Research on the Construction Elements of the New Generation Power System

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Abstract. With the massive consumption of fossil energy, the traditional power system can no longer meet the high-quality development of the economy and society and the strict requirements of the ecological environment. The whole society urgently needs to build a new generation of power system to achieve the healthy development of the economy and society under increasingly strict constraints. For the new generation of power systems, the mainstream direction is that they should promote the deep replacement of fossil energy with electric energy in the energy consumption link, and increase the proportion of electricity in the final energy consumption and clean power generation. In addition, it should also include the informatization, intelligence and digitization of the power and even energy systems, and realize the iterative optimization of the whole system with faster communication and faster computer processing technology. In this paper, Dematel analysis method was used to identify and screen the construction elements of the new generation power system. And the role of each element in the construction process was analyzed, thus the key areas in the construction of the new generation power system were clarified.

1. Introduction
In recent decades, the rapid development of the global economy has benefited more from traditional fossil energy[1-2]. However, with the rapid decline of environmental carrying capacity, countries around the world are facing an energy crisis brought about by resource and environmental constraints. The large-scale development and utilization of fossil energy has caused a series of problems including the shortage of energy resources, the deterioration of energy security situation, the decline in the quality of the ecological environment, and the prominent pressure on greenhouse gas emission reduction. It is a direct threat to the sustainable development of mankind. At present, human society has faced huge challenges in energy resources and ecological environment. The traditional power system is far from being able to meet the needs of economic development, and the construction of a new generation of power system is imminent.

2. Introduction to the new generation power system
Generally, the new generation of power systems should be widely interconnected through the power grid to build a platform for the optimization of a wide range of resources. Centralized access to new energy power generation, pumped storage, and electrochemical energy storage, as well as decentralized access to distributed power generation, distributed energy storage, microgrid, electric vehicles, and deep integration with traditional heating, gas and other energy supply networks. In terms of operating mechanism, it is characterized by intelligence and interaction, and is closely integrated with the electricity market. Moreover, the new generation of power systems needs to actively adopt
innovative technologies to improve the flexibility and adaptability of new energy operations. It is precisely because of the wide range and uncertainty of the elements of the new generation of power systems that the key areas of its development have not yet reached a consensus, and new explorations are needed.

3. Analytical model of the construction elements of the new generation power system
The way to rank the importance and relevance of construction elements is difficult to reflect completely through objective data. The Dematel model is introduced here for analysis.

3.1. Optional elements
1 Renewable energy power generation: The main utilization of renewable energy resources is to convert them into electric energy. The large-scale development of new energy will utilize and promote the adjustment of energy structure. In the future, with the gradual maturity of wind power and solar power technologies and the gradual decline in costs, the large-scale application of renewable energy will become an inevitable trend.

2. Clean coal-fired power applications: Coal is the most important energy category in my country, and it will be the same for a long time in the future. If it is possible to speed up the conversion of loose-burning coal to electric coal and achieve clean utilization, coal-fired power will play a more significant role in the electrification process.

3. Promotion of transportation electrification: The electrification of transportation will greatly promote the improvement of electrification level, which mainly includes rail transit and EVs.

4 Rural energy use electrification: Agricultural electrification refers to the widespread use of electricity in agriculture. An important part of agricultural modernization mainly includes the use of electricity as a power resource for agricultural mechanization, and the use of electrical devices for heating, cooling, and lighting.

5 Distribution network control optimization: With the continuous improvement of distributed power generation and the on-site consumption balance mechanism of new energy, the distribution network side is gradually showing the characteristics of the integration of the transmitting and receiving end grids, and the load characteristics, power flow direction and control requirements are all There are obvious differences compared to before. For this reason, the distribution network control technology needs to be enhanced urgently to meet the increasingly complex power grid control requirements.

6 Modern communications industry: communications technology and communications industry is one of the fastest growing fields in the world since the 1980s. my country's signal coverage rate is among the top in the world, and its communication technology is also competitive with developed countries and even has certain advantages.

7 Construction of large-scale AC and DC transmission projects: The reverse distribution characteristics of my country's energy resources and economic development determine that large-scale transmission technologies, including UHV and flexible DC transmission technologies, will play a long-term role, which is to ensure future energy supply Important way.

8 Energy storage and hydrogen energy technology promotion: With the development of science and technology, the utilization of hydrogen energy as a low-carbon and zero-carbon energy source has made great progress, especially the industrialization prospects of hydrogen fuel cells and hydrogen vehicles.

9 Integrated energy construction: The integrated energy system generally takes the energy supply network as the skeleton and the energy station as the hub, and realizes the interaction of energy, transportation network, load, and energy storage in the park, and complements the heterogeneous energy of electricity, gas, cold and heat.

10 Industrial energy conservation: Industry is an important economic pillar of our country, and it is also the concentrated area of the highest energy-consuming industries in my country. Therefore,
Industrial energy-saving technologies play a pivotal role in the energy-saving and emission reduction of the whole society.

11 Industrialization of Carbon Capture and Storage (CCUS): CCUS and CCS (Carbon Dioxide Capture and Storage) technologies are one of the important technological choices for the low-carbon conversion and utilization of fossil energy to combat climate change.

12 Smart home and building energy saving: This technology uses residential as a platform, using integrated wiring technology, network communication technology, security technology, automatic control technology, audio and video technology to integrate facilities related to home life, and build efficient residential facilities.

3.2. Dematel analysis model construction

At a conference in Geneva in 1971, the methodology proposed by scholars A. Gabus and E. Fontela of the American Battelle Laboratory for understanding complex and difficult problems in the real world was a systematic analysis using graph theory and matrix tools. Methods. Through the logical relationship between the various elements in the system and the direct influence matrix, the influence degree and influence degree of each element on other elements can be calculated, and the reason degree and center degree of each element can be calculated as the basis of the structural model. To determine the causal relationship between the elements and the status of each element in the system[3-4].

Implementation steps for the use of DEMATEL for the identification process[5]:

Step 1: Starting from the research purpose, determine the technological indicators according to the chosen n elements. Each element is defined as a technology or field related to the re-electrification process. Preliminary analyze the relationship between one indicator to another, for example, the i-th indicator is directly related to the j-th indicator, then the element aij in the direct influence matrix should be valued from min to max, which depends on the influence caused by the former indicator. This gives a direct influence matrix Xd.

\[ X^d = (a_{ij})_{n \times n} \]  

Step 2: By normalizing the original relation matrix, Get the normative influence matrix N. Normalization is the normal operation of standardizing things, in this model the key to normalization is to use a maximum value as a standard.

\[ \text{Max var} = \max \left( \sum_{j=1}^{n} a_{ij} \right) \]  

\[ N = \left( \frac{a_{ij}}{\text{Max var}} \right)_{n \times n} \]

Step 3: Calculate the total relation matrix T. After the direct influence matrix is continuously self-multiplied, all values of the matrix will approach 0. The self-multiplied process represents the increased indirect influence between elements. After all, T can be shown as

\[ T = N + N^2 + N^3 + \cdots + N^k = \sum_{k=1}^{\infty} N^k \]  

\[ T = N(I - N)^{-1} \]

Where I is unit matrix .

Step 4: Calculate the Influence Degree (Di), Influenced Degree (Ci), Prominence (Pi) and Relation (Ri) of each element according to the total relation matrix.

Influence degree, which can be calculated by the sum of the elements of each row in the total relation matrix, is used for indicating the combined effect of the corresponding elements of each row on all other elements, which can be demonstrated as
Influenced Degree can be calculated by the sum of the values, indicating the intensity of the corresponding elements of each column are affected by the total impact of all other elements.

\[ D_i = \sum_{j=1}^{n} a_{ij}, (i = 1, 2, 3, ..., n) \] (6)

Prominence can be obtained by Influence Degree plus Influenced Degree, which is used to characterize the magnitude of the influence of the element in the evaluation system.

\[ C_i = \sum_{j=1}^{n} a_{ji}, (i = 1, 2, 3, ..., n) \] (7)

Relation can be obtained by subtracting Influenced Degree from Influence Degree. A higher value means that the element can be defined as a Reason Factor, which tend to influence other elements. A lower value means that the element can be defined as a Result Factor, which tend to be influenced by other elements.

\[ R_i = D_i - C_i \] (9)

Step 5: Drawing a figure and perform further processing. Analyze the importance and influence of each element, then define the different role of each element.

4. Calculation and Analysis

Substituting the aforementioned elements into the evaluation model to evaluate one by one, and the evaluation score is represented by the sum of the scores of 27 experts. The 12-element correlation evaluation is carried out through the Delphi method, and a 12-dimensional square matrix is obtained, that is, the direct influence matrix.

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|----|-----|-----|
| 1 | 0 | 101 | 113 | 155 | 114 | 32 | 214 | 167 | 232 | 116 | 54 | 67 |
| 2 | 212 | 0 | 152 | 128 | 115 | 59 | 178 | 147 | 96 | 74 | 67 | 65 |
| 3 | 135 | 109 | 0 | 99 | 122 | 96 | 136 | 118 | 116 | 142 | 52 | 99 |
| 4 | 122 | 113 | 136 | 0 | 120 | 112 | 130 | 108 | 149 | 75 | 63 | 80 |
| 5 | 233 | 116 | 203 | 191 | 0 | 62 | 115 | 126 | 186 | 59 | 54 | 110 |
| 6 | 118 | 63 | 207 | 184 | 211 | 0 | 165 | 120 | 179 | 72 | 79 | 217 |
| 7 | 236 | 136 | 124 | 93 | 120 | 125 | 0 | 152 | 124 | 108 | 61 | 53 |
| 8 | 229 | 149 | 173 | 182 | 115 | 89 | 188 | 0 | 231 | 145 | 88 | 133 |
| 9 | 140 | 136 | 134 | 169 | 93 | 111 | 139 | 138 | 0 | 123 | 84 | 121 |
| 10| 109 | 197 | 126 | 90 | 103 | 84 | 79 | 109 | 160 | 0 | 58 | 86 |
| 11| 47 | 220 | 61 | 73 | 55 | 82 | 59 | 57 | 143 | 72 | 0 | 77 |
| 12| 92 | 90 | 151 | 180 | 86 | 137 | 91 | 113 | 102 | 69 | 55 | 0 |

After a series of transformation of matrix, the total relation matrix T can finally be written as

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|----|-----|-----|
| 1 | - | 0.0767 | 0.0009 | 0.0047 | 0.0334 | 0.0197 | 0.0259 | 0.0723 | 0.0461 | 0.0770 | 0.0229 | 0.0014 |
| 2 | - | - | 0.0641 | 0.0053 | 0.0341 | 0.0192 | 0.0214 | 0.0026 | 0.0486 | 0.0354 | 0.0123 | 0.0023 |
| 3 | - | - | - | 0.0190 | 0.0143 | 0.0063 | 0.0022 | 0.0281 | 0.0222 | 0.0275 | 0.0205 | 0.0064 |
| 4 | - | - | - | - | 0.0111 | 0.0019 | 0.0255 | 0.0584 | 0.0268 | 0.0327 | 0.0232 | 0.0146 |
| 5 | - | - | - | - | - | 0.0675 | 0.0123 | 0.0606 | 0.0519 | 0.0552 | 0.0063 | 0.0001 |
| 6 | - | - | - | - | - | - | 0.0140 | 0.0036 | 0.0476 | 0.0344 | 0.0689 | 0.0549 |
| 7 | - | - | - | - | - | - | - | 0.0797 | 0.0289 | 0.0118 | 0.0082 | 0.0214 |

Table 1. The Direct Influence Matrix (Xd) of Construction Elements.

Table 2. The Total Relation Matrix (T) of Construction Elements.
Then the Influence Degree (Di), Influenced Degree (Ci), Prominence (Pi) and Relation (Ri) of the 14 technologies can be obtained. Influenced Degrees and Influenced Degrees can be directly obtained by the sum of the elements in each row and each column.

Table 3. The Influence Degree and Influenced Degree of each Element

| Number of Element | Influence Degree | Influenced Degree | Number of Element | Influence Degree | Influenced Degree |
|-------------------|------------------|------------------|-------------------|------------------|------------------|
| 1                 | 0.1770           | 0.2016           | 7                 | 0.1578           | 0.1725           |
| 2                 | 0.1753           | 0.2080           | 8                 | 0.2614           | 0.1550           |
| 3                 | 0.1604           | 0.2158           | 9                 | 0.1922           | 0.2406           |
| 4                 | 0.1518           | 0.2052           | 10                | 0.1641           | 0.1379           |
| 5                 | 0.2133           | 0.1586           | 11                | 0.1284           | 0.0802           |
| 6                 | 0.2656           | 0.1206           | 12                | 0.1484           | 0.1516           |

Then the Prominence (Pi) and Relation (Ri) of the 12 elements can be obtained by the sum and the difference of the Influence Degree and the Influenced Degree of each element.

Table 4. The Prominence and Relation of each Element

| Number of Element | Prominence | Relation | Number of Element | Prominence | Relation |
|-------------------|------------|----------|-------------------|------------|----------|
| 1                 | 0.3786     | -0.0246  | 7                 | 0.3303     | -0.0147  |
| 2                 | 0.3833     | -0.0327  | 8                 | 0.4164     | 0.1065   |
| 3                 | 0.3762     | -0.0554  | 9                 | 0.4328     | -0.0483  |
| 4                 | 0.3570     | -0.0534  | 10                | 0.3020     | 0.0262   |
| 5                 | 0.3719     | 0.0548   | 11                | 0.2085     | 0.0482   |
| 6                 | 0.3862     | 0.1450   | 12                | 0.3000     | -0.0032  |

Taking the Prominence as the vertical axis and the Relation as the horizontal axis, the diagram factors of the influencing factors can be obtained.

Figure 1. The Diagram Factors of Different Construction Elements of New Generation Power System

5. Conclusions
It can be seen that the elements numbered 10, 11 and 12, namely industrial energy saving, CCUS and smart home, are slightly less important in each element. Although the above-mentioned technologies and industries do not mean that they have no development value, the development in these fields is actually isolated to a certain extent and it is difficult to promote the development of other industries and technologies. Some elements such as 5, 6, and 8, namely distribution network control optimization, modern communication technology and energy storage technology, are important reasons. The
development of these elements will greatly benefit the progress of other elements, thereby providing more assistance for the construction of a new generation of power systems. The elements 1, 2, 3, and 9, namely renewable energy power generation, clean utilization of coal power, transportation electrification, and integrated energy, are important result factors. In other words, these elements can greatly benefit from the development of other elements, and they are also an indispensable part of the new generation of power systems.

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