International Journal of Research in Industrial Engineering
www.riejournal.com

# Optimum Solar and Wind Model with Particle Optimization (PSO)

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**A B S T R A C T**

Although the development of science and technology in the present era has increased human satisfaction from life, it has caused the problems such as environmental pollution and increased demand for energy carriers, especially fossil fuels. Considering that fossil fuels can be exhausted, the most suitable solutions to address the consequences are the use of renewable energy sources to generate electricity. In this paper, using the Particle Cumulative Optimization (PSO) algorithm, we have tried to design an optimal photovoltaic and winding model to supply the power of an area in such a way that the electrical charge generated by this system has the reliable capability and economically viable.

**Keywords**: Renewable energy, Energy economics, Particle cumulative optimization (PSO) algorithm.

***Article history:*** *Received: 30 July 2018* *Revised: 18 November 2018* *Accepted: 06 December 2018*

## 1. Introduction

Considering the high importance of electrical energy in the development of the modern world, the importance of its production plays a key role, and the damage that the lack of electricity supply for consumers creates is not comparable to other sectors. One of the effective factors in moving towards sustainable development is the development of energy systems at a low, reliable, and environmentally friendly cost. Restrictions on access to fossil fuels and environmental degradation caused by the use of these resources have led humans to seek new sources of energy.

Renewable energy refers to a state of energy whose source, unlike fossil fuels, is capable of being re-created by nature over a short period of time. Although the renewable energies are not ideal, the factors such as reduced consumption of petroleum products, reduced costs, increased employment, and reduced environmental pollution have led to attention [6].

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DOI: 10.22105/riej.2018.148836.1059

The purpose of this paper is to design a photovoltaic and wind-combined hybrid system using a cumulative particle optimization algorithm in such a way that the electric charge generated in this system is reliable and economically feasible.

Particle optimization algorithm is a computational method based on population of responses that optimizes the problem with repeated attempts to improve a solution according to the assumed quality criterion. This method moves the set of answers into a search space by simple mathematical formulas for computation. Moving each answer is influenced by the best known position, which at the same time, leads to the best known positions throughout the search space. This process leads to the best solutions.

## 2. Introducing Model Components

### 2.1 Solar Panel (PV Panels)

Photovoltaic technology (PV) is a kind of solar power generation system [2, 3, 4, 5], which allows the direct production of electricity from sunlight by using the solar cells. Solar cells are semi-conductive, made of silicon, and the second most abundant element of the earth's crust. When the sun goes down to a photovoltaic cell, there is a potential difference between the two negative and positive electrodes, which causes the flow to flow between them.

The electrical energy produced by photovoltaic cells (PPV) at time t is calculated using the following equation:

$$P_{PV}(t) = \eta_{PV} \cdot A_{PV} \cdot I(t)\,, \qquad (1)$$

where ηPV is photovoltaic cell efficiency, APV is total surface area occupied by photovoltaic cells per square meter, and I is the intensity of solar radiation in kilowatts per square meter. The amount of energy produced in an hourly intervals per kilowatt-hour is equal to

$$E_{PV}(t) = P_{PV}(t). \qquad (2)$$

### 2.2 Wind Turbines

Wind turbines transform the kinetic energy of the wind into a mechanical power, and this mechanical power is transmitted to the generator and ultimately generates the electrical energy. The base of wind turbines is the twin or triple rotating wind turbine rotor. The rotor is connected to a central shaft, which rotates with the rotator and generates electricity.

The turbine efficiency is defined as the function of the surface swept by wind turbine blades (Aw), air density (ρa), wind speed (Vr), power factor (Cp), and wind turbine generator efficiency (ηg).

$$P_r = \frac{1}{2} \cdot C_p \cdot \rho_a \cdot \eta_g \cdot A_w \cdot V_r^3 . \tag{3}$$

## 2.3 The Battery

The battery is a source of electrical potential energy in which the chemical energy is converted into electrical energy; this energy is available in battery poles. The battery used in this model is a rechargeable battery that is less costly than other batteries that are used for a single charge with the less environmental impact. The amount of energy produced by the photovoltaic array and wind turbines at time t is:

$$P_g(t) = P_{PV}(t) + P_w(t) . \tag{4}$$

The purpose of using a charged battery is that when the solar and wind power production can cover the demand for electricity, this battery is capable of recharging, so that when the flow is not capable of responding to demand, the flow is required by battery.

## 2.4. Diesel Generator

It is a device for the production of electricity at an industrial scale commonly used for emergency power when the nationwide network is interrupted or when it is unavailable. The purpose of putting the diesel generator in the above model is to ensure that the load is supplied when the system cannot meet the demand for the electricity.

## 2.5 Inverter

A device converts direct current into alternating current. The reason for using the converter in the above model is that the current produced by the solar panel, the wind turbine and the direct current battery, and because the current flow is intermittent in the metropolitan area, then this direct current should be converted to alternating current.

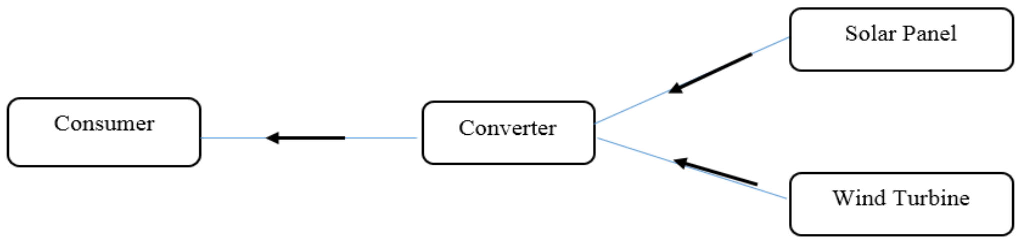


**Figure 1. The General Form of the System Used in the Model.**

## 3. Particle Cumulative Optimization (PSO) Algorithm

The particle aggregation optimization algorithm is a population-based optimization method developed by Eberhart and Kennedy [1]. This algorithm is inspired by the group's search for food by birds or fish. Particle optimization algorithm is a computational method based on population of responses that optimizes the problem with repeated efforts to improve a solution according to the assumed quality criterion.

This method moves the set of answers into a search space by simple mathematical formulas for computation. Moving each answer is influenced by the best known position, which at the same time leads to the best known positions throughout the search space. This process leads to the best solutions.

## 4. Optimization Model

$$\begin{aligned} &\text{Min.} \quad Of = (NPV_{PV} + NPV_{W} + NPV_{Bat} + NPV_{Dg}) \\ &A_{PV} \geq 0 \\ &A_{w} \geq 0 \\ &N_{bat} \geq 0 \end{aligned} \tag{5}$$

The main issue in this study is to find the optimal value for the following three parameters:

- A) Solar panel area (m2).
- (B) Surface vacuumed by wind turbine blades (m2).

## 5. Results

The results of this model have been used to measure the optimum system of renewable energy for electricity to a small area far from the national network in Kerman province. This area has a latitude of 51/19 degrees north and a latitude of 35.01 degrees east.

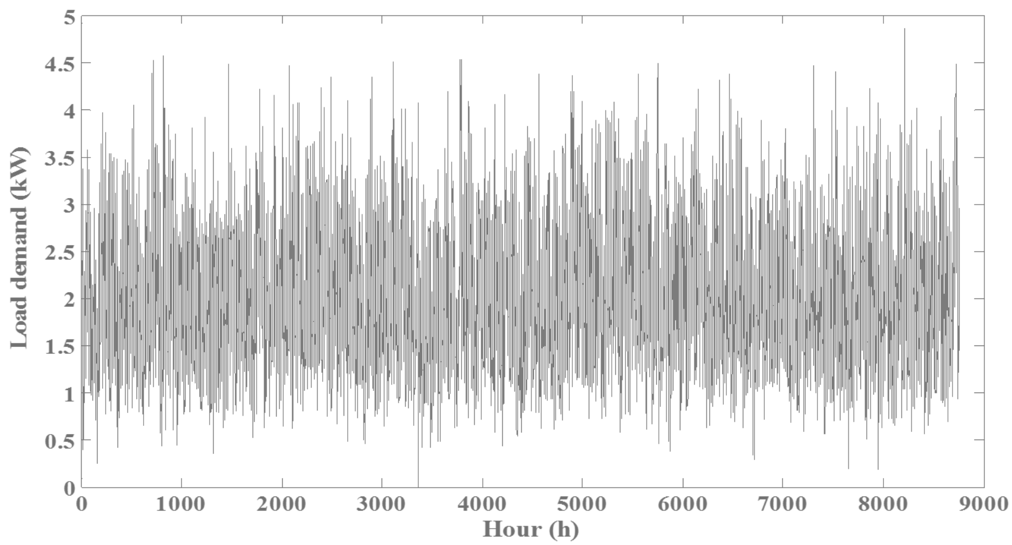


**Figure 1. Characteristic of the Electric Charge in the Desired Area throughout the Year.**

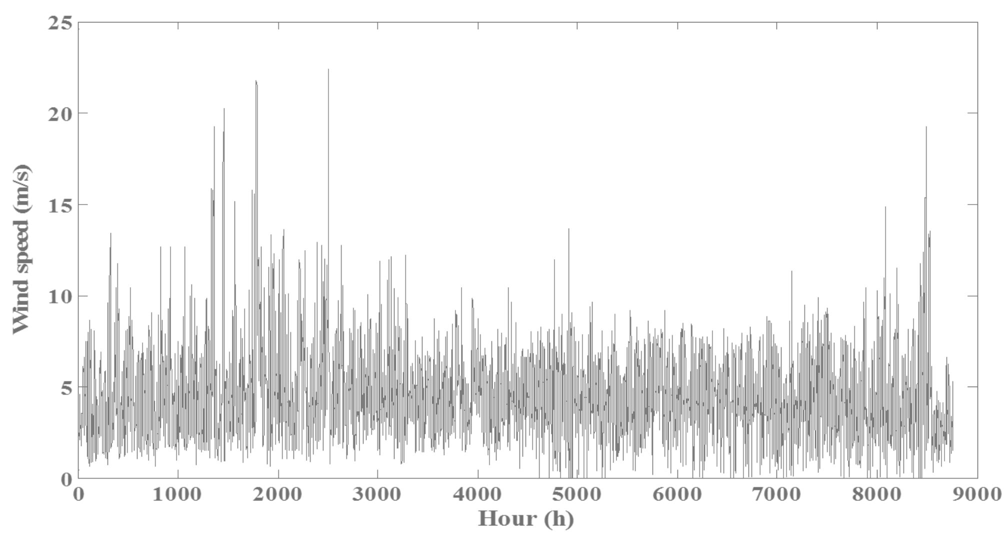


**Figure 2. The Shape of the Wind Speed in the Area Desired during the Year (Height 10 Meters).**

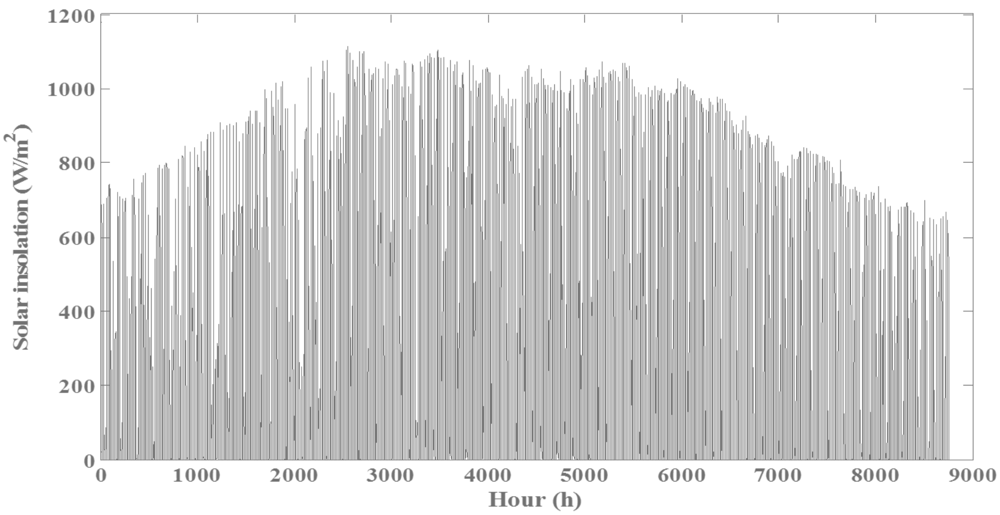


**Figure 3. The Shape of the Intensity of the Sun's Radiation in the Target Area throughout the Year.**

In this paper, finding the optimal value of a problem is difficult due to the nonlinearity of the objective function. This issue consists of three decision variables; two of which are the surface of the photovoltaic cells and the surface of the wind turbines, and the third variable is the number of batteries. To solve the optimization problem, the problem and the PSO algorithm are coded and implemented in the software environment of MATLAB. The maximum number of repetitions is 150.

In this issue, an area of a hybrid solar, wind, and battery system is used to supply electricity. The system uses the wind turbines and solar panels to generate electricity, and the reason for using the battery is that the battery stores the flow when the system is in surplus production. This shortage will be offset when the system is running low. Given that our goal is to design a system to produce a reliable electric current; a diesel generator is also included in this system that if the system does not have the ability to meet the demand for the electric current; it will enter the circuit and load the required to provide.

**Table 1. The Used Parameters.**

| | | | |
|---|---|---|---|
| (years) | 15 | $N$ | Lifetime of the project |
| | 0.04 | $\delta$ | Inflation |
| ($/m$^2$) | 540.7 | $\alpha_{PV}$ | The initial cost of the photovoltaic cell |
| ($/m2/year) | 0.01× $\alpha_{PV}$ | $\beta_{PV}$ | The annual cost of maintaining and utilizing photovoltaic cells |
| (years) | 25 | | Lifetime photovoltaic cell |
| ($/m$^2$) | 550.2 | $\alpha_w$ | Wind turbine initial cost |
| ($/m2/year) | 0.02× $\alpha_w$ | $\beta_w$ | Annual cost of maintenance and operation of wind turbines |
| (years) | 30 | | Lifetime of wind turbine |

**Table 2. The Optimally Measured Results Correspond to the Best Performance of the Algorithm.**

| *i* | $A_{PV}$ (m$^2$) | $A_w$ (m$^2$) | *Cost ($)* |
|---|---|---|---|
| 0.12 | 30.60 | 4.61 | 42715.04 |

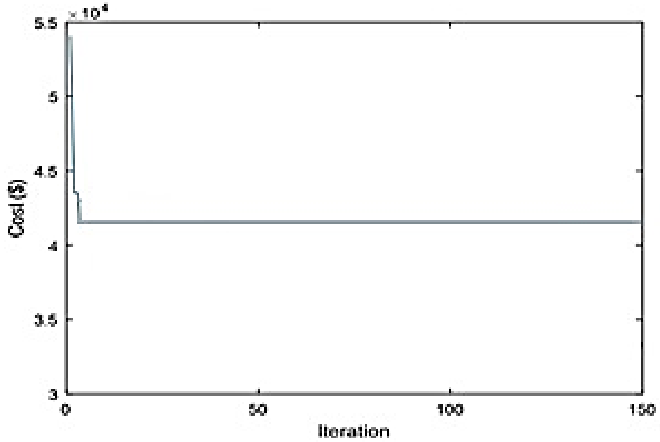


**Figure 5. Settlement Cost at a Rate of 12%.**

The optimal result of this problem is examined at a rate of 0.12. At this rate, the required solar panel requires 30.62 square meters and the surface area to be swept by wind turbines is 4.61 square meters. This is where the cost of the project is $ 42715.04.

## 6. Conclusion

In this plan, the purpose of supplying the electricity required by an area using a solar hybrid system was to inflate the most reliable electricity at the lowest cost. In this design, the flow was produced by the solar panels and wind turbines, and the batteries and diesel generators that only play a supportive role in ensuring the correct system performance. The main purpose of this paper was to provide an optimization algorithm for finding the optimal value of the solar panel area (m2) parameters and the surface swept by wind turbine blades (m2). According to the results of the particle optimization algorithm (PSO) at a rate of 0.12, the cost of production is $ 42715.04.

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