Research on Multi-dimensional Energy Efficiency Assessment Technology of RIES

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Abstract. At present, there is a lack of regional comprehensive energy multi-dimensional evaluation system and calculation of different quality energy in the energy efficiency evaluation of regional integrated energy system. Based on this, this article carries out research on multi-dimensional energy efficiency evaluation index system and evaluation methods. First, this article form quantifiable evaluation indicators from the aspects of energy supply subsystem energy efficiency, energy conversion subsystem energy efficiency, grid energy efficiency, economic benefits and social benefits, and clarify the calculation methods of each evaluation indicator. Then this article calculate the indicator combination weight. Finally, a multi-dimensional energy efficiency assessment method for a regional integrated energy system is proposed, and an example is used to prove the effectiveness of the method.

1 Introduction

As an important carrier of the energy internet, the regional integrated energy system is the frontier for studying the internal operation mechanism of different energy sources and promoting advanced energy technologies[1-4]. Scientific and reasonable energy efficiency assessment method is extremely important for the healthy development of regional integrated energy system. In the research of multi-dimensional energy efficiency assessment technology for regional integrated energy system, the following problems still exist:

1) Establish a comprehensive multi-dimensional evaluation index system for regional comprehensive energy.

The multi-dimensional energy efficiency evaluation index of the integrated energy system is an important basis for system planning, design and regulation and optimization. A reasonable evaluation index structure is set up to integrate the five dimensions of energy supply system, energy conversion system, power transmission process, system economy, and environmental evaluation. Taking these into account will help to assist the better planning and operation of the integrated energy system.

2) The relationship between "quality" and "quantity" of energy should be fully considered in the assessment.

In the integrated energy system, the conversion process between different energy sources has the 'quantity' conservation and the 'quality' difference. Traditional energy efficiency calculations usually simply superimpose the energy of different qualities, which can only analyze the conservation of 'quantity', but lack of analysis of the difference of 'quality' and cannot scientifically characterize the degree of energy utilization. Therefore, it is necessary to convert different energy sources to the same energy level to measure the grade difference.

Under this background, the multi-dimensional energy efficiency evaluation index system and evaluation method are studied in this paper.

2 Multi-dimensional energy efficiency evaluation index system of regional integrated energy system

2.1 Construction principles of indicator system

In order to ensure the scientific rationality of the comprehensive energy efficiency evaluation results, the principles and directions of the evaluation indexes are determined according to the evaluation purpose and data collection conditions.

On the basis of the above principles, the evaluation index system is established by using the hierarchical analysis model. The hierarchical analysis model is divided into three layers, namely the target layer, the criterion layer and the scheme layer. The target layer is integrated energy efficiency. Energy efficiency of energy supply subsystems, energy efficiency of energy conversion subsystems, energy efficiency of the grid, economic benefits and social benefits as the criterion layer, and the scheme layer is a variety of energy efficiency indicators.

2.2 Composition and architecture of indicator system

This paper adopted the criterion layer evaluation index by the power subsystem indicators of energy efficiency, energy conversion system indicators of energy efficiency,
In the energy efficiency module of the energy supply subsystem, consider gas supply, power supply, heating, and cooling subsystems, including their respective energy systems and power trains. The power system includes the power transmission link, which mainly takes into account the energy consumed by the power equipment in the power transmission process. In the energy efficiency module of the energy conversion subsystem, the conversion process between electric/thermal, gas/heat, gas/electricity, electricity/cold, heat/cold. Electrical energy is also lost during transmission, so the energy efficiency of the grid frame also needs to be taken into account. In the economic sub-module, the comprehensive cost method is adopted to reflect the economic level of the integrated energy system by the initial investment cost, operation maintenance cost and scrap cost index. In the Social Benefits submodule, climate change indicators and pollutant emission indicators are used to evaluate the environmental benefits of the benchmark system due to the replacement application of renewable energy and the efficient use of multi-energy synergies[6]. The establishment of an evaluation indicator system is as follows.

![Comprehensive energy multi-dimensional energy efficiency evaluation system](image)

Table 1. Comprehensive energy multi-dimensional energy efficiency assessment index system.

| Level indicators              | The secondary indicators                                                                 |
|------------------------------|------------------------------------------------------------------------------------------|
| Energy supply efficiency     | Power supply efficiency                                                                  |
|                              | Air supply efficiency                                                                     |
|                              | Power system efficiency                                                                   |
| Energy conversion efficiency | Electricity to heat/cold energy conversion efficiency                                    |
|                              | Gas to electricity/thermal energy conversion efficiency                                  |
|                              | Heat to cold energy conversion efficiency                                                |
| Energy supply reliability    | Power supply reliability rate                                                             |
|                              | Qualified rate of outlet pressure of gas pipeline network                                 |
|                              | Failure rate of cooling and heating equipment                                             |
| Energy supply quality        | Qualified rate of harmonic content in medium and low voltage station area                 |
|                              | Voltage combination rate of medium and low voltage station area                           |
|                              | Qualified rate of export natural gas quality                                              |
|                              | Qualified rate of cold and hot outlet temperature fluctuation                            |
| Economic benefit             | Unit energy cost                                                                          |
|                              | Unit investment to increase energy supply                                                 |
|                              | Unit investment reduces supply shutdown time                                             |
|                              | Financial net present value                                                              |
|                              | Payback period                                                                           |
|                              | Financial internal rate of return                                                         |
| Social benefit               | Renewable energy consumption rate                                                         |
|                              | Proportion of renewable energy capacity                                                   |
|                              | Annual CO2 emission reduction                                                            |
|                              | Annual sulfur dioxide emissions reduction                                                |

**2.3 Normalized treatment of indicators**

There are different types of indicators, including ositive type and inverse type. In order to unify the types of indicators and evaluate the system more accurately, it is necessary to normalize the indicators. The normalization method is as follows.

1) Positive indicators

For positive indicators, which can be calculated by (1):

$$a_{ij} = \frac{x_{ij} - m_j}{M_j - m_j}$$  (1)
Among them, \( M_j = \max \{x_{ij}\}, m_j = \min \{x_{ij}\}. \) By processing the index, the value of the index will be \( 0 \leq a_{ij} \leq 1. \)

2) Inverse index
For reverse indicators, which can be calculated by (2):

\[
a_{ij} = \frac{M_j - x_{ij}}{M_j - m_j} \quad (2)
\]

Among them, \( M_j = \max \{x_{ij}\}, m_j = \min \{x_{ij}\}. \) By processing the index, the value of the index will be \( 0 \leq a_{ij} \leq 1. \)

3 Weight analysis of multi-dimensional energy efficiency evaluation index of regional integrated energy system

In the process of evaluation, it is inevitable to combine subjective and objective evaluation. The subjective weight was determined by AHP and the objective weight was determined by entropy weight method, and the final weight was determined by combining the two to get a more reasonable conclusion[7].

3.1 Calculation method of subjective weight

The basic principle of AHP method is as follows: First, the complex problem is divided into several levels, and the elements of the same level are judged in pairs according to the criteria of the elements of the previous level, and their importance is compared. Then calculate the weight of elements of each level. Finally, the optimal level, and their importance is compared. Then calculate according to the criteria of the elements of the same level are judged in pairs

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3.2 Calculation method of objective weight

As an objective weighting method, entropy weight method mainly aims to determine the entropy value through the information entropy of each index[9].

3.2.1 Construct index matrix

The number of evaluation samples was \( M; \) the evaluation index was \( N, \) and each index value was \( v_{ij}(i = 1, 2, \ldots, m; j = 1, 2, \ldots, n); \) the index matrix is as (7):

\[
V = \begin{bmatrix}
v_{11} & \cdots & v_{1n} \\
\vdots & \ddots & \vdots \\
v_{m1} & \cdots & v_{mn}
\end{bmatrix} \quad (7)
\]

3.2.2 Normalized index matrix

The normalized index matrix is obtained \( X = (x_{ij})_{mn} \) can be calculated by (8):

\[
x_{ij} = v_{ij} / \left(\sum_{i=1}^{n} (v_{ij})^2\right)^{1/2} \quad (8)
\]

In the expression, \( x_{ij} \) is the value of the \( j_{th} \) index of the \( i_{th} \) sample in the matrix.
3.2.3 Use entropy weight method to determine the index weight

Index weight can be calculated by (9), (10) and (11):

\[ h_{ij} = \frac{1 + x_{ij}}{\sum_{i=1}^{m} (1 + x_{ij})} \]  \hspace{1cm} (9)
\[ k_i = \frac{1}{\sum_{i=1}^{m} h_{ij} \ln h_{ij}} \]  \hspace{1cm} (10)
\[ s_j = \frac{(1 - k_i)}{\sum_{j=1}^{n} (1 - k_i)} \]  \hspace{1cm} (11)

Among them, \( h_{ij} \) is the occurrence probability of each indicator, \( k_i \) is the information entropy of the system, \( s_j \) represents the entropy weight of the \( j \)-th index.

The index weight column vectors are as (12):

\[ S = (s_1, s_2, ..., s_n)^T \]  \hspace{1cm} (12)

Among them, \( S_n \) is the weight of the \( n \)-th index.

3.2.4 Weighting standardization

The weighted standardization matrix is as (13):

\[ Y = (y_{ij})_{mn} = (s_j x_{ij})_{mn} \]  \hspace{1cm} (13)

\( y_{ij} \) is the \( j \)-th index value of the \( i \)-th sample of the standardized matrix.

3.3 Calculation method of combined weight

In order to reflect the subjective nature of decision-making and the objectivity of decision-making in evaluation, it is necessary to integrate the results of the hierarchical analysis method and the empowerment of entropy method.

Based on the weighted results of the above analytic hierarchy process and entropy weight method, the weight vector calculated by the AHP is \( T \), the index set is \( \{t_1, t_2, ..., t_n \} \), the subjective weight vector calculated by the entropy weight method is \( S = \{s_1, s_2, ..., s_n\} \). Suppose the relative importance of the subjective weight vector to the combined weight is \( \alpha \), the relative importance of objective weight vector to the combined weight is \( \beta \), and it satisfies the minimum deviation between the combined weight vector \( W \) and the subjective weight vector \( T \), which can be described by (14) and (15).

\[ \min H (w_j) = \alpha \times (w_j - t_j)^2 + \beta \times (w_j - s_j)^2 \]  \hspace{1cm} (14)
\[ \Sigma w_j = 1, 1 \leq j \leq n \]  \hspace{1cm} (15)

In this paper, the expected value of subjective weight and objective weight is the actual value of each index weight, namely \( S \). The relative important coefficients of the subjective and objective weight vectors of a single index can be calculated by using the subjective and objective weight actual values of each index, which can be calculated by (16):

\[ \alpha_j = \frac{t_j}{t_j + s_j} \]
\[ \beta_j = \frac{s_j}{t_j + s_j} \]  \hspace{1cm} (16)

For the evaluation index in the multi-decision matrix, the relative important coefficient of the overall subjective and objective weight vector can be calculated by (17):

\[ \alpha = \frac{\sum_{j=1}^{n} \alpha_j}{\sum_{j=1}^{n} \alpha_j + \sum_{j=1}^{n} \beta_j} = \frac{\sum_{j=1}^{n} \alpha_j}{n} \]
\[ \beta = \frac{\sum_{j=1}^{n} \beta_j}{\sum_{j=1}^{n} \alpha_j + \sum_{j=1}^{n} \beta_j} = \frac{\sum_{j=1}^{n} \beta_j}{n} \]  \hspace{1cm} (17)

For each of the indices \( x_i \), with \( H(w_j) \) as the minimum of the optimal, which can be converted into (18):

\[ (\min H = \{H(w_1), H(w_2), ..., H(w_n)\}) \]  \hspace{1cm} (18)

\[ s. t. \sum_{j=1}^{n} w_j = 1, 0 \leq w_j \leq 1, 1 \leq j \leq n \]

The multi-objective optimization model can be transformed into a single-objective optimization model for solution, which can be calculated by (19):

\[ \min H = \sum_{j=1}^{n} [\alpha \times (w_j - t_j)^2 + \beta \times (w_j - s_j)^2] \]  \hspace{1cm} (19)
\[ s. t. \sum_{j=1}^{n} w_j = 1, 0 \leq w_j \leq 1, 1 \leq j \leq n \]

4 Research on multi-dimensional energy efficiency assessment methods for regional integrated energy systems

4.1 Multi-dimensional energy efficiency assessment technology based on TOPSIS method

The evaluation method is TOPSIS, which is an analysis method suitable for comparison and selection of multiple plans based on multiple indicators[10]. It can eliminate different indicators Dimensional influence, and can make full use of the information of the original data, so it can fully reflect the gap between the various programs, objectively reflect the actual situation, has the advantages of being true, intuitive and reliable, and it has no special requirements for sample data. Compared with the mutual analysis method of individual indicators, the TOPSIS method can collectively reflect the overall situation. The basic calculation process is as follows:

1) Multi-objective decision matrix construction

The scheme set of multi-index decision problem is set as \( C = \{C_1, C_2, ..., C_m\} \), the index set is \( M = \{M_1, M_2, ..., M_m\} \), scheme \( M_i \) versus index \( C_i \). The evaluation value is \( r_{ij} (i = 1, 2, ..., n; j = 1, 2, ..., m) \), the multi-objective decision matrix \( R \) can be obtained, as shown in (20).

\[ R = \begin{bmatrix}
  r_{11} & r_{12} & \cdots & r_{1m} \\
  r_{21} & r_{22} & \cdots & r_{2m} \\
  \vdots & \vdots & \ddots & \vdots \\
  r_{n1} & r_{n2} & \cdots & r_{nm}
\end{bmatrix} \]  \hspace{1cm} (20)

For the evaluation index in the multi-decision matrix, the relative important coefficient of the overall subjective and objective weight vector can be calculated by (17):

\[ \alpha = \frac{\sum_{j=1}^{n} \alpha_j}{\sum_{j=1}^{n} \alpha_j + \sum_{j=1}^{n} \beta_j} = \frac{\sum_{j=1}^{n} \alpha_j}{n} \]
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\[ \min H = \sum_{j=1}^{n} [\alpha \times (w_j - t_j)^2 + \beta \times (w_j - s_j)^2] \]  \hspace{1cm} (19)
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\[ \min H = \sum_{j=1}^{n} [\alpha \times (w_j - t_j)^2 + \beta \times (w_j - s_j)^2] \]  \hspace{1cm} (19)
\[ s. t. \sum_{j=1}^{n} w_j = 1, 0 \leq w_j \leq 1, 1 \leq j \leq n \]
2) Calculation of positive and negative ideal solutions
By the matrix $R = (r_{ij})_{m \times n}$ and the weight vector $W = (w_1,w_2,...,w_m)$. Multiply form a weighted decision matrix $Z = (Z_{ij})_{m \times n}$. Calculate the positive ideal solution and negative ideal solution of the index, and get the positive ideal solution vector $Z^+$ and negative ideal solution vector $Z^-$, $Z^+ = (Z_1^+,Z_2^+,...,Z_m^+)$ . $Z^- = (Z_1^-,Z_2^-,...,Z_m^-)$, as shown in (21) and (22).

$$z^+_i = \max(z_{i1},z_{i2},...,z_{im})$$  \hspace{1cm} (21)

$$z^-_i = \min(z_{i1},z_{i2},...,z_{im})$$  \hspace{1cm} (22)

3) Calculation of relative distance
The distance from the positive ideal solution and the distance from the negative ideal solution can be calculated by (23) and (24).

$$D^+_j = \frac{1}{\sqrt{\sum_{i=1}^{m} (z_{ij} - z^+_i)^2}}$$  \hspace{1cm} (23)

$$D^-_j = \frac{1}{\sqrt{\sum_{i=1}^{m} (z_{ij} - z^-_i)^2}}$$  \hspace{1cm} (24)

Among them, $i = 1,2, ..., m$; $j = 1,2, ..., n$

4) Calculation of comprehensive evaluation value
The comprehensive evaluation relative closeness degree of each evaluation object can be calculated by (25). The relative closeness degree represents the closeness degree of each program to the optimal program. The greater the relative closeness degree is, the more similar the program is to the optimal program, and the higher the ranking is.

$$C_j = \frac{D^-_j}{D^-_j + D^+_j}, j = 1,2, ..., n$$  \hspace{1cm} (25)

5) Ranking of evaluation results
According to the above formula, rank $C_j$ from the large to the small of the evaluation objects for the pros and cons of the order.

4.2 Regional comprehensive energy multi-dimensional energy efficiency assessment process
Combined with the above research content, the multi-dimensional energy efficiency assessment process of comprehensive energy is shown in the figure below.

5 Energy efficiency assessment and analysis of typical regional integrated energy systems

5.1 Calculation parameters of energy efficiency assessment
A typical area consists of industrial production area and commercial area. In consideration of multi-energy complementary characteristics and renewable energy
access, the electrical load demand of the area is supplied by external power grid and CCHP unit, the thermal load of the area is supplied by CCHP unit and electric boiler, and the cooling load of the area is supplied by conventional cooling machine, ground source heat pump, lithium bromide refrigerator and cold storage pool.

Taking into account the pollution-free emission conditions of renewable energy input in various energy technologies, all pollutant emissions from the operation of the final integrated energy system can be traced back to the production of electricity. The pollutant emission intensity is used to measure the pollutant emission per unit of power generation, as shown in the following table.

Table 3. Pollution emission intensity.

| Power generation technology | SO2   | NOx   | CO2    | CO    |
|-----------------------------|-------|-------|--------|-------|
| Gas power generation        | 0.000928 | 0.618 | 184.083 | 0.1702 |
| A fuel cell                 | 0     | < 0.023 | 635.04 | 0.0544 |
| Wind power generation      | 0     | 0     | 0      | 0     |
| Photovoltaic power generation | 0   | 0     | 0      | 0     |

The regional land scale is 138.13 million square meters, and the construction area is estimated to be 227.92 million square kilometers according to the planning scheme. According to the general land use plan, all urban construction land within the planning scope, without basic farmland. Among them, the total area of the living area is 66.14 million square meters, the total area of the commercial area is 7.41 million square meters, and the total area of the industrial area is 61.49 million square meters based on 30% of the reserved land for unplanned projects.

Based on the heating load index and land use planning, the heating load, cooling load and domestic hot water load are simulated and estimated. The annual cumulative heating and cooling days are selected as 120 days. The specific results are as follows[11-12]:

Table 4. Calculation results of heating load of various buildings.

| Building type                      | Construction area (10000 square meters) | Design heat load (kw) | Typical daily cumulative load (MWh / D) | Annual cumulative load (MWli / a) |
|-----------------------------------|---------------------------------------|-----------------------|----------------------------------------|----------------------------------|
| Residence and apartment           | 56.70                                  | -                     | -                                      | -                                |
| Senior living garden              | 8.39                                   | 3834                  | 57.5                                   | 6902                             |
| business                           | 9.68                                   | 4704                  | 70.6                                   | 8468                             |
| to work in an office               | 6.07                                   | 3563                  | 53.4                                   | 6413                             |
| school                             | 6.67                                   | 3915                  | 58.7                                   | 7047                             |
| Pharmaceutical R & D workshop     | 61.49                                   | 39007                | 598.6                                  | 71833                            |
| Pharmaceutical intelligent manufacturing workshop | 31.84 | 20664 | 310.0 | 37195 |
| total                             | 176.11                                  | 76588                 | 1148.8                                 | 137859                           |

Table 5. Calculation results of cooling load for various buildings.

| Building type                      | Construction area (10000 square meters) | Design load (kw) | Typical daily cumulative load (MWh / D) | Annual cumulative load (MWli / a) |
|-----------------------------------|---------------------------------------|----------------|----------------------------------------|----------------------------------|
| Residence and apartment           | 56.70                                  | -              | -                                      | -                                |
| Senior living garden              | 8.39                                   | 4448           | 126.7                                  | 13297                            |
| business                           | 9.68                                   | 10899          | 163.5                                  | 19619                            |
| to work in an office               | 6.07                                   | 5930           | 88.8                                   | 10675                            |
| Learning comparison                | 6.67                                   | 7510           | 112.7                                  | 13518                            |
| Pharmaceutical R & D workshop     | 61.49                                   | 50857          | 762.8                                  | 91542                            |
| Pharmaceutical intelligent manufacturing workshop | 31.84 | 28528 | 427.9 | 51351 |
| total                             | 176.11                                  | 112174         | 1682.6                                 | 201914                           |

Considering the multi energy complementary characteristics and renewable energy access, the electric load demand of the park is supplied by the external power grid and CCHP units, the thermal load of the park is supplied by CCHP units and electric boilers, and the cooling load of the park is supplied by conventional chillers, ground source heat pumps, lithium bromide chillers and cold water storage tanks. Among them, ground source heat pump can be used to cool underground water by electricity in summer. The cop-e of the equipment varies with the temperature of underground cooling water.

5.2 Efficiency assessment of system energy

In the multi-dimensional energy efficiency assessment of this chapter, typical areas are selected for multi-dimensional energy efficiency assessment.

When the regional integrated energy system is in the source grid load storage configuration, the optimal capacity allocation can ensure that the system can achieve the lowest cost investment under the conditions of meeting the reliability and security constraints, and ensure that the system operates in the optimal situation. Excessive capacity allocation of system equipment will increase the cost of the system, but insufficient configuration will lead to the waste of renewable energy and the shortage of energy supply. Therefore, in order to
compare and analyze the multi-dimensional energy efficiency of the system under different configuration modes, this chapter selects two different schemes of single objective optimal configuration mode and multi-objective optimal configuration mode of regional comprehensive energy system for multi-dimensional energy efficiency evaluation.

5.2.1 Overall energy efficiency assessment of areas

The different capacity configuration schemes are as follows:

1) Single objective optimal energy supply mode
Under the optimal mode of environmental benefits, the capacity allocation is carried out to reduce carbon emissions and pollutant emissions. The capacity of typical areas is as follows: photovoltaic power generation 10000kW, gas turbine 117630kw, absorption chiller 70578kw, waste heat boiler 56462kw, gas boiler 24527kw, electric refrigerator 10534kw, and other energy is provided by the grid.

2) Multi objective optimal energy supply mode
Under the multi-objective benefit optimal energy supply mode, the appropriate distributed energy equipment is selected for the typical regional resource situation, and the capacity allocation is carried out with the minimum annual cost as the goal. The configuration capacity is as follows: photovoltaic power generation system 10000kW, gas turbine 59627kw, absorption chiller 35776kw, residual heat boiler 28620kw, gas-fired boiler 50078kw, electric refrigerator 25327kw, and the rest energy is provided by the grid.

According to the calculation method of indexes, the results are as follows:

**Table 7. Indexes and calculation results of different energy supply modes in typical areas.**

| Serial number | Secondary indicators                  | The single objective benefit is the best | Multi objective benefit optimization |
|---------------|---------------------------------------|------------------------------------------|--------------------------------------|
| 1             | Power supply efficiency                | 0.95                                     | 0.96                                 |
| 2             | Efficiency of cooling and heating network | 0.95                                     | 0.96                                 |
| 3             | Gas supply efficiency                  | 0.94                                     | 0.96                                 |
| 4             | Power system efficiency                | 0.97                                     | 0.97                                 |
| 5             | Conversion efficiency of electric to hot / cold energy | 3.5                                      | 4.7                                  |
| 6             | Conversion efficiency of gas to electricity / thermal energy | 0                                      | 2.1                                  |
| 7             | Conversion efficiency of hot to cold energy | 1.1                                      | 2.5                                  |
| 8             | Power supply reliability               | 99.9815%                                 | 99.9832%                             |
| 9             | Qualified rate of outlet pressure of gas pipeline network | 99.5%                                   | 99.5%                                |
| 10            | Failure rate of cooling and heating equipment | 1.1%                                    | 0.2%                                 |

The subjective weights of the first and second level indexes are calculated by analytic hierarchy process (AHP), and the objective weights of each secondary index are calculated by entropy weight method. Then, based on the idea of moment estimation, the objective function of combined weights is constructed, and the optimal combination weights are obtained by solving nonlinear programming.

**Table 8. Calculation results of index combination weight under multi-objective benefit optimal energy supply mode.**

| Serial number | Secondary indicators                  | Subjective weight | Objective weight | Combination weight |
|---------------|---------------------------------------|-------------------|------------------|--------------------|
| 1             | Power supply efficiency                | 0.0716            | 0.0001           | 0.0573             |
| 2             | Efficiency of cooling and heating network | 0.0779            | 0.0001           | 0.0623             |
| 3             | Gas supply efficiency                  | 0.0296            | 0.0002           | 0.0237             |
| 4             | Power system efficiency                | 0.0322            | 0.0031           | 0.0258             |
| 5             | Conversion efficiency of electric to hot / cold energy | 0.0440           | 0.0377           | 0.0427             |
| 6             | Conversion efficiency of gas to electricity / thermal energy | 0.0638           | 0.0008           | 0.0512             |
| 7             | Conversion efficiency of hot to cold energy | 0.0279           | 0.2722           | 0.0768             |
The TOPSIS evaluation method is used to evaluate the energy efficiency of two energy supply modes in each typical scenario. Through the simulation, the energy efficiency evaluation results of different energy supply modes in typical regions are as follows.

Table 9. Calculation results of typical regional energy efficiency assessment.

| Energy supply mode | The single objective benefit is the best | Multi objective benefit optimization |
|--------------------|-----------------------------------------|-------------------------------------|
| score              | 0.79612                                 | 0.90367                             |

Through the evaluation of multi-dimensional energy efficiency under two kinds of energy supply modes in typical areas, the results are shown in the table above. Through the evaluation, it is found that the energy efficiency of the energy supply mode with multi-objective benefit is better than that under the mode of environmental single objective benefit optimization.

6 Summary

The evaluation of integrated energy systems at the regional level has helped to form a closed loop in the planning of integrated energy systems at the regional level and guide the planning of integrated energy systems better. This paper studies the evaluation index system of regional-level integrated energy system, puts forward the multi-dimensional energy efficiency evaluation method, assists the better planning and operation of the integrated energy system, gives full play to the advantages of the system in the coordination of various energy technologies, reduces the cost of multi-energy coupling, and improves the comprehensive energy efficiency.

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