However, since 2015, in the wake of the success of the discourse on climate change in the international space, Iran has begun dangerous development programs in the field of new energy, and by expanding the policy of encouragement and support provided by the Trustee of the Organization of Renewable Energy and Energy Performance (Ab. in Persian is SATBA), has been trying to expand the culture of private investment in this area. Due to these reasons and the growing importance of clean energy in the international space and global energy security, this study examines the potential of each of the three renewable technologies such as solar, wind, and biomass in Qazvin province as a case study. The study seeks to prioritize the superiority of each technology and select the best option for investing in the field of renewable energy in each area using the fuzzy logic algorithm as well as the principles of engineering economics and feasibility studies.

keywords: *Renewable energies, Feasibility studies, Economics, Fuzzy logic, Energy.*

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1. INTRODUCTION

Iran is one of the wealthiest countries in the world in terms of energy resources because it possesses vast resources of non-renewable fossil fuels such as oil and gas and, on the other hand, has great potential in renewable energy such as wind. With the development of environmental attitudes and cost-effective strategies for utilizing renewable energy sources, the use of wind energy is on the rise in many countries around the world. To this end, the construction and operation of renewable energies and the establishment of wind farms with the participation of the private sector have been a priority for the Ministry of Energy and the country's macro energy policies [1, 2]. However, this God-given energy, similar to solar energy, has not been utilized as much as it should and perhaps following Iran's capabilities. There are currently about 300 megawatts of renewable energy capacity in the country, which is projected to add about 8,000 megawatts of wind and solar energy over the next ten years. It is perhaps these capacities and attractions that have prompted some foreign investors to come to Iran and, in the midst of political and economic negotiations, tackle the issue of new energy.

Takestan city, selected as the pilot in this study, is one of Qazvin province of Iran. The center of this city is the city of Takestan. Tati is the name of the city of Siaden, which was mentioned in Persian sources before the establishment of the Iranian Academy. Takestan city is the most populated area of Tatvan, Iran. Khorramdasht, Esforin, Narjeh, and Ziaabad and Vannikuyeh are other cities in Takestan County. According to the 2016 census, the population of this city was 80299. The city has a population of more than 80,000 in 2016 and is the most populous city after Qazvin. Takestan city in the northwest of the central plateau of Iran between the circles of 49 degrees 10 minutes to 49 degrees 48 minutes east of the Greenwich meridian and 35 degrees 40 minutes to 36 degrees 21 minutes north of the equator. The town of Takestan is 1265 meters above sea level. This city is 49 degrees 42 minutes east of latitude 36 degrees 4 minutes 15 seconds. The distance from Takestan to Qazvin is 35 km and 185 km to Tehran. The distance to Takestan is 149 km. Transit from east to Qazvin from south to Danesfahan Bojin Zahra and Saveh from west to Abhar city of Zanjan province. In the lowland climate, the productive factors are divided into two types: local and external: Local Factors: These factors include

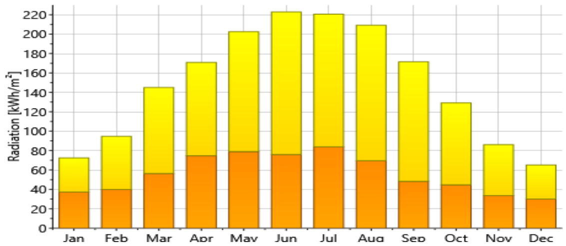

Fig. 1. Diagram of the intensity of radiation during the year in this area (Source: Meteonorm software).

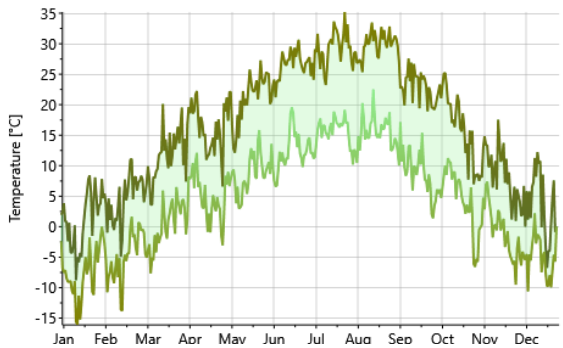

Fig. 2. Temperature changes throughout the year in this area.

latitude, altitude, and direction of creases, etc. Due to the low latitude of the province, the angle of sunlight in the northern and southern regions of Qazvin province is slightly different.

Therefore, the different regions of the province are not significantly different in terms of latitude and its effect on climate. As the altitude increases, the temperature decreases, resulting in cooler air on the mountains and highlands of the province than on lowland plains and valleys.

The most important external factors affecting the climate of Qazvin province are the air masses that enter the province from different regions in different seasons of the year and have different effects depending on their characteristics. Most of these air masses are:

- Western humid air mass.
- North cold and dry air mass.
- south hot and dry air mass.

Western Wetland Massive: Most of the province's rainfall in the cold six months of the year is caused by the impact of the humid western weather. These humid climates in the western winds bring the Mediterranean and Atlantic humidity into the province in the cold season, causing snow and rain. As a result, the primary source of moisture and rainfall in the Mediterranean and the Atlantic.

Cold and Dry Air Mass: The source of this air mass is the colder Siberian regions, and due to the extreme cold, it does not have much moisture and reduces the temperature. South and hot air masses: The source of this mass is the central deserts of Iran and Saudi Arabia. The climate is very hot and dry, affecting most of the province's warm seasons. The entry of this mass of air is usually accompanied by a secret wind blowing, which causes the temperature to rise and evaporate.

According to the map, the average annual precipitation of the province varies from 210 mm in the eastern regions to more than 550 mm in the northeast elevations. The maximum rainfall in the northeast slopes of Alamut is more than 550 mm with precipitation. Also, Avaj (southwestern province) has more than 450 mm of rainfall. The minimum rainfall in Qazvin province is in the areas around Buin Zahra to the southern parts of Takestan city with 210 to 230 mm and areas around Manjil Dam in the Tarom Sefli section with 210 mm of rainfall [3, 4].

According to the annual temperature map, the northeast and north elevations of the province and Avaj heights in the southwest of the province have the lowest temperatures, and the central regions of Qazvin plain and around Manjil Dam Lake have the highest temperatures. The average annual temperature of the meteorological stations from the plain to the foothills and mountain areas is gradually reduced (except the Shahroud Valley, which is a 24 ° C in July and it is minimum/local climate). The maximum temperature recorded at Qazvin station during the thirty years was 4.19 degrees in January [5, 6].

In recent years many types of research have been focused on the techno-economic multi-criteria analysis to provide the basis of the evergrowing energy industry. The efficient utilization of the mentioned method and analysis for the local and national goals is the main target of this field to support the industrial development with the logical multi-disciplinary decision-making process. Nadu et al. state that the electrical grid is not surplus the demand, and 40% of the power generation capacity are not reliable (dropping down more than 10hr a day) [1, 6].

Alireza et al. studied the photovoltaic technology, wind, and diesel generators in a standalone system in the rural districts of Iran to decide which one is the best option [7]. Tawil et al. studied the sizing and optimization of the renewable hybrid systems of wind, tidal, and pumping hydroelectric technologies for the most suitable option [8]. Hassan et al. analyzed the operational efficiency and performance of the tracking PV systems in Makkah, Suadi Arabia, with the HOMER software. This report stated that the tracking PVs are 34% more efficient comparing to the tilt PV systems. Munuswamy et al. [9] conducted a cost comparison study of the hydrogen system performance and the stable grid-connected fuel cell systems [10]. This study takes place in India and done using the HOMER software for the simulation and reporting the results. This paper suggests that grid electricity is more feasible in the long-distance(more than 44Km).

All mentioned references show that the multi-criteria analysis is a locally based study, and its novelty for this research is implementing this study for the local Iranian regions, which similar studies not being implemented on them. The central research gap which has been detected in the literature review process done in this paper is the single disciplinary criteria selections of all the papers mentioned above. This paper aims to fill this gap with a multi-disciplinary criteria selection from social, ecological, economic, and technological fields. This will help the analysis to reach higher accuracy compared to the previous studies.

2. METHODOLOGY

A. Wind energy

Wind energy is the energy generated by moving air. When the sun's radiation reaches uneven terrain, it causes changes in temperature and pressure, resulting in wind changes. The Earth's atmosphere also transmits heat from the tropics to the polar regions due to the Earth's motion, which in turn causes wind [6].

The construction of wind power plants will make much physical progress in the future; as far as we can say concerning the penalties for post-2020 hybrid power plants under the Kyoto Treaty, the activity and production of electricity are more economical than new energy. In the future, renewable energy plants will receive awards, while fossil energy plants will be penalized. Also, there are many high-lying areas in the country, and, according to surveys, there are up to 60,000 MW of wind power in Iran. They are fueled by wind and have only a propeller that rotates in the sky. They only need turbines and masts, but the combined cycle power plant needs heat, steam, and gas turbines, and their construction is even more complicated than building a refinery.

In Iran, to utilize existing wind resources to generate electricity, reliable information on the wind potential of the area in question is needed to construct a wind power plant. Due to the presence of windy areas in Iran, a suitable platform is provided to expand the exploitation of wind turbines.

Based on wind atlas, based on information from 60 stations in various parts of the country, the nominal capacity of the sites is about 60,000 MW. According to forecasts, the country's wind power is estimated at 18,000 MW, which confirms the country's significant potential for wind power generation and the cost-effectiveness of investment in the wind energy industry. Lamair, Germany, has also been a consultant in the implementation of the wind potential assessment project in Iran. Based on the studies of this company, the potential of wind power available in Iran is estimated at 100,000 MW, and the development is auspicious for the private sector [5, 7].

Due to the operational problems and sustainability of large-scale networks, the distributed electricity generation reduces the reliance on long-distance networks, and this is one of the advantages of the wind power industry. Not only is this economically costly, but also by reducing the transmission and distribution network losses as well as reducing the need for stored generation capacity and increasing the reliability of the grid, the overall cost of electricity will be significantly reduced. The best type of dispersed generation is wind power plants, small hydroelectric, biomass, geothermal and solar, which are not only dispersed in terms of electricity generation but also terms of primary sources and do not require the use of gas or oil pipelines. This activity is considered as one of the essential passive defense measures. The realization of this goal means that the country will have the facilities that can meet the most urgent needs of the various sectors by relying on local resources and facilities in the event of various accidents and disasters [6].

The advantages of this energy include the need for wind turbines for fuel, the reasonable price of electricity, diversification of energy sources, and the creation of a sustainable energy system, with no need for water and no environmental pollution. Wind turbines can be used in industrial, recreational centers, and places of interest away from the global electricity grid. This clean energy can also be used in villas and suburbs and even in villages and agricultural and poultry farms.

The energy supply market is a competitive market where electricity generation in wind power plants offers new advantages over users compared to fossil fuel power plants. One of the advantages of wind power plants is that they will generate many years of energy without the need for fuel over their lifetime, while the cost of other energy sources will increase over these years [8].

The widespread activity of many countries around the world to generate electricity from wind energy is a role model for other countries that have a long way to go. Many of the growing economic resources are located in the Asian region, and the growing economies of Asian countries, including Iran, have increasingly felt the need to generate electricity and generate electricity from non-fossil sources. Also, the lack of a national electricity grid in many rural areas in Asian countries has confirmed the stamping of wind power generation systems [9, 10].

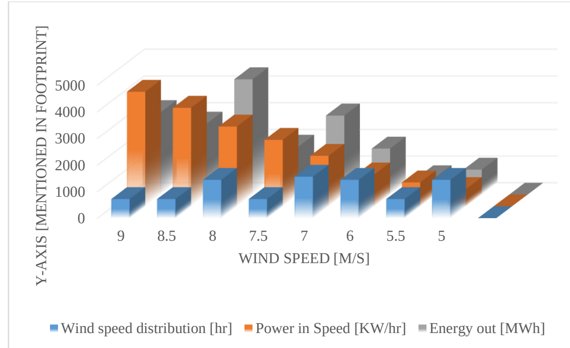

Fig. 3. Energy generated by the Vestas wind turbine in this area.

Today, the power generation capacity in Iran has reached 75,000 MW while the share of electricity generation from wind power plants is negligible. The total of renewable power plants minus the hydropower plants is below one percent, and wind power plants are much smaller than this, so there is no significant contribution from wind power plants. In Iran, however, there is electricity generation capacity in wind power plants.

It is enough to study the wind atlas of the country to gauge the country's inherent potential in terms of climate and the significant areas where a wind farm can be built. Unfortunately, however, not much has been done in this area because of the reliance on fossil fuel power generation. The low cost and availability of fossil fuels have led to little investment in wind energy. However, according to the Ministry of Energy's plans for the future in terms of electricity generation and the addition of 10,000 MW to renewable energy capacity, there should be significant improvements in wind energy use [9, 11].

Sadid Company has been operating in this sector for about 20 years and is working with 100% domestic equipment. However, between 70% and 80% of equipment is manufactured domestically, and only 30% is supplied overseas and requires items such as turbines. Mapna also produces turbines, but some of the main turbine components are imported from abroad. All parts of wind power plants are built up to 700 kW in the country, as they have been operating for a long time. 3 MW power plants have also been operating for two years, and some parts are imported from abroad. Assuming total turbine parts are imported from abroad, up to 70% of equipment is still supplied in Iran, and only 30% is imported from abroad. Of course, the plan is to use Vestas's large 2-megawatt turbines.

Based on the above data, it can be seen that the desired location has a relatively favorable speed, in addition to high air humidity and, consequently, high air density, and the minimum wind speed is such that by selecting the appropriate turbine. We can see the power generation in all seasons of the year.

B. Solar energy

Since the birth of the first life on Earth, solar energy has been used in photosynthesis. Humans used the sun to heat their housing in the building. Humans later used sunlight to dry fruits and vegetables in the open air and to evaporate seawater in shallow ponds and produce salt. The first and perhaps only military use of solar energy was carried out by Archimedes in the city of Syracuse on the east of Sicily. He was able to set the sun on fire by focusing several mirrors on the sails of the ships [12, 13]. Industrial and modern uses of solar energy began in the 1770s. Perhaps the most interesting use of the sun has been in the discovery of oxygen gas. In 1774 Priestley was able to concentrate sunlight on a container containing mercury oxide and produce a gas, later called oxygen. Numerous experiments were carried out by Lavazier using lenses and sunlight. Old Sun Photo in Zoom Image Human life is drawn in the sun's tabs. In 1872 the first solar unit for the desalination of seawater was built in northern Chile. In the late 1800s and early 1900s, several solar concentrators were built to achieve high temperatures and steam generation in France, the US and Egypt, using steam generated for steam and irrigation machines. Since the 1940s, the use of solar energy in the production of hot water and heating in buildings in the United States, Russia (Tashkent and Ashgabat), Australia, and elsewhere has expanded. In 1946, solar-powered furnaces were built in India. The solar cell (photovoltaic) first came on the market in the first half of the 1950s without much fuss and received considerable acclaim. In 1958, American designers hesitated to use a 2MW solar-powered converter in the Vanguardik spacecraft but were surprised to find that the ship's radio system had been operating continuously for up to six years. The radio message landed on the ground. In 1961, for the first time in Italy, solar thermal energy was used to generate electricity by small steam turbines [12, 14]. With the energy crisis of 1973, the use of solar energy has increased, and many investments have been made in most countries of the world (especially industrialized countries) to research and achieve optimal designs of different solar energy applications. In the 1980s, with the collapse of the energy crisis, attention to solar energy diminished, and now the most critical issue in industrialized countries is solar cells. Also, solar-heating methods in many countries of the world (especially the United States) have been the focus of attention in the past decade. In the 1980s, with the collapse of the energy crisis, attention to solar energy declined. Studies on solar energy in Iran began about 35 years ago at approximately the same time at Shiraz and Sharif University of Technology. One of the critical projects considered at these centers was the design of the 10 MW solar power plant at Shiraz University and the design and development of the photoelectric cells at the center mentioned above. Solar energy projects are currently underway in the country by the Iranian New Energy Organization.

In Iran, there is an average of 5.5 kWh of solar energy per square meter per day, and there are 300 sunny days in 90% of the country's soil. Iran has an area of approximately 1,600,000 square kilometers or about 1.2 trillion square meters. The daily amount of solar radiation in Iran is 8.8 trillion kWh. With 9,000,000,000 MWh. If only 1% of the area of Iran absorbs solar energy and the efficiency of the energy system is only 10%. Again, we can get 9,000,000 MWh of solar energy daily. With studies carried out by the German DLR, it is possible to install more than 60,000 MW of solar thermal power plants in an area of more than 2000 km2. If we allocate an area of 100*100 km to the construction of a photovoltaic solar power plant, the electricity produced will be equivalent to the total power generation in 2010.

The way the photovoltaic system works is to call the phenomenon of electricity generated by light without the use of excitation mechanisms, a photovoltaic phenomenon, and any system that uses this phenomenon. Photovoltaic systems are one of the most widely used renewable energy applications and have so far installed various systems with different capacities (0.5 W to Multi MW) around the world, depending on reliability and performance. These systems are increasing in number every day. An acceptable current and voltage can be obtained by series and parallelizing solar cells. As a result, they are called a series of parallel and parallel cells of the photovoltaic panel. Nowadays, such cells are generally made of silicone material, and the required silicon is made of sand, which is abundantly found in the desert regions of the country. So there is no shortage of raw materials for these cells in Iran. Photovoltaic systems can generally be divided into three main sections, which are briefly panel, structure, and inverter [14].

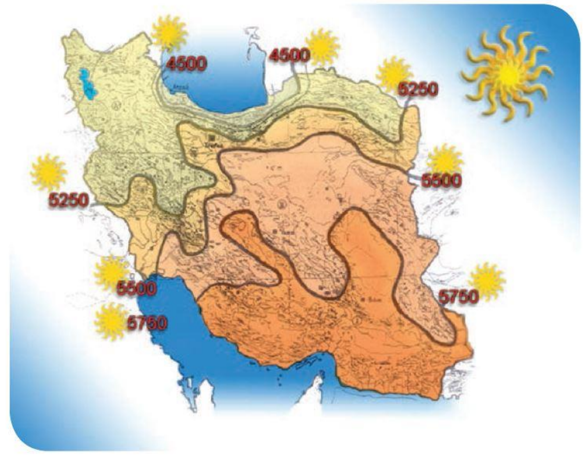

Fig. 4. The amount of sunshine in different parts of Iran (Source: Iranian New Energy Organization).

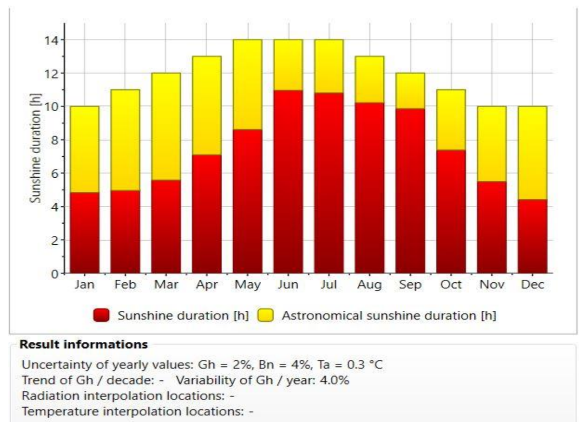

Fig. 5. The amount of sunshine in the pilot area.

According to the charts above, this area of the country has relatively good potential, and on the other hand, the sunshine hours are desirable. However, in Fig. 2, which shows the temperature tolerance in different months, the ambient temperature is very suitable for panel operation and will always operate close to maximum temperature-efficiency [15].

Using the meteorological data, the theory radiation of the light in the study site, which is considered as a Takestan pilot, has an average value of 29.6 MJ/m^2, and the diagram is plotted daily.

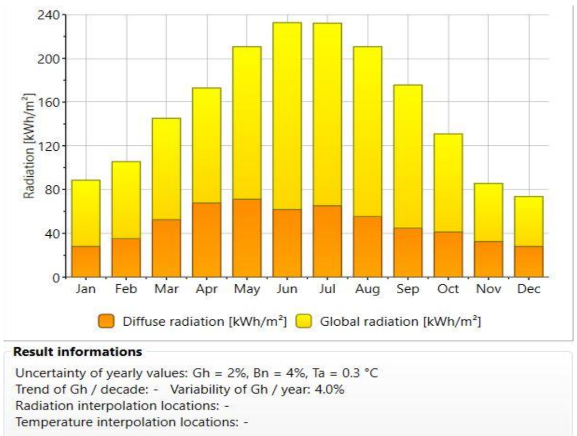

Fig. 6. Sunlight radiation graphs.

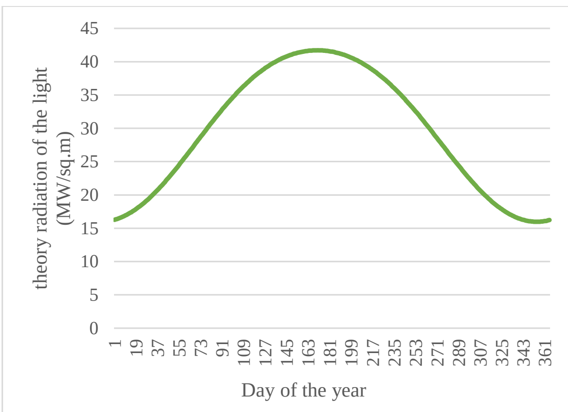

Fig. 7. Light intensity diagram in the Takestan.

According to the actual Meteorological Organization data, the average is about 19.04 MJ/m^2, with a mean filter coefficient of 0.643 [16].

C. Biomass energy

Biomass or biomass is a renewable source of energy derived from biomaterials. Generally, waste that is biologically derived from cell proliferation is called biomass. Such as forests and forest waste, agricultural products and waste, horticulture and the food industry, animal waste, municipal and industrial wastewater, sewage, industrial organic waste, and municipal solid waste [18].

Biomass also includes combustible bio-waste but does not include biomass, such as fossil fuels (oil, gas, etc.) that have been altered during geological processes, such as coal or oil. Although fossil fuels are rooted in biomass in ancient times, biomass is not referred to as biomass because the carbon in them has been removed from the natural cycle of nature, and their burning disrupts the balance of carbon dioxide in the atmosphere.

The EU definition of biomass, as set out in the Guide (2001/77 / EC) of 27 September 2001, reads: Biomass is the biodegradable component of agricultural products, waste, and animal waste (including vegetable and animal waste).), Forests and related industries, as well as decomposable industrial and municipal waste. According to the scientific definition provided for biomass in this regulation, biomass refers to fuels made from

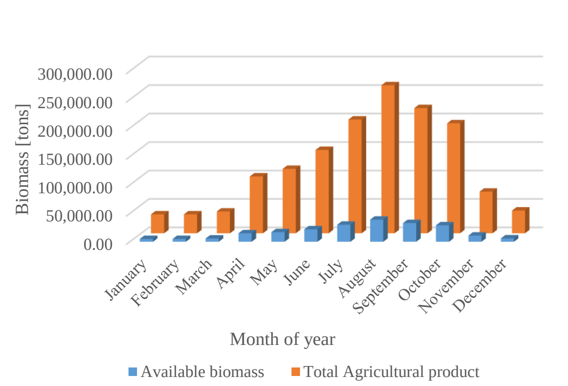

Fig. 8. Total agricultural production and the amount utilized as biomass fuel for study limit per 2000 population.

the mass of phytoplankton and the mass of zooplankton.

In general, everything that is created in nature with a biological origin is biomass at the end and fermentation of its components—even energy from body heat. Today, it has been shown that biofuels derived from the waste of forests and agricultural products in the world can make as much as 70 billion tonnes of crude oil available to humans annually, which is ten times the annual energy consumption in the world. These fuels can also be used to generate more heat because they can save a significant amount of money. Biomass also includes combustible bio-waste.

The graph above shows that only about 15% of the total crop production is available as biomass, averaging about 18,400 tons per month per 2000 people. Using conventional gas turbine technology, Siemens can generate about 83500 MWh of electricity by biomass. Using this technology to generate this volume of electricity generates about 47,000 tons less CO2 than conventional fossil fuels, which is about 5,000 hectares of the forest [17].

D. Formulation and modeling

D.1. AHP method

Analytic hierarchy process or AHP is a multi-criteria decision-making approach, which is to assess and priorities the list of alternative solutions that help the easification of the complex systems of decision-making. The steps of this method are [19]:

Step 1- structuring the model of problem: in this step, the complex system is decomposed as a hierarchical structure, Which at the lowest level is a set of decision alternatives and comprehensive options. In this step, the problem functions are being developed in order to identify the best suitable option and decision.

Step 2- Evaluating the decision criteria: in the second step, the main disciplines of the criteria are decomposed into sub-criteria to help the better and more comprehensive model of this problem. The decision-makers make their choice according to the comparing and evaluations and rankings that they have for each prioritize. This method does a similar process using the saaty scale, and this process introduces an n*n matrix of importance [A], which holds the most significant real Eigen Value (λ_{max}) and normalized Eigen-vector (w_i), which is the local importance vector of the weights [19].

Step 3-Alternatives: in the process, the consistency index (C_i) is used to check the consistency of each decision matrix, given the equations [20]. The consistency ratio (C_r) is the measure of consistency. Considering the size of the matrix, the random consistency ratio (R_i) varies. In the final step, if the C_r is less than 0.1, then the decision matrix is detected to be consistent. Otherwise, the decision-makers have to perform the same process to make it consistent [21].

Step 4-Prioritization: the priority weights are multiplied with the local priority vectors, resultant vector (r_i) gives the priority of all alternatives [22].

$$\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & a_{23} & \vdots \\ \vdots & 1/a_{23} & \ddots & a_{(n-1)n} \\ 1/a_{1n} & \cdots & 1/a_{(n-1)n} & 1 \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = \lambda \begin{bmatrix} r_1 \\ r_2 \\ \vdots \\ r_n \end{bmatrix} \quad (1)$$

$$w_i = \left(\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \right), i = 1, 2, ..., n \quad (2)$$

$$c_i = \frac{\lambda_{\max} - n}{n - 1} \quad (3)$$

$$C_r = \frac{c_i}{R_i} \quad (4)$$

D.2. VIKOR method

Multi-criteria decision making (MCDM) is one of the most common methods in the field of fuzzy logic for solving conflict management problems. This decision model considers the multiple criteria and the importance of each of the issues related to decision making and planning. Among many MCDM approaches, VIKOR is a compromise evaluation method for optimizing the multi-response process. Using a multi-criteria ranking index that is used to compare the proximity of each criterion to the ideal alternative. The central concept of VIKOR is to focus on ranking and selecting from a set of options in the presence of conflicting criteria. At VIKOR, the ranking index is derived from both the maximum use of category and the least weakness of choice [23–26].

VIKOR has different options like a1, a2; Each represents an alternative, the competence of the aspect j is represented by fij; that is, fij is the value of the criterion function j for the options, n is the number of criteria. The VIKOR method is divided into five steps:

(1) The best f_j and the worst f_j of all benchmark functions are determined. If the criterion function j represents a competence, then [27]:

$$f_{j^*} = Max_i f_{ij}, f_j^- = Min_i f_{ij} \quad (5)$$

(2) The values of S_i and R_i are calculated, i = 1,2,3 to m, by the following equations:

$$s_i = \sum_{j=1}^{n} \frac{w_i \left(f_j^* - f_{ij}\right)}{\left(f_j^* - f_j^-\right)} \quad (6)$$

$$R_i = \max \left[\frac{w_i (f_j^* - f_{ij})}{(f_j^* - f_j^-)} \right] \quad (7)$$

Where w_i is the weight of the criterion j, their relative importance expresses the criterion [28].

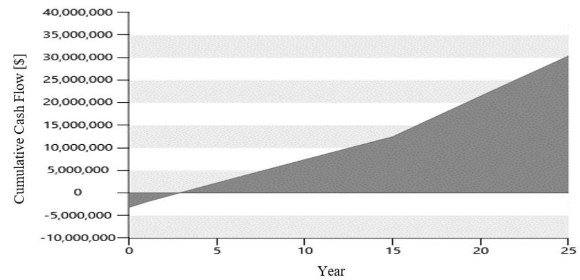

Fig. 9. 10 MW wind power system cash flow.

(3) $Q_{i,i} = 1, 2, 3,$ to m is calculated by the relation:

$$Q_i = v \left(\frac{s_i - s^*}{s^- - s^*} \right) + (1 - v) \left[\frac{R_i - R^*}{R^- - R^*} \right] \quad (8)$$

Where S^* = miniSi S^-= maxi Si, R^* = miniRi, R^- = maxi R_i, and v are the weightings of the maximal benefit strategy of the group, while (1-v) is the weight of one's regret. Here, when V is more significant than 0.5, the Qi index follows the rule of the majority [28].

(4). Alternatives are ranked by decreasing S, R, and Q values.

Based on the concepts presented and using the concept of fuzzy logic to address the uncertainties in new energy technologies, we decide and prioritize each of these technologies for use in supplying the energy needed for each region. The results of the analysis are mentioned in Appendix 1 [29], and the HOMER and MATLAB 2015a are used for modeling and the simulation process in this paper.

3. RESULTS AND DISCUSSION

Wind Power Systems: This energy supply technology provides 20 percent of the German energy portfolio, although European countries are not suitable for solar power technologies (because of minimal potential for solar radiation), wind potential is significant in this region. In Iran, governmental encouragement policies that have been set in recent years have an improved investment in renewable and wind energy as well. A 1 MW capacity of this kind of Power plant in Iran, initially Costs 1.3 Million Dollars. (Fig. 9) Data that are mentioned in Fig. 11 Shows that Revenue of this kind of power systems starts after 24 months (Construction period). This step includes applying for governmental, Environmental, and grid management acceptances and other official agreements. After this period and a visit of inspectors, if all steps are accepted, the power plant connects to the grid, and each 45 days energy bills are paid to the investor. The internal rate of return for this investment in wind power plants is about 34.9%. Moreover, the usual return on investment is about three years. The cash flow of this investment (Fig. 9) Illustrates that this investment is acceptable and desirable, comparing to the interests stated by the Iranian National Banks and most of the National banks throughout the world.

The initial cost of this kind of power system is highly spending on the turbine itself (about 64-82%). This includes transportation and installation costs. Grid connection and related devices share 9-14% of this cost. Construction and foundation of turbines Cost about 4-16% of the Initial Cost and Consultant, and Administrative, Design, Improvement Costs share about 4-10% of the initial Total Costs.

Solar photovoltaic Power Systems: In 2015 Iranian government started development progress in the Energy industries

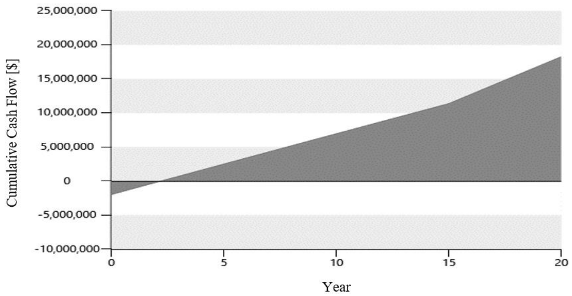

Fig. 10. 10 MW photovoltaic power system cash flow.

which aims to improve sharing of renewable in the Iranian Supply portfolio, and this progress plan contains many encouragement policies (Tax-free import of Devices, Tax-free incomes and 20 years Guaranteed governmental purchase to ten times of the usual price).

The initial cost of this kind of power plant is about 0.75 million dollars, after all the steps of the construction and inspectors acceptance which takes 12 months long, every 45 Days legislative Energy bills are paid to the investor who is according to an inflation rate of the country (9% is taken into account). Moreover, usual Variable Costs of maintenance and an inverter replacement cost are considered in these calculations [30]. The Internal Rate of Return (IRR) in this investment is about 45.9%, which is also desirable and acceptable comparing to the deposit interests of the National Bank of Iran and the most of the other Countries (Iranian Deposit interest is ranked fifth in the world ranking). Furthermore, the return on the investment period is calculated for about 2.2 years, which is also acceptable in the Iranian Energy investments and industries.

Fig. 10, which mentions the cash flow of photovoltaic investments, illustrates the acceptable investment in the solar energy systems, which Iran is one of the most suitable countries in this kind of technology. Iranian Capacity of Solar Energy has been just comparable with its Rich gas and oil reservoirs of energy, which Iran is on a top status in both energy reservoirs.

Biomass Power Systems: this kind of energy is known to humans since the first sparks of fire through human history. Branches and leaves usually used by primeval humans as fuel for the fire. Biogas is also used in the 17th for the first time through human Civilization.

Data that are mentioned in Fig. 11 Shows that Revenue of this kind of power systems starts after 24 months (Construction period). This step includes applying for governmental, Environmental, and grid management acceptances and other official agreements. After this period and a visit of inspectors, if all steps are accepted, the power plant connects to the grid, and each 45 days energy bills are paid to the investor/owner. The internal rate of return for this investment in wind power plants is about 18.5%.

Moreover, the usual return on investment is about seven years. The cash flow of this investment (Fig. 11) Illustrates that this investment is not acceptable and desirable, comparing to the interests stated by the Iranian National Banks and the most of National banks throughout the world and the other projects and investments which are done in the industry of energy in Iran.

Fig. 11, which mentions the cash flow of biomass investments, illustrates the undesirable investment in the biomass energy systems, which Iran is not a suitable country in this kind of power technology. Iranian Capacity of biomass Energy is at hand and can be used to relieve the fossil supply of energy, but it is not financially desirable yet.

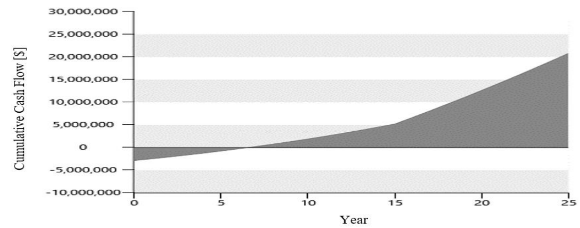

Fig. 11. 10 MW biomass power system's cash flow.

4. DISCUSSION

In 2015, the Iranian government launched a new program on energy and energy systems to reduce its local demand for fossil fuels. Nevertheless, there are many incentive policies to provide a more favorable investment for the renewable industry in the country, in which the government was willing to participate in the investor and provider of capital. The Iranian government's policies in this regard include tax exemptions (according to Iran's direct tax code 132), a 20-year government procurement contract for renewable electricity under the government's approved government bill, and the exemption for imports of renewable energy sources.

All of these rates are regulated by regulation set by the National Bank based on currency and investor counseling and inflation rates. After the first decade of the contract, all the technologies mentioned in Table 1 include wind power systems with a ratio of 0.7 and for wind power plants. If the energy efficiency is 40% or more, this ratio is 0.4, and less than 20% is 1; in the range of 20-40%, the appropriate ratio has been considered. After the end of 20 years, the electricity contract produced by this system can be exported or injected into the country's open electricity market. Concerning supporting policies, each power plant that uses Iranian technical experts and tools rather than imports from other countries will receive 30% more than the government received. The Iranian government has a 30-month deadline for biomass, geothermal and small water systems, 24 months for wind, thermal recovery and development turbines, and 18 months for fuel cells and 15 months for solar fields in which the system should be connected to the network. To be determined. Nine months after the deadline, the Iranian government can cancel the contract, and after two years, it is possible to reapply a new contract. In the following, we examine the output of the simulation of the energy system of each technology.

According to Table 1, it is evident that the cost of wind power is lower than the rest of the energy sources. However, because of high maintenance costs, etc., As well as the cost-benefit of a series of worst-case series, it can be said that the photovoltaic system is relatively cost-effective in terms of relative superiority there are other options. In the following, fuzzy logic is used to conclude accurately on the prioritization of each technology. This algorithm is used as a method to decrease uncertainty and is one of the best aphorisms of decision making. In the fuzzy logic domain, multiple logic FG-VIKOR and AHP methods are used. In this algorithm, we examine production capacity indicators - technology maturity - investment costs - maintenance costs-biological effects-land use-general acceptability-employment creation. These indicators are classified into four categories of

Table 1. Numerical output table simulation of systems

	photovoltaic	Wind	Biomass
Return of capital period [years]	2.2	2.8	6.5
Total cost per kilowatt hour [$/kWh]	3.6	2.9	3.9
The rate of carbon reduction compared to natural gas [%]	95	91	78
Land use per [hectares]	22.5	17.5	2
Energy production per year [MWh-year]	18315	40296	83386
Employment index per megawatt [person/MW]	22.4	6.4	1.1
Technology maturity index [-]	0.93	1	0.89
General acceptability index [-]	0.98	1	0.49

Table 2. Prioritizing technology selection for the site

Energy Type	Rank Vikor	Rank AHP
Solar	1	1
Wind	2	2
Biomass	3	3

cluster-technical-economic-social-social indicators. Finally, by examining the coefficients and prioritizing the technologies, the following result has been obtained.

According to Appendix 1, the results of both AHP and VIKOR methods show similar results for the prioritization of renewable energies. Moreover, in this rankings, solar technologies with the highest importance index are the best option for investment in the renewable energy industry in this region.

Solar energy is the best type of technology that can be said with certainty that it has obtained a firm and high score in most of the indicators and is considered as the best power generating method for power supply in Iran considering the results obtained in the pilot regions.

5. CONCLUSION

Considering the recent technological, economic, and social advancements occurred in the renewable energy industry [47]. The energy systems model developed for the supply side of the Iranian energy sector evaluated solar energy as the best option among renewable power supply technologies studied in this paper. Wind energy seems to have lost its advantages against the solar energy during 2018-2019 because of a significant decrease in the investment cost of the solar energy (from 1100$/KW in 2016 to 700$/KW in 2018) and because of its sound pollution and environmental effect on the life of animals, stands in the 2nd rank [48, 49]. The biomass potential of Iran is almost zero compared to the other two kinds of renewable energies, and because of its carbon emission and hygienic problems is not socially accepted [50, 51]. Because of those characteristics of the biomass energy, it stands in the 3rd place of the best renewable energy for Iran [52, 53].

Although, participation among Iranian government and non-governmental investors (which formed a Market economic system in the Wind, Solar, and biomass energy industries) helped the energy industry to thrive and bloom; but still there are many shortages in the energy system and macro-scale power management policies [54–56]. The main problems and obstacles against the renewable energy revolution in the Iranian energy system are included [57]:

- Unrealistic pricing of conventional energy resources, including natural gas, Oil and Coal [58].
- A considerable amount of suicides spends on fossil fuel power systems (which causes renewable technologies to become highly unable to compete with conventional sources [59].
- Parallel structure and prolonged bureaucracy of the macro-decision making organizations (including petroleum and Power ministries which both are considered as a ministry of energy)[60].
- lack of investment in the studies and development of new technologies like Hydrogen fuel cells [61].

Accordingly, governmental interference in the renewable energy sector is one of the main disincentive factors against the development of renewable and higher efficient energy systems [62]. Because of the wrong policies and the multi parallel structure of the energy decision-making organizations, investment in this sector requires a prolonged bureaucratic process, which caused the establishment of geothermal power plants to become some kind of fantasy in Iran [63]. (The only Iranian geothermal power plant located in Meshkin-Shahr is not entirely operated over 23 years since 1996 [53, 64]) Also, lack of investment in the studies and development of the new technologies caused inadvertency toward the hydrogen power units [65]. These primary shortages in the local Iranian policies caused the inoperativeness of hydrogen and geothermal power units in the current political status of the energy decision making organizations of Iran [66]. According to the shortages mentioned before, a comprehensive study is advised to be done to discuss the particular insufficiency of Iranian energy sector policies in the term of geothermal and hydrogen power units [67].

APPENDIX 1: COMPARISON ANALYSIS

Table A2. Results of AHP (Criteria importance)

	Social	Environmental	Economic	Technical	Global Priority
Social	1	1	3	1	0.1431
Environmental	1	1	5	0.2	0.2974
Economic	0.33	0.2	1	0.2	0.3851
Technical	1	5	5	1	0.3199

Table A3. Results of AHP (Technical Criteria)

	Solar	Wind	Biomass	Global Priority
Solar	1	0.33	0.2	0.5446
Wind	3	1	0.33	0.4188
Biomass	5	3	1	0.3122

Table A4. Results of AHP (Economic Criteria)

	Solar	Wind	Biomass	Global Priority
Solar	1	1	3	0.3723
Wind	1	1	5	0.3831
Biomass	0.33	0.2	1	0.2135

Table A1. The results of the VIKOR analysis

		Decision Makers						
Criteria	Energy Type	Social	Environmental	Economic	Technical	Weight	Defuzzified Value fij	Criteria Ideal and Anti-Ideal Values
Energy Production Capacity	Solar	(0.35,0.5,0.65)	(0.5,0.65,0.8)	(0.65,0.8,0.95)	(0.5,0.65,0.8)	(0.35,0.63,0.95)	0.63	
	Wind	(0.5,0.65,0.8)	(0.5,0.65,0.8)	(0.65,0.8,0.95)	(0.5,0.65,0.8)	(0.5,0.68,0.9)	0.71	fj*= 0.69
	Biomass	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.5,0.65,0.8)	(0.2,0.47,0.8)	0.49	fj-=0.25
Technological Maturity	Solar	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.05,0.27,0.5)	0.27	
	Wind	(0.05,0.2,0.35)	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.05,0.23,0.5)	0.25	fj*=0.2 8
	Biomass	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.05,0.29,0.5)	0.28	fj-=0.2
Investment Cost	Solar	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.2,0.36,0.65)	0.39	
	Wind	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.2,0.36,0.65)	0.39	fj*= 0.2
	Biomass	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.05,0.26,0.5)	0.26	fj-=0.36
Maintenance Operations Costs	Solar	(0.35,0.5,0.65)	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.2,0.39,0.65)	0.41	fj*=0.2
	Wind	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.2,0.47,0.65)	0.44	fj-=0.4 4
	Biomass	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.05,0.39,0.65)	0.37	
Ecological Effects	Solar	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.5,0.65,0.8)	(0.35,0.5,0.65)	(0.05,0.38,0.8)	0.4	
	Wind	(0.05,0.2,0.35)	(0.35,0.5,0.65)	(0.5,0.65,0.8)	(0.35,0.5,0.65)	(0.05,0.44,0.8)	0.43	fj*= 0.43
	Biomass	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.5,0.65,0.8)	(0.35,0.5,0.65)	(0.05,0.38,0.8)	0.4	fj- =0.31
Land Use	Solar	(0.35,0.5,0.65)	(0.5,0.65,0.8)	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.2,0.53,0.8)	0.51	
	Wind	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.5,0.65,0.8)	(0.35,0.51,0.8)	0.54	fj*= 0.7
	Biomass	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.05,0.39,0.65)	0.37	fj-=0.2 6
Social Acceptability	Solar	(0.5,0.65,0.8)	(0.2,0.35,0.5)	(0.65,0.8,0.95)	(0.5,0.65,0.8)	(0.2,0.56,0.95)	0.56	fj*=0.54
	Wind	(0.5,0.65,0.8)	(0.2,0.35,0.5)	(0.65,0.8,0.95)	(0.65,0.8,0.95)	(0.2,0.57,0.95)	0.57	fj-=0.24
	Biomass	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.2,0.35,0.5)	(0.05,0.29,0.5)	0.28	
Employment	Solar	(0.5,0.65,0.8)	(0.65,0.8,0.95)	(0.35,0.5,0.65)	(0.35,0.5,0.65)	(0.35,0.66,0.95)	0.65	fj*=0.71
	Wind	(0.5,0.65,0.8)	(0.65,0.8,0.95)	(0.5,0.65,0.8)	(0.5,0.65,0.8)	(0.5,0.71,0.95)	0.71	fj-=0.26
	Biomass	(0.2,0.35,0.5)	(0.05,0.2,0.35)	(0.2,0.35,0.5)	(0.35,0.5,0.65)	(0.05,0.3,0.65)	0.32	

Table A5. Results of AHP (Social Criteria)

	Solar	Wind	Biomass	Global Priority
Solar	1	3	5	0.5146
Wind	0.33	1	3	0.2452
Biomass	0.2	0.33	1	0.0974

Table A6. Results of AHP (Ecological Criteria)

	Solar	Wind	Biomass	Global Priority
Solar	1	5	3	0.7842
Wind	0.2	1	1	0.4313
Biomass	0.33	1	1	0.2275

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