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Energy Efficiency Calculation Based on Ant Colony Algorithm

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Abstract: The energy issue has always been the focus of attention of the international community. On the one hand, it is due to the limited and scarcity of energy, and on the other hand, energy is of great significance to the sustainable improvement of human society. In this context, as an important economic improvement area in China, the exploration of energy efficiency is of great significance for accelerating the realization of sustainable economic improvement in the future. The purpose of this paper is to calculate the energy efficiency based on the ant colony algorithm. Using the ant colony algorithm and the stochastic frontier model, the results based on the common frontier model, the results of the subregional frontier model and the empirical results of the input of classified energy elements are respectively carried out in the experiments.

1. Introduction

In recent years, the rapid improvement of economic globalization has led to a rapid increase in energy demand, and energy consumption has also increased, resulting in a series of problems such as resource shortages and environmental changes. In the process of social and economic improvement in my country, the supporting role of energy is inseparable, but some energy types in my country depend on imports [1].

The country's extensive improvement mode for a long time has made the energy constraints on the economy and the impact of the environment more and more significant, which has also increased the pressure on my country's resources and environment.Elnaghi BE believes that cloud computing is rapidly evolving as a successful example of delivering on-demand infrastructure, platform services and software to customers. Load balancing is one of the important issues in cloud computing, which is to distribute dynamic performance evenly among all nodes to avoid situations where some nodes are overloaded and others are overloaded. Many algorithms have been proposed

to perform this task. Recently, the world view is shifting towards the best new research methods, applying the osmotic method of chemical science to osmotic computing. Osmotic balancing aims to achieve balance in a distributed environment. Since hybrid artificial bee colonies and insect swarms have already demonstrated their performance in the power domain of cloud computing, the main goal is to propose a hybrid algorithm that combines hacking and biomimetic balancing algorithms. Vulnerabilities can automate the deployment of virtual machines migrated through cloud infrastructure [2]. Limiting availability and reducing the production cycle of scheduled transactions is a new issue for Mahato D P. There are currently limited ways to find a practical solution to this problem. Aiming at the above problems, a task scheduling algorithm based on swarm optimization is proposed. The method first assesses the availability of the system and then uses error detection behavior to organize transactions to find the best solution. Well-known meta-indices, genetic algorithms, and maximum efficiency have been modified to accept transactions. The configuration algorithm is used for comparison with the proposed algorithm [2].Therefore, how to use energy efficiently is very important, and the level of energy conversion efficiency is related to the speed and quality of economic improvement.

This paper studies the research background and significance of energy efficiency measurement. The definition of energy efficiency is divided into single factor energy efficiency and total factor energy efficiency, energy efficiency measurement methods and research backgrounds at home and abroad, and the concept of ant colony algorithm. The ant colony algorithm was used in the experiment to evaluate the overall total factor energy efficiency value of the manufacturing industry in each province and region based on the ant colony algorithm and the stochastic frontier model. In the experiment, the results based on the common frontier model and the results of the regional frontier model were compared. And the empirical results of classified energy factor input are investigated and analyzed respectively.

2. Research on Energy Efficiency Measurement Based on Ant Colony Algorithm

2.1. Research Background and Significance

Energy is essential for the improvement of human beings and society as a whole. With the continuous improvement of social economy, the energy supply is far insufficient for the needs of the society [3]. Due to the scarcity of energy, human needs cannot be endless, which is contrary to the theory of sustainable improvement. After entering the country, the amount of energy consumed by China has increased substantially with the improvement of the economy. From a global perspective, energy supply is far less than energy consumption. China is the most populous improving country in the world, and energy consumption has increased significantly. Therefore, it is the improvement of unconventional resources, and stability and prudence are the best choice. [4].

China has a large population, a large amount of energy consumption and a serious shortage of energy supply. Not only does China have energy problems, but the global economic improvement depends on energy. Energy shortage is a major problem faced by the entire human society [5]. In addition, the environmental problems brought by energy will become more and more prominent. On the one hand, the gap between the energy supply of the whole society and the energy consumption of the whole society is getting bigger and bigger. At the same time, in the process of energy use, waste problems are everywhere, making the energy saving potential more and more On the other hand, the use of energy produces a large amount of waste water and waste gas, which makes the problem of environmental pollution increasingly serious, and the environmental pollution caused by energy consumption has threatened human life [6]. Energy shortage and environmental pollution are

two important issues that affect the improvement and progress of Chinese society and the entire human society. Therefore, saving energy, reducing waste, protecting the environment, and improving new energy have a vital role and status in extending future generations, which is an inevitable choice for the whole society to move forward [7]. In particular, in order to maintain better and faster sustainable improvement of the national economy, and at the same time to better protect national energy, a lasting revolution in energy efficiency is required.

2.2. Definition of Energy Efficiency

In the definition of energy efficiency, there is still some controversy in the academic circle. Taking the number of factors introduced into the energy efficiency measurement as the classification basis [8]. Others also use the inverse of energy intensity. Because single-factor energy efficiency has the advantages of being easy to understand and easy to operate. When conducting relevant energy efficiency research, energy consumption intensity is used to represent energy efficiency. The total factor energy efficiency index builds a framework that includes multiple inputs and overcomes the problems [9]. Because total factor energy efficiency is more in line with the actual situation, it has been widely used in academia.

(1) Single factor energy efficiency

Single Factor Energy Efficiency uses energy consumption intensity to express energy efficiency, and through data analysis, it is found that since the first oil crisis, rising per capita income and energy prices and appropriate government intervention have continued in the United States energy consumption intensity played an important role in the descending process [10]. The energy consumption intensity of my country's manufacturing industry is decomposed by the Die and pull decomposition methods, and it is found that the change of economic structure leads to the decrease of energy efficiency, and the improvement of production efficiency has a very large contribution to the decrease of energy consumption intensity. By analyzing the energy consumption data of major industries in the United States, it is found that changes in the economic structure can significantly reduce the energy consumption intensity of the entire society, especially in the fields of commerce and industry. The U.S. energy consumption intensity is decomposed from five perspectives: technological progress, labor-to-energy ratio, capital-to-energy ratio, technological catch-up and output structure. The study finds that technological progress, output structure, and changes in capital accumulation have contributed to the energy consumption of the United States in the past three decades. The main reasons for the decline in consumption intensity, and the differences in time and space are more obvious in these five parts [11]. Energy consumption intensity is decomposed into several aspects, such as changes in economic structure, changes in production levels, changes in efficiency, and changes in fuel sources. Energy consumption intensity is still widely used in academia because it is simple to calculate, facilitates the comparison of different periods in the same economy, and more intuitively reflects the relationship between economic output and energy consumption [12].

(2) Total factor energy efficiency

The single factor energy efficiency index is simple and easy to understand and easy to calculate, but there are many ways to select the two indicators of "energy input" and "useful output", such as how to deal with various energy factor inputs, and the definition of household consumption output etc., all of which make the calculated energy efficiency results cannot truly reflect the actual energy efficiency [13]. In addition, energy has a variety of outputs, such as desirable output and even non-desirable output, environmental pollution, and is also affected by the exchange rates of various

countries when making international comparisons. Finally, single factor energy efficiency indicators may not really reflect actual energy efficiency [14]. Many factors such as energy structure or industrial structure, energy price, external environment, etc. will affect the index system of energy efficiency, which will hinder the analysis of the information hidden behind the real efficiency, and will inevitably affect the proposal and guidance of relevant policies. , the guidance of the social economy is impossible to talk about.

Under the total factor productivity, the concept is defined: "under the premise of given other factor inputs, according to the best way, the minimum energy required to produce a certain product is the percentage of actual energy", and Different from the indicators of energy productivity, total factor energy efficiency includes the input of various energy factors, including not only energy input, but also the input of other factors. The omnipotent factor efficiency is when other factors are fixed, the output is maximized and the environmental impact is minimized, or when the output is fixed, the resource input is minimized and the environmental impact is minimized [15]. This definition includes elements in addition to energy and adds environmental impact to output.

2.3. Energy Efficiency Measurement Method and Research Background

Aiming at the current situation of energy efficiency in China, energy efficiency measurement methods include single factor GDP energy efficiency index, DEA model and comprehensive efficiency index, energy efficiency index considering energy use redundancy, and stochastic frontier SFA and its energy efficiency index [16]. Through reading and combing literature, it is found that there are two types of energy efficiency measurement methods: one is a non-parametric method represented by data envelopment analysis (DEA).

(1) Current status of foreign research

Stochastic frontier analysis is one of the methods commonly used by scholars from all over the world to evaluate efficiency [17]. Using a stochastic frontier analysis model, the relative technical efficiency of European container ports is assessed. Using the panel data of each country for many years, a stochastic frontier analysis model is adopted to effectively estimate the relative technical efficiency of the total R&D activities in these countries. Using this method, the Fourier cost function of the European insurance industry was estimated, and three independent frontiers were constructed for each of the three types of companies. It also estimates factors such as firm size and market structure that affect the efficiency of each unit. This method can control for the effect of heteroscedasticity in the assessment of economies of scale.

(2) Current status of domestic research

The stochastic frontier analysis method is a method that scholars use more in efficiency evaluation. The algorithm is widely used in many fields, such as in China's electronics industry, using the method to evaluate the efficiency of the listed companies; the economic growth is affected by the required energy input, while reducing environmental pollution; using the analysis method to investigate various provinces and cities Research on the efficiency of resource R&D allocation in China; study the spillover effects of China's provinces and cities affected by multinational companies' R&D investment and the differences between provinces and cities in a certain period of time.The results show that the first method has a good discriminating power, and the efficiency results are very robust. more reliable evaluation results

2.4. Ant Colony Algorithm

Ant colony algorithm is a nature-inspired swarm intelligence algorithm. In the early stages of ant

colony foraging, an algorithm aimed at finding optimal paths in graphs based on ants finding paths between food and the colony [18]. The original idea has grown large enough to solve some other broader numerical problems, and the result is articles that draw on various performance ants to solve various problems. Heuristic information is a kind of prior information related to a problem, which can guide or inspire the solution of the problem.

In the real world, ants are always wandering randomly at first, but when they find food and return to the colony, they sprinkle chemicals called pheromones on their paths, which other ant mosquitoes have discovered. Given a path, they will likely not follow it randomly, but choose to follow the path, and if they eventually find food, they will return to the group and reinforce the pheromone along the way. However, as the pheromone volatilizes, the attractiveness of this route is reduced at this time. The longer it takes an ant to travel from the colony to its food, the more pheromones will evaporate on its path. The volatilization of pheromone also has a good effect on preventing the convergence of the local optimal path. When an ant chooses a good path, such as a short path, other ants are likely to follow this path, and will eventually give positive feedback to all ants, so that all ants choose this path. The idea of ant colony algorithm is to simulate this behavior of ants to solve some problems in graph theory. Finally, the non-uniform distribution of pheromones will attract more and more ants to gradually progress towards a shorter path. In the past few years, ACO has attracted a lot of research attention and solves combinatorial optimization problems, and the ant colony algorithm has the characteristics of pheromone deposition and pheromone following. Therefore, the algorithm is a very promising algorithm.

3. Investigation and Research on Energy Efficiency Calculation Based on Ant Colony Algorithm

3.1. Research Objects

It mainly measures the total factor energy efficiency value of the overall manufacturing industry in each province and region, and does not consider the impact of failure rate factors on energy efficiency. The scale of the data is first processed before being brought into the model. The variables of the first step estimation model mainly include energy consumption expressed as thermal energy, regional capital stock, labor force and total manufacturing output value. The independent variable is the logarithm of gross output, labor and capital stock and the cross term is obtained by multiplying them in pairs, while the dependent variable is the logarithm of the reciprocal of energy consumption.

3.2. Ant Colony Algorithm

At the initial moment of the algorithm, m ants are randomly placed in the solution space. At this time, there is no pheromone on each path (or the initial pheromone is equal), and the ants independently according to the amount of pheromone remaining on the path and the heuristic information Choose a path. In the formula, S represents the set of states that ant k can choose in the next step, τ_{ij} represents the pheromone concentration from the current i state to the j state, and η_{ij} is a heuristic factor, which represents the transition from the current i state to the j state. Expectation degree, α is the pheromone importance degree parameter (pheromone heuristic factor), β is the heuristic factor importance degree parameter (expectation heuristic factor). At time t, the probability of the ants transitioning from the k state to the j state is as shown in Equation (1).

When all ants complete all state transitions and reach the destination point, they start to release pheromone to the path, and then update the pheromone. The pheromone update formula is formula (2). The specific formula is as follows:

$$P_{ij}^{k}(t)=\frac{[\tau_{ij}]^{\alpha}[\eta_{ij}]^{\beta}}{\sum_{S}[\tau_{is}]^{\alpha}[\eta_{is}]^{\beta}} \tag{1}$$

$$\tau_{ij}(t+1)=(1-\rho)\tau_{ij}(t)+\Delta\tau_{ij} \tag{2}$$

4. Calculation Results and Comparative Analysis of Total Factor Energy Efficiency of the Country's Provincial Manufacturing Industry Based on Ant Colony Algorithm

4.1. Results Based on the Common Frontier Model

Based on the ant colony algorithm and the stochastic frontier model, it is divided into two models according to whether the efficiency changes with time, which are called time-varying model and time-invariant model. Since the time span of the sample is 10 years, technological changes may occur, and the impact of time factors on the results of technical efficiency should be considered. The estimated parameters and efficiency results of the two models are given in the following tables as shown in Table 1 and Figure 1:

Table 1. Average TFEE score of manufacturing industry in some parts of China

Area	Time-invariant model	Time-varying model
A	0.9365	0.9136
B	0.5484	0.5361
C	0.7541	0.6562
D	0.6874	0.6721
E	0.3541	0.3365

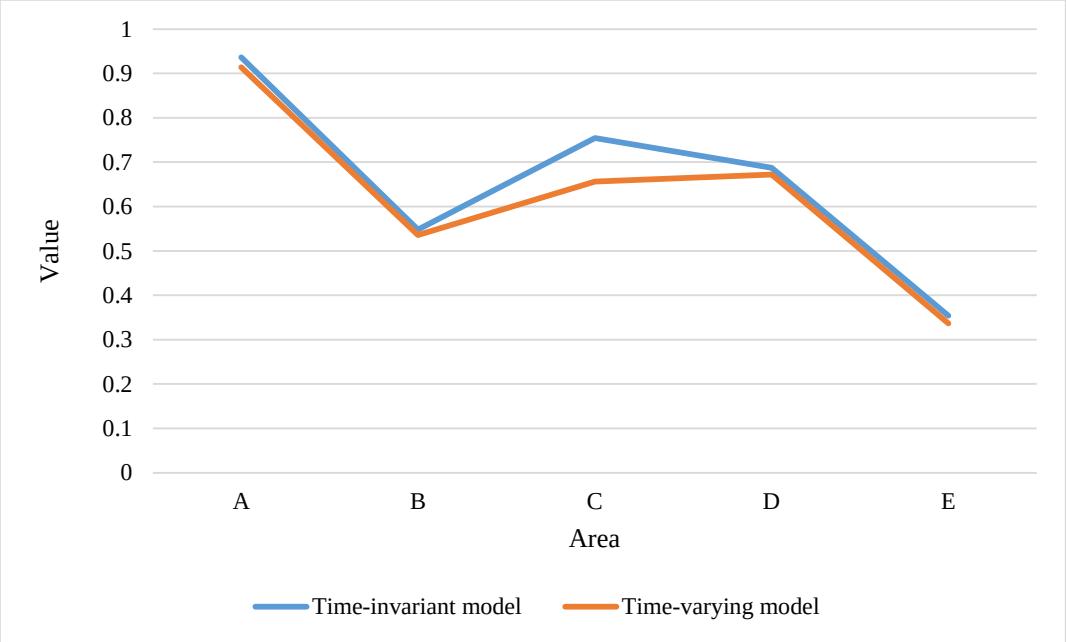

Figure 1. Efficiency results of time-varying and time-invariant model

The test results show that the time-invariant model should be chosen. The first and last provinces in terms of efficiency in the two models are A and C, respectively, which is consistent with the results of most domestic studies, and there are significant differences in energy efficiency between provinces. The calculation of the total factor energy efficiency value mainly depends on the production technology level and the actual energy input. The output value affects the determination of the frontier and thus the energy efficiency obtained by the distance function.

4.2. Results Based on the Subregional Frontier Model

Due to the differences in resource endowment, technical level and economic improvement level, there are significant gaps between provinces in my country. Therefore, it is necessary to re-measure the energy efficiency of manufacturing in each region based on the subregional frontier. The subregional frontier model does not consider the time-varying model, but directly selects the panel data time-invariant model. According to the reference of the National Bureau of Statistics on the division of eastern, central and western regions, the results of regional division are shown in Figure 2 and Table 2:

Table 2. Average TFEE value of manufacturing

Area	Mean	Contrast the mean	S.D.
A-East	0.5842	0.6548	0.3141
B-Central	0.6914	0.4421	0.3248
C-Western	0.7541	0.4526	0.3598

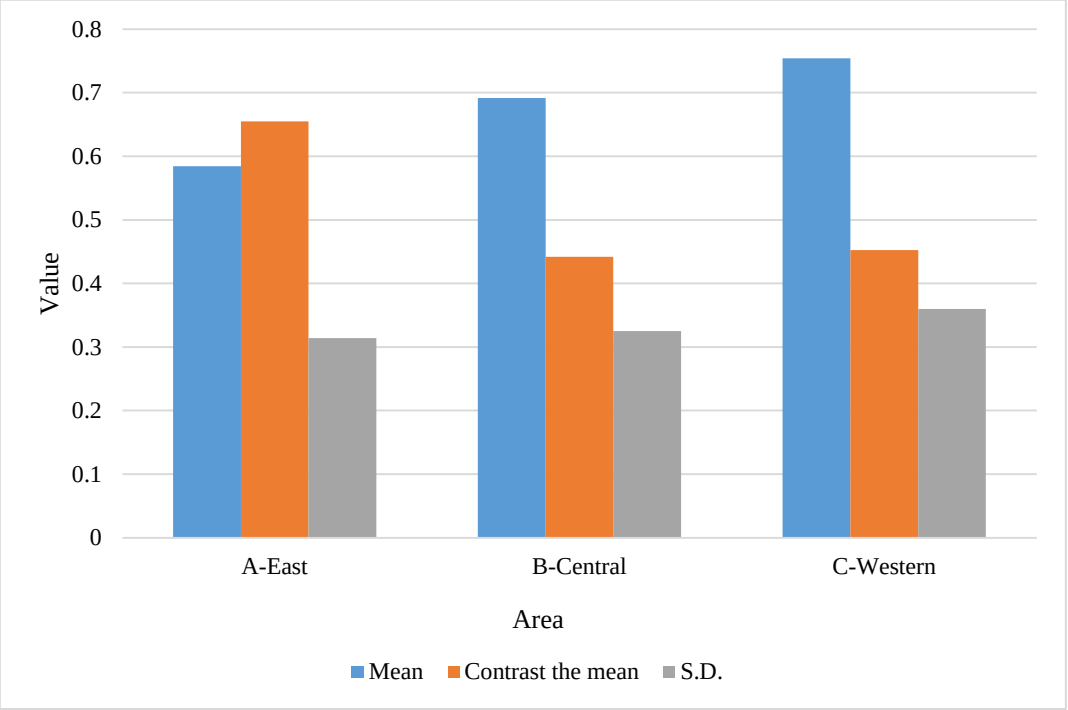

Figure 2. Comparison of average TFEE values in East and West

Among them, the comparative mean is the average energy efficiency of the eastern, central and western provinces calculated based on the common frontier time-invariant model. The eastern region is higher, followed by the western region, and the central region has the lowest energy efficiency.

4.3. Empirical Results Based on Classified Energy Factor Inputs

Assuming that the input of capital and labor in each province remains unchanged, the eight energy sources are divided into three categories. Coke and coal are used as coal energy sources, and oil products include crude oil, gasoline, kerosene, and diesel. Undesirable outputs such as carbon dioxide and sulfur dioxide are produced as clean alternative energy sources. In order to compare statistics, all energy units are uniformly converted into calorific value. Based on the assumption of regional technological invariance, the proportional division of energy and production in each region is brought into the stochastic frontier analysis model, and the results are shown in Table 3 and Figure 3:

Table 3. Variety of energy use efficiency

Area	Coal	Oil category	Clean and alternative energy category
A	0.4581	0.8545	0.7851
B	0.3256	0.9871	0.9654
C	0.0745	0.5471	0.4215
D	0.1025	0.3521	0.6514
E	0.2545	0.7845	0.8123

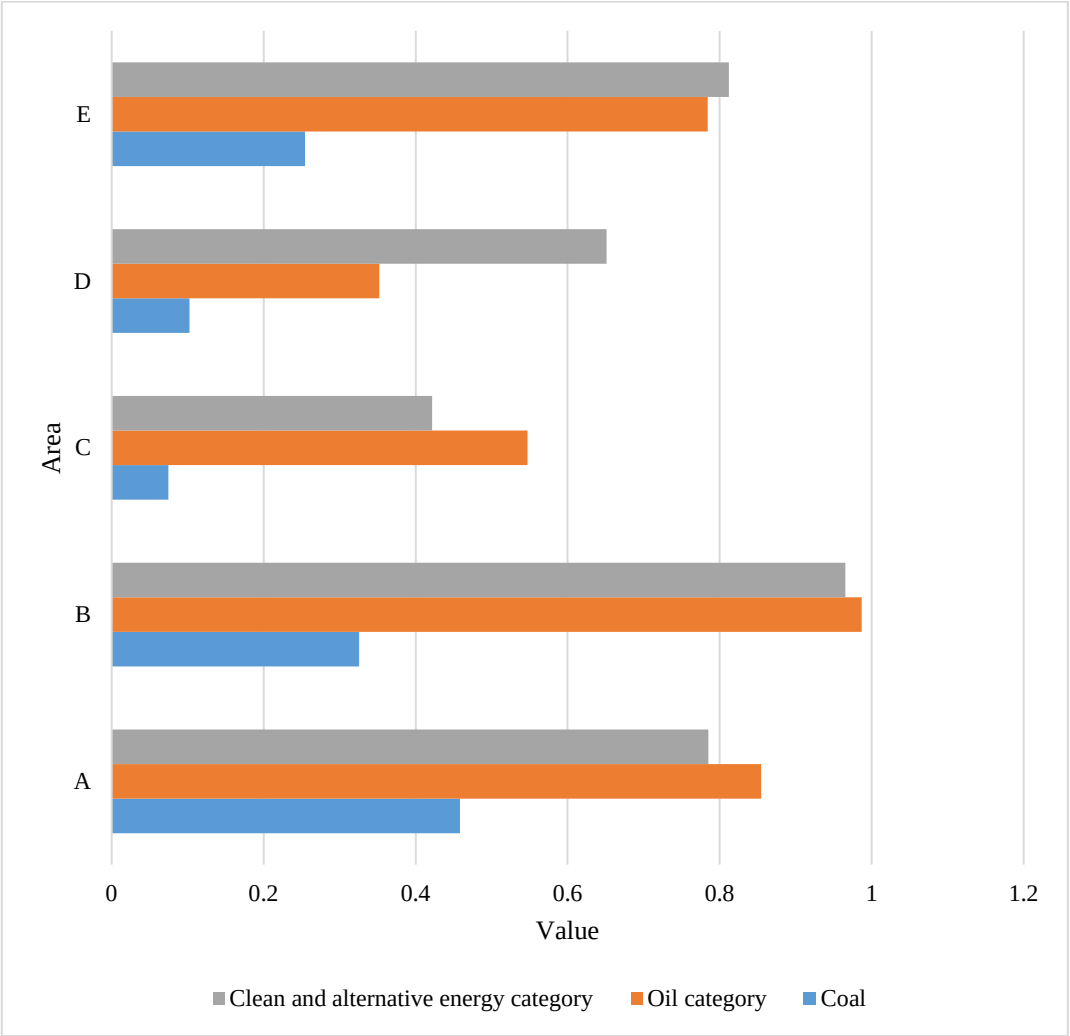

Figure 3. Figure comparing different energy use efficiency in each province

The calculation results of energy use efficiency of various provinces and varieties can reflect the energy use situation in various regions, and have important guiding significance for the transformation of energy consumption structure.

5.Conclusion

Increase investment in science and technology, improve technical level. Identify various external factors that affect energy efficiency as early as possible, and try to avoid the unchangeable external factors. Based on your own situation, you must promptly discover and adjust various obstacles that are not conducive to improving energy efficiency, and give full play to your own advantages. , to effectively avoid its own disadvantages. Optimize the investment structure and closely combine energy saving with improving economic benefits. Combining the economy with the achievable energy-saving goals and achievable emission reduction efforts, the investment in high energy consumption and high pollution is minimized.

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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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