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Potentiometry and prioritizing of renewable energies exploitation Case study in Ardabil province of Iran

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Abstract
Due to the needs of the modern societies to provide their energy, fully or partially, from the renewable energy sources and its necessity as a main principle of sustainable development, it is necessary to assess and evaluate a renewable energy and its integration for utilizing a part of the consumed energy for the societies from a cheap energy resource and solving the ecological and social problems. Despite the great potentials of the Ardabil province in agriculture, water streams, climatic precipitation, and climatic conditions, the necessity of appropriate investments to better exploite these capabilities (renewable energies) increases. The goal of this research work is to exploite renewable energies (solar, wind, biomass and bio-energy, water) based on farming, improvement of policy-making for developing renewable energies, developing atlas of renewable energies based on farming, and improving policy-making of developing renewable energies in the Ardabil province. According to the results obtained from this work, the most talented town of the Ardabil province in terms of renewable energies is Meshgin-shahr. The solar energy of 3/449 kW h/m^2/y, hydropower of 270/34 Gw h/y, and geothermal of 76/11kw h/y rank Meshgin-shah as the first among all the cities of the Ardabil province; the lowest is the Sarein city.

Keywords: Renewable energy, sustainable development, security of energy, potentiometry, energy exploitation.

1. Introduction
The Ardabil province in Iran is considered as one of the most important poles in the agriculture of the country by having about 700,000 hectares of arable lands and the production power for more than 3 million types of crops, animals, and horticultural products. Despite the great talents in the agricultural sector, water streams, precipitation, and climatic condition, this province requires appropriate investments on renewable energies for a better exploitation of these capabilities. Due to its climate variability, Ardabil has various suitable resources for renewable energies, and a correct use of these major energy sources, estimating the exact qualitative and quantitative potentials, and providing the atlas of renewable energies for the Ardabil province could have a significant contribution in utilizing energy and protecting the environment along with a sustainable development [1]. In order to achieve the real position in this field, there is a requirement for potentiometry studies aiming to enhance the relationship between this province and some foreign countries, investment and accessibility of clean energy, security of energy, and exporting energy surplus because of neighborhood and entrepreneurship. Renewable energies are novel issues in our country, and in the world as well. Morever, the stages of developing various technologies for renewable energies are different for fifferent countries. Some of them have achieved high levels of development and some others are in lower levels of development; however, all of them require research and development in order to improve the performance. There are few studies for the Ardabil province about the renewable energies in terms of the exploitation and application policies in order to achieve a comprehensive model to benefit from the renewable energies (solar, wind, biomass and bio-gas, bio-fuels) from the total energy according to the sustainable development parameters. Regarding the novelty of the renewable energy technologies, carrying out research works is of high significance. Increasing the demand for energy in various sectors of the society and energy consumption causes the world to face big challenges. On the one hand, international

contracts aim at reduction of the pollution level, and on the other hand, universal warming have caused limitation of CO_2 release. These issues cause replacement of the traditional methods by the novel ones in order to produce energy using renewable energies. In the next 30 years, the amount of CO_2 release due to the production and consumption of energy will be increased faster than the growth of basic energy consumption. Its emission level in 2000-2030 with a consistent growth of 1.8% per year will achieve 38 billion tons per year, which equals 70% increase in the emission rate rather than the current rate level per year. 2/3 of this enhancement is due to consumption in the developing countries, and the sector of power generation and transportation will cause more than 75% enhancement in CO_2 emission, and the geographical location of CO_2 emission growth will be transferred from the industrial countries to the developing countries [1]. The complexity and broadness of relationships and the indices of supply and demand for various energy carriers, the situation of various local and universal markets, and the environment issue and its effect on the global energy equation have led to the fact that the management and planning and even commenting in the fields related to the energy for the countries and/or various regions in the world are not possible easily. Thus beginning to use effective devices that have the ability to manage complexity and expand amount of related measurements has resulted in significant evolutions in the context of modeling and using computer analyses. Many models with various goals have been developed for investigating various aspects of energy so that today using these patterns for planning and projecting the future is considered a necessary affair [2]. Sustainable development is a novel area that supports policy, culture of economic prosperity, business, industry, equal rights of humans, internal affairs of the countries, international issues, environment, and coexistence with the nature [3]. Formulating an energy model will help the researchers to use vast renewable energy sources such as the solar, wind, bio-energy, and water energies in order to answer future demands of the world’s requirements. Omer evaluated and eventually presented a perennial data about the wind rate, the times for sunrise and sunset, and the solar radiation resulting from a horizontal surface in Sudan. Also according to the projected amount of radiation, the map of Sudan was prepared. The average wind speed and related production power were calculated by analyzing the data obtained from 70 various stations in Sudan. Also the monitoring map of the wind level of Sudan was prepared on this basis [4]. Meyer introduced an energy model based on the two parameters of total daily radiations and maximum temperature of the environment. This model could be used to project the amount of the energy generated by photovoltaic modules under certain climatic conditions. For this purpose, by using the regression analysis, it was possible to formulate the model so that the daily energy modules could be predicted just by using two mentioned parameters [5]. Sen and Tan also used a three-parameterd model for the monthly, daily, and hourly predictions of emissive and/or spherical radiations in the northwest of Turkey. For this purpose, by considering the radiation hours of the sun per day designed from seven models, the average amount of daily spherical radiation was predicted [6]. Sfetses conducted a comparative study using various predictive techniques based on the average wind rate per hour in a year. He used the analysis of time series, linear models, neural networks, phase-neural integral systems, and logical-neural networks. The model of wind rate mean projection was introduced by contribution of the time series analysis [7]. Jagadeesan presented a renewable energy model in order to find the optimized level of renewable energy resource in India in 2020-2021. The goal of this model is to minimize the ratio of cost to efficiency and find the optimized dedicated amount of each available renewable energy source [8]. In a near future, the renewable sources for energy might have a significant role in meeting the energy requirements of the developing countries like India. Using the linear programming methodology based on current energy optimization could present a bottom-up model for the energy optimization. This model was introduced with the goal of reinforcing the planning and culture development policies. The environmental restrictions were also considered in this model [9]. Snakin used a regional engineering model for a region in Finland in order to assess the warming energies of the weather and emissions. The goal of this modeling was the qualitative and quantitative improvement of the data related to the thermal energy and greenhouse gas emission, especially for use in local decision-makings [10]. Cannemi conducted a research work on the decision-making models for priority of the investors in biomass power plants using the analytical network process (ANP) in Italy, and the goal of this work was to improve support devices for the policy-makers in the field of renewable energies. He designed two scenarios; first, the study of decision in the normal condition of the current process, and second, suggestion of decision-making improvement [11].

Some common plans of public and private sectors were performed in Laos and Nepal in order to generate energy in a poor level. The goal of this model is the improvement of access to energy services for all levels of rural community, increasing knowledge about policies, providing the capacity in the national and local level, development of integration of energy, and the policies of rural development, creating an appropriate environment for the private sector, entrepreneurship. and more value creation in investment that could enhance energy sustainability [12]. In his research work about wind energy potentiometery in the Boroujerd city for generating some part of the required energy for agricultural process, Jalalvand used the wind information of Boroujerd region that was registered with a three-hour time frequency during a 10 year period (2002-2011). The results obtained suggested that in the studied region, there was a need of almost 15 turbines with the power of 1500 Kw and 85 m tower height [13]. In the study on the technical analysis and the function of applying the biogas production system in rural areas of Gorgan, Farhadi Roud baraki concluded that the potential of power generation from biomass equaled 7676 Gw/h per year [14]. In the study of feasibility in the optimized use of the combination of livestock waste and milking waste in a large animal husbandry in the Moghan agro-industry, Asad-pour Asl concluded that the amounts of the produced biogas from bovine and milking waste and an integration of bovine and milking wastes from 30 L of raw material by 18 g of solid material per kilogram would be equal to 61.35, 0.04, and 55.05 during a fifteen days of period, respectively. Investigating the results suggested that more use of milking waste reduced the generated gas volume and also gas generation time would be decreased [15]. San martin and his colleaqes studied the feasibility of applying the energy created by the integral system of PV-diesel for providing loads in remote regions. These studies considered the amount of hybrid system, cost, and climate condition, which were done by the HOMER software [16].

2. Methods and Materials

First, the current situation of exploitation potential from renewable energy for the regions of the Ardabil province was specified. According to the potential of the existing materials, the capability of transformation into various renewable energies was specified. Along with achieving a comprehensive model for using renewable energy in the province, at first, the potential of renewable energy (solar, wind, biomass, biogas, and geothermal) was analyzed, and the energy with the highest potential in the region took the highest weight coefficients. However, it should be pointed that in order to achieve the real coefficients, it should be compared with the standard potential, which is the highest potential in the country. After acquiring the weight coefficients, the model could be generalized in two provinces and national levels. Also it should be noted that in each model of energy, the most significant part is the source or the same potential energy studied in various years in order to achieve the potential level. In this research work, the possibility of accessing various energies in Ardabil was studied in order to provide a strategic appropriate framework to develop new energies. The Ardabil province is one of the northwest provinces. The area of this province is 17953 km^2, about 1.09% of the country, and its population is 1,288,155 people according to the statistics of 2011. The capital of this province is the Ardabil city, and according to the statistics, the last divisions of this province include 10 towns, 23 cities, 26 districts, and 68 villages.

2.1 Wind energy

Potential mapping of wind energy: Generally, the environmental condition affects wind condition in three ways a) barriers, b) surface roughness, c) topography (ups and downs). In this part, at first, wind potentiometry among the towns of the Ardabil province was specified, and then according to the results obtained for the density, the wind power of towns was specified. In order to measure the wind power density, at first, the density of the region’s weather should be identified. For calculating the density of the region’s weather, some indices like temperature and humidity of the region should be identified. In this research work, the data related to the temperature and humidity of the towns was adopted from the Meteorological Organization of Ardabil province [17]. Calculating the weather density was done according to the following equation [18]:

$$P_{\text{dry air}} = \frac{P}{R.T} \tag{1}$$

where:

$P_{\text{dry air}}$ = Density of dry air (kg/m s)

P = Air pressure (pa)

R = Specific gas constant for dry air; 287.05 J/(kg/K)

T = Temperature (0k)

The results obtained are in table 1

Table 1. Level of weather density in Ardabil towns, respectively

Town	Average rate (m/s)	Temperature (k)	Humidity %	Weather density (kg/m³)
Sarein	3.83	6.68	38	1.26
Namin	5.78	6.63	41.81	1.25
Germi	2.32	9.16	37.92	1.25
Meshgin shahr	2.66	8.01	35.62	1.25
Bilesevar	4.73	10.43	41.03	1.25
Ardabil	3.69	9.79	69.30	1.24
Khalkhal	2.53	8.99	60.06	1.24
Parsabad	2.17	15.00	72.82	1.22

According to the densities obtained for each town, the following equations can be used to calculate the wind power for each town:

Wind power relationship: (Equations. 2, 3), [18].

$$P_w = 0.5\ \rho\ A\ V^3 \quad (2)$$

$$(P/A) = 0.5\ \rho\ V^3 \quad (3)$$

where P_w is the theoretical power of turbine according to (w), p is the weather density (kg/m^3), A is the surface (m^2), and V is the wind rate (m/s). Then according to the power obtained for the Ardabil province cities, weighting was done. The energy with the highest potential in the region would have the highest weight factor. However, it should be noted that in order to reach the real weight factor, it should be compared with the standard potential, which is the highest potential in the country. The results obtained are as follow (Table 2).

Table 2. Density of wind power in Ardabil towns, respectively.

Town	**Mean annual speed (m/s)**	**Weather density (kg/m³)**	**Wind power density in surface unit (w/m²)**	**Weight factor**
Namin	5.78	1.25	159.15	1
Bilasavar	4.73	1.25	50.11	0.31
Sarein	3.83	1.26	44.97	0.28
Ardabil	3.69	1.24	36.68	0.23
Meshgin-shahr	2.66	1.25	20.54	0.129
Khalkhal	2.53	1.24	13.32	0.083
Germi	2.32	1.25	10.27	0.064
Parsabad	2.17	1.22	6.77	0.042

2.2 Solar energy

Potentiometry study of solar energy: in this phase of the work, at first, the data required like the studied town coordinates, air filter factor, and the amount of solar radiation intensity was obtained. Then the diagram of solar energy mean for the Ardabil towns during 2014 was provided by the Homer software. Eventually, by weighing of the towns by the weight factor and by considering reliability, the considered weighing system of the towns was specified (Table 3).

Table 3. The rate of annual solar radiation Ardabil province over ally

Ardabil province town	**Annual average radiation (kw h/m²/y)**	**Weight factor**
Parsabad	3.449	1
Meshgin-shahr	3.449	1
Ardabil	3.350	0.971
Germi	3.350	0.971
Sarein	3.350	0.971
Bilasavar	3.350	0.971
Namin	3.350	0.971
Khalkhal	3.346	0.970

2.3 Biomass energy

Potentiometry study of biomass energy: in this part, the biomass potentiometry was studied in three distinct parts (landfills, food industry wastes, animal wastes), and the producible energy was calculated for all the towns in the Ardabil province and prioritized by their weighings.

Part I

Biogas production potentiometry from landfills: practically, the urban wastes consist of various components some of which are not organic (metals, glass, garbage), and although some others (like plastic and resin) are considered organic, they could not be analyzed by the biological methods. Therefore, in order to estimate the theoretical efficiency of landfill gas from urban wastes, the following equation was used [19].

$$Y_{LFG} = 1.867 \sum_{i=1}^{n} OC_i \left(f_b\right)_i \left(1 - w_i\right) pi \quad (4)$$

Y_{LFG}= Theoretical efficiency of landfill gas from wet garbage unit (m³/kg $_{MSW}$)

CO_i= Amount of existing C in the i component from urban waste (kg C/kg $_{MSW}$)

Fb_i = Ability for bio-degradability in the i component from urban waste (kg/kg $_{dry}$).

P_i= Ratio of the i component in whole waste (kg/kg $_{MSW}$)

As stated earlier, the degradability of organic materials is inversely related to the existing lignin in those materials and its relation is repeated here [20]:

$$fb = 0{,}83 - 0{,}028LC$$

LC = Percent of lignin existing in the organic material

After obtaining thetheoretical efficiency of landfill gas, by multiplying this number into the produced garbage size in each town, the total producible theoretical gas from the garbage in a certain time in a city was acquired. In this work, using the capita numbers of the household-commercial waste and the habitants in the urban areas [21], the generated waste mass was estimated during one year and was considered as a basis for the measurements. The data related to the theoretical efficiency of landfill gas from generated wastes in the towns of Ardabil per year and the whole producible gas from this amount of waste (theoretical) was suggested (Table 4).

Table 4. Theoretical efficiency of landfill gas, the annual mass of the waste and total size of producible gas in a year

Town	Theoretical efficiency of gas (m^3/kg)	Annual generation of waste (ton/year 1000)	Theoretical production of gas (m^3/y)
Ardabil	0.258	207.3	53.5×10^6
Parsabad	0.237	104.2	24.7×10^6
Meshgin-shahr	0.278	100.7	28×10^6
Khalkhal	0.252	274.6	692×10^6
Germi	0.257	999.2	256.8×10^6
Bilasavar	0.259	598.5	155×10^6
Namin	0.240	638.3	153.2×10^6
Sarein	0.273	473.6	129.3×10^6

Part II

Potentiometry of food wastes: in this part, the food wastes were studied. Using the scientific resources and conducted research works, the factors size, waste, and pollution generated for every mentioned industry unit were determined and the industries existing in the Ardabil province, their nominal capacity, and their annual production were adopted from statistic office of administration of mining industry and trade in the region, office of statistics department of agriculture, department of environment, department of standard, sewage administration of Ardabil province, and governorship of Ardabil province. Using these statistics and mentioned factors, the total volume of waste water and produced pollution for each city was calculated and used in the next calculations (Equations. 5 and 6) [19].

$$V_w=\Sigma(m_{pi}.U_{wi}) \quad (5)$$

$$M_c=\Sigma(m_{pi}.U_{wi}) \quad (6)$$

V_w = Volume of wastewater for food industry of the town

M_{pi} = Town dairy production related to the i group

U_{wi} = Factor of waste generation from a production unit related to the i group

M_c = Total mass of produced pollution (according to BOD or COD) in the province

U_{ci} = Pollution index from a generated product unit related to the i group

Then the producible methane is calculated from produced COD or BOD mass.

V_{CH4}=Volume of methane in conventional condition (pressure of 1 atom and temperature of 273 k)

Y_{CH4}= Theoretical efficiency of methane from COD or BOD mass unit

E = Practical efficiency of the process

In the following, the energy capacity of industrial wastes was assessed **(**Table 5).

Table 5. Milk, cheese, and alternant products (yogurt and ice cream), COD domain and methane producible from waste water.

Town	Products	Milk (ton/y)	Cheese (ton/y)	COD (kg/y)	Minimum of methane (m^3/y)	Maximum methane (m^3/y)
Ardabil	-	10000	800	350400	66225	180196
Parsabad	-	60307	1300	1998805	37770	119798
Meshgin-shahr	3775	5000	500	24570-61452	4644	19994
Khalkhal	71730	93100	6680	728724-1554610	137729	506025
Germi	9300	68300	13500	757280-1029280	77814	335030
Bilasavar	9300	68300	13500	757280-1353200	143126	440467
Namin	7400	96980	2500	389464-873660	73608	284376
Sarein	8500	31600	28180	1239480-1971500	234262	641723

Part III

Potentiometry of livestock waste: The major livestock of Iran includes cow, sheep, goat, buffalo, horse, donkey, mule, and camel. The wastes of these animals could create methane in an anaerobic digestion process. There is an attempt to estimate the producible methane from waste mass unit and total producible methane in each town of the Ardabil province. In order to estimate the amount of animal waste, at first, the statistics of livestock was provided. In order to do this, the official report of bureau of labor statistics department of livestock in agricultural organization of Ardabil in 2011 was used, and various animals and the numbers related to each kind were adopted regarding the towns. The relationships between the number and kind of the animals and the amount of generated wastes were identified by referring to the books and various scientific resources. Using the available data, the amount of livestock waste generation in each town was estimated (Eq. 7) [19].

$$M_{tm}=\sum_1^n(N_i.C_{mi}) \quad (7)$$

Total mass of generated wastes in the province

N_i = Available livestock in towns

C_m = Mass of generated wastes from each animal per day

The significant point here is the available wastes. Since a significant amount of the province livestock (especially sheep and goat) live delocalized and mobile, the factor of establishment time should also be considered in the equation. Thus the modified equation is as follows [19]:

$$M_{tm}=\sum_1^n(N_i.C_{mi}Tf) \quad (8)$$

Mass of collectable wastes

C_m = Mass of generated wastes from a livestock per day

T_f = Establishment duration per day

Determining the producible methane from wastes and multiplying it to the mass of collectable wastes

(Table 6 and table 7).

Table 6. Limit of biogas generation from various livestock wastes and biogas methane percentage.

Livestock type	Biogas (m^3/ton per day)	Methane percentage
cow	260-280	50-60
sheep	260-280	50-60
Horse	200-300	50-60

Table 7. Rate of dry material in livestock wastes and producible methane and biogas from mass unit of fresh waste types.

Animal	Dry material rate	Methane (Gr/gr-m)	Biogas (L/gr-m)
Cow and buffalo	16	0.05	0.125
Sheep	30	0.085	0.212
Horse	22	0.062	0.124
Chicken	17	0.033	0.122

Estimation of collectable livestock wastes and producible methane in the province

In this section, at first, the mass of the produced wastes from various animals was identified, and then its renewable and collectable rate was determined. Afterward, the producible methane and biogas were estimated regarding the numbers recorded in the table. The mass of the generated wastes from the major animals (cow, sheep and goat, horse and donkey, chicken) was inferred from the references [20,22], and was tabulated in Table 8).

The amount of wastes that is collectable and could be transferred to the digester tank differs based on the livestock keeping style. Regarding that, during a year, the cows that are kept in the villages go around and graze and stay in barn during cold days and nights, and their wastes are different. In Iran, the sheep and goat mostly move around and graze. In cold provinces, they stay at corral, and in other regions, in half of the nights of the year and in 2/3 of cold months stay at corral, and thus 35% and 38% rates of generated wastes are considered collectable for cold provinces and other regions, respectively.

Also the horse and donkey stay at the corral half of the year, and for them, also 50% of the waste is considered collectable. In order to estimate the power of methane production of the towns, the following relationship is used [19]:

$$M_{CH4} = 365\sum_{1}^{n}\left(N.U_{MP}.P_R.Y_{CH4}\right) \quad (9)$$

N = Considered animal number

UMP = Mass of fresh waste of each animal

PR = Rate of collectable wastes

YCH4 = Methane efficiency from wet mass unit (kg/kg)

The methane efficiency and the mass of fresh waste mass are adopted from the mentioned tables. The power of methane generation and its equal energy from active industrial cattle breeding in the towns of the Ardabil province are observed in tables 9 and 10).

Table 8. The mean generated wastes from each animal per day.

Dairy cow	Bull	Heifer	6 months calf	Under 6 months calf	Sheep and goat	Horse	Chicken
41	25	25	14	6	1	15	0.08

Table 9. Producing methane and its impure energy from active cattle breeding center wastes in the towns of the Ardabil province.

Town	Dairy cow	Bull and calf	Methane (kg/y)	Biogas (m^3/y)
Ardabil	5805	10890	7920956	19802390
Namin	51343	64973	59761030	149402575
Parsabad	477	585	54987	1372719
Meshgin-shahr	42	58	50480	126199
Khalkhal	142228	166732	161193563	402983907
Germi	70635	81708	79693716	199234290
Bilasavar	6262	15800	9875841	24689604
Sarein	13372	54471	24942822	62357056

Table 10. Statistics of the existing livestock in 89-90.

Town	Sheep and goat	Cow and calf		Horse and donkey
		Traditional	Cattle breeding	
Ardabil	9781	418360	264200	87700
Namin	80447	467860	3591300	57400
Parsabad	754	87690	1749500	28000
Meshgin-shahr	45	042700	558450	18600
Khalkhal	136430	311370	2064040	53000
Germi	75118	531790	12488000	290500
Bilasavar	9627	16390	4183600	30000
Sarein	28746	421270	8450000	95100

The statistics of the above table are used in order to estimate the capability of biogas generation and its equal energy in the towns of the province. Regarding the renewable rates of animal wastes and coldness of the province, 45% coefficient was considered. The other coefficient in this measurement is the efficiency of the anaerobic digestion process that is practically lower than 100%, and since the temperature is an effective factor involved in the efficiency of an anaerobic digestion process, 80%, 85%, and 90% coefficients were considered for the cold, mild, and tropic towns. The results related to the whole produced power from garbage, industrial waste water, and livestock wastes are given in tables 3-19. In calculating the total biomass power, estimation of the production power of the whole generated biogas was multiplied by the rate of 60% methane and its thermal value, which was 5000 kcal/m3. Then it was expressed as kw/h by transforming the unit. Eventually, the sum of these energies was weighed and prioritized for all towns of the region (table 11).

Table 11. Total producible energy rate from biomass of the towns in the Ardabil province.

Town	Total biomass power (kw h/y)	Weight factor
Ardabil	256799878.5	0.067
Namin	1057434031	0.276
Parsabad	91664341.9	0.023
Meshgin-shahr	98248573.4	0.256
Khalkhal	3823341387	1
Germi	1593051837	0.416
Bilasavar	629498344	0.164
Sarein	672423087.6	0.017

2.4. Hydro-power energy

Hydro-power potentiometry: hydropower is an available, reliable, sustainable, and cost-efficient energy resource. Hydro-power just requires streams, rivers, oceans, and other currents. This energy is local and sustainable. The capacity of hydro-power provides so many job opportunities. In hydro-power plants, the potential power of water is used due to its height. The amount of turbine power, rotational speed, and amount of stream is based on the water height, and in order to provide the best efficiency for turbines in hydro-power plants, they should be structured considering the height and input water pressure. There are three kinds of hydro-turbines for three kinds of pressures:

Pelton turbine having the rate of 5-35 rpm and a water height more than 300 m

Francis turbine having 60-450 rpm and a water height of 25-400 m

Kaplan turbine having 400-1000 rpm and a water height of 5-40 m

In the rivers, along the transformation path, turbines are considered. Also the turbines are used behind dams, which are completely different. At first, the amount of river discharge in all towns is measured and altered to the annual amount.

Annual discharge = discharge m³/s × 60 m × 24 h × 365 days

Then the amount of producible power is calculated according to the following relation [23]:

$$P = \eta . \rho . g . h . v \quad (10)$$

in which η is the turbine efficiency, ρ is the water density, g is the gravity velocity, h is the height, e.g. water pressure, and v is the water discharge. The power obtained is in Watts (w). It is transformed into kw h/y by dividing into 1000 and multiplying on 24 days in 365 days. The rivers having a discharge less than 20 m^3/s are removed due to the lack of economic justification and little production power (Tables 12-16).

For all kinds of turbine and related dam, there is a certain relationship for the height of dam to power plant turbine. The following curves also suggest such a relationship, and are useful for the initial studies and primary selections. The curves suggest that the Pelton turbine is appropriate in 90-1100 m heights and in the speed of 10-40 rpm.

For the Francis turbine, 14-300 m height and the speed of 95-440 rpm is appropriate.

For the Kaplan turbine, 3-30 height and the speed of 550-830 rpm is appropriate.

Table 12. Comparison of various turbines.

Turbine	Classification	Height (m)	Speed (rpm)
Pelton	Traumatic	90-1100	10-40
Francis	reactive	14-300	95-400
Kaplan	Reactive	3-30	550-830

Table 13. Operating dams in Ardabil by energy production power.

Row	Dam name	Current situation of exploitation	Significant volume (Million m^3)	Total volume (Million m^3)	Height from substrate	Dam capacity (m^3/s)	Power (km h/y)
1	Guri chai	operating	17.71	18.07	24	2.5	4635792

Table 14. Operating dams in Meshgin-shahr by energy production power.

Row	Dam name	Current situation of exploitation	Significant volume (Million m^3)	Total volume (Million m^3)	Height from substrate	Dam capacity (m^3/s)	Power (km h/y)
1	Sabalan	In operation	94	0.4	77	16.5	98162895.6
2	Beig baghlou	In operation	2.7	0 .5	20	1.4	2163369.6
Total							100326265.2

Table 15. Level of producible energy from the rivers and dams in the towns of Ardabil province.

Row	Dam name	Current situation of exploitation	Significant volume (Million m^3)	Total volume (Million m^3)	Height from substrate	Dam capacity (m^3/s)	Power (km h/y)
1	Saqezchi	operating	3.4	3.65	19.1	0.95	1401940.7

Table 16. Level of producible energy from the rivers and dams in the towns of Ardabil province.

Town	Total energy of rivers (kw h/y)	Total energy of dams(kw h/y)	Total power of hydro-power (kw h/y)	Weight factor
Ardabil	43255802.4	4635792	47891594.4	0.177
Namin	9472468.2	1401940.7	10874400.9	0.402
Parsabad	166309038	-	166309038	0.615
Meshginshahr	170017335	100326265.2	270343600.2	1
Khalkhal	51812701.6	-	51812701.6	0.019
Germi	58797238.8	-	58797238.8	0.191
Bilasavar	-	-	-	0
Sarein	-	-	-	0

2.5. Geothermal energy

The systems used in direct applications of geothermal energy resources use sources with a temperature range of 20-150 °C. For a comprehensive development of geothermal energy, there is a need for potentiometry. In the first stage, a significant database about the geothermal energy resources was provided in the Ardabil province. Undoubtedly, the mentioned regions have different characteristics, and thus at this stage of the strategic procedure, the identified regions were prioritized according to the approximate temperature, expansion, geographical location, and other factors. After identifying the geothermal areas in each town, the most susceptible areas could be suggested by a sustainable view. The volume and temperature of hot water was specified carefully. In the next stage, considering the specifications of geothermal energy and also considering the environmental conditions like agricultural, farming, climate, social, environmental, and industrial conditions, it was possible to introduce the performable cases by hot water discharge of the wells.

3. Potential of spa in Ardabil province

Spa is a place in which warm or hot water exits consistently. Due to the high rate of inorganic solutes, some of these springs have therapeutic uses. Having more than 118 spa [24], Ardabil has the first order in this regard. Morever, the Shabil Lahroud spa has the highest spring by a 50 degree temperature hot water in a height of 2700 m and Gavmishgoli in Sarein has the highest level of water in Iran (Table 17).

Total geothermal power energy of Meshgin-shahr is 11.76 Kw h/y; it was calculated as the first rank in the highest weight factor priority. The total geothermal energy for Sarein, Ardabil, and Khalkhal was 1.222 Kw h/y, 0.35 Kw h/y, and 0.065 Kw h/y, respectively; their weight factor was calculated according to the highest weight factor.

Table 17. Rate of total producible energy from the spas in the towns of the Ardabil province.

Row	Town name	Unit name	Temperature (K)	Temperature difference (ΔT)	Average discharge (l/s)	Average discharge (m^3/s)	Geothermal power (Kw h/yr)	Weight factor
1	Sarein	Gavmishgoli	319	30.5	66	0.066	0.95	0.084
2	Sarein	Sari soo	319	30.50	4.8	0.0048	0.07	0.006
3	Sarein	Aasab soo	315.5	27	0.5	0.0005	0.006	0.0005
4	Sarein	Pehenloo	316.5	28	1.4	0.0014	0.01	0.0008
5	Sarein	Zheneral	316	27.5	3	0.003	0.03	0.002
6	Sarein	Besh bajilar	314	25.5	11.3	0.0113	0.13	0.011
7	Sarein	Ghahve sooei	316	27.5	0.8	0.0008	0.01	0.0008
8	Sarein	Ghoz sooei	315	26.5	0.5	0.0005	0.006	0.0005
9	Sarein	Viladarreh	28.5	-	11.6	0.0116	0	
11	Ardabil	Sardabeh	309	20.5	25	0.025	0.24	0.021
12	Ardabil(Nir)	Booshli(Borjloo)	326	37.5	2.5	0.0025	0.04	0.003
13	Ardabil(Nir)	Ghainarcheh (Nir)	343	54.5	3	0.003	0.07	0.006
14	Meshgin shahr	Moeeil	318.1	29.6	1.3	0.0013	0.01	0.0008
15	Meshgin shahr	Ilandoo	308.4	19.9	14.8	0.0148	0.14	0.012
16	Meshgin shahr	DooDoo	319.1	30.6	1.4	0.0014	0.02	0.001
17	Meshginshahr	Shabil	321.2	32.7	4.2	0.0042	0.06	0.005
18	Meshgin shahr	Ghotoor sooei	309.4	20.9	12.8	0.0128	0.12	0.010
19	Khalkhal (kosar)	Ghivi	331	42.5	3.2	0.0032	0.06	0.005
20	Meshgin shahr	Geothermal plant	250-500				11.41	1

4. Conclusion

Based on the results for the wind energy, the Namin city has the first priority with the amount of wind of 5/78 m/s; the wind power is 159/15 w/m^2. Regarding the biomass energy potential, the khalkhal city has the first priority in the Ardabil province with the 3823/34 Gw h/y potential. Regarding the hydro- and geothermal energy

(including power plants), Meshgin-shahr has the first priority in the cities of the Ardabil province with the power of 270/34 Gw h/y and 76/11 kw h/y, respectively.
Regarding the solar energy, the Parsabad and Meshgin-shahr cities with the radiation intensity both in 3/449 kw h/m^2/y are the first priorities. According to the results obtained, prioritization of the use of renewable energy would be as follows (Table18):

Table 18. Order of priority of total renewable energy in the Ardabil province.

First priority	Meshgin shahr
Second priority	Namin
Third priority	Germi
Fourth priority	Khalkhal
Fifth priority	Parsabad
Sixth priority	Bilasavar
Seventh priority	Ardabil
Eighth priority	Sarein

According to a potential survey conducted in the Ardabil province in terms of the wind power density based on the parameters such as air density, temperature, and humidity, the Namin city was identified as the most talented area to install wind turbines. For policy and investment in wind energy in the province of Ardabil, the Namin city is recommended. In the case of solar energy, Meshgin-shahr and Parsabad have the first priorities for investment. The Khalkhal city's priority is investment in biomass energy, and in the field of hydro-power, Meshgin-shahr has the first priority for investment (Table 19).

5. Nomenclature

P Density of dry air (kg/m.s)
P_{air} Air pressure (pa)
R Specific gas constant for dry air (287.05 J/(kg/K))
T Temperature (0 k)
P_w Theoretical power of turbine
p Weather density (kg/m^3)
A Surface (m^2)
V Wind rate (m/s)
Y_{LFG}Theoretical efficiency of landfill gas from wet garbage unit (m^3/kg MSW)
CO_i Amount of existing C in the i component from urban waste (kg C/kg MSW)
Fb_i Ability for biodegradability in the I component from urban waste (kg/kg dry).
P_i Ratio of the i component in the whole waste (kg/kg MSW)
LC Percent of lignin existing in organic material
V_w Volume of wastewater for food industry of the town
M_{pi} Dairy production related to the i group
U_{wi} Factor of waste generation from a production unit related to the i group
M_c Total mass of produced pollution (according to BOD or COD) in the province
U_{ci} Pollution index from a generated product unit related to the i group
V_{CH4} Volume of methane in conventional condition (pressure of 1 atom and temperature of 0 k)
Y_{CH4} Theoretical efficiency of methane from COD or BOD mass unit
E Practical efficiency of the process
Ni Available livestock in towns
C_m Mass of generated wastes from each animal per day
T_f Establishment duration per day
N Considered animal number
U_{MP} Mass of fresh wastes of each animal
P_R Rate of collectable wastes
η Turbine efficiency
ρ_w Water density
g Gravity velocity
h Height
v Water discharge

Table 19. Prioritizing the towns in the Ardabil province according to weight factor of renewable energies.

Town	Weight factor of solar energy	Weight factor of wind energy	Weight factor of biomass energy	Weight factor of water energy	Weight factor of geothermal energy
Ardabil	0.971	0.23	0.027	0.177	0.03
Khalkhal	0.970	0.083	1	0.019	0.005
Sarein	0.971	0.28	0.017	0	0.1
Meshgin-shahr	1	0.129	0.256	1	1
Namin	0.971	1	0.276	0.402	0
Germi	0.971	0.064	0.416	0.191	0
Parsabad	1	0.042	0.023	0.615	0
Bilasavar	0.971	0.31	0.164	0	0

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