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Improving Renewable Energy Policy Planning and Decision-Making Through MCDM Combined Method

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***Abstract*—** Renewable energy (RE) is one of the potential solutions for climate change, energy security and sustainable growth. Considering the reduction of fossil fuels and the resulting environmental problems, the use of renewable energy is very important, and it is expected that the use of renewable energy will play a prominent role in the world's energy portfolio. In this research, the best place to build a combined solar wind power plant is determined among different options, and then a combined energy production system is designed in the desired location, and the proposed plan is examined from a technical and economic point of view. In this research, renewable energy production sources are examined from various aspects. Renewable energy production sources each have advantages and disadvantages, which can be superior to each other according to the area of use. For this purpose, in this research, the AHP algorithm is used to construct the cost function. For each hour of the day and night, a pair matrix is considered, in which the benefits of two power plants are given, and based on the formed matrix, the benefits of each can be Calculated to the other numerically. In the end, the meta-heuristic algorithm is used to choose the right option. The dragonfly algorithm has the ability to be less stuck in the local optimum and to calculate the optimal solution in less time than other meta-heuristic algorithms.

Keywords: improving planning - decision-making - renewable energy policy - MCDM combined method

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I. INTRODUCTION

Renewable energy (RE) is one of the potential solutions for climate change, energy security and sustainable growth.

The quest for sustainable energy solutions has gained unprecedented urgency due to the depletion of fossil fuel reserves and their associated environmental impacts. The integration of renewable energy (RE) sources is a critical step in addressing the global energy crisis, transitioning towards a cleaner and more sustainable energy landscape. This literature review synthesizes key findings from recent studies concerning the various facets of renewable energy technologies, public perceptions, and the challenges faced in their implementation [1-4].

REs is produced using harmless techniques that have a less harmful effect on the environment compared to other energies. Therefore, renewable energy sources seem to be an effective solution to achieve sustainable development [5-9]. Renewable energy has been used in many issues [10-14]. Considering the reduction of fossil fuels and the resulting environmental problems, the use of renewable energy is very important, and it is predicted that the use of renewable energy will play a prominent role in the world's energy portfolio. Many countries have established legal frameworks to encourage the use of RE resources [14-18].

Renewable or so-called "green energy" such as wind, solar, geothermal and hydropower is inexhaustible, clean and free. The global share of RE is not significant (18% of global energy consumption) (Figure 1). However, its growth rate is projected to increase faster in all future scenarios.

Figure 2 shows the global deployment potential of different RE sources in final energy consumption by 2050. As shown in this figure, the contribution of bioenergy and wind energy is higher than other sources.

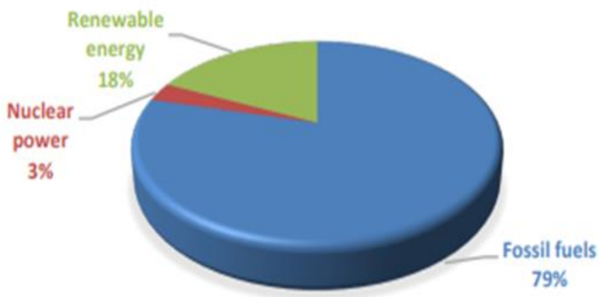

Figure 1. Energy consumption around the world

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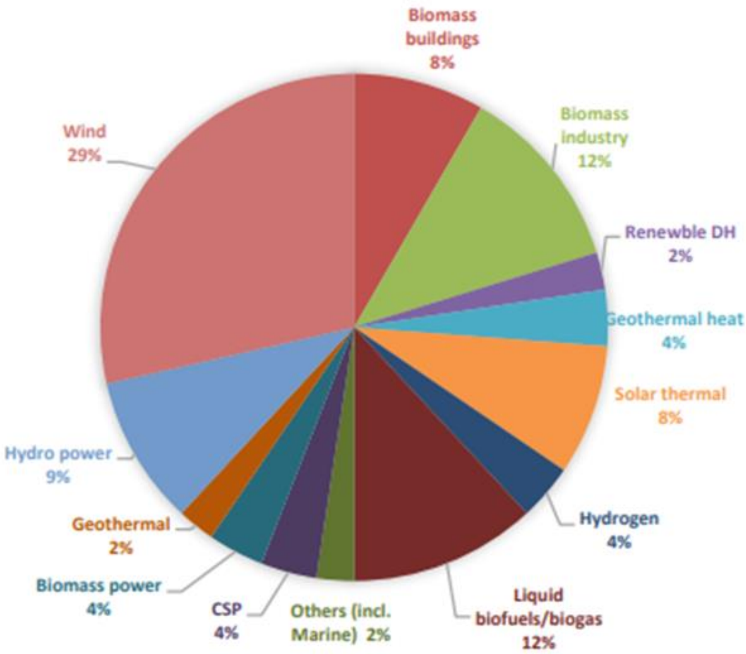

Figure 2. of the global deployment potential of different RE sources in final energy consumption, 2050

Iran has the fourth largest proven reserves of crude oil (10% of the world's crude oil reserves) and the second largest natural gas reserves in the world (17% of the world's natural gas reserves). Iran's economy is highly dependent on energy exports, and Iran's main exports are natural gas and oil. In addition, due to its geographical location, Iran has a high potential of renewable resources such as wind, sun, geothermal and biomass [19-21]. Unfortunately, due to having abundant natural gas and oil reserves, the development of these energies has been neglected for a long time. Figure 3 shows the share of renewable energies in Iran's primary consumption. The share of RE in Iran's energy supply is very low. Currently, all types of renewable energy are receiving government attention, in some cases less and in some cases more [22-27].

Some types, such as the hydrogen fuel cell, have not yet shown signs of significant progress despite large budgets and are not expected to reach the commercialization phase in the near future.

There are also other types of RE that are capable of providing energy security in Iran, but they badly need more incentives and continuous support from the host government.

The most important reasons for the lack of proper development of renewable energies in the country are poor operational planning, numerous RE documents and offices, and the lack of proper use of the private sector.

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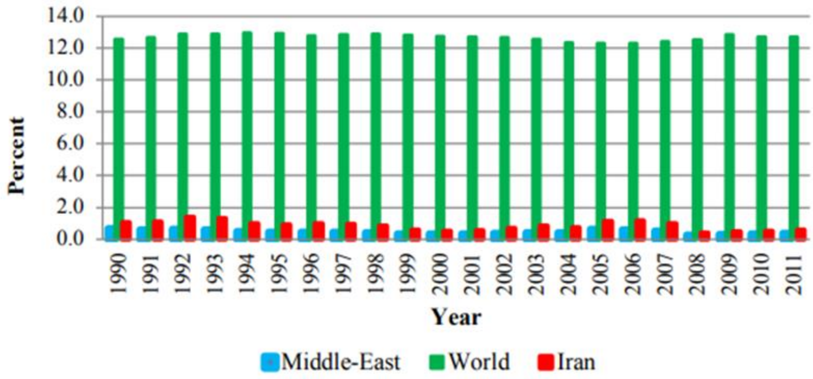

Figure 3. Contribution of renewable energies in primary consumption

In the past years in Iran, there have been discussions in the scientific community about the prioritization and allocation of funds for each RE, which indicates unfavorable views about the five main sources of RE (solar, biomass, hydropower, wind and geothermal). Therefore, this research deals with this issue in the hope of making more correct decisions and avoiding knee-jerk policies [28-34].

In this study, a new MCDM hybrid method is proposed for ranking Iran's RE resources. Analytical Hierarchy Process (AHP) has been used as one of the most common MCDM methods to identify the key drivers in RE development in Iran and to weight the criteria and sub-criteria. In this research, with the help of combining the AHP method with the meta-heuristic algorithm, we will select the appropriate power plant. With the help of the AHP method, the cost function is created and with the help of the meta-heuristic method, all possible situations are examined day and night to finally choose the best option.

II. RELATED WORKS

In the article [5], uses econometric strategies to examine the hypothetical relationship between the specified indicators for the period 2000-2016 in sub-Saharan African countries. Empirical results show that human development index (HDI)1, access to clean energy and technological innovation show a long-term equilibrium relationship. Subsequently, this finding showed that access to energy and technological innovation in the sample countries stimulate higher HDI indices.

[1] Human Development Index

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The paper [6] uses data envelopment analysis, namely bounded-adjusted measurement (BAM)2 relying on additive structure, to measure technical inefficiency and productivity change across TRTAs in China.

The paper [7] considered a practical situation where the location selection of RES3 owners can conflict with the operational goal of the systems to improve the hosting capacity. To deal with this challenge, a three-level ESS4 planning formula with the risk constraint "min-max" is developed. Also, a scenario-based stochastic program model is included in the lower-level problem to handle the stochastic fluctuations of RES outputs.

The article [8] systematically examines discoveries and practices related to wind and photovoltaic electricity consumption in China. According to the difference in the methods of completing the variable and intermittent output of wind and PV electricity, it is drawn in five consumption modes:

Microgrid energy absorption, power grid peak operation consumption, wind-photovoltaic storage consumption, wind-photovoltaic-heat supplement. and complementing the blue photovoltaic wind. The theories, characteristics, current status and growing trends of each mode are analyzed. Finally, several suggestions, including promoting the application of multi-energy complementary microgrid and installing large-scale pumped storage hydropower, are made to improve the efficiency of renewable energy development in China.

In this paper, we present a systematic analysis of the factors shaping the global energy trade network, taking into account several indicators of energy security as well as broader economic considerations. We observe that, in line with energy security considerations, most countries have actually increased the number of their commercial connections, resulting in a denser global energy network [9].

This study proposes a Gaussian Stochastic (GPR) based machine learning process model for short-/medium-term energy, solar and wind (ESW) forecasts using two different temporal resolutions of data. Four experimental stages (EXMS) were designed. Each EXMS is designed with four separate fitting and prediction methods, and the GPR model uses seven kernel covariance functions for hyperparameter optimization. Real-time data is used for predictive analysis in three different locations. Prediction results are verified using three existing models [14].

The concept of smart city was proposed in the wave of "new urbanism". To improve the quality of urbanization, China has launched the smart city construction since 2012. Taking 153 cities

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[2] Business activity monitoring
[3] Renewable energy
[4] executive support system

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from China as a research sample, the impact of smart city policy (SCP) on total urban ecological energy efficiency (ETFEE) was evaluated using generalization [15].

This study aims to develop possible mechanisms for energy and environmental policy perspectives by examining the mediating role of renewable energy patents. Non-radial data envelopment analysis and panel data models are used using panel data from 2010 to 2017 from 30 provinces in China.[16]

The continuous growth of the world population and the global economic development of countries along with the effects of industrialization, urbanization and technological developments have caused a significant increase in the consumption of resources. Meanwhile, the level of consumption, the most unavoidable of which is the need for energy, continues to increase in many ways, despite the limited and rapidly decreasing fossil resources of the world. Since the world currently has limited reserves in terms of fossil fuel resources and these resources are not equally distributed among countries, it is not possible to meet the energy needs with existing fossil resources in the short term. In addition, the use of fossil fuels causes damage to the environment and disruption of living conditions, especially human health, animal life and nature. This situation is also considered as another threat. Therefore, it seems that the issue of energy is one of the major challenges of humanity in the short term, because energy is one of the most important issues on the agenda of policymakers. In this situation, decision makers have started to find alternative sources to meet energy needs. Renewable energy sources are primary alternative energy sources that require strategic planning in terms of sustainable development.

Therefore, reducing the use of fossil resources and replacing them with renewable energy sources in a controlled manner is critical for both energy sustainability and long-term energy planning. Energy planning, which is critical in technical, economic, social, political and environmental aspects, Recently, it has become one of the most discussed topics. Therefore, the planning process requires special attention to determine the appropriate energy types and the most suitable areas in an optimal route. In the meantime, meeting energy demand is critical, as it is predicted by EIA [8] in the World Energy Outlook 2019 report that between 2018 and 2050, global energy consumption will increase by almost half. For this reason, in order to meet the energy demand, decision-makers who are interested in energy planning should give due importance to the issue, knowing the seriousness of the problem, especially in areas with limited access. have limited natural resources or opportunities in terms of using fossil fuels. In other words, overall energy planning by itself will not be sufficient in all cases. Therefore, energy planning from a regional perspective has a fundamental place in this process in order to cope with the increasing energy demand of each developing region. This process should mainly cover the analysis of the needs and requirements of specific areas, taking into account the importance of technical adaptation and financial analysis to minimize the total cost, examining

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social and employment issues and the environmental effects of energy sources. Although fossil fuels are still known as the energy source with the largest share of use in the energy sector, it can be seen that due to the growing environmental concerns and global economic conditions, the share of renewable energy in the energy sector is increasing day by day. Without a well-designed energy planning mechanism, the energy industry is closely related to environmental factors that damage the ecosystem if fossil fuels are used unbalanced. This situation adds more complexity to the problem, because it is very difficult to control or include these factors in investment planning [7].

Therefore, energy planning is considered one of the leading issues in future strategic plans, which is of great importance for developing countries around the world. On the other hand, the country's energy situation, whether it has sufficient reserves to supply its energy needs from domestic sources or is highly dependent on energy imports, is one of the most important factors of economic growth that shows the level of production and production.

The aim of this study is to analyze the current situation and future potential of renewable energy sources in electricity production and to provide a multi-objective model for regional energy planning. Using the developed model, the process of determining the most suitable renewable energy sources for the potential location and the amount of energy production from these sources will be determined under multiple objectives. In order to decide on the most suitable diversification of sources, the main focus is on five types of energy from renewable energy sources, namely solar, wind, geothermal, hydroelectric and biomass. The main reason for choosing these five types of energy is that they are the best and most efficient types in electricity production. Another goal of this study is to reduce foreign energy imports and increase the use of domestic energy sources, especially renewable energy alternatives, by developing a multi-objective decision-making model with the aim of optimal use of renewable energy. In this way, this study aims to raise awareness about the preference of renewable energies in energy consumption. In addition, with the proposed method, countries will be able to use their energy potential in the best way, not only considering the cost, but also considering the social and environmental factors.

III. DRAGONFLY ALGORITHM

The interesting fact about dragonflies is the unique and rare swarming behavior of this insect. The mass of dragonflies is formed for two purposes only: hunting and migration, which is called static mass or feeding, and migration is called dynamic mass or migrant. In a fixed or static mass, dragonflies form small groups and move back and forth in a small area to hunt other flying insects such as butterflies and mosquitoes. Environmental movements and sudden changes in the flight path are the main characteristics of static masses. In dynamic masses, a large number of dragonflies form a mass to migrate in one direction and over a long distance.

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The main idea of the dragonfly algorithm originates from static and dynamic crowding behaviors. These two crowding behaviors are very similar to the two main stages of optimization with meta-heuristic algorithms: Exploration and exploitation, dragonflies form smaller groups and fly in different areas as a static group. This work is the main goal in the discovery phase. In the dynamic group, dragonflies fly in larger groups and along the same direction, which is a desirable behavior in the exploitation phase. To simulate the intelligent behavior of dragonflies, we have considered the three basic principles of insect masses proposed by Reynold, as well as two other new concepts, which are shown in the figure below: The primary modification patterns between individuals in the dragonfly group are:

Separation or dissociation: This operator refers to the avoidance of a person with other neighboring people in the same space.

Alignment: not exceeding the speed of particles or objects compared to other neighbors in a single space or adjusting the speed of people according to other neighboring people.

Coherence: This operator also refers to the tendency of people towards the center of gravity of their neighbors.

The main goal of each mass and group in the above scenario is to maintain survival. Therefore, all individuals must be attracted to the food source and stay away from enemies. According to these two behaviors of particles, there are 5 main factors in updating the position of particles as shown in the above figure.

These 5 concepts allow us to simulate the behavior of dragonflies in static and dynamic masses. Each of the above behaviors are formulated using models that are discussed in the following section.

The separation operator is modeled in the following formula.

$$S = \sum_{j=1}^{N}(X - X_j)$$

In the above formula, X represents the position of the current person, Xj represents the position of the jth person in the neighborhood, and N represents the number of neighbors in the person's neighborhood. Alignment is also modeled using the following formula:

$$A = \frac{1}{N}\sum_{j=1}^{N} V_j$$

In the above relation, Vj also shows the speed of a person. In fact, in the proposed method, the above formula can be used to obtain the average speed of execution of tasks by virtual machines or to calculate the average speed of exchanging information between virtual machines. In general, the above calculations can be calculated by dragonflies. The coherence operator is modeled by the following formula.

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$$C = \frac{1}{N}\sum_{j=1}^{N}(X_j - X)$$

In the above formula, X is the position of a person, Xj is the position of the jth neighbor in the environment, and N is the number of neighbors related to the desired person. The above formula is very closely related to the separation formula and is used in order to find the average difference between the current virtual machine position and other virtual machines in the proposed method. The jump to the food source by people is formulated using the following relationship:

$$J = X^{+} - X$$

In the above formula, X represents the position of the individual and X+ represents the position of the food source. In the above formula, after finding a low-load virtual machine in order to execute tasks with higher priority by the dragonflies, a jump is made to the corresponding virtual machine, which is discussed in the form of a relationship. Escape from the enemy is also shown by the following formula:

$$E = X - X^{-}$$

In general, by using the above formula, virtual machines that are not suitable for selecting and executing the desired task are removed from the selection list. Dragonfly's behavior is a combination of these 5 patterns. In order to update the position of artificial dragonflies in the search space and simulate their movement in a limiter, the dragonfly algorithm considers two vectors: 1- Step length vector (Delta X) and 2-X position vector- The step length vector is the same as the speed vector in the PSO optimization algorithm, and the dragonfly algorithm is also developed based on the PSO framework. The step length vector determines the direction of dragonfly movement, which is analyzed in the following relation:

$$\Delta X^{t+1} = w\Delta X^{t} + sS_i + aA_i + cC_i + F_i + E_i$$

where s shows the separation coefficient, Si is the separation rate for the i-th individual and a shows the alignment weight. A is the alignment of the i-th person, c is the cohesion coefficient and Ci is the cohesion value of the ith person. F is the food criterion and Fi is the food source of the i-th person. E is the enemy factor and Ei is the position of the i-th enemy. w is the weight of inertia and finally t shows the number of iterations of the algorithm. After the step vector is calculated, the position vectors are calculated using the following formula:

$$X^{t+1} = X^{t} + \Delta X^{t+1}$$

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xt shows the current position. In general, the above-mentioned vectors are used by dragonflies to manage neighbors and provide a report of the position and the way virtual machines communicate with each other. By using the factors of separation, alignment, cohesion, food and enemy, various exploratory and exploitation behaviors occur during the execution of the algorithm. The neighbors of dragonflies are very important, therefore, a neighborhood in the form of a circle in the two-dimensional space of the sphere in the three-dimensional space dimension and the supersphere is considered in n-dimensional space with a certain radius around each artificial dragonfly.

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According to the figure above, you can see that dragonflies tend to direct their flight. while maintaining appropriate separation and cohesion in dynamic crowding. In static swarming, there is very little orientation, while swarming is high for prey attack. Therefore, we consider dragonflies with low orientation and high coherence when exploiting the search space. In order to switch between exploration and exploitation, the radius of the neighborhood increases with the number of iterations of the algorithm. Another way to balance exploration and exploitation is to adaptively adjust the congestion factors (s, a, c, f, e, and w) during optimization. A question that may arise is how the convergence of dragonflies is guaranteed during optimization. Dragonflies need to adapt their weights to transition from exploration to exploitation in the search space. It is also assumed that dragonflies tend to see more dragonflies to adjust their flight direction in the optimization process. In other words, the neighborhood area is increased, whereby the swarm becomes a group in the final stage of optimization to converge to the global optimum. The food source and enemy area are obtained from the best and worst answers found in the entire swarm so far. This causes convergence towards promising regions of the search space and divergence towards unfavorable regions in the search space. where t is the current repetition counter and the dimensions of vector is position and the value is calculated using the following equation.

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$$\text{Lévy}(x) = 0.01 \times \frac{r_1 \times \sigma}{|r_2|^{\frac{1}{\beta}}}$$

that r1, r2 are two random numbers in the range of zero and one and one is fixed (which is considered equal to 1.5 in this work). DA optimization algorithm is discussed in the following section?

The DA algorithm starts the optimization process by generating a set of random solutions for the given optimization problem. In fact, the position and step vectors related to dragonflies are randomly initialized according to the lower and upper limits of the variables. In each iteration, the best position and location of each dragonfly is updated by using the above relations. To update the X and DX vectors, the neighborhood of each dragonfly is done by calculating the Euclidean distance between all dragonflies and selecting N of them. The process of updating the position continues iteratively until the stopping condition is met. Here we point out the main difference between DA and PSO algorithms. Considering the concepts of separation, alignment, cohesion, attraction, repulsion or distraction in this work and random walk are the most important differences.

The steps of implementing the DA algorithm are as follows:

1. value to Algorithm parameters

2. Creating the initial population of dragonflies randomly

3. Assess the position of each dragonfly and calculate its merit

4. Identifying the best dragonfly as a Food Source and the worst dragonfly as an Enemy

5. Continue steps 6 to 13 until the stop condition is met.

6. Update the value of parameters e, w, s, a, c, f and neighborhood radius.

7. Repeat steps 8 to 12 for each dragonfly.

8. Update the neighborhood radius.

9. Update E, F, C, A, S values.

10. Update the velocity vector and position vector of the dragonfly.

11. Calculate the merit of the updated dragonfly.

12. If the merit level of the new dragonfly is better than the food source, place the new dragonfly as the food source, and if the merit level of the new dragonfly is worse than the enemy, replace it with the enemy.

13. If the stop condition has not been established, go to step 5, otherwise, the end is observed according to the check of the dragonfly algorithm, which can be used at any moment to select the most suitable virtual machines to perform the necessary processing in order to reduce

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energy consumption in the data center, maintaining load balance and providing a task scheduling mechanism.

In this problem, it is possible to choose one of the 4 power generation options for each hour of the day and night, which results in a total of 4 possible 24 modes, which according to the dimensions of the problem, this is a non-convex problem and should be solve with the help of heuristic algorithms. Considering the efficiency of the dragonfly algorithm in finding the global optimum, it is suggested to use this algorithm.

IV. SUGGESTED METHOD

For this research, the ahp method is used for the purpose of multi-criteria decision-making. At this stage, the cost function is created with the help of multi-criteria methods, and then with the help of the dragonfly algorithm, we will have the best answers for selection.

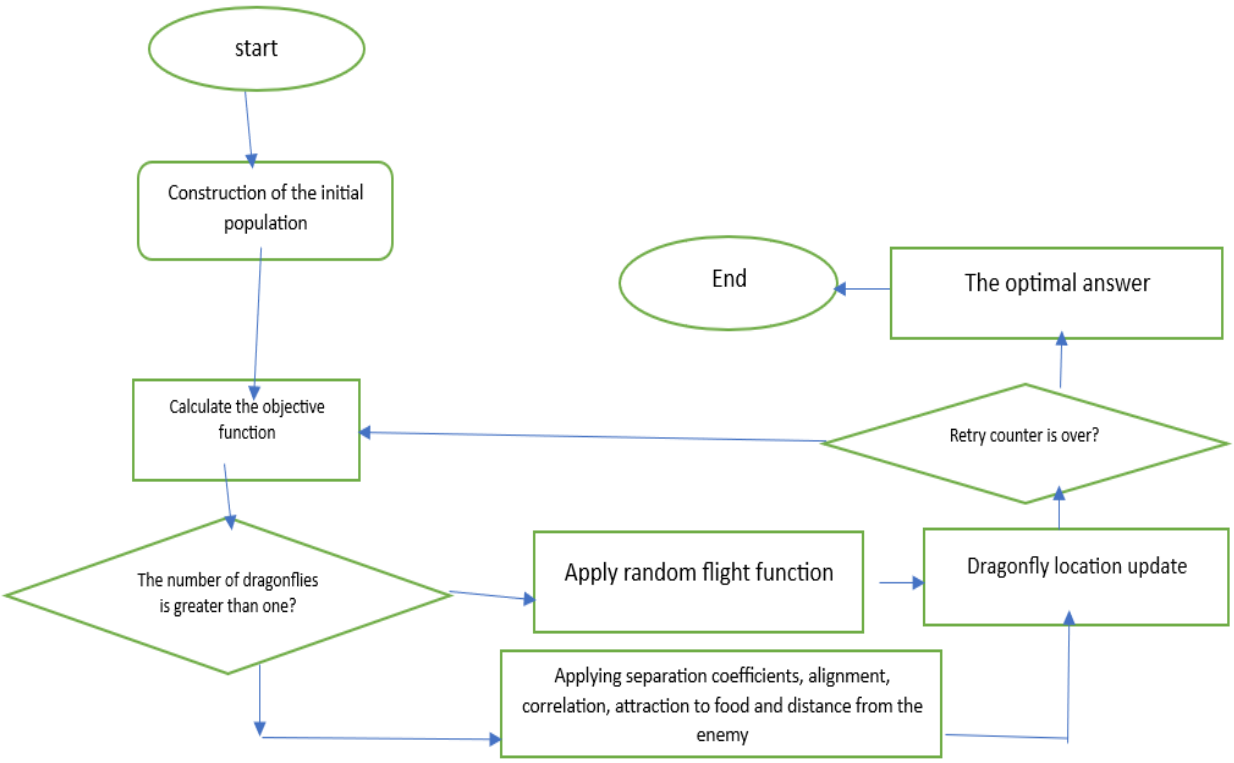

Figure 4. Dragonfly algorithm

Hierarchical tree of choosing the best option for building wind power plant, solar power plant, using battery and load responsive program is shown in order.

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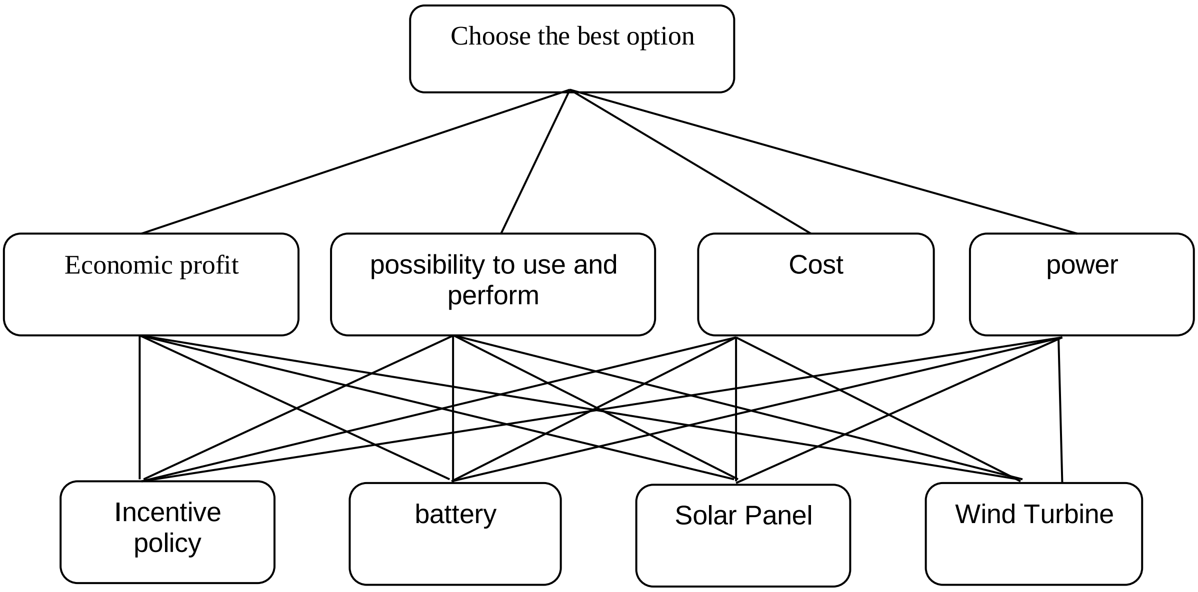

Figure 5. Hierarchical tree diagram for equipment deployment

Table 1. RM scenarios from all four sources

RM	References
RM1	**DG only**
RM2	**WT+DG**
RM3	**SPVA+DG**
RM4	**WT+BS**
RM5	**SPVA+BS**
RM6	**WT+SPVA+DG**
RM7	**WT+SPVA+BS**

In this section, the problem is simulated for one hour and the method of calculating the cost function for one hour is described in detail. It is assumed that the matrices of pairwise comparisons are obtained from the experiences of the expert.

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A. CREATING A MATRIX OF PAIRWISE COMPARISONS OF INDICATORS

Table 2. Matrix of pairwise comparisons of indicators for the construction of wind power plant

indicator	**power**	**Establishment cost**	**Ease of installation And operation**	**Economic profit**
power	1	5	3	**7**
Establishment cost	.2	1	1	**3**
Ease of installation And operation	.33	1	1	**3**
Economic profit	.14	.33	.33	**1**

Table 3 Matrix of pairwise comparisons of options, ratio of power index

Power	**solar power station**	**Wind power plant**	**Incentive policies**	**battery**
solar power station	1	1.5	1.4	**1.6**
Wind power plant	5	1	2	**1.3**
Incentive policies	4	1.2	1	**1.4**
Battery	6	3	4	**1**

Table 4 Matrix of pairwise comparisons of options, implementation and establishment cost ratio

Establishment cost	**solar power station**	**Wind power plant**	**Incentive policies**	**battery**
solar power station	1	1.3	1.2	**1.6**
Wind power plant	3	1	5	**1.4**

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Incentive policies	2	2	1	**1.3**
Battery	6	4	3	**1**

Table 5. matrix of pairwise comparisons of options, the ratio of installation convenience index

Easy installation	solar power station	Wind power plant	Incentive policies	battery
solar power station	1	1	2	**1.4**
Wind power plant	5	1	2	**1.2**
Incentive policies	5	1.2	1	**1.4**
Battery	**4**	**2**	**4**	**1**

Table 6. Matrix of pairwise comparisons of options, economic benefit ratio

Economic profit	solar power station	Wind power plant	Incentive policies	Battery
solar power station	1	1.3	4	**1.6**
Wind power plant	3	1	3	**1.3**
Incentive policies	1.4	1.3	1	**1.4**
Battery	6	3	4	**1**

The cost function is created for a set of matrices and it is necessary to choose the best option that has the lowest cost function. After constructing the cost function, it is time to solve the problem with the help of the dragonfly algorithm that can optimize this cost function.

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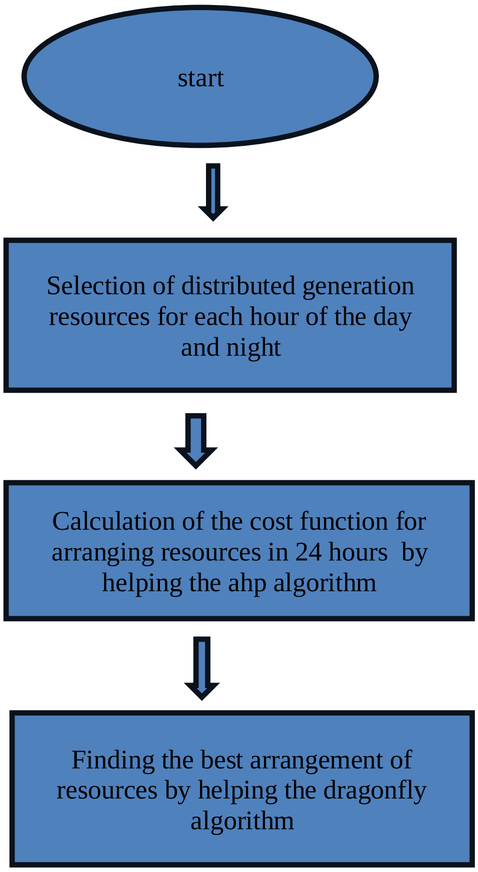

Figure 6. Proposed algorithm

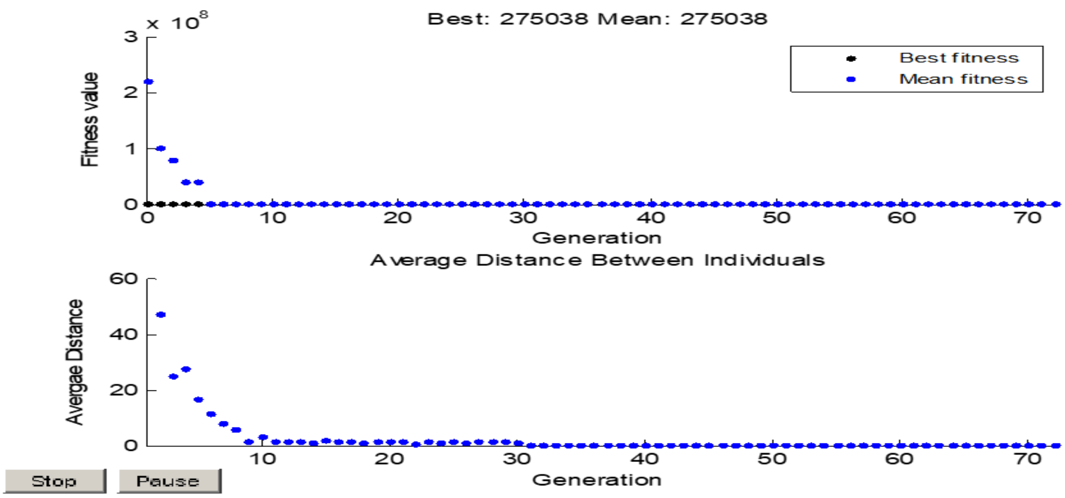

Figure 7. The diagram related to the algorithm execution process

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As you can see, the dragonfly algorithm can get the best answer after 31 iterations

Table 7. cost amount matrix

Cost function	optimization Algorithm
7.4	**Genetics**
5	**Pso**
4.3	**dragonfly**

As it can be seen, the dragonfly algorithm has the best cost function among the usual meta heuristic algorithms. The dragonfly algorithm has the shortest time among meta-heuristic algorithms.

V. CONCLUSION

The production of electrical energy using clean and renewable wind and solar energy promises the reconstruction of the energy industry, which is moving from fossil fuels to renewable fuels. The combined energy production system has become one of the most promising solutions to meet the electricity needs of different regions. At the same time, there are still many problems in this field waiting to be solved. In this research, the best place to build a combined solar wind power plant is determined among different options, and then a combined energy production system is designed in the desired location, and the proposed plan is examined from a technical and economic point of view.

By Using the Analytical Hierarchy Algorithm (AHP) method, the best option is determined, according to this, it is selected for the construction of wind and solar power plants, both separately and in combination.

In this research, sources of renewable energy production were examined from various aspects. Renewable energy production sources each have advantages and disadvantages, which can be superior to each other according to the area of use.

For this purpose, in this research, AHP algorithm has been used to construct the cost function, for each hour of the day and night, a pair matrix is considered, in which the benefits of two power plants are given, and based on the formed matrix, the benefits of each can be Calculated numerically to another. Finally, the meta-heurist algorithm has been used to select the appropriate option. The dragonfly algorithm has the ability to be less stuck in the local optimum and to calculate the optimal solution in less time than other meta-heuristic algorithms.

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