Research on the Evaluation Index of Grid Enterprises' Innovation Index Based on the Same Industry Benchmark

Yan Chang¹,a,*, Weixuan Meng

¹State Grid Energy Research Institute, CHINA

*Corresponding author: ¹emily_chang@126.com ²Cdream46@163.com
³17303166@qq.com

Abstract: Based on the in-depth analysis and construction of the technology innovation index and evaluation system that meet the characteristics of power grid enterprises, this paper studies the key technical issues involved in the technology innovation index system of different types of units, such as indicator dimension, indicator type, indicator application, indicator management, application technology route and evaluation results. By constructing an evaluation index system for the technology innovation index of power grid companies, this paper proposes a linkage strategy between the index and technology innovation management, promptly discovers the gaps, diagnoses the cause of the problem, formulates effective countermeasures, provides effective technical support and systematic decision-making basis.

1. Introduction

The Fourth Plenary Session of the Nineteenth Central Committee made new arrangements for improving the technological innovation system and other aspects, and emphasized "to improve the scientific and technological management system and policy system in line with the laws of scientific research, improve the scientific and technological evaluation system, and improve the scientific and technological ethics governance system." Grid companies have put forward the development strategy of science and technology, vigorously promoted independent innovation, and achieved fruitful scientific and technological achievements and a number of world-class major breakthroughs, which has made great progress in China's power grid technology development. Therefore, the evaluation of scientific and technological innovation plays a very important role in guiding the direction of technological innovation of power grid enterprises and implementing key innovation tasks.

2. The importance of the construction of technological innovation index of power grid companies

At present, global science and technology development is showing new trends and characteristics. Major countries in the world are accelerating technological and industrial reforms. The central government attaches great importance to the development of scientific and technological innovation and puts forward higher requirements for central enterprises to optimize their scientific and technological management system and enhance their independent innovation capabilities. Under the new situation, the reform of science and technology management of power grid enterprises still has a long way to go. Enterprises urgently need to establish a complete, scientific and oriented scientific and technological innovation index system, and establish a scientific and technological innovation evaluation system that is linked to performance evaluation and industry benchmarking.

Constructing a scientific and technological innovation index and evaluation system is a key move for grid companies to accelerate the construction of world-class enterprises. At present, with the rapid
development of a new generation of energy technology and information technology, the Sino-US struggle highlights China's deficiencies in cutting-edge technology and "jam neck" technology. Enterprises should follow the essential laws of scientific and technological innovation activities and conduct a comprehensive evaluation of scientific and technological innovation inputs, processes, outputs and benefits in accordance with the principles of full-scale evaluation.

The establishment of a scientific and technological innovation index and evaluation system has a guiding role in the innovation-driven development of power grid companies. In the construction of the scientific and technological innovation evaluation system, it emphasizes the linkage with the performance evaluation practice, which fully embodies the principle of "classification construction, difference assessment", and realizes the linkage between the scientific and technological innovation index and evaluation results and the peer benchmarking and performance assessment of power grid companies, providing a more scientific and complete scientific and technological evaluation index database for power grid companies. This article points out the gaps and deficiencies through horizontal and vertical evaluations, and guides all units to focus on the technological development strategies of power grid companies to improve their technological innovation capabilities, which is conducive to improving innovation performance.

The scientific and technological innovation index and evaluation system are an important support for grid companies to implement national policies and formulate grid companies' technology strategies. The construction of a scientific and technological innovation index and evaluation system for world-class enterprises is the specific implementation of the implementation of the national science and technology policy, which is conducive to the overall analysis of the index results from both vertical and horizontal dimensions. A vertical overall analysis of the index situation since the establishment of the power grid enterprises, and a horizontal benchmarking with international first-class companies over the same period to identify gaps are conducive to a comprehensive disclosure of the advantages and disadvantages of the power grid enterprises' technological innovation system. This can provide a scientific reference for grid companies to improve their strategic planning for scientific and technological innovation, effectively promote the reform of scientific and technological management of grid companies, open up the technological innovation chain of grid companies, promote the coordinated development of innovation entities, and improve the efficiency of technology input and output.

3. Innovation Index Indicator Framework
The fundamental purpose of technological innovation in the evaluation system of technological innovation of power grid enterprises is to transform innovation advantages into development advantages. On the one hand, it transforms into a realistic productivity and realizes the progress of the international leading enterprise of the power grid company; on the other hand, it promotes the optimization of the technology management system and key mechanisms of the power grid company. Therefore, it is necessary to start with the technological foundation of power grid enterprises, gather talent chains around the innovation chain, give full play to the capital chain, and strengthen the investment and support of science and technology. By opening up the entire process of innovation management, accelerating the cultivation of key technologies, doing a good job of technology integration, forming a technology chain, and improving the technology innovation system of power grid companies, in order to support the high-quality development of power grid companies and form an innovation chain of power grid companies' scientific and technological innovation results. In the end, the role of the central enterprise of the person in charge of the power grid enterprise will be played, and innovation will be used as the fulcrum to improve the quality of the innovation chain and promote the integrated development of the entire ecosystem.

Innovation foundation. The satisfaction of the enterprise's technological innovation resources reflects the enthusiasm, initiative and forward-looking nature of technological innovation activities. Its core elements are three aspects of R&D funding investment, R&D talent input and scientific research resource allocation. Among them, the degree of R&D investment reflects the focus and direction of
technological innovation of power grid companies. Talent input reflects the horizontal coordination of talents in different technical fields and the vertical undertaking of the same professional talents. High level of R&D investment, excellent R&D talent team and reasonable allocation of scientific research resources are the prerequisites for building first-class enterprise technological innovation capabilities.

Innovation management. The dynamic capability based on innovation management is an important bridge throughout the entire process of technological innovation from input to output, and it is also an important foundation for the input-output chain. Dynamic capability is a soft condition for enterprises to grasp the direction of scientific and technological innovation, effectively allocate scientific and technological resources, cultivate and encourage talent innovation, and promote the transformation of scientific and technological achievements into enterprise benefits. Enterprises need to continue to deepen the reform of the technological innovation mechanism of power grid enterprises, establish a full-chain collaborative innovation mechanism based on the transformation and application of achievements, improve the innovation system of division of labor, cooperation, distinct levels, and high-efficiency collaboration, and realize the orderly connection of all links of the innovation chain.

Innovation achievement. Scientific and technological achievements are a series of mutually different but interrelated, supporting enterprises to improve the efficiency and effectiveness of production and operation activities. Scientific and technological achievements are a series of mutually different but interrelated, supporting enterprises to improve the efficiency and effectiveness of production and operation activities. In a narrow sense, an enterprise's technology "input-output", in which output measures the enterprise's scientific and technological achievements, is an important output content of the enterprise's micro-technology innovation chain. Enterprises should realize economic and social value by forming more high-quality intellectual property rights and technical standards.

Innovation effectiveness. Technological innovation, innovation and effectiveness are the sum of value creation activities of all links in the technological innovation chain of power grid enterprises, mainly through the transformation and application of scientific and technological achievements to create economic and social value. General Secretary Xi Jinping pointed out that only by combining scientific and technological achievements with the needs of the country, the people, and the market, and completing the three-level jump from scientific research, experimental development, and promotion and application, can we truly realize the value of innovation and achieve innovation-driven development.

The above four dimensions are the basic framework for the construction of the evaluation index system of the technology innovation index of power grid enterprises. Its dimensional framework can become a general standard for an enterprise's scientific and technological innovation capabilities, which is suitable for both scientific research enterprises and production enterprises. The overall evaluation of grid companies and the evaluation of different types of units within the grid companies all use this framework, but on the second or third level indicators, the indicators are designed for different levels and types.

Based on the above analysis, the research group proposed the overall idea of the construction of the grid enterprise technology innovation index system: Based on the actual development of power grids and enterprises, external benchmarking is the guide, internal classification and evaluation is the main line, investment in scientific and technological resources is the foundation, improvement of the scientific and technological management mechanism is the guarantee, and innovation achievements and innovation are the key points. It will further enhance the technological innovation and development of power grid companies, continue to promote the development level of power grid companies, and provide support for grid companies to become world-class energy companies.

4. Science and technology innovation evaluation method based on benchmarking

Using the linear power coefficient method, each index is assigned a score, and the score interval of each index is set to [50,100], which is divided into 5 intervals and the interval is 10.
According to the relationship between each index and the value of the power coefficient, all kinds of indexes can be roughly divided into two types: the first type is an extremely large variable. The value of the power coefficient of a single item increases with the value of the corresponding index, so this index is an extremely large variable. The second is a very small variable. The power coefficient of a single item decreases with the increase of the value of the corresponding indicator, so this indicator is a very small variable.

For the indicators that fall into different intervals, the calculation methods of the power factor values are as follows according to the different types of indicators.

First, the calculation formula of the power factor value corresponding to the extremely large variables.

$$d_{i1} = \frac{X_i - X_{si}}{X_{hi} - X_{si}} \times a + a' \quad X_i < X_{hi}$$

($$d_{i1}$$ is the power factor value corresponding to the $$i$$very large variable, $$X_i$$ is the actual value of the $$i$$very large variable, $$X_{hi}$$ is the upper limit of the interval of the $$i$$very large variable, and $$X_{si}$$ is the lower limit of the interval of the $$i$$very large variable.)

Second, the formula for calculating the power factor corresponding to the extremely small variable.

$$d_{i2} = \frac{X_i - X_{si}}{X_{hi} - X_{si}} \times a + a' \quad X_i > X_{hi}$$

($$d_{i2}$$ is the value of the $$i$$power coefficient corresponding to the smallest variable, $$X_i$$ is the actual value of the $$i$$smallest variable, $$X_{hi}$$ is the upper limit of the interval of the $$i$$smallest variable, and $$X_{si}$$ is the lower limit of the interval of the $$i$$smallest variable.)

Based on the score result of a single indicator and the weight setting of specific indicators in each dimension, calculate the comprehensive score $$D_{ij}$$ of each dimension separately, as follows:

$$D_{ij} = \sum_{i=1}^{m} d_{ij} \omega_{ij}$$

Where $$d_{ij}$$ is the power factor value of the specific index in the jth dimension, and $$\omega_{ij}$$ is the weight corresponding to the specific index in the jth dimension.

The weight setting of each dimension and the comprehensive score results of each dimension are integrated to calculate the world-class comprehensive score $$D$$ of the enterprise, as follows:

$$D = \sum_{j=1}^{n} D_j$$

Among them, $$D$$ is the comprehensive evaluation score of the enterprise and $$D_j$$ is the comprehensive score of the jth dimension.

5. Evaluation system of technology innovation index of power grid enterprises based on peer benchmarking

Using the provincial power grid enterprise scientific and technological innovation index system and evaluation method, the main principles of the system are large scale, strong driving force, high innovation ability, and good data structure. Screening Beijing, Tianjin, Shandong, Jiangsu and Zhejiang for Empirical analysis objects, using the 2018 data to rank the five provincial power grid companies overall, to determine their position in the provincial power grid companies, and analyze the main advantages and gaps. At the same time, the countermeasures to improve the competitiveness of science and technology are put forward in a targeted manner. On the basis of the trial calculation results, this subject classifies the technological innovation level of provincial power grid enterprises and analyzes the reasons for the gap.
At present, the evaluation system of the provincial power grid enterprise scientific and technological innovation index evaluation trial includes 14 key indicators of 4 primary dimensions and 8 secondary dimensions. In the process of calculation, part of the current data information is obtained through the support of the scientific and technological department of the power grid enterprise, and the remaining data information is graded by inviting well-known experts in the system.

Table 1 empirical indicators of technological innovation of provincial power grid enterprises

| Serial number | The secondary dimension          | Key indicator name                      | Unit     |
|---------------|----------------------------------|----------------------------------------|----------|
| 1             | Invest resources                 | The intensity of scientific research funding | %        |
| 2             | Invest resources                 | Talent equivalent density              | /        |
| 3             | Innovative entrepreneur          | Proportion of entrepreneur resources    | %        |
| 4             | Innovation platform              | Number of national/provincial laboratories | Pc      |
| 5             | Innovation platform              | Number of major national science and technology projects undertaken | Pc      |
| 6             | Innovation management            | Training of scientific researchers      | The relative indicator /% |
| 7             | Innovation management            | Innovation incentive effect             | The relative indicator % |
| 8             | Achievemen output                | National/provincial awards              | value    |
| 9             | Achievemen output                | Number of invention patents             | value    |
| 10            | Achievemen output                | Quality of research results              | %        |
| 11            | Achievement transformation       | Patent conversion income                | value    |
| 12            | Economic benefit                 | "Double Innovation" Economic Benefits   | %        |
| 13            | Social benefit                   | The leading role of related industries  | /        |

(1) Overall actual evaluation results
The research group first made a comprehensive score, and the score results were as follows:

Table 2 Overall ranking of provincial power grid enterprises

| Serial number | Grid enterprises                          | Total score | Overall ranking |
|---------------|------------------------------------------|-------------|----------------|
| 1             | Beijing Electric Power Grid Enterprise   | 87.2        | 1              |
| 2             | Tianjin Electric Power Grid Enterprise   | 77.9        | 4              |
| 3             | Shandong Electric Power Grid Enterprise  | 78.2        | 3              |
| 4             | Jiangsu Electric Power Grid Enterprise   | 75.7        | 5              |
| 5             | Zhejiang Electric Power Grid Enterprise  | 84.1        | 2              |

As can be seen from the analysis in the following figure, among the five provincial power grid enterprises, Beijing power grid enterprise, Zhejiang power grid enterprise and Shandong power grid enterprise are the top three. The average values of the five grid enterprises are 20.6, 21.0, 18.3 and 20.7, respectively. Compared with the other three aspects, the provincial power grid enterprises have the worst performance in innovation achievements.

(2) Display of scores of each secondary evaluation dimension
In the dimension of innovation foundation, the average value of the five provincial power grid enterprises invested in resources, innovative entrepreneurs, and innovation platforms are 6.9, 7.0, and
6.7 respectively. In terms of input resources, Beijing Power Grid Enterprises and Tianjin Power Grid Enterprises are at the forefront.

The situation of the secondary dimension is shown in the figure below. Provincial grid enterprises perform poorly on the innovation platform, and the supporting role of entrepreneurs and invested resources on the innovation foundation is more obvious.

In terms of innovation process dimensions and innovation management, the average value of the five provincial power grid companies in the training of scientific research personnel and innovation incentives were 10.8 and 10.2, respectively. Among which Beijing power grid companies, Tianjin power grid companies and Zhejiang power grid companies were basically in the top three. As shown in the figure below, the provincial power grid companies in developed regions have paid more attention to personnel training and incentives, which also reflects the risk of brain drain and the difficulty of echelon construction.

In terms of the dimension of innovation achievements, the average value of achievement output and achievement transformation is 7.6 and 10.7 in the five provincial power grid companies respectively; in terms of achievement output, the patent output of Shandong power grid companies is far ahead, but the overall innovation output level of the provincial power grid companies is still relatively low; in terms of achievement transformation, the performance of southern provinces is better than that of northern provinces. This situation may be related to the development of innovation markets in different regions.

In terms of the dimension of innovation and effectiveness, the average economic benefit and social benefit of the five provincial power grid enterprises are 10.6 and 10.0 respectively. Zhejiang has outstanding performance in two aspects. In addition, Beijing and Jiangsu have advantages in economic and social benefits, respectively.

6. Results application and analysis
Provincial power grid enterprises' scientific and technological innovation activities need to rely on major projects and scientific and technological projects, and coordinated with grid companies and their own needs. From the analysis results, there is still much room for improvement in the level of technological innovation of provincial power grid enterprises. The overall performance is shown as important investment, insufficient process management flexibility, less output and conversion of results, and a greater gap between innovation and effectiveness.

At present, the operating profitability of provincial power grid enterprises is further reduced, and the profitability is further narrowed. There is an urgent need to accelerate the transformation of the working logic of important investment and light mechanism transformation, and change the situation of "science and technology to accompany the run". First, in the field of science and technology, accelerate the implementation of provincial power grid enterprises' powers in engineering management, talent management, project management and institutional management, and simplify the technology management process; The second is to promote the provincial power grid enterprises to further strengthen the cultivation and incentive of scientific research talents, and establish a rich talent reserve as soon as possible in important fields and emerging fields; Third, with the help of infrastructure sharing, provincial power grid enterprises should actively expand the internal and external innovation markets of the system and strengthen the transformation of results.

Table 3 Analysis of the advantages and disadvantages of technological innovation of provincial power grid enterprises and influencing factors

| First dimension       | Advantage                                                                 | Disadvantage                                                                 |
|-----------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Innovation foundation | With continuous investment in scientific research resources, the main professional talent echelon is relatively complete; there are many types of professional leading | 1. The lack of top experts and talents in emerging fields and the lack of comprehensive scientific research personnel; 2. R&D investment is constrained by |
experts, which play a big role; provincial grid enterprises undertake the construction of national and grid enterprise-level laboratories and bases, and their scientific research capabilities are rapidly improved.  

| Innovation process | Provincial power grid enterprises pay more attention to scientific research, continue to optimize the management of scientific research projects, and pay more attention to the cultivation and incentive of scientific and technological talents. |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                     | 1. The project management process is still relatively cumbersome, and the lack of decentralization of approval authority, project duration and other restrictions have greatly improved technological innovation;  
                        | 2. Provincial power grid enterprises are insufficient in planning their own scientific research needs and organizing their own scientific and technological projects. |

| Innovation achievement | There are abundant innovation achievements and more application scenarios; some achievements have high technological content, and some have reached the international level. |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | 1. The conversion channels are limited and the conversion rate is still low;  
                        | 2. The market-oriented business model of scientific research achievements has not yet been established, and the conversion income is relatively low. |

| Innovation and effectiveness | The driving force of scientific and technological innovation is strong, and the sharing of scientific research infrastructure such as laboratories is conducive to further enhancing the economic and social benefits of innovation. |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                            | 1. The immature internal and external innovation markets limit the sharing of innovation results;  
                        | 2. It is more difficult for provincial power grid enterprises to operate, and reducing the cost of technological innovation, completing basic scientific research tasks, and boosting revenue may become major concerns. |

Acknowledgement
This research was financially supported by the SGCC’s science and technology projects—Research on the power transmission model and evaluation index system of "five chains" fusion under the new corporate strategy

References
[1] Bloomstrom, Kokko, and Zejan, "Host Country Competition, Labor Skills, and Technology Transfer by Multinationals", Weltwirtschaftliches Archiv, vol.34, (1994).
[2] Kokko A., “Technology, Market Characteristics and Spillover”, Journal of Development Economics, vol. 43, (1994).