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Energy Efficiency and Energy Conservation and Emission Reduction based on Intelligent Optimization Algorithm

Lixi Liu[1] and Linyuan Fan[2*]

[1]*Fujian Lide Automation Equipment Limited Company, Fuzhou 350199, China*

[2]*College of Mathematics and Data Science, Minjiang University, Fuzhou 350108, China*

fanlinyuan@mju.edu.cn

[*]*corresponding author*

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Abstract: Under the development requirements of low-carbon economy, China has put forward specific targets and requirements for energy conservation(EC) and emission reduction(ER) for various industries. Due to the significant differences in the development of different industries between regions, accurately measuring the energy efficiency(EE) and EC and ER potential of the steel industry in various regions is an important basis for the rational allocation of EC and ER targets. Therefore, this paper proposes an intelligent optimization algorithm(IOA) to analyze the EE and EC and ER of resource-based cities. This paper briefly introduces the single factor EE and total factor EE, discusses the improvement of EE by EC and ER, and puts forward the ant colony algorithm of IOA. Taking the iron and steel industry as an example, the EC and ER and EE of iron and steel industry in different regions are analyzed. The test results show that the IOA proposed in this paper is effective and accurate, and has achieved good results.

1. Introduction

The rapid development of economy makes the contradiction between production and life more and more intense, and the realization of sustainable development is the general trend. However, due to the existence of a series of problems such as single industrial structure, over exploitation of resources and lack of awareness of environmental protection, the development of resource-based cities has encountered bottlenecks, and many cities are directly facing resource depletion. At the same time of vigorously promoting EC and ER, how to take the lead in completing EC and ER in resource-based cities should become the focus of work at this stage. Therefore, this paper proposes an IOA to study and analyze the EE and EC and ER of resource-based cities.

Many scholars at home and abroad have studied and analyzed the analysis of EE and EC and ER based on IOA. Park K et al. Proposed an efficient and energy-saving dangerous gas intelligent multi-sensor system, whose performance can be adaptively optimized through multi-mode structure and learning based pattern recognition algorithm. Multimode operation provides the ability to control the tradeoff between accuracy and power consumption. Pattern recognition combined with dimension reduction neural network is used to improve the selectivity of MEMS gas sensors [1].

In order to achieve the goal of EC and ER, this paper comprehensively considers the minimization of unit coal consumption and pollutant emissions, and proposes a multi-objective EC and ER IOA based on EE. It adopts and improves the algorithm to solve it, and analyzes the EE and EC and ER of resource-based cities; The optimal scheduling scheme of energy consumption and emission is given, which effectively reduces the coal consumption and pollutant emission of the system. The test results verify the feasibility, efficiency and stability of this algorithm [2-3].

2. Analysis of EE and EC and ER

2.1. Connotation and Classification of EE

EE, referred to as EE, is a kind of technical efficiency, which reduces the input dominated by energy factors as much as possible, so as to increase useful output as much as possible. EE can be divided into single factor EE and total factor EE according to the different number of input and output factors included in efficiency measurement. Input factors include not only energy input in production, but also other input factors related to product production, such as capital, labor, land, etc. the output mainly includes a variety of outputs dominated by useful (expected) output and unexpected output.

2.1.1. Single Factor EE

Single factor EE only considers energy as a single input factor, and only one output is considered for output, so EE can be expressed as the ratio of output to energy input [4]. According to the different output objects, the single factor EE indicators can be divided into four categories: one is to examine the thermal efficiency of energy based on the laws of thermodynamics. Obtaining heat is the original intention of energy use, so the thermal efficiency of energy is the most basic EE. When examining the thermal efficiency of energy, we mainly want to examine the utilization and loss of heat in all links of energy use, So as to evaluate the energy use under different technical levels; The second is to analyze the EE by taking the number of end products produced as output, mainly focusing on the amount of energy consumed by the production of unit products. Physical efficiency can directly compare the EE of the production process, and comparing the EE of the same production process in different time periods can be used to reflect the technological progress of production; The third is to compare and analyze the energy use from the perspective of economic output. The main measurement index of output is output value GDP. At this time, EE can be expressed as the ratio of output value GDP and energy input, so as to reflect the impact of energy input on economic output. Therefore, this kind of EE is also known as the economic efficiency of energy. The main measurement indexes include energy consumption per unit of GDP and energy production efficiency; The fourth is the value efficiency index of energy, which includes the market price factors of energy input and production output factors into the EE evaluation index. EE can be expressed as the ratio between the input cost and output value of energy [5-6].

2.1.2. Total Factor EE

Single factor energy can directly reflect the impact of energy input on specific output, which has the advantage of simple calculation, but its disadvantage is also relatively obvious: only considering energy as a production input factor can not reflect the substitution relationship of other input factors on energy consumption and the impact on output, and can not reflect the real reasons for the changes in EE, so it can not meet the needs of actual research and analysis, For this reason, researchers have put forward all factor EE indicators. The theoretical framework of total factor production is the theoretical basis for the establishment of total factor EE evaluation [7-8]. The theory of total factor production believes that various factors of production input can be replaced each other, so the production output cannot only consider the influence of a single factor, but also consider the substitution relationship of other input factors. The output depends on the combination of input factors rather than a single factor input.

2.2. EC and ER

EC and ER refers to the use of EC and the reduction of emissions of harmful substances to the environment. Reducing emissions of harmful substances to the environment refers to the reduction of SO_2, suspended particles, nitrogen oxides, greenhouse gases and other harmful substances to the environment in industrial production. This paper mainly studies energy consumption and carbon emissions under the condition of low-carbon economy, so the EC and ER referred to in this paper mainly refers to EC and CO_2 ER.

EC and ER, improvement of EE and reduction of industrial pollution emissions "EC" is to reduce waste and material loss, and strengthen the management of the quality and quantity of energy consumption; "ER" is to reduce the emission of harmful substances to the environment. Internationally, it is generally required to reduce the emission of greenhouse gases. From the two connotations of EC and ER, combined with the current characteristics of resource-based cities, such as low total factor EE, large energy consumption, serious environmental pollution, excessive resource exploitation and so on, the previous link can be deduced from the response of EC and ER, which corresponds to EC and ER [9]. This paper divides it into two points. The first is to improve total factor EE, namely "EC"; The second is to control the total energy consumption, namely "ER". With the improvement of total factor EE, the waste of energy is bound to be reduced. However, this does not necessarily achieve the effect of reducing pollution emissions. If the waste is reduced and the investment is significantly increased, it will still cause a lot of environmental pollution, so it is still important to control pollution emissions [10-11].

2.3. EC and ER Improve EE

The improvement of EE, the reduction of industrial pollution emissions, the full utilization of resources, the reduction of total energy consumption, and the increase of pollution control investment. Taking the total factor EE and the reduction of industrial pollution emissions as the reaction, it is deduced that the stimulation in the previous stage is the full utilization of resources, the reduction of total energy consumption, and the increase of pollution control investment. First of all, the "resources" in the full utilization of resources do not only refer to the energy put into production, but also include labor, capital and other production factors. While striving to improve science and technology, adopt cleaner production, and develop circular economy, we must also strengthen enterprise management, reasonably arrange enterprise resources, and formulate strict enterprise regulations, so as to achieve efficient production and greatly improve the total factor EE [12-13]. Secondly, the reduction of industrial pollution emissions must be carried out from two major aspects, one is the pollution source, that is, to control energy consumption, and the other is the pollution process, that is, to use advanced equipment and technology to control pollution emissions, which must increase investment in pollution control and reduce the generation of pollutants in a series of processes such as energy refining, processing, recycling and emission.

We should make full use of resources, reduce total energy consumption, increase investment in pollution control, optimize the allocation of means of production, improve policies and systems, upgrade industrial structure, and make scientific and technological progress. The optimal allocation of means of production is to allocate labor, capital, and energy input reasonably. According to the above analysis of total factor EE, we can see that the total factor EE of resource-based cities in China is generally low, and there are both insufficient and excess capacity, This is due to the lack of reasonable allocation of means of production. The allocation of means of production in a scientific way can make full use of labor, capital and raw materials, which can greatly improve the total factor EE [14-15].

The factors that can affect the EC and ER of resource-based cities in China. The analysis of EC and ER path of resource-based cities can be abstractly summarized as capital labor ratio, tax policy, proportion of industrial industry, foreign direct investment, scientific and cultural level. Of course, there are many factors that can affect the effect of EC and ER in reality. Therefore, the initial path of EC and ER of resource-based cities can be intuitively reflected in Figure 1 [16].

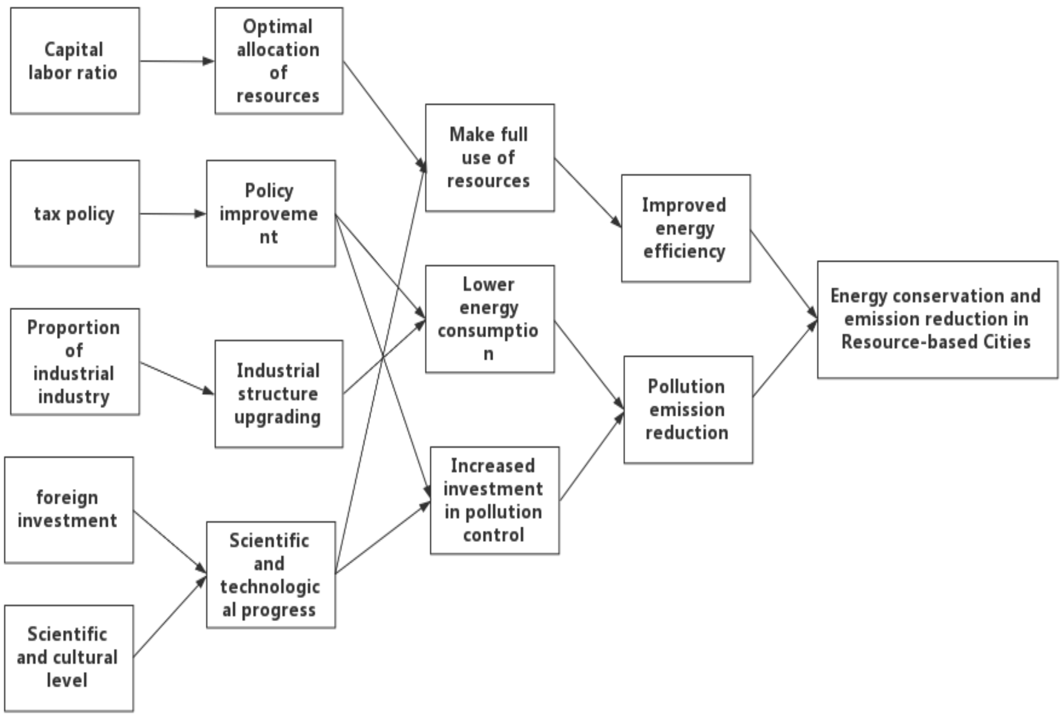

Figure 1. Initial path of EC and ER in resource-based Cities

It can be seen from Figure 1 that the preliminarily designed EC and ER path is basically divided into four links, which are formed by 13 factors in turn, including the factors with dual effects. However, in reality, only the first five influencing factors and the final EC and ER effect are directly shown, and the intermediate influencing factors are seen as the internal mechanism, so in the later analysis, Only for the five influencing factors in the first link.

The EC and ER path of resource-based cities finally established after empirical analysis is formed by 14 influencing factors, which are divided into five links. The initial motivation for resource-based cities to achieve EC and ER is to increase the tax amount of polluting enterprises, strengthen education and scientific and technological research and development with the theme of environmental protection, adjust the proportion of capital and labor, reduce the proportion of industrial industries, and expand foreign investment. The effect of its realization is reflected through the improvement of EE and the reduction of pollution emissions [17-18].

3. IOA

This paper mainly studies ant colony algorithm in IOA. Ant colony optimization is an optimization algorithm based on the foraging behavior of ants. It belongs to the category of bionic intelligent algorithm. Simulating the path of ants looking for food is the solution of the optimization problem. When ants look for food, they release pheromones on their path. Many ants accumulate a lot of pheromones when searching. The distance of the path is affected by the pheromone concentration. The longer the time, the lower the pheromone content.

This paper introduces the elite strategy to improve the pheromone update formula. The optimal solution can guide the path selection of all ants, help the algorithm converge quickly and reduce the operation time. Elite ant and common ant can accelerate algorithm iteration together.

In the elite ant colony algorithm, the state transition probability and pheromone volatilization formula remain unchanged, but the elite strategy ant system is introduced into the pheromone update mechanism of the algorithm. As shown in formula (1) (2).

$$\lambda_{ij}^{h} = \frac{\Lambda G}{L_{\min}} * x_{hij} \tag{1}$$

$$x_{hij} = \begin{cases} 1, h = 1 \\ 0, otherwise \end{cases} \tag{2}$$

Among them, G and Λ are constants, lmin represents the minimum value of the sum of the weights of path length and energy consumption loss, xhij is the decision variable, and λ_{ij}^{h} is an additional strengthening term for the current optimal path solution determined by the value of the objective function. This improvement can make the algorithm converge quickly if it encounters a good solution.

4. Analysis of EE and EC and ER based on IOA

Taking the iron and steel industry as an example, this paper analyzes the carbon emissions of the iron and steel industry in various regions based on the intelligent ant colony optimization algorithm introduced above. Because carbon emissions will be generated in all links of iron and steel production, and carbon will also be included in raw material input and output products, it is difficult to make on-site statistics of carbon emissions. Carbon emissions are mainly estimated through later models. The carbon emissions of the steel industry in various regions are shown in Table 1 and Figure 2.

Table 1. Carbon source conversion coefficient of main energy

Types of fossil energy	Coal	Coke	Crude oil	Gasoline	Kerosene	Diesel oil	Fuel oil	Natural gas
Calorific value (kj/kg)	20.908	28.435	41.816	43.07	43.07	42.652	41.816	38.931(KJ/m3)
Carbon emission coefficient (t/tj)	25.8	29.2	20	18.9	19.6	20.2	21.2	15.3
CO2 emission coefficient (g/kg)	1.977	3.042	3.065	2.984	3.096	3.16	3.236	2.184(kg/m3)

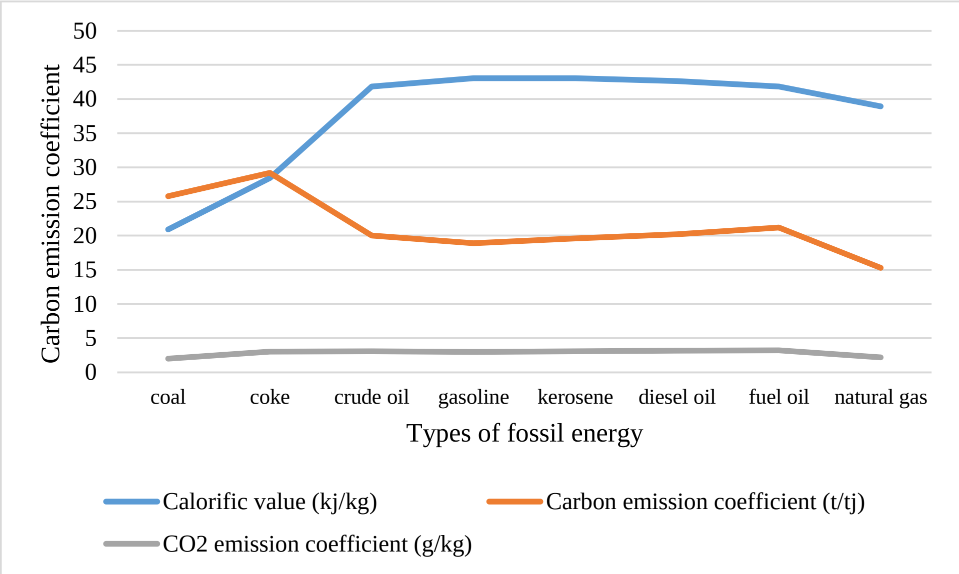

Figure 2. Comparison data chart of energy and carbon source conversion coefficient

The carbon emissions from energy consumption in the production of iron and steel industry can be divided into direct emissions and indirect emissions. Direct emissions refer to the CO2 emissions from the combustion of fossil fuels in the primary outsourcing energy of iron and steel enterprises, and indirect emissions refer to the indirect carbon emissions from the outsourcing power of iron and steel enterprises. Since the power in China's iron and steel industry is mainly coal-fired power, a large number of carbon emissions will also be generated in the process of coal power generation, Therefore, to comprehensively calculate the carbon emission level of the steel industry, we need to include the indirect carbon emissions generated by power consumption.

Based on the calculation and decomposition of the total factor EE of China's major resource-based cities and the comparison with livable cities, this paper further divides 106 resource-based cities into four categories by industry: coal resource-based cities, steel resource-based cities, oil resource-based cities and non-ferrous metal resource-based cities, and analyzes the characteristics and differences of these four representative industries in total factor EE, The specific calculation results are shown in Table 2 and figure 3.

Table 2. Calculation of total factor EE of resource-based cities by industry

Types of Resource-based Cities	Coal type	Steel type	Petroleum type	Non ferrous type
Comprehensive technical efficiency	1.000	1.000	0.982	1.000
Pure technical efficiency	1.000	1.000	0.984	1.000
Scale efficiency	1.000	1.000	0.998	1.000

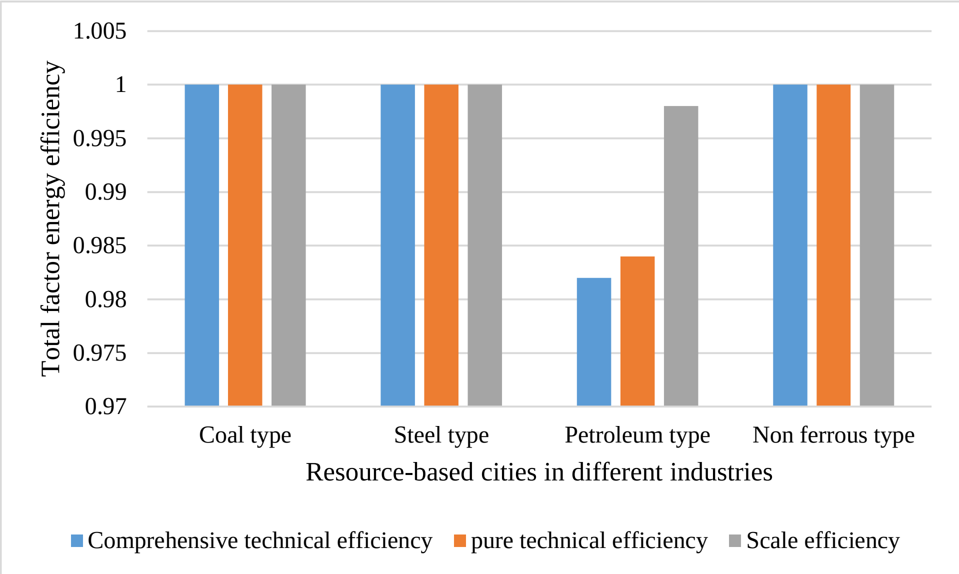

Figure 3. Comparison chart of total factor EE measurement data in different industries

It is obvious from the above chart that only oil-based resource-based cities have insufficient total factor EE, and both scale efficiency and pure technical efficiency have not reached the cutting edge. The low scale efficiency shows that the resource-based cities in China, which are dominated by the oil industry, have not formed large-scale production and scale efficiency; Pure technical efficiency shows that the management level of oil-based resource-based cities is not high enough, and the professional and technical level of staff is also relatively low. It is necessary to further improve the work level of enterprise leaders and employees to achieve efficient management and work.

5. Conclusion

This paper proposes an ant colony optimization algorithm based on IOA under the multi-objective of EC and ER and EE. Taking the iron and steel industry as an example, the carbon emissions of the iron and steel industry in various regions are tested, and the EE and EC and ER of Resource-based Cities are analyzed, and good calculation results are achieved. However, there are also shortcomings. The analysis of EC and ER only analyzes the steel industry. The reduction of pollution emissions is not limited to the industrial field. The control of pollution emissions in other industries can also play a certain role in promoting EC and ER. It also needs to be analyzed for other industries. Therefore, the analysis of EE and EC and ER based on IOA needs to be further studied.

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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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