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Unlocking green financing for building energy retrofit: A survey in the western China

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ABSTRACT

Energy service companies (ESCOs) play crucial role in building energy efficiency retrofit sector. However limited access to green financing has prevented ESCOs in their expansions in China. This paper, based on a survey of 469 samples and on-site visiting to and interviewing relevant 50 actors of ESCOs, financial institutions and local housing authorities, identifies main barriers of accessing to green financing at both systemic policy level and operational meso and micro level in China, and analyzes good practices at local level that overcome the barriers. The paper concludes that, although there are barriers existing at the policy level in China, substantial attentions and priorities should be given to take actions for overcoming the barriers existed at the operational meso and micro level. The paper suggests that the good practices of capacity building for ESCOs and local financial sector, intensifying participation of intermediate organizations or facilitators and diversifying financial sources and funding mechanisms and models that emerge from the local level should be disseminated in China.

1. Introduction

In China, the building sector accounts for about a quarter of total final energy consumption and CO_2 emission. According to the Ministry of Housing and Urban-Rural Development of China (MoHURD), the total floor area of existing buildings in cities is about 60 billion M^2 and it is increasing by 2 billion M^2 annually. More than 90% of the existing buildings in China that were constructed before 2010 are not energy efficiency (EE) and are not complying with energy standards of China [1,2]. Thus, the building energy retrofit sector plays a vital role in China's pursuit of a more energy and resource efficient and low carbon pathway. Over the last decade, the Chinese government has promoted energy efficiency building practices. Its first National Design Standard for Energy Efficiency of Public Buildings (GB50189-2005) was issued in 2005 and then revised in 2015 (GB50189-2015). Its Green Building Standard was issued in 2006. Since then the government formulated various laws & regulations, policies, building codes, technical standards and guidelines to accelerate the development of green buildings, including energy retrofit of existing buildings in China. China's policies being implemented in building energy retrofit are categorized into four groups of control and regulatory instruments; economic/market-based instruments; fiscal instruments and information and voluntary actions. China is now facing two major challenges in the enforcement of building energy retrofit. One is that the existing regulations, policies, technical standards and guidelines are focusing on phases of building design and construction that were implemented by professional institutes and companies. It is lack of effective polices and standards for improving building energy performance that were implemented by building owners who are normally non-professional in building energy performance. The other is that China is suffering from inefficient enforcement, insufficient levels of information and awareness and immature financial regulation system [3]. Both challenges call for solutions for China improving building energy performance that has substantially driven the demand for energy retrofit in the building sector. It is estimated that more than 30%–50% of the existing building energy consumption can be saved [4] by adopting various energy efficiency solutions.

In building energy retrofit, China favors energy performance contracting (EPC) that is a performance based business model. In this study, EPC is defined as a fixed-period and performance-based contract between an energy service company (ESCO) and a building owner/user to provide an energy performance service, in which the company bears significant risk, management responsibility, and remuneration is linked to performance. There are basically three EPC models worldwide: 1) shared savings model, 2) guaranteed savings model and energy-cost

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trust model. The most popular EPC model is shared savings internationally and more than 90% of Chinese EPC model in building energy sector is also the shared savings, which is the targeting model of this research. By adopting the shared saving model, ESCO bears risk of investment and thus financing is crucial for ESCO. For implementing and scaling up EPC in building energy sector, Chinese government has rolled out a number of policies, including a significant amount of subsidies, to improve building energy performance since 2006. The most important policies are included in two government documents of 1) Speeding up the Implementation of Contract Energy Management to Promote the Development of Energy-Saving Service Industry and 2) Measures for the Management of Financial Incentive Funds for Contract Energy Management Projects that are published in 2010. In these two documents, public financing has provided a major incentive for various market actors. However, given the huge financing gap, public subsidies alone are far from sufficient to mainstream sustainable building development and building energy retrofit in China. Thus, it is essential to develop innovative financing mechanisms for attracting private investment to fill in the immense financial gap to reach the national greenhouse gas reduction target. EPC provided by Energy service companies (ESCOs) is a market-based mechanism performance-oriented instrument for building energy retrofit. ESCOs in China have limited access to financing, which represents a key challenge for realizing energy efficiency projects in the building sector at a substantial scale. At the same time, financing EE projects in the building sector represents an attractive investment opportunity for financial institutions due to the high overall investment volume and the decreased risks due to EE improvements. However, financial institutions also face substantial barriers to seize these benefits and accelerate financing for building energy retrofit and ESCOs.

ESCOs play crucial role in building energy retrofitting. Majority of ESCOs is micro- and small & medium size enterprise (MSME) [4], which is defined by the Ministry of Industry and Information Technology of China (MIIT) as an enterprise having less than 300 employees or total of assets below 1.2 billion Chinese Yuan. Limited access to financing has been the key constraint for ESCOs expanding their building energy retrofit business and adopting of deep solutions in energy retrofit. Zhang [4] has conducted a nationwide EPC survey in China and an important finding is that, due to lack of access to green financing, majority of EPC projects in building sectors are taking solutions of adopting smart monitoring and managing system and investing new facilities for improving cooling, heating and lighting system. Zhang's survey found that there is no case that ESCO is investing building itself energy retrofitting, given to the high investment and long payback time. Literature points out that there are various barriers, especially financial, have diminished the building energy retrofit market [5]. Bertone et al. [6] has conducted a comprehensive review that identified building energy retrofit project financing to be the greatest deterrent, although other factors such as education and awareness-raising were also recognized as being critical. International Energy Agency [7] has recognized the main barriers of up-front costs and dispersed benefits discourage investors, perception of EE investments as complicated and risky, with high transaction costs and lack of awareness of financial benefits on the part of financial institutions. Various researches have recognized the following key financing barriers of ESCOs [8–12].

1) Limited assets and weak balance sheets: Banks often provide only asset-based loans, but ESCO projects usually involve insufficient assets and working capital. Banks usually regard future cash flows from energy savings as intangible and uncertain as collateral. Service-oriented ESCOs often have limited collateral and rely primarily on cash flow from energy savings, which are not conventional revenues in an asset-based financing culture.
2) Lack of financial track records: Many ESCOs do not exist long enough to provide adequate credit histories to banks. Such a credit history is often required to receive loans.
3) Lack of financial literacy: For many ESCOs, application for loans is difficult due to a lack of accounting and financing knowledge. Many ESCOs often lack the necessary financial management capacities and accounting skills that are required for a comprehensive loan application.
4) Low awareness and knowledge on funding opportunities: ESCOs often do not have enough capacities to systematically assess suitable green financing and funding opportunities dedicated to them [13].
5) High financial burdens and risk: Many ESCOs in China operate under the "shared savings model" in order to become eligible for the ESCO support scheme provided by the central and local governments [4, 14] Shared savings contracts require that ESCOs provide the project financing, thus bearing the financial risk.

From supply side, financial institutes play crucial role in providing access to financing for ESCOs. However financial institutions also face substantial barriers to seize business opportunities and to accelerate green financing for building energy refurbishment and ESCOs. Based on literature study, the following barriers of financial institutes are summarized [8,11,15]:

1) Lack of transparency of the ESCO market and a general lack of trust in the energy service business.
2) High lending risk due to low collateral asset value, a long project lifetime, and often high performance risks of EE projects. In the absence of trust, lenders rely on collaterals. Generally, ESCOs tend to have small production scales that do not qualify for bank requirements. Service-oriented companies such as ESCOs rely primarily on shared energy savings or other irregular cash inflows as the revenue source and thus lack collateral [16]. The collateral requirements, both for bank lending and capital markets, are usually too rigorous for Chinese ESCOs [17].
3) Lack of technical knowledge, which makes it difficult to assess risks and future cash flows of energy service projects.
4) Lack of tools to assess ESCOs' credit default risk. One of the most challenging problems that hamper ESCOs' access to financing is the risky business environment in which they operate. Many ESCOs in China operate on markets with fluctuating supply and demand [16]. At the same time, financial institutions and investors often lack the ability and tools to assess default risks of ESCOs, particularly in emerging sectors. Consequently, it becomes very difficult and costly for banks to evaluate ESCOs.
5) Lack of generally accepted monitoring & verification (M&V) standards: ESCOs often have their own M&V systems making it difficult for financial institutes to evaluate projects.
6) High transaction costs: ESCO projects are often small and transaction costs are relatively high if the projects cannot be effectively aggregated [18].
7) Financial institutions charge high interest rates for lending. ESCOs usually pay higher interest rates on loans than larger companies.

Chinese national and local governments have developed and implemented various policies to overcome the mentioned-above barriers of both ESCOs and financial institutes and have achieved considerable progress in building energy retrofitting. During the 12th Five-Year Plan period (2011–2015), over 700 million m^2 of existing residential buildings in northern China were retrofitted, in which public financing has played a major role. However, Public subsidies alone are far from sufficient to mainstream energy retrofitting in China. Thus, the development of innovative financing mechanisms is essential for attracting private investment to fill in the immense financial gaps to reach the national targets. Theoretically all mentioned-above barriers can be overcome with the design and implementation of targeted building EE policies. Green financing is a proven instrument to increase ESCOs' access to financing. For increasing access to green financing, the People's Bank of China, the Ministry of Finance, the National Development and

Reform Commission, and other Departments have jointly issued a Guideline of Building a Green Financial System in 2016. This guideline defines that green finance is various economic activities for the purpose of supporting the improvement of environment, responding to climate change, and conserving and efficiently using resources, i.e. the financial services provided to project investment and financing, project operations, risk management, etc. in the fields of environmental protection, energy conservation, clean energy, green transport, green architectures, etc. In this research, we define that green financing in building energy retrofit is the institutional arrangements which support improvement of building performance through financial instruments, such as green credit, green bonds, green stock index and relevant products, green financial funds, green insurance and carbon finance, as well as the relevant policies.

The key question is then how the key barriers within the context of China building energy retrofit can be accurately recognized and then tailor-made policies at systemic level and distinct business models at operational micro level can be developed and implemented. This study, based on literature review, face-to-face interview and a nationwide survey, aims to identify and analyze the key barriers in terms of access to green finance encountered by ESCOs of demand side and financial institutes of supply side. Drawing on the survey data, this paper constructs a profile of Chinese ESCOs in access to green finance and makes recommendations how the barriers can be overcome. The results of this study can be used to inform relevant stakeholders on the situation regarding access to finance by ESCOs in China's building energy retrofit sector. This shall especially foster the development, up-scaling and replication of green financing schemes for ESCOs to enable more investments in building energy retrofit sector. Specifically this paper addresses the following issues:

1) The status of ESCOs in building energy retrofitting sector in terms of access to green finance;
2) Key barriers of both demand and supply sides at the systemic level, and for which broader interventions of financial sector development would be needed (e.g. legal-regulatory and supervisory issues; financial infrastructure gaps);
3) Key barriers of supply sides at the meso and micro levels, and for which distinct business models would be needed (e.g. banking training institutes/associations, technical providers in the financial sector, individual financial institutions such as banks, leasing companies, in some cases also microfinance institutions);
4) Key barriers of demand side at the operational level, and for which ESCOs' capacity needs to be improved;
5) Concrete recommendations to facilitate ESCOs to improve their access to green finance.

This study targets the key stakeholders of ESCOs that need to have access to green financing, local financial institutes that provide green financing and local housing authorities that facilitate green financing and foster market development through policy framing. The surveyed results are given back to the stakeholders under this survey for getting their feedbacks. The final results of this study are provided to the targeted housing authorities and local financial institutes for them taking improvement actions in speeding up green financing development in building energy retrofit sector. Types of buildings are categorized into public buildings (so called commercial buildings internationally), urban residential buildings and rural residential buildings in China. This study is targeting EPC projects in energy retrofit of public buildings and urban residential buildings, given to the fact that all EPC projects in building energy retrofit [4] exist in public buildings and urban residential buildings and none of EPC project exists in rural residential buildings.

2. Methods

Data collection was conducted in the period of July to November 2018 through literature review, nationwide questionnaire surveys and face-to-face interviews. Reviewed literature includes national and international studies, reports and publications and best practices on green financing in building EE sector. In particular, the following four types of China national and local financial policies have been reviewed and analyzed: (1) the green credit policy that was launched by China Banking Regulatory Commission (CBRC), the Ministry of Environmental Protection, and the People's Bank of China to encourage banks to lend more to energy efficient and climate friendly projects, while lending less to highly polluting and energy-consuming projects. (2) National SME development fund that was released by China State Council and it aims at alleviating financing difficulties for SMEs and intensifies the efforts to promote mass entrepreneurship and innovation and create new growth momentum. (3) Policies launched by the individual banks that are responding to the mentioned-above (1) and (2) national policies. (4) National and local policies on promoting Energy Performance Contracting (EPC) development.

Questionnaire design: Pre-coded questionnaire developed by this study include three types of questions that are developed, based on the mentioned-above literature reviews: (1): General questions about profiles of the targeted ESCOs and financial institutes that are answered by the surveyed ESCOs and financial institutes; general questions about national and local polices in supporting green financing to building EE retrofit that are answered by all surveyed ESCOs, financial institutes and local housing authorities; general questions on policy implementations that are answered by all surveyed ESCOs, financial institutes and local housing authorities. (2) Questions to ESCOs, which covers all aspects of difficulties, constraints and barriers that the targeted ESCOs encountered in their access to green financing. (3) Questions to financial institutes, which covers all aspects of barriers and constraints that the targeted financial institutes encountered in their providing financial services to ESCOs.

Sampling: The survey is one of the activities of the EU-China cooperation project, entitled Up-scaling and mainstreaming sustainable building practices in western China (SusBuild), which is being funded by the European Commission (contract number: DCI-ASIE/2015/368–399). The SusBuild is targeting China western provinces of Yunnan, Shaanxi, Gansu and the mega city of Chongqing, the survey sampling is also from the SusBuild targeted region. Selection of ESCOs is from two sources. One is from the lists of ESCOs provided by local housing authorities and the ESCOs on the lists are doing EPC business in building energy retrofit sector in the target region. The other is from the EPC database on building EE established and being updated by China Association of Building Energy Efficiency. From this database, we got full coverage of ESCOs that are active the targeted region. By combing these two sources, we found that total of 366 ESCOs that are doing EPC business in building energy retrofit in the targeted region and, among these 366 ESCOs, 341 are MSMEs and the rest 25 are big companies. All 366 ESCOs are included in this survey. There are total of 49 financial institutes in the target region and all these 49 are big or very big companies and all of them have been selected to participate in the survey. There are 117 local housing authorities (municipal housing department) in the target region and all these 117 are invited to participate in the survey. Therefore the survey under this study has full coverage of ESCOs, financial institutes and local housing authorities.

Survey and interview: Based on the sampling above, this survey has sent out questionnaires to 366 ESCOs, 49 financial institutes and 117 local housing authorities in China western provinces of Yunnan, Shaanxi, Gansu and mega city of Chongqing. 348 ESCOs are responded with the response rate of 95.1%, 37 financial institutes are responded with the response rate of 75.5% and 84 housing authorities are responded with the response rate of 66.1%. The selected ESCOs, financial institutes and local housing authorities have good representativeness of both climatic zones and economic development scales. High response rate of ESCOs shows that they are very much interested in unlocking green financing and much willing to expand their activities on

building energy retrofit with the support of green financing. Key reason of relatively low response rate of financial institutes can be that many local banks do not have staff who only manage green financing (e.g. green financing is only small part of their business) and it is difficult for this study to find the right persons from local banks who could fill in the questionnaires. Although it is not clear why the response rate from local housing authorities is worrying low, telephone calls to several housing authorities who did not send back the filled in questionnaires show that they are lack of human resources and they have no time to answer the questionnaires.

Based on the preliminary questionnaire survey results, this study has conducted face-to-face interviews to the 21 ESCOs, 12 local banks and 17 local housing authorities that are selected from the questionnaire responders, based on the principle of willingness to be interviewed. Unfortunately, a lack of resources did not allow us for more face-to-face interviews. Face-to-face interviews allow responders to have more open exchanges and comments on green financing and can get much detailed information on the constraints they face, practices they implemented, experiences they had and recommendations they would like to make for overcoming the barriers. Face-to-face interviews have also set up exchanges of understanding and ideas about promoting green financing to building EE retrofit, which helps this study to provide concrete and tailor-made recommendations.

Data quality control: For ensuring quality and reliability of data collected, a quality assurance (QA) committee has been established by the mentioned-above SusBuild project and this research team has participated in the QA. In addition, 2 experts from Chongqing Association of Building Energy Efficiency, 2 experts from Yunnan Provincial Centre for Building Technology Development, 2 experts from Shaanxi Provincial Association of Building Energy Efficiency and 3 experts from China Association of Building Energy Efficiency have participated in the QA. Main tasks of QA include reviews of all received questionnaires, contacting responders by phone in case clarifications are needed, and data checking and processing.

3. Results

3.1. Status of green financing in building EE retrofit

Since 2007, China national and local governments have adopted various regulatory, technical and financial policies for demonstrating and mainstreaming energy retrofit of the existing 43 billion M^2 civil buildings, in which more than 90% are not complying with building EE standards [19]. As a result, market of building EE retrofit is growing in leaps and bounds. There are total of 6500 ESCOs in China at the end of 2017, in which about 3000–3500 are working in building EE sector [4]. Number of ESCOs who are responded in this survey is 348, which is equivalent to about 10%–12% of the total ESCOs that are working in building EE sector in China. China's national standard on the size-classification of enterprises shows that a MSME has staff of 300 below or total asset of 1.2 billion Chinese Yuan for the service sector. Building energy retrofit belongs to service sector. In this study, we define that a micro ESCO has staff below 20, a small ESCO has staff between 20 and 50 and a medium and above ESCO has staff more than 50.

One the demand side, Table 1 provides information on the surveyed 348 ESCOs related to access to green financing. It shows that about 90% (11% + 79.6%, as indicated in Table 1) of the surveyed samples that can be a representative sample of the ESCOs total population of China are micro and small, and only 10% of the surveyed samples are medium and above. In average, Chinese ESCO in building EE sector has size of 44.7 staff (N = 348) and 11% of the 348 ESCOs in this sector has staff less than 20. In average, 17.8% of the 348 ESCOs have got green loans from banks. Table 1 shows that the smaller the ESCO is, the more difficult the ESCO could have access to green financing. Thus only 2 micro-ESCOs out of the surveyed 38 micro-ESCOs have had access to green loans.

Unlike to the limited access to green loans (only 17.8% of the 348 ESCOs had access to green loans), governmental subsidy and grant play crucial role in providing financial supports to ESCOs. Among the 348 surveyed ESCOs, 155 (44.5%) have got subsidies or grants from national and local governments. Table 1 shows significant differences of access to public subsidies/grants among the different sizes of ESCOs. None of the surveyed 38 micro ESCOs has got governmental subsidies or grants. However 122 of the surveyed 277 small ESCOs (44%) have got governmental subsidies and all 33 medium and above ESCOs have got governmental subsidies or grants. The average size of an EPC project in building EE retrofit sector is 1.72 million Chinese Yuan (CNY, eq. 0.23 million euro, N = 348) under this survey, which is very small as compared to EPC projects in the fields of EE in industrial and transportation sectors. The key reason is the limited floor areas of each EPC project in building sector and the smaller EPC project in building EE retrofit sector has been one of the key constraints to access to loans from commercial banks [20]. Significant differences of EPC project sizes in building EE retrofit sector also exist among the different sizes of ESCOs. The average EPC project size implemented by medium and above ESCOs is 3.26 million CNY under this survey, which is 4.3 times of the project size of 0.75 million CNY implemented by micro ESCOs. Regarding to the structure of investment in building EE retrofit, 55.5% of the 348 ESCOs rely primarily on their own cash flow from energy savings, which are not conventional revenues in an asset-based financing cultures. Only 45.5% of the 348 ESCOs are doing investment by both their own resources and other financial sources (loans, subsidies or other financial products).

One the supply side, Table 2 shows that average share of green loans provided by the surveyed 37 banks is 7.6%. In China, national banks are mainly cooperating with large companies, in particular those state-owned companies. Service-oriented ESCOs are mainly micro-, small- and medium-size enterprises, and thus ESCOs are mainly working with local banks. Table 2 shows that 86.5% of the 37 banks are local banks and 94.6% of the 37 banks are commercial. Given to the green financing policies established jointly by China Banking and Insurance Regulatory Commission (CBIRC), China National Development and Reform Commission (NDRC) and Ministry of Ecology and Environment (MEE), providing green financing services have been compulsory for banks and thus all surveyed 37 banks have already established their own green

Table 1
Status of the ESCOs in building energy retrofit sector related to access to green financing, N = 348.

Factors	Number	In %
Average number of ESCO staff	44.7	
ESCO with staff below 20 (micro)	38	11%
ESCO with staff between 20 and 50 (small)	277	79.6%
ESCO with staff more than 50 (medium and above)	33	9.4%
Number of ESCO access to green loan	62	17.8%
Number of micro ESCO access to green loan	2	10%
Number of small ESCO access to green loan	41	14.8%
Number of medium and above ESCO access to green loan	19	57.6%
Number of ESCO access to public subsidy or grant	155	44.5%
Number of micro ESCO access to public subsidy or grant	0	0%
Number of small ESCO access to public subsidy or grant	122	44.0%
Number of medium and above ESCO access to public subsidy or grant	33	100%
Average project size of building EE retrofit, million CNY	1.72	
Average project size implemented by micro ESCO, million CNY	0.75	
Average project size implemented by small ESCO, million CNY	1.67	
Average project size implemented by medium and above ESCO, million CNY	3.26	
Average shares of project investment		
By ESCO own financing		55.5%
By own financial source and other sources (loan, subsidy, other financial products)		44.5%

Source: Primary data, 2018

Table 2
Status of banks in providing green loans, N = 37.

Factors	Number	In %
Average share of green loans in the bank's total loan (in 2017)		7.6%
Local bank	32	86.5%
National bank	5	13.5%
Commercial bank	35	94.6%
Development bank	2	5.4%
Banks with green loan policies	37	100%
Banks without green loan policies	0	0
Banks with specific policies supporting SMEs	31	83.8%
Banks without specific policies supporting SMEs	6	16.2%
Banks with professional staff only dealing with green loans	6	16.2%
Banks without professional staff only dealing with green loans	31	83.8%

source:Primary data,2018

financing policies. In addition, 83.8% of the 37 banks have also developed their SME-oriented supporting policies. One of the challenges that banks are facing in providing green financing service is that most of banks (83.8% of the 37 banks) have no professional staff who are solely working on green loan projects.

Main findings of the surveys on the status of green financing in building EE retrofit can be summarized at the follows:

1) More than 90% of ESCOs in building EE retrofit sector are micro- and small-size enterprises, with average staff of 44.7.
2) Only 17.8% of ESCOs in building EE retrofit sector have access to green financing, while the bigger the ESCO is, the easier the ESCO has access to green financing.
3) Unlike to the limited access to green loans, most ESCOs rely on governmental subsidies and grants. About half of ESCOs (44.5%) have already received governmental subsidies, and thus governmental funding is still play crucial role in increasing access to green financing for ESCOs.
4) Average project size of building EE retrofit is 1.72 million CNY, which is significantly smaller than EPC projects in the sectors of industries and transportations.
5) Local commercial banks are the main financial institutions in providing green financing services to ESCOs. Although all banks have already set up their green financing policies, lack of professional staff is the main challenge for banks increasing their green financing activities.

3.2. Main barriers at the systematic policy level

For identifying main barriers at the systematic policy level, a checking list of 10 checking points is developed, based on literature study. All 348 ESCOs, 37 financial institutions and 84 housing authorities have evaluated the 10 checking points by applying scoring rule of: 9–10: fully agree, 7–8: agree, 5–6: in between, 3–4: disagree, 1–2 fully disagree. This yielded an average score for each of checking points and for each of three surveyed groups of ESCOs, financial institutions and housing authorities. The quality assurance (QA) committee established by this study contacted the responders in case questions about the scores or clarifications from responders are needed. Table 3 presents the survey result that can be summarized as the follows:

1) The overall average is 5.4, which is between 5 and 6. This means that all responders are neutral between agreeing and disagreeing the 10 barriers. However difference exists among the three groups of actors. Housing authorities seems to disagree with the 10 barriers (average score of 4.5) and both ESCOs and financial institutions seems to agree that the 10 barriers do exist in certain degree but not significant.
2) Significant differences do exist among the 10 barriers. The most significant barriers identified by the responders are 1) short or uncertain lifetime of local governmental funding schemes; 2) relatively lower energy price and 3) split incentives/Principal-Agent Problem.
3) ESCOs have identified the main policy-level barriers of short or uncertain lifetime of governmental funding schemes, split incentives/Principal-Agent Problem and relatively lower energy price. Financial institutions identified the main policy-level barriers of lack of transparency of the ESCO market, low awareness, short or uncertain lifetime of governmental funding schemes and relatively lower energy price. Housing authorities recognized that low energy price and split incentives are the main barriers at the policy level.
4) We made a conclusion that main barriers at policy level are short or uncertain lifetime of public funding schemes, relatively lower energy price and split incentives. Overall, some barriers at policy level do exist in Chinese EPC projects on building EE retrofit, however they are not significant.

Table 3
Identification of policy-level barriers in EPC project s of building EE retrofit.

10 checking points	348 ESCOs	37 Financial institutions	84 housing authorities	Average
Lack of transparency of the ESCO market	6.7	7.5	4.5	6.2
Low awareness on building EE retrofit	5.4	8.1	3.3	5.6
Short or uncertain lifetime of national governmental funding schemes	7.2	7.5	4.2	6.3
Short or uncertain lifetime of local governmental funding schemes	8.7	8.8	6.7	8.1
Lack of effective national regulations on building EE retrofit	4.4	2.9	2	3.1
Lack of effective local regulations on building EE retrofit	3.9	2.4	3.3	3.2
Lack of technical standard on existing building EE	2.8	3.3	2.8	3.0
Lack of technologies and materials on building EE	2.5	3.6	2.6	2.9
Split incentives (investors cannot capture the benefits of improved efficiency)	8.2	7.4	7.4	7.7
Relatively lower energy price	7.9	8.3	7.8	8.0
Average score	5.8	6.0	4.5	5.4

Source: Primary data, 2018

3.3. Main barriers of ESCOs at the operational meso and micro level

Various reports, scientific articles, legal documents, grey literature and case studies on EPC projects in building EE retrofit have recognized various barriers of ESCOs in their access to green financing [5–18]. By the reviews of literature and relevant reports and case studies, this study has summarized 8 main worldwide barriers of ESCOs at the operational level as presented in Table 4. By the questionnaire survey, all 348 ESCOs have checked the 8 points in Table 4 through scoring 0–10. The higher the score is, the more important the barrier is. Answers from the surveyed 348 ESCOs have clearly revealed that there are considerable barriers of Chinese ESCOs in building EE retrofit sector (score of 7.0) and the key barriers identified by this research are.

1) Limited assets and weak balance sheets of ESCOs (score of 8.8). Necessary assets and strong balance are always required by the

Table 4
Main barriers of ESCOs at the operational meso and micro level, N = 348.

8 checking points	Average
Low awareness and knowledge on funding opportunities	3.7
Lack of financial literacy (lack of accounting and financing knowledge)	7.5
Lack of financial track records (no adequate credit histories to banks)	7.2
Limited assets and weak balance sheets	8.8
High financial burdens and risks	6.3
High transaction costs (project development costs are high relative to energy savings)	7.5
Inadequate project readiness (EPC project manager has poor capacity to develop qualified applications to banks for loans)	8.7
Big gaps between SMEs and financiers on type of financial and technical information required in credit approval processes.	6.3
Average score	7.0

Source: Primary data, 2018

conventional commercial banks in providing loans and ESCOs are often small size and service-oriented and thus they lack of collaterals and their assets and financial balance don't meet the criteria of banks.

2) Inadequate project readiness (score of 8.7). Unlike to the big companies, the SME-oriented ESCOs are incapable of developing qualified funding proposals that meet the requirements of banks.
3) High transaction costs (score of 7.5). Comparing to economic profits generated by energy savings, the transaction costs are rather high, as there are complex procedures set by banks that ESCOs have to follow.
4) Lack of financial track records and financial literacy (scores of 7.2 and 7.5). Most Chinese ESCOs lack good quality financial records and reliable financial statements or documents that banks usually require for evaluating borrower's credit eligibility.

3.4. Main barriers of financial institutes at the operational meso and micro level

Building EE investments represent a significant new business opportunity for financial institutions. It is estimated that the market of building EE is 400 billion Chinese Yuan in 2016 and it is increasing by more than 10% annually [21]. Theoretically, building EE retrofit investment should be attractive for market actors. In practices, however, financial institutions face substantial barriers to seize the above-mentioned benefits and to accelerate green financing for building energy refurbishment and ESCOs. By reviewing literature and relevant reports, 8 barriers of financial institutions that are common in international EPC market have been identified and are listed in Table 5. Table 5 shows that there are even more substantial barriers of financial institutions at the operational level (overall average score of 7.4), with comparing to the barriers of ESCOs (overall average score of 7.0). This study has identified the following key barriers of Chinese financial institutions in the EPC projects of building EE retrofit.

Table 5
Main barriers of financial institutions at the operational meso and micro level, N = 37.

8 checking points	Average
Lack of transparency of the ESCO market and a general lack of trust in the energy service business	8.6
High collateral requirements (collateral requirements are too rigorous for ESCOs)	9.2
Lack tools and capacity to assess SME-oriented ESCOs' credit default risk.	8.7
Charge high interest rates for lending (loan is unattractive for ESCOs)	6.3
Guidelines for ESCO lending and green lending are not fully complied with	7.8
Hesitant to provide SMEs with financing	5.5
Small lending institutions that are important sources of funding SMEs suffer from low financial capacity	4.9
Big gaps between SMEs and financiers on type of financial and technical information required in credit approval processes.	8.4
Average score	7.4

Source: Primary data, 2018

1) High collateral requirements (collateral requirements are too rigorous for ESCOs). Although banks' recognition of future receivables from energy savings is important for ESCOs, banks are more financially constrained after the financial crisis, which could limit lending to low carbon assets such as building energy renovation projects. In addition to the questionnaire survey, this study has also face-to-face interviewed 12 local banks, and all 17 banks express that they are not willing to decrease their collateral requirements when offering loans to SME oriented ESCOs, in which 8 banks have even increase their collateral requirements, as comparing to providing loans to big companies. One of the key reasons is the high risk in lending to SMEs, in particular ESCOs with limited assets and weak balance sheets.
2) Lack tools and capacity to assess SME-oriented ESCOs' credit default risk. Although all banks have set up their green financing policies as required by national banking authorities, their operations on green financing services are not as expected. Banks often lack technical skills or the organizational processes necessary to evaluate green projects and smaller, newer and more opaque firms. One of the most challenging problems that hamper ESCOs' access to financing is the risky business environment in which they operate. Financial institutions and investors often lack the ability and tools to assess default risks of ESCOs, particularly in emerging sectors of building EE.
3) Lack of transparency of the ESCO market and a general lack of trust in the energy service business. Banks' awareness on the green credit guidance documents released by governments remains low. Banks understand that an increase in production will increase the chance of returning the loan; however, it is more difficult for banks to understand that efficiency improvements also yield financial returns.
4) Big gaps between SMEs and financiers on type of financial and technical information required in credit approval processes. This is related to inadequate capacities of both ESCOs and banks in dealing with green loans. Face-to-face interviewing the 17 banks shows that more than 80% of loan application documents prepared by ESCOs are not complying with the criteria set by banks and thus those application documents have to be returned to ESCOs for revision. This time-consuming loan appraisal process and the cost of loan applications make external finance unattractive for ESCOs.
5) Guidelines for ESCO lending and green lending are not fully complied with. Lack of implementation and monitoring capacity leads to the ESCOs and Green Lending Guidelines for financial institutions not being strictly followed. In spite of government guidelines for SME lending, banks use loopholes allowing them to avoid lending to SMEs. For example, loans to state-owned enterprises (SOEs) can be disguised as SME loans by making loans to small subsidiaries or paying small suppliers on behalf of SOEs.

3.5. Strategies and solutions for unlocking green financing in building EE retrofit

Access to green finance is a challenge that SMEs all over the world face, since most green activities are focusing on efficiency improvement that is not the core business of conventional commercial banks that are always doing investments in production. Various barriers at policy level and operational meso and micro level have been identified under this study within China context of EPC projects. The main conclusion, based on the survey results in section 3.2-3.4, is that the key barriers that China's ESCOs face in access to green financing are not at systemic level, but at the operational meso and micro level that can be dealt with by working with stakeholders of financial sector. Various feasibility studies,

demonstrations and practices took place in the past decade in China for exploring how the barriers at operational level can been overcome.

For identifying the successful measures adopted by ESCOs and financial institutions, this study has on-site visited to and face-to-facto interviewed 21 ESCOs, 12 local banks and 17 local housing authorities. Purpose of the visits and interviews are to communicate the results of main barriers identified by the survey of this study and, in particular, to get insights of the measures that are adopted by relevant actors and best practices being implemented for overcoming the main barriers mentioned in section of 3.2–3.4 of this paper.

At the policy level, one of the main barriers identified by this study (refer to Table 3) is the short or uncertain lifetime of local governmental funding schemes. This is reinforced by the fact that many of them are highly dependent on public funds. This is particularly true for grant/subsidy schemes, while local housing authorities have clearly pointed out that energy efficiency obligations have the advantage of placing no burden on the national and local budget and are therefore independent of budgetary changes. They, however, require political support for their continuation. Interviews to ESCOs and banks show that public funding is crucial at the current stage and should be kept until the building EE retrofit market is mature. When this study is asking ESCOs and local banks how long the public funding should be available, most interviewees suggest that the current public funding should exist at least for another five years.

Another main barrier at the policy level is split incentives or Principal-agent problem [22]. The existing public subsidy from central government goes to local housing authorities. By adding local matching funds, subsidy goes to building owners. In this case, ESCOs as investors cannot capture the benefits of improved energy efficiency. Main purpose of public subsidy is to incentivize building EE improvement that is done by ESCOs. However, in many cases, subsidy doesn't go directly to ESCOs but to the building owners. Another issue is that an ESCO could receive public subsidy only if it has been registered by National Development and Reform Commission (NDRC) of China. To be eligible for registration, the ESCO should be at certain scale and most micro-size ESCOs are ineligible. Thus they are ineligible in receiving public subsidy. For overcoming this barrier, some local authorities are experiencing building EE performance-oriented subsidy scheme, in which all ESCOs are eligible and receive directly subsidy that is calculated based on improvement of building EE. This will ensure that financial incentives reach the right actors, namely those who have the ability to act.

Relatively lower energy price is a substantial barrier at the policy level, while increasing energy price is a complex issue. Energy production and distribution are highly subsidized, in particular for citizens, in China, and lower energy price constrains energy saving and EE improvement. Interviews to the housing authorities under this study present that, instead of increasing energy price, China national and local authorities are preparing to include building sector into national Emission Trading Scheme (ETS). As a start point, the Ministry of Housing and Urban & Rural Development (MoHURD) has published National Standard for Building Carbon Emission Calculation (GB/T51366-2019), which is effective as per the December 1, 2019. After certain years (e.g. 5 years) of registration of building carbon emission by applying this standard, building sector will be ready for participating in national ETS. Zhang et al. [4] has concluded that ETS is a vital driving force for up scaling EPC in Chinese building sector and stimulates improvement of EE as well as adoption of sustainable energy or clean energy.

By visiting to ESCOs, local banks and local housing authorities, in particular, visiting to relevant best practices on unlocking green financing for building EE retrofit, solutions and best practices are collected, analyzed and identified.

Four main barriers of ESCOs as indicated in Table 4 are limited assets and weak balance sheets of ESCOs, inadequate capacity of ESCOs in developing green financing proposal, high transaction costs and lack of financial track records and financial literacy. These four barriers are related to the poor capacities of small- and micro-size ESCOs in financial management and technical proposal development. Best practices and successful solutions are the follows:

1) ESCOs' and financial institution's capacity building programme have been developed and being implemented jointly by the building EE sector associations, banking associations and local authorities. In many cities, such capacity building programme are funded or partly funded by local authorities. The capacity building programme includes green-loan technical guideline development, both on-line and in-site trainings for ESCOs and local financial institutions, and exchanges between ESCOs and local banks.
2) Supporting local banks establishing taskforce that is solely dealing with small-size green-loan applications.
3) Local building EE sector associations and local banking associations jointly organized various match-making events for building up contacts and dialogues of ESCOs and local financial institutions.
4) Contracting third-party intermediate organizations for supporting ESCOs in developing loan-application documents. Many best practices shows that contracting intermediate organizations are efficient and successful in facilitating ESCOs in access to green financing.
5) Demonstrating and up scaling different financial mechanisms and products that are particularly tailor-made for local small- and micro-size ESCOs.
6) There are some best practices on standardizing underwriting procedures internally. There are also initiatives implemented by external actors that support banks in evaluating energy efficiency projects in a standardized manner.

Main barriers of financial institutions as indicated in Table 5 are high collateral requirements, lack of tools and capacity to assess SME-oriented ESCOs' credit default risk, big gaps between SMEs and financiers on type of financial and technical information required in credit approval processes, guidelines for ESCO lending and green lending are not fully complied with. Best practices and successful solutions identified by this study for overcoming mentioned above barriers are the follows:

1) Involving producers/suppliers of EE products and materials into the loan-application. Major investment from ESCOs is to buy EE products and materials from producers and suppliers. Producers have considerable assets (e.g. factory, industrial land and production facilities) that meet the collateral requirements of banks. Various best practices collected by this study show that participation of producers/suppliers can significantly increase the chance for ESCOs in getting green loans and other financial sources.
2) Involving insurance companies. Insurance companies are doing risk-related business and many practices at Chinese local level shows that most insurance companies are willing to provide guarantee services to small- and micro-size ESCOs in building EE projects.
3) Involving building owners. Improved building energy efficiency decreases the energy costs and increases the property value of the refurbished building and ensuring wealth conservation. Thus participation of building owners is crucial and can diminish the negative impacts resulted from the limited assets and weak balance sheets of ESCOs.
4) Establishing SME Fund. SME funds share many characteristics with microcredit, micro-enterprise, and village banking, namely providing loans to persons or groups of people that do not qualify for traditional financial services or are otherwise viewed as being high risk.
5) Diversifying financial resources for avoiding high collateral requirements required by traditional commercial banks. In this study, numbers of successful practices on applying non-deposit taking lenders (NDTL) are found. NDTL varies between sources but usually comprises loan companies, financial leasing companies, microcredit companies, pawn shops, etc. Other financing sources available in

China include interpersonal borrowing, money lenders, loan brokers, private money houses, etc. These sources are informal and sometimes even illegal [23,24].

Another barrier of financial institutions as indicated in Table 5 is the lack of transparency of the ESCO market and a general lack of trust in the energy service business. This is the key barrier of financial institutions and number of practices on overcoming this barrier is presented below:

1) Awareness-arising campaigns aiming at improving deep understanding of financial sector on the green microcredit guidance documents released by governments.
2) Communicating the ESCOs market information in financial sector, in particular, informing the standardized procedures for energy audits and measurement and verification (M&V), which will ensure high acceptance of financial sectors on recognition of future energy saving as a guarantee.
3) Long-term SME oriented financial supporting policies are needed, in particular in the sector of energy and resource efficiency.
4) Building business alliance by involving energy-end users, building owners, ESCOs, intermediate organizations and producers/suppliers of EE facilities and materials and local financial institutions.
5) In many Chinese cities, local building EE sector association and local banking association are cooperating in jointly organizing ESCOs-local banks matchmaking and meeting & exchange events for improving their contacts and their mutual understandings.

4. Conclusions and policy implications

Enhancing building EE retrofit, in which ESCOs play crucial role, is of utmost importance for China, since this sector contributes to a large share of China overall energy consumption and GHG emissions, and moreover it creates additional crucial benefits to the real economy and society (including energy security, in-house comfortability, employment and innovation). However, limited access to green financing and with limited working capital, many EPC projects are kept small and only 17.8% of ESCOs is accessing to green loans.

There are considerable barriers in accessing to green financing in building EE retrofit sector existing at policy level and at both supply and demand sides. However the findings reported in this study indicate that more substantial barriers exist not at the systemic policy level, but at the operational meso and micro level. This is quite different from other developing and emerging economies, where regulatory and policy barriers are the main constraints for their ESCOs access to green financing [25,26].

China has adopted an aggressive approach to foster energy efficiency in building sector and there are considerable feasibility studies and best practices on overcoming the barriers identified by this research. For overcoming barriers at the policy level, best practices include 1) reforming the public subsidy scheme towards ensuring that financial incentives reach the right actors (e.g. ESCOs), namely those who have the ability to act, 2) keeping the local subsidy schemes as long as possible (e.g. for at least another five-years period) and 3) involving building sector into national Emission Trading Scheme that will result in increasing of economic profit from energy saving and offsetting low energy price.

For overcoming the barriers of both ESCOs and financial institutions at the meso and micro operational level, the best practices focus on capacity buildings for both ESCOs and financial institutions, matchmaking and toolkits development for facilitating ESCOs preparing high quality loan application proposal and local banks evaluating the proposals, in particular evaluating the loan risks that are always on the top agenda of banks. In addition, best practices at local level show promising results of inviting third-party intermediate organizations to provide consultancy services for both ESCOs and banks.

Based on the main conclusion generated by this research, more attentions, instead of formulating more new policies and regulations at systemic level, should be given to take actions for overcoming barriers at the operational level in China. This study suggests the following priority actions for unlocking green financing for China's small- and micro-size ESCOs.

Integrated capacity building is crucial and urgently needed for unlocking green financing for ESCOs. National and local housing authorities, local building EE associations and banking associations could play leading role in establishing and implementing capacity building programmes. Capacity can be built up and improved through building up technical capacities for ESCOs in developing loan applications and for financial sector in evaluating and approving the loan projects. Technical capacity can be improved through the development of toolkits, sectoral technical guideline and criteria, training curriculum and standardizing the underwriting process of financing energy refurbishment projects.

Building up dialogue and cooperation alliance among stakeholders is utmost important for unlocking the green financing market. Such alliance is established and functioning by initiating exchange and dialogues platforms, demonstrations and practices of matchmaking, and implementing pilot brainstorm & networking events that will bring together a diverse group of practitioners, from ESCOs and financial sector, policymakers and intermediate organizations from civil society.

Evidences from the good practices interviewed by this study show that participation of intermediate organizations such as "One-stop-shop (OSS) can play an important role in facilitating ESCOs' access to green financing. These OSSs could facilitate the comprehensive and complex energy contracting process between ESCOs, building owners and financial institutions by offering a range of services. Their activities could range from quality assurance, verification and certification of ESCOs and financial advice for ESCOs and their clients, to the aggregation of projects in order to reduce transaction costs and diversify the risks for financiers and ESCOs.

Since most ESCOs are small- and micro-size and most EPC projects are small, it is necessary to diversify financial products and funding mechanisms that are tailor-made for ESCOs, and to establish alternative financing models based on features of measures being taken by ESCOs. As discussed in this paper already, involving EE materials and equipment producers and suppliers are proven very successful in facilitating ESCOs in access to green loans and it can be disseminated to other regions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Mingshun Zhang: Conceptualization, Methodology, Data curation, Writing - original draft, Writing - review & editing, Supervision, Writing - review & editing. **Ya Lian:** Conceptualization, Methodology, Data curation, Writing - review & editing. **Hui Zhao:** Conceptualization, Methodology, Data curation, Writing - original draft, Writing - review & editing. **Chun Xia-Bauer:** Conceptualization, Methodology, Supervision, Writing - original draft, Supervision, Writing - review & editing.

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