

Energy Performance Contracting from the Perspective of Public Sector—A Bibliometric Analysis

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Abstract

In advocating energy-saving and low-carbon today, energy performance contracting has become an important policy tool for energy management in the public sector. Based on the perspective of public sector, this article uses hotspot comparison to find trends and policy issues in energy performance contracting. Through the cluster analysis of the literature co-citation network and the frequency analysis of keywords, it is found that the Chinese energy performance contracting research needs to be improved in four aspects: Industry and sector, Financing, Evaluation criteria and Supporting measures. Based on these, we put forward policy implications for improving Chinese energy performance contracting in the future.

Keywords

Public Sector, Energy Performance Contracting, Hotspot Comparison, Bibliometric Analysis

1. Introduction

With the growing global population and economic and social development nowadays, energy shortage has become an increasing concern of countries around the world. The Global Renewable Energy Status Report 2017 states that, a worldwide revolution in energy transformation should be promoted and energy conservation and emission reduction policies should be implemented. The report of the 19th Party Congress emphasizes accelerating the reform of the ecological civilization system and building a beautiful China, and proposes to promote green development and establish a sound economic system with green, low-carbon and circular development. In order to actively address global energy and envi-

ronmental issues, conserve resources and develop a low-carbon economy, contract energy management has emerged from this energy revolution. Energy Performance Contracting (EPC) refers to the contractual agreement between an energy-saving service company and an energy-using unit on the energy-saving targets of a project. The energy-saving service company provides the necessary services to the energy-using unit to achieve the energy-saving targets, and the energy-using unit pays the service company's input and its reasonable profit with the energy-saving benefits.

Compared with industrial energy efficiency, building energy efficiency and transport energy efficiency, the public sector has the advantage of easy centralized management and strong execution, with a high degree of social concern and influence. Therefore, as an important part of the construction of energy conservation and ecological civilization, the public sector is an important subject in promoting EPC development. Although the proportion of applications in the public sector has increased in recent years with the strong support of central policies, compared to other countries, the EPC projects currently applied in China are still concentrated in the private sector, and the energy-saving potential of the public sector needs to be further released.

Based on the existing literature, this paper makes the following marginal contributions: First, most of the review articles on EPC in China currently focus on the application in the private sector or discuss a particular issue in the process of project implementation, which has the limitation of not providing a comprehensive understanding of the overall research status and trends in the field. Both Chinese and foreign scholars rarely provide an overall overview of the research and application of public sector EPC, and this paper adds to this. Secondly, this paper uses CiteSpace software to generate relevant knowledge maps from the collected literature data, presenting the research content under different topics and making the research results more objective and intuitive. Thirdly, by analyzing and summarizing the global research results, we discuss in depth the hotspots and cutting-edge developments in the field, compare the differences between China and other countries, identify the shortcomings of EPC in practice in the public sector, and provide an empirical explanation from the field of bibliometrics for the better realization of "effective markets and responsive government". It provides a practical explanation from the relevant field of bibliography.

2. Data and Method

2.1. Research Method

As a new fusion and development in the field of bibliometrics and informetric, scientific knowledge mapping has the dual characteristics and advantages of both "graph" and "spectrum" (Chen et al., 2015). The application of this method was initially focused on the field of intelligence but is now rapidly spreading to other disciplines in academia (Hu et al., 2013). Therefore, this paper intends to use bibliometric methods to visually analyze the research on public sector EPC

in China and abroad through scientific knowledge mapping. The study is designed to better promote the study and application of public sector EPC in China and promote the sustainable development of energy and the “double carbon” goal.

2.2. Data Resource

In order to analyze the current research status and development trend of EPC in the public sector at home and abroad, this paper selects two major databases, China Knowledge Network (CNKI) and Web of Science (WOS), respectively, and uses the relevant literature from 1980 to 2020 in them as the source of this paper’s Chinese and English literature data.

Since a large amount of literature on EPC exists in the research fields of business administration and engineering technology, which are not related to the research topic of this paper. Therefore, in order to ensure the scientific standardization and accuracy of the research data, this paper uses the advanced search setting conditions, setting the topics as “energy performance contracting” and “energy performance contracting” + “government” or “public”, respectively. The two searches yielded articles on EPC and articles on EPC in the public sector. The documents obtained from the two searches were manually ranked one by one, and reports, reports and articles not related to EPC were excluded from the sample and then de-duplicated by CiteSpace software to obtain 3213 and 891 Chinese articles respectively; the English articles were sourced from English journals in the Web of Science core database, after manual and software de-duplication, we finally obtained 1427 and 208 English papers in the categories of EPC and EPC in the public sector in SCI and SSCI, respectively. Among them, there are 891 articles in Chinese and 208 articles in English in the category of public sector EPC, which constitute the main object of analysis and research content of this paper. **Figure 1** illustrates the collecting and filtering process of the research sample in the paper.

3. Hotspot Comparison

3.1. Identification of Hot Keywords in Research

The keywords of an article are a highly condensed and summarized version of

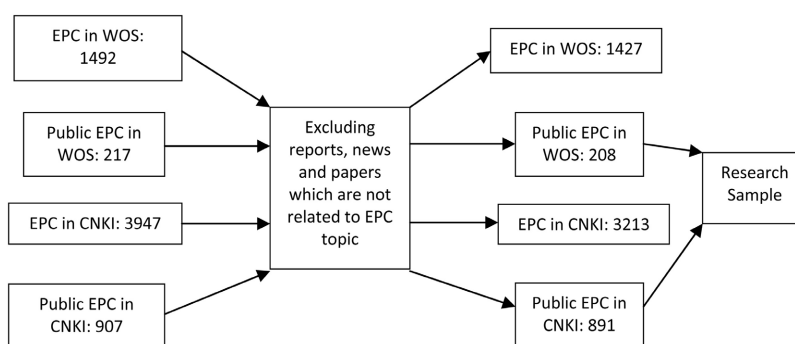


Figure 1. Collecting and filtering process of the research sample.

the content of the paper, therefore, by studying the keywords collected in the literature and analyzing them econometrically, we can better understand and grasp the research content and hotspots in the field.

Each keyword corresponds to a node, and the node's color and size represent the year of occurrence and frequency of the keyword, respectively. The warmer the color of the node, the later the occurrence of the keyword, and the larger the node, the more frequent the occurrence of the keyword. By analyzing the knowledge graph of keywords at home and abroad, it can be seen (Figure 1) that the high-frequency keywords in this field are basically convergent at home and abroad, but there is a certain degree of difference in the class groups corresponding to the keywords.

However, it is not possible to understand the differences between domestic and international research attention through knowledge mapping alone. Therefore, in order to visualize the research hotspots of EPC in the public sector at home and abroad, CiteSpace software was used to cluster the keywords in Chinese and foreign literature by LLR (Lender of Last Resort), and the clustering results were sorted and analyzed. The extracted keywords were sorted out, such as deleting keywords that did not meet the requirements of EPC, China, etc. and combining similar words such as “energy-saving service” and “energy-saving service industry”. The keywords were divided into four categories: industry and sector, financing, evaluation criteria, and supporting measures (Table 1 and Table 2).

However, simple cluster analysis will not identify the specific details underneath the clusters, nor will it be possible to identify valuable issues. Based on this, this paper analyses four types of clusters in the Chinese and foreign literature.

Table 1. Chinese research in EPC of high-frequency keyword distribution.

Categories	Keywords
Industry and sector	Construction, Industry, Public institutions
Financing	Financing models, Financial management, Investment
Evaluation criteria	Energy saving, Energy conservation, Energy renovation, Energy saving and emission reduction
Supporting measures	Energy Service Companies, Policy, Markets, Management, ESCOs, Energy Service Companies

Table 2. English research in EPC of high-frequency keyword distribution.

Categories	Keywords
Industry and sector	Building, Industry
Financing	Subsidy, Investment, Public-private partnership
Evaluation criteria	Performance, Energy efficiency, Model, Sustainability
Supporting measures	Management, Policy, Market

By analyzing the high-frequency cited literature and reviewing the advanced experiences of other countries abroad and the current state of research in China, the paper draws out the relevant lessons and promotes the development of EPC research in China based on public sector applications.

3.2. Industry and Sector

EPC is used in many public institutions in the US, with public customers mainly including governments, schools and public hospitals, also referred to as the “MUSH” market (Municipal, Universities, State governments, and Hospitals) (Figure 2). As shown in the figure, the related industries of MUSH account for 69% of the market share of contract energy management in the US, making it the leading area for EPC applications. The Federal Energy Management Program (FEMP) was enacted in 1995 to provide for the retrofitting of government office buildings (Hughes & Muessel, 2000; Long & Zhang, 2004). In addition to the building sector, EPC models have emerged in various segments such as traffic signal systems, sewage treatment plants, landfill methane recovery, street lighting and water metering systems (Goldman et al., 2005).

In several countries besides the US, energy efficiency service companies (ESCOs) have identified the municipal sector and market as the main target for the development of EPC services, and in countries such as Austria, Canada, the Czech Republic, Hungary, Italy, Lithuania and Poland, ESCOs’ activities in the public sector exceed 50% of the industry (Murakoshi & Nakagami, 2009). Over the last 10 to 15 years, EPC has become a popular tool for optimizing and modernizing federal and municipal buildings in Austria, which has used this tool for energy optimization in over 1000 facilities (Berger & Schafer, 2010). Canadian energy companies’ energy efficiency technology services are mainly aimed at government buildings, commercial buildings, hospitals, schools and industrial enterprises. Government departments and utilities in the country have set up their own ESCOs (Morcillo-Bellido et al., 2018). Spain has the scarcest electricity resources among EU member states, and in order to achieve sustainable development of resources, Spain pays particular attention to the EPC of electricity

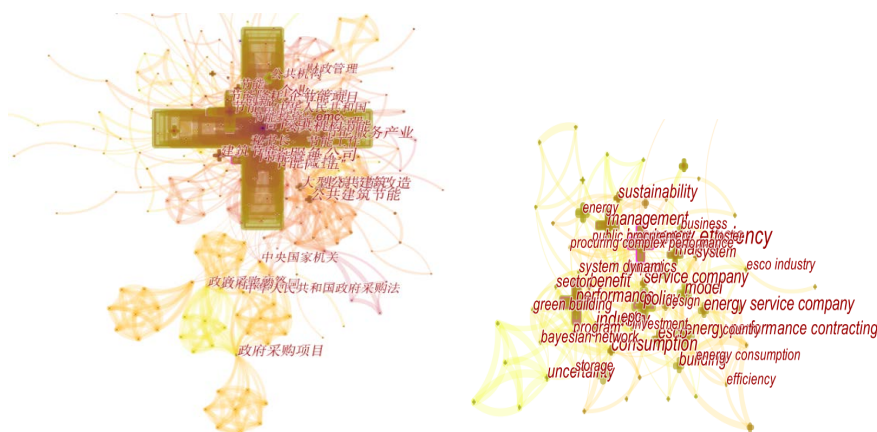


Figure 2. Knowledge graph of literature keywords in Chinese and English.

development projects, where hospitals, schools and government offices, which have relatively stable returns, are the main clients of ESCOs (Lee et al., 2003).

According to statistics from Chinese industry associations, the application areas of EPC in China are currently concentrated in industrial and commercial buildings and transportation (Figure 3), with a higher proportion of applications in the private sector and relatively few in the public sector adopting the EPC model (Zhang et al., 2015), and mostly in the public building sector. As can be seen from Figure 4, according to the statistics, EPC on China’s industrial and commercial sectors account for 87% and 66% of investment and volume respectively, far ahead of EPC implementation in the public sector.

3.3. Financing

Most of the EPC projects implemented in China are of a large scale, so these projects usually require a large amount of capital investment in the initial stage and last for a long time, and the riskiness of the invested capital is also relatively high. However, for SMEs involved in EPC, their own financial strength is relatively weak and it is difficult to obtain the desired amount of bank loans (Duan, 2013). The difficulty of financing has therefore become a major obstacle limiting the development of EPC in various countries, and has received the attention and

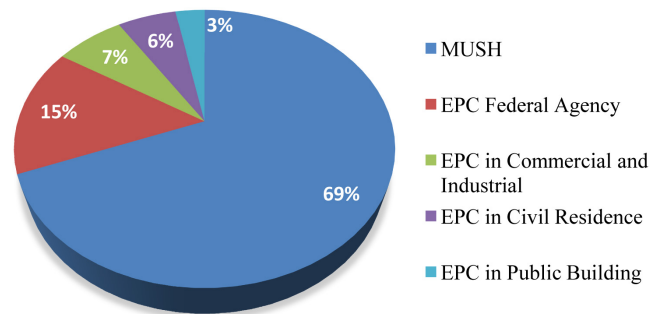


Figure 3. EPC market segmentation and value ratio in the U.S.

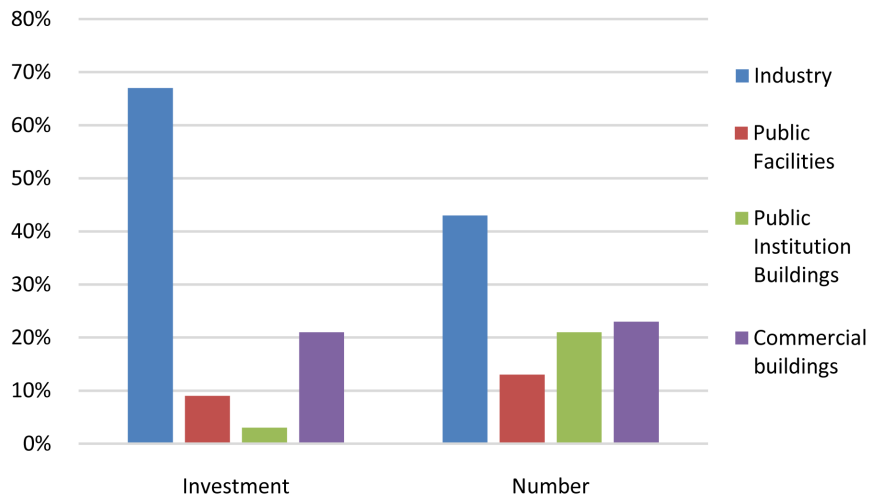


Figure 4. Distribution of EPC investments and numbers in China by sector.

discussion of many scholars (Jia & Yang, 2012; Li, 2012; Shang & Li, 2013; Bai & Li, 2015).

European scholars Limaye and Limaye, 2011 pioneered the concept of “Super ESCO” or “Integrating Organization”, which means the integration of resources into bankable energy efficiency projects helps local ESCOs to grow. The Fedesco agency in Belgium and the “HEP ESCO” in Croatia, for example, are seen as examples of “Super ESCOs” active in Europe, which contract directly with public entities (customers) and then subcontract on a competitive basis. These companies contract directly with public entities (clients) and then subcontract tasks to smaller private suppliers on a competitive basis, making it easier to obtain financing from banks and other institutions while enabling energy-saving projects to be completed efficiently and with high quality. Developing countries such as Bulgaria and Hungary (Roshchanka & Evans 2016), on the other hand, have relied more on assistance from other international donors, such as the World Bank, to achieve domestic investment in municipal energy efficiency projects.

Most applications of EPC in China are in the “benefit-sharing mode”, where the ESCOs provide the main investment funds for energy efficiency, guarantee the energy savings and recover the investment through a large share of the energy cost savings (Zhang, 2014). In June 2010, the National Development and Reform Commission promulgated the Interim Measures for the Administration of Financial Incentive Funds for EPC Projects, which provided one-off financial incentive funding support to ESCOs who using energy efficiency “benefit-sharing” mode contract. In 2015, the State decided to abolish financial incentive support for energy management, and the trend in China’s EPC industry has seen a significant decline. The trend of changes in the industry shows that the initial rapid growth and development of the industry were mainly driven by incentive support from government funds (Li et al., 2017; Lu & Sun, 2012). The intention of China’s financial incentive funding policy is to guide the development of the industry, and EPC should ultimately rely on a market-based operating model to achieve its own progress and gradually establish a comprehensive and complete industry financing mechanism to achieve profitability in the country.

3.4. Evaluation Criteria

Spain has a shortage of electricity resources, so government departments have put forward the goal of protecting the environment and saving energy, and have formulated numerous policies and measures around renewable energy development (Martinez-Budria et al., 2003). The release of the UK’s Sustainable Development Strategy in 2005: Securing the Future, which for the first time incorporated government departments’ own energy savings into the country’s sustainable development strategy, further regulating and clarifying the energy-saving and emission reduction targets of government departments, and local governments across the country began to actively implement EPC in public institutions (Boyd et al., 2008). Legislation such as Germany’s Renewable Energy Heat Act (EEWärmeG) has also promoted the development of sustainable concepts in

EPC in the country (Long & Zhang, 2004).

In the application of EPC in the public sector in China, the calculation and evaluation of energy savings not only determine the final distribution of benefits, but also forms the basis for the finance department to set the annual departmental energy cost budget. However, due to the influence of the concept of production units under the planned economy for many years, and the current situation of soft budget constraints of public institutions in China, public institutions and organizations in China are less likely to take the initiative to consciously consider the concepts of environmental protection and development, the use of green energy and sustainable development, etc. Although China promulgated the Green Building Evaluation Standards in March 2006, the degree of popularity in the public sector is low. The willingness of energy-using units in public buildings to take the initiative to implement green buildings or building energy efficiency is not strong.

3.5. Supporting Measures

Since the 1970s, the US government has enacted more than 50 bills, laws, regulations and implementation programs related to energy efficiency, including energy audits, building energy efficiency, project financing, energy efficiency education, and many other aspects. The Federal Energy Management Program (FEMP) was launched in 1973 to maintain and strengthen national energy and environmental security through sound and efficient energy management and related investments (Penate-Valentin et al., 2018). Policy Act of 1992 (EPACT), which formally legislated EPC services within the 46 states of the US, mandating government departments to accept the EPC model for a maximum number of years (Williams and Denenberg, 1994). In Asia, the Korean government improved the Energy Utilization Act in 1991 in order to establish a legal assurance assistance system for EPC in the country (Vine, 2005). The Japanese government introduced the Green Procurement Act in 2001 to promote the market development of EPC through government green procurement (Zhang, 2014).

During the 12th Five-Year Plan period, China has continued to pay more attention to the development of energy conservation and environmental protection industries, and relevant policies have been introduced since 2010 (Cao & Ma, 2011; Zhang, 2011). However, there is still a lack of legal and mandatory documents on EPC at the national level, and even if some regulations and normative documents contain statements related to “Energy Performance Contracting”, most of them are promotional in nature, lacking in operability and implementation, with the provisions explicitly requiring public institutions to use energy management (Shang & Guo, 2011).

In addition to national laws and regulations, the establishment of a framework of rules and regulations is crucial to the development of EPC in the public sector. Streamlining the processes related to the procurement of services in the public sector can help reduce the transaction costs associated with EPC (Nolden &

Sorrell, 2015; Bolton & Hannon, 2016). Adopting a series of measures, such as revising the contractual framework for government procurement, can reduce investors' perception of risk as well as improve the synergy between contractual frameworks, which is crucial in the public sector (Nolden et al., 2015).

4. Discussions and Conclusions

4.1. Establishing EPC Projects List

Compared to the share of EPC in the public sector abroad, China currently has more industrial and commercial applications, with public institutions accounting for a smaller share of the EPC market, and there is huge scope for domestic development. In order to promote awareness and application of this energy-saving model among all sectors of society, the government should give full play to its exemplary and leading role and lead all sectors of society to actively participate in EPC projects. At the same time, it is important to address the institutional barriers to the purchase of services and the implementation of EPC projects by public institutions as soon as possible, so that the existing market for energy efficiency in public institutions in China can be fully explored and effectively utilized.

4.2. Improving EPC Financing System

Since 2015, when China formally abolished its five management measures for fiscal incentives, the government's use of subsidies to stimulate the development of EPC is no longer the main means, and government support for the EPC model has gradually shifted to providing a good institutional environment and policy guidance. Using green finance through credit, bonds, funds and other financial means, to seek to carry out the project capital investment.

4.3. Clarifying EPC Evaluation System

In the absence of clear and reliable measurement standards and evaluation systems, energy efficiency projects are likely to lead to disputes among participants and ultimately to lawsuits or project failure, so it is crucial to establish a sound statistical and evaluation system as soon as possible for the development of EPC (Chen & Guo, 2021). The government should always consider "value for money" as the ultimate goal of the public sector when judging whether a project has met its standards. Governments should adopt a "life-cycle cost approach" to evaluate projects, and apply evaluation criteria throughout the entire process of pre-procurement. Governments should actively promote the importance of sustainable energy management to the public sector. Government departments should also actively promote the use and promotion of sustainable green energy, not only by introducing and improving relevant green evaluation standards, but also by calling on other sectors to pay more attention to sustainable energy (Xu et al., 2011) and increasing the popularity of sustainable energy in all sectors.

4.4. Optimizing EPC Institutional Environment

A good institutional environment and policy guidance are the prerequisites and guarantees for the development of EPC in the public sector. On the one hand, the state should introduce legal provisions that clearly stipulate the use of EPC in public institutions as soon as possible, so as to strengthen and improve the use and development of EPC from a legal point of view, and to increase the public sector's attention to the EPC model. On the other hand, it should also speed up the formulation of operational and implementable policies and regulations to regulate the scope of use, steps, processes, and other relevant aspects of EPC.

5. Limitations and Future Research

First, the research topic of this paper focuses only on public sector EPC implementation, although the application of EPC in the public sector has great potential for development, but the role of the private sector market still cannot be ignored. In the future, the research scope can be further expanded to explore the hot spots of private sector of EPC.

In addition, this paper is only an overview of the research hotspots. CiteSpace can also provide statistics on the basic characteristics of published articles, such as author, institution, and publication year, which can help us better understand the development of the research in this field. In the future, more research can be conducted in the relevant area.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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