Key technology and evaluation management of Green Power Grid construction

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Abstract. The construction of Green Power Grid is not only a strong measure responding to national policy to build beautiful China for power grid enterprises, but also one of the social responsibilities they should take. Combining both domestic and international green building standards, this paper is aimed to introduce and summarize the design management, investment research and post-evaluation management in the construction of Green Power Grid of Guangdong Power Grid Corporation.

1 Introduction

Building Green Power Grid, namely actively using low-pollution and even non-polluting technologies, processes and techniques during construction and operation of the power grid, and reducing the consumption of high-pollution energy, as well as positively taking the responsibilities of environmental protection, are the innate missions for power grid enterprises[1]. It is also the inevitable choice to improve the efficiency of energy utilization, develop emerging technologies, build ecological civilization and achieve a win-win situation between power development and environmental protection [2]. As a member of power grid construction, Guangdong Power Grid Corporation is always active in green standard benchmarking with various construction industries both at home and abroad and Green Power Grid research, and consciously incorporating the concept of Green Power Grid into all aspects of design, review and cost management, so as to establish a comprehensive and sound system for evaluation and management.

2 Current standards of green building

2.1 Foreign green building evaluation standards

Ever since the concept of green building was first proposed in the *United Nations Conference on Environment and Development (Earth Summit)* held in Rio de Janeiro, Brazil in 1992, the progress of green building has been drawing attentions worldwide. After a decade of development, the research on green building in China has been gradually upgraded from individual, technical level to systematic level, and extended from architectural design to multiple fields such as environmental assessment and regional planning, which is now becoming holistic, comprehensive and interdisciplinary.

Most of the developed countries and regions in the world have promulgated their own green building evaluation standards successively, such as LEED in America, BREEAM in UK, DGNB in Germany, CASBEE in Japan, Green Star in Australia, HQE in France, Green Mark in Singapore, HK-BEAM standards in Hong Kong and so on. These standards all reflected the demands of sustainable development, namely the “four sections” (land saving, energy saving, water saving and material saving) and environmental protection, which were involved throughout the whole life cycle of a building, containing the stages of design, construction and operation. By establishing authoritative system of green building evaluation, countries can better regulate green building management, provide guidance for green building development, and strengthen market orientation. The green evaluation standards issued by various countries are shown in Fig. 1.

Figure 1. Distribution map of foreign green building evaluation standards

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2.2 Chinese green building evaluation standards

2.2.1 Green building evaluation standard

The latest version of Green Building Evaluation Standard (GB/T50378-2014) was published in December 2014. The new standard extended the scope of application from residential buildings and certain types of public buildings such as office buildings, commercial buildings and hotel buildings to all sorts of civil buildings [3]. The new standard clearly divided the evaluation into two aspects, namely design and operation. For the evaluation of operation, *Operation Management* and *Construction Management* were added based on the five existing categories, including *Land Saving and Outdoor Environment*, *Energy Saving and Energy Utilization*, *Water Saving and Water Resource Utilization*, *Material Saving and Material Resource Utilization* and *Indoor Environment Quality*. The evaluation method was also adjusted, where the score counting were adopted to determine the level. With each evaluation indicator passing the required minimum score, the total score is added up to determine the green building level. In addition, the regular items and premium items in the old standard were merged into rating items in the new one, and bonus items were employed to encourage the innovation and improvement of green building technology and management in resource conservation and environmental protection.

2.2.2 Guidelines for Evaluation of Green Industrial Buildings

The Guidelines for the Evaluation of Green Industrial Buildings was issued in August 2010, with seven categories: *Land Saving and Sustainable Sites*, *Energy Saving and Energy Utilization*, *Water Saving and Water Resource Utilization*, *Material Saving and Material Resource Utilization*, *Outdoor Environment and Pollutants Control*, *Indoor Environment and Occupational Health*, and *Operation Management* [4]. Technological progress and innovation items were added to encourage innovation and improvement in technology and management of industrial buildings.

3 Green Power Grid design management

In view of design and evaluation of Green Power Grid projects, Guangdong Power Grid Corporation has formulated relevant management system and requirements. Design departments is asked to carry out targeted design work of Green Power Grid throughout the design process.

3.1 Green Power Grid rating target

During the feasibility study stage, the target of the green evaluation level of the project should be proposed by design departments according to its Green Power Grid construction plan and specific technical conditions, which serves as the basis for classification of green level in the subsequent stages.

3.2 The performance of evaluation indicators and the level of division

During the feasibility study and preliminary design stage, Guangdong Power Grid Corporation requests design departments to set up chapters in their reports, and check the application condition of each mandatory item, regular item and premium item for the project corresponding to the "3C Green Power Grid Construction Guideline (Green Part)". For any inapplicable situation, brief explanation is required. Based on the application condition of the evaluation indicators, the green level of the project is ultimately determined by the approval opinions of review departments, also according to the "3C Green Power Grid Construction Guideline (Green Part)".

3.3 The investment and benefit analysis of Green Power Grid

During the feasibility study and preliminary design stage, considering both the feasibility analyses and the relevant investment requirements regulated by the depth of the preliminary design, relevant departments should carry out the analysis of changes in Green Power Grid investment and the whole life-cycle economic benefits.

3.4 Technical solutions on the green indicator

During the construction drawing design stage, according to the selected green evaluation indicators, the design departments ought to focus on specific implementation measures combined with the actual situation of the project. Implementation measures should cover specific technical programs, technical indicators, etc. and compare with the requirements of the green evaluation indicators.

3.5 Green Power Grid implementation

During the Green Power Grid implementation stage, the design departments are required to issue a "Green Power Grid Design Plan", and implement the principles of Green Power Grid identified by preliminary design into construction drawings, which are considered as a special review for the construction plans review. The design departments are also required to submit Green Power Grid design results to the construction departments.

4 Green Power Grid Investment Research

The purpose of building Green Power Grid is to construct environmentally friendly substations, transmission lines and distribution networks that have the advantage of land-saving, energy-saving, material-saving, and water-saving. To investigate the impact of Green Power Grid construction on project cost, Guangdong Power Grid

Corporation has conducted a Green Power Grid investment research so as to carry out Green Power Grid planning and construction more reasonably, and eventually achieve a win-win situation for economic benefits and social benefits [5].

4.1 Research principles

1) The impact of undetermined factors do not be considered. Relevant indicators for investment such as site selection, topography, traffic environment and route are analyzed, while the relevant indexes such as house demolition, deforestation and land value are not included in analyzation.

2) Indicators related to design input conditions, such as wind pressure and altitude, should all be assumed according to the standard design of China Southern Power Grid, with a certain representation.

3) For different level of equipment procurement, estimated quota should be adopted to set the base of a uniform platform. For different technical indicators such as energy consumption, noise, electromagnetic, enquiries with various manufacturers should be taken to determine the price difference, so as to find out the regularity of effects of green level on investment estimation.

4) Economic research is conducted by combining the maximum and the minimum investment portfolio within the reasonable range of actual project requirements to ensure a representative indicator analysis.

5) Various typical cost options should be selected or merged.

4.2 Research methods

The theory of incremental analysis is to analyze the difference between cost and benefit of the compared schemes, and then optimize the scheme. The significance of this analysis lies in judging the economic rationality of incremental investment, that is, whether a large investment program can bring satisfactory incremental revenue compared to a small investment program. Net present value, net annual value, payback period, internal rate of return and other indicators can be used for incremental analysis.

The basic method for the economic evaluation of the Green Power Grid by Guangdong Power Grid Corporation is to compare the original projects and examine the economic effects of each reform measure based on the increments including changes in investment, costs and annual operating expenses, that is, incremental investment analysis method is used for economic analysis, and various investment portfolios are examined based on the diversity of indicators.

4.3 Research results

The investment incrementary ratio of green substations at all levels are as follows:
Level 1: Minimum investment increment combination, -0.37% ~ 0.70%; Maximum investment increment combination, 5.95% ~ 12.10%.
Level 2: Minimum investment increment combination, -0.35% ~ 0.75%; Maximum investment increment combination, 6.3% ~ 12.10%.
Level 3: Minimum investment increment combination, 0.21% ~ 4.73%; Maximum investment increment combination, 6.64% ~ 12.39%.

The investment incrementary ratio of green transmission lines at all levels are as follows:
Level 1: Minimum investment increment combination, -1.37% ~ -0.04%; Maximum investment increment combination, 15.86% ~ 23.14%.
Level 2: Minimum investment increment combination, -1.17% ~ -0.0%; Maximum investment increment combination, 15.89% ~ 23.19%.
Level 3: Minimum investment increment combination, -0.99% ~ 7.38%; Maximum investment increment combination, 15.89% ~ 23.19%.

The investment of green distribution network at all levels is increased as follows:
Level 1: Minimum investment increment combination, -1.468% ~ -28.894%; Maximum investment increment combination, -0.024% ~ 59.7%.
Level 2: Minimum investment increment combination, -1.54% ~ -28.813%; Maximum investment increment combination, -0.992% ~ 59.07%.
Level 3: Minimum investment increment combination, -1.514% ~ 28.652%; Maximum investment increment combination, 0.885% ~ 57.623%.

Through the investigation, the investment levels of Green Power Grid construction were determined by Guangdong Power Grid Corporation, which can provide better guidance for Green Power Grid planning and construction. With the green power grid investment analysis as bases, the construction departments can better grasp the economic measures and make favorable decisions when conducting Green Power Grid plan.

5 Green Power Grid post-evaluation management

5.1 Evaluation organization

In order to better conduct the construction of Green Power Grid, and test the construction effectiveness of Green Power Grid projects, Guangdong Power Grid Corporation actively carried out post-evaluation management for Green Power Grid and has established a complete post-evaluation management system [6]. For Green Power Grid evaluation, Guangdong Power Grid Corporation serves as the organizer, with construction departments, design departments, construction departments, supervision departments and operation department of the project as participators, and a third-party expert group is founded during each evaluating process.

The evaluation is carried out through centralized assessment by the expert group, whose members should be experienced in construction, design and consultation of power grid projects, covering the fields of electrical and civil engineering. Besides, the selected experts should be qualified with technical titles of intermediate

and above.

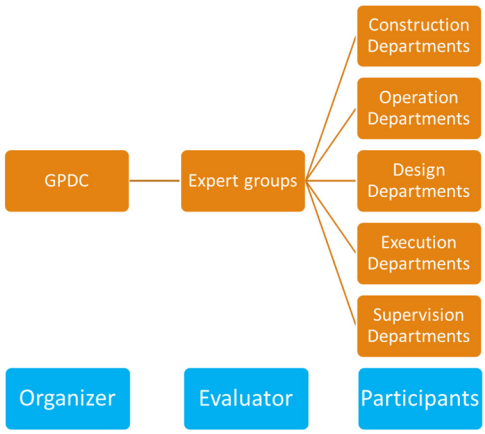

Figure 2. Framework of Green Grid Evaluation by Guangdong Power Grid Corporation

5.2 Evaluation procedure

The evaluation of newly-built Green Power Grid project by Guangdong Power Grid Corporation take place after one-year commissioning. Firstly, the construction departments undertake self-assessment, and submit a written application for evaluation of green substations / transmission lines / distribution network to Guangdong Power Grid Company after passing self-assessment. Next, a third party expert group is appointed by the subsidiary company to evaluate the Green Power Grid formally. Evaluation of Green Power Grid is based on self-assessment of the construction departments. Evaluation agencies inspect the site and check relevant technical and management materials, after which the Green substations / transmission lines / distribution network levels are determined accordingly. The flow chart is shown in Figure 3.

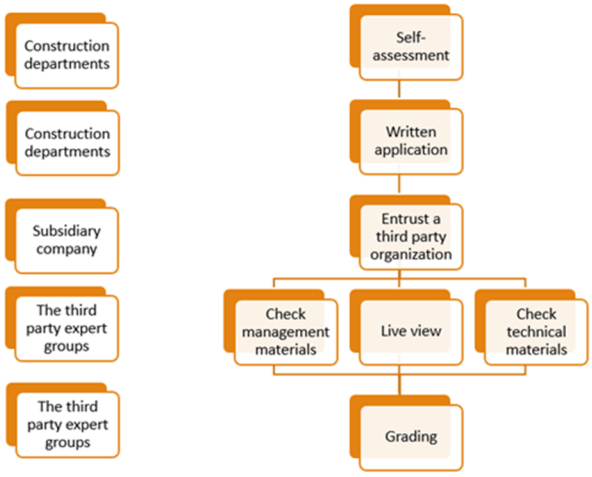

Figure 3. Flow chart of Green Grid Evaluation by Guangdong Power Grid Corporation.

5.3 Evaluation materials

Applicants should first complete the entire life-cycle technical and economic analysis of the power grid, and then process control over site selection, design, construction and operation stages according to regulations with relevant documents submitted. Green Power Grid evaluation materials include:

Project approval documents and product manual;

Completed drawings, design specifications, and project inventory;

Product Routine Test Report;

Product Testing Report;

Water supply and drainage quality inspection report;

Water consumption record report;

Materials of project final bill (material manufacturer's name and address);

Soil and water conservation and environmental impact assessment acceptance report;

Specific section of Green construction organization design, and record of green construction requirements and technical disclosure by construction group;

Construction process records and supervisor records;

Field test report (after operation);

Green Power Grid evaluation data should be documented according to the regulations.

6 Conclusion

Building Green Power Grid is a powerful measure for grid enterprises to respond to national policies of building a beautiful China, and is one of the social responsibilities they have to take. A construction enterprise of power grid must fully broaden its horizons, positively benchmark advanced national and international green building standards and industrial building standards, recognize the trend in development of key technologies for Green Power Grid construction, and well organize Green Power Grid design management, cost management and post-evaluation management.

References

1. A Hu. China: Green development and Green GDP (1970-2001). Bulletin of National Natural Science Foundation of China. 84-89, **2** (2005).
2. A Hu. The implementation of green development strategy is the only way for China. Green Leaf. 50-51, **6**(2003).
3. H Lin, Z Ye, L Ye. The New Green Building Standard - Interpretation of the National Standard "Green Building Evaluation Standard" GB/T50378-2014. Construction Science and Technology. 10-14, **16** (2014).
4. T Zhong, M Liu.Comparative Analysis of Evaluation System of Green Industrial Buildings in China and Abroad. Journal of Civil, Architectural &Environmental Engineering. 1-3, **s2** (2012).
5. China Southern Power Grid. The 12th Five-year Energy Saving and Emission Reduction plan for China Southern Power Grid. (2012) No. 10.
6. China Southern Power Grid.3C Green Power Grid construction guide. (2012) No.52