



Research on EPC Construction Mode of China Informatization Project

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Abstract: EPC(Engineering, Procurement, Construction) has a history of decades in global development, has been introduced to China for more than 40 years, and is widely used in China's chemical, electric power, construction, energy, and other construction projects. With the development of informatization in China, the construction mode of informatization projects continues to evolve, and the EPC construction mode has also been applied and promoted in the informatization industry and has promoted the construction efficiency of informatization projects. The author analyzes and studies the development of EPC in China and the application and practice of EPC mode in informatization projects, and makes a case analysis through the EPC construction mode practice of informatization projects. Through the analysis and case study, the author provides reference and reference for the construction of informatization projects using EPC mode in the development of the digital economy in China.

Keywords: informatization project, smart city, government informatization, EPC project, general contracting

Introduction

Since 2010, smart city construction has become synonymous with the construction of informatization projects in China, and smart city projects have played a key role in the development of the information industry and digital economy. Due to the increasing investment scale of informatization construction projects, more and more stakeholders, more and more complex data fusion and application integration, and more and more difficult project management, informatization project construction mode has received attention and research from all walks of life, among which EPC mode is the most sought after and recognized. However, the application of the EPC mode in informatization projects is still in exploration and practice, and owners and general contractors still lack theories, tools, and methods that can be used for reference. How to adopt EPC mode in informatization construction projects and carry out effective management and control is the primary question studied and answered in this paper. The project phase division of EPC mode is different from that of PMI and OGC, and information construction projects also include software engineering, and the changing demand leads to a huge workload of customized development. How to combine software engineering and EPC mode and manage them is also crucial.

Literature Review

The operation mode of general engineering contracting first originated in the 1960s, and the operation mode of China's EPC engineering contracting project originated in the 1980s^[1]. The operation mode of EPC projects has been applied more and more widely in China's engineering project management and has made considerable development and progress^[2]. EPC is a variant of the "Design-Build" procurement system^[3] and an expansion and extension based on "Design-Build". EPC not only includes the specific design but also the overall planning of the entire project implementation content and the organization and management planning of the entire implementation process^[4]. In a broad sense, informatization projects refer to newly built, expanded, or operated maintenance projects that take modern information technology as the main means of information infrastructure construction, information network construction, information application system construction, information security construction, system integration, and information resources development and utilization^[5]. China's informatization projects account for a relatively large proportion of the field of government affairs. The Smart City is an advanced form of urban informatization after the digital city and intelligent city, and a deep integration of informatization, industrialization, and urbanization^[6]. On April 11, 2016, the National Development and Reform Commission and the Cyberspace Affairs Commission of the CPC Central Committee co-chaired the First meeting of the "Inter-Ministerial Coordination Working Group on New Smart Cities", which pointed out that new smart cities are a positive practice to implement the development of "five modernizations" such as informatization^[7]. Under the current government-led development model, most investment entities of smart city projects are still local governments, and one of the main construction modes of smart city projects is EPC^[8], which accounts for the largest proportion^[9].

Origin of EPC

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EPC mode has been widely used in domestic and foreign engineering projects, involving construction, power, water conservancy, petroleum, and petrochemical industries. The so-called EPC (Engineering, Procurement, Construction) mode refers to the contracting of the whole process or several stages of the survey, design, procurement, construction, and trial operation (completion acceptance) of the engineering project, which is entrusted by the owner.

The EPC model originated in the United States in the 1960s, developed rapidly in the 1970s, gradually took shape in the 1980s, and was widely adopted. By the 1990s, EPC general contracting mode had become the mainstream mode of international project contracting. In 1999 FIDIC (International Federation of Consulting Engineers) issued a contract template specifically for this model. According to relevant statistics, the proportion of EPC general contracting mode in international large-scale engineering projects exceeds 80% ^[10].

EPC development in China

After the implementation of reform and opening up in 1979, China introduced a large number of foreign advanced technologies and complete sets of equipment. At the same time, foreign funds and project contractors also entered the Chinese market, bringing to China the internationally accepted method of project management and project contracting.

In the early 1980s, the former Ministry of Chemical Industry took the lead in exploring the promotion of project general contracting in design units. In 1982, the former Ministry of Chemical Industry issued the notice "Opinions on Reforming the current management System of Capital Construction and Trying out the design-based General Contract System of Projects" ^[11]. At the end of the year, the Ministry of Chemical Industry and the Jiangxi Province jointly determined that Wuhan Chemical Engineering Company would be responsible for the urea project of Jiangxi ammonia plant under the general contract system based on design, which was the first trial in China.

After China acceded to the WTO at the end of 2001, the protection period of the construction industry was applied for 6 years, but the market must be unconditionally opened 12 years after China acceded to the WTO ^[12]. In this international situation, The State Council calls for the acceleration of the project general contracting model.

After more than 40 years of research on EPC development in China, it is concluded that its development has experienced four stages: pilot, promotion, standardization, and development. The pilot phase completed the first batch of 12 project general contracting pilot units, the second batch of 31 project general contracting pilot units, and the survey and design units in 21 industries. The promotion stage mainly completes the Grade A and B qualification certification of the general contracting of the project and the deepening reform of the survey and design unit system. The landmark event of the regulation stage is that in May 2005, China's first national standard "Construction Project General Contracting Management Code" was formally promulgated, and in September 2011, the Ministry of Housing and Urban-Rural Development and the State Administration for Industry and Commerce jointly issued the "Construction Project General Contracting Contract Model Text (Trial)". The development stage has realized the comprehensive development of the general contracting of the project from the industrial field to the construction, municipal, transportation, and other professional fields, and the Ministry of Housing and Urban-Rural Development and the National Development and Reform Commission formulated the "Management Measures for the General Contracting of Housing Construction and Municipal Infrastructure Projects" on December 23, 2019. On November 25, 2020, the Ministry of Housing and Urban-Rural Development and the General Administration of Market Supervision issued the "Construction Project General Contracting Contract (Model Text)", which is not only the landing of the major strategic deployment of the Party Central Committee and The State Council to promote the general contracting of projects but also effectively promote the rule of law and professional development of China's general contracting of projects.

The practice of EPC in China's informatization projects

Evolution of China's informatization project construction mode

Informatization is a historical process of making full use of information technology, developing and utilizing information resources, promoting information exchange and knowledge sharing, improving the quality of economic growth, and promoting the transformation of economic and social development ^[13]. The author summarizes the evolution of China's informatization project construction mode, which has experienced four stages and four modes.

(1) The development mode in the period of planned economy

From the early days of the founding of New China to the Third Plenary Session of the Eleventh Central Committee, China was under the planned economy system, and the construction task was issued by the administrative department using the mandatory plan, during this period, bidding was suspended, and China's informatization projects adopted the research and development mode. The domestic universities, research institutes, design institutes, and other units are responsible for the design and development, and the state-owned communication construction company and its affiliated construction enterprises are responsible for the production and construction, that is, the construction mode of "first research, then application".

(2) The general contracting mode with design as the main body in the initial stage of the market economy

Since the reform and opening up, China has entered the era of a market economy system, especially in the field of information technology, foreign technologies and products have been introduced into China, which has promoted the rapid development of information applications. Major domestic design units closely follow the market system and

transform to the design-build mode. Design units complete the design and implementation of informatization projects by cooperating with product and equipment manufacturers, construction and installation enterprises, and secondary developers, and design units play the role of the general contractor or sole contractor in the whole process.

(3) The rise of the system integration construction model at the turn of the century

At the end of the last century, China's informatization project construction entered a stage of rapid development, and computer information system integration gradually emerged in domestic academia, industry, and government. To strengthen the standardized management of the computer information system integration market, the former Ministry of Information Industry formulated and issued the "Measures for the Management of Computer Information System Integration Qualifications". In the following 10 years, the system integration construction mode has played a huge role in promoting the construction of informatization projects and industrial development in China.

(4). In the 2010s, we will launch a diversified construction model

In 2008, IBM proposed the concept of "smart Earth" for the first time, and in 2012, the Chinese central government proposed the construction of smart cities for the first time, and the information construction project reached unprecedented popularity and height. The typical characteristics of information construction projects in this period are a complex technology, large investment scale, long construction cycle, and difficult management. The government encourages project construction units to adopt EPC project general contracting, government purchase services, government and social capital cooperation (PPP), and other diversified models. EPC is the evolution of the DB model, and PPP is the evolution of the BT model. Since 2017, the proportion of EPC mode has been increasing.

The characteristics of informatization projects are quite different from projects in other industries such as construction, so the evolution of its construction mode is different from the development of EPC. The development of EPC is obviously affected by the international environment, while the construction mode of informatization projects is more diverse and flexible according to its unique industry characteristics and social and economic forms.

Policy support for EPC construction mode of informatization projects

The EPC construction mode of China's informatization projects has been widely promoted and has become the preferred construction mode adopted by government departments at all levels in large-scale informatization engineering projects, thanks to the national and local governments having issued many policy documents to promote and support.

First of all, at the national level, the National Development and Reform Commission issued the "13th Five-Year Plan" National Government Information Engineering Construction Plan in 2017 and encouraged the use of new models such as commissioned construction, rental construction, BOT, and service outsourcing. The General Office of the State Council issued the Measures for the Management of the Construction of National Government Affairs Informatization Projects in 2019 to encourage construction units to give full play to the role of functional departments or outsourcing and reduce self-construction, self-management, self-use, and self-maintenance. These policy documents promote the adoption of EPC construction mode for information engineering projects.

Secondly, at the local level, In December 2021, the Office of the People's Government of Futian District of Shenzhen issued the General Contracting Management Measures for the Design - Procurement - Construction (EPC) Project of Futian District Government Investment Project, which for the first time put forward the implementation path and key points of control of EPC mode for the construction of large-scale and complex information construction projects. In 2022, Chongqing High-tech Zone Reform and Development Bureau issued the "Rules for the Management of Chongqing High-tech Zone Government Informatization projects", which proposed that the government informatization projects with higher requirements for the integration of design and construction (procurement) and tight construction period can adopt the general contracting model. In April 2023, the Data Resources Administration Bureau of Chizhou City in Anhui Province issued the "Management Measures for the Construction of Government Informatization projects in Chizhou City" (draft for comments), encouraging informatization projects to use the government purchase service, agent construction or project general contracting (EPC) model.

National and local governments have successively issued many policy documents to encourage, guide and standardize the adoption of EPC construction mode for informatization projects, creating a favorable environment for the implementation of EPC mode in the field of information technology.

In summary, it can be seen that the national and local governments have successively issued several policy documents to encourage, guide and standardize the adoption of EPC construction mode for informatization projects. First, it has created a favorable environment for the implementation of EPC mode in the field of informatization, and second, it also highlights the recognition of the EPC mode by the government and the informatization department.

Research on EPC construction mode of China Informatization project

EPC construction mode process and content of informatization projects

The informatization project adopts the EPC construction mode, and its process is mainly divided into three stages, which are the EPC pre-stage, the EPC implementation stage and the completion acceptance stage.

The main process of the EPC pre-stage includes project approval, feasibility study report, budget estimate preparation and approval, preliminary design, bidding, EPC contract signing, etc. These contents are generally completed by the government informatization project department, and the bidding and EPC contract signing can also be completed by

the project construction unit or construction agent. Bidding and EPC contract signing are the two key links for the project to be characterized as EPC construction mode. The EPC general contractor is determined through bidding and signing an EPC contract with the general contractor, which is generally a floating contract of the estimated total price.

The EPC implementation stage is the core stage of implementing Design-Procurement-Construction, and the design stage includes two core contents: deepening the scheme design and budget review. The deepening plan design also includes the drawing of construction drawings and budget preparation. The deepening plan is completed by the review of the expert group, and the construction drawings must be reviewed by the third-party drawing review agency. The budget is prepared based on the deepening plan and construction drawings within the scope of the budget estimate and must be approved by the government financial department or the third-party financial evaluation agency. The review of the in-depth design plan, construction drawings, and budget is the baseline basis for procurement and construction. From the beginning of the design phase, the EPC general contractor is responsible for leading the completion of various tasks.

In the procurement stage, EPC general contractors purchase appropriate subcontractors and related materials, products, and services, etc. The procurement of informatization EPC projects generally includes three core processes and contents: procurement preparation, procurement evaluation, and procurement performance. Procurement preparation is subdivided into the establishment of a procurement working group, the preparation of procurement requirements documents, primary potential suppliers, and other tasks, of which the procurement requirements documents are mainly based on the deepening of the design phase of the design plan, construction drawings, while the procurement requirements documents should be echoed with the relevant terms and requirements of the EPC general contract. Procurement evaluation is subdivided into bidding, bid evaluation, bid selection, signing, and other tasks, in the informatization EPC project most of the general contractors adopt the invitation to bid. Procurement performance is the performance of the contract by the contracted supplier.

The construction phase is the most important and longest phase of an EPC project, and its process and content are also the most complex. EPC projects generally include software engineering, outfield construction (narrowly referred to as electronic and intelligent engineering), and infield or infrastructure engineering construction. The process and content of software engineering include requirement analysis, outline design, detailed design, coding and testing, system deployment, training, software evaluation, security level protection evaluation, etc. The process and content of field construction mainly include design disclosure, drawing review, site resurvey, construction scheme and special scheme design approval, construction permit processing, foundation and pole construction, equipment arrival and inspection, equipment inspection, equipment installation, equipment commissioning, etc. The construction process and content of the infield or infrastructure include construction scheme design, business requirement verification, integrated wiring, equipment arrival and inspection, equipment installation, equipment commissioning, safety level protection evaluation, and so on.

The completion acceptance stage is for the acceptance of technology, documents, and economy of the EPC project after the completion of construction. Technical acceptance is whether the construction content meets the technical requirements of the approved design documents, bidding documents, contracts, and other documents. Documents acceptance refers to the acceptance of the documents of the whole process of informatization EPC projects following the national, local, and industry-related file management requirements. Economic acceptance refers to the settlement and final accounts of EPC projects. The process and content of the complete acceptance of an informatization EPC project generally include acceptance application, institutional pre-review, expert review, and acceptance closure.

Key points of management in each stage of EPC construction mode of informatization project

(1) Pre-stage management points

The first is to identify the conditions of contract issuance. The conditions of contract issuance of informatization EPC projects are slightly different from those of traditional EPC general contracting of construction projects, mainly because informatization EPC projects have two significant characteristics, one is that the project must be driven by business needs, the other is that the technical scheme of the project is complex, which leads to the preliminary design and budget of informatization EPC projects may not be completed before contract issuance. To be effective and conducive to the construction of later EPC projects, some local governments have issued detailed rules for the management of government informatization projects and stipulated that the contract can be issued after the approval of the feasibility study report.

Secondly, for the qualification of the general contractor, in smart city large-scale EPC projects, it is more common to form a consortium of hardware and software equipment integrators, civil construction units, and design units. In informatization EPC projects, it is the qualification of hardware and software equipment integrators, paying particular attention to their design, construction, and installation qualifications, and in a narrow sense, it is usually required to have special qualifications for building intelligent system design and professional contracting qualifications for electronic and intelligent engineering.

(2) Key points of management in the EPC implementation phase

First of all, in the design stage, the construction environment and conditions of the intelligent engineering part should be investigated on the spot to provide a basis for the construction drawing. Demand investigation and field surveys determine the construction content, scope, and engineering quantity of EPC projects, and play a decisive role in the

preparation of the budget. The two basic elements of construction items and engineering quantity included in the preparation of the budget come from the investigation and survey.

The second is the procurement stage, the main part of the informatization EPC project, the key word can not be subcontracted, the general contractor should complete the main work within the scope of the contracted project, and shall not subcontract this, otherwise, it will constitute illegal subcontracting. In EPC projects, the "main part" of EPC projects is usually assessed according to the nature of the project, its use, the importance of each part of the work, and its amount.

Third, in the construction stage, the primary management point is safe and civilized construction. Before the construction of the project, the risk sources and environmental factors should be identified and evaluated, risk management and control plans and special plans for safe construction should be formulated, safety disclosure and safety education should be carried out when the construction is started, and safety inspection and pre-control should be carried out regularly during the construction process. Secondly, during the construction process, the changes in additions and subtractions should be controlled and approved based on software development and field construction, and the supporting materials in the process should be consistent with the completion data, to ensure the technical and economic compliance of the project and facilitate the audit in the later stage of the project.

EPC construction mode practice case of informatization project

Basic information about the project

A smart city EPC general contracting project includes data center, smart city governance application, smart government management application, smart industry development application, and smart people's livelihood service application. The total investment amount of the project is 218 million yuan, the construction mode is EPC general contracting.

The process and best practices of the project adopting EPC mode

This project is a key informatization project of the city, which is supported and concerned by leaders at all levels in the urban area. Because the investment scale of the project is very large, the construction content is very complex, and the project landing cycle is short but the construction cycle is long, so the EPC general contracting mode is selected when the project is bidding. The EPC contract was signed with full reference to the terms of the 2017 edition of the Design Procurement Construction (EPC)/Turnkey Project Contract Conditions (Silver Book) and the General Contract for Construction Projects (Model Text) (GF-2020-0216). Bidding and contract signings are major milestones and turning points of the project, and the project has decided to carry out construction in EPC mode.

After signing the contract, the project entered the deepening design stage. Due to the coarse granularity of the feasibility study report and preliminary design scheme in the EPC advance stage, the workload in the deepening audit stage was huge. The construction of this smart city project includes three major sections: software engineering, outfield construction, and infield infrastructure construction. To make up for the work in the EPC advance stage and avoid procurement and construction risks, the general contractor has set up a professional design team in the deepening design stage. The key roles and members of the team include consultants, architects, designers, consultants, product managers, technical managers, structural engineers, cost engineers, etc., fully investigate the needs of the business units and investigate the construction environment and conditions of the outer and inner fields, combined with the assessment requirements at the urban level, and follow the principles of emergency first, division and itemization. High-quality output of in-depth design proposals, construction drawings, and budgets.

Combined with the needs of business units, the general contractor gives priority to the procurement and construction of sub-projects with low difficulty in software engineering and field construction and simultaneously carries out the design and procurement of complex and difficult sub-projects. Through the measures of prioritization and task parallelization, the project duration and investment completion rate are guaranteed. In the procurement and construction phase, to control the delivery quality of the EPC general contract project, the general contractor selects suppliers whose business and technical capabilities are complementary to those of the general contractor, thus strengthening the cooperation viscosity and efficiency, and guaranteeing the project duration and quality.

During the construction of the project, the general contractor fully took into account the project process compliance and later audit risks. The technical and economic compliance of the process is ensured mainly through the expert review and multi-party joint confirmation of the design scheme, the engineering quantity review based on the construction drawing, the budget preparation and review based on the "Construction Engineering quantity Bill Valuation Code" (GB50500-2013) and the "Software and Information Engineering Cost Management Measures". In the process of EPC implementation, the general contractor shall prepare and assemble documents on time following local file requirements to ensure management compliance and lay a good foundation for completion acceptance and post-audit.

Conclusions and Recommendations

This paper analyzes the origin and development of EPC mode in China, and provides corresponding references and suggestions for the application of EPC construction mode in informatization projects according to the research results, to provide help for informatization project construction and digital economy development. The conclusion is as follows: First, there are various modes of informatization project construction. This paper focuses on the analysis of the evolution of China's informatization project construction mode and obtains four construction modes, such as research,

design general contracting, system integration, and diversification. At present, it coincides with the key stage of the development of the digital economy, and the construction mode of informatization projects provides a reference for the competent departments and construction units to make decisions about the construction mode of projects.

Secondly, the EPC construction mode of informatization projects is divided into three stages: pre-stage, implementation, and acceptance. In this paper, the process, content, and control points of each stage are studied in detail, providing detailed reference and guidance for EPC project participants to adopt EPC mode and carry out effective control, as well as the combination of software engineering and EPC mode and control points, especially the tripartite evaluation is particularly important.

Third, risk pre-control and compliance control of informatization EPC projects are crucial. The EPC construction mode of informatization projects is still being explored. This paper presents risk pre-control and compliance measures with practical value through practical cases.

Looking forward to the implementation of the 14th Five-Year Digital Economy Development Plan, the construction of informatization projects is a new historical opportunity, ushering in a new period of innovation and development. EPC construction mode has paved a new optimal path for the rapid landing of informatization projects and the realization of social and economic benefits. Based on the research conclusions of this paper, to continuously develop the application of EPC mode in informatization projects, the author puts forward the following recommendations.

First, the government improved its policies and regulations. At present, the government departments at all levels still lack policies, regulations and management methods for informatization EPC projects, through the release and improvement of policies, regulations, and management methods, to provide a good environment for informatization project EPC construction mode.

The second is to strengthen the training of informatization EPC personnel. The operation and landing of large-scale informatization EPC projects require the support of a professional EPC talent team. At present, colleges and universities have no corresponding majors, and vocational training institutions have no corresponding training courses. At present, most of the personnel involved in the construction of informatization EPC projects are traditional informatization project talents, and it is urgent to empower and cultivate them.

Third, strengthen the construction of major informatization EPC model projects. At present, the development trend of the digital economy is rising, planning informatization EPC projects with high added value of economic benefits and carrying out key construction is conducive to the development of information and digital industries and regional economy, and creating better digital economic and social benefits.

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