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# *Renewable Energy System Based on Genetic Algorithm*

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***Abstract:*** With the continuous increase of energy demand and the continuous escalation of traditional energy and environmental problems, energy based on carbon emissions can no longer meet the future energy demand, so renewable energy power generation has attracted global attention. The purpose of this paper is to study the multi-objective optimization of VM cycle heat pump by using NSGA-II genetic algorithm within a given range of heat source temperature, average cycle pressure, volume ratio of cold and hot chambers and rotational speed of a renewable energy system based on genetic algorithm. Finally, compared with the traditional genetic algorithm, neural network algorithm and traditional subcontracting system, the optimal solution set of the production system obtained in this work has the advantages of energy saving. The initial investment cost of Algorithms 1-3 is 160.1%, 170.2% and 178.4% higher than that of the production division system, respectively. In terms of annual operating costs, the optimization algorithm is obviously superior, saving 60.45%, 57.15% and 53.14%, respectively. Compared with the other two algorithms, the investment cost ratio of Algorithm 1 has the highest operating cost saving rate. Therefore, the multi-objective genetic algorithm based on NSGA-II is superior to the other two algorithms.

## 1. Introduction

Growing energy demands and escalating environmental concerns Traditional energy sources, namely fossil fuels, are unlikely to meet future energy demands. Energy demand is growing and resources are attracting global attention [1]. Renewable energy is the fastest growing energy source in the world, and it is estimated that the consumption of electricity from renewable energy will increase by about 2.6% annually until 2040. A renewable energy system can be defined as an electrical system consisting of renewable energy sources and one or more sources, conventional or RE or hybrid, that can operate independently of mods or connected network (grid) mods.

Renewable energy sources can be used alone and can operate autonomously or in grid mode to the grid. Therefore, research on renewable energy systems is the general trend [2].

At present, extensive and in-depth research on genetic algorithms and renewable energy has been carried out at home and abroad. Dawid H studies the concept of using artificial adaptive agents in economics, modeling the behavior of adaptive coordination and rational agents in economics using GA. The behavior of the genetic algorithm was analyzed in two versions of the spider web model, one in which the company only makes quantitative choices, and one in which the company first decides to exit or stay in the market and then decides how much it will sell. Given the simulations of different coding systems, and using the mathematical framework of genetic algorithms with state fitness functions, it is instructive to see rather important differences between the results of the different systems and the differences between the coding and editing properties of genetic algorithms [3]. Fulzele J B presents the simulation and optimization of a hybrid renewable energy system consisting of solar and wind energy with battery energy storage. The site selected for simulation and optimization is located in Dudhgaon village, Yavatmal district, Maharashtra, India. The main goal of hybrid system optimization is to select the right combination of components, control technology and power flow management to ensure a reliable supply of demand, thereby reducing the overall cost of the system [4]. Giassi M proposed a waveform optimizer based on genetic algorithm. The internal parameters of the receiving field wave sensor (buoyancy radius, drag and generator damping) are optimized and the results are guaranteed according to the optimized sensitivity parameters. Additionally, the tool can be used to find the best locations for parks, as the various devices in the park interact through diffuse and diffuse waves propagating in all directions [5]. We can be seen that the renewable energy system has significant advantages and has excellent application and promotion prospects at home and abroad.

In this paper, the research on renewable energy system has great potential for development. However, the availability of various renewable energies is different. Wind energy resources are greatly affected by weather. In addition, the research on renewable energy systems is at an early stage, and this topic aims to study the capacity allocation and influencing factors of regional fully renewable energy systems in different building climate zones and different natural resource areas, which will affect the application of fully renewable energy systems. Instructive for promotion.

## 2. Research on Renewable Energy System Based on Genetic Algorithm

### 2.1. Genetic Algorithm

It is an automated algorithm that simulates the selection and adaptive evolution of the biological environment. It is a better solution algorithm for multipurpose optimization problems. The algorithm starts by creating a random initial population. Then, the algorithm will create a series of new populations [6-7]. Members are selected based on their expectations and are called parents. Some people who don't fit into today's crowd were selected to stand out. Raise the next generation by replacing the current population with children. The algorithm stops when one of the stopping conditions is met [8-9].

### 2.2. Current Status of Renewable Energy Use

Energy is the blood of modern human society and the foundation of social progress. Since the industrial revolution, developed countries have used fossil energy on a large scale, and the consumption of fossil energy has increased sharply since then. At present, China is in a period of

rapid development, and the demand for fossil energy is also increasing rapidly. Due to the non-renewability of fossil energy itself and the rapid growth of consumption. In addition, with the increasingly prominent environmental problems in my country, air pollution, soil erosion, droughts and floods, etc., not only affect people's physical and mental health, but also cause huge economic losses [10-11].

A large number of related researches on distributed energy systems coupled with various renewable energy sources have carried out to make full use of renewable energy, . Fully renewable energy system is a kind of distributed energy, which can meet regional energy demand by using only renewable energy. The energy input in the all-renewable energy system is 100% renewable energy, without consuming fossil energy, and through the transformation and utilization of equipment, the load required by the user is output [12-13].

## 2.3. Genetic Algorithm Process

The flow of genetic algorithm is shown in Figure 1:

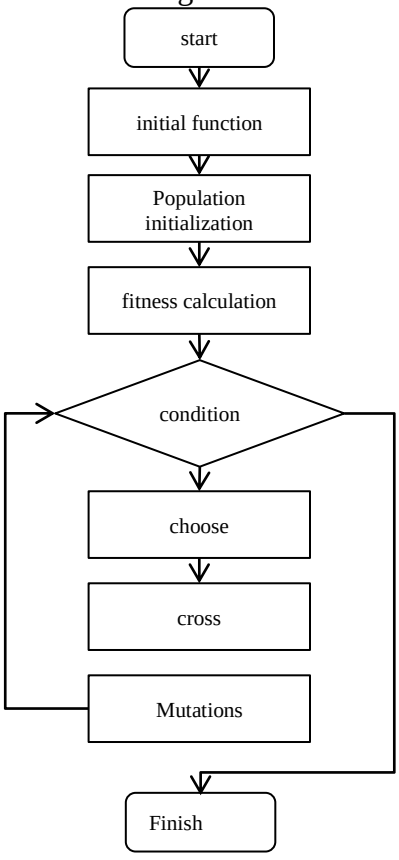


*Figure 1. Genetic algorithm flowchart*

Selection: Determines the individuals to be used for crossover, and how many sub-individuals the selected individual will produce. That is, from the current population, select the excellent individuals through the fitness function as the parent body and use it for the generation of the child body. This genetic algorithm uses the commonly used roulette method, that is, the selection probability of an individual is proportional to the value calculated by its fitness function [14-15].

Crossover: Crossover is the process of recombining genes in biological reproduction. From the

parent population, the information of the selected individuals is combined to generate new individuals. For the more traditional crossover method, two chromosomes are usually randomly selected in the population, and then gene exchange is carried out according to a certain probability. Because the model established in this paper is relatively complex, there are many variables, and there are constraints between each variable [16-17].

Mutation: After the crossover, the offspring continue to undergo the mutation process, which is essentially due to the change in the gene structure of the offspring under the influence of small probability perturbations. In a common research model, similar to the crossover process, real-valued mutation is used, which is randomly selected, so that after mutation, the occurrence of the obtained offspring individuals not meeting the constraints can be greatly reduced [18].

## 3. Model Optimization of Renewable Energy System Based on Genetic Algorithm

### 3.1. Optimizing Design Variables

(1) Gas turbine generator power

The design of distributed energy system starts from the utilization rate of energy, economic benefits and environmental benefits, and carries out multi-objective collaborative optimization design. Gas generator set is the core equipment of distributed energy system. The size of the unit power is the key to affecting the operation. If it is too small, it will require too many other energy supply methods, losing the advantages of the distributed energy system. If the power is too low, the energy saving efficiency will be reduced, resulting in unnecessary resources. For the power of the generator set. Every time the power generation efficiency is increased by one percentage point, the economic benefits of the system can be increased by 1%-2%.

(2) Electric-heat ratio coefficient of refrigeration unit

The use of electric refrigerators for cooling is powered by the power grid to meet the cooling load needs of users when the distributed energy system does not generate electricity when the urban power grid is in a trough period. When the waste heat of the generator set is not enough to meet the needs of the user, the generator set or the air outlet can be used for additional combustion to increase the cooling capacity. In this way, the cooling capacity is increased, which is conducive to energy saving and emission reduction, and is also a better and more economical operation mode. The proportional coefficient of electric refrigeration is the ratio of the total output of the electric refrigeration unit to the total demand when the waste heat and supplementary combustion are used for mixed refrigeration.

(3) Minimum load rate of gas turbine units

In order to avoid the low-load and light-load operating state of the system, prevent the power generation efficiency from decreasing and affect the overall energy utilization rate of the system, so that the system can always maintain a high operating efficiency. Obviously, for the non-large distributed energy cooling, heating and power cooperative system, after using multiple small-capacity units in parallel, only one unit is used to operate under the condition of very low load, which is very important for practical operability and economy. Saying it is impossible. Therefore, it is necessary to set the minimum load rate when the gas turbine generator set is running to ensure that the generator set will not run under light load.

### 3.2. Optimization Objective Function

(1) Economic benefits

Whether the system can be widely used depends largely on the economic benefits of the system. The indicators of economic benefit After selecting the distributed energy combined cooling, heating and power system and comparing with the traditional sub-supply system, the cost saved is used to increase the number of years required for the purchase of equipment recovery, that is, the annual cost recovery efficiency of the system:

$$A = \frac{\sum_{t=1}^{8760} (\Delta E(t) P_e(t) + \Delta G(t) P_g(t))}{\Delta C} \quad (1)$$

In the formula, R2 is the total cost of the main equipment of the distributed energy cogeneration system; R1 is the total cost of the main equipment of the traditional sub-supply system; A is the annual cost recovery rate of the distributed energy cogeneration system.

(2) Environmental benefits

The carbon dioxide emissions of the system can be expressed by the following formula:

$$E_{CO_2} = E_{GB}\mu_G + E_p\mu_p \quad (2)$$

In the formula, Pg is the electricity generated by the gas turbine, and kW and ug are the carbon dioxide emissions produced by burning natural gas.

(3) Social benefits

The utilization of energy has always been a hot issue of social concern. This chapter selects the energy-saving indicators described in Chapter 2 as the social performance evaluation indicators, heating and power system, which can well reflect the energy saving of the combined cooling, heating and power system. sex. The weight factors are used to weigh the optimization objectives. Due to the competition and contradiction between the objectives, the final optimization result is essentially one of the comprehensive solutions, and the optimization results obtained by different weights are also different. Therefore, the multi-objective optimization function of the cooling, heating and power cooperative system of the distributed energy system involving economic, environmental and social benefits is:

$$Z\_\max = \varepsilon_1 A + \varepsilon_2 R_{CO_2} + \varepsilon_3 PER_F \quad (3)$$

In the formula, is the weight factor of economic benefit; is the weight factor of environmental benefit; is the weight factor of social benefit; Z_max is the objective function.

### 3.3. Constraints

Usually, combined with the actual operation situation and the rationality of the model, the energy balance constraints of cold, heat and electricity are satisfied. In order to make the optimization more perfect, this paper also adds inequality constraints and domestic hot water balance demand constraints:

$$z(t) \times (q_1(t) + q_2(t)) + (1 - z(t)) \times h(t) \geq m(t) \quad (4)$$

Limit the value of the optimization variables within a reasonable range to ensure that the unit consumes gas instead of producing gas, and determines the maximum cooling capacity of the absorption chiller and electric chiller according to the variable working condition characteristics of the chiller, and the generator set does not generate excess electricity. Power supply when the power supply is insufficient.

## 4. Evaluation and Analysis of Renewable Energy System Based on Genetic Algorithm

### 4.1. Economic Evaluation

This article compares with the traditional subcontracting system. Traditional subsystems include: primary energy supply, gas boilers that provide heating and heat loads to consumers, and electric refrigeration units that provide summer cooling loads. The power of each electrical appliance to meet the user's load demand is: the heating gas boiler power is 20 kilowatts, the domestic hot water boiler power is 4 kilowatts, and the electric cooling power is 18 kilowatts. Table 1 Comparison of three system capacity optimization algorithms with conventional backup system evaluation indicators, where Algorithm 1 represents a multi-objective genetic algorithm based on NSGA-II, Algorithm 2 represents a genetic algorithm, and Algorithm 3 represents a neural network.

*Table 1. Comparison and analysis of the evaluation indicators of the three algorithms*

| Evaluation item (yuan) | Production system | Algorithm 1 | Algorithm 2 | Algorithm 3 |
|---|---|---|---|---|
| Initial investment (yuan) | 15200 | 40300 | 43400 | 43500 |
| Total annual cost (yuan) | 350 | 450 | 469 | 560 |
| Annual emissions (hundred tons) | 15890 | 40560 | 43681 | 44568 |
| Annual primary energy consumption (kW.h) | 79864 | 52648 | 52100 | 51460 |

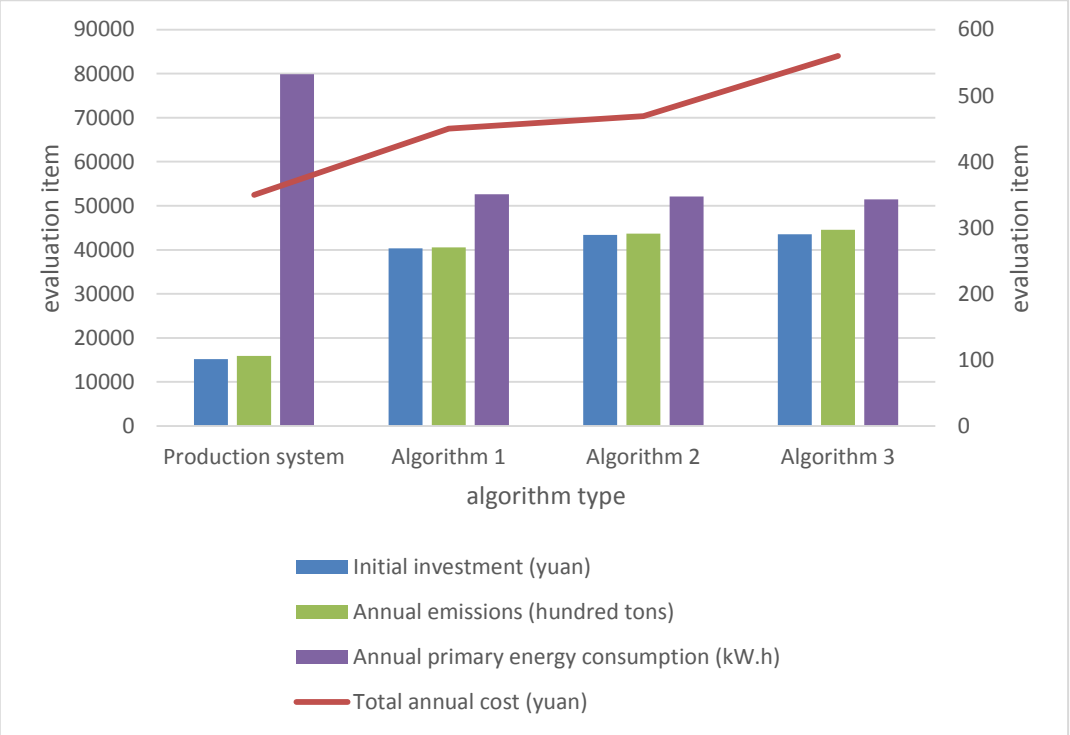


*Figure 2. Comparison of evaluation indicators of three algorithms*

As shown in Figure 2, in the comparison between the optimization algorithm and the production

system, the initial investment cost of the optimization algorithm is higher than that of the production system. The initial investment cost of Algorithms 1-3 is 160.1%, 170.2%, and 178.4% higher than that of the production division system, respectively. In terms of annual operating costs, the optimization algorithm is obviously superior, saving 60.45%, 57.15%, and 53.14% respectively. Compared with the other two algorithms, the investment cost ratio of Algorithm 1 has the highest operating cost saving ratio. Therefore, the multi-objective genetic algorithm based on NSGA-II is due to the other two algorithms in terms of investment cost and operating cost.

## 4.2. Emissions Evaluation

This paper analyzes the emission characteristics of the renewable energy system in the heating and cooling seasons based on the emission characteristics of typical days (working days) in winter and summer. Algorithm 1-3 Hourly specific CO2 and NO2 emissions on typical days in winter, as shown in Table 2.

*Table 2. Typical daily hourly emissions distribution of the system in winter*

| | 0:00 | 5:00 | 10:00 | 15:00 | 20:00 |
|---|---|---|---|---|---|
| Algorithm 1 | 3.1 | 3.2 | 2.8 | 2.5 | 2.7 |
| Algorithm 2 | 3.2 | 3.1 | 2.9 | 3.1 | 3.0 |
| Algorithm 3 | 3.1 | 3.2 | 3.1 | 2.9 | 3.0 |

In the 0:00-5:00 stage, the emission trends of all optimization algorithms are consistent, the emission of Algorithm 1 and Algorithm 2 is relatively small, while the emission of Algorithm 3 is the largest. Because during this period, the whole system is mainly powered by natural gas, supplemented by some energy storage devices, and the low power generation efficiency of Algorithm 1 is mainly due to the fact that the Stirling engine is not working at full load. During the period from 10:00 to 20:00, the emission of Algorithm 1 is smaller than that of the other two algorithms, and Algorithm 2 and Algorithm 3 tend to be consistent, so Algorithm 1 consumes less primary energy and emits more energy. Period 10:00-20:00 Combustion of CO2, NO2.

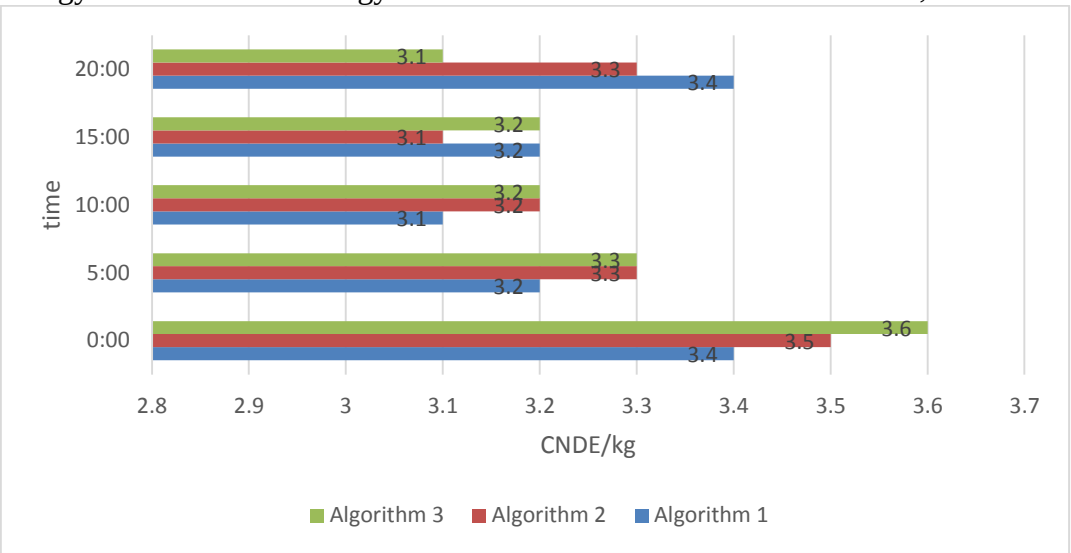


*Figure 3. Typical daily hourly emissions distribution of the system in summer*

In Figure 3, a typical summer day cools down throughout the day. In the 0:00-5:00 stage, the

cold-to-electricity ratio is close, about 3.5. The renewable energy system mainly uses natural gas to drive the Stirling engine to generate electricity, and the waste heat of the exhaust gas drives the VM circulating heat pump for cooling. 6:00-8:00 is the morning peak of cooling load demand. 9:00-16:00 As residents go to work and do outdoor activities, the indoor cooling load demand is small, and the pollutant emission is also reduced accordingly. Compared with the other two algorithms, the energy consumption of Algorithm 1 is lower and the pollutant emission is less.

## 5.Conclusion

Renewable energy system can play a positive role in alleviating energy shortage and solving environmental problems. Realize the efficient use of various types of energy in the fields of production, transmission, distribution, etc., pay attention to the efficient management of energy, effectively alleviate the problems of energy loss and energy waste, improve the production efficiency of energy equipment, reduce the rate of capital loss, echo the sustainable The developed energy development concept, in line with the beautiful vision of building a conservation-oriented society, has become an effective method to solve the major contradiction between energy production and energy consumption for a long time, enhances the stability of the energy system, stimulates the self-healing ability of the energy system, and makes the system More flexible and more reliable. It can be seen that the development and construction of the renewable energy system is the only way to transform the energy structure in the future, and it has great feasibility and great engineering application value.

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## Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

## Conflict of Interest

The author states that this article has no conflict of interest.

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