An energy internet efficient regional optimal allocation method based on block data

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Abstract: In the operation of energy internet, the problem of uneven regional energy distribution which caused by the different social, economic, geographical and environmental factors has existed for a long time, and has become the most complex and intractable problem to solve at the Multi-space energy allocation. To alleviate the problems of uneven regional energy distribution, combined with the rapid development of block data, in this paper, an energy internet efficient regional optimal allocation method based on block data is explicitly proposed. Especially, by means of considering the difference of social, economic, geographical and environmental factors in each region, a concept of dynamic spatial energy allocation adjustment is proposed in this paper. Energy utilization rates and a new objective functional is proposed to support regional energy allocation strategy which adjusting dynamically to optimize the energy utilization ratio when the regional energy allocation is found to be unreasonable. The traversal algorithm method is applied in the strategy to ensure the comprehensiveness and stability of adjustment scheme selection in practical application. A fractional steps computing solution that simultaneously emphasizes the insufficient computational capabilities of hardware and out of memory error is implemented to deal with the huge amount of block data caused by complex energy internet. As a result, a promising approach is introduced for the energy internet efficient regional optimal allocation adjustment.

1. Introduction
In recent years, with the rapid development of society and economy, the deviation of energy supply and consumption is increasingly exposed. Furthermore, the randomness and difference of the types and quantities of energy needed in different regions are increasingly obvious. Although the aim of energy internet [1-3] is to realize the efficient and reasonable allocation of multiple type of energy sources in different regions [4-6], there are still specific problems to be solved in practical application, such as the timeliness of allocation. Due to the actual energy demand and energy consumption of different regions is irregular and unpredictable, dynamic regional energy allocation method is considered as a feasible and promising solution.

The way of regional energy distribution needs to be adjusted according to the development of social, economic, geographical, environmental and other factors. With the rapid development of block data, integrated data with multi-source information provides more convenient conditions for regional energy allocation, which make the dynamic adjustment of regional energy possible. To alleviate the problem of uneven regional energy distribution, an energy internet efficient regional optimal allocation method based on block data is explicitly proposed in this paper. The rest of this paper is
organized as follows. In Section 2, the objective functional and the energy regional optimal allocation strategy are presented. In Section 3, traversal algorithm is developed for solving the proposed commutation adjustment strategy. In Section 4 the main conclusions are summarizes.

2. Mathematical model

The mathematical modeling of the energy allocation options operation mechanism is beneficial to study the feasibility and accuracy of energy allocation results. According to the social, economic, geographical and environmental factors reflected in the block data, and combined with the historical information of energy demand in each space, the mapping between the types of energy and the mathematical model is established, which is outlined in Figure 1.

![Mathematical model of energy allocation adjustment](image)

In the equation (1), \( m \) express the types of energy (“a” stand for electric energy, “b” can represent water resource, etc.), \( n \) stand for the number of spaces, matrix \( E \) represents Pre configuration details of each energy source. For the sake of easy computation, the \( E \) can be specified as:

$$E = \begin{bmatrix} E_{01,a} & E_{01,b} & \cdots & E_{01,m} \\ E_{02,a} & E_{02,b} & \cdots & E_{02,m} \\ \vdots & \vdots & \ddots & \vdots \\ E_{0m,a} & E_{0m,b} & \cdots & E_{0m,m} \end{bmatrix}$$

(1)

In the equation (1), \( m \) express the types of energy (“a” stand for electric energy, “b” can represent water resource, etc.), \( n \) stand for the number of spaces, matrix \( E \) represents Pre configuration details of each energy source. For the sake of easy computation, the \( E \) can be specified as:

$$E = [E_{01}, E_{02}, \ldots E_{0n}]$$

(2)

Corresponding to each vector in matrix \( E \), \( E \) also represents all initial energy allocation options.

2.1 Objective functional

In practical applications, it is necessary to calculate the energy utilization rate firstly. In this paper, the energy utilization rate is computed by:
where $E_{1}, E_{2}, \ldots, E_{n}$ separately stand for the energy utilization rate in every space areas; $E_{01}, E_{02}, \ldots, E_{0n}$ separately represents the actual energy consumption; $E_{00}$ denotes the initial planning energy allocation in the region, including electric energy, water resources, oil and natural gas, etc., which are obtained through block statistics. In particular, the energy allocation is the sum of all the energy resources planned to be provided in the region, including electric energy, water resources, oil and natural gas, etc., which are obtained through block data statistics. Corresponding to all the factors in the vector $E$, the three-phase unbalance degree vector $e_{E}$ will be obtained by solving equation (3).

In the process of energy allocation, the total amount of all planned energy allocation cannot be greater than the total capacity of all energy sources in the region. Which the constraints of equation (3) can be specified as:

$$s.t.: E_{01} + E_{02} + \cdots + E_{0n} = E_{0}$$

Where $E_{0}$ represents the total capacity of all energy sources. For the sake of further comprehension, it can be seen clearly that the parameters of energy utilization rate which calculated in equation (4) may be greater than 100% or less than 100%. When $e_{E}$ is greater than 100%, it means the initial planning energy allocation in the region is less than the actual energy consumption in the region, otherwise it means the energy distribution in the region meets the energy consumption demand. In this paper, the energy allocation criteria are designed as follows: when more than three $e$ values are higher than 120% or lower than 80%, the spatial energy allocation is considered unreasonable.

$$\begin{cases}
  e_{m} < 80\% \quad \text{or} \quad e_{m} > 120\% \\
p > 3
\end{cases}$$

Following the above discussions, finally, an objective function can be proposed for energy internet efficient regional optimal allocation method, which can be specified as:

$$\eta_{\text{min}} = \left\{ \frac{1}{n} \left( e_{E1} + e_{E2} + \cdots + e_{En} \right) \right\} \times 100\%$$

where $\left( e_{E1} + e_{E2} + \cdots + e_{En} \right)$ represent the average value of all energy utilization rates, $\eta_{\text{min}}$ is the minimum deviation between the average value of energy utilization rate and data “1”. $\delta_{\text{min}}$ is the minimum deviation between every energy utilization rate and data “1”.

2.2 Energy regional optimal allocation strategy

In the process of energy regional allocation, it is necessary to identify the development and change of energy application and supply according to the change of block data. In order to finish the task of energy regional allocation, the energy internet efficient regional optimal allocation method suitable for practical applications is crucial.
Following the discussions presented in previous sections, the energy internet efficient regional optimal allocation method proposed in this paper can be departed in 5 main parts:

(1) Real-time monitoring of energy utilization rate;
(2) Data collection (After the unreasonable spatial energy allocation occurred);
(3) Preparatory scheme of energy allocation;
(4) Solving of the objective functional
(5) Unique scheme determination.

The energy internet efficient regional optimal allocation strategy which use dynamic spatial transfer model is designed for adjusting dynamically to optimize the energy utilization ratio when the regional energy allocation is found to be unreasonable. The details procedure is outlined in Figure 2.

**Figure 2. Energy allocation adjustment strategy**

### 3. Objective functional solving

Many intelligent optimization algorithms could use for solving the objective functional (equation (7) in this paper). For example, genetic algorithm [7-8], Particle Swarm Optimization [9-10] and so on. However, in the application of complex practical problems, the stability of intelligent algorithms is worrying, Genetic Algorithms and Neural network has some disadvantages, such as slow convergence speed, apt to fall into local optimum and unable to get global optimal solution. In order to finish the task of regional energy allocation adjustment, the Solution method suitable for practical applications is crucial. The traversal algorithm method is applied in the strategy to ensure the comprehensiveness and stability of commutation scheme selection in practical application.

Due to the huge amount of block data generated by complex energy internet operation, meanwhile, the traversal algorithm method also increases the amount of data, controller with the powerful computational capabilities is required. However, in practical applications, hardware may not have strong enough computational capabilities because of cost considerations or other factors. Once the hardware capacity are insufficient, it will tremendously impact on dynamic spatial transfer model adjustment. At the same time, hardware upgrades will be unrealistic and lagging. On the contrary, software upgrading can improve the ability of hardware to deal with practical problems. Therefore, the adjustment strategy proposed in this paper provides a fractional steps computing solution to deal with the insufficient computational capabilities of hardware and out of memory error. Figure 3 shows the details of fractional steps computing.
Figure 3. Fractional steps computing of partitioned matrix

If the computational capabilities of hardware are insufficient, it is very likely to cause the controller to crash when it faces dealing withhuge block data amount generated by complex energy internet operation. As the figure 3 shown, a new method which can convert the original global space energy allocation task into multiple local space energy allocation problems. The application of block matrix ensures that the controller has sufficient computational capabilities for a subset of data. By solving of partitioned matrix, the computational burden of the controller can be effectively reduced. Meanwhile, the global optimal results can be obtained by comparing the results of each partitioned matrix.

4. Conclusion
In this paper, we propose an energy internet efficient regional optimal allocation method which is based on block data. Energy utilization rates and a new objective functional is proposed to support regional energy allocation strategy. Dynamic spatial adjustment method is used to optimize regional allocation of energy when the regional energy allocation is found to be unreasonable. The main research findings can be summarized as follows:

(1) According to the social, economic, geographical and environmental factors reflected in the block data, the mathematical model which describe the relationship between the block data and energy types is established

(2) A new regional energy optimal allocation strategy is presented. The strategy aims to alleviate the uneven regional energy distribution phenomenon and improve energy supply reliability.

(3) The traversal algorithm method is applied to seek the result, which can ensure the comprehensiveness and stability of regional energy allocation scheme in practical application.

(4) Due to the huge amount of block data generated by complex energy internet operation, controller with the powerful computational capabilities is required in three-phase imbalance load adjustment. However, in practical applications, hardware may not have strong enough computational capabilities because of cost considerations or other factors. A fractional steps computing solution is proposed to deal with the insufficient computational capabilities of hardware and out of memory error.

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