Available online at www.sciencedirect.com
SciVerse ScienceDirect
Energy Procedia 14 (2012) 121 – 126
Energy Procedia

AHP-Fuzzy Evaluation on Financing Bottleneck in Energy Performance Contracting in China

Yan Li*
School of Environmental and Nature Resources, Renmin University of China, Beijing 100872, China

Abstract

Energy Performance Contracting (EPC) conserves energy as a market-based mechanism in many countries and has demonstrated its efficiency in this respect. EPC has been developing in China rapidly in recent years. The main bottleneck for EPC projects in China lies in the lack of enough and efficient financing. The paper, adopting the method of AHP-Fuzzy evaluation, evaluates the EPC financing bottleneck in China across five sectors, namely, iron and steel, chemical industry, buildings, electricity and energy, and discusses the current financing constraints for these sectors. To enable the rapid development of EPC in China, the policy support should be outlined, and sources of finance should be widened.

Keywords: AHP-Fuzzy Evaluation， Energy Performance Contracting（EPC）， Financing, China

1. Introduction

As one of the fastest growing economies in the world, China has been the second largest energy producer and consumer in the world since 2004 (SCIF,2007). There seems little doubt that future energy supply will present a severe challenge to all communities in this country including governments, industries and individual citizens. According to Shi and Bi (2010), China's current industrial energy efficiency and scale efficiency, particularly industry energy of pure technical efficiency, fall into the backward league. Thus, efficiency improvement in China still enjoys a great potential (Yu, 2010), and it is imperative for China's energy security and sustainability to improve energy efficiency (Hübler，2011). In fact, as a proven market-based mechanism, EPC can provide a cost-effective routine to overcome technological barriers to energy efficiency (Sorrell, 2007). Furthermore, EPC can effectively expand information channels, and cut transaction and implementation costs (U.S. Environment Protection Agency, 2007).

Since its first introduction into China in 1997, EPC as a market-based mechanism for energy conservation has achieved leapfrog development in the following decade or so, especially from 2006 to 2010, when the number of Energy Service Company (ESCOs) grew by almost tenfold, and amount of investment for EPC projects, nearly fourteen times .(EMCA , 2010). Indeed, EPC has experienced rapid development during the eleventh five-year plan period in China; yet this momentum hasn't depleted EPC of its great potential, which will guarantee its continued expansion momentum in the foreseeable future (EMCA，2010), with the primary focus on energy intensive sectors, such as industries, transportation, and buildings. According to the statistic data from China Energy Conservation Association (CECA).

Frequently, in developing nations like China, a lack of access to capital hinders EPC from getting its investment financed (Têbar Less and Mcmillan, 2005). Also the insufficient infrastructure of financial markets, moreover, investors sometimes overestimate the investment risks, thus leaving sound and theoretically profitable investment

* Corresponding author. Tel +0086-10-82502982
E-mail address: liyan@ruc.edu.cn

doi:10.1016/j.egypro.2011.12.887

projects without necessary funding(Wilkins, 2002). Besides traditional financing from banks, numerous new financing modes such as equity financing and finance lease are being explored and tried in China , which would be very helpful to share investment risks. However, the overall picture for financing channels still provides limited and narrow choices for EPC projects to choose from.

2. Developing a Fuzzy comprehensive model

As one of the two main applications of Fuzzy set theory, a widely acknowledged and applied theory which was first introduced by professor Zadeh in 1965. Fuzzy comprehensive evaluation is broadly used in multi-object comprehensive evaluation. The reason why Fuzzy evaluation model is applicable to EPC is that implementation of EPC projects involves multiple stakeholders, such as ESCOs, clients, banks, guarantors and lessors (FIDRG, 2009). Each side of the stakeholders can affect the financing process of EPC projects in intricate and tangled ways, hence the ever-present fuzzy scenarios and concepts in the evaluation of EPC projects.

From 2007 to 2010, ESCO committee of China Energy Conversation Association, by handing out questionaires, surveyed numerous ESCOs with regard to the targeted clients, technologies adopted, amount of investment, source of finance, term of contracts and policy support for the EPC projects these ESCOs implemented. In addition, special questionaires were designed for EPC clients and potential clients in the industrial and business sectors. The new questionaires included questions like client's degree of acceptance for EPC projects, the consideration made by clients in choosing ESCOs in the market, difficulties for the implementation of EPC projects, and ways to enhance policy support. All-together, the survey included 162 EPC projects which had been brought into effect during 2007 to 2010, covering numerous sectors such as textile, iron and steel, chemical, metallurgy, coal, light industry, energy, buildings, and transportation. This paper looks into the survey results and experts' suggestions, and conducts Fuzzy comprehensive evaluation on the current financing bottleneck for EPC projects in China.

The first step is establishing the evaluation index systems, and there are three evaluation factors being determined: the status of EPC projects (B_1), source of finance for EPC projects (B_2), and policy support (B_3). Furthermore, each of the three evaluation factors is divided into different secondary indicators. For the status of EPC projects ($B_{1)}$, the secondary indicators are investment scale, energy savings, credibility of ESCOs and operational status of clients.

For source of finance for EPC projects (B_2), there are three secondary indicators, namely, bank loans, investment capacity of ESCOs and proprietary capital of clients——determination of these three indicators depends on the consideration of the limited channels to finance EPC projects in China and the predominance of ESCO investment and bank loans as the major sources of finance. Of the surveyed 162 projects, only two of them adopted the financing mode of finance lease; other projects saw their capital take the form of ESCO investment, bank loans or proprietary capital of the clients. Four out of the 162 projects chose guarantees as a way to reduce project risks since they all involved an investment scale of ￥40 million or more.

For policy support (B_3), there are three secondary indicators, policy guarantee, subsidies and special funds——a division made by considering that seen in the implementation process of EPC projects over the last several years, both the central and local governments allocated fiscal input of various degrees; yet the form of financing has gradually transformed from subsidies to special funds.

Firstly, analytic Hierarchy Process (AHP) is used to determine weighting factor for different factors in developing the following evaluation matrix of primary indicators:

$$B=\begin{bmatrix} 1 & 4 & 5 \\ 1/4 & 1 & 6 \\ 1/5 & 1/6 & 1 \end{bmatrix}$$

With the software yappy0.5.2 and a calibration of e^(0/5)~e^(8/5), this paper has examined the judgment matrix consistency for primary indicators which turned out to be 0.0688＜0.1, passing the consistency test.

AHP is also applied to determine weighting for secondary factors and develop judgment matrices, for each of which the maximum eigenvalue and consistency are calculated. All judgment matrices have passed the consistency examination, proving that the design of indicators is reasonable. By again using AHP to determine weighting, the final weight coefficients for second indicators are produced, as shown in Figure 2 .

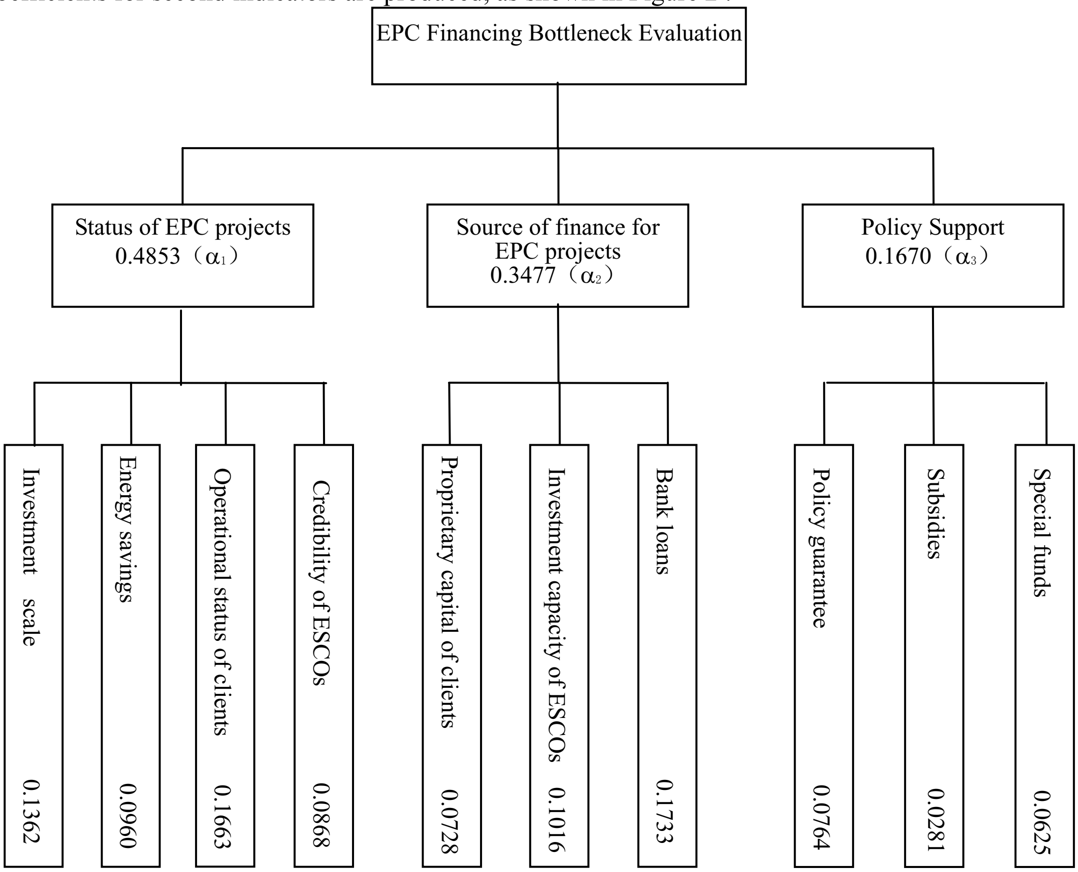

Figure 2 Weighting for evaluation factors determined through AHP

Secondly, a Fuzzy Evaluation factor set is developed as follows for the evaluation factors, divided into four categories:

U={U1， U2， U3， U4}={very important, important, general, less important}

The status of the projects (B_1) is related with whether an EPC project can be implemented directly or not; and source of finance (B_2) and policy support (B_3) borders on the implementation of the EPC project. Each of these factors exerts varying impact as the chosen sector is changed. EPC projects in China are disproportionately practiced across sectors, but typically in energy-intensive industries. This paper makes use of the available survey data and chooses to analyze the financing status of five sectors, iron and steel, chemical, energy, electricity and buildings, through the following Fuzzy Comprehensive Evaluation function:

Putting the weighting factor of the status of EPC projects (α_1), source of finance for EPC projects (α_2) and policy support (α_3) and their respective evaluation values as calculated above into the following formula: $Fi = \alpha_1 F_1 i + \alpha_2 F_2 i + \alpha_3 F_3 i$

we get the final evaluation values for five sectors, as presented in Table 1:

Table 1 Final evaluation of financing bottleneck for EPC

	Iron and steel	Chemical	Buildings	Electricity	Energy
Status of EPC projects（0.4853）	0.235	0.242	0.2629	0.2603	0.249
Source of finance for EPC projects（0.3477）	0.4948	0.4936	0.4198	0.5108	0.3756
Policy support（0.1670）	0.4336	0.4536	0.4368	0.4349	0.4324
Final evaluation	0.3585	0.3648	0.3465	0.3783	0.3236

As is clear from the final evaluation, the difficulty for financing in a descending order for the implementation of

EPC projects across the five sectors is:
electricity (0.3782)>chemical industry (0.3648)>iron and steel (0.3585)>buildings (0.3465)>energy (0.3236)

3. Discussion

In the form of EPC, ESCOs serve their clients by helping to conserve energy in projects. Economic benefits from energy savings are used to pay back the previous technology investment, or financing, whose availability is the key to the successful implementation of EPC projectsm.

(1) Weighting factor aside, source of finance for EPC projects (B_1) presents itself as the largest hurdle, as is most prominent in electricity, chemical industry and iron and steel sectors, where EPC projects tend to involve high amount of investment, and a long investment period before return sets in, and depend primarily on bank loans or ESCO's self-investment for financing. Since ESCOs typically have limited investment capacity, bank loans become the primary source of finance. Not familiar with the risks inherent in EPC projects, banks get more prudent in lending so as to minimize the projects risks. Even when banks assent to provide the needed loans, the term of loans, most likely secured with guarantees or collateral, lasts only one to two years. Projects with longer contracting periods than the term of loans have no alternative but resort to revolving credit, shooting up the costs for EPC projects and risks for ESCOs.

In contrast with sophisticated EPC market overseas, domestic EPC market lags behind for its limited channels for financing projects and difficulty in access to finance, both of which have emerged as the major obstacles for the further development of the market. Indeed, numerous domestic banks in China, such as Industrial Bank of China, Minsheng Banking, and China Construction Bank, have started and expanded loans for EPC projects. But more bank loans alone could not meet all the need for financing in an expanding EPC market. That's why the improvement of the current source of finance and introduction of more sources of finance, such as finance lease, special fund and VC, are necessary. When such channels of finance are made accessible to relevant projects, improvement and expansion of this sort will further spur the development of EPC market in China.

(2) As made clear from the surveyed projects, in terms of average amount of investment either for ordinary projects or for projects involving ￥10 million’s investment or more, three sectors, electricity, chemical industry and iron and steel, surpass those of the other two sectors, buildings and energy, making it more difficult for the three sectors to get their projects financed (as shown in Table 2 on Page 11). Notably, while the average amount of investment either for ordinary projects or for projects involving ￥10 million’s investment or more in the iron and steel sector is higher than those of the power and chemical sectors, the former faces fewer difficulties in securing finance compared to the latter. A possible explanation for this disparity can be that EPC projects in the iron and steel industry involve large amount of investment and sophisticated technologies and thus can only be taken on by ESCOs better positioned in capital strength and technology accumulation. Participation of more credit-worthy ESCOs contributes to the reduction of comparative financing and technology risks of the EPC projects, and eventually the decrease of financing difficulties. That being said, a general pattern still exists: the larger the amount of investment required for a project, the more difficult it gets for the project to secure financing.

Table 2 A comparison of investment status for EPC projects across the five chosen sectors

Sector	The average amount of investment involved per EPC project (￥10,000)	The percentage of EPC projects that involve￥10 million’s investment or more(%)	Final evaluation
Electricity	1433.5	33.3	0.3783
Chemical industry	1422.5	37.5	0.3648
Iron and steel	9662.3	70	0.3585
Buildings	449.3	9.1	0.3465
Energy	238	0	0.3236

(3) The average ratio between expected energy savings per year and amount of investment for the surveyed projects stands at 1:1.93. This ratio seems to demonstrate that EPC practices are concentrated in projects which boast technologies with prominent energy savings and short investment periods. The same ratio for projects involving ￥10 million’s investment or more is 1:2.38, higher than 1:1.93. High investment projects of a similar nature, compared to

their small counterparts, usually require longer average investment return periods and bring more risks. Unless much more government support and encouragement are provided for them, these EPC projects will face far greater hurdles both in securing more financing and finding more sources of finance than smaller ones.

(4) Values for policy support (B_3) across five sectors are all very high, a surprising coincidence, proving the need of more government support for the development of EPC in China.

When asked to choose among institutional guarantee, subsidies and special funds, more ESCOs placed institutional guarantee before the other two factors. Many of the ESCOs also expressed hope for better legal framework and government procurement of energy efficiency services, expansion of the market, improved publicity and marketing for ESCOs, government promotion for financial products and services and support for the growth of the energy service market.

More subsidies and special financing are being provided to the EPC market. But both forms of support, not open for application or approval until a project has reached a certain stage of its implementation, fail to provide capital support for the initial stage of EPC projects. In this respect, experiences from the US might prove applicable in China. In the US, a proportion of fiscal revenues both at the federal and state level is set aside as super EPC funds, directly providing finance to EPC projects.

There is yet another merit in the establishment of EPC funds. Currently, subsidies and special funds are provided directly to ESCOs either in the name of subsidies or assistance. Clients might regard it as unfair that ESCOs could reap benefits from both government support in the form of subsidies or special funds and from energy savings. Seeing things in this light, the clients feel less willing to adopt EPC. If EPC funds are set aside, this potential problem could be gotten rid of, as the new funds could support the initial stage of EPC projects when financing is in shortage and be used to finance even more other projects when the financed projects are finally secured with energy savings produced by ESCOs to replace the initial investment.

(5) As EPC projects usually involve long period contracts, both ESCOs and clients face the great potential risk of the other breaching the contract. In our survey, 81% of the surveyed subjects rated operational status of clients as 'very important', and 59%, for ESCO credibility. In other words, the risks are made higher for both parties in an unsophisticated market.

To reduce the risk of the other breaching the contract, ESCOs and clients tend to shorten the contracting periods in unison. Of the 162 surveyed projects, the contracting period averages 4.49 years; and only 41.2% of them have contracts that last for five years or more，undermining technology diffusion and transfer in the energy service sector, where technology is at the core, and constraining the application of green technologies that demand high investment and long investment periods.

A case in point is the electricity sector where projects share the above-mentioned characteristics. Projects in this sector face serious challenges even if they have great potential in yielding handsome energy savings. In the survey, contracting period in the power sector averages only 3.64 years, lower than the 4.49 average across sectors. For the iron and steel sector which has the highest average amount of investment across the five sectors, the contracting period averages only 4.99 years; and only 31.6% of the projects have contracting periods that last for five years or more. Our future studies will try to quantify the impact on technology diffusion and transfer.

On the government side, regulations of the ESCO market can help to reduce risks in EPC projects significantly. In the US, a super-ESCO database is established to include credit-worthy ESCOs, adding a new channel for clients to get information.

(6) Final evaluation value on EPC financing in the buildings sector is lower than those of the electricity, chemical and iron and steel industries, but higher when it comes to the status of EPC projects (B_1) than the other four sectors, a notable contrast.

The ratio between expected energy savings and amount of investment in the construction sector is 1:2.00, higher than the average of five sectors. Still, amount invested per project in this sector averages only ￥3.35 million; and less than 10% of the projects enjoy investment of ￥10 million or more. Most EPC projects in the sector are focused on lighting and air-conditioning, where energy savings are neglectable compared to the large amount of energy consumed by buildings.

Evaluation of energy savings is made all the more necessary in the construction sector by the fact that buildings are more susceptible to multiple changes, such as weather and human usages. In the current stage, EPC projects in China are mostly seen applied in the industrial sector and few are being adopted in the buildings sector, let alone in the area of overall efficiency improvement for buildings. Without a series of practical evaluation criteria, money-guzzling overall efficiency projects for buildings will hardly get implemented.

5. Acknowledgements

This work is sponspered by the Science& Technology Ministry of People's Rebulic of China, the international corperation project, under grant #2010DFA91600, The relative study between US and China governments on the effect of promoting Energy Performance Contracting. My thanks go to ESCO committee of China Energy Conversation Association for its support and help.

Reference

[1] ESCO committee of China Energy Conversation Association, ,2010, 2009 Report on the Development of Energy Service Sector.

[2] Foreign Investment Department of the NDRC energy efficiency technical assistance of ADB Research Group, 2009. The development and suggestion of the energy performance contract in China. China Technology Investment,8,56-58.

[3] Gill Willkins, 2002. Technology Transfer for Renewable Energy Overcoming Barriers in Developmeing Countries. Earthscan, London.

[4] Guang-Ming Shi, Jun Bi,Jin-Nan Wang, 2010, Chinese regional industrial energy efficiency evaluation based on a DEA model of fixing non-energy inputs. Energy Policy 38, 6172-6179.

[5] Myung-Kyoon Lee, Hyuna Park, Jongwhan Noh, J.P. Painuly, 2003, Promoting energy efficiency financing and ECSOs in developing countries: experiences from Korean ESCO business, Journal of Cleaner Production 11, 651-657.

[6] Perry Sadorsky, 2010, The impact of financial development on energy consumption in emerging economies, Energy Policy 38, 2528-2535.

[7] Michael Hübler, 2011, Technology diffusion under contraction and convergence: A CGE analysis of China, Energy Economics, 33, 131-142.

[8] Steve Sorrell, 2007, The economics of energy service contracts, Energy Policy 35,507-521.

[9] Têbar Less, C., and McMillan S., 2005, Achieving the successful transfer of environmentally sound technologies: trade-related aspects, In.: Environment, J. W. P. o. T. a., (Ed.), OECD Trade and Environment Working Paper no. 2005-2, OECD. Paris.

[10] U. S. Environmental Protection Agency, 2007, Introduction to Energy Performance Contracting.

[11] Yongzhen Yu, 2010. Policy redesign for solving the financial bottleneck in demand side management(DSM) in China, Energy Policy, 38, 6101-6110.