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Part 1: Barrier Analysis

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Acronyms and Abbreviations

BOMA	Building Owners and Managers Association
CABEE	China Association of Building Energy Efficiency
CDM	Clean Development Mechanism
DOE	U.S. Department of Energy
EMCA	Energy Management Company Association
ESCO	Energy Service Company
EPC	Energy Performance Contracting
IFC	International Finance Corporation
IRR	Internal Rate of Return
LEED	Leadership in Energy and Environmental Design
MOHURD	Ministry of Housing and Urban-Rural Development
M&V	Measurement and Verification
NDRC	National Development and Reform Commission
NGOA	National Government Offices Administration
PCDM	Programmatic Clean Development Mechanism
PG&E	Pacific Gas and Electric
SCE	Southern California Edison
SME	small-to-medium-size enterprises

Executive Summary

For the past three decades, China has experienced unparalleled economic growth to become the second largest economy in the world, and also the largest carbon dioxide (CO_2) emitter (Mo, 2016). Building operation accounts for 19.5% of China's total energy consumption, and commercial buildings consumed 211 metric tons carbon equivalent (Mtce) in 2013, accounting for 27.9% of total building operation energy usage (THUBERC, 2015). With increasing urbanization and building stocks, energy retrofitting for commercial buildings[1] is becoming an important strategy that China can use to reach its carbon emissions reduction target. Favorable government policies have greatly advanced building energy efficiency efforts, for both government-owned public buildings and privately owned commercial buildings. Building energy efficiency policy goals were set up in the Eleventh Five-Year Plan (FYP) (2006–2010) and Twelfth FYP (2011–2015); those goals are achieved by government programs such as the Top Runner program, and by monetary incentives like grants and subsidies (Yu, Evans, & Shi, 2014; NDRC, 2015; State Council, 2017).

A self-sustaining and mature building energy efficiency retrofit market mechanism is, however, yet to be established. Going forward into the Thirteenth FYP (2016–2020), China's commercial building energy efficiency industry will transition from government subsidy-driven to market-driven with legislative support (State Council, 2017). The Chinese government's advocacy of the green finance system has provided new opportunities for the building energy efficiency market to go through this transition (IPECC, 2016). However, significant barriers still remain if the building energy efficiency market wants to become self-sustaining and prosper; this requires a set of supportive government policies that set up a healthy market ecosystem.

This study examines existing energy efficiency upgrade barriers for commercial buildings, and then presents a series of stakeholder interviews with energy service companies (ESCOs), commercial banks, hosts, property management companies, measurement and verification companies, and government. Interviewees range from high level executive teams and middle managers to ground-level staff, depending on staff availability and accessibility.

Results of the interviews suggest that stakeholders in the market-driven building energy efficiency space face significant barriers. The market can become self-sustaining only by government policies creating a market mechanism that creates win-win situations between the stakeholders. Key barriers associated with each stakeholder are summarized below:

- **ESCOs:** ESCOs play a key role in advancing energy efficiency upgrades in public buildings. ESCO companies in building energy efficiency have difficulty maintaining profitability if they only focus on the building energy efficiency market, thus prompting companies to seek new areas of growth (Yu, Wu, & Xu, 2011; Pan, 2016). Small- to medium-size enterprise (SME) ESCOs[2] dominate the building energy efficiency market, and can hardly scale their business (Yu & Wang, 2017; Pan, 2016), for the following reasons:

[1] Commercial buildings in this report, if not specified, mean both private commercial buildings and public buildings. (Yu, Evans, & Shi, 2014)

[2] The gross assets of 2,339 Chinese ESCOs were 80 billion renminbi (RMB) ($11.7 billion) in 2012. The average assets were therefore 34.19 million RMB ($5 million) among which 1,898 ESCOs' assets were less than 30 million RMB, ($4.4 million) accounting for 81% of all Chinese ESCOs (IFC, 2012).

- ESCOs receive financial pressure from both hosts and third-party lenders; it is difficult to gain trustworthy hosts who will pay the ESCOs back. It is also difficult to gain third-party financing from banks (Yu & Wang, 2017). Therefore, building energy efficiency ESCOs can hardly scale.
- ESCOs face high transaction costs because the customer acquisition process is long and not necessarily cost effective (Tongfang Taide, 2017; Pan, 2016).

- **Hosts[3]:** Building hosts can be further separated into government-owned public buildings and privately owned commercial buildings.
    - **Government-owned public buildings:** Government-owned public buildings have overarching barriers of "budget driven" energy efficiency upgrades. Utility costs are covered in the annual budget. Government-owned entities estimate the potential utility cost for the upcoming year based on previous year's utility cost. Conducting energy efficiency upgrades actually results in a reduced budget in future years, which results in decreased motivation from building owners (Evans, et al., 2015).
    - **Privately owned commercial buildings:** Privately owned commercial buildings are excluded from the government's Top Runner program[4] (NDRC, 2015). There is a lack of government policy support for building energy efficiency improvements in privately owned commercial buildings.
    -

- **Property management companies:** Although property management companies could play a crucial role in enabling energy efficient upgrades, they rarely tap into the energy efficiency market. There exists a lack of technical capability, as well as a split incentives issue, where property management companies do not necessarily pay for utility costs. Therefore, property management companies have low motivation for them to actively engage in energy efficiency upgrades (BOMA China executive team round table discussion, 2017).

- **Measurement and verification (M&V) companies[5]:** China still lacks a comprehensive M&V protocol that considers the interactions of individual energy efficiency technologies (Evans, et al., 2015). Furthermore, currently ESCOs pay for M&V services. This creates a conflict of interest, because M&V companies want to please their customers and report that the energy efficiency project generated the promised savings, which lead to M&V results that are not necessarily trustworthy (Wei & Chen, 2017).

- **Government:** Institutional barriers exist in government. Each government department has its own interests and does not collaborate effectively on designing impactful and self-sustaining

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[3] Host is referred the property owner of the building where energy efficiency improvements are implemented.
[4] The National Development and Reform Commission (NDRC) has set up a Top Runner program for government-owned public buildings to reduce their building energy use, where top performance entities are recognized and publicized annually (State Council, 2017).
[5] Third-party companies that provide measurement and verification for actual energy saved for building energy efficiency improvement projects. Third-party M&V companies are recognized by the central or municipal government.

policies to encourage building energy efficiency upgrades, leaving on the table simple measures such as direct subsidies. Overly relying on subsidies to scale the market without other supporting policies creates risks of stalling the market if subsidies are withdrawn. (Yu & Wang, 2017).

- **Commercial banks:** Difficulty in obtaining third-party loans is one of the key barriers that inhibits the development of the building energy efficiency service industry and business growth of ESCOs (Yu & Wang, 2017; Evans, et al., 2015). Current Chinese ESCOs are a mismatch with commercial banks' lending requirements. Banks prefer low risk and a stable return with heavy asset collateral, while ESCOs have light assets and conduct relatively high financial-risk and low-return building energy efficiency projects (Chen, 2017).

The interviews pinpointed additional, overarching barriers. Deep building retrofits are difficult to obtain and have a low return on investment (Yu, Wu, & Xu, 2011). The general lack of creditworthiness and a sound credit system leaves the creditworthiness of hosts, ESCOs, and accredited M&V companies unchecked. Financial institutions therefore consider the building energy efficiency sector a high-risk one (Oct. 2016 workshop, 2016; Tongfang Taide, 2017; Yu & Wang, 2017). Currently, the energy service industry is also very fragmented, resulting in un-systemic and un-optimized energy efficiency upgrades in buildings (University, 2017; Hospital hosts discussion, 2017; Yu & Wang, 2017).

Barriers to building energy efficiency retrofits also exist in the U.S. China and the U.S. each have their own unique commercial building energy efficiency upgrade barriers. Given the difference between the Chinese and U.S. political and market environments, some U.S. solutions are applicable to China and some solutions are not. However, some U.S. government program experiences, such as the Better Buildings Initiative, could provide inspiration to Chinese government to design effective building energy efficiency programs. In Accelerating Energy Efficiency in China's Commercial Buildings - Part 2: Solutions and Policy Recommendations, detailed solutions and policy recommendations are illustrated.

1 Introduction

Building operation accounts for 19.5% of China's total energy consumption, and commercial buildings consumed 211 metric tons carbon equivalent (Mtce) in 2013, accounting for 27.9% of total building operation energy usage (THUBERC, 2015). With increasing urbanization and building stocks, energy efficient retrofits for commercial buildings[6] are becoming an important strategy for China to reach its carbon emission reduction target. Favorable policies and subsidies have greatly advanced building energy efficiency efforts. Going forward into the Thirteenth Five-Year Plan (FYP)[7], China's commercial building energy efficiency industry aims create more policies in addition to subsidies or grant that could scale up building energy efficiency retrofits. This chapter will first outline China's policy targets and existing supportive policy legislation for commercial building energy efficiency upgrades, then outline the paper scope and methodology.

1.1 Overview of China's commercial building energy efficiency targets in past Five-Year Plans

For the past three decades, China has gone through unparalleled economic growth to become the second largest economy in the world, and also the largest carbon dioxide (CO2) emitter (Mo, 2016). Recognizing the urgency of climate change challenges, China has taken a leadership role in the international community to address climate change issues. During 2016's G20 Summit, China and the United States were the first countries to ratify the Paris Agreement. Under the Paris Agreement, China aims to reach its peak CO2 emissions by 2030 (Climate Action Tracker, 2017), and it aims to realize those policy targets in its FYPs. In China's Twelfth FYP (2011–2015), China successfully reduced energy consumption per-unit gross domestic product (GDP) by 18.4%. Going forward into China's Thirteenth FYP (2016–2020), China set the new target of reducing per-unit GDP energy consumption by another 15% compared to 2015 levels and keeping the total energy consumption under 5 billion standard coal tonnes of coal equivalent (tce) (State Council, 2017).

China's urbanization rate rose from 37.7% to 53.7% from 2001 to 2013, and new building construction is still rapidly growing, contributing to ever-growing energy consumption. Commercial building energy usage intensity (EUI) continues to grow. Different types of commercial buildings' energy end uses, such as air conditioning, lighting, and equipment, are main contributors to the growing energy usage intensity. Some newly constructed commercial buildings are equipped with a centralized heating, ventilating, and air conditioning (HVAC) system, contributing to much higher energy usage compared to similar types of commercial buildings without centralized HVAC systems (THUBERC, 2015).

Building energy efficiency—especially commercial building energy efficiency—is an important strategy that China can use to help it reach its energy consumption target. Starting from the Eleventh FYP (2006–2010), China has systemically set commercial building retrofit goals while establishing technical infrastructure such as building monitoring systems to enable deeper building energy efficiency diagnoses and retrofit opportunities. This effort is currently carrying into the Thirteenth FYP. Table 1 summarizes efforts achieved during the Eleventh and Twelfth FYP, as well as proposed efforts for the Thirteenth FYP.

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[6] Commercial buildings in this report, if not specified, mean both private commercial buildings and public buildings. (Yu, Evans, & Shi, 2014)

[7] China structures its development phases into every five years. At the beginning of every "Five Year", China will come up with a "Five Year Plan" (FYP) to set development target for the upcoming five years. The 13th Five-Year Plan covers time period from 2016-2020 (Central Compilation & Translation Press, 2016).

Table 1. Chinese commercial building energy efficiency targets and achievements in 2006–2020 (Yu, Evans, & Shi, 2014; State Council, 2017)

Eleventh FYP 2006–2010 (Achieved)	Twelfth FYP 2011–2015 (Achieved)	Thirteenth FYP 2016–2020 (ongoing)
• Energy data on 33,000 buildings • Energy audit for 4,850 buildings • 9 provincial level commercial building energy consumption monitoring platforms • 72 energy efficient campuses • Sub-metered energy monitoring for 1,500+ buildings	• Set up sub-metered energy monitoring platforms in 33 provinces. 9,000+ commercial buildings are dynamically monitored. • Pilot energy efficiency retrofit for 233 campuses, 44 hospitals, and 19 research institutions • Set 11 cities for commercial building energy efficiency retrofit. Retrofit 48.64 million square meters, which encouraged other building retrofits to reach 0.11 billion square meters.	• Retrofit 0.1 billion square meters of commercial buildings • Encourage energy consumption data statistics, energy auditing, and disclosure • Continue the commercial building energy data monitoring platform • Enhance the usage of monitored building data, and use those data to support the establishment of energy efficiency quota standards, demand side management, etc. • Support market approaches such as Energy Performance Contracting (EPC) and the Public-Private Partnership (PPP) • Support local government to establish commercial building energy quota standards for high-energy usage buildings with dynamic pricing • Continue to promote energy efficient schools, hospitals, and research labs. Promote policies, codes, standards, and pilot projects for energy efficient schools and hospitals.

Privately owned commercial buildings and publicly owned public buildings receive different types of government incentives and programs. Government-owned public entities are required to establish building energy efficiency leadership for the rest of the society. Those requirements are detailed in the FYPs. The National Development and Reform Commission (NDRC) has also set up the energy efficiency Top Runner program[8] for government-owned public buildings. Privately owned commercial buildings do not participate in the Top Runner program, but China encourages commercial building retrofits by providing incentives to energy service companies (ESCOs). Error! Not a valid bookmark self-reference. summarizes favorable central government policies for government-owned public building retrofits and privately owned commercial building retrofits.

Table 2. Summary of policies and incentives for retrofits of government-owned public buildings and privately owned commercial buildings

<table>
<tr><th>Type of incentives</th><th>Sub-category</th><th>Government-owned public building retrofits</th><th>Privately owned commercial building retrofits</th></tr>
<tr><td>Provide building energy efficiency information to building owners and suppliers</td><td></td><td colspan="2">• List of recommended building technologies[9]
• Recommended targeted building materials that increase building energy efficiency[10]
• Mandatory energy data monitoring platforms, data disclosure[11]</td></tr>
<tr><td>Standard</td><td></td><td colspan="2">• National or local energy quota standards[12]
• Voluntary green building labeling[13]</td></tr>
<tr><td rowspan="2">Incentives</td><td>Subsidies</td><td colspan="2">• Central and local governments provide subsidies[14] for energy service companies (shared savings model[15])</td></tr>
<tr><td>Grant</td><td>• Central and local government direct</td><td></td></tr>
</table>

8 Energy efficiency Top Runner Program is initiated by National Development and Reform Commission in China where appliances, high energy consumption industry and buildings of government owned public entities participate. Top energy efficiency performance appliances, industry entities, and government owned buildings are recognized by government and publicized (NDRC, 2015).

9 The National Development and Reform Commission (NDRC) publishes a key energy saving technologies menu annually. Technologies that contribute to building energy efficiency are a part of the menu (NDRC, 2017). The Ministry of Industry and Information Technology (MIIT) also publishes a menu on energy efficiency technologies (MIIT, 2016).

10 The Ministry of Housing and Urban Rural Development (MOHURD) published a book on building materials that increase building energy efficiency (MOHURD, 2008).

11 Refer to the Thirteenth FYP in Table 1.

12 Refer to the Thirteenth FYP in Table 1.

13 China is establishing new green building standards for existing buildings (MOHURD, 2017).

14 Energy service companies receive 20 RMB ($2.90) per square meter ($m^2$) of subsidies by adopting shared saving model in key pilot cities. This subsidy was canceled in late 2016. The local government also provides various levels of subsidies to energy service companies.

15 Please refer to Table 9 for the shared savings model.

		grant for equipment replacement[16]	
	Pricing	• Utility companies' dynamic pricing[17]	
	Tax benefit	• Tax benefit for ESCOs[18]	
Government programs		• Top Runner program[19]	
		• Public-private partnership[20]	

Currently, China has building energy efficiency standards for new construction, but few for existing buildings. China has started to introduce an energy quota standard for commercial buildings, where buildings are given a maximum electricity consumption limit based on building type or past electricity consumption. This energy quota standard has only been implemented in a few regions such as Beijing or Shandong Province (Beijing government, 2013; SDHURC, 2016). Promoting an energy quota standard in more regions is an important policy action that will help to promote commercial building energy efficiency upgrades during the Thirteenth FYP, as shown in Table 1 above.

In China, subsidies, grants, and direct government mandates to retrofit buildings provide the greatest motivation to advance the building energy efficiency market. Thus, commercial building energy efficiency upgrades in four government-appointed key cities were introduced, as well as the Top Runner program, which greatly advanced government building energy efficiency upgrades in China. These are detailed in the following section.

Government-led commercial building retrofits: Key cities

In 2011, the Ministry of Housing and Urban-Rural Development (MOHURD) and Ministry of Finance jointly initiated private commercial and public building energy efficiency retrofit work under the Twelfth FYP. Four key cities were selected: Shanghai, Shenzhen, Chongqing, and Tianjin. Those four cities were selected because buildings in those cities established energy monitoring platform, and energy-saving potentials have been identified. Those four cities were given a retrofit goal of at least 4 million square meters (m^2) per city, and a target of lowering per-unit energy consumption by at least 20% (Hou, Wu, Xu, Li, & Xu, 2015).

For all four cities, the central government provides 20 RMB/m^2 ($2.90/$m^2$) subsidies to ESCOs[21]. Follow-up grants are also given after the retrofitted buildings reach energy-saving goals. Each city also provides subsidies, depending on each city's plan. In all four cities, both government-owned public buildings and privately owned commercial buildings are included as a part of the retrofit target (Hou, Wu, Xu, Li, & Xu, 2015).

Tianjin retrofitted at least 80% of its buildings through government direct request. Chongqing engaged ESCOs and building owners, and at least two-thirds of the building retrofits came from voluntary market

16 Government-owned public buildings receive a direct grant for replacing equipment.
17 Refer to the Thirteenth FYP in Table 1.
18 Refer to Section 2.1.
19 Refer to Table 3 for detailed information on the Top Runner program.
20 Refer to the Thirteenth FYP in Table 1.
21 Typical building energy efficiency retrofit cost is about 200 RMB/m^2 ($29/$m^2$) (Li, Ma, & Liang, 2007)

participation. Shanghai and Shenzhen reached their energy efficiency retrofit targets with a combination of a strong government mandate and market drive (Hou, Wu, Xu, Li, & Xu, 2015).

Other provinces and cities also publish policies that encourage building energy efficiency retrofits in privately owned commercial buildings. Subsidies and grants are the most direct approach.

Government-owned public buildings and Top Runner programs

Government-owned public entities refer to all government entities that rely entirely or partially on government financial support. Such entities include government agencies, schools, hospitals, and sports stadiums, managed by their corresponding ministry. For example, public hospitals are managed by the Ministry of Health, and public schools are managed by the Ministry of Education. By 2015, China had 1.755 million public entities, and their buildings consumed 183 Mtce of energy and used 12,531 billion cubic meters of water (Cui, 2016).

China has specific energy-saving requirements for government-owned public entities to establish leadership for the rest of the society. Those requirements are detailed in the FYPs. The National Development and Reform Commission (NDRC) has set up a Top Runner program for government-owned public buildings to reduce their building energy use, where top performance entities are recognized and publicized annually. In the Twelfth FYP, government-owned public entity buildings reduced per capita energy consumption by 17.14%, (Energy Usage Intensity) EUI by 13.88%, and water usage by 17.84%. In the Thirteenth FYP, government-owned public buildings have a goal of reducing per capita energy consumption another 11%, per-unit area energy consumption 10%, and water usage 15% (State Council, 2017). Detailed criteria are summarized in Table 3 (NDRC, 2015).

Table 3. Energy efficiency Top Runner program for government-owned public entities (NDRC, 2015)

Requirements	1. Top runners' energy efficiency should advance other similar types of buildings in similar climates 2. Public entities shall not use inefficient equipment and products 3. Establish an advanced energy management system. Establish energy data management and measurement requirements. Satisfy GB/T 29149-2012: *Requirements for equipping and managing of measuring instruments of energy and resource in public institutions* 4. Annual energy consumption is no lower than 50 tce per building 5. No major safety incidents for the past three years
Selection and public announcement	1. Local provincial governments form an expert committee and select energy efficiency top runners for all types of public-entity buildings and submit them to the National Government Offices Administration (NGOA) 2. NGOA and NDRC conduct an expert review of those results and publish them for at least 15 business days. After public display, NGOA and NDRC inform the participating agencies 3. The Top Runner program for government-owned public entities is announced annually
Reward	NGOA and NDRC work with other government agencies to reward the top runners.

Public recognition	Select and publish good case studies from the Top Runner program to convey them to the general public.
Include in performance review	Turn Top Runner results into future energy efficiency targets, and use those results as evidence in order to set future energy efficiency performance review criteria.

1.2 Transition from government-driven policies to market-driven policies

China's building energy efficiency work has largely been government policy-driven. The command and control approach, coupled with subsidies and grants, have largely pushed forward the building energy efficiency retrofit market in commercial buildings. As illustrated in Section **Error! Reference source not found.**, government subsidies and grants are still the most dominant approach to cultivating an energy efficiency services market. To reduce the ESCO industry's reliance on government subsidies, the Chinese national government is working to shift the building energy efficiency industry from being supported by government subsidies to being driven by market forces. The 20 RMB/m^2 subsidies from the central government to ESCOs were cancelled in 2016 (Yu & Wang, 2017). However, the subsidies are not completely going away. Some provincial or local governments still provide subsidies to ESCO companies. Government owned building hosts can also acquire building energy efficiency retrofit grants from government agencies (Mo, 2016).

The Chinese government's advocacy of a green finance system has provided legislative support for the building energy efficiency market to transition away from a subsidy-driven model. China has a comprehensive top-level policy package to encourage green finance. It includes (1) the China Banking and Regulatory Commission (CBRC) Green Credit Guidelines, (2) the Energy Efficiency Credit Guidelines, and (3) the Guidelines for Establishing the Green Financial System (IPECC, 2016). Such policy packages together seek to encourage private capital to enter industries that support China's low carbon sustainable development goal. The policy package includes the primary and secondary market, bond, debt, insurance systems, and public-private partnerships to work together to provide a sound green finance framework. China is moving toward combining the China Securities Regulatory Commission, China Insurance Regulatory Commission, and China Banking Regulatory Commission together into one single organization that manages China's financial system (Wu, 2017). This institutional change would break down barriers so the three agencies can work together and produce future green finance-related policies. The China Banking Regulatory Commission currently is working with MOHURD to draft a green finance guideline that is specific to building energy efficiency (Wu, 2017).

The establishment of the green finance system provided the necessary framework to explore potential opportunities that could scale up public building energy efficiency upgrades. Commercial banks in China, such as Xingye Bank, Pudong Development Bank, Shanghai Bank, and Beijing Bank all offer financial products that could provide third-party financing for building energy efficiency upgrades (Mo, 2016).

China also has initiated its nationwide carbon market in 2017, making China the largest nationwide carbon market in the world (Tanpaifang.com, 2017). The establishment of this market encourages hosts to conduct building energy efficiency upgrades (Hospital hosts discussion, 2017).
Establishing a complete building energy efficiency market still requires thorough research and collaboration among various stakeholders. Those green financing policy frameworks, however, set a good starting point.

1.3 The current commercial building energy efficiency market

Currently, as categorized by the Energy Research Institute (ERI) of NDRC, building energy efficiency projects are funded typically through three main channels: owner, government, and third-party private capital, including ESCOs, as illustrated in **Figure 1**.

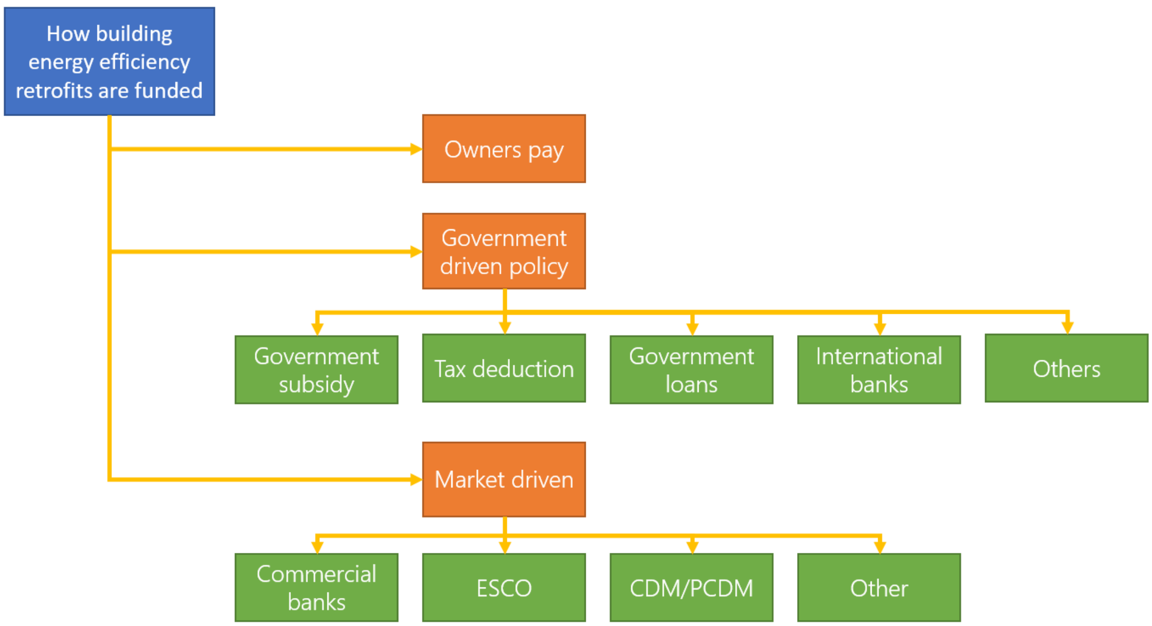


Figure 1. Main financing channels of an energy efficiency building retrofit (ERI, 2010)[22]

Commercial building energy efficiency retrofit financing comes from a combination of sources. Most commonly, government cash subsidies are given to ESCOs after project completion, with ESCOs obtaining a portion of the financing from commercial banks. Owners also pay for the energy efficiency upgrades themselves in guaranteed saving projects.
Who pays for building energy efficiency upgrades depends on which stakeholder is motivated to conduct the upgrade. In some cases, this is owners, as both public and private building owners have the incentive to retrofit the buildings themselves. This happens more when equipment is worn out and requires replacement. ESCOs have a strong motivation to acquire customers and also educate building owners about energy efficiency. During this process, the government incentivizes both ESCOs and building owners to conduct building energy efficiency by providing subsidies.

[22] ESCO: Energy Service Companies; CDM: Clean Development Mechanism; PCDM: Programmatic Clean Development Mechanism (PCDM)

Energy performance contracting (EPC) was introduced to China by the World Bank/Global Environment Facility in 1998 (Evans, et al., 2015). ESCOs play the most vital role in market-driven building energy efficiency projects. EPC dominates the market-driven approach that is heavily promoted in China.

Commercial building energy efficiency retrofits also come in three types: (1) low cost/no cost, (2) medium cost, and (3) high cost, as indicated in Table 4 and Figure 2. Low-cost or no-cost measures are conducted almost exclusively by ESCOs. Deep retrofits, which include changing equipment or the building envelope, have a long payback period and require much higher capital costs and stakeholder coordination. Additional incentives are needed to motivate the market to conduct deep retrofits (Hou, Wu, & Liu, 2014).

Table 4. Energy efficiency strategies, costs, and key measures (Hou, Wu, & Liu, 2014)

Energy Efficiency Improvement Goal	Strategy	Cost	Key Measures	Time to Recover the Investment
5%–10%	a	No cost/low cost: 0–50 RMB/m^2	a: management (building automation and control) and behavior energy-saving measures. Improve building management protocols, provide trainings to building operators	1–3 years
20%–30%	b	Medium cost: 100–150 RMB/m^2	b: a + equipment retrofit (HVAC, lighting, plug load, motor and others). Individual equipment replacement or whole-system retrofit	3–5 years
30%–50%	c	High cost: 300 RMB/m^2	c: b + building envelope retrofit (doors, windows, walls and roofs). Improve whole-building energy efficiency by conducting both equipment retrofit and building envelop retrofit	More than 5 years

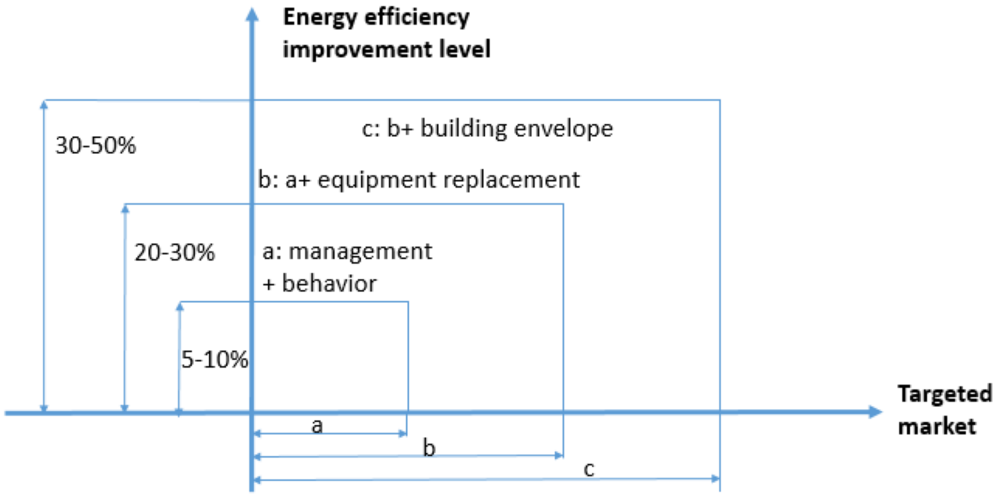


Figure 2. Commercial energy efficiency retrofit measures and targeted market (Hou, Wu, & Liu, 2014)

In this paper, energy performance contracting is a key focus, as it is one important market mechanism that drives the building energy efficiency retrofits. As China aims to transition the drivers for building energy efficiency retrofits from government policies to market forces, energy service providers and market mechanisms become increasingly important.

1.4 Challenges facing commercial building energy efficiency and paper's purpose

Despite significant government efforts made to encourage building energy efficiency upgrades, major barriers still impede progress, particularly for deep-saving integrated retrofits in commercial buildings. Past literature (Gan, 2009) has identified some noteworthy barriers that apply to both government-owned public buildings and privately owned commercial buildings. These barriers can be placed into two categories: demand-side and supply-side. Both are summarized in Table 5.

Table 5. Summary of commercial building energy efficiency upgrade barriers from past literature (Evans, et al., 2015; Khanna, 2014; Li, Ma, & Liang, 2007; Richerzhagen, et al., 2008)

Barriers	Description
Demand-side barrier (lack of building energy efficiency motivation or demand from building hosts)	
High upfront costs and long payback time	Initial investment for energy efficiency is high and building owners are reluctant to accept a long payback time.
Split incentive	Building owners do not directly benefit from energy savings.
Complicated ownership structure	Commercial buildings sometimes have a complicated ownership structure, where one building may have multiple owners—sometimes more than 10.
Lack of creditworthiness	Hosts lack confidence in energy service providers' reported energy savings.
Lack of	A lack of a comprehensive M&V protocol that considers the interaction of

comprehensive measurement and verification (M&V) protocol[23]	different retrofit technologies.
Lack of information and awareness	Chinese commercial building owners have little knowledge or information about the full benefits of an energy efficiency upgrade.
Supply-side barriers (Barriers facing energy service providers)	
Capital shortage and lack of access to external financing	ESCOs in China are mainly SMEs that lack the credit history financial institutions seek in loan recipients.
A lack of a standardized contracting procedure	In China, only a shared savings project has standard contracting guidelines. No standardized contracting guidelines are available for a guaranteed savings business model. Establishing a comprehensive M&V protocol enables the establishment of standardized guidelines.
Lack of market consolidation	Smaller project developers or ESCOs conduct projects individually, which decreases the possibility of achieving deep energy-saving measures across the project portfolio.
Government barriers	
Legal	Regulatory or legal supports for building energy efficiency, as well as laws to govern building energy efficiency upgrades, are lacking. No sufficient penalties exist.

Although summarizing barriers from past literature provides a good snapshot of the challenges of commercial building energy efficiency upgrades, Chinese policies and market environments have changed in the years since they were written. As China phases out its grants and subsidies supporting commercial building energy efficiency upgrades, but retains very ambitious policy targets in the Thirteenth FYP, it is necessary to conduct another round of barrier analyses of commercial building energy efficiency upgrades to inform decision makers about the latest industry challenges, so they can design enabling legislation accordingly.

On the green finance system front, even though China is building a comprehensive green finance system, with total green finance target of over 1 trillion RMB from the China Banking Regulatory Commission, the green building industry has only allocated several hundred billion RMB. The Paulson Institute estimates that this industry alone would require 1.65 trillion RMB to reach Thirteenth FYP green building and efficiency targets, whereas the public building energy efficiency retrofit would require 776 billion RMB (Mo, 2016). Detailed green finance legislative support would be needed to mobilize social capital to building energy efficiency.

[23] Measurement and verification protocol refers to a set of standards to determine actual energy saved for building energy efficiency improvement projects.

Data and information collected in this paper came from in-person stakeholder industry interviews. Firsthand sources and information will benefit decision makers as they craft effective legislative support.

This paper aims to identify market and policy barriers in China's commercial building energy efficiency retrofit market as a part of the "50/50" project supported by Energy Foundation China, which aims to help China to reduce building energy consumption by 50% by 2050. Lawrence Berkeley National Lab (LBNL) is working in collaboration with China Association of Building Energy Efficiency (CABEE) to implement this project.

1.5 Methodology and data sources

Data sources included a literature review and two rounds of in-person interviews with relevant stakeholders. The first round of interview took the form of a group discussion workshop to understand financing barriers in building energy efficiency in October 2016, in Shanghai, China. The second round of interview took place in February 2017, in the form of one-on-one interviews with relevant stakeholders in both Shanghai and Beijing, China: ESCOs, hosts, property management companies, measurement and verification companies, governments, and commercial banks.

Round one interview:

The group discussion gathered stakeholders, including financial institutions, ESCOs, property management, private equity firms, and local governments in Shanghai's Changning district. Each stakeholder took a few minutes to discuss building energy efficiency upgrade financing barriers from their perspective. The group discussion was not detailed enough to uncover sufficient reasons for those barriers, so another round of interview was conducted.

Round two interview:

For the round two interviews, stakeholders were categorized as energy service companies, hosts, property management, measurement and verification companies, government, and commercial banks. Among hosts, university and hospitals were specifically interviewed. Table 6 summarizes the stakeholders who were interviewed.

Table 6. Building energy efficiency stakeholders interviewed

Represented Stakeholder	Name of the entity	Interviewee's position
Energy Service Company (ESCO)	Twenty First (integrated energy service provider)	Business development manager
	Tongfang Taide (integrated energy service provider)	Executive
	Zhonghuihaojing (energy management system vendor and service provider)	Executive
	Energy Management Company Association (EMCA)	Research director. Director of international collaboration

Hosts		
Hospital	Peking University Third Hospital	Facility management
	Huilongguan Hospital	Facility management
	Fuwai Hospital	Facility management
University	Beijing Jiaotong University	Facility management
Facility management	Building Owners and Managers Association (BOMA) China	China regional lead
	Jones Lang LaSalle	Facility manager at Beijing's Yintai building
Government	China Association of Building Energy Efficiency (CABEE) under the Ministry of Housing and Urban-Rural Development (MOHURD)	International collaboration manager
	Shanghai's Changning district low carbon development office	Director
Banks	Xingye Bank	Green finance department researcher
	International Finance Corporation (IFC)	Energy efficiency program manager

Other indirect stakeholders, including real estate companies and a Clean Development Mechanism (CDM) representative, were also interviewed. These are summarized in Table 7.

Table 7. Other relevant stakeholders interviewed

Stakeholder	Name of the entity	Interviewee's position
Real estate companies	Landsea Group	Executive
	Tishman Speyer	China regional manager
	Shuion Group	Senior engineering manager
Other	Clean Development Mechanism (CDM)	Manager
	China Academy of Building Research (CABR)	Building energy efficiency experts

Information about privately owned commercial buildings was based on interviews with other stakeholders. Information about M&V companies was also inferred from interviews from other stakeholders—in particular from the interview with CABR. For each interview, a set of prepared questions were followed; however, during the actual interviews, some conversations were more spontaneous and involved questions that were not originally prepared. The prepared interview questions are summarized in Appendix A.

1.6 Paper organization

As China transitions from a government policy-driven (especially subsidies and grants) system to a market-driven system, it is important to identify barriers impeding building energy efficiency upgrades. Such analyses help to form a basis for potential policy solutions that can ensure the healthy development of the building energy efficiency market. This report focuses on barriers only, in Barriers to Improving Energy Efficiency in China's Commercial Buildings and Policy Recommendations (Part 2), detailed policy recommendations are illustrated.

Chapter 2 describes each interviewed stakeholder's characteristics and background information.

Chapter 3 presents detailed finding of barriers facing each stakeholder.

Chapter 4 summarizes barriers facing each stakeholder and overarching barriers.

Chapter 5 provides a background of commercial building energy efficiency retrofits, barriers in the U.S. market, and lessons learned for China.

2 Stakeholder Description

This chapter describes each relevant energy efficiency upgrade stakeholder type, including energy service companies (ESCOs), hosts, government, measurement and verification (M&V) companies, property management companies, and commercial banks.

2.1 Energy service companies

China's ESCO industry has grown out of the energy performance contracting (EPC) mechanism introduced in 1998 by an international cooperation project, the World Bank/Global Environment Facility China Energy Conservation Promotion Project. Designed to mobilize private investment in retrofit projects at buildings, industrial sites, and other facility types, EPC is a key approach that has fostered private sector energy efficiency retrofit work in the country (Evans, et al., 2015).

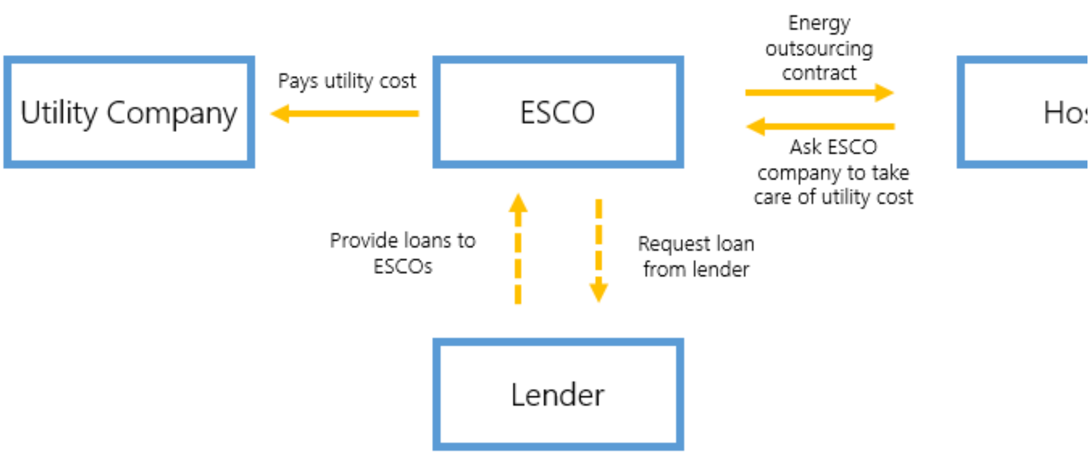
Since EPC's introduction, China's ESCO industry has quickly expanded (Evans, et al., 2015). In 2011, China's EPC market was worth about $6.4 billion, while the U.S. market was worth about $6.3 billion. By 2013, China's market had grown to $12 billion in terms of EPC investments, to a large extent because of significant government incentives for shared savings contracts (Yu, Evans, & Shi, 2014). Key stakeholders in energy performance contracting include building hosts, ESCOs, lenders, third-party M&V companies, and equipment vendors. Definitions of each key stakeholder are summarized in Table 8.

Table 8. Definitions of key stakeholders involved in energy performance contracting (Evans, et al., 2015)

Technical Term	Definition
Host	The property owner of the building where energy efficiency improvements are implemented
Energy Service Company (ESCO)	Companies that provide energy performance contracting (EPC) to the hosts
Lender	Financial institutions that provide third-party financing for building energy efficiency companies
Third-party Measurement and Verification (M&V) companies	Third-party companies that provide measurement and verification for actual energy saved for building energy efficiency improvement projects. Third-party M&V companies are recognized by the central or municipal government.
Technical vendors	ESCOs buy equipment from technical vendors to perform EPC. ESCOs sometimes are technical vendors themselves.

Currently, three major types of contracting agreements for EPCs in China are documented by the ESCO Committee of the China Energy Conservation Association (EMCA): shared savings, guaranteed savings, and outsourcing of energy management (Table 9). According to EMCA's survey, in 2013, the market share for each ESCO business model is 45% for shared savings, 42% for guaranteed savings, and 6% for outsourcing (Evans, et al., 2015).

Table 9. Types of EPC services in China (Evans, et al., 2015)

Type of EPC services	Definitions
Shared savings	An ESCO provides project financing and is paid by the host for a share of energy cost savings resulting from the project. Assets received from the project are owned by the ESCO until the contract is fulfilled. Once the contract is fulfilled, those assets are transferred to the host without additional payment. The contract period ranges from 4–8 years, with longer ones over 20 years. Refer to Figure 3 for a detailed description and Figure 7 for an illustration of a shared saving model process.
Guaranteed savings	The host provides project financing and owns the asset. The ESCO designs and implements the project while guaranteeing energy savings. The ESCO also specifies consequences related to performance, such as penalties if the project fails to achieve the contracted energy savings. Guaranteed savings projects typically have a short project cycle. Refer to Figure 4 for a detailed description.
Outsourcing of energy management	The ESCO invests in and develops the project, owns it, and operates it throughout the contracting period. The ESCO's return on energy savings achieved or energy delivered could be agreed to in contracts signed by the ESCO and the host. The contracting period ranges from 8–12 years. Please refer to  Figure 5 for an energy outsourcing management model.

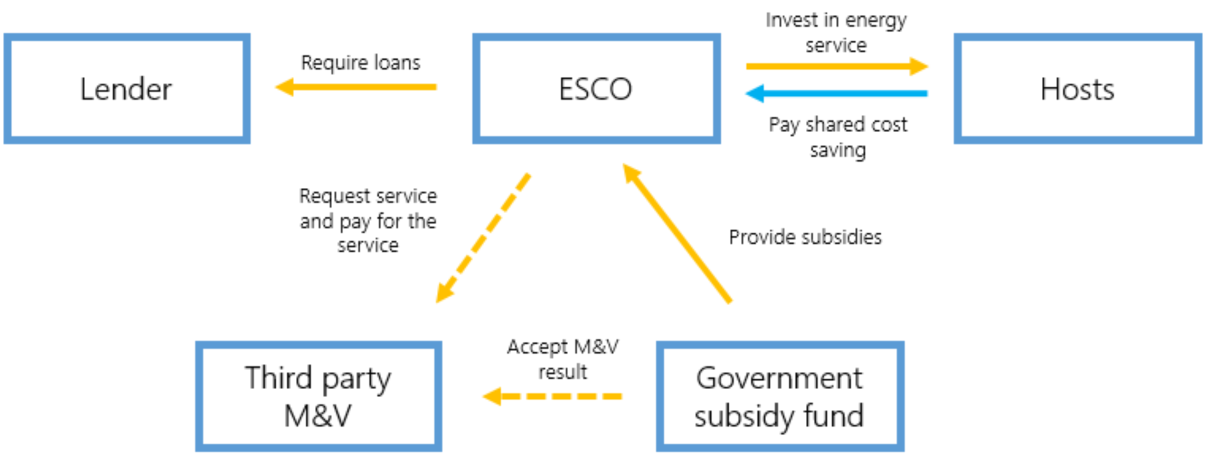


Figure 3. A shared savings model, if ESCOs want to claim subsidies from the government. Often, the government requires a third-party M&V report.

In a shared savings model, the ESCO carries the financial burden of the initial project investment. The ESCO must either invest in the project from its own cash pool, or obtain loans to cover the initial project investment. The government has set up a special subsidy program to encourage the shared savings model, to reach deeper retrofits. The shared savings model is slightly more complicated because it requires the ESCO and the host to agree on an energy savings amount, and potentially the ESCO would also request government subsidies. Third-party M&V is required in the shared savings model in order for the host and the ESCO to agree upon a contract, and the government uses the third-party M&V report to provide direct cash subsidies to ESCOs. A full illustration of the shared model process is described in Figure 7.

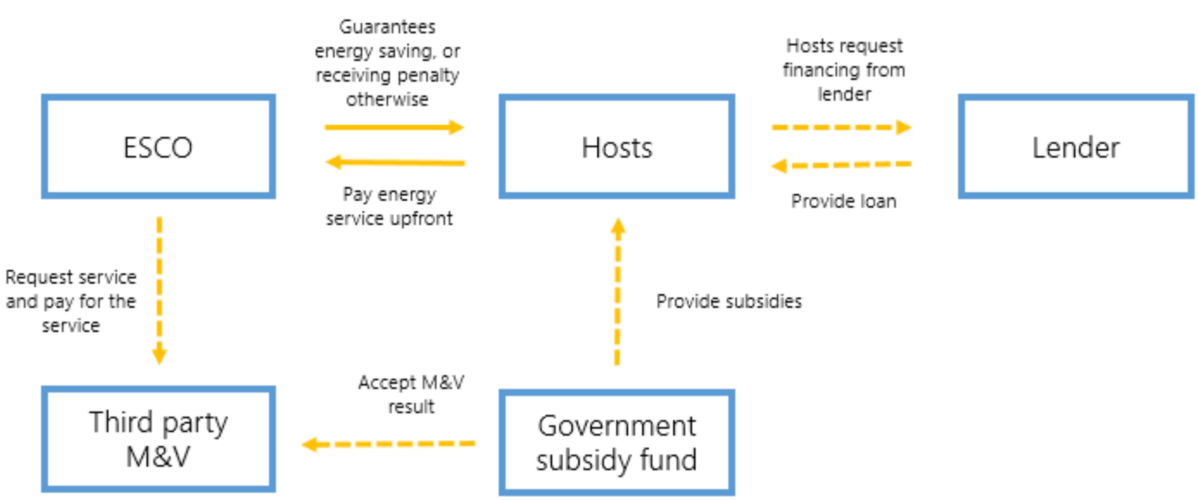


Figure 4. Guaranteed savings model in China.

It is relatively rare for hosts to acquire loans from lenders to conduct a building energy efficiency retrofit. In the guaranteed savings model, it is more common for the government to provide a grant to the host if it is a government-owned public building. The ESCO and the host also often do not involve a third-party M&V as long as the ESCO and the host agree on the energy saved between them. The guaranteed savings model is different from the shared savings model, mostly because the host pays directly for the energy efficiency retrofit, removing the financial burden from the ESCO. In a guaranteed savings model, the host often pays for the entire energy efficiency improvement and does not get third-party financing from lenders. Instead of directly buying off equipment, in this scenario, the ESCO pays the host if the promised energy efficiency is not realized. The main reason for this is that, unlike ESCOs, which are generally light in assets and small, hosts often have a rich cash flow, and an energy efficiency retrofit cost can easily be covered by their existing cash flow (Evans, et al., 2015). The guaranteed savings model is more prevalent in government-owned public buildings because the government provides direct grants for equipment replacement, as a part of NDRC's *Top Runner* program (Hospital hosts discussion, 2017; University, 2017).

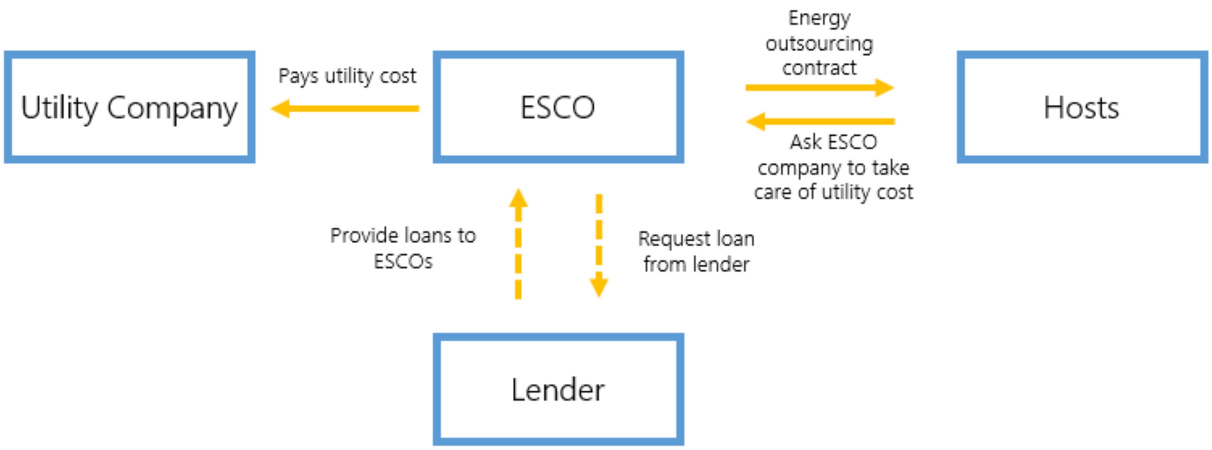


Figure 5. Energy outsourcing management model. The government currently has few incentives to encourage this model. M&V is not involved.

Energy outsourcing management is relatively new in China and the project size is also relatively large. This model is often used between a few large hosts and large ESCOs, where the energy contract from the hosts becomes very stable long-term income (Yu & Wang, 2017). A heat retrofit is one example of a project that fits this model. Energy outsourcing management is gradually moving into a smaller project

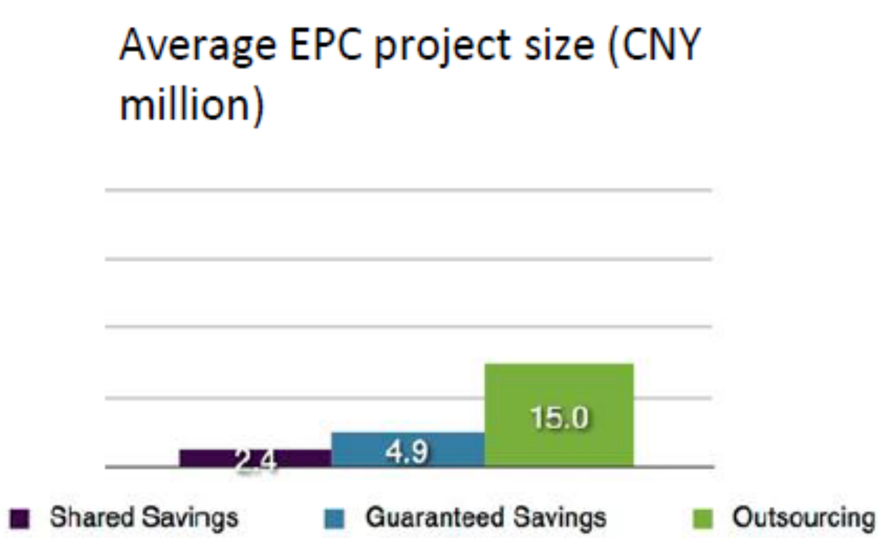


Figure 6. Average size of EPC projects by model type (Evans, et al., 2015)

size (Evans, et al., 2015).

Different levels of government have provided additional incentives for the shared savings model during the Twelfth FYP. Please refer to Section 2.1 for detailed subsidy information for the shared savings model. Since the 20 RMB/m^2 subsidy was cancelled for the shared saving models in 2016, there has been a decrease of projects in the shared savings model, and an increase in those fitting the guaranteed savings and energy outsourcing models (Yu & Wang, 2017).

Typically, services that ESCOs provide to hosts come in two types of approaches: single technology-oriented or integrated energy service solutions. Single technology-oriented services often aim at one particular component of a building's energy system, such as the HVAC system or lighting system. Single technology-oriented service providers are often equipment vendors.

Integrated energy service companies evaluate possible energy-saving solutions in buildings and purchase equipment from other equipment vendors (Evans, et al., 2015).

Building energy efficiency ESCO companies are generally small- to-medium-size enterprises (SME). Shared savings were more popular at the beginning stage of ESCO industry development, usually due to lack of interest from hosts (building owners). Therefore, ESCO companies would have to carry the financial burden to initially invest in the project, and would require those SME ESCO companies to obtain third-party financing. Commercial banks are the most common lender channel for ESCO companies (Evans, et al., 2015).

The government provides subsidies to whoever paid for the service, ESCO or host, upon completion of the energy efficiency project, with the energy savings verified by third-party M&V companies (Evans, et al., 2015).

In addition to the subsidies from different levels of government, ESCO companies benefit from numerous government incentives (Yu, Evans, & Shi, 2014):

Exempting ESCOs from the business tax and value-added tax on qualified projects

Exempting qualified ESCO income from income taxes (100% for the first three years and 50% for the next three years)

Allowing clients to deduct expenses for energy-saving services before taxes

Treating assets transferred to clients after the service period as fully depreciated for tax purposes

Figure 7. Illustration of a complete EPC process for shared savings model (Quan, 2013)

2.2 Hosts

Hosts in commercial buildings are organized into two types: government-owned public buildings and privately owned buildings. Government-owned public buildings are described in Chapter 1.1, and those buildings participate in NDRC's Top Runner programs, which includes schools, hospitals, sports stadiums, and more. To align with the public schools' and hospitals' energy efficiency improvement efforts that CABEE conducts under the 50/50 project, those two building types are especially examined in this paper. Privately owned buildings, including both mixed-owner and single-owner buildings, such as office buildings, shopping malls, hotels, and supermarkets, are also examined. Those key market segments are defined in Table 10.

Table 10. Summary of commercial building market segments

Market segments	Definitions
Public Hospitals	Public hospitals owned and operated by National Health and Family Planning Commission of the People's Republic of China (NHFPC) or local NHFPC
Public Universities	Public universities operated by the Ministry of Education of the People's Republic of China
Mixed-Owner Commercial Buildings	Non-residential buildings used for commercial purposes owned by multiple owners, such as commercial offices or shopping malls
Single-Owner Commercial Buildings	Non-residential buildings used for commercial purposes owned and occupied by a single corporation (e.g., corporate headquarters, hotels, private schools, and private hospitals)

An increasing number of building energy efficiency ESCOs have contributed to customer education, as they must approach hosts and try to convince them to conduct energy efficiency retrofits. Now hosts' awareness of energy efficiency has greatly improved compared to several years ago, and ESCOs no longer need to deliver basic education about the concept of energy efficiency (Yu & Wang, 2017; Zhonghui Yuanjing, 2017). From a developers' perspective, providing energy efficient buildings to their renters or future owners is not necessarily attractive, but their potential customers might pay for green brand such as a LEED (Leadership in Energy and Environmental Design) or China green building Three-Stars rating to improve their own brand image. For example, LENOVO's new headquarters in China is a LEED-certified building. As LEED is an internationally recognized brand, owning a LEED-certified building matches LENOVO's positioning as an international brand (Pratt, 2017).

2.2.1 Private mixed-owner or single-owner commercial buildings

Private commercial buildings in China are organized into a variety of categories. Here, we will use the Shanghai categorization, "Rational use of energy guide for large-scale commercial buildings," including: department stores, shopping center/shopping malls, supermarkets, warehouse stores, department stores, home appliance specialty stores, restaurants, and bath centers. Those types of commercial buildings can be either mixed-owner or single-owner buildings.

Currently, for those "non-government-owned" commercial buildings, energy retrofit work is left to the market. Private commercial buildings do not participate in NDRC's energy efficiency Top Runner program. The only subsidies those private building owners would receive is the central government's 20 RMB/m^2 payment for ESCOs if shared savings business models were used. Even though central government's 20 RMB/m^2 subsidy has been cancelled, some local governments still have some subsidies in different forms given to private commercial buildings.

Single-owner private commercial buildings such as hotels and supermarkets are preferred by ESCO companies, as they only need to deal with one owner when discussing business. ESCOs find mixed-owner commercial buildings, such as office buildings or shopping malls, less attractive.

One overarching observation on mixed-owner or single-owner commercial buildings is that owners rarely consider third-party financing because the debt will appear on their balance sheet, which is undesirable (Hospital hosts discussion, 2017; University, 2017).

2.2.2 Government-owned public buildings

Government-owned public buildings have overarching barriers based on "budget-driven" energy efficiency upgrades. Utility costs are covered in the annual budget. Government-owned entities would estimate the potential utility cost in the upcoming year based on previous year's utility cost. Conducting energy efficiency upgrades actually results in a reduced budget in future years, which results in decreased motivation from building owners (Evans, et al., 2015).

Currently, government-owned public buildings have two motivations for retrofitting their buildings: (1) to obtain a government grant for an energy efficiency upgrade, or (2) to take advantage of government programs and include the building energy efficiency as a part of their performance review.

1. **Government grants for building energy efficiency**
   Currently energy efficiency upgrades in government-owned public buildings are largely driven by grants. A scheduled equipment replacement is one key reason for government-owned public buildings to "upgrade" energy efficiency, as new equipment is often more energy efficient anyway. In addition to equipment replacement, government-owned public buildings also work closely with ESCOs to conduct building energy efficiency upgrades, but pay off the upgrades directly from a government grant (NDRC, 2015; University, 2017; Hospital hosts discussion, 2017).
2. **Government programs and organization's performance review**
   Top Runner programs provide some motivation for government-owned public buildings to pay attention to utility costs. Well-performing organizations are publicly announced in the Top Runner program. The government sometimes also assigns government-owned public building owners an energy efficiency "target" to reach, and failure to reach that target may reflect negatively on the organization's performance review.

Hospitals and universities are highlighted as unique examples of how government-owned public buildings conduct a building energy efficiency upgrade.

Hospitals

Hospitals have complex end-use behaviors. Unlike shopping malls or hotels, hospitals have special characteristics, and increased comfort and health requirements have steadily increased their energy consumption. In addition, the amounts of energy used in different areas of a hospital can vary dramatically, depending on what is being done in a particular area and what types of equipment are being used (Liu & Fu, 2014).

Public hospitals owned by the National Health and Family Planning Commission of the People's Republic of China (NHFPC) or local NHFPC apply for energy efficiency improvement grants from a central or local NHFPC. The NHFPC also runs a Top Runner program for public hospitals to promote building energy efficiency upgrades (Hospital hosts discussion, 2017).

This year, the NHFPC-controlled hospitals were directed to establish an energy monitoring platform for the hospitals they operate. It is still awaiting completion and NHFPC's approval. The establishment of the energy monitoring platform will help hospitals identify their energy-saving potential, encouraging them to conduct energy efficiency improvements (Hospital hosts discussion, 2017).

Public Universities

By the end of 2011, there were 2,409 universities in China, with 23.26 million students. Total campus area reached 78 million m^2, five times the 1988 level. By 2014, universities used 30 Mtce annually—four times the average per capita energy consumption in China. In 2008, MOHURD initiated a series of technical and management guidelines to construct low-energy green campuses. Over 200 campuses have joined the initiative to build low-energy green campuses. Among those, over 30 campuses have established a comprehensive energy consumption monitoring platform and passed government inspection (Yang, 2014). Universities participate in NDRC's energy efficiency Top Runner program.

Campuses can request energy efficiency retrofit grants from the Ministry of Education, MOHURD, and NDRC.

2.3 Property management companies

Traditionally, property management companies in China have four fundamental duties: (1) ensure security of managed property, (2) ensure cleanness of the managed property, (3) repair broken equipment and other facilities, and (4) ensure a pleasing outdoor environment, such as lawn maintenance. For a long time, property management companies were positioned to manage, service, and maintain owners' properties (Xiao, Xu, & Fan, 2011).

Traditional property management firms are low-profit-margin businesses, and they run into problems such as having limited market space and difficulty getting paid; as a result, many property management companies are barely surviving. Therefore, to save on costs, property management companies hire employees who are not well educated. Property management companies rarely innovate on the services they provide (Xiao, Xu, & Fan, 2011).

However, property management companies serve a crucial role with regard to building energy efficiency, as they serve between the building host and the ESCO. All energy efficiency upgrades require the help and collaboration of property managers to ensure that the entire energy performance contracting process, diagnosis, construction, and follow-up maintenance runs smoothly (Xiao, Xu, & Fan, 2011; Zhang & Deng, 2016).

2.4 Measurement and verification companies

China is on its way toward developing a comprehensive M&V technical standard package. In 2010, China issued GB/T 24915-2010: *General Technical Rules for Energy Performance Contracting,* which provided general technical requirements for EPCs to follow regarding the energy auditing, baseline determination, and M&V processes. This document also provides a standardized contract format for EPCs to follow, but it only applies to shared savings projects, which discourage other contracting options, such as guaranteed savings.

Specifically, for M&V protocols, China issued recommendation standard GB/T 13234-2009: *Calculating Methods of Energy Saved for Enterprise*, which helps enterprises estimate their energy savings. Another standard, GB/T 28750-2012: *General Technical Rules for Measurement and Verification of Energy Savings,* provides definitions and a calculation methodology and standardized practices that relate to M&V energy savings. It is adopted from the International Program Measurement & Verification Protocol (IPMVP). China has started to develop a series of national standards entitled *Technical Requirements for Measurement and Verification of Energy Savings*, which cover areas in sheet metal heating systems, residential building heating systems, cement waste heat power generation projects, telecommunication stations, lighting systems, and central air conditioning systems.

2.5 Government

As indicated in Chapter 1, government targets and policies play a key role in cultivating the energy efficiency market. By setting government targets and providing subsidies and grants, the government has successfully cultivated the energy service market and conducted building energy efficiency improvements. However, continued modification of those policies is required to ensure long-term industry growth. Both the central and local governments have crafted incentives to encourage building energy efficiency upgrades.

2.6 Commercial banks

Commercial banks are the most frequent channel for ESCO companies to gain third-party financing. Numerous commercial banks in China, including Xingye Bank, Shanghai Bank, and Pudong Development Bank offer building energy efficiency loans.

3 Interview Findings: Energy Efficiency Upgrade Barriers Associated with Each Stakeholder

As described in the data sources section, two rounds of interviews provided insights into barriers to energy efficiency retrofits in China. This section presents findings from the interviews, organized by stakeholder type.

3.1 Energy service companies

Energy service companies play a key role in advancing building energy efficiency upgrades in public buildings. Despite favorite government subsidies on public building retrofits, and policies to encourage ESCO company growth (such as no tax within the first three years and half the tax after three years), ESCO companies in building energy efficiency have faced tremendous pressures, and these require that the companies look into new areas of growth.

3.1.1 Small and Medium ESCOs dominate the building energy efficiency market

Building energy efficiency ESCO companies are generally SMEs. Industrial energy efficiency improvement projects are more lucrative, ranging from 10 million RMB to 134 million RMB ($1.5 million to 19.6 million), attracting large and established ESCOs[24] (Ronabjuewucz, Shen, Price, & Lu, 2012; Pan, 2016). Building energy efficiency projects are typically much smaller; a 5 million RMB ($750,000) investment would be called a "large project" and would require extensive customer negotiation. Therefore, these are generally left out by established large ESCOs (Pan, 2016). As observed in the industry, in 2013, the share of the total industrial sector of EPCs was 72%, compared to 21% in buildings, and 7% in transportation (Evans, et al., 2015). Large ESCOs, even if they have building energy efficiency as a part of their service, often have other more lucrative business branches such as industrial energy efficiency projects, or have connections to high-quality large bundled building energy efficiency projects (Pan, 2016; Tongfang Taide, 2017). The current building energy efficiency market segment is described in Figure 8.

[24] Refer to ESCOs that are financially established with strong cash flow, or even publicly traded.

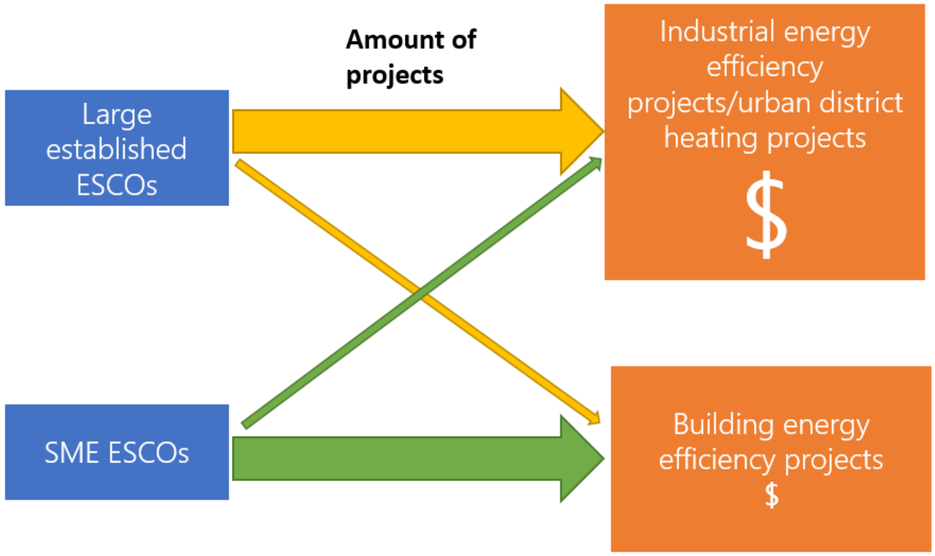


Figure 8. Building energy efficiency-focused ESCOs are small and unable to grow.

3.1.2 ESCOs encounter pressure from both hosts and lenders

ESCOs get pressure from both hosts and lenders. Customer acquisition in the building energy efficiency industry is very much financially burdensome for ESCOs. ESCOs are also face the risk of untrustworthy hosts failing to pay them back in shared savings contracts. Extra labor costs require projects to deliver an internal rate of return (IRR) of at least 30% to even be profitable for shared saving projects (Pan, 2016). Even reaching an IRR of 50% would require ESCOs to sign a five-year shared saving contract, which is typically not easy to obtain. Acquiring low interest and high-quality loans also can be very challenging, which limits the growth of building energy efficiency companies (Yu, Wu, & Xu, 2011).

High transaction cost: A burdensome customer acquisition process

A typical customer acquisition process in the building energy efficiency industry starts with an ESCO approaching potential hosts to engage their interests, conducting an energy savings evaluation for the host's buildings, and providing the host with a proposal. Multiple ESCOs may approach the same host, offering different energy service packages (Pan, 2016; Tongfang Taide, 2017; Zhonghui Yuanjing, 2017; Yu & Wang, 2017). Engaging a host's interest is the first step. Hosts in general are not very keen on building energy efficiency upgrades, as there are always other priorities, and they would like to avoid long contracts. If the host is interested in conducting an energy efficiency improvement, it will issue a public tender invitation (Zhonghui Yuanjing, 2017). It is very common for ESCO companies, after spending months developing project proposals, to fail to get the customer's business (Pan, 2016; Tongfang Taide, 2017; Zhonghui Yuanjing, 2017; Yu & Wang, 2017).

This type of market structure does not necessarily reward better technology and services (Tongfang Taide, 2017). Government-backed ESCOs sometimes have to help the government fulfill its duty, and do not necessarily get high-profit work (Pan, 2016; Tongfang Taide, 2017). For example, Twenty-First is an ESCO backed by Shanghai's Changning district government. Even if building owners within the Changning district are not willing to retrofit their buildings, Twenty-First must continue trying to convince them in order to help the Changning government achieve its retrofit target, which adds a financial burden to the company (Pan, 2016). As a result, getting customers can be very challenging and time-consuming, thus significantly increasing business costs.

Untrustworthy hosts

Host creditworthiness also becomes an issue for ESCO companies, creating financial losses and uncertainties (Tongfang Taide, 2017; Yu & Wang, 2017; Pan, 2016). In the past few years, it has become very common for hosts to not fulfill their shared savings contract with ESCO companies. Lawsuits against untrustworthy hosts were prevalent. This year the issue is becoming better, mainly because ESCOs have learned to choose better-quality hosts. Even government contracts can have creditworthiness problems in certain regions, such as some governments in the northeast. Staff turnover in government agencies might lead to stagnation in paying back shared savings to ESCOs, and ESCO companies could not even sue the government (Tongfang Taide, 2017; Yu & Wang, 2017). For SME ESCOs, one untrustworthy host could put the company into bankruptcy (Pan, 2016).

3.1.3 Difficulty in gaining suitable third-party financing from lenders

Acquiring long-term, low-interest loans from lenders is also very difficult for energy efficiency ESCO companies. Banks in general are not very keen on building energy efficiency loans because the projects are not standardized, deal sizes are small and the risks are high (Oct. 2016 workshop, 2016). Even if banks do provide building energy efficiency loans, bank-furnished loan products often have high interest rates with terms that are not preferable for ESCOs, making the loans not attractive for them. For example, World Bank's low-interest energy efficiency loan provided to Shanghai's Changning district originally had an interest rate of 0.35%; after refinancing by Pudong Development Bank and Shanghai Bank, the rate rose to 6%–7% (Figure 9), making it uncompetitive for ESCOs to borrow (Mao, 2017).

Figure 9. The World Bank's low-interest loan became a high-interest loan after it was refinanced by SPD Bank and Bank of Shanghai (Mao, 2017)

ESCOs generally only find loans with an interest rate below 4% attractive; otherwise, they would rather pay for the retrofit first cost from their existing cash flow, which inhibits scaling up of the market (Yu & Wang, 2017; Tongfang Taide, 2017). Two years after the World Bank loan was initiated, by the end of 2015, only 4% of the total loan was disbursed. World Bank downgraded this project rating to Moderately Unsatisfactory (Mo, 2016).

3.1.4 Building energy efficiency ESCOs run into bottlenecks that inhibit future growth

After more than 10 years of development, the building energy efficiency ESCO market is still segmented. High cost, low return, and difficulty gaining financing inhibit the growth of the building ESCO industry. "The building energy efficiency business is very difficult" was one of the most commonly heard phrases during the interviews. SME ESCOs easily run into bottlenecks, resulting in those companies being unable to continue their growth (Yu & Wang, 2017; Zhonghui Yuanjing, 2017). Banks further lost interest in providing building energy efficiency loans after cancellation of the central government's 20 RMB/m2 subsidies (Chen, 2017). This created even more hurdles for building energy efficiency companies. Difficulty obtaining third-party financing has been identified as the number one barrier inhibiting the growth of the building energy efficiency industry (Yu & Wang, 2017). An inability to streamline energy-saving products and maintain a steady cash flow means the building energy efficiency ESCO business will continue to be labor-intensive because of the lengthy customer acquisition process. This issue applies to both government-backed large ESCOs and privately owned SME ESCOs. ESCOs with fewer than 50 staff are fairly common (Zhonghui Yuanjing, 2017). Building energy efficiency is a labor-intensive industry, and requires additional financing to expand and grow. A guaranteed savings model is becoming increasingly popular because it can avoid the issue of non-payback by untrustworthy hosts (Zhonghui Yuanjing, 2017; Yu & Wang, 2017). However, the guaranteed savings model is generally less lucrative.

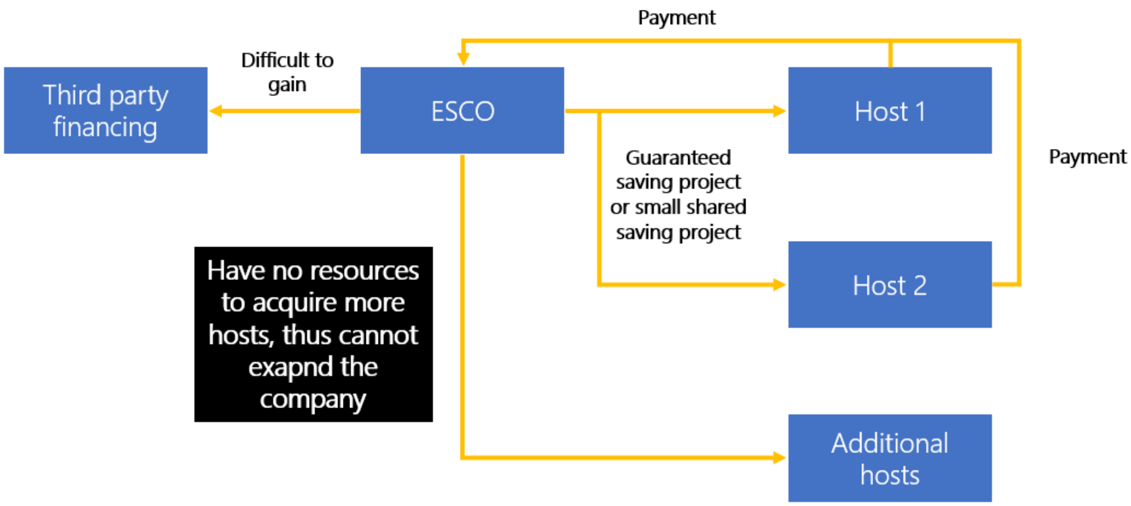


Figure **10** illustrates how ESCOs ran into bottlenecks for continued growth.

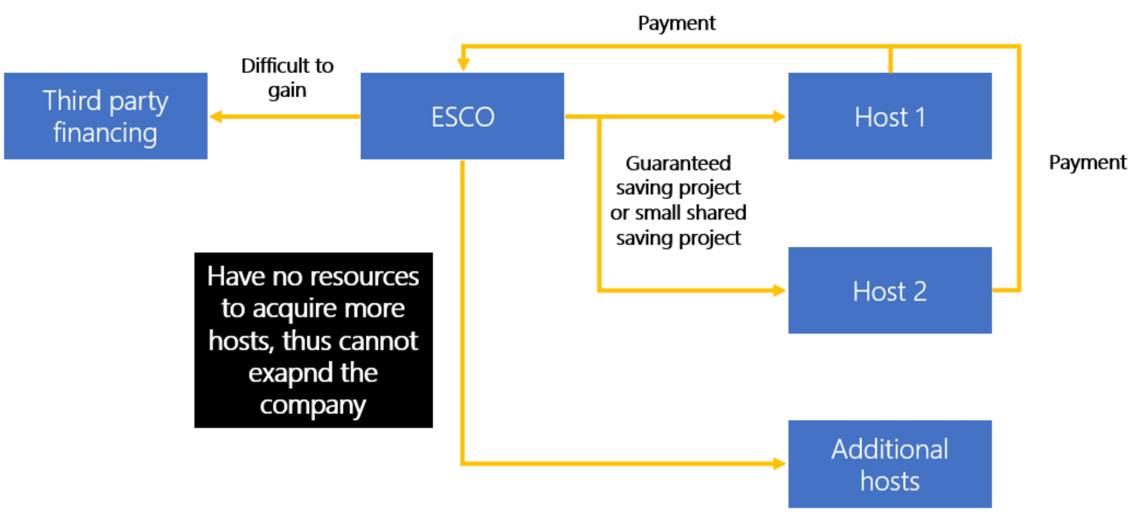


Figure 10. ESCOs reach bottlenecks for continued growth

Building energy efficiency ESCOs are forced to look into other business opportunities for continued growth. Even established foreign ESCO companies such as Johnson Controls, in order to avoid high transaction cost, have to focus their business on equipment sales, instead of providing energy-saving services in China (Pan, 2016). From the stakeholder workshops and interviews, it is clear that, even after more than 10 years of development, China's building energy efficiency ESCO market is still in its infancy, but it will not grow into a mature market unless there is systemic change in other aspects of China's societal structure, such as the perfection of the green financing system and credit system.

3.2 Hosts

Hosts in general still lack incentives to conduct building energy improvements, especially if subsidies are not available. Utilities are often a very small portion of a host's operating budget. Hosts commonly have other concerns such as interference of operation, safety concerns, etc. (Pan, 2016). Barriers for different types of hosts differ as well.

Unlike in the United States, hosts in China rarely acquire loans from banks for energy efficiency retrofits, which results in a generally small project size and a piece-by-piece retrofit approach (Oct. 2016 workshop, 2016; Chen, 2017). A host's motivation to conduct energy efficiency upgrades is generally low; most are approached by ESCO companies for retrofits. Hosts in China rarely initiate their own energy usage evaluation and then look for energy services.

3.2.1 Barriers facing privately owned commercial buildings

Mixed-owner commercial buildings

Mixed-owner commercial buildings such as office buildings are the most complicated cases for building energy efficiency upgrades. In the United States, mixed-owner commercial buildings are very rare, but in China it is prevalent (Linkletter, 2016). There are generally three groups of stakeholders involved in mixed-owner commercial buildings: building owners, renters, and property managers. Building owners pay the energy cost if they use the building; renters generally pay for their own energy costs; and property managers do not pay for energy costs or only pay for energy cost in common areas—and sometimes that includes heating and cooling for the entire building. Split incentive is a common issue for mixed-owner commercial building energy efficiency retrofits (Pan, 2016).

Property managers sometimes pay for the utility cost of common areas, such as parking lots, and also pay for heating and cooling of the building for centralized HVAC systems. Heating and cooling can be expensive for property managers, which motivates them to reduce such costs. However, replacing equipment requires the owner committee to vote, which can make the process very complicated. In this case, HVAC improvements that can be conducted through property managers without going through the owner committee are limited to measures such as installing a building management system to save energy (JLL property manager from Taida Building, 2017).

The owners of multiple-owner commercial buildings must reach consensus to approve energy efficiency upgrades. However, energy efficient improvements may disturb their renters (JLL property manager from Taida Building, 2017). Renters are often outside of the decision circle for building energy efficiency upgrades. Owners are risk-averse, and therefore sometimes decline energy efficiency improvement opportunities to ensure that their renters are not disturbed. As a result, even though mixed-owner commercial buildings are potentially good candidates for building energy efficiency upgrades, complicated split incentive issues make those projects less viable. ESCO companies sometimes do not even know which party to approach to sign contracts. Another concern is that owners from multiple buildings might share the same system. If one owner requires equipment replacement, they have to coordinate with other buildings too, further complicating the matter (Yu & Wang, 2017). An example of split incentive is shown in Figure 11 (Yu & Wang, 2017).

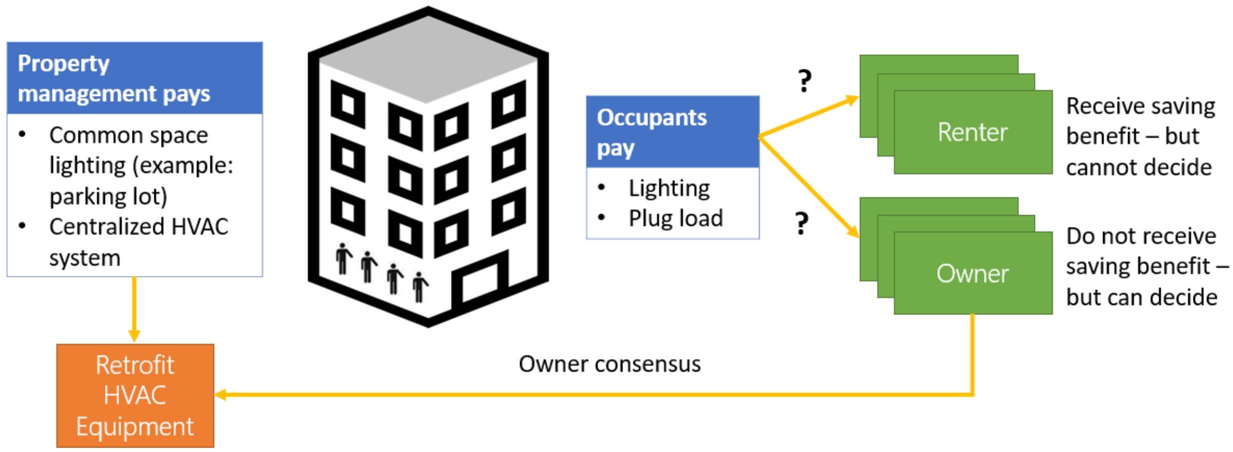


Figure 11. Example of split incentive by property management, renters, and owners

Single-owner commercial buildings

Single-owner hosts are more favorable ESCO customers, as they do not face split incentives. However, single-owner private business owners are not qualified for the same government grants for building energy efficiency projects that public hospitals and schools can access.

Single-owner business chains can be desirable customers for ESCOs, but can also be difficult to deal with. Local owners often do not have the authority to proceed with retrofits without permission from their headquarters (Yu & Wang, 2017).

3.2.2 Barriers facing publicly owned public buildings

Without the Top Runner program and direct government grants to encourage building energy efficiency upgrades, the budget-driven utility cost structure in government buildings demotivates energy efficiency upgrades. Government-owned public buildings have overarching barriers of “budget driven” energy efficiency upgrades. Utility costs are covered in the annual budget. Government-owned entities estimate the potential utility cost for the upcoming year based on previous year’s utility cost. Conducting energy efficiency upgrades actually results in a reduced budget in future years, which results in decreased motivation from building owners (Evans, et al., 2015).

Without government incentives, neither the organizations that own the building nor the employees themselves are motivated to save on utility costs. Hospitals and universities are studied as examples.

Barriers facing hospitals

Despite NHFPC grants that made promising progress on public hospitals’ energy efficiency upgrades, barriers still exist for public hospitals when those grants no longer exist. In general, public hospitals have low motivation to pay attention to energy efficiency upgrades. The income of large public hospitals is on the scale of billions of RMB annually, and hospitals must prioritize patient care, so energy costs are lower priority, even though compared to other types of buildings, hospitals have higher energy usage.

Non-systemic energy efficiency upgrades

Hospitals have a very unique indoor environment, and satisfying patients' needs is always the first priority. Hospitals also have special medical equipment that contributes to high energy usage. Energy efficiency upgrades in hospitals must always satisfy specific indoor environmental conditions for patients and work around the fact that special medical equipment cannot be replaced.

Energy efficiency improvements for hospitals are thus very unique and require specialized energy services. However, in most hospitals, energy efficiency improvements are not systemic and do not target sources of high energy use.

Hospitals do not prefer a shared savings model, as M&V results might cause discrepancies with ESCOs. They have an annual budget to spend on equipment replacement, so those replacements are opportunities for hospitals to choose more energy-efficient equipment. However, ensuring the hospital's smooth operation is still the first priority, and those replacing the equipment may not pay special attention to energy savings (Hospital hosts discussion, 2017).

Poor construction and maintenance in hospitals

A lack of well-trained personnel often results in poor construction and maintenance. Much hospital equipment cannot even meet operating conditions when it is first installed. To keep costs within budget, hospitals often immediately begin to use new facilities as soon as they are built, leaving no time for commissioning. This leaves a latent hazard, and if equipment needs further repair or replacement, hospitals filled with patients add extra layers of difficulty when trying to address that.

Maintenance is also a huge issue for hospitals. Large hospitals often have more specialized maintenance personnel, but smaller hospitals have no qualified facility management teams. Some hospitals do not even have their own facility managers, so they contract part-time facility managers from property management companies (Hospital hosts discussion, 2017).

Barriers facing universities

Currently universities apply for grants from the Ministry of Education to conduct energy efficiency improvements. There are also multiple other channels where universities can apply grants for efficiency improvement. Without a government grant, a university tends to lose its motivation for improving energy efficiency. Energy-saving projects are done unsystematically in universities. As with hospitals, universities do not prefer the shared savings model, as ESCOs and universities might have a dispute over M&V. The shared savings model also makes accounting inconvenient. Turnover in university administration adds extra uncertainties to ensure payback to ESCOs (University, 2017).

A university's energy cost, compared to large commercial buildings such as hospitals, is rather low. There is still great potential for energy efficiency upgrades, but compared to larger energy users, universities are not very attractive to large and established ESCOs for conducting integrated energy efficiency upgrades (Tongfang Taide, 2017).

3.3 Property management

Property management plays a key role in enabling energy efficiency upgrades in commercial buildings; however, significant management and technical barriers currently exist in property management companies, inhibiting the scale-up of energy efficiency upgrades in commercial buildings.

3.3.1 Management barriers

Even if the property management company pays certain commercial building utility costs, such as those for the common areas, individual property managers still often have low levels of interest in conducting building energy efficiency improvement projects (Zhonghui Yuanjing, 2017). One reason that has been identified is that helping the property management company reduce costs or conduct building energy efficiency improvements is not a part of property manager's performance review. As a result, property managers are not willing to take on additional projects on top of their daily duties, or to take on any potential risks associated with building energy efficiency improvements (Zhonghui Yuanjing, 2017).

3.3.2 Technical capability barriers

Employees in property management companies are generally not well educated, so in general, property managers have no technical understanding of how to operate buildings properly, let alone conduct an energy efficiency upgrade. Even with additional energy efficiency equipment in place, property managers may not know how to operate upgraded equipment properly, which results in sub-optimal energy performance (BOMA China executive team round table discussion, 2017).

Energy management education of property managers is crucial. Improving a property management company's technical service capability requires broad education on all aspects of building management; energy management is only a part of the whole picture (BOMA China executive team round table discussion, 2017). The lack of technical capabilities in property management are actually seen by ESCOs as a business opportunity. Building energy efficiency ESCOs are increasingly interested in the energy outsourcing model, where ESCOs manage buildings' energy operation instead of the property management company (Yu & Wang, 2017; Tongfang Taide, 2017; Zhonghui Yuanjing, 2017).

3.4 Measurement and verification companies

While individual standards have been developed, there is no comprehensive whole building protocol that considers how those measures interact. Especially for deep energy savings projects, integrated solutions are often needed and involve multiple energy conservation measures (Evans, et al., 2015).

The absence of a comprehensive whole building technical M&V protocol is only one aspect of the problem; current market design creates deeper issues. ESCOs and hosts often decide between them how M&V will be conducted. In cases where third-party M&V is involved, hosts must pay for M&V services. Therefore, quality control for M&V is very problematic, as many of the third-party M&V companies provide a complete report without even visiting the site (Wei & Chen, 2017).

However, no government agencies provide quality control for M&V companies. The General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ) would generally play the quality control role in China, but M&V falls into a grey area. The GAQSIQ considers M&V as a service, and they cannot conduct quality control for low quality services (Wei & Chen, 2017).

Lack of a trustworthy M&V protocol and market mechanisms discourage banks from lending to ESCO companies, and also create false claims of government subsidies. This conflict of interest issue is illustrated in Figure 12.

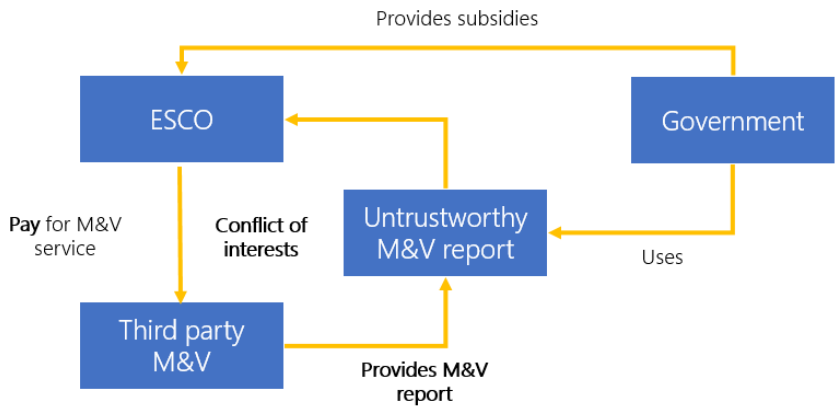


Figure 12. Conflict of interests between ESCOs and third-party M&V

3.5 Government

Government legislation and policies play the most significant role in enabling energy efficiency upgrades in commercial buildings. However, the current policy structure and incentives are not necessarily sustainable. New enabling policies would be needed to encourage energy efficiency upgrades after the direct subsidies are reduced.

3.5.1 The limitation of government subsidies and grants

The market could go in different directions, depending on how the government policies are constructed. Immediate cancellation of central government subsidies puts the building energy efficiency market into a more difficult situation. Interviews with representatives from hospitals and schools indicated that, without government grants, they would lose motivation for continued retrofits (Hospital hosts discussion, 2017; University, 2017). Changning district government in Shanghai, for example, awards ESCOs about 20-25% of their energy efficiency investment if those retrofitted buildings can reach a one-time 15-20% energy efficiency upgrade. In this case, project investment between 5 million RMB ($730,000) to 10 million RMB ($1.5 million) most easily falls into the range that can qualify for the subsidy. As a result, buildings that have already experienced some energy efficiency upgrades but may not have an additional 15%–20% potential sometimes simply stop their current energy efficiency upgrade effort and wait a few years until more equipment that need to be replaced altogether (Pan, 2016).

Uncertainty toward policy outcomes has hindered the government's favorable policy consideration toward the building energy efficiency industry. Grants and subsidies help to achieve targets quickly, but often fall into loopholes. Subsidy frauds often put the government into an awkward situation. For example, buildings that have attained Chinese green building standards have not yet received any promised subsidies because the buildings that were built following green building standards are not necessarily green due to potential low quality construction issues. Difficulty in accessing trustworthy M&V and real "green" buildings has also kept policy makers from putting more financial resources into this industry and setting up government targets. Another drawback right now for the government subsidies model is that the 20 RMB/m^2 was only given to ESCOs that conducted a shared savings project, discouraging other contracting models such as guaranteed savings. After the cancellation of the subsidy, this policy no longer favors the shared savings model, creating opportunities to encourage a guaranteed savings model and shift focus from ESCO-oriented to host-oriented EPC projects (Yu & Wang, 2017).

3.5.2 Institutional barriers

Interdepartmental collaboration is always an issue in China. Different government ministries or departments have different responsibilities and limitations. Creating policies that require cross-departmental collaboration often requires careful planning to ensure that they do not encroach upon other departments' boundaries. This results in policies created with institutional limitations.

The central government often does not make policies directly, but rather, waits for local governments to pilot solutions so it can translate experiences to other cities. However, if a local government already has made certain investments in some effort, the central government's new policy would be to immediately replace the local government's effort, making local government reluctant to try new policies (Tongfang Taide, 2017).

Government needs to come up with more creative policies and mechanisms that mobilize private capital to enter the energy efficiency market without subsidies and grants.

3.6 Commercial banks

Currently, the Chinese building energy efficiency industry is a mismatch with commercial banks' lending requirements, resulting in difficulty obtaining bank financing for building energy efficiency projects. Banks prefer low risk and would like to ensure guaranteed payback. As long as their loans are paid back, banks do not care if the retrofit program resulted in energy savings or not. The ability to pay back to the bank is the first priority; then banks evaluate if it is a "green" loan based on other criteria (Oct. 2016 workshop, 2016; Chen, 2017).

Banks evaluate loans based on the debtor instead of project itself (Chen, 2017). Lacking a comprehensive credit system is only a part of the issue. Even in the United States, where the credit system is comprehensive for both individuals and companies, commercial banks rarely lend to SME ESCOs. A typical ESCO loan structure creates both performance and credit risks for the lender. In the United States, commercial bank loans are given to hosts and large ESCOs with their own equipment and assets, instead of SME ESCOs (Freehling & Environmental, 2011). Yet in China, it is very rare for hosts to initiate a loan process. ESCO companies still typically require third-party financing to grow their business.

The most common debtor that needs funding, SME building ESCOs, are banks' least favorable type of debtor. Banks like a low-risk, heavy-asset, high-reward, and large-size standardized product, and SME building ESCOs are completely the opposite in every single category. Common issues are listed as follows and summarized in Figure 13:

1. **Unstable cash flow**
   Banks require a potential debtor to have a stable cash flow in order to provide loans. However, it is more like a chicken-and-egg problem for SME building ESCOs. Without third-party finance, they can hardly expand their team and gain customers. This is not unique to SME ESCO companies. This issue exists for all types of SME in China. SME ESCOs have higher risks of running into low-quality customers (Yu & Wang, 2017).
2. **No tradable collateral**
   Banks prefer lending to companies with assets that they can turn into cash. Light-asset building ESCOs have no collateral to offer to banks. Banks have looked into having a project's future energy savings used as collateral, but at the current stage, energy savings cannot be traded. Even though China is establishing an "Energy Savings" trading platform, it is not yet fully

implemented, and the mechanism is not ready. Therefore, banks cannot yet trade or sell "saved energy" (Oct. 2016 workshop, 2016; Chen, 2017).

3. **Risks are too high**
   High risks relate to both unstable cash flow and the issue with collateral. During China's Twelfth's FYP, multiple banks in China introduced asset-backed security, where future income from shared savings could be used as collateral. However, banks have seen that for building energy efficiency ESCOs, those collaterals are more difficult to realize. This is partially due to overestimated energy saving potential claimed by ESCOs. Overall, banks consider building energy efficiency ESCOs to be high-risk debtors. Banks provided building energy efficiency ESCO products during the Twelfth FYP because of favorable subsidies and government policies. With reduced subsidies, banks also reduced their participation in this high-risk industry (Chen, 2017).
4. **IRRs are too low**
   Due to extensive transaction costs, a building energy efficiency project's IRR is not very high. Without a high IRR, building ESCOs do not find bank loans attractive (Tongfang Taide, 2017).
5. **Small project, high transaction cost, and not standardized projects**
   Banks like a large and standardized project to reduce transaction costs and increase income. Banks find projects even at the scale of 100,000 RMB (14,600 USD) a small project. Even if one ESCO can gain bundled contracts with multiple buildings, banks still need to treat each building's project individually (Oct. 2016 workshop, 2016; Chen, 2017).

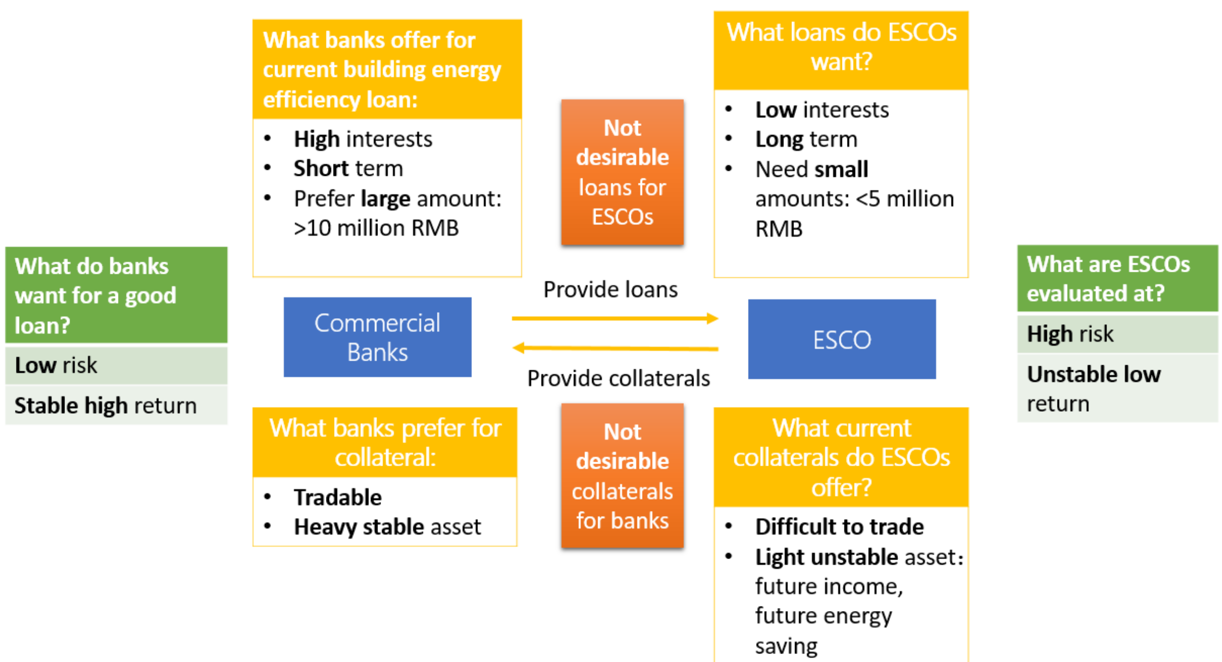


Figure 13. Commercial banks' lending interests are a mismatch of ESCOs' loan request

In general, banks consider building energy efficiency ESCOs to be high risk and low return, which does not match well with a bank's financial structure and needs. With large ESCOs, even if they could easily get access to loans provided by banks, they would not want it because bank terms are still not desirable. Any measures that can ensure that banks receive loan payback will encourage banks to invest in this sector and provide longer-term, lower-interest loans.

4 Summarized Commercial Building Energy Efficiency Barriers

In this chapter, barriers associated with key energy efficiency upgrade stakeholders are summarized. Overarching barriers observed from the interviews are also summarized.

4.1 Summarized key commercial building energy efficiency barriers from stakeholder interviews

Barriers associated with each individual stakeholder group from Chapter 3 are summarized in Table 11.

Table 11. Summary of stakeholder-oriented commercial building energy efficiency upgrade barriers from interviews

Stakeholder	Barrier	Description
Energy service company	Building energy efficiency focused ESCOs have difficulty growing	SME ESCOs cannot compete for large industrial energy efficiency projects while building energy efficiency projects' size is too small.
	Customer acquisition process is burdensome	Very competitive market. Require customer education and proposal phase. Customers might still not be interested in selecting the service.
	Untrustworthy hosts	Hosts might not pay back to ESCOs due to savings disputes or ethical issues.
	Difficulty gaining third-party financing from commercial banks	SME in general have difficulty obtaining bank loans. Large ESCOs prefer low-interest loans but bank loans have high interest.
Privately owned commercial building hosts	Split incentive	Occupants, property management, and owners have different priorities. Building energy efficiency upgrades do not necessarily provide incentives for all parties. Especially an issue in multiple-owner commercial buildings where owner consensus is required to conduct building energy efficiency upgrades.
Government-owned public building hosts	Budget utility cost structure	Building owners are not motivated if government grants for energy efficiency upgrades go away. Do not prefer shared saving model due to balance sheet complications.
Property management	Lack of technical capability	Lack of trained professionals that have an accurate understanding of the building system.
	Lack of incentives	Individual property managers are salary-based. Improved energy efficiency is not a part of their performance review, thus they are not

		motivated.
Measurement and verification companies	Lack of a comprehensive whole building M&V protocol	Current M&V protocols do not consider the interaction of energy efficiency technologies.
	No quality control for M&V companies' results	General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ) considers M&V to be a service. GAQSIQ cannot control for a low-quality service.
	Conflict of interest	ESCOs pay for M&V companies to produce savings reports. M&V companies often provide energy savings numbers only to satisfy their customers' (ESCOs) request, instead of actual energy saved.
Government	Subsidies and grants have loopholes as designed	Current market is too subsidy- and grant-driven. Little enabling legislative support is available after subsidies phase out.
	Interdepartmental policies are lacking	Current policies have limitations due to lack of interdepartmental collaboration within the government.
Commercial banks	Commercial banks' loan service and ESCOs lending request is mismatched	Banks like a low-risk, heavy-asset, high-reward, and large-size standardized product, and SME building ESCOs are considered to be high-risk, light-asset, low-reward, and small unstandardized projects. Large building ESCOs that banks are willing to lend to would prefer a low-interest loan, but banks provide high-interest loan to ESCOs.

4.2 Overarching issues and barriers inferred from stakeholder interviews

Despite a prospering energy efficiency market, and progress achieved in the past, China's energy efficiency market is facing tremendous pressure, inhibiting the market from growing.

The current ecosystem of ESCOs, hosts, and lenders is not conducive to growth. The market relies heavily on subsidies to even survive. Due to low return on projects, ESCOs need to acquire third-party financing to grow. Difficulties in gaining bank loans have inhibited ESCOs from growing and consolidating the market. Building energy efficiency is not an attractive market to begin with, so with low demand from hosts and supplier difficulties, a significant amount of legislative support is needed to overcome those barriers. This section summarizes overarching issues inferred from stakeholder interviews.

4.2.1 Building energy efficiency's internal rate of return is too low for deep retrofits

The building energy efficiency improvement market is not very profitable. After the low-hanging fruit, such as lighting replacement, is harvested, the deeper energy retrofit projects' IRR is relatively lower. Customers are also more reluctant to take on the long payback periods of deep retrofit projects. With high transaction costs and relatively small project sizes, building energy efficiency is not a very attractive market. Yu, Wu & Xu (2011) indicated that project IRR for traditional building energy efficiency ESCOs would need to be at least 30% to be profitable in China. In addition, with a low barrier to entry, the building energy efficiency market is very competitive, making profitability even more difficult (Yu, Wu, & Xu, 2011). Interviews with ESCOs indicated that hosts cannot accept high ESCO profitability. Even if project IRR goes beyond 30%, some hosts start to feel uncomfortable, feeling that ESCOs are taking advantage of them (Pan, 2016).

Government subsidies and grants help to increase a project's IRR, but after grants and subsidies are reduced, host motivation decreases and customer acquisition becomes more difficult for ESCOs. Because of low IRR and the small deal size of the building energy efficiency projects, large ESCOs try to avoid building energy efficiency businesses and focus on other, more lucrative businesses, such as industrial energy efficiency retrofits (Tongfang Taide, 2017; Pan, 2016). As a result, building energy efficiency-focused SME ESCOs are barely surviving in this market.

4.2.2 Lack of creditworthiness hinders sector growth

The building energy efficiency industry is especially influenced by a lack of creditworthiness. Interviews have indicated that this issue exists for ESCOs, hosts, and M&V companies. SME companies historically have a difficult time obtaining bank loans. For building energy efficiency ESCOs that rely heavily on bank loans, untrustworthy hosts, ESCOs, and M&V results are important factors that lead banks to consider building energy efficiency ESCOs higher risk, and are unwilling to provide loans. It also causes unlawful claims of government subsidies and loans. For a service sector that requires heavy bank loans to sustain it, a lack of creditworthiness significantly hinders its development (Oct. 2016 workshop, 2016). The current absence of a comprehensive credit system hinders the ability for hosts to identify trustworthy ESCOs, for ESCOs to identify trustworthy hosts, and also for financial institutions to identify trustworthy borrowers.

4.2.3 Lacking systematic diagnostics, planning, and market consolidation

Commercial building energy efficiency upgrades are not done systematically, resulting in sub-optimal retrofits. This also hinders a host's ability to choose the most suitable ESCOs or equipment from vendors (University, 2017; Hospital hosts discussion, 2017; Yu & Wang, 2017). Due to difficulty in getting third-party financing, ESCOs are very limited by their ability to grow. Individual SME project developers conduct energy efficiency projects separately. Hosts still have little choice or understanding on which ESCOs they could choose in order to conduct a trustworthy systematic diagnostic. Therefore, they miss the opportunity to conduct comprehensive, deep energy savings projects.

Many projects focus on acquiring energy efficient equipment but pay less attention to how that equipment is managed and maintained, leading to a situation where buildings are not performing optimally. This issue is especially outstanding when those retrofits are provided by individual SME projects instead of a systematic energy service that includes diagnosis, retrofit, and continued energy management. Buildings in China generally are equipped with HVAC systems that are overcapacity. A lack of experienced property management is a universal issue in China (BOMA China executive team round table discussion, 2017). This is especially true for many building hosts that conduct initial energy efficiency retrofits but do not necessarily have the right team to ensure that equipment is properly configured, commissioned, and run at its optimized mode and schedules.

Sub-metering is often not in place for many buildings. Installation of sub-meters help hosts to identify high energy usage sources and come up with energy saving strategies accordingly (Hospital hosts discussion, 2017).

5 Lessons Learned from the U.S. Commercial Building Market

The United States has been through a long journey to encourage commercial building energy efficiency upgrades. This chapter will first provide an overview of commercial building energy efficiency in the United States, then illustrate existing barriers that prevent market scaling. It then summarizes existing key solutions to overcome those barriers such as a special government program called the Better Buildings Initiative. Also, private commercial building upgrade barriers and solutions in U.S. and China are compared and contrasted to provide inspiration for Chinese decision makers.

5.1 Overview of commercial building energy efficiency in the United States

In the United States, commercial buildings contribute to 87 billion square feet (ft^2) of floor space and account for approximately 18% of total U.S. energy consumption, 35% of U.S. electricity consumption, and 18% of U.S. nationwide CO_2 emissions. In 2012, the most consumptive end uses in commercial buildings were lighting, refrigeration, ventilation, cooling, and other end uses. Electricity end-use consumption in the commercial sector is projected to increase by 0.7% annually from 2015 to 2040, from 1.365 terawatt-hours (TWh) to 1.615 TWh, along with a projected 0.4% per year decrease in electricity intensity and 1% per year increase in floor space (Schwartz, et al., 2017).

5.1.1 Typical commercial building energy efficiency improvement measures

Similar to energy efficiency improvement measures in China, energy efficiency retrofit measures in commercial buildings in the United States include simple activities, partial retrofits, or whole-building integrated solutions. Simple activities such as fine-tuning or management improvements generate a savings of 5%–20%, with a payback within 12 months. An integrated whole-building retrofit consists of an energy retrofit of individual components and a building envelope upgrade. This type of retrofit can bring energy savings of 40% or more, with a payback period that takes a decade or more. Some building owners choose a partial retrofit, where individual components such as inefficient equipment are replaced, or components like lighting fixtures, HVAC systems, or windows are retrofitted (ESMAP, 2014).

5.1.2 Current market actors in the energy efficiency retrofit market

During a building operation phase, when an energy efficiency retrofit takes place, key market actors include building owners and tenants, property management companies, real estate professionals, equipment suppliers, energy service suppliers, building auditors, and retro-commissioning agents. In addition, intelligent control system providers are emerging market actors, competing with existing control system providers.

Energy service companies (ESCOs) are also important market actors in United States. ESCOs in the United States provide integrated technical measures to building hosts. In 2014, the total U.S. ESCO industry reached an estimated revenue of $5.3 billion. It is expected that ESCO industry revenue will grow to $7.6 billion in 2017, primarily in buildings (Larsen, Carvallo, Goldman, Murphy, & Stuart, 2017). A typical performance contract saves 15% to 30% of total performance contracting (Patterson & Hessler, 2014). Municipalities, universities, schools, and hospitals (MUSH) accounted for three-quarters of U.S. ESCO industry from 2003 to 2012. Privately owned buildings only accounted for 8% of ESCO industry revenues in 2011, as privately owned commercial buildings prefer a payback less than two years, making it difficult for ESCOs (Schwartz, et al., 2017; Stuart, Larsen, Goldman, & Gilligan, 2013).

5.2 Barriers facing commercial building energy efficiency retrofits

Commercial building energy efficiency only accounted for 8% of U.S. ESCO industry revenues in 2011. Numerous barriers have been identified for this sector. From the building owner or demand side, there is a lack of interest in building energy efficiency upgrades. This is mainly due to issues such as split incentives, unclear benefits, constrained capital, potential debt constraints, and tax treatment. Lack of in-house technical expertise is also considered to be a barrier to energy efficiency upgrades. From a supply-side perspective, the size of commercial building projects are often small and require a complex sales process. Suppliers often have to approach a potential customer with a split incentive, building owners, renters, or property managers. Overall, the sales cycle is burdensome and not cost effective (DB Climate Change Advisors, 2012). Reviewed literature examining past barriers is summarized in Figure 14.

Demand

- ❑ Lacking motivation from building owners
    - Lack of energy efficiency upgrade information and merit is not clear
    - Energy saving can be difficult to measure and evaluated by end use
    - Do not want potential risks and inconvinence
- ❑ Split incentives
- ❑ Lack of technical expertise
- ❑ Capital access constraints

Supply

- ❑ Small deal size
- ❑ Need to deal with potential customers with split incentives
- ❑ Complex sales
- ❑ Private customers prefer short payback time

Figure 14. Summary of energy efficiency upgrade barriers in commercial buildings (Larsen, Carvallo, Goldman, Murphy, & Stuart, 2017; DB Climate Change Advisors, 2012; Granade, et al., 2009; RMI, 2014)

5.3 United States solutions for overcoming those barriers

To overcome barriers in commercial building energy efficiency upgrades, the U.S. government and state utility regulatory agencies initiated different types of programs. Financial innovations were created to overcome the barrier where a lack of capital creates issues for energy efficiency upgrades. State regulatory agencies create tax benefits, as well as favorable utility incentives and rebates, all foster the adoption of energy efficiency upgrade measures (Schwartz, et al., 2017; Stuart, Larsen, Goldman, & Gilligan, 2013; Larsen, Carvallo, Goldman, Murphy, & Stuart, 2017; Granade, et al., 2009). Individual solutions were created to overcome those barriers (Table 12). The U.S. government also created a comprehensive program called the Better Buildings Initiative, which aims to overcome privately owned commercial building energy efficiency upgrade barriers, from both the demand side and supply side, and provide systematic solutions. The Better Buildings Initiative is discussed in the next section.

Table 12. A summary of selected key barriers and solutions

Barriers	Solutions
Lack of motivation from building owners	**Information and Awareness** Design benchmarking and data disclosure policies that require building owners' energy data, to raise building owners' energy usage awareness. Benchmarking and data transparency policies in different forms have been adopted by 8 states and 14 cities (Schwartz, et al., 2017; NYC Mayor's Office of Sustainability, 2017). **Incentives and Rebates** Certain utilities such as Pacific Gas and Electric (PG&E) and Southern California Edison (SCE), as well as federal and local governments, provide incentives and rebates that encourage energy efficiency upgrades by owners. In California alone, in 2014, over $1.7 billion was budgeted for energy efficiency programs in the state (DOE, 2015). Technology-specific programs are most common, and some rebates are offered based on whole-building energy savings achieved. The commercial building tax deduction applicable for expenses was incurred for energy efficiency building expenditures made by a building owners and capped at $1.80 per ft^2 (Schwartz, et al., 2017). **Rate Design** Electricity utility tariff structures in United States attract investments in energy efficiency by providing customer price signals. Improving rate designs could help to encourage energy efficiency investments, as summarized in **Error! Reference source not found.**. Common rates include tiered rates,[25] demand charges,[26] and time-varied pricing[27] (Schwartz, et al., 2017).
Capital constraints	**Financial Innovation** In addition to traditional financing options that include leases and loans, specialized energy efficiency programs and products have been developed to encourage energy efficiency. Specialized energy efficiency payments are summarized into on-bill financing and repayment,[28] Property Assessed Clean Energy (PACE)[29] financing, and savings-backed arrangements.[30]

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25 *Tiered rates* refers to a common practice worldwide, where a higher electricity rate is associated with a higher incremental block of energy usage (Schwartz, et al., 2017).

26 *Demand charge* refers to monthly charges based on a customers' maximum usage in an hour or a shorter period of time. Embracing energy efficiency measures can reduce maximum demand possible and reduce demand charges (Schwartz, et al., 2017).

27 *Time-varied price* refers to a utility charge that varies daily and seasonally, encouraging electricity usage during off-peak hours, and encourages more efficient energy use during on-peak hours (Schwartz, et al., 2017).

28 On-bill financing allows borrowers to pay back energy efficiency costs through their utility bill (Schwartz, et al., 2017).

29 PACE allows building owners to pay off clean energy investment through property tax bills (Schwartz, et al., 2017).

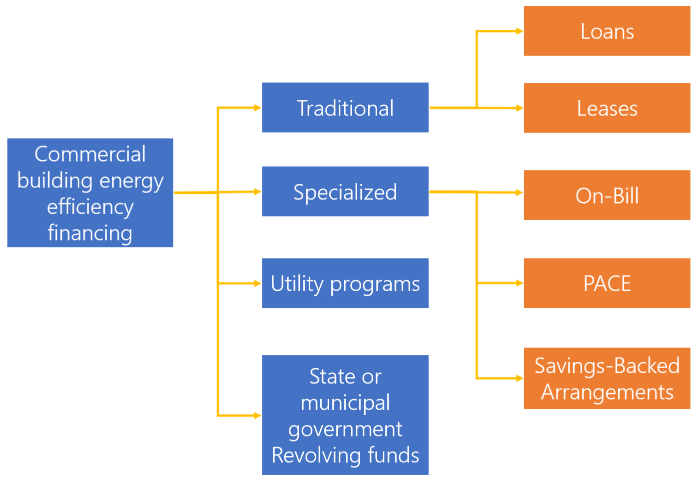
	Utilities sometimes design their own financing programs[31] for building owners. State and local government frequently offer unsecured loans from revolving loan funds or loan loss reserves[32]. (Leventis, Fadrhonc, Kramer, & Goldman, 2016; Deason, Leventis, Goldman, & Carvallo, 2016; Schwartz, et al., 2017). 

Figure 15. Summarized financing options and descriptions of energy efficiency upgrades in the United States (Leventis, Fadrhonc, Kramer, & Goldman, 2016; Schwartz, et al., 2017)

Special government program example: Better Buildings Initiative

The United States created the Better Buildings Initiative to help achieve a national target of improving energy efficiency in commercial buildings 20% by 2020. It was initiated in 2011 by President Obama and executed by the U.S. Department of Energy (DOE). Within the Better Buildings Initiative, the Better Buildings Challenge (BBC), gets corporate entities (called *partners*) to pursue the 20% energy efficiency reduction goal across their entire building portfolio, support their energy efficiency retrofit ideas with actual action, share their successes, and create solutions for others to follow. Since the program's launch, partners have cumulatively saved 160 trillion Btu and an estimated $1.3 billion (U.S. Department of Energy, 2016).

This program has been successful at overcoming the different obstacles that discourage energy efficiency upgrades in the private commercial building sector, as illustrated in
Table 13. The Better Buildings Initiative also established supporting mechanisms that help private

30 Savings-backed arrangements include Energy Savings Performance Contracts (ESPC), Energy Service Arrangements (ESA), and Managed Energy Service Agreements (MESA) that typically enable an energy service provider to assume an energy efficiency projects' performance risks by guaranteed shared savings (Schwartz, et al., 2017).

31 Utilities provide financing programs that customers do not pay back on the bill, but rather to capitalize loans, provide credit enhancement, or buy down interest rates to customers (Leventis, Fadrhonc, Kramer, & Goldman, 2016).

32 Revolving loan funds are where loans are lent to qualified energy efficiency projects and the loan is paid back to the same fund (Leventis, Fadrhonc, Kramer, & Goldman, 2016).

sector leaders achieve their goals. The program aims to help commercial building owners retrofit buildings through the following strategies:

1. Share knowledge and information about how to conduct building energy efficiency upgrades by conducting seminars and technical support.
2. Ask financial institutions to commit appropriate loans that help Better Buildings partners with upfront costs and help building owners find the right financing options and institutions.
3. Create Better Buildings Accelerators to address specific institutional barriers on building energy efficiency upgrades.
4. Provide energy efficiency retrofit measures in a solutions center that gathers how energy efficiency upgrades are conducted by other buildings, to create peer comparison.

Table 13. Summary of barriers that the Better Buildings Program is overcoming and appropriate measures (DOE, 2017)

Key Barriers	Key Solution
Lack of upfront cost on energy efficiency upgrades	◆ DOE secured $5.5 billion in commitments from financial institutions to help BBC partners with upfront cost on energy efficiency upgrades. ◆ Created a financial navigator to help building owners to find appropriate financing options and institutions.
Lack of technical knowledge on building retrofit approaches	◆ DOE established a solutions center that gathers existing energy efficiency upgrades from partners or previous case studies. ◆ DOE establishes technical research teams to research different areas of energy efficiency upgrades. ◆ Regular webinars, summits, and other events provide opportunities for organizations to gain up-to-date technical approaches to further reduce their energy consumption. ◆ A benchmarking program helps building owners compare their building's energy usage with similar buildings.
Organizations' lack of interest in participating in BBC	◆ DOE has put effort into establishing partnerships and reaching out to organization leaders to educate them on the benefit of energy efficiency upgrades. ◆ Through BBC's solution center, organizations can find solutions that worked on buildings similar to their own. Organizations can get a sense of how much energy and money they can potentially save.
Institutional barriers	◆ Better Building Accelerators address specific challenges for organization leaders to engage in energy efficiency upgrades. Currently there are 13 Better Building Accelerators.

5.4 Lessons learned for China

Given the difference between the U.S. and China energy efficiency market structure, some commercial building energy efficiency barriers in U.S. are not the same for Chinese market, and solutions that can address those barriers in the U.S. might not apply to the China market. Major differences and similarities of the barriers between the China market and the U.S. market are summarized in **Error! Reference source not found.**.

Table 14. Comparison of the U.S. and China key market barriers to commercial building energy efficiency upgrades

Barrier	U.S.	China
Lack of creditworthiness	Not a major issue in the U.S.	A major issue in China
Capital constraints	Numerous programs help to mitigate this issue	A major issue in China
Property management company or building owners lack professional expertise	Much less of an issue in the U.S.	A major issue in China
Split incentive	Applies in the U.S.	Applies in China
General lack of interest in energy efficiency upgrades by private commercial building owners due to low energy costs	Applies in the U.S.	Applies in China
Lack of Information awareness and transparency	Numerous programs help to mitigate this issue	A major issue in China. Data access is very difficult in China.
Upfront cost and short payback times	Applies in the U.S.	Applies in China
Creates inconvenience in buildings	Applies in the U.S.	Applies in China

Further details on the country differences affecting solutions to overcome building energy efficiency upgrades are as follows:

Creditworthiness: Lack of creditworthiness is a major issue in China. Many programs in the U.S. count on building owners to report their energy usage data truthfully, but in China, it can be expected that many data will be false.

Data transparency: Data transparency is also a huge issue in China. It is extremely difficult to acquire building data from owners and the government, where those data owners worry about data quality and a negative potential use of the data that could hurt their reputation.

Utility companies: The electricity market is dramatically different between the U.S. and China. In China, the electricity market is heavily regulated with no market competition in transmission and distribution. Therefore, utilities do not directly participate in energy efficiency upgrades in China, while in the U.S., through government intervention, utility companies often design building energy efficiency programs.

Government policy approach: In the U.S., states can form their own laws and regulations, and innovate from a state and city level. In China, the central government has power over the local governments. From a policy and program standpoint, the U.S. mostly adopts a bottom-to-top approach, whereas China usually takes a top-to-bottom approach.

Financial innovations: Certain solutions, such as PACE financing, would not adapt to Chinese system, as China does not yet have property tax. On-bill financing is also not suitable in China at the moment because the current utility companies' system would not allow such arrangements, but ongoing electricity market reform in China might change that situation.

Despite the differences, similar solutions to overcome current market barriers have been noted in both China and U.S. For example, subsidies or financial incentives are available in both countries to encourage building energy efficiency upgrades. In both China and the U.S., utility companies also have tiered pricing and time-varying charges, yet the demand charge does not exist in China yet.
Some U.S. policies and programs may provide helpful information for China's efforts. The Better Buildings Initiative provides a great example of how to use peer pressure to encourage energy efficiency upgrades in commercial buildings. Through the adoption of this program, U.S. private building owners get a set of information and education on energy efficiency improvements, as well as access to resources such as financing options, favorable rebates, technology solutions, and appropriate ESCOs. Best practice and information-sharing is the first step in bringing awareness to building owners and to gain their interest in energy efficiency upgrades.

Creating mandatory data disclosure policies in China would certainly provide benefits to building owners, but first China needs to develop solutions to mitigate data access issues. Creating credit enhancement measures for Chinese financial institutions also would help spark the interest of financial institutions in creating products for building energy efficiency upgrades. The ESCO market in the U.S. is much more mature compared to the ESCO market in China. Improvements of energy efficiency awareness and credit systems, and mitigating the difficulty of gaining third-party financing would certainly open more business opportunities for ESCOs in China, help consolidate the currently fragmented market, and provide building owners with systemic and complete energy efficiency upgrade solutions.

6 Conclusion

Government-driven policies such as grants and subsidies successfully encouraged energy efficiency retrofits during the Eleventh and the Twelfth FYPs. Moving into the Thirteenth FYP, China aims to move from government policy-driven model, such as providing subsidies, to a market-based economy for building energy efficiency. However, a mature building energy efficiency market mechanism has not yet been established. Without the incentive of subsidies, the building energy efficiency market could easily stagnate. Significant market barriers to building the energy efficiency market exist, and systemic policy direction and market mechanism improvement is necessary to overcome those barriers.

Deep building energy efficiency retrofits are difficult to obtain, while return on investment is low (Yu, Wu, & Xu, 2011). After low-hanging fruit such as lighting replacement is harvested, the deeper energy retrofit projects' internal rate of return is relatively low, because hosts are not very motivated by energy efficiency retrofits, and building energy efficiency-focused energy service companies (ESCOs) are barely maintaining operation (Oct. 2016 workshop, 2016; Tongfang Taide, 2017; Yu & Wang, 2017).

The general lack of a sound credit system leaves the creditworthiness of hosts, ESCOs, and measurement and verification (M&V) companies unchecked, partially inhibiting third-party financing of building energy efficiency, and inhibiting ESCO growth (Oct. 2016 workshop, 2016; Tongfang Taide, 2017; Yu & Wang, 2017). The current energy service industry is also very fragmented, resulting in unsystematic and sub-optimal energy efficiency upgrades in buildings (University, 2017; Hospital hosts discussion, 2017; Yu & Wang, 2017). Building energy efficiency upgrades focus much more on equipment, but less on management (Evans, et al., 2015) which means energy savings are not optimized to their fullest, even with efficient equipment.
Each stakeholder in the market-driven building energy efficiency market faces significant barriers. Those stakeholders include ESCOs, hosts, property management companies, measurement and verification companies, governments, and commercial banks.

In this stakeholder ecosystem, **ESCOs** often provide energy retrofit service to hosts, and have to engage property managers during this process. If hosts do not want to pay for upfront energy retrofit cost, then ESCOs must pay for themselves. ESCOs play a key role advancing building energy efficiency upgrades in public buildings. ESCO companies in building energy efficiency have undergone tremendous financial pressures, due to a difficult customer acquisition process and an inability to gain third-party financing (Yu, Wu, & Xu, 2011; Pan, 2016).

Building hosts lack the motivation to conduct an energy efficiency retrofit. Government grants help to incentivize them. Although **property management companies** play a crucial role in enabling energy efficient upgrades, they rarely tap into the energy efficiency market. This stems from a lack of technical capability and a split incentives issue, which result in low motivation from property management companies to actively engage in energy efficiency upgrades (BOMA China executive team round table discussion, 2017).

Measurement and verification companies in China are hampered by the lack of a whole building level comprehensive M&V protocol that considers the interactions of individual energy efficiency technologies (Evans, et al., 2015). Further, the market mechanism of energy service companies paying for the M&V creates conflict of interests, resulting in M&V results that are not necessarily trustworthy (Wei & Chen, 2017).

Government departments face institutional barriers because different interests do not collaborate effectively on designing impactful and self-sustaining policies to encourage building energy efficiency upgrades, leaving in place simple yet flawed measures, such as direct subsidies. Without a mature building energy efficiency market, cancellation of subsidies has a hobbling effect (Yu & Wang, 2017).

Commercial banks are the most common third-party financing option that ESCOs use to fund energy efficient retrofit projects. Difficulty in obtaining third-party loans is a key barrier that inhibits the development of a building energy efficiency service industry and business growth of ESCOs (Yu & Wang, 2017; Evans, et al., 2015). Current Chinese ESCOs are a mismatch with commercial banks' lending requirements; banks prefer low-risk, stable-return, and heavy-asset collateral, while ESCOs are light-asset, with building energy efficiency projects relatively high risk and low return (Chen, 2017). Only by creating a market mechanism that creates win-win outcomes between the stakeholders, the market can become self-sustaining.

As China has decided to transition from a government-driven system to a market-driven system for building energy efficiency, enabling legislative support is crucial to overcome those market barriers. Overcoming those barriers will require systematic improvements to the Chinese policy framework, to create a healthy, self-sustaining, and prosperous building energy efficiency market.

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8 Appendix A

Questions to Energy Service Companies

1. What services do you provide?
2. Who are your customers?
    a. Type of customers? (Public/private)
3. What is your business model? Shared savings, guaranteed savings, or energy outsourcing?
4. How do you finance your projects?
5. Do you find it difficult to gain third-party financing? Which financial institutions do you approach for third-party financing?
6. If hosts pay for the project, how do they finance their own projects?
7. Do your customers find it difficult to finance energy efficiency upgrades?
8. What is the cost breakdown of your company and the revenue breakdown?
9. Who conducts measurement and verification? How is it done?
10. What is your approach of obtaining customers? How much does customer acquisition cost? How many customers are gained through public bidding?
11. How is the overall building energy efficiency market? Is there a lot of competition?
12. Do you have any public-private partnerships?
13. Do you provide follow-up services to your customers after you finish the initial retrofit process?
14. Please illustrate the process of an entire project cycle, and what you do in each step.
15. What is one typical project size? What is the payback period?

Commercial banks

1. What types of energy efficiency financial products do you provide?
2. Who comes to you for energy efficiency financial products? What are their financing needs? Whom do you provide financing to? What percentage of those companies will you provide with funding?
3. Do hosts come to you for financing or do ESCOs come to you for financing?
4. What factors do you use to evaluate whether you should provide financing to projects?
5. What is the entire process that you use to provide third-party financing?

Real estate companies

1. Do you manage the buildings you developed? Do you pay for utilities?
2. Do you aim for green building certification for the buildings you developed?
3. Do you think customers would pay more for greener buildings?
4. What types of customers would prefer greener buildings?
5. What strategies do you use to engage customers' interests in buying or renting more energy efficient buildings?
6. Do you have a specific department on energy efficiency?

Property management

1. What types of property management services do you provide to customers?
2. Do you pay for utilities?

3. Have you retrofitted the buildings you manage? What do you retrofit if you have already done so or want to do so in the future?
4. Do you pay for energy efficiency upgrades yourself or obtain third-party financing?
5. If you work with ESCOs, what types of contracts do you sign with them? What payback period would you like?

Universities

1. Does your university participate in the Top Runner program?
2. Does your university conduct building energy efficiency retrofits? If so, what do you retrofit?
3. If you work with third-party energy service companies, what types of retrofits do you conduct?
4. On what types of buildings have you done energy efficiency retrofits?
5. If you have done energy efficiency retrofits with ESCOs, how long is the warranty?

Hospitals

1. Does your hospital participate in the Top Runner program?
2. Does your hospital conduct building energy efficiency retrofits? If so, what do you retrofit?
3. If you work with third-party energy service companies, what types of retrofits do you conduct?
4. On what types of buildings have you done energy efficiency retrofits?
5. If you have done energy efficiency retrofits with ESCOs, how long is the warranty?

Government

1. What is the local government's goal for commercial building energy efficiency retrofits?
2. What supportive policies do you provide?
3. How do you evaluate building energy efficiency goals?
4. Do you support more energy efficient buildings in the future?