INSTITUTIONAL EFFECT ANALYSIS COMPARING ENERGY EFFICIENCY RETROFITTING FOR EXISTING RESIDENTIAL BUILDINGS PATTERNS IN CHINA

Junna Zhao
MES University of Waterloo, Canada
Fanghong Lou
MA Renmin University of China, China

Abstract:

Buildings in China are important contributors to the country's energy consumption and CO2 emissions. Energy use in building in northern heating regions of China accounts for more than 40% of secondary energy consumption in urban areas. The total building areas has increased 75% over the past decade. Approximately 2.5 billion m2 (nearly 1/3) of existing residential buildings in Northern China are worth retrofitting. Efficiency Retrofitting for Existing Residential Buildings (EERFERB) in China is undergoing a fast development support by both the Chinese Central Government and international governments and institutions. These international and domestic projects have not only played a significant role in enhancing China's building energy efficiency, but also significantly promoted the quality of housing conditions for low- and middle- income populations. It is recognized that projects with government cooperation among countries and central-to-local government projects have different implementation patterns. These differences provide valuable lessons for selecting efficient project delivering institutions. This research will develop criteria to compare international government-to-government projects and domestic central government projects. Two typical projects in Beijing and Tangshan will be evaluated from the perspectives of regulatory support, organizations, retrofitting effects, financing mode, management structure, incentive and technical support, and community sustainability improvement. Based on it, both the strengths and weaknesses of both retrofitting delivery patterns are presented. Finally, lessons and experiences are extracted and the implications for instruction and decision-making for the Chinese EERFERB policy design are identified.

Key Words: EERFERB, building energy efficiency, institutional effects, China

Introduction

Approximately half of worldwide new buildings in this century were built in China. It is predicted that building stock in China will reach 70 billion m^2 in 2020, which is three times of the number in 2000. With the dramatic increase of building stock and urbanization, building energy consumption has also nearly doubled in the past decade, from 0.4 billion tce (tons coal equivalent) to 0.7 billion tce. The total building energy consumption made up roughly 1/5 of Chinese total energy consumption. Among nationwide building energy consumption, space heating for Cold and Severe Cold zones accounts 40%.They are referred to together as the Northern Heating Zone, where installing space heating system is required by law. The energy consumption for heating per area in this zone is two to three times of the average in western countries. (Li 2009)

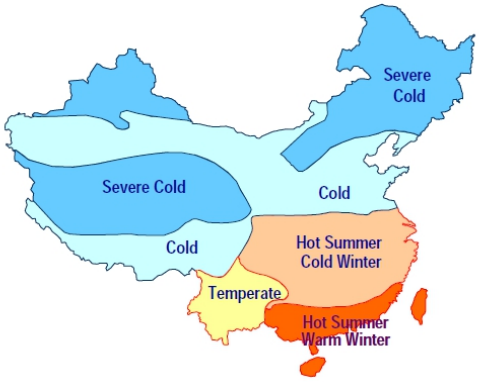

Figure 1 China Climate Regions Defined by the MOHURD
Source: (Huang and Deringer 2007)

Existing buildings are crucial for reducing the total building energy consumption. Ninety-five percent of existing buildings fail meeting the Chinese Building Energy Saving Standard and have potential energy for efficiency improvement. (Jin and Shakil 2010). The Ministry of Housing and Urban-Rural Development of the PRC (MOHURD) claimed that most buildings built before 2000 are non-energy saving buildings. Approximately 3.5 billion m^2 residential buildings in the Northern heating zone need to be retrofitted. These buildings were built over 20 to 30 years ago with high energy consumption and low living comfort. Some of them cannot be fully heated to 10℃ in winter.

China has already retrofitted 0.182 billion m^2, half of the total residential buildings in Northern heating zone at the end of 2010. As a result, new heating supply system and heating meters have been installed, so that heating is charged based on heat load. The total retrofit is estimated to contribute with to 2 million tce energy consumption reduction and 5.2 million tons CO_2 emission reduction. For the 12th Five Years, the Chinese Central Government set a new goal of retrofitting over 0.4 billion m^2 residential building in the Northern heating zone. 6 million tce of energy saving will be achieved as a result of retrofitting for residential buildings, public building, and public institution buildings, (State Council of the People Republic of China 2012).

However, even though the Energy Efficiency Retrofit for Existing Residential Buildings (EERFERB) program is moving quickly and has enormous potential, the actual work in local levels has confronted hindrances originating from the retrofitting patterns. These include institutional failures, such as absence of standard, inefficient diffusion mechanism, inflexible fund-raising channel, and incompetent organizing and coordinating (Shilei, Wu and Sun 2009). Therefore, it is significant to analyze the institutional effect of the current retrofitting pattern. Experiences drawn from western countries have been discussed in previous studies (Shilei, Wu and Sun 2009), but the fundamental differences between western and Chinese buildings structures, and political contexts were ignored. Thus the feasibility of imported retrofitting patterns cannot be guaranteed.

This research is conducted to explore effective retrofitting patterns by comparing two kinds of institutional frameworks in existing Chinese projects. These two projects represent central government management-based institutions and international government co-management-based institutions respectively. Because these have been implemented under the same political, social and economic context, it is more explicit in answering which retrofitting pattern is more feasible to China. Analyzing and summarizing the experiences will give specific guidance to upcoming residential building retrofitting, and accordingly contribute to the overall achievement of energy saving goals.

For addressing this research question, Part Two introduces institutional effect assessment framework for comparative study. Part Three presents the China EERFERB institutional framework, including the retrofit subjects, retrofit content, funds-raising, organization and management and related policies. Part Four compares two retrofitting patterns. The institutional effects are addressed in analyzing the differences of institutional framework and evaluating the corresponding specific projects. Conclusion is explained in the Part Five.

Institutional Effects Assessment

Institutional arrangements are formal government organizational structures and the integration of policies and governance (Akgün, Leeuwen and Nijkamp 2012). These are set in order to arrange

the policies and government programs. The formulation and implementation of policies at all levels---central government, provincial government, and local government, are under the framework of institutional arrangements. Thus, a quality institutional framework is seen pivotal for sustainable development (Haanyika 2008). The effect of institutional frameworks refers to the credibility, transparency and predictability of the operations under the framework. The frameworks are crucial to government programs because these institutions have a direct impact on extent of policy goals achievement and overall effectiveness of the program. In terms of house retrofitting programs, the institutional framework is also a central component of the retrofitting patterns. Embedded in Chinese government hierarchy, the institution framework determines the actual implementation mechanisms and even the content of house retrofitting.

In the previous case study (Stefopoulou, et al. 2008), legislation framework, administrative framework, and economical and market framework are three main domains of institutional frameworks. Similar research on rural electrification highlighted the significance of policy and institutions in dealing with energy saving issues, especially when related to high poverty and low skills group. The research defined key considerations of the Rural Electricity institutional framework as a statutory body with a clear mandate and responsibility, liaison facilitating participation by public and private players, and technologies support. This research discussed policy measures and strategies, and institution frameworks separately. (Haanyika 2008) . However, as policy and institutions are always discussed as a package, the institutions are also interpreted as "rules in use" (Brown 2003), and include formal constraints (constitutions, laws, legal standards), and informal constraints (self-imposed codes of conduct), and their enforcement characteristics (North 1990).

The assessment of institutional effects on two EERFERB retrofitting patterns is divided into two phases: an analysis of the institutional frameworks and coordination mechanisms, and a comparative analysis on the institutional effects on different retrofitting patterns.

EERFERB institutional and policy framework in China

EERFERB is the fundamental institutional background for EERFERB implementation. The origin and development of EERFERB is introduced. Furthermore, administrative framework and coordination hierarchy explains the inner coordination within the government hierarchy, and the implementation mechanism illustrates the steps of developing a specific project and the main stakeholders. As a crucial part, the sources and allocation of incentives for EERFERB are also addressed.

EERFERB Program in Northern Heating Zone

EERFERB program in China can be traced back to several small scale pilot programs in the 1990s. Lacking a corresponding institution, theses attempts were not popularized (Li, 2009). In 2000, MOHURD issued *Technical specification for energy efficiency retrofit for existing buildings（JGJ129-2000）*, which took into effect on 2001 as an industry standard. It illustrates the principles and contents of EERFERB, including wall insulation, air tightness of doors and windows, and heating systems. However, as a technical standard, it is seen as a "dead letter" without either mandates requirements or incentives matched attached. This advancement also failed to bring about actual building retrofit. To implement EERFERB, pilot projects and isolated technical guidance are insufficient. To completely implementing a retrofitting program calls for a whole institutional mechanism with specific goals, regulatory support, technique support, and financial support.

During the 11th Five Years, to achieve the goal of 20% reduction in energy consumption per GDP, State Council issued *Information related to Comprehensive Energy Saving and Emission Reduction* in 2007, which set a goal of achieving 0.15 billion m^2 EERFERB in Northern Heating Zone by the end of 2011. This document eventually activated a large scale EERFERB in 15 Northern provinces.

Based on the achievement over the 11th Five Years, China National Development and Reform Commission (NDRC) and MOHURD issued a *Green Building Action Plan* on 1st January 2013.It pointed out that more than 0.4 billion m^2 out of 3.5 billion m^2 houses should be retrofitted by the end of 12th Five-Year (2015), and basically all eligible buildings in Northern Heating Zones should be retrofitted by the end of 2020. This ambitious goal and its challenges are shared by all related local governments. For example, Beijing new EERFERB goal for 12th Five Years is 0.15 billion m^2 (Beijing Municipal Commission of City Administration and Environment 2011), which is the total

number for the national EERFERB during 11th Five Years. (National Development and Reform Commission and MOHURD, 2013)

Administrative Framework and Coordination Hierarchy

MOHURD and Ministry of Finance (MOF) are responsible departments of EERFERB program. MOHURD is responsible for making EERERB plan, setting and allocating goals to the 15 provinces. Based on the received provincial goal, each provincial government signs a letter of guaranty, namely *Energy Efficiency Retrofitting for Existing Residential Buildings Protocol* with MOHURD to ensure the accomplishment. During the 11th Five Years, Beijing signed the highest goals among all provinces, namely 25 million m^2. Provincial governments further divide its goal to local governments, where the goals are further broken down to district/ county level. In this terminal level, specific EERFERB projects are developed. Legal guiding documents issued for EERFERB include (MOHURD 2008):

- A general guidance
  - *Implementation Guidance for The Promotion of Energy Efficiency and Heat Metering Retrofitting for Existing Residential Buildings in Northern Heating Region (* hereinafter to be referred as "*Implementation Guidance for EERFERB*")
- Implementation and evaluation guidance for specific EERFERB project:
  - *Technical Guidance for Energy Efficiency and Heat Metering Retrofitting for Existing Residential Buildings in Northern Heating Region (* hereinafter to be referred as "*Technical Guidance for EERFERB*")
  - *Project Evaluation Principles* for *Energy Efficiency and Heat Metering Retrofitting for Existing Residential Buildings in Northern Heating Region (* hereinafter to be referred as "*Project Evaluation Principles for EERFERB*")

To further support EERFERB, MOF provides incentives based on rules in *Administrative Measures of Incentive Funds for Energy Efficiency and Heat Metering Retrofitting for Existing Residential Buildings in Northern Heating Region (hereinafter* to be referred as "*Measures of Incentive Funds for EERFERB*"). As the only guideline for incentive funds, it covers the scope, principle, and approaches for practical incentive funds. The incentive mechanism will be discussed in the part 3.4.

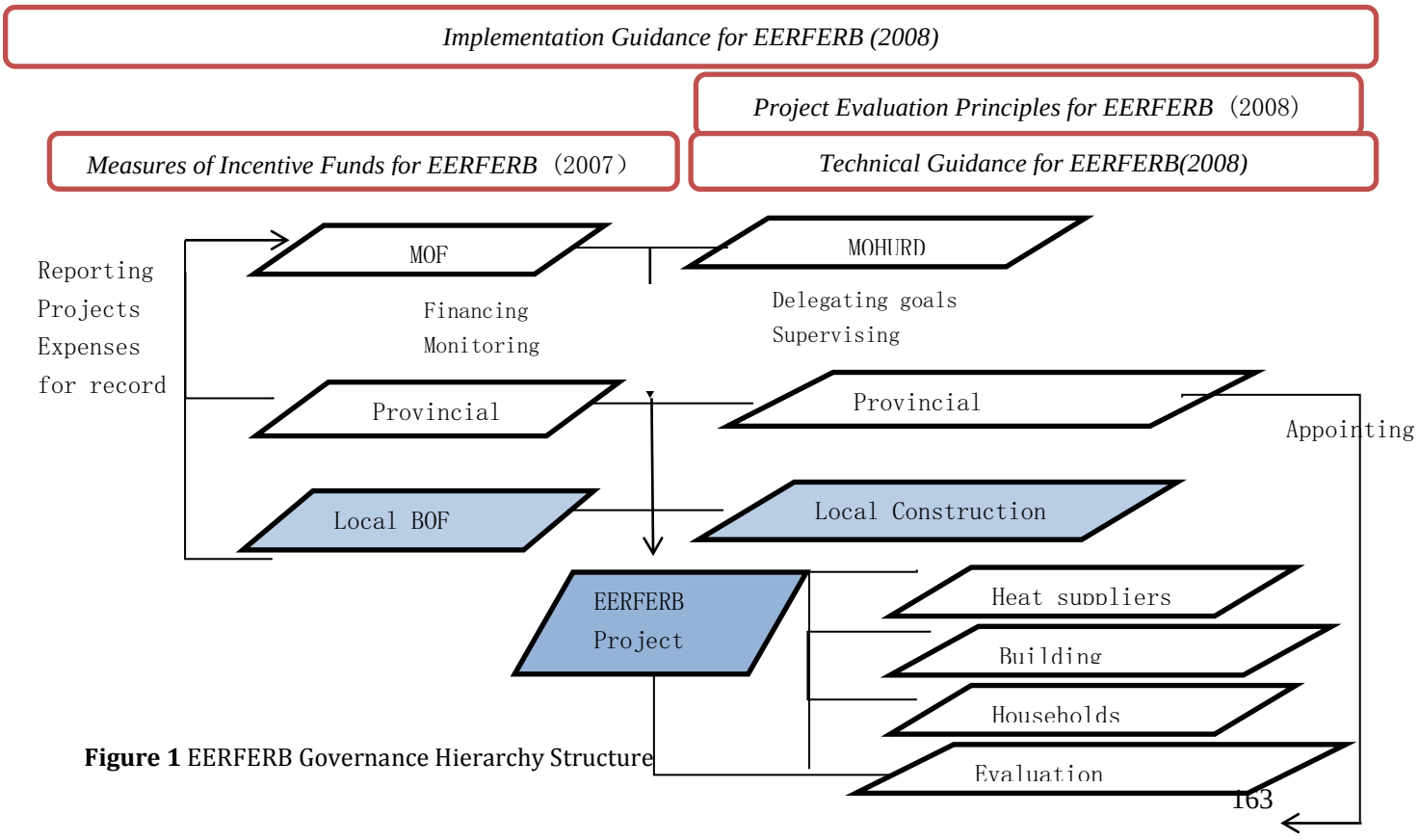

Figure 1 EERFERB Governance Hierarchy Structure

As shown in Figure 2, MOF is in charge of the disbursement of funds and clearing the incentive after retrofitting. MOHURD provides technical guidance, manages and evaluates provincial EERFERB programs. According to the *Implementation Guidance for EERFERB* (MOHURD; MOF 2008), the provincial Bureau of Construction (BOC) makes overall EERFERB plan and sets goals for local governments, while Bureau of Finance (BOF) makes retrofitting budgets for all allocated programs. Specific EERFERB projects are arranged and planed in the construction department of the district or county level. Corresponding budgets for projects are reported from local government to provincial government (MOF 2007). In the process of retrofitting construction, construction departments at all levels are administrators of their sub-level EERFERB work. Additionally, independent evaluation institutions are assigned by the provincial BOC to evaluate the specific projects in the territory (MOHURD 2008).

Apart from departments of construction and departments of finance, some other government departments and institutions are also involved. For instance, retrofitting for energy-saving residential buildings (ESB) in Beijing is undertaken by Municipal Administration Commission, instead of the Beijing Construction Committee on Housing and Urban (BCCHU), while BCCHU is in authority for non-energy-saving residential buildings (NESB)' retrofitting under a co-management system with Beijing BOF, the Beijing Municipal Development and Reform Commission (BJMDRC), the Beijing Municipal People's Government State-owned Assets Supervision and Administration Commission.

Implementation Mechanism

Implementation Process

Central Heating systems are the main heating supply systems in Northern China. The average single heating system can heat approximately 10 million m^2 (Li 2009). Thus to improve the overall energy efficiency of space heating, retrofitting must include the whole the heating chain, from heating sources to end users. The stakeholders are not only the local government and households, but also heat suppliers. Heat suppliers are the main implementers and involved throughout the eight step process: general building and demographic survey, households mobilization, building retrofitting plan and design, project budget making and incentive application, retrofitting construction, project quality examination and acceptance, energy saving effects evaluation, and sampling re-examination (Figure 3).

In the specific retrofitting construction process, either the heat supplier or households invest in upgrades one or more the following: heat source, thermal station, outdoor heating supply network, indoor heating systems and heat metering and doors/ windows. Without government incentive, the investments require high initial capital with long payback terms. Even though both heat supplier and households can benefit from long term energy saving, they still lack strong motivation to pay for the non-monetary social benefits. This market challenge can be eliminated to some extent through involving government efforts. Therefore, governments at all levels are still leading stakeholder of driving EERFERB in China.

Retrofitting Contents

Technical Guidance for EERFERB explicates three main entities for residential building retrofitting, namely building envelope, heating metering, and heating balance of the pipe network. As shown in Figure 4, to be eligible for retrofitting, the building should be safely used for 20 more years. This is determined through an initial safety examination, including seismic capability, building structure, and fire safety. Eligible buildings are further examined on energy consumption and energy saving potential before retrofitting. This pro-retrofitting examination is crucial because it provides the basic information for retrofitting design, cost and benefit estimation, retrofitting materials and updated products selection, and investment payback terms.

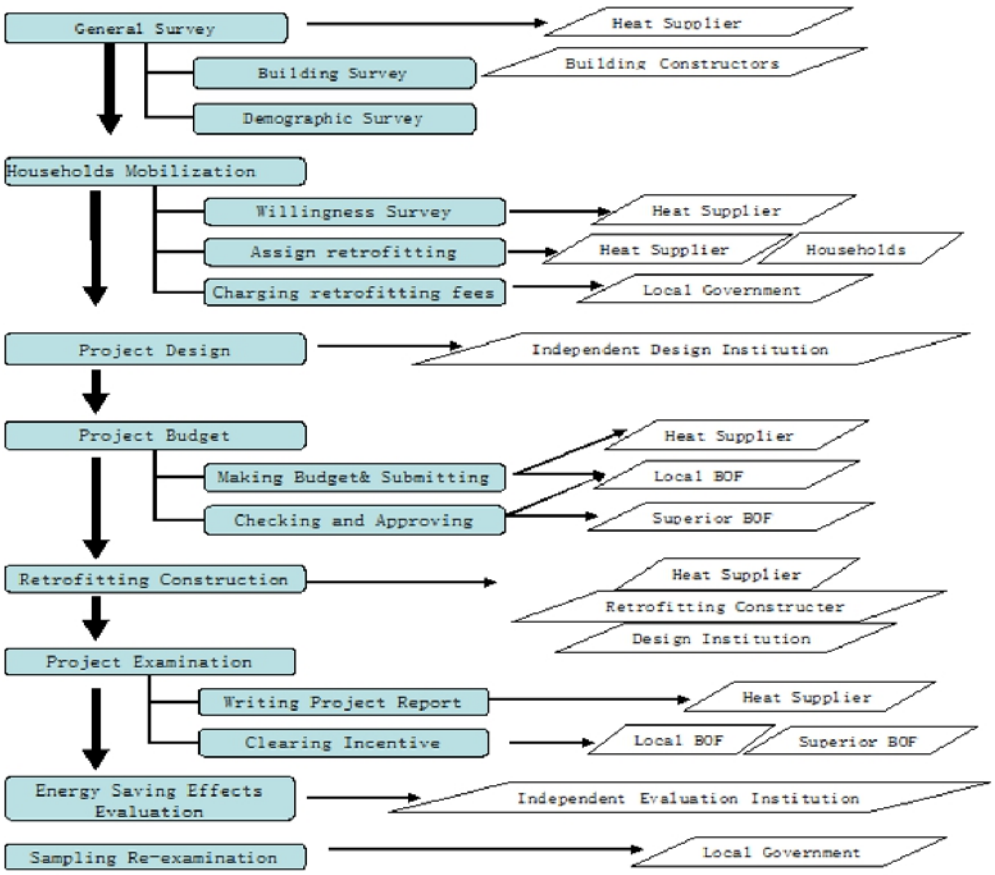

Figure 3 Implementation Process of EERFERB (MOHURD 2011)

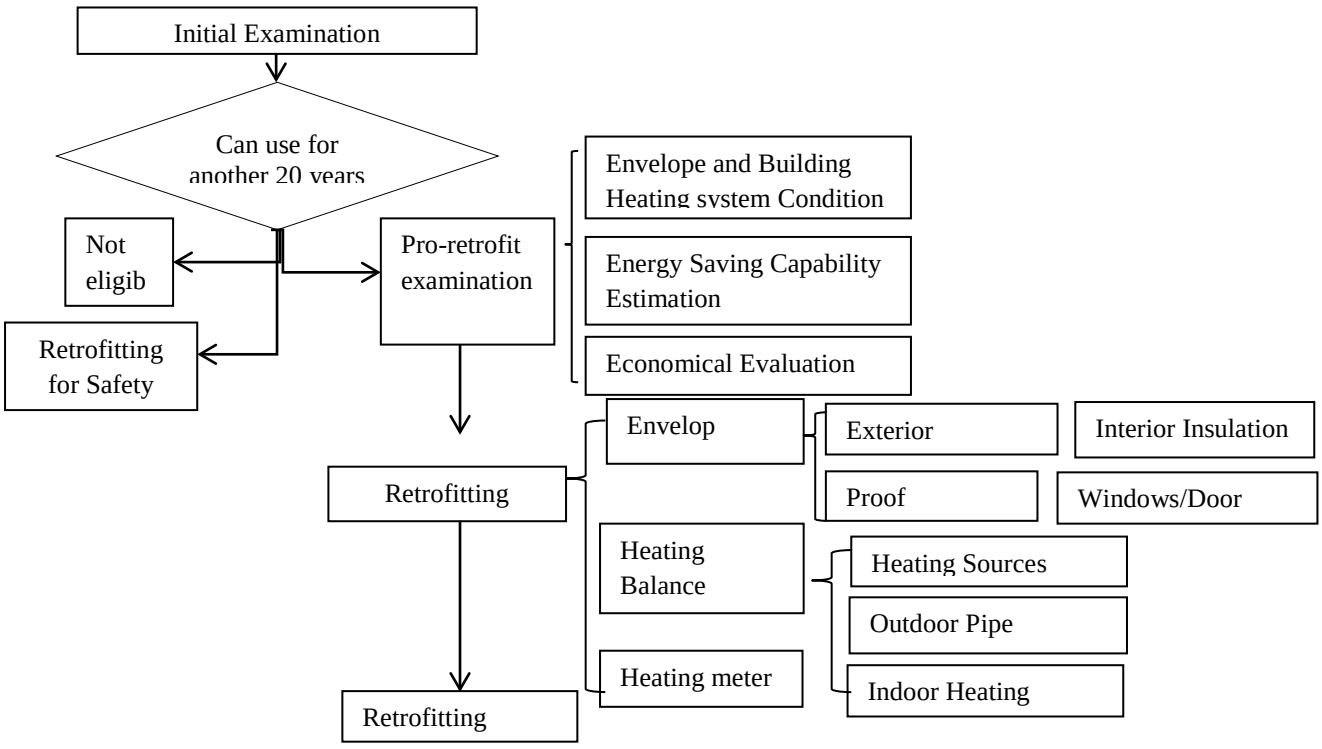

Figure 4 EEREFRB Project Content and Retrofitting Process (MOHURD 2008)

Funding and Incentive Framework

The funding for EEREFRB comes from multiple sources (Figure 5). Central Government incentive and specific local government incentives are two main sources. Apart from governments, heating suppliers are required to self-finance through multiple channels, and households are also encouraged to invest in retrofitting, such as upgrading windows. The local funding sources vary by provinces.

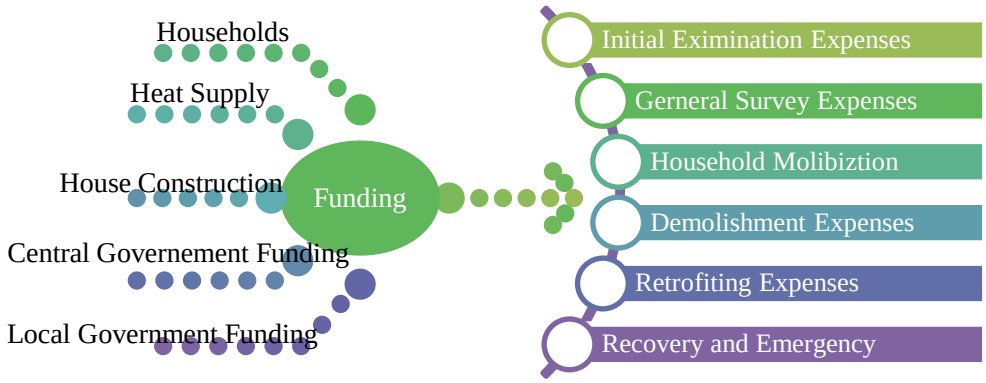

Figure 5 EEREFRB Funding Flow

Funding Sources Analysis

（1） Central Government Incentive

Central Government Incentive provides subsidies for envelop retrofitting, indoors heating meter, and heating sources and heating pipe network. The amount of incentive for each province varies based on the specific climate zone, retrofitting working load, energy saving effect and retrofitting progressing. To be specific, the incentive for particular area is calculated in the following form (MOF 2007).

Central Government Incentive for Particular Area= Incentive Base line for specific climate zone×[∑（Particular Entity Retrofitted Area × Weight of the Particular Entity）×70% +total retrofitting area×Energy Saving Effect Coefficient×30%]×Progressing Coefficient

Where：

- Incentive Base line for specific climate zone is 55 RMB/ m^2 for Severe Cold zones, and 45 RMB/ m^2 for Cold Zones;
- Particular Entity refers to envelop retrofitting, indoor heat meter retrofitting, and heating sources and pipeline network retrofitting. Their perspective weights of the particular entity are 60%, 30%, and 10%;
- Energy Saving Effect Coefficient is determined by the actual energy consumption reduction;
- Energy Saving Effect Coefficient is divided into three levels (1.2, 1, 0.8) based on the retrofitting goal accomplishment time(before heating season of 2009,2010,2011 respectively)

（2） Local Government Incentive

Some provincial governments set budget funding to match Central Government incentives. Some areas also provide further subsidy for using heating meters after retrofitting. For instance, Tianjin has issued more subsidies for low-income groups and reduced their space heating bills.

Incentive Disbursement and Usage of Funding

Incentive disbursement in all levels is divided into two periods: prepay before retrofitting and clear incentive after retrofitting. In terms of Central Government Incentive, MOF prepays 6 RMB/ m^2 (equivalent to 0.98 CAN dollars) for installing heat meter. After retrofitting, MOF and MOHURD settle the accounts and offer all the left incentive based on the actual accomplished retrofitting projects. In 2007, the average incentive from central government is 9 RMB/m^2 (equivalent to 1.47 CAN dollars) (Zhong, 以及其他人 2009). During the 12th Five Years, totally 13.5 RMB/m^2 will be

provided for heating meter system retrofitting, and 4.5 RMB/ m^2 (equivalent to 0.74 CAN dollars) for heating sources and pipe line networks (BJMCCAE; BJBOF 2011).

Institutional Effects on Comparative Retrofitting Patterns

A pilot project in Tangshan was established before the EERFERB program was widely applied. The following policies and institutions are synthesis of experiences from Tangshan project and existing government institutional framework. Beijing retrofitting pattern is a typical case. From Tangshan projects to Beijing projects, retrofitting pattern changed along with changes to institutional frameworks. The changes are mostly reflected in institutional frameworks, including the polies, contents, stakeholders, funding, and coordination mechanisms. These changes eventually result in significant impacts on retrofitting patterns and outcomes. Institutional effects are discussed from the perspective of policy roles, coordination, integration of private sectors, community acceptance, and financial and technique supports.

Institutional Frameworks of EERFERB projects in Beijing and Tangshan

Tangshan project is a model project for following up provincial projects, such as Beijing project. Lessons from Tangshan project was summarized and applied in the policy designed. What left different between Tangshan project and Beijing project is the institution frameworks, which resulted in various project achievements.

Central Government retrofitting pattern---Beijing

The EERFERB projects in Beijing are delivered under the central government-to- local government institution. It is a typical widely-used retrofit pattern shared by all 15 participating provinces. Existing residential buildings were divided into two categories in Beijing: energy-saving buildings (ESB) and non-energy-saving building (NESB). The energy-saving buildings were built after July 1998, when all new buildings were required to meet new energy efficiency standard. Retrofitting for ESB and NESB are undertaken by different departments, but the retrofitting mechanism and process are essentially the same.

International governments co-management retrofitting pattern---Tangshan

The Energy Efficiency in Existing Buildings (EEEB) project No.1 Quarter, Tangshan, is a demonstration project commissioned by the German Federal Ministry for Economic Cooperation Development (BMZ) and executed by MOHURD. This project lasted for 5 years (2005 to 2010). It reported success with an average 4-6ºC increase of indoor temperature, and 30 % reduction of energy consumption within the first year of retrofitting (Shilei, Wu and Sun 2009). As a pilot project, the Tangshan EEEB project was an integrated with retrofitting for energy efficiency, and community light, façade, and building automation. To implement this project, a temporary co-management office, the Tangshan BEE office, was established with representatives from local community, local government, German government, Germany and Chinese experts, heat suppliers. A detailed comparison of retrofitting patterns is presented in Table 1.

Table 1 EERFERB Retrofitting Patterns Comparison

		Beijing Central Government EERFERB Projects		Tangshan Co-management EEER Project[1]
		EERFERB for NESBs[2]	**EERFERB for ESBs[3]**	
Policy Role	Polies	Administrative Measures of Beijing energy efficiency retrofitting for existing NESBs Financing Measures of Beijing energy efficiency retrofitting for existing NESBs	Administrative Measures of Beijing energy efficiency retrofitting for existing ESBs Financing Measures of Beijing energy efficiency retrofitting for existing ESBs	Research Institute Standards and Norms (of MOHURD) Investment and financing modes of EEEB (not accessible)
	Authorities	BJMCHURD, BJMCCAE, Beijing Municipal Commission of Urban Planning (BJMCUP), Beijing Municipal Commission of Development and Reform (BJMCDR), BJ BOF	BJMCCAE, BJ BOF	MOHURD
Eligible Buildings		All Private NESBs	ESBs built after 1998	three selected residential buildings
Stakeholders	Governments	BJMCHURD, BJMCCAE, BJBOF, BJMCDR, Municipal Industry Association, State-Owned Assets Supervision and Administration Commission of the People's Government of Beijing Municipality	BJMCCAE BJ BOF	MOHURD, Tangshan BEE office, BMZ, Tangshan Municipal Government(TMG)
		District/ County Department of Construction District/ County BOF	District/County MCCAE District/ County BOF	
	Companies and Institutions	Local Heat Supplier Independent Project design Institution Construction companies Independent Project Evaluation Institution assigned by Beijing government	Same as NESBs	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) Local Heat Supplier CABR – China Academy of Building Research, Information Centre of MOHURD, China Building Material Academy (CBMA)
	Households	Building owners	Building owners	Building owners

[1] China-Germany Existing Energy Efficiency Retrofitting Program Report (MOHURD, 2011)
[2] Administrative Measures of Beijing energy efficiency retrofitting for existing NESBs
Financing Measures of Beijing energy efficiency retrofitting for existing NESBs
[3] Administrative Measures of Beijing energy efficiency retrofitting for existing ESBs
Financing Measures of Beijing energy efficiency retrofitting for existing ESBs

		Beijing Central Government EERFERB Projects		Tangshan Co-management EEER Project[1]
		EERFERB for NESBs[2]	**EERFERB for ESBs[3]**	
Retrofitting Contents		• Building Envelope • Indoor Heating meter and temperature adjusting system • Heating Sources and Heating Pipeline Network	• Indoor Heating meter and temperature adjusting system • Heating Sources and Heating Pipeline Network	• Building Envelope • Indoor Heating meter and temperature adjusting system • Heating Sources and Heating Pipeline Network • Facade, community light, building automation
Responsible Implementation Actor		• Building Envelope Retrofitting: Original Building Construction companies • Heating Meter Retrofitting: Heat Supplier	Heat supplier	Tangshan BEE office
Funding	Sources	Central Government Incentive, Municipal Government Incentive provides 100 RMB/ m^2, Heat supplier, Households	Apart from Central Government Incentive, Municipal Government Incentive and District/ County Government Incentive filled 80% of the rest expenses in 5:5[4]. Heat suppliers take care of the rest.	5 million Euro from German government, 40 million RMB from China Central Government[5], Households(20% of the total retrofitting expenses) (Shilei, Wu and Sun 2009)
	Principles of funding usage	Encouraging Multi-funding sources Government Incentives follow funding and incentive framework (3.4)	Government Incentives follow funding and incentive framework (3.4) The expenses apart from incentives was raised by heat suppliers	Information not accessible.
	Used for	• Indoor Heating meter and temperature adjusting system • Heating Sources and Heating Pipeline Network	• Indoor Heating meter and temperature adjusting system • Heating Sources and Heating Pipeline Network	• All retrofitting expenses
Technology Support and Project		Materials and Products are determined by heat supplier	Materials and Products are determined by heat supplier	German and Chinese techniques and products were selected by the Tangshan BEE

[4] Municipal prepaied incentive is 6.3 RMB/ m^2 in 2011

[5] As Tangshan EEER Project was part of overall EEER program, this is the total amount of German and Chinese governments funding. The specific funding for Tangshan project was not announced.

The required implementation process of both Beijing and Tangshan projects are the same. In launching the EERFERB program, lessons from the Tangshan project were drawn and applied to other areas. Thus, the required retrofitting steps are almost identical in both projects. However, the specific implementation mechanism and corresponding retrofitting effects vary due to the involved stakeholders, informal rules accompanied with different management and coordination frameworks, and funding.

Institutional effects on EERFERB projects

Policy Roles

Beijing's projects were conducted in line with national policies and municipal policies. The municipal policies are consistent with national policies and provide detailed guidance to specific projects. Unlike Beijing, however, Tangshan project did not have specific issued policy to follow when the project started. How to work on this project mainly depended on agreements among stakeholders.

Since the Tangshan project was a demonstration project for nation-wide promotion, experiences from its first implementation year (2005-2006) should be reflected on the national policies issued in 2007. For example, the retrofitting contents required in *Implementation Guidance for EERFERB* (MOHURD; MOF 2008) were selected among the retrofitting entities in Tangshan projects. Additionally, the step of household mobilization was a lesson drawn from Tangshan projects.

It is easy and infallible for local governments and retrofitting implementers to only do what the policies require. In national and municipal policies, the quality and energy efficiency coefficient of products and materials are vaguely demonstrated. Thus product and materials suppliers and construction companies are not regarded as key players in Beijing projects. Heat suppliers are in charge of choosing products mainly based on cost-benefits in Beijing, which is the responsibility of BEE office in Tangshan project. This results in a gap of energy efficiency improvement indemnification between Beijing projects and Tangshan projects.

Coordination inter- and inner- levels of government

Coordination in the Beijing projects is embedded in the top-down government hierarchy. As shown in Figure 2, governments in upper level supervise and finance the work in lower level. Achieving satisfactory EERFERB effects is also associated with the personal career of the local department head (MOHURD;NDRC;MOF;General Administration of Quality Supervision, Inspection and Quaratine of The people's Republic of China 2010). To gain the incentive from the central government, and confirm good personal working performance to upper level government, local governments are promoted to achieve EERFERB goals

In the Beijing experience, the responsibility of departments of finance and departments of construction at all levels seems clearly separated. The departments of finance care about incentive allocation and proper use, while the departments of construction concerns mainly about the retrofitting target achievement and outcome. A questionable blank remains on the effectiveness of investment on actual energy efficiency improvement.

Unlike Beijing, in Tangshan projects, BEE office guarantees communication across hierarchy boundaries. As energy consumption reduction was the shared goal within BEE office, it more focused on achieving actual energy saving.

Integration of private sectors and community acceptance

Local heating suppliers in China are government-owned corporations, which are created by the government undertaking heating supplying on the behalf of an owner government. In the Beijing pattern, private sectors such as retrofit design institutions, construction companies, and materials and products suppliers act as service or product suppliers, who are not responsible for energy saving outcomes. Project examination institutions are assigned by the provincial government. They act on behalf of provincial government to evaluate and check the retrofitting achievement. Therefore, there are no independent sectors from the market. Information is blocked from media, NGO and the public due to the lack of an information publicity platform.

Moreover, although households were required to pay for part of the retrofitting, they are not actually involved in the projects. Feedback about the energy efficiency effects is not provided. Without capability to examine the retrofitting effects, it is less possible for residences to express themselves and be heard.

In Tangshan projects, academia, as a third party, was included in decision making. It partly prevented project design from purely seeking economic benefits. Unfortunately, this is not passed down to wider national EERFERB projects.

Financial and technical support

Financial support is the core influential factor on the effectiveness of retrofitting. At central government level, more weights in incentives are set in envelop retrofitting and heating meter retrofitting. It results in strong preferences to these entities in Beijing municipal policies, and real EERFERB projects.

As both heat suppliers and households have low motivation toward retrofitting, the effectiveness highly depends on incentives from governments. The investigation results indicate that the average retrofit expense excluding the price of heat metering device was 200–230Yuan/m^2 (equivalent to 32.77-37.69 CAN dollars) (Ding, et al. 2011), so the current 45-55 Yuan/m^2 (equivalent to 7.37-9.01 CAN dollars) central government incentive accounts for only 24% of the total expense. Many retrofitted buildings are located in poor urban areas, where local governments are not financially capable of providing enough incentives. The funding gap can only be filled by establishing more flexible financing institution. Investments from the market can be driven by obvious and visible energy efficiency improvement.

Conclusion

Based on a thorough analysis of institutional framework of EERFERB program in China, two retrofitting projects were selected to compare institutional effects on retrofitting effectiveness. The international government co-management based institution (i.e. the Tangshan case) shows higher capability achieving retrofitting effectiveness, with involvement of academia, co-management framework sharing goals, and more stable funding and technique supports. To carry forward EERFERB in China, a more flexible and transparent institution is needed. It is crucial to establish an efficient vertical and horizontal coordination systems to break constrains of hierarchy. The motivation towards retrofitting can be activated through clarifying energy efficiency goals and explicating benefits. Even though China has widely impelled energy efficiency retrofitting in Northern Heating Zones, there is still a long way to go in institution building. A self-motivated institution encompasses continuous investments from not only governments but also private sectors. A big potential market with 2.5 m^2 buildings for retrofitting has been recognized, so it is crucial to establish a sustained institution framework to make it happen.

References:

Akgün, Aliye Ahu, Eveline van Leeuwen, and Peter Nijkamp. "A multi-actor multi-criteria scenario analysis of regional sustainable resource policy." *Ecological Economics*, 2012: 19-28.

Beijing Municipal Commission of City Administration and Environment. *Drafting Instruction for Administration of Energy Efficiency Retrofitting for Beijing Existing Energy-Saving Residential Buildings.* January 21, 2011. http://www.bjmac.gov.cn/pub/guanwei/F/C/C6_1/201109/t20110914_22872.html (accessed March 10, 2013).

BJMCCAE; BJBOF. *Financing Measures of Beijing energy efficiency retrofitting for existing NESBs.* September 14, 2011. http://zfxxgk.beijing.gov.cn/ (accessed March 1, 2013).

Brown, Katrina. "Integrating conservation and development: a case of institutional misfit." *Front Ecol Environ*, 2003: 479-487.

Ding, Yan, Zhe Tian, Yong Wu, and Neng Zhu. "Achievements and suggestions of heat metering and energy efficiency retrofit for existing residential buildings in northern heating regions of Chian." *Energy Policy*, 2011: 4675-4682.

Haanyika, Charles M. "Rural electrification in Zambia: A policy and institutional analysis." *Energy Policy*, 2008: 1044-1058.

Huang, Joe, and Joe Deringer. "Energy Efficiency Building Standards in China 2007." *Asia Business Councial.* 2007. www.asiabusinesscouncil.org/docs/BEE/papers/BEE_Policy_China.pdf (accessed 3 16, 2013).

Jin, Ruidong, and Alyas Shakil. "China Building Green Practice." *2010 ACEEE Summer Study on Energy Efficiency in Buildings.* CA, 2010.

Li, Dongyan. "Fiscal and tax policy support for energy efficiency retrofit for existing." *Energy Policy*, 2009: 2113–2118.
MOHURD. *China-Germany Existing Energy Efficiency Retrofitting Program Report* . Octobor 12, 2011. http://www.mohurd.gov.cn/zxydt/201110/t20111012_206559.html (accessed March 10, 2013).
Akgün, Aliye Ahu, Eveline van Leeuwen, and Peter Nijkamp. "A multi-actor multi-criteria scenario analysis of regional sustainable resource policy." *Ecological Economics*, 2012: 19-28.
Beijing Municipal Commission of City Administration and Environment. *Drafting Instruction for Administration of Energy Efficiency Retrofitting for Beijing Existing Energy-Saving Residential Buildings.* January 21, 2011. http://www.bjmac.gov.cn/pub/guanwei/F/C/C6_1/201109/t20110914_22872.html (accessed March 10, 2013).
BJMCCAE; BJBOF. *Financing Measures of Beijing energy efficiency retrofitting for existing NESBs.* September 14, 2011. http://zfxxgk.beijing.gov.cn/ (accessed March 1, 2013).
Brown, Katrina. "Integrating conservation and development: a case of institutional misfit." *Front Ecol Environ*, 2003: 479-487.
Ding, Yan, Zhe Tian, Yong Wu, and Neng Zhu. "Achievements and suggestions of heat metering and energy efficiency retrofit for existing residential buildings in northern heating regions of Chian." *Energy Policy*, 2011: 4675-4682.
Haanyika, Charles M. "Rural electrification in Zambia: A policy and institutional analysis." *Energy Policy*, 2008: 1044-1058.
Huang, Joe, and Joe Deringer. "Energy Efficiency Building Standards in China 2007." *Asia Business Council.* 2007. www.asiabusinesscouncil.org/docs/BEE/papers/BEE_Policy_China.pdf (accessed 3 16, 2013).
Jin, Ruidong, and Alyas Shakil. "China Building Green Practice." *2010 ACEEE Summer Study on Energy Efficiency in Buildings.* CA, 2010.
Li, Dongyan. "Fiscal and tax policy support for energy efficiency retrofit for existing." *Energy Policy*, 2009: 2113–2118.
MOHURD. *China-Germany Existing Energy Efficiency Retrofitting Program Report* . Octobor 12, 2011. http://www.mohurd.gov.cn/zxydt/201110/t20111012_206559.html (accessed March 10, 2013).
MOF. *Information related to Administrative Measures of Incentive Funds for Energy Efficiency and Heat Metering Retrofitting for Existing Residential Buildings in Northern Heating Region.* 12 20, 2007. http://www.mohurd.gov.cn/zcfg/xgbwgz/200712/t20071228_159878.html (accessed 4 1, 2013).
MOHURD. *China-Germany Existing Energy Efficiency Retrofitting Program Report* . Octobor 12, 2011. http://www.mohurd.gov.cn/zxydt/201110/t20111012_206559.html (accessed March 10, 2013).
MOHURD. *Information related to Technical Guidance for Energy Efficiency and Heat Metering Retrofitting for Existing Residential Buildings in Northenrn Heating Region.* 7 10, 2008. http://www.gov.cn/gongbao/content/2009/content_1205389.htm (accessed 4 1, 2013).
MOHURD; MOF. *Implementation Guidance for the Promotion of Energy Efficiency and Heat Meter Retrofitting for Existing Residential Buildings in Northern Heating Region.* 5 21, 2008. http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/200806/t20080613_171707.html (accessed 4 1, 2013).
MOHURD;NDRC;MOF;General Administration of Quality Supervision, Inspection and Quaratine of The people's Republic of China. *Suggestions on Further Implementing Heating Meter Reform.* 2 2, 2010. http://www.gov.cn/gzdt/2010-03/17/content_1557963.htm (accessed 4 1, 201).
North, D. *Institutions, institutional change and economic performance.* Cambridge, UK: Cambridge University Press, 1990.
Shilei, Lv, Yong Wu, and Jinying Sun. "Pattern analysis and suggestion of energy efficiency retrofit for existing residental buildings in China's northern heating region." *Energy Policy*, 2009: 2102-2105.
State Council of the People Republic of China. "State Council Inform of Twelveth Five Year Energy Saving Emssion Reduction Plan." *The Central People's Government of the People's Republic of China.* 8 21, 2012. http://www.gov.cn/zwgk/2012-08/21/content_2207867.htm (accessed 3 10, 2013).
Stefopoulou, Aggeliki, Konstantinos Soulis, Michael Papapetrou, Spyros Kyritsis, and Christian Epp. "Institutional and policy framework analysis in relation to the application of autonomous desalination systems-Greece." *Desalination*, 2008: 455-567.

Zhong, Y., W.G. Cai, Y Wu, and H. Ren. "Incentive mechanism design for the residentia lbuilding energy efficiency improvement of heating zones in North China." *Energy Policy*, 2009: 2119-2123.

List of Acronyms

BJMCCAE Beijing Municipal Commission of City Administration and Environment
BJMCDR Beijing Municipal Commission of Development and Reform
BJMCHURD Beijing Municipal Commission of Housing and Urban-Rural Development
BJMCUP Beijing Municipal Commission of Urban Planning
BJ BOF Beijing Bureau of Finance
BJMPGSASAC Beijing Municipal People's Government State-owned Assets Supervision and Administration Commission
BMZ German Federal Ministry for Economic Cooperation and Development
CABR China Academy of Building Research
CBMA China Building Material Academy
CO_2 Carbon dioxide
EEEB Energy Efficiency in Existing Buildings
ESB Energy-Saving Building
EERFERB Energy Efficiency Retrofitting for Existing Residential Building
FYP Five Year Plan
GDP Gross Domestic Product
GTZ Deutsche Gesellschaft für Technische Zusammenarbeit
HSCW Hot Summer and Cold Winter
HSWW Hot Summer and Warm Winter
MOF Ministry of Finance
MOHURD Ministry of Housing and Urban-Rural Development
Mt Million ton
Mtoe Million ton of oil equivalent
NDRC National Development and Reform Commission
NESB Non-Energy-Saving Building
RISN Research Institute Standards and Norms (of MOHURD)
RMB Chinese Yuan
Tce tons coal equivalent
TMG Tangshan Municipal Government
11th Five-Year 2006-2010
12th Five-Year 2011-2014