Research on the Construction Management and Sustainable Development of Large-Scale Scientific Facilities in China

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Abstract—As an important platform for scientific and technological development, large-scale scientific facilities are the cornerstone of technological innovation and a guarantee for economic and social development. Researching management of large-scale scientific facilities can play a key role in scientific research, sociology and key national strategy. This paper reviews the characteristics of large-scale scientific facilities, and summarizes development status of China's large-scale scientific facilities. At last, the construction, management, operation and evaluation of large-scale scientific facilities is analyzed from the perspective of sustainable development.

1. Introduction
Since mid-20th century, a new trend showed in scientific advancement, that was, large-scale scientific facilities was becoming increasingly important to the major scientific breakthrough progress. The large-scale scientific facilities are regarded as an important component of basic research and a hiding drive of innovation. Since then, heavy investment was allocated in building large-scale scientific facilities. Developed countries, such as the United States, Germany, the United Kingdom and Japan, established a comprehensive science center relying on large-scale scientific facilities. These science centers conducted international scientific research, and has achieved a series of major achievements. Similarly, China has been building large-scale scientific facilities in order to build a scientific and technological innovative country. Under such situation, construction management and sustainable development on large-scale scientific facilities is very important in China. This paper will research on construction management and sustainable development of China's large-scale scientific facilities.

2. The concept of large-scale scientific facilities.
Large-scale scientific facilities have different names in different countries. China called the large-scale scientific facilities for the major scientific and technological infrastructure. Large-scale scientific facilities is a large facility which is built through large-scale investment and engineering construction for the purpose of achieving key scientific and technological goals through long-term stable operation and continuous scientific and technological activities. The scientific and technological goals of large-scale scientific facilities should be geared to the forefront of science and technology and to contribution to national economic development, national security and social development. According to different application purposes, large-scale scientific facilities can be divided into three types: public experiment platform, special research device and public welfare infrastructure. Large-scale scientific facilities are an important foundation in the construction of innovation system, which is a necessary condition for a breakthrough in modern scientific research. It is also a strong ability of large-scale
scientific facilities to promote the development of multidisciplinary and to break high-tech breakthrough bottleneck. Large-scale scientific facilities are an important symbol of a national science and technology strength and the comprehensive national strength. The construction and utilization of large-scale scientific facilities are very different from the general scientific instruments and equipment. Also, it is different from general construction projects. The special points of the large-scale scientific facilities are shown as follow:

1 Building large-scale scientific facilities is of great significance, and have wide and long-term impacts. Meanwhile, both scale and cost of construction are large and the duration of construction is long.
2 Comprehensive and complex technology is needed in the construction of large-scale scientific facilities, a large number of non-standard equipments are also needed.
3 Large-scale scientific facilities output is scientific knowledge and technological achievements, rather than direct economic benefits. The target of large-scale scientific facilities will be achieved through long and stable operation and continuous scientific activities after the completion of the construction.
4 From the whole process of establishment to utilization, large-scale scientific facilities has shown strong openness and internationalization.

3. The construction of large-scale scientific facilities in China.
In recent years, many large-scale scientific facilities were built or planned with the increase of investment in science and technology in China. Since the reform and opening up, China's investment in major scientific and technological infrastructure sees a considerable increase. There were two major scientific projects during the “seventh five-year period”. Project investment in large-scale scientific facilities was 340 million CNY, but investment increased to nearly 4 billion CNY during the period of “ninth five-year plan” and “tenth five-year plan”. In this term, China deployed twelve large-scale scientific facilities, including the spallation neutron source and the strong magnetic field. The total investment was more than 6 billion CNY during the “eleventh Five-Year” period. China deployed sixteen large-scale scientific facilities in seven scientific fields. During the “twelfth Five-Year Plan” period, the total investment was more than 10 billion CNY. The specific situation is shown in the Chart 1. The construction of large-scale scientific facilities in China has shown a trend of increasing year by year both in quantity and the amount of investment. As the country strengthens the top level planning and increased investment of large-scale scientific facilities, the scientific and technological strength of our country will be in the forefront of the world.

(Note: some data is missing)

Chart 1 Large-scale scientific facilities situation from the tenth Five-Year Plan period to the thirteenth Five-Year Plan period

Chinese Academy of Sciences is the main force for the construction and operation of China's large-scale scientific facilities. Their construction of major large-scale scientific facilities has been steadily advancing. These facilities include Beijing electron positron collider (BEPC), large-scale
heavy ion research device (HIRFL), etc. They play an important role in basic scientific research and economic and social development in China. Currently, seventeen large-scale scientific facilities run in Chinese Academy of Sciences and are distributed in different provinces. The amount is shown in Chart 2.

![Chart 2 The amount of large-scale scientific facilities in different provinces](image)

4. Construction management and sustainable development of China's large-scale scientific facilities

China will focus on the construction of 16 large-scale scientific facilities in the thirteenth Five-Year Plan period. The number will reach dozens plus the large scientific devices that have been built. The construction and management of these large-scale scientific facilities are particularly important. In particular, the sustainable development of large-scale scientific facilities is more important. While due to the short history of large-scale scientific facilities development in our country, some management methods are not perfect enough. There is a need to develop a long-term management plan according to large-scale scientific facilities characteristics. The following advices are suggested.

4.1 Establish a scientific management system to promote the opening and sharing of large-scale scientific facilities.

The public property and resource scarcity of large-scale scientific facilities require that the facilities to be shared to maximize utility. The user participation mechanism should be strengthened aiming to form joint management and promote share among research institutes, universities and enterprises. It should be fully open to domestic and foreign users under certain conditions. Attract top talents and outstanding teams at home and abroad to carry out research by devices. Build the large-scale scientific facilities laboratory into talent training base and popular science education base. Attract foreign resources to participate in the construction of large-scale scientific facilities for introduction of foreign advanced technology and management experience.

4.2 Guarantee enough investment to ensure the normal operation of large-scale scientific facilities.

The operation and development of the large-scale scientific facilities are mainly supported by government investment. The government should set up a special fund for the construction and operation of large-scale scientific facilities. The special funds mainly include two parts. One is construction funds and the other is operation funds. The construction funds are mainly used for the early research, construction and major reform of large-scale scientific facilities. The operation funds are mainly used for the daily operation, maintenance and improvement of large-scale scientific facilities. There should be enough investment in the construction and management of large-scale scientific facilities to guarantee the project quality. The government should ensure the continuous
investment to guarantee large-scale scientific facilities sustainable development.

4.3 Promote transformation of scientific and technological achievements from large-scale scientific facilities.

The research institutions of large-scale scientific facilities should establish the transformation platform of scientific and technological achievements with local enterprises. Promote the application of the industrialization of scientific and technological achievements for local economic development. Develop science and technology service industry, including technical consultation industry, intellectual property services industry concerning large-scale scientific facilities to optimize local industrial structure. Large-scale scientific facilities should also promote enterprise-university-research institute cooperation, thereby serving for economic development.

4.4 Establish a scientific evaluation system to promote healthy development of large-scale scientific facilities.

Establish an evaluation system in accordance with the characteristics of the scientific activities to make the best use of large-scale scientific facilities. The index directly reflects the operation efficiency and quality of the device. The scientific evaluation criteria should include: operation conditions of the device, the realization of the experimental target, the level of equipment management, research personnel training, research fund use effect, etc. The evaluation system should be set up according to both state current situation and international standards. Followed by the international practice, the evaluation cycle is once a year.

5. Conclusion

The large-scale scientific facilities are important research and development infrastructure. The facilities have significant economic and social impacts as construction management of large-scale scientific facilities belongs to the field of basic research engineering. National and international advanced experiences of the construction should be studied and learnt to promote the sustainable development of large-scale scientific facilities. China needs to attach importance to construction, management operation, open sharing service and evaluation mechanism of large-scale scientific facilities for developing towards an innovative country.

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