Conférences & Séminaires

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Implementing Large-Scale Energy Efficiency Programs in Existing Buildings in China

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Implementing Large-Scale Energy Efficiency Programs in Existing Buildings in China

Collected papers of the conference organized by Agence Française de Développement and the Commission of Housing, Urban and Rural Development of the Hubei Province, in Wuhan (China), on May 12-13, 2009.

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Conférences et séminaires

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Foreword

The papers collected in this volume were presented during a conference held in Wuhan, the capital city of the Province of Hubei, on May 12-13, 2009. The purpose of this conference was to conclude the first phase of a research program launched in 2006, by the Commission of Housing, Urban and Rural Development of the Hubei Province and Agence Française de Développement (AFD) with the support of the French Environment and Energy Management Agency (ADEME). The conference was attended by more than 200 participants, including representatives of the Commissions of Housing, Urban and Rural Development of all the Chinese Chiang Jiang region provinces, representatives of the federal level of the Chinese government, Chinese bankers and researchers, as well as international experts and representatives from other emerging countries such as India, Indonesia, South Africa and Vietnam.

The launch of this joint research program was a response to a request from the Commission of Housing, Urban and Rural Development of the Hubei Province. The Chinese Government was implementing the 11th Five Year Plan, one of the very ambitious targets of which was to reduce the national economy's energy intensity by 20% between 2006 and 2010. Besides, the "Energy Conservation Law of the People's Republic of China" was to be promulgated, so as to determine more precisely the energy efficiency measures and objectives for various sectors of activity. In that context, the Commission of Housing, Urban and Rural Development of the Hubei Province, which was in charge of achieving major energy consumption reductions in the building sector of the Province (and more specifically in the existing public and tertiary buildings), expressed a keen interest in benefiting from foreign experiences and knowledge in the energy efficiency field. AFD then offered to mobilize all needed expertise so as to carry out a research-action program on the financial mechanisms to be developed so as to implement a large scale energy efficiency retrofitting program in the existing building sector in China. Such a subject is actually of great interest to several emerging countries in which AFD has operations, and more generally, appeared relevant with regard to the burning issue of climate change mitigation.

The "research-action" dimension of the program, more precisely the involvement of local stakeholders in the research activities thanks to training and continuing on the ground testing of methodological tools and hypotheses, appeared as a *sine qua non* to AFD and the Commission of Housing, Urban and Rural Development of the Hubei Province. Their major concern was that the technical, financial and institutional solutions proposed in the framework of that research program shall not be the result of "armchair research". On the contrary, these solutions shall be produced and owned by those involved in their actual implementation in the medium to long run. As a result, the research teams consisted of a variety of local stakeholders, including representatives of the local government and administration, bankers, energy producers, energy service company representatives, project owners, construction company representatives, installers, manufacturers and professional associations, as well as researchers from universities and research centers. In order to provide guidance and coordination among the different research groups, AFD and ADEME

facilitated the intervention of a team of French specialists, headed by an international expert, Dr. Bernard Laponche. AFD also coordinated additional research on "best practices" so as to answer specific technical questions. For instance, a report entitled *Promoting Energy Efficiency Investments, Case Studies in the Residential Sector* was co-published by AFD and the International Energy Agency. These case studies were then translated into Chinese.

The results of this three-year research program are summarized in the collected papers.

With the end of this research program it appeared that additional investigations, particularly on financial mechanisms, needed to be carried out with the support and involvement of stakeholders from the federal level of the Chinese Government. A high level working group with representatives from the Ministry of Housing, Urban and Rural Development, the National Development and Reform Commission and the State Council of the People's Republic of China, was thus organized in Paris in October 2009. It aimed at facilitating face to face technical discussions with a larger number of French experts, and at discussing the follow-up of the program. The major conclusion reached was that a second phase would require some innovative research experiments, including the constitution of "dialogue and research groups" looking specifically at financial mechanisms in different Provinces.

All publications related to this research program are available on the AFD website, on the "Research" webpage. For any further information, or specific queries, you can contact AFD's program manager, Mr. Nils Devernois (devernoisn@afd.fr).

Acknowledgements

First, we would like to thank Mrs. Liang and Mr. Devernois, the two persons who conceived of this research-action program, and made continuous efforts so as to turn it into a reality. Mrs. Liang was the leader of the Chinese team, and has done her utmost to coordinate a large number of professionals from a variety of fields, using both diplomacy and persuasion. We are very grateful for the profound trust that she put in the French team, and for the unyielding support that she granted to them. On the *Agence Française de Développement* (AFD) side, Mr. Devernois played a significant part in the definition and management of the research program, and strove to mobilise the most proficient French experts in the energy efficiency field. We wish to thank him for the passion and commitment that he put in the research program during its entire duration.

Second, we would like to thank the speakers of the conference and the authors of the papers, as well as all other Chinese and French research team members, for their fruitful collaboration and the quality of their contribution to the research program. Among others, we are very thankful to Mr. Dai Yande, Mr. Gao Yong, Mr. Michel Hamelin, Mrs. Ke Ying, Dr. Bernard Laponche, Mr. José Lopez, Dr. Li Jing, Dr. Li Yuyun, Dr. Lu Shilei, Mrs. Ma Yanlin, Mr. Aymeric Novel, Mr. Michel Raoust, Mr. Shen Longhai, Dr. Sun Jinying, Mr. Tong Mingde, Mr. Wang Bing, Mr. Wu Yong and Mr. Zhang Jian. We would also like to express our special thanks to Mr. Liu Yazhong, who played an invaluable part as the intermediary between the Chinese and French cultures, in addition to sharing its rich experience in the energy efficiency field.

Third, we would like to thank those who carried out the proceedings' publication process within AFD. Mrs. Laureline Krichewsky was in charge of directing and supervising the papers' collection as well as of their translation, editing and proofreading. We are very thankful to her for her patience and dedication, without which the proceedings could not have been published. We would also like to thank Mrs. Tang Yan, from the resident mission of AFD in Beijing, who has played a major part in facilitating communication with the members of the Chinese team. Last, we are very thankful to Mr. Philippe Cabin, head of AFD's Publication Division, for his patience and involvement throughout the entire publication process.

Last but not least, we would like to thank all those who have facilitated or have contributed the publication of these proceedings, including Mrs. Lara Andahazy-Colo, Mrs. Céline About, Mrs. Dai Mei, Mr. Edouard Danjoy, Mrs. Jin Xiaoting, Mrs. Annie Lopez-Portzert, Mr. Philippe Percheron, Mrs. Vannina Pomonti, Mrs. Bridget Rooth and her translators and editors team from English Trackers Co. Ltd, Mrs. Zheng Qi.

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Opening Remarks

Mr. Tian CHENGZHONG
Deputy Governor of Hubei Province

Mr. Li DEBING
Chief of the Department of Construction of Hubei Province

Mr. Hervé LADSOUS
Ambassador of France in China

Mr. Michel FREYMUTH
Consul of France in Wuhan

Speech Delivered by Mr. Tian Chengzhong, *Deputy Governor of Hubei Province*

Consul-General Michel Freymuth, Director Robert Peccoud, Vice-Director Hamelin, distinguished guests, friends, ladies and gentlemen: Good Morning.

Generously supported by the Chinese Ministry of Housing and Urban-Rural Development and ADEME (French Environment and Energy Management Agency) jointly organized by the Hubei Province Department of Construction and *Agence Française de Développement* (AFD), the "Sino-French International Symposium on Financial Mechanisms for Energy Efficiency Retrofitting of Existing Buildings in Hubei Province and the Construc-tion of a 'Two-Oriented Society' in the Wuhan City Cluster" opens here today in the beautiful riverside city of Wuhan. On behalf of the Hubei Provincial Government, I would like to offer my congratulations on its successful opening and extend a heartfelt welcome to all participants.

Hubei Province lies in the central region of China, midway along the Yangtze River. It covers an area of 185,900 km^2 and has a population of 61 million people. Hubei's geographical position is blessed by its centrality: endowed with the benefits of the east, yet open to the west, it cuts through north and south and provides access to the sea. Hubei has experienced rapid economic growth in recent years. In 2008, the provincial GDP reached RMB1.133 trillion, and the total import-export volume was US$20.5 billion. In December 2008, the Wuhan City Cluster was chosen by the central government as an experimental region for the implementation of a comprehensive reform package: the construction of a "Two-Oriented Society". Within the next 5-12 years, at the forefront of innovative institutional mechanisms aimed at saving natural resources and environmental protection, the Wuhan City Cluster will provide valuable experience and serve as a national example of how to promote scientific and harmonious social development. Energy efficiency construction has been prioritized as an important element in the overall implementation of a "Two-Oriented Society" in the Wuhan City Cluster.

Energy is an important building block for mankind's survival and development. The State Council's decision on strengthening energy conservation work states that energy efficiency construction is one of six important fields in energy conservation. Energy efficiency construction includes energy-efficient new-builds and energy efficiency retrofitting of existing buildings. In terms of energy-efficient new-builds, every year Hubei Province constructs around 30 million m^2 of energy-efficient new building stock by using energy-efficient materials and technologies, reducing energy consumption of buildings by around 330,000 metric tons of carbon equivalent (MTCE) and decreasing CO_2 emissions by about 864,600 tons. In terms of the energy efficiency retrofitting of existing buildings, by the end of 2008,

there were already 800 million m^2 of urban building stock in Hubei Province, most of which were energy inefficient. The implementation of energy efficiency retrofitting is thus an arduous task, requiring huge amounts of sustained financial investment. To begin tackling this issue, in June 2006, the Hubei Province Department of Construction and AFD signed the "Framework Agreement for Sino-French Research Partnership in Developing Financial Mechanisms for Energy Efficiency Retrofitting of Existing Buildings in Hubei Province". Both sides formed research teams, drawing on the pioneering experience of countries such as France, to explore financial mechanisms for energy efficiency retrofitting of existing buildings with government policy support, taking Wuhan Municipality as their case study. This research has important and far-reaching significance for energy efficiency retrofitting of existing buildings in Hubei Province, and indeed other Chinese regions with similar climatic conditions. The Hubei Provincial Government has followed the project with interest, providing it with its full support.

Today, Chinese and foreign experts are brought together under one roof to share their research findings and valuable experience. I firmly believe that this symposium will breathe new life into the research, increase common knowledge, and lead to substantial successes in breaking the "bottleneck" in financial mechanisms, furthering the energy efficiency retrofitting of existing buildings, and responding to the issues of climate change. It is certain to contribute positively to the construction of a "Two-Oriented Society" in the Wuhan City Cluster, allowing man and nature to live together in harmony.

May this symposium enjoy complete success and may Sino-French cooperation and exchange never cease to move forward!

Thank you

Speech Delivered by Mr. Li Debing, *Chief of the Department of Construction of Hubei Province*

Mr. Director, Mr. Deputy Director Hamelin, Ladies and Gentlemen.

First of all, allow me to extend a warm welcome to the leaders, distinguished national and international guests and delegates on behalf of the Department of Construction of Hubei Province. I would like to express my sincere gratitude to both national and international experts, and the entire community for your continuous support in the energy efficiency retrofitting of existing buildings in our province.

We are extremely honored to have the opportunity to be here with experts and scholars from home and abroad, to study and discuss the issue of buildings' energy efficiency retrofits. It is a fantastic opportunity for Hubei and Wuhan to come face to face to discuss such issues. Statistics and analysis by experts show that building energy consumption accounts for more than a quarter of all energy consumption, and consumption is still rising. This is partly due to the existence of large buildings that do not integrate energy-saving measures. A prerequisite to easing the tension in the current use of energy is to upgrade energy-saving measures, reduce energy consumption in existing buildings, and to improve building energy performance both economically and technically. The structure of energy consumption must be adjusted, and the sustainable development of the social economy must be promoted.

According to the strategic requirements of scientific development, the government is applying an *energy-saving and emission reduction* policy, which actively propels the construction of a "two-oriented society" (a resource-conserving and environment-friendly society), and concentrates on energy consumption reduction. In the past few years, our province has undertaken the retrofitting of existing buildings, and made progress in construction energy consumption statistics; energy audits; the calculation of energy-saving potential; power analysis of energy-saving; pilot projects; and establishing a financing mechanism. At the same time, the province set up *Energy-Saving Regulations for Civilian Construction in Hubei Province* according to the main framework of *Energy-Saving Regulations for Civilian Construction* by the State Council. Hubei Province specifically requested energy efficiency retrofits to existing buildings, as well as renovating and extending existing buildings, decorating exterior structures, and updating energy systems. A special fund for energy efficiency retrofitting has been set up to encourage financial institutions to provide credit to retrofit existing buildings; encourage social funds to invest in a variety of means to retrofit existing buildings to save energy and

provide energy-saving services; encourage and support renewable energy sources, such as solar and geothermal energy, in buildings; implement preferential electricity prices or free water in buildings that implement energy-saving modifications with geothermal heat pump technology; and establish an electricity quota whereby buildings are penalized for exceeding their quota.

In today's seminar, leaders from relevant ministries and experts from home and abroad have discussed China's energy policy along with the policies of France and the rest of the world, and the significance of these policies from a broader perspective. Introductions and exchanges were made from a more professional perspective on theory and practice, means and methods, financial service systems, types of financing mechanisms, development of energy-saving services, and existing financial instruments used in the energy retrofit of existing buildings. The following basic consensus was reached:

The energy efficiency retrofitting of existing buildings is an essential requirement in the push to decrease energy consumption. The Chinese government regards "resource saving" as its basic State policy. It is not only a requirement for China but also a commitment to the world to build a "resource-conserving and environment-friendly society". Reducing building energy consumption; improving the energy consumption structure of buildings; promoting the application of new energy and renewable energy sources which are important for mitigating energy shortages; and promoting the harmonious development of society can all be pushed further forward by implementing energy-saving strategies.

Propelling forward the retrofitting of existing buildings is one way to cope with the current financial crisis. It will create an emerging investment market by activating demand for renovations to save energy in existing buildings. It is vital for coping with the global financial crisis and especially important for the Chinese government to implement its policy to "expand domestic demand, guarantee economic expansion, adjust the economic structure, and improve people's living standards".

Retrofitting existing buildings is a task for society as a whole. Because the ownership of existing buildings is complex, government guidance is needed along with market propulsion and technical and financial support.

Management departments, building owners, intermediary organizations, research institutes, material and equipment manufacturers, design and construction units, and financial institutions are all crucial in realizing this potential. It is vital to coordinate and organize all aspects of society to participate in and push forward energy-saving strategies in existing buildings.

Establishing financial mechanisms and confirming the development path for energy retrofits of existing buildings are key points in achieving results. Initially, renovations need investment guidance from the government, as the work requires a huge initial outlay. However, once a certain stage has been reached, developments will be self-funding and able to rely on the market itself. Today's seminar has already achieved positive results with its discussion on debt financing in order to stimulate demand; the impact of third party financing on the process of marketization; and the establishment of a financing mechanism with the equity financing model.

We are trying to build an innovative country, a "two-oriented society". The construction of Wuhan's Metropolitan Area also calls for institutional innovation. On the first level, it needs innovative theories and concepts. Today's meeting has moved the level of exploration and research work forward, clarified the concepts, defined the objectives, and enabled us to take a big step toward putting the project into practice and making it feasible. I sincerely hope for further cooperation between China and France, and between China and other countries, both in terms of exploring financing mechanisms and carrying out energy retrofits to existing buildings. Efforts must also be made to find new ways to renovate existing buildings which are in line with scientific developments in the Hubei and Wuhan Metropolitan Area, and to build a harmonious world between constructors and buildings, human beings and the environment, people and the planet.

Once again, I extend my thanks to both our national and international experts.

Hubei is the birthplace of the Chu culture and has a long, impressive history. It is also a land of thousands of lakes and natural abundance. I sincerely wish all leaders, international friends, experts, professional peers and friends a pleasant stay and good health while working in Hubei.

Finally, I would like to wish the seminar great success.

Speech Delivered by Mr. Hervé Ladsous, *Ambassador of France in China*

It is a great pleasure to be with you today in Wuhan for the opening of this seminar on sustainable urban development. I fully understand just how important this seminar is in view of the challenges facing both China and the rest of the world. I would like to extend my thanks to AFD and the Wuhan Development and Reform Commission for this initiative.

Events did not turn out as expected, since at this very moment I am with the President of the People's Republic of China, Mr. Hu Jintao, who has invited representatives from a certain number of countries that actively participated in emergency relief for, and then the reconstruction of, Sichuan in the aftermath of the earthquake of which we are commemorating the sad anniversary today. I believe that this invitation from the Chinese President is a sign of China's gratitude toward France for all the solidarity efforts we have made. And when I say "we", I am referring to the entire French community, the State, as well as the French Chamber of Commerce and Industry in China, the operators, the companies that were also eager to show their active solidarity for the victims and survivors when this terrible disaster occurred.

It is consequently from a distance that I express my very best wishes for the success of your research. Once again, these are major challenges. There is the challenge of climate change. There is the challenge of sustainable development. And Central China, Hubei, the Wuhan region are key areas for operations because we have before us a municipality and a province, Wuhan and Hubei, that are extraordinarily motivated, and also because there has been a privileged development partnership between France and this region for nearly thirty years now.

So, once again, I wish you every success in your research. I will devote a lot of attention to reading your conclusions and supporting their implementation in every possible manner. France's entire network in China is working on this major topic, as well as French authorities at the highest level, to ensure that there are outcomes on these topics, follow them up, and support all our operators. So I thank you for your attention and every success in your research.

Speech Delivered by Mr. Michel Freymuth,

Consul of France in Wuhan, China

Mr. Vice Governor, I would especially like to extend my warmest thanks to you for honoring us with your presence at the opening of this seminar. We are obviously very, very pleased that you could be here. I would also like to thank everyone who has made the long trip from Beijing, other provinces and elsewhere, to take part in this event and ensure its success, and of course, the French and Chinese organizers of this seminar, AFD and the Commission for the Construction of Hubei Province, with a special mention for Mrs. Liang who was one of the mainsprings in its preparation.

Ladies and Gentlemen, as we are all aware, the spiral of economic development leads to rising demand for energy, which comes up against the problem of limited resources and increasingly restrictive environmental standards. In the face of these constraints, individual solutions country by country are not possible. Solutions must be sought via joint strategies, and particularly, strategies based on societies that save their resources and respect the environment. Energy efficiency in the building sector is, in this respect, a priority because it is important to understand that buildings consume high amounts of energy whether for improving individual comfort or for the activities of services, administrations or businesses. It is in this framework – energy efficiency in existing buildings – that a particularly innovative program has been ongoing for over three years now between the Commission for the Construction of Hubei Province and AFD's Research Department, with support from ADEME. This program aims to prepare the implementation of energy rehabilitation projects in public and service sector buildings with a concern for financial equilibrium. In other words, it aims to find the best possible balance between the investments that are made and the energy that is saved.

I very much welcome the organization of this first France-China seminar in Wuhan, where the green economy will be a dominant theme. It is being held at a timely moment since it follows on from the symposium on sustainable urban transport organized by Mission Economique - Ubifrance a few weeks ago. These two events demonstrate the priority given by both our governments to sustainable development in this conurbation, the 8+1, which by a fortunate coincidence has, at the same time, been selected by the Council for State Affairs as a pilot area in this sector for the whole of China, and as a model city for the France-China Agreement on Sustainable Development. The original aspect of this process must also be underscored as it combines, on the one hand, a multidisciplinary Chinese group steered by the Commission for the Construction of the Province, made up of universities, administrations, technical departments, practitioners and experts from the private sector (such as banks or energy service

companies), and on the other hand, French public agencies that associate experts or national or international research institutes. I am fully confident that your exchanges will be fruitful and I hope they will lead to a concrete demonstration operation.

To this end – without wanting to prematurely anticipate future discussions – I am pleased to inform you that AFD has entered into discussions with the Municipality of Wuhan about the best way to financially support the first phase of a thermal rehabilitation program for existing buildings. This type of financing may, for example, be mobilized via a municipal line of credit allocated for sectoral projects.

I hope the exchanges will be extremely fruitful for you all, and thank you for your attention.

Conférences & Séminaires

Part 1. Brief Presentation of the Research Program

1.1. A Brief Introduction to the Research Program

Mr. Nils Devernois, Senior research officer, Sustainable Urban Development Unit, Research Department, AFD.
He was the research program manager on the French side.

Mr. President, Mr. Chief Engineer of the Commission for Construction, Ladies and Gentlemen, I would first of all like to thank you for your welcome and the excellent organization of this seminar, which will allow us to present the initial results of this research program on financial mechanisms for energy rehabilitation in existing buildings, which began just over three years ago.

1.1.1. Introduction

This morning you were presented the contextual elements of energy efficiency (EE) in China and France and this afternoon you will have the opportunity to listen to different experts present the results of this research program.

In order to avoid repeating what other speakers might say, I will just be speaking about how this program came about, what it is about and its general philosophy, and finally, the principles of its organization and the methods that have been adopted and followed over these past three years. I will emphasize some of the methodological aspects, as well as the reasons why this project is particularly innovative, before concluding with some of the lessons learned from this program.

1.1.2. Origin of the Program

This partnership was built as a logical follow-up to the signing of an establishment agreement for *Agence Française de Développement* (AFD) in China. This agreement was signed with the Chinese Ministry of Finance and explicitly sets out the parties' commitment to developing intellectual cooperation programs.

The topic of this program is at the crossroads of, on the one hand, the orientations of China's 11th Five-Year Plan, particularly in terms of reducing energy intensity and, on the other hand, the mandate given to AFD by the French Government that defines the sectors where it operates. It is therefore quite logical, and within the sphere of concerns shared by both parties, that this program came about. It was developed via a partnership between the Commission for the Construction of Hubei Province and AFD's Research Department.

Its content is the result of jointly defined objectives and the common will to ensure that this program provides a sound base for the development of large-scale energy efficiency programs.

1.1.3. What Are the Issues?

The first point is that all over the world energy efficiency has become one of the priorities of the international agenda. This awareness is relatively recent and began less than ten years ago. EE has now become one of the major areas for combating climate change, particularly since the IEA demonstrated that EE alone accounts for 45% of the solutions that need to be implemented. Moreover, bearing in mind that almost 40% of global final energy consumption is in buildings (currently 27% in China), this sector has the highest potential.

Making buildings more efficient in terms of energy consumption also presents major issues in many other areas:

- Environmental issues: at both the global and local level, for example, the quality of air, or different forms of pollution caused by the use of fossil energies;
- Energy issues: as a result of the predicted scarcity of, or at least the pressures observed on, fossil resources and the impact this has on supply circuits;
- Political issues: in terms of sustainable development and the commitments made for this at the local, national or international level;
- Economic issues: thermal rehabilitation of buildings is key to the development of a new green economy that creates activities, employment, economic growth with a better use of investments; and
- Social issues: energy efficiency in buildings brings about better living conditions by improving comfort under the same economic conditions; the aim is not to consume less, but to consume better.

1.1.4. Why Conduct a Research Program on this Topic?

These numerous issues demonstrate all the interest of a policy to implement energy efficiency programs on a large scale. Yet, the subject is much more complex than it would seem on the face of things for the following reasons:

- Actors are multiple and diverse: a number of responsibilities (competence shared among several administrations that must work in synergy and not in their own corners), public and private sector, companies, banks and, finally, a whole host of beneficiaries;
- Technical solutions are not always easy to identify, especially when there are temperate conditions like the ones here in Wuhan;
- The level of energy efficiency must be defined on a case-by-case basis according to multiple criteria: technical (in terms of the characteristics of the building), economic (time required for returns), institutional (status of the building, characteristics of joint ownership) and legal (liability and guarantee for works);
- Finally, and this last point is not the least important, financial aspects play a key role. Indeed, besides pilot or demonstration projects, if we want to scale up, it is necessary to develop appropriate and innovative financial mechanisms. These mechanisms must aim to address the considerable resources that are required,[1] and also allow many different types of financing to be implemented (subsidies, zero-rate or subsidized loans, venture capital, etc.) in order to adapt to the vast number of cases that exist;

[1] In France, the cost of thermal rehabilitation in buildings for the part of the building stock that corresponds to housing is estimated at some 600 billion euros.

- Moreover, to promote the development of the energy efficiency market, it is necessary to envisage incentive mechanisms which may be of a fiscal nature (tax breaks or exemptions, etc.), or via tariffs or other mechanisms. They must be able to evolve over time and help make these financial mechanisms more elaborate.

The ideal thing would be to promote a financial approach by which investments in energy efficiency works would be covered, at least partly, by savings made on the energy bill. However, for the public sector, investment and operating budgets are, like in most countries, watertight budgets and, for the private sector, the savings are often very quickly offset by improvements in comfort.

Most countries are currently researching systems and mechanisms that would allow such programs to be implemented. However, we have to admit that no country has actually managed to scale up. Many interesting experiments are underway, in most cases at regional or provincial levels. It is interesting to draw inspiration from them, but unfortunately, as they stand, none can really be reproduced because they are all heavily dependent on local or national contexts. Most come up against the problem of EE governance.

Following this brief presentation of the issues and difficulties of such a program, I would like to come back to the methodological and organizational principles of this research program.

1.1.5. Methodological Principles

The methodological principles defined in the framework of this program are as follows:

In Terms of the Composition and Organization of the Team

Multidisciplinary teams were formed right from the start and combined academics, administrators, bankers, engineers and practitioners from both the public sector and the private sector, as well as international experts. Synergies and cross-disciplinary contacts among the different members of the team, as well as with the other administrations and organizations concerned, have been encouraged throughout the program. This team has been divided into three groups that respectively work on the institutional, technico-economic, and financial aspects.

In Terms of Partnerships

Each of the parties finances its experts and the studies for which it is responsible. For example, research on the analysis of the context, the existing building stock and national experiences was of course conducted by the Chinese side, whereas the analysis of international experiences and best practices was conducted by the French side. Research such as that relating to determining the issues was conducted jointly.

Generally speaking, the principle adopted in the framework of this partnership is based on the fact that the French side provided, where necessary, materials, information, and specific methods or training, but that it would not make proposals. This is indeed a factor for taking ownership of the research that is conducted and also ensures the "sustainability" of the research and the process initiated in the framework of this program.

This is why, and it is important to emphasize this, the results and proposals that will be presented to you during this seminar mainly come from the Chinese side.

In Terms of Content

It is important to remember that the methodology was defined jointly and that it not only provided an outline, it also gave a detailed definition of all the research to be conducted in the framework of this program.

Energy efficiency in existing buildings has always been dealt with in a comprehensive manner by integrating all aspects and using in-depth knowledge of the context. Moreover, throughout the duration of the program, the team strived to permanently combine the overall vision (satellite vision), which is essential for defining issues and strategies and helps maintain the main orientations, without necessarily eliminating the detailed and in-depth research that is required in order to understand the scientific aspects, such as management methods or energy consumption in buildings, or the calculation of potential energy savings. Moreover, the team was able to draw on experience gained in five countries (England, France, Germany, Japan, and the United States) as well as at the level of the European Union in terms of energy efficiency in existing buildings. Finally, whenever required, training was given in specific tools (energy audits in buildings and simulation tools: DesignBuilder and EnergyPlus).

1.1.6. How Is this Program Innovative?

This program has a number of original and innovative aspects that are worth highlighting. They stem partly from the methodological principles.

First of all, the partnership itself is different from more classic partnerships in which a local team is financed by the international side. Generally, at the end of a project, the team is dissolved and the project stopped. The solution adopted – joint definition of objectives and each party financing its own teams – promotes the creation of a process that is likely to allow the research to be continued.

The program is also innovative by its content. It is indeed one of the only programs currently known that addresses energy efficiency in existing buildings via a comprehensive and such a complete approach. It is also a program that from the very beginning placed research on financial mechanisms at the center of the process. Indeed, the implementation of specific financial mechanisms is a key factor for the success of large-scale programs. These financial mechanisms are also essential tools for supporting incentive policies and developing new markets.

The composition and variety of local teams in charge of this research program is also a strong innovative element. The initial core group was made up of engineers, academics, administrative executives from public services, as well as private sector organizations. The core team was designed to be open and was gradually strengthened as the program advanced by new partners such as ESCOs, development companies, banks or new administrative departments.

The approach for this program, which is halfway between research and being operational, is also an element of innovation. Indeed, to meet the operational objectives, it appeared necessary to bring out proposals for solutions from the real actors and not from the team itself. This approach makes it possible to both

raise the awareness of the actors that are essential to the implementation of large-scale projects and anchor these proposals for solutions in the real situation.

International experience has shown that most of the successful examples are still only at the regional scale and that the different systems that have been implemented – whether institutional or financial – are, in most cases, based on local initiatives and rarely national initiatives.

1.1.7. Obstacles and Difficulties

The team obviously came up against a certain number of difficulties or obstacles during the implementation of this program. These are, however, not specific to China and stem from the particular nature of energy efficiency, which is not a specific sectoral activity and is an activity for which financing cannot be provided by traditional mechanisms.

It is quite simply the opposite: it is a cross-sectoral activity and most administrations in the world share the same operating methods and the same reluctance to work in a cross-sectoral manner.

In all administrations and local authorities all over the world, the search for innovative financial mechanisms, based on recovering financing in energy efficiency investments via the savings that are made, comes up against the same arguments of independence between operating and investment budgets.

Many other examples could be quoted. However, although these difficulties certainly constitute considerable obstacles at the beginning, international experience has shown that exemplary projects that are successful are those that, faced with these same stumbling blocks, manage to overcome them. This should be the case in China.

1.1.8. Some Lessons Learned

There is no universal solution or model for implementing large-scale energy efficiency programs in existing buildings.

The solutions that should be explored must be innovative, hybrid and combined: (i) at the institutional level where incentive and regulatory mechanisms can be reconciled, (ii) at the technical level where there are multiple solutions that depend on the technical features of the building (equipment, budget, etc.) and (iii) at the financial level where public financing must allow the energy efficiency market to develop and act as a lever to mobilize private financing.

Moreover, to be viable these solutions must also be adapted to the local context, as well as to each specific category of building.

Public intervention is needed, but its role must be clarified. As Bernard Laponche points out: "*Public intervention is essential in order to guarantee the long-term interest of the local authority, and integrate concerns over the long term, and the environmental and social externalities that the market itself cannot take into account. The role and responsibility of public authorities are to create the mechanism and means that will allow energy efficiency to be an integral part of all the activities of these actors and economic agents.*"

Finally, to conclude, I would remind you that energy efficiency generally and in existing buildings in particular, is an essential key without which there cannot be sustainable development in our cities and that the success of large-scale programs remains one of the major challenges of the coming decades.

1.2. Summary of the Research Program on Financing Mechanisms for Energy Efficiency Retrofitting of Existing Buildings in Hubei Province

Dr. Ma Yanlin, Professor and Associate Dean,
College of Public Administration, Huazhong University of Science and Technology

1.2.1. Background Information

As the use of energy and global environmental issues becomes increasingly salient, the Chinese government is attaching great importance to energy-related topics.

Energy consumption in buildings currently exceeds that in other areas such as industry and transport, accounting for 30 percent of overall consumption. Based on statistics from developed countries, this consumption will continue to grow to at least 40 percent, as people's standards of living rise. This means that energy saving in buildings must be a key component of energy-saving undertakings. This has repercussions on:

- The increase in the number of air-conditioners in 100 households of urban residents in Hubei Province;
- The increase in the number of shower sets in 100 households of urban residents in Hubei Province.

Energy consumption in Hubei Province increases on an annual basis, with an annual growth of 13.48% in buildings between 2002 and 2007. At the end of 2007, the production-to-consumption ratio was as high as 1 to 6.74. Hubei Province is a typical province with a shortage of energy sources.

Energy-saving renovation for buildings is of great significance and has the potential to produce enormous social, economic, and environmental benefits. It can:

- Save energy;
- Promote environmental protection,
- Raise people's living conditions;
- Boost industry development and domestic demand; and
- Spur sustainable industrial development and technological advancement.

By the end of 2007, the Eight-Plus-One Urban Circle of Wuhan Municipality covered a total building area of 447 million m^2, 58 percent of the total building area of Hubei

Province. As these buildings were constructed a fairly long time ago without considering energy-saving factors or resorting to energy-saving measures, 90 percent of them were not built with energy-saving measures and, as a result, have a high energy consumption and low efficiency.

Mock analysis and evaluation has shown that if existing buildings within the Circle implemented an energy-saving standard of 50 percent, 4.47 million tons of standard coal could be saved and a reduction made of 9 thousand tons of dust, 11.12 million tons of CO_2, 73.8 thousand tons of SO_2 and 69.7 thousand tons of nitrogen oxides. Energy-saving renovation can also improve people's living conditions (by improving home heating), enhance the urban landscape (by exterior refurbishment), boost domestic demand, and promote and upgrade industrialized development. It is estimated that energy retrofitting existing buildings can help boost markets for energy-saving materials, doors, windows and renewable energy, creating a new engineering and investment market of RMB60 billion within the Circle.

More importantly, energy-saving techniques, project operations, and investment recovery of different kinds can be put to the test during the renovation process, conducive to the exercise of Wuhan Urban Circle's model role in the construction of a resource-saving and environment-friendly society. This can also set a leading pace for the nation's existing building energy retrofitting program, conducive to the realization of reducing energy consumption per GDP by 20 percent as envisioned by the 11th Five-Year Plan.

Energy-saving renovation for buildings is an essential element in implementing the *Scientific Viewpoint of Development* and constructing a resource-saving and environment-friendly Wuhan, with profound significance and potentially enormous social, economic and environmental benefits.

Need for Research

Currently in China, at least 10 billion m^2 of existing buildings are in need of energy retrofitting, which will require enormous capital injection of at least RMB1.5 trillion, according to the Ministry of Construction. While creating big market opportunities, there are problems in how to raise this initial sum of money. Financing is therefore a key point in existing building energy retrofitting, and necessitates intensive and systemic research.

On June 2, 2006, based on agreements between AFD and the Ministry of Finance, the Department of Construction of Hubei Province and AFD signed a partnership framework agreement, *Research on the Financing Mechanism of Energy Efficiency Retrofitting for Existing Buildings in Hubei Province under a Sino-French Partnership*, with a view to strengthening Sino-French cooperation, exploring implementation measures of renovation plans in Hubei Province and a financing mechanism suitable for the plan, and ultimately putting forward proposals for relevant government organs.

Headed by the Department of Construction of Hubei Province, the Chinese side has put together a cross-discipline, cross-industry and multi-department research team.

1.2.2. Team Introduction

The French side is headed by Mr. Nils Devernois, AFD Research Department, responsible for forming the international

panel, which includes members such as Mr. Liu Yazhong, Mr. Bernard Laponche, and Mr. Jose Lopez.

The Chinese side is headed by Ms. Liang Xiaoqun, Director of the Surveying, Design and Science and Technology Division under the Department of Construction of Hubei Province. She is in charge of forming a pool of graduates from the College of Public Administration at Huazhong University of Science and Technology, the Hubei Institute of Architectural Design and Research, the Wuhan Municipal Construction Commission, Wuhan University of Science and Technology, and the Wuhan Municipal Bureau of Land Resources and Housing Management.

According to the research plan, under the guidance of the coordinating office, the task team is divided further into three groups: Team A, Team B, and Team C.

Team A is the Technology and Economy Team, headed by the Wuhan Municipal Construction Commission.

Team B is the Regulation and Management Team, headed by the College of Public Administration at Huazhong University of Science and Technology.

Team C is the Financing Team, headed by the College of Public Administration at Huazhong University of Science and Technology.

1.2.3. Project Progress (achieved in the past two years)

For the past two years, team members have engaged in fruitful investigations and research work, by means of interviews, field surveys, symposiums, questionnaires and in-depth analysis. These efforts include:

- Census and audit of the energy consumption of buildings. In the general survey, 389 buildings were covered: 106 were examined and 26 were audited. Systemic research was also conducted into the energy-saving potential of existing office buildings and public buildings in Wuhan, and energy-saving renovation plans and measures;
- Analysis of the energy expenditure of different types of buildings and of the interest groups in existing building energy retrofits was conducted. Interest concerns of various groups and the motivation for renovation were extensively discussed;
- Analysis of the characteristics of financing for existing building energy retrofits was carried out. The problems in this regard and their causes were discussed, and the challenges analyzed;
- Analysis of the channels and modes of financing energy retrofitting was undertaken. Potential channels were identified based on existing structures, and financing modes were also explored;
- Policies and measures adopted by France, Japan and the US to raise energy efficiency were compiled by international experts under the auspices of AFD and translated by the Chinese team. Relevant domestic laws, regulations and policies in buildings' energy-saving capabilities were analyzed and compared to experiences from other leading countries;
- Analysis of financing mechanisms of existing building energy retrofitting applicable to Hubei Province was conducted. The feasibility of establishing a renovation fund and financing platform in Hubei Province and its possible forms was explored.

In the course of our project research, we have conducted a number of technical training sessions and symposiums. We have also invited representatives of relevant government organs and financial institutions to participate in our discussions and consultations. Team members have engaged in broad and in-depth exchanges, and symposiums between the French and Chinese sides in particular have helped lay a solid foundation for carrying out this project. At the Periodical Evaluation and Assessment Meeting on April 2009, experts put forward valuable ideas and proposals, essential to the further research work of this project.

Today, on behalf of all team members, I would like to take this opportunity to extend our heart-felt gratitude to the various departments, units and enterprises who have lent us their solid support, and for the officials and experts who have given the research project such a lot of attention. The Consulate General of France in Wuhan, the Hubei Province Development and Reform Commission, the Hubei Province Department of Finance, the Wuhan Municipal Development and Reform Commission, and the Wuhan Municipal Bureau of Finance, I thank you all.

1.2.4. Tentative Conclusions

- The characteristics of energy consumption differ according to different types of building, with office buildings at the lowest level and buildings for commercial use at the highest.
- With different ownership and financial management systems, residential buildings, public buildings and public buildings for commercial use differ in terms of energy consumption patterns, resulting in varying levels of motivation for energy-saving renovation.
- Residential apartment buildings make up the absolute majority over single-unit residential buildings. Their complex ownership, high costs and long process of decision-making hinder energy-saving renovation initiatives to a great extent, especially with regard to building envelopes. As a result, energy-saving renovation for public buildings should be given precedence.
- Because energy use system retrofitting is low cost in terms of internalizing externalities, financing can be carried out through market mechanisms (energy management contracting). As the energy-saving rate is difficult to measure and ownership is complex, the renovation of the building envelopes cannot be financed through a market mechanism, nor can it be completely separated from energy use system retrofits.
- For different types of existing buildings, the characteristics of financing for energy retrofitting varies, with a pointed conflict between fund demands and investment willingness. Financing for existing building energy retrofits is facing difficulties caused by many factors.
- The challenges faced by financing come mainly from insufficient effective regulatory support, a lack of incentive policies for energy retrofitting industry development and a shortage of mandatory measures.
- Channels of financing currently in effect for energy retrofitting include budgetary allocation, bank loans and financial guarantees. Bank loans are mostly provided by overseas financial institutions, such as the World Bank, international financial companies, AFD, and the Asian Development Bank.
- Potential channels of financing for existing building energy retrofitting include the establishment of funds for specific purposes

(such as construction investment, subsidies, low interest rates and guarantees); the utili-zation of credit funds from national de-velopment banks; capital funds; guarantee agencies; the reduction or exemption of taxes; and revolving funds.

- In existing building energy retrofitting in Hubei Province, the Energy Management Contracting, Saving Energy to Service Enterprises, and Saving Energy to Service Industry mechanisms are still in their infancy, and need the government to issue relevant policies to provide support and incentives.
- Recycling funds specifically for energy-saving renovation for buildings and financing platforms for energy saving and emissions reduction is an important guarantee to bring about overall scale effects, promote comprehensive energy-saving renovation and introduce international capital in a sustainable way. Financing platforms for energy-saving and emission reduction can take the form of:
  - Liabilities financing;
  - Third-party financing; or
  - Rights and interests financing.

1.2.5. Closing Remarks

The establishment of an effective, long-term financing mechanism for building energy retrofits is the key to undertaking renovation work for buildings on a large scale. Various methods to apportion renovation expenses put forward in the *Managing Regulations on Energy Conservation for Civilian Buildings* lay a sound foundation, but they still need to be perfected. Backed by various parties, this research team has carried out preliminary research in this regard and put forward tentative proposals. They are not mature and have room to improve, and comments from officials and experts are most welcome.

Conférences & Séminaires

Part 2. The Challenges of Energy Efficiency in Buildings

2.1. Global Energy Challenges: Energy Efficiency in Buildings, a Priority for China

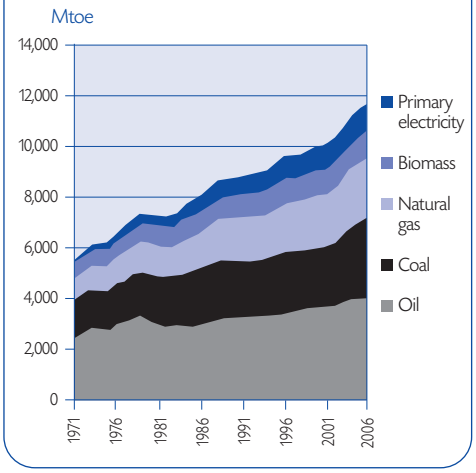
Dr. Bernard Laponche, Independent consultant
and international expert in energy and energy efficiency policies

2.1.1. World Energy Consumption

Primary Energy Consumption

Figure 1

World Energy Consumption by Source



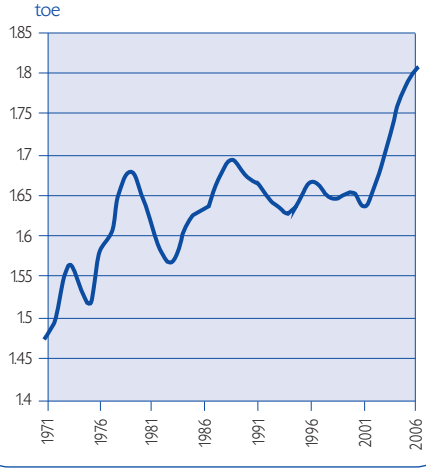
Source: Enerdata.

In the thirty-five year period between 1971 and 2006, the world's total demand for primary energy increased from 5.5 to 11.7 billion tons of oil equivalent (toe). Petroleum was the dominant source of energy, making up 34% of all sources in 2006. The share of natural gas in the mix increased the most.

The sharp increase in demand seen starting in 2000 comes from coal, especially in China. Biomass had a relatively large share in 2006 (10%), slightly larger than the share of primary electricity, generated in equal degrees by hydropower and nuclear power plants. Primary heat, that is solar and geothermal heat, makes only a very small contribution to overall energy consumption and does not appear in Figure 1.

Figure 2

World Primary Energy Consumption Per Capita



Source: Enerdata.

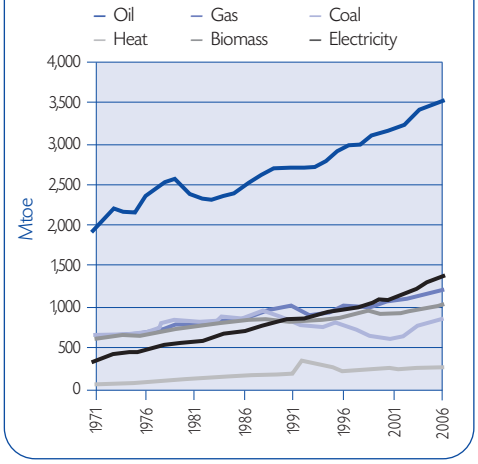
Between 1971 and 2006, global primary energy demand per capita increased from 1.47 to 1.8 toe. Figure 2 shows the decrease of primary energy following the two oil shocks of 1973-74 and 1979-80, then its increase with the oil counter-shock in 1986, and the reversal marked by the decrease in demand by the former Soviet Union countries after 1990. Together, all of these fluctuations contributed to the average demand per capita in 2000 being about the same level as in 1980.[1] After 2000, growth is higher, as seen in the total demand figures. Much of this growth was due to the growing economies of Asia and especially China.

Final Energy Consumption

Final energy refers to the energy products that are delivered to the end consumer.

Figure 3

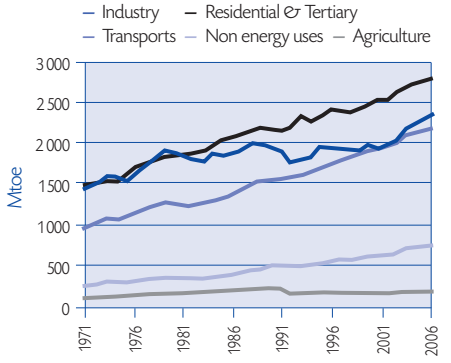
World Final Energy Consumption by Product of Activity



Source: Enerdata.

Figure 4

World Final Energy Consumption by Sector of Activity



Source: Enerdata.

The three largest energy-consuming sectors of activity are industry, transportation and the combination of residential and tertiary (public and commercial services) sectors.

In 2006, final energy consumption totaled 8,133 Mtoe (million tons of oil equivalent) split among the following sectors of activity: resid-ential and tertiary used 34% of the total; industry, 28%; transportation, 27%; agriculture, 2%; and "non energy uses", 9%.

Residential, tertiary and the transport sectors show strong and regular growth in energy demand. A breakdown of consumption by fuel product shows that petroleum products lead the pack with a 43% share of final demand, followed in nearly equal shares by natural gas and electricity at 13% each. It is striking to see the parallel between the growth of transportation and the increased

[1] Stable consumption between 1980 and 2000 was the result of three things:
- The increase in energy consumption slowed down considerably in industrial counties, in great part because of efforts directed at energy efficiency;
- The low economic growth of most developing countries; and
- The economic crisis in countries "in transition" reduced their energy consumption considerably.

use of petroleum products. In 2006, transportation, which runs almost entirely on petroleum fuels, consumed 62% of all petroleum products.

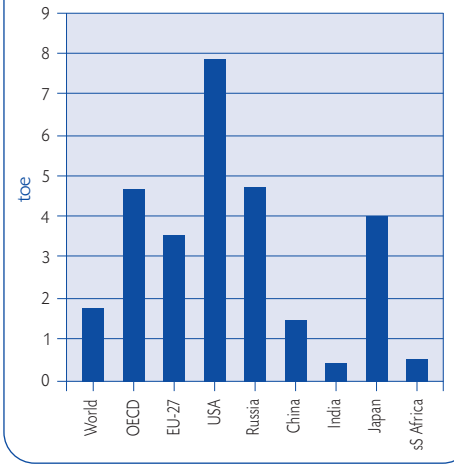
Inequalities in Energy Consumption

At Global Level

Inequalities between countries and regions in per capita energy demand are quite large, as seen in Figure 5. In 2007, primary energy demand ranged from 7.9 toe per year in the United States to 0.62 toe per year in sub-Saharan Africa (not including South Africa).

Figure 5

Primary Energy Consumption Per Capita (2007)



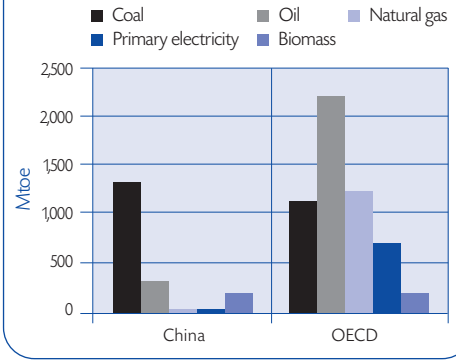
Source: Enerdata.

Two Comparable Entities: China and OECD Countries

China and OECD member countries are comparable in terms of population, with 1.32 billion people in China and 1.18 billion in OECD countries. It is interesting to compare their energy consumption by source to understand the gap between so called "developed" countries and the largest of the emerging countries.

Figure 6

Primary Energy Consumption by Source in China and the OECD (2007)



Source: Enerdata.

Coal consumption is 20% higher in China than in OECD countries, while biomass consumption is the same for the two entities. OECD countries consume 6 times more oil, 22 times more natural gas, and 13 times more primary electricity than China.

2.1.2. Energy Outlook And Constraints

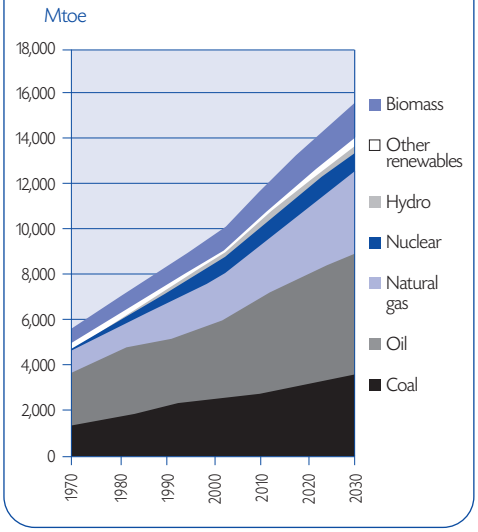
Following Current Trends and Policies

The International Energy Agency (IEA) publishes an annual "outlook" on world energy, the "World Energy Outlook," which is based on an analysis of needs and resources according to current policies and practices by countries and businesses. This is known as the "Business as Usual" or BAU scenario. In terms of methodology, econometric relationships provide the basis for the models, adjusted mostly on past trends and the effects of energy pricing on supply and demand. Focus is on energy supply with few details about energy demand. Despite these caveats, IEA's BAU outlook provides an important reference point. It represents the "official view" of the OECD and is quite interesting as such.

Figure 7, from the IEA 2005 report,[2] shows its view of energy demand to the year 2030.

Figure 7

IEA's "Business as Usual" Scenario



Source: Enerdata.

Starting in 2003, the tendency is for total consumption to increase by about 1.4% per year. Natural gas increases by 2.1% per year; nuclear power increases 0.4% per year; and "other renewables" increase a modest 6.2%.[3,4] The trend for worldwide primary energy demand is to increase 1.8 times between 2000 and 2030, with carbon emissions increasing 1.6 times, and demand in OECD countries increasing 1.4 times. Between 2000 and 2030, a US$16 trillion investment is expected in ener-gy production, of which 60% for electricity (production, transmission and distribution).

Developing countries would account for 62% of the increase in energy demand. Their share of energy consumption would increase from 30% today to 43% in 2030. China would take the biggest share of the increase, with nearly a third of the total, followed by Brazil and India, which would each account for 5%. By 2030, China's energy demand would be equivalent to all of Europe's, an amount equal to that consumed by North America today.

In the BAU scenario, the IEA foresees an energy landscape in 2030 where energy consumption would remain, for the most part, oil-dependent and greenhouse gas emissions would continue to increase despite the dual threats of diminishing resources and climate change.

This is not Sustainable

Pursuing current trends in energy consumption at the global level will come up against insurmountable constraints, limit development, accentuate inequalities between rich and poor countries, and contribute to divisions in society.

Economic and social development is a legitimate aspiration that requires access to energy. The lack of energy-security will slow down or stop economic and social development. Development is dependent on geopolitical constraints, access to resources, price increases, diminishing supplies in the medium term, local pollution and environmental accidents, as well as global climate change. Additionally, high oil prices will ruin fragile economies.

[2] The fluctuations in consumption prior to 2000 that were due to the oil shocks are not visible because of the 10-year scale used in the graph.

[3] "Modest" considering the recent development, in particular for wind energy, and the very low starting value.

[4] Note that electricity production by nuclear and hydraulic means remains at about the same level as in 2004.

The IEA's BAU perspective on energy shows that developing countries who take the OECD countries' model as the one to emulate will be faced with the impossibility of matching it, either because it will be too costly or difficult, or that because of energy constraints, development will be radically compromised, and not only for the poorest countries.

The World energy system is submitted to four large constraints of increasing magnitude:

a) Economic constraints: The amount of money invested in energy evoked previously is substantial. Furthermore, the price of energy, especially oil, whose price increases in spring 2008 brought fragile economies to their knees, will likely increase after the current economic crisis is over. If emerging from the crisis requires reinstating the previous development model, demand pressures will be such that the prices will increase straight away;

b) Supply constraints: Even if the question about the size of remaining oil stocks remains unanswered, there are limits and the 21st century will very likely see diminishing supplies and therefore price increases. Oil cannot be the basis for sustainable future development;

c) Security constraints: Energy independence is not necessarily required for a country's security, although a too-great dependency on external sources can weaken an economy because of supply risk and the potential for cost increases. Extreme dependency, such as is the case for transportation and petroleum products, can lead to major conflicts;

d) Environmental constraints: Energy production and consumption can cause damage to the environment, life and human health through air and water pollution, serious accidents and climate change. The international community mobilized to address such issues through the 1992 UN Framework Agreement on Climate Change and the 1997 Kyoto Protocol, which took effect in 2005.

The IEA's BAU outlook should not be taken as a forecast but as a warning.

What if all Countries Matched the OECD Model?

The traditional model of energy development could probably last a while longer if it was limited to OECD countries. But the planet has five other entities of the same size – China, India, other Asia and Pacific countries, Africa and Latin America – that have legitimate and desirable objectives for economic and so-cial development. The current OECD energy system, based as it is on gluttonous energy consumption and ever-increasing production, is untenable due to the above constraints.

In fact, if China, India and the other non-OECD countries on the planet were to consume annually the same quantity of primary energy per capita as the average of the OECD countries (about 5.5 toe) in the 21st century, the total quantity of primary energy consumed by 9 billion people would be about 50 billion toe. That is more than four times the energy currently consumed, which means we would need four "planet Earths" to meet the energy demand. This is impossible.

2.1.3. Energy Services And Energy Efficiency

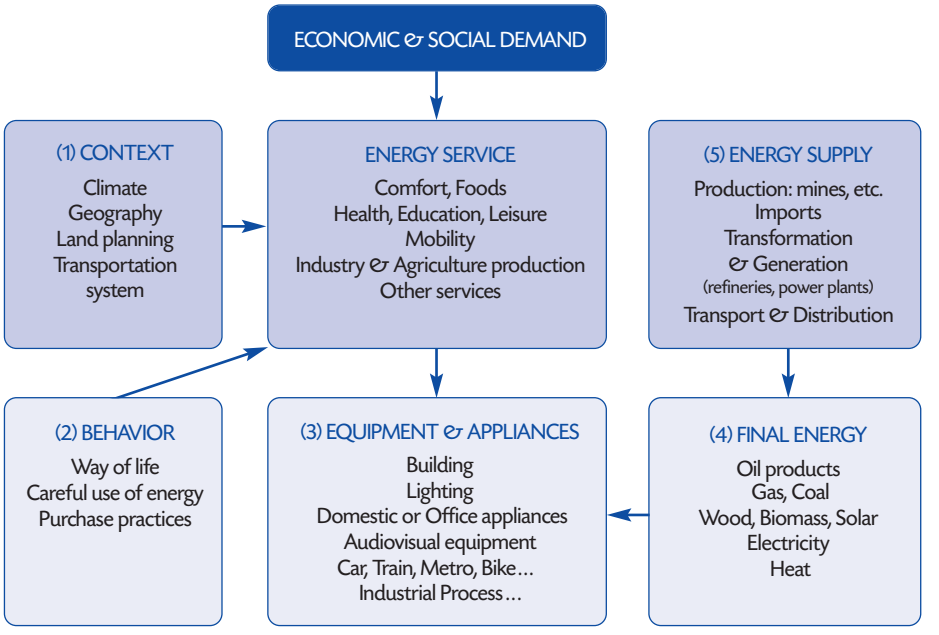
The Real Need: Energy Services

The direct needs of a society (households, companies, local communities) are not energy products, but goods and services indispensable for their well being and quality of life.

Obtaining these goods and services requires the consumption of energy to satisfy these needs. The products and services that require this energy consumption are called "energy services".

Figure 8 shows that the consumption of final energy needed to ensure "energy services" at the consumer level depends on several different factors. It can vary widely, even for the same service, depending on each factor.

Figure 8 *Energy Services and Energy Efficiency*



Source: Author.

The first factor (1) characterizes the "**context**" in which the needed service will be obtained. Contextual characteristics include the climate, which necessitates a greater or smaller degree of the "comfort" service. Also included is the size and type of geographic territory, whether large expanses, mountain zones or great distances, and the type of building development, such as urban or rural areas, urban density, types of buildings, along with the means of transportation, whether by road, rail or rivers, etc.

The second factor (2) characterizes **"behavior".** It includes lifestyles, such as the "American way of life", for example. Behavior affects the ways things are used, such as taking the car for short distances instead of walking, or leaving lights on in houses or offices even when no one is present. The way needs are expressed even, mixing lifestyle with behavior, is a very important aspect of this factor. For instance, does someone really "need" three televisions in an apartment, or only one? It depends on the behavior of the consumer but also of those who, at every level, make decisions about things that affect "context" as

well as "behavior". A "frugal" behavior means moderation in energy consumption.

The third factor (3) relates to the machines or **"equipment"** used to obtain the needed service. For example, comfort depends on the technical qualities of house construction, the type of heating used, the efficiency of electrical appliances, etc. This third factor applies to every type of energy use: motors, hot water heaters, or ovens in industry; cars, trains, subways or bikes for transportation; building, appliances, heating and cooling systems, lighting in tertiary and residential buildings.

Depending on "context," "behavior," and "equipment," the **final energy** (4) required for a given service can be radically different. There are many examples, such as the quantity of combustible material necessary to attain the same interior temperature in a well-insulated building compared to one that is not. Another example is the amount of gasoline used to go a certain distance depends on the means of transportation, or the electricity used by an incandescent light bulb compared to a compact fluorescent bulb to get the same level of lighting.

Reducing final energy consumptions leads to a reduction in primary energy consumption (5), whether primary energy comes from national or imported sources.

The new energy paradigm consists in creat-ing an "energy system" that includes not only the energy sector (supply), but also the consumption of energy (demand) and ensures its development in such a way as to obtain energy services under optimal conditions in terms of resource supplies, economic and social costs, and local and environmental protection.

End-Use Energy Efficiency: a Win-Win Strategy

An end-use energy efficiency policy consists in implementing measures and actions that lead to reductions in energy consumption for all economic and social activities. Actions should affect the context, behavior and equipment of energy service delivery.

Actions related to "context" include urban planning and building, transportation systems and the way traffic is organized, as well as housing policies. These are infrastructure policy choices and depend mostly on decisions made by business and political leaders for the community, rather than on decisions made by individual citizens.

Affecting "behavior" means actions to increase energy awareness at all levels and requires a substantial effort to inform, advise and teach people about appropriate energy use. It also implies that citizens discuss and debate the energy policy choices and decisions.

Actions related to "equipment" have a large technical component. Research and innovation are essential elements for an energy efficiency policy, but are only part of the solution. Energy-efficient equipment and appliances must penetrate the marketplace and become commonplace. Several complementary tools can be used, such as industrial policy, training for trades and professions, consumer information, offerings and various financial incentives or appropriate financial mechanisms.

An energy efficiency strategy touches on all economic and social activities. The characteristics of industrial and consumer civilization must evolve in a significant way as soon as possible.

Reducing final energy demand for the same level of service leads to a reduction in primary energy demand, which in turn leads to less money spent on production and the importation of oil and natural gas. The favorable consequences for the environment are easy to understand: the energy that pollutes the least is that which, for equal service, is neither consumed nor produced. For a given use, every time we lower energy consumption, we reduce the pollution and risks due to the energy system.

Financial resources that the consumer or community would have spent on obtaining energy can be spent on other needs and improve the quality of economic growth. For instance, funds can be spent on building housing or health care and education facilities, developing mass transit, etc. Periods of energy price increases, particularly for oil, increase the economic benefits of energy efficiency, for the State as well as for consumers.

In addition, investments made in energy efficiency create jobs and employment. Manufacturing new construction materials, high-performance equipment, reinforcing building insulation, installing mass transit systems, developing expertise and consultancy, along with motivational and educational efforts, are all sources of new jobs.

Economic and social development to meet internal demand is particularly important during this period of worldwide recession and reduction in international trade.

New Deal and New Actors

Traditionally, energy production and distribution companies, with government support, have been in charge of all matters related to energy. The growth and the energy policies these companies have imposed have led to economic and environmental dead ends. The end user has been relegated to a passive role, reduced to paying the bill, when energy was furnished and he was in a position to pay for it.

The field of action for energy efficiency is not limited to energy production and distribution companies. It includes companies in the manufacturing, construction and transportation industries, as well as consumer behavior and modes of consumption. Obtaining energy services depends on development planning, building construction quality, production of equipment and materials, and transportation policies oriented toward using mass transit and rail. Architects, urban designers, builders and equipment manufacturers have as important a role to play as the energy production and distribution companies. Each consumer, household, business and community becomes not only a consumer of energy, but also a participant in conceiving and putting into place a new energy policy. It should, in fact, be called a new "energy services policy".

In this new context of "re-appropriating" the subject of energy, new participants with important roles to play appear. The State has a role to play, but more as a regulator than master of the game. Energy suppliers have to modify their practices and move from a role of simply providing an energy product to an overall role of meeting an energy service need. It means that demand and supply be put on equal footing with demand focused on lower energy consumption for the same level of service and comfort, and supply focusing on production and delivery of energy products to satisfy consumption needs.

Thirty Years of Experience in the European Union: "Negajoules"

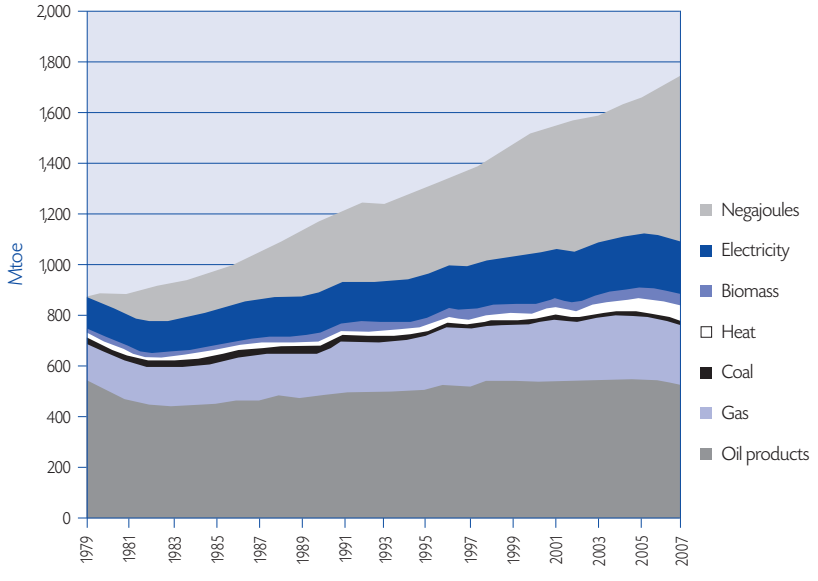
By implementing energy efficiency policies, European Union countries (EU15) succeeded in preserving economic growth despite major oil price increases following the oil shock in 1973-74 and especially that of 1979. Between 1979 and 2007, final energy demand increased only 6% per capita even though the gross domestic product (GDP), adjusted for inflation, increased 67% per capita.

If the EU15's final energy intensity (units of energy per unit of GDP at purchasing power parity) had stayed at the *status quo* level after the 1979 oil shock, final energy demand would have increased from 955 Mtoe in 1979 to 1764 Mtoe in 2007. Because of the efficiency measures taken, actual final energy demand was only 1117 Mtoe. The quantity of energy saved through the decrease in energy intensity can be called "negajoules". The "negajoules" in 2007 were therefore 647 Mtoe. The savings exceeded the 523 Mtoe of petroleum products consumed that year.

Nearly a cumulative total of 5.8 billion toe of final energy was saved over the 30-year period between 1979 and 2007. Part of the savings was due to structural changes in the EU economy, but a finer analysis shows that the bulk of the savings came from improvements in energy efficiency, particularly in industry and buildings through improved equipment performances and better construction quality.

Figure 9

EU15 Final Energy Consumption: "Negajoules"



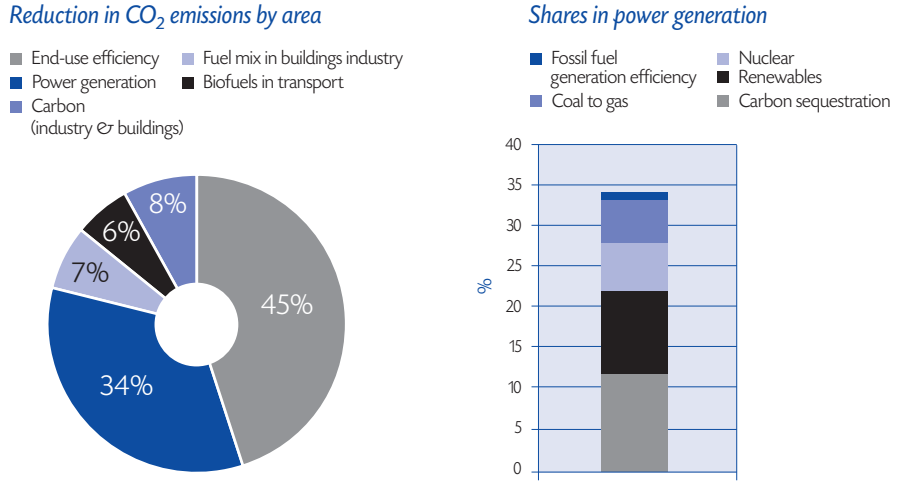
Source: Enerdata.

An Emission Reduction Forecast

In 2006, the IEA published a study, "Energy Technology Perspectives", about technologies that should help reduce greenhouse gas emissions in the future. The report presented various scenarios, from a baseline "reference" scenario that extended past trends into the future, to several Accelerated Technology (ACT) scenarios, including the most ambitious one, the "TECH Plus" scenario. The latter, known as the "Climate" scenario, would reduce CO_2 emissions in 2050 to a level 13% less than the 2003 level. It is the most favorable scenario in terms of emission reduction.

Figures 10 & 11 reproduce the results for the "Climate" scenario as presented in the 2006 study and show that end-use energy efficiency is the most important instrument for lowering CO_2 emissions. Modifying the technologies of electricity generation, which is generally considered to be the most decisive way of reducing emissions, would result in only 34% of reductions compared to 45% resulting from end-use efficiency.

Figure 10/11 *2006 IEA "Climate" Scenario for 2050*



Source: "Energy Technology Perspectives" – IEA, 2006.

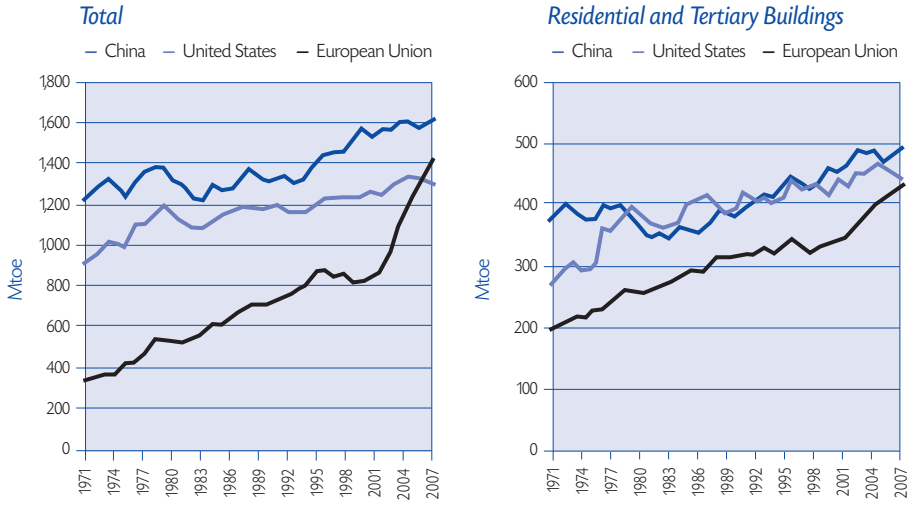
2.1.4. The Stakes Of Energy Efficiency In Buildings

Energy Consumption in Buildings in Three Representative Countries

Comparing China, the United States and the European Union (the present EU at 27 countries) shows what is at stake in terms of buildings' energy consumption.

China is the largest of the emerging countries and its strong economic growth has led to a rapid increase in energy demand. The United States and the European Union are representative of the OECD countries, but with growth models and lifestyles that are quite different from one another, and that result in very different energy demand structures.

Figure 12/13 *Final Energy Consumption*

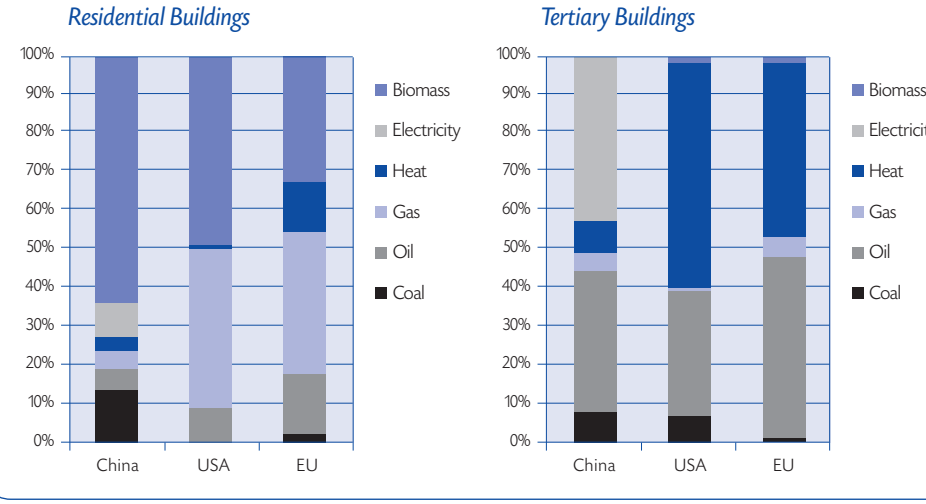


Source: Enerdata.

Figure 12 shows that final energy demand for the three countries was very similar in 2007; growth was very moderate in the EU and USA and very high in China. The same is true for final energy demand in residential and tertiary sector buildings (or "building sector") in the three countries, although energy demand in the building sector was less rapid than for total demand (Figure 13).

In Figures 13 and 14, buildings in China, the USA and the EU show significant differences in the structure of their final energy demand.

Figure 14/15 *Final Energy Consumption by Source*



Source: Enerdata.

Residential buildings show the largest differences in types of final energy consumed. Biomass is the main source of energy in China, due to a largely rural population that uses wood for heating and cooking. The USA and the EU use mostly fossil fuels, especially natural gas, and electricity.

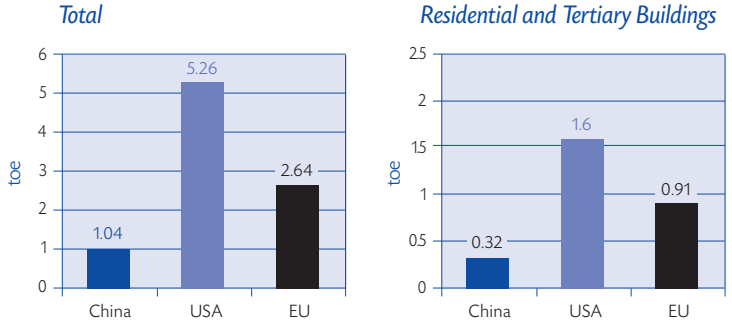
Tertiary building consumptions are more similar between the three entities. Most tertiary buildings are located in urban areas and large cities, and rely on electricity and fossil fuels. In China, there is a preponderance of coal use compared to a greater use of natural gas in the USA and the EU.

Per Capita Energy Consumption

Overall comparisons of energy consumption provide useful information and show relative sizes, but the population must be taken into account for a realistic comparison. In 2007, China had a population of 1.32 billion consumers; the USA, 302 million, and the EU, 494 million.

On a per capita basis, final energy consumption is very different, for both total consumption and residential and tertiary building consumption, as seen in Figures 16 and 17.

Figure 16/17 *Final Energy Consumption per Capita*



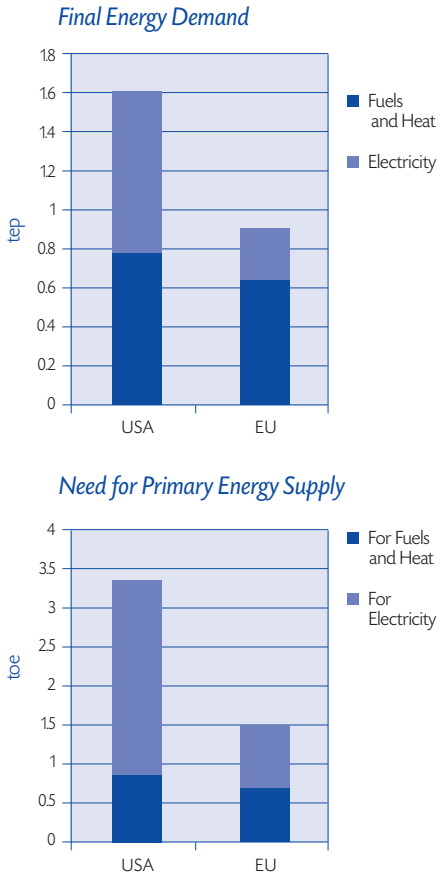
Source: Enerdata.

A Comparison Between USA and EU Energy Consumption in Buildings

It is interesting to compare the type of primary energy consumed per capita in buildings in the United States and the European Union. Figure 16 shows the share of fossil fuels and heat, which are mostly used for thermal purposes such as heating, hot water and cooking, compared to electricity, which is used for electricity-specific purposes such as lighting, appliances, audiovisual and office equipment.

Figure 18/19

Final Energy Consumption Per Capita by Product in Residential and Tertiary Buildings and Primary Energy Requirement to Satisfy this Demand



Source: Enerdata.

In 2007, final energy demand per capita in residential and tertiary buildings was 1.60 toe in the United States and 0.91 toe in the European Union. That is a difference of 0.69 toe per capita. The per capita consumption of fossil fuels and heat, used for thermal purposes, is about the same in the USA as in the EU. However, there is three times as much electricity per capita in the USA.

Some of the differences between the USA's electricity consumption and that of the EU may be considered "improvements" in the standard of living (notably the use of air-conditioning), but many are the result of a lifestyle built on wasting energy resources and neglecting environmental protections.

Large differences in final energy demand cause even bigger differences in primary energy supply needed to satisfy the final energy demand. The quantity of primary supply can be calculated by taking a factor of 1.1 for fossil fuels and heat consumption and a factor of 3.04 for electricity consumption, which equals an average yield between primary and final energy of 0.33, including production, transportation and distribution losses. Figure 17 shows that the primary energy supply needed is 2.3 times higher for the USA.

Assessing Energy Efficiency Potential in China's Buildings

In China, there are great differences in energy demand between ultra-modern urban cities that are "energy gluttons" and rural regions where there is little supply and most energy comes from traditional sources.

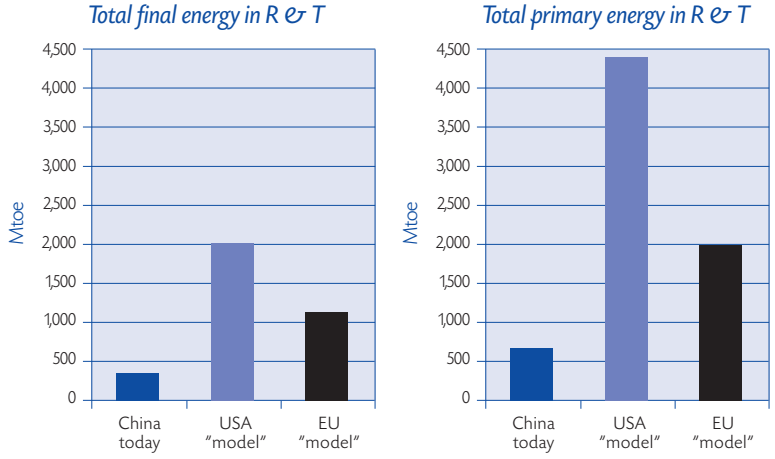
Economic growth in China will progressively lead to a higher standard of living and a generalization of energy services for a larger portion of the population along with higher urban growth. The demand gap between rural and urban areas will be reduced, and there will be a general increase in the amount of energy consumed per capita as there is an increase in the number of people accessing additional energy services. In parallel, an

increased use of modern energy products and/or technologies will replace traditional energy products, and renewable energy will gain a larger share.

This development will take place within the geographic and climatic context of China, of course. It will also follow the special characteristics of the Chinese lifestyle and people, as well as urban development, and housing and construction policies. Further, it will take into account a greater or lesser degree of energy efficiency, both in technical and economic terms, as well as in terms of behavior. It is important for policy-makers to have an idea of the stakes associated with one or other policy and behaviors.

Two scenarios show simulations of the evolution of energy demand in residential and tertiary buildings in China, based on the comparison in the previous chapter showing per capita consumption. The first scenario ("USA model") assumes that per capita energy demand increases to match the current USA consumption of 1.60 toe per capita. The second scenario ("EU model") assumes per capita energy demand increasing to match the current EU demand of 0.91 toe per capita. Catching up with either the USA or the EU would take place at an indeterminate date, within a few decades.

Figure 20/21 *Two "Models" for Future China's Energy Consumption in Buildings (2)*



Source: Enerdata.

In the first scenario, assuming a stable Chinese population, energy demand in residential and tertiary buildings would reach 2.1 billion toe versus 1.2 billion toe in the second scenario, for a difference of 900 Mtoe in annual final energy demand for all residential and tertiary buildings.

If the same yield between primary energy demand and final energy demand is assumed for each scenario at the present value, the total quantity of China's primary energy demand to fulfill the needs of the building sector would be annually: 4.4 billion toe in the first scenario (the "USA model") and 2 billion toe in the second scenario (the "EU model").

The stakes are high: a difference of 2.4 billion toe in annual primary energy demand.

This simulation is neither a projection nor a prescription. China's development will certainly follow new models and lifestyles that will be different from those of the United States and the European Union today. However, the results of the simulation provide a reasonable order of magnitude of the differences inherent in the choice or pursuit of an "energy gluttonous" model of consumption, particularly as regards electricity use.

Similarly to the IEA's "Business as Usual" scenario presented in Chapter 2, simulations based on the idea of matching energy demand in the USA or the EU should be taken as a warning for economic and political decision makers. It provides precious arguments in favor of constructing a civil-ization that is frugal and efficient in its consumption of energy.

2.1.5. Conclusion

The pursuit of current trends in the world's energy consumption is coming up against insurmountable constraints and leading to an impasse. It accentuates inequalities between rich and poor countries and contributes to social divisions. Energy insecurity will hamper, if not make impossible, economic and social development. Geopolitical constraints, price increases, diminishing supplies in the medium term, technological risks, and external shocks of all kinds will challenge physical delivery, as will environmental degradation, pollution, accidents and global climate change.

The only way to meet the challenge is by putting into place a new model of energy systems, which would be compatible with sustainable development. It is necessary to "respond to current needs without compromising the possibility of future generations to meet their own needs".

An overall energy efficiency strategy is necessary and possible, applicable to all sectors of activity, in all countries and territories. Interest in energy security converges with the fight against climate change for large-scale applications. An overall strategy for energy efficiency is the first line of defense in reducing energy security vulnerability. In many countries, energy efficiency is the primary source of energy ("negajoules"). It is also the key to mitigating greenhouse gas emissions. In addition, such a strategy helps economic development through reductions in spending on energy and by creating new activities and jobs. In fact, economic development is one of the key imperatives for energy and economic policies. The stakes are high in terms of energy, the environment, and the economy, especially for fast growing countries that need infra-

structure such as housing and transportation systems, as seen in the Chinese building sector example.

Capitalizing on these potential gains requires one to mobilize financial and human means that are commensurate with the stakes at hand. The means themselves create value. Priority should be given to increasing human and institutional capacity in terms of quantity and quality for local teams, agencies, experts and networks at all levels. In addition, specific financial resources and mechanisms should be put into place: dedicated public funds, guarantee funds, public-private investment funds, along with the creation of "Energy Service Companies". Transportation policies should be radically re-oriented toward mass transit in urban and suburban areas, and toward railroads to carry people and freight on long distances. Energy companies should contribute to this effort.

If rich and industrialized countries, particularly those who waste energy resources, were to put an ambitious energy efficiency strategy in place, they could reduce their energy demand substantially. Emerging and developing countries need to increase their energy consumption, at lower levels for the same services than those of rich countries in the past, levels that have done much damage already.

In the coming decades, energy efficiency will be the main source of energy for most nations, including the big energy-producing countries. The policies that emerging countries, particularly China, put in place in the next ten years will be decisive for the countries, and for the planet.

China needs strong economic growth to satisfy the needs of its large population. Such growth is necessary and legitimate but needs to occur within a huge effort for energy efficiency in all sectors and all areas, both urban and rural. Designing and building new infrastructure, urban development, buildings and transportation systems, and renovating existing buildings and industrial plants for energy efficiency has great potential for saving energy.

A combination of energy efficiency and the development of renewable energies, allied with China's capacity for innovation, will allow it to invent and execute a "new energy model" for sustainable development. Energy efficiency is a formidable source of businesses and jobs in every sector and territory and helps overcome social problems caused by the current economic crisis.

2.2. On the Significance of Promoting Energy Efficiency Retrofitting of Buildings in View of China's Social and Economic Problems and Challenges

Mr. Dai Yande, Deputy Director of the Energy Research Institute, National Development and Reform Commission, Beijing

2.2.1. Introduction

This report has been prepared for the Sino-French Workshop on Energy Efficiency Retro-fitting of Existing Buildings, with a view to analyzing the social, economic and envi-ronmental significance of building energy retrofits. The report begins with the current situation of China's energy consumption and demand-supply trends over medium- and long-term periods in order to clarify the problems and challenges faced in achieving national sustainable economic development goals, and pinpoint energy saving as the stra-tegic choice for sustainable development.

The second part of this report deals with the current situation of China's energy consumption and the energy efficiency of buildings, and points out, based on the experiences of developed countries, that the energy efficiency level of buildings has a direct impact on China's energy demand and supply.

Finally, it focuses on the significance of building energy retrofitting for social and economic development. It argues that energy retrofits for existing buildings can not only reduce energy consumption and protect the environment, but can also play an important part in various other aspects. It can directly mitigate the pressure of energy supply by urban development, boost national economic growth, promote technological innovation of related products and enhance international competitiveness. It can also raise urban residents' living conditions and standards, promote the city image and improve the environment for investment and tourism. It can also raise property values and narrow the gap between the rich and the poor. The report concludes energy retrofits for existing buildings is essential for sustainable urban development, and should be carried out along with current work that aims at expanding domestic demand and maintaining growth.

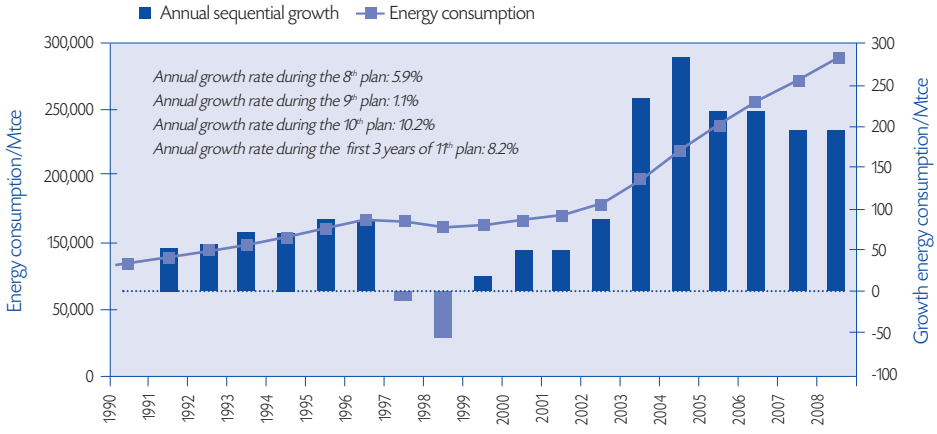
2.2.2. Current Situation of China's Energy Production and Consumption

Since the arrival of the new century, China's energy production and consumption has

developed rapidly and unconventionally, as opposed to the mild growth after the founding of China and especially since the inception of the Reform and Opening-up policies. Between 2001 and 2008, total energy consumption achieved a net growth of 1.47 billion tce (ton of standard coal equivalent), twice the growth of the period between 1981 and 2000. The energy consumption elasticity coefficient also increased dramatically from around 0.5 to the current 1.0.

Figure 22

Growth of Total Energy Consumption in China since 1990

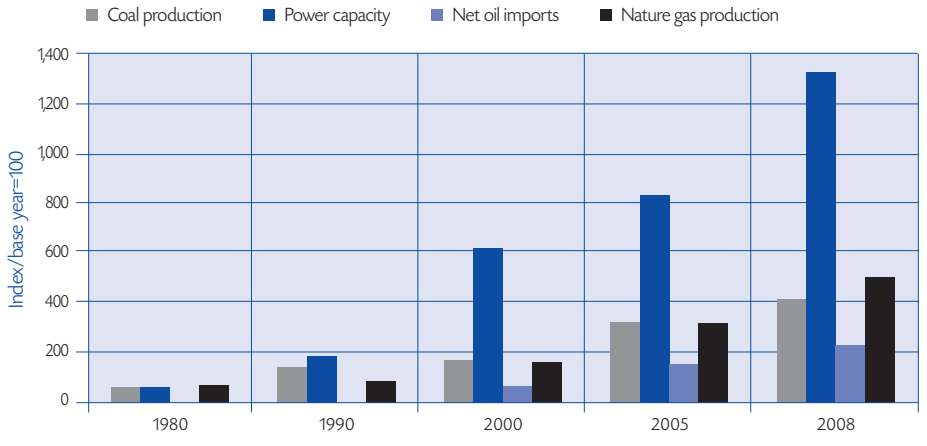


Source: Energy Research Institute of the National Development and Reform Commission in Beijing.

In 2008, China's coal production totaled 2.8 billion tons, 1.5 billion tons more than in 2000, doubling production capability for the past 8 years and growing by 200 million tons per year. Power capacity has expanded to 793 million kW, 2.9 times capacity for the year 2000, with a net growth of 521 million kW, that is, 65 million kW of annual growth at a rate of 14.3 percent. Domestic crude oil production had a limited increase, but oil imports grew to almost 200 million tons, 2.64 times more than in the year 2000, with a net growth of 124.24 million tons at an annual growth rate of 12.9 percent. Dependency on foreign oil increased from 33.8 percent to 51.3 percent. Natural gas production grew to 76.08 billion cubic meters, 2.8 times the figures for 2000, with an annual growth rate of 13.7 percent.

Figure 23

China's Energy Production and Supply Capacity since 1980 (indexed)

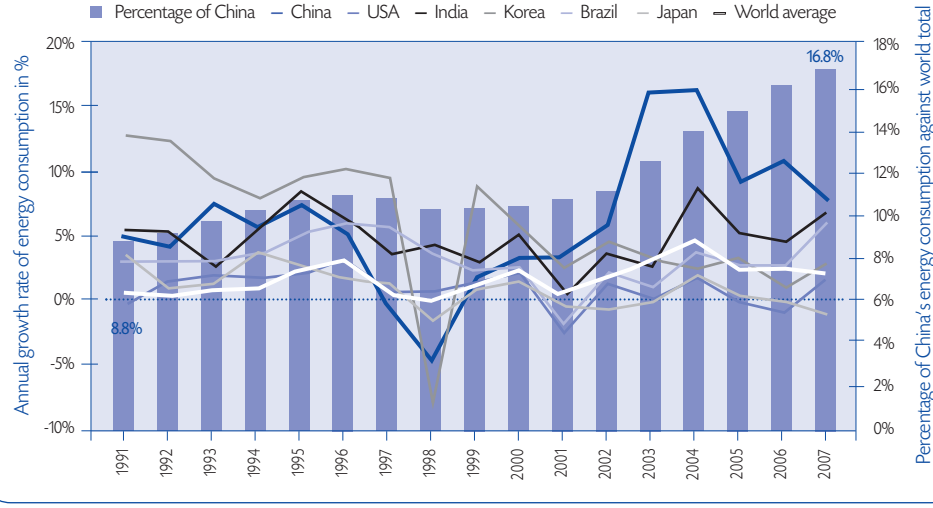


Source: Energy Research Institute of the National Development and Reform Commission in Beijing.

Globally, China's energy consumption growth rate since 2001 is much higher than in the world's average and developed countries, and has also surpassed those of rapidly developing countries such as India and Brazil. Energy consumption accounted for 16.8 percent of the global total in 2007, rising from 8.8 percent in 1991 and thus exerting a larger influence on world energy consumption.

Figure 24

Energy Consumption of Major Countries since 1990



Source: Energy Research Institute of the National Development and Reform Commission in Beijing.

The rapid growth of China's energy consumption is driven by the ongoing industrialization and urbanization process, and is also boosted by Chinese people's rising standards of living, which makes it a reasonable and inevitable phenomenon. But this unconventional growth has exerted enormous pressure on energy supply, and resulted in a negative impact on ecology and the environment, thus posing a grim challenge to China's sustainable development.

2.2.3. Energy Problems and Challenges in Future Development

The Chinese economy, with its rapid and unprecedented growth over three decades, has pushed itself into the top three countries in the world; nevertheless, its economic development levels are still low, considering its poor base and large population. In 2006, the world GDP per capita was US$7,158, while the Chinese GDP per capita of the same year was US$2,042, 28.5 percent of the global average and less than 10 percent of the GDP per capita of OECD members.

On the other hand, with its low level of economic development, its energy consumption has grown alongside the economy to 2.85 billion tons of standard coal in 2008, becoming the world's number two consumer, using 18 percent of the world's total. However, because of its large population base, energy consumption per capita in China actually lags far behind the world's average. In fact it is just 90 percent of the world average, less than 20 percent of the USA, and 30 percent of OECD members.

For the foreseeable future, China's top priority will be to develop its national economy, eliminate poverty, significantly raise people's living standards and build a well-off society in an all-round way to benefit the people. This means that the Chinese economy will keep its rapid growth, with accelerated industrialization and urbanization, rendering increasing energy consumption inevitable. Looking further ahead, to realize the economic development goals set for 2050, it is unavoidable that energy consumption will rise dramatically over the current level.

The experiences of developed countries demonstrate that in societies with clean environments, comfortable standards of living and convenient transportation, energy consumption per capita exceeds four tons of standard oil, with power capacity per capita of at least 1.5 kW and power consumption per capita over 6,500 kWh. If energy efficiency in China equaled that of Japan and Germany, the highest in the world, to achieve the fixed economic development goals for 2050, with its projected population of 1.5 billion, the total energy needed would be the equivalent of 6 billion tons of standard oil. This is 60 percent of the current world's total, and three times the current figure in China. This scenario must be avoided in the light of global warming and regional environmental protection issues. In any event, the situation is not likely to emerge because of the Chinese and global energy supply situation. But the irrefutable conclusion is that if the targeted economic development goals are to be achieved in full, energy demand will unavoidably rise dramatically over the current level.

Even if the demand could be met, domestic energy resources will not be enough. China is rich in coal resources, but scarce in oil and natural gas. As of the end of 2007, estimated reserves of coal in China make up 13.5 percent

of the world total, of oil 1.3 percent and of natural gas 1.1 percent. Because of China's large population base, the known energy resources amount per capita compared to the world average is 67 percent for coal, 6.3 percent for oil and 5 percent for natural gas. In the long run, the shortage of energy will become a bottleneck for social and economic development. In order to maintain economic growth, importing oil and natural gas will be inevitable, and this poses a challenge to China's energy security.

Environmental pollution caused by energy consumption is also an important factor hampering social and economic development. In 2006, more than 80 percent of the SO_2 (smoke and dust) emissions from energy consumption set a record of 20 million tons. Acid rain zones across the country accounted for 30 percent of the total area. With regard to water resources, water quality across the country is deteriorating, threatening crops, food safety and people's health. Experts estimate that the direct economic loss caused by pollution every year accounts for 1-2 percent of GDP, with the potential loss as high as 4 percent or even more.

Further, greenhouse gases, such as CO_2, from global energy consumption are affecting the global climate to such an extent that the very survival and development of mankind is threatened, making it a focal point of the international community. China is known for its massive energy consumption, as well as its energy consumption structure of coal as the major component. Currently its CO_2 emissions account for more than 20 percent of the world's total, making it a country with one of the highest levels of emissions in the world, second only to the USA. China's energy and environmental issues have inevitably become important to the world as a whole.

2.2.4. Energy Saving – the Inevitable Choice of Energy Strategy

China will face a host of problems and challenges in its future social and economic development because of energy shortages, energy security, ecological protection, and climate change. To confront and solve these issues is an extremely complicated project that will require enormous financial and social costs. Economization and raising energy efficiency is one low-cost method that can yield quick results and has no side effects. The experiences of successful energy-saving countries such as Japan, and the great effects on social and economic development which have resulted from China's efforts to raise energy efficiency and promote energy-saving in the past few decades, show that to raise energy efficiency and promote energy-saving is part of the long-term, effective solution to China's future energy problems. Because of this, China's energy development strategy has changed from "regarding coal as the basis and electricity as the center" to "giving priority to con-servation, promoting diversified development, protecting the environment, and building a stable, economical, clean and safe energy supply system to achieve sustainable energy development as a foundation for social and economic sustainable development". Thus prioritizing energy saving is identified as an important component of the energy development strategy.

Guided by this energy development strategy, in its social and economic development of the past few years, China has endeavored to optimize its energy structure, increase the percentage of low-carbon and non-carbon fuel use, and reduce the dependency of economic development on fossil fuels. As well as

efforts in energy production and supply, China has worked hard at exploring a brand new industrialization path of low consumption and emissions and high benefits and output in energy consumption. It is building an energy-saving, environment-friendly society, reforming the economic development pattern to realize the harmonious development of society, the economy and the energy environment. It is also promoting an energy-saving lifestyle to usher in a new wave of economization across the country.

2.2.5. Significance of Energy Saving in Buildings for Social and Economic Development

Clothing, food, shelter and means of travel are the fundamental needs of people's everyday lives. Whether for industrialized countries that embarked on rapid development a hundred years ago, or for emerging economic powers such as China, construction is at the core and is a benchmark of development. The social development goals defined a hundred years ago were to satisfy people's ever-rising material and spiritual needs, and in fulfilling these goals, global energy consumption has shot up a hundred times since a century ago. But human life still revolves around the basic necessities. Looking at the current status of developed countries, energy consumption can be divided into three equal parts: energy for production activities; energy for transportation; and energy for buildings. To date, the accumulated energy consumption of buildings accounts for more than 50 percent of total energy consumption. Thus energy saving in buildings can have a great effect on energy consumption.

China is in a period of heavy industrial development, with energy consumption mostly in industry. But for the foreseeable future, energy consumption in buildings and transportation will inevitably increase rapidly. The experiences of developed countries show a pattern of growth and energy efficiency in these two areas that will have a major impact on China's energy supply and demand, and its treatment of environmental pollution.

Currently, China's energy consumption in buildings is well below that of developed countries, but as an emerging economy, China is creating a market with the fastest growth in the world. China has 40 percent of the world's buildings and the area of new construction is increasing at an annual rate of 2 billion m^2. Energy consumption is also rising sharply. In 1978, buildings' energy consumption accounted for 10 percent of all energy consumption, but today, coal consumption for heating alone is 10 percent of all coal consumption. In a rough estimate, buildings' energy consumption today has increased to 20 percent of all energy consumption: the same as the nation's entire energy consumption at the end of the 1970s. With accelerated urbanization, expanding new construction, rising demands for housing quality, as well as new energy needs for transition zones, the projected energy consumption of buildings in 2020 is one third of all energy consumption, in other words, more than a billion tons of standard coal.

This prediction was made with full consideration of energy-saving factors. If energy-saving policies and measures are not formulated and implemented, demand for energy will rise by several hundred million tons more than the current figure. Thus the implementation of energy retrofitting for buildings will have a larger and larger impact on future energy supply and demand. In developed countries, energy-

saving in buildings has achieved remarkable results. Since the energy crisis of 1973, developed countries have paid a lot of attention to this need and, after 30 years the energy used by new buildings has decreased to between a third and a fifth of the original figures. Two billion m^2 of new construction appears in China every year, and it is predicted that by 2020, 40 billion m^2 of buildings will be added. If the current energy consumption level of buildings continues, 1.2 trillion kW of power and 400 million tons of standard coal will be consumed annually. If the energy consumption of the production of construction materials is included, by 2020 more than half of China's energy will be consumed by construction. If new buildings were to meet energy-saving criteria, and existing buildings underwent retrofitting phase by phase, by 2020, 420 billion kW of power, or 260 million tons of standard coal, could be saved annually. If 300 million m^2 of public buildings were constructed every year, at a calculation of a 50 percent energy-saving standard per m^2, 30 kg of standard coal per m^2 of public buildings could be saved, that is, 9 million tons of standard coal every year. This is equivalent to 10 coal mines each with a capacity of 1.26 million tons. In a nutshell, energy-saving renovation for buildings would have an enormous impact on future energy supply and demand in China.

Energy-saving work on new and existing buildings is carried out simultaneously. So far, this work in new buildings has made good progress. The relevant mandatory standards and regulations have been issued and the process of design, construction and examination is closely supervised. Energy efficiency labeling is being promoted to promote energy saving from a market perspective. Nevertheless, the observance of energy saving standards for new buildings is less than satisfactory and requires more commitment, or else it will prove difficult to renovate the several billion m^2 of new buildings that go into use every year.

In existing buildings, the work is an arduous task fraught with problems because of their large number, their wide geographic distribution, and insufficient policy guidance. Progress is difficult. The renovation target for existing buildings set by the Ministry of Construction for the 11th Five-Year Plan period is 25 percent for major cities, 15 percent for medium-sized cities, and 10 percent for small cities. By 2010, 13 billion m^2 of existing urban buildings must be renovated across the country. This target will be difficult to meet because of problems in financing, implementation mechanisms, and the measurement of energy saving for the renovation work. There is also a distinct lack of awareness of the potential social and economic benefits brought about by this work.

In light of China's social and economic development, especially with the background of the global economic recession, slack demand and employment pressure, boosting this renovation will have a direct impact on energy conservation, lightening energy supply pressure and increasing environmental protection. Furthermore, it can play a positive role in the following aspects.

Boosting Domestic Demand and National Economic Growth and Creating Job Opportunities

The construction industry is a mainstay in China, creating enormous social wealth and job opportunities. In 2003, it employed 4.8 percent of the nation's workforce, including

the rural surplus labor force of 30 million people, a third of all migrant workers.

In the current global financial crisis, real estate markets in developed countries as well as developing countries are facing a downturn, resulting in a shrinking of building material markets and the employment prospects of construction workers. The situation in the construction industry has led to an economic slump. To what extent are China's economy, which has maintained a rapid development momentum for 30 years, and the real estate markets affected by the global crisis? How long will the situation last? Experts' answers differ. But the fact is that real estate markets and the manufacturing industry are on a downhill run. Since October 2008, the industry's need for labor shrank, leading to a sharp rise in unemployment. Against the backdrop of expanding domestic demand, maintaining growth and solving unemployment issues, to expedite energy retrofits for existing buildings can not only save energy and alleviate urban environmental pollution caused by energy consumption, but also expand domestic demand and create more jobs, making a contribution to economic development and social stability.

It is estimated that as of 2006, the total floor space of buildings in cities amounts to 17.45 billion m^2. Seven percent of the buildings are energy saving, which means 16.23 billion m^2 have yet to go under renovation. If the task is to be finished in 10 years, at a cost of RMB200 per m^2, annual input will be RMB324.6 billion for 1.623 billion m^2 a year. If the GDP growth rate of 2009 is calculated at 8 percent, renovation for existing buildings will account for 1 percent of GDP and provide 9 million new jobs. Furthermore, energy saving in buildings can also boost related industry development, such as technological innovation in room-temperature control devices for home heating and control sets of heat supply systems, radiators and pipes. It can also lead to an improvement in heat preservation products for building envelopes in northern China, and promote the development of the construction material industry. Rough estimates claim that if renovation is carried out rigorously according to plan in the next 5 to 10 years, annual production values of the related sectors driven by energy saving in buildings will reach RMB100 billion, sufficient to push the national economic growth rate up by 1 percent.

Promoting Technological Innovation of Related Products and Enhancing International Competitiveness

Market demand is the driving force of technological innovation, while technological innovation in turn pushes market development. This is what economic restructuring in China has achieved over the past three decades. As a major country, China should foster its own R&D capability based on the vast markets. In recent years, with the rapid development of new construction markets, innovative products have mushroomed in the markets, some reaching world-leading standards.

The rejuvenation of China through science and education is mostly the result of government policy-backing and market development. To expand the market of existing building energy retrofits will create more space for intellectual activities in research institutes, driving them to meet specialized demands. For instance, there is a lack of sunshade products in China, and automatic controls for buildings' energy systems lag far behind world-leading standards. If, under the govern-

ment's guidance, the market for energy efficiency retrofitting is established, it will not take long for products independently developed by domestic teams to reach world standards. Similarly, independent innovation and application of energy saving products such as wall materials and energy saving doors, windows and rooftops will lead to the overhaul of building material markets, and the strengthening of exported products' competitiveness.

Raising Urban Residents' Living Conditions and Standards

Many residents in northern China will not tolerate wearing thick clothes indoors in winter, while using air conditioners in summer. Along with rising living standards, they expect more comfort and better living conditions. The renovation of existing buildings and a better capability to preserve heat will no doubt raise room temperatures in winter as well as in transition intervals before and after the heating period. It can shorten the amount of time using air-conditioning in summer. Thus people's need for comfort can be satisfied while energy expenditure is reduced, and in some cases, spending on air-conditioning rendered unnecessary. Money saved from reducing energy consumption can then be diverted to other areas to improve living conditions.

Promoting the City Image and Improving the Investment and Tourism Environment

As the saying goes, "fine clothes maketh the man". A city's image is reflected by the appearance of its buildings. In many cities, on both sides of the streets, there are matchbox-like old buildings with blackened exteriors and rusty windows, a direct contrast to the modern luxury buildings nearby.

In the large-scale renovation of existing buildings, when projects of heat insulation and sun-shading are carried out, the uniform flat rooftops can be replaced by sloping roofs of various designs, to strengthen the city's traditional cultural identity while adding a fitting sense of modernity. This can create a refreshing environment for investment and tourism, providing more space for the sustainable development of the urban economy and society.

Raising Property Values and Narrowing the Gap Between the Rich and the Poor

Renovated buildings will greatly improve in terms of exterior appearance, interior comfort and spending on energy, which will raise property values. Low- or medium-income families who have benefited from government welfare housing programs can reap sizable profits from leasing these houses or putting them on the market. If they decide not to, they can still appreciate the value added from energy saving renovation. Increasing people's wealth will help ease social issues caused by the widening income gap of urban residents.

Extending Building Lifespan and Reducing Energy Waste

In China, demolished buildings account for 40 percent of new buildings in terms of floor space every year. The average lifespan of buildings in many cities is 20 to 30 years, half the designed 50 to 70 years (while the lifespan of buildings in Europe exceeds 80 years). This short lifespan undermines the accumulation of wealth and leads to an enormous waste of energy.

Buildings in cities are a reflection of cities' history and culture. Demolition is not only a drain on wealth, but also the destruction of

cities' historical and cultural values. It means not only more energy consumption, but also more dust, noise pollution and waste. Experience shows that extending buildings' lifespan by renovation can directly conserve energy, but more importantly, help save resources, and indirectly also help accumulate more wealth.

To sum up, energy efficiency retrofitting of existing buildings not only eases the pressure of energy demand and environmental pollution faced by urban development but in current times of economic recession, slow demand and tightening employment pressure, it can also become an effective means of combating the financial crisis and boosting domestic demand and economic growth. In light of the various above-mentioned positive effects, it is also a realistic approach in implementing the Scientific Outlook on Development and building a harmonious society, and promoting sustainable urban development.

To solve the problems of capital, systems and technology in the process of renovation, all the relevant departments must recognize the significance of these undertakings, and coordinate their interests and resources into an overall plan. Renovation of existing buildings must be carried out under the theme of accelerating urban development, raising people's living standards and strengthening cities' competitiveness. Otherwise, if reduction of energy consumption alone is considered, and renovation results are measured only by the amount of energy saved, the financing and implementation of renovation works will be extremely difficult.

2.3. A Study of Examples and Problems of Energy Efficiency Retrofitting of Existing Residential Buildings in Areas with Heating in Northern China During the 11th Five-Year Plan

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2.3.1. Preface

It is stipulated in the *Notice of the State Council on Printing and Distributing Arrangements for Energy Conservation and Emission Reductions* (N°. 15 [2007] of the State Council), that during the period of the 11th Five-Year Plan, heat metering and energy efficiency retrofitting will be completed on 150 million m^2 of existing residential building stock across 15 provinces, autonomous regions and municipalities directly under the Central Government in Northern China. *The Notice on Printing and Distri-buting the "Plan of the Ministry of Construction for Implementing the 'Notice of the State Council on Printing and Distributing Arrangements for Energy Conservation and Emission Reductions'"* divides the task of retrofitting these 150 million m^2 between these 15 regions. *The Provisional Regulations on the Management of Reward Funds for Heat Metering and Energy Efficiency Retrofitting of Existing Residential Buildings in Areas with Heating of Northern China* (N°. 957 [2007] issued by the Ministry of Finance), grants financial subsidies for the 150 million m^2 of retrofitting projects. This includes RMB45 per m^2 in cold zones, and RMB55 per m^2 in extremely cold zones.

By the end of 2008, the 15 provinces, autonomous regions and municipalities directly under the Central Government in Northern China had retrofitted a total of 30.65 million

m^2 of building stock. The Central Government had appropriated a total of RMB 1.54 billion worth of subsidies and the task of energy efficiency retrofitting of existing residential buildings was well under way.

2.3.2. Policy Measures and Methods

By adhering to the principles of scientific development, using innovative models, and being practical and realistic, the government has formulated policies and systems that promote the energy efficiency retrofitting of existing residential buildings and has established mechanisms that will allow for its sustainable development.

• Clarify retrofitting targets. The sole target for this project during the period of the 11th Five-Year Plan is "to promote heat metering and energy efficiency retrofitting of 150 million m^2 of existing residential buildings in areas with heating in northern China", as stipulated in the *Notice of the State Council on Printing and Distributing Arrangements for Energy Conservation and Emissions Reduction* (N°. 15 [2007] of the State Council). It assigns the task to the 15 regions in accordance with factors such as their concentration of heated surface area, level of economic development, technolo-gical capabilities and foundation work;

• Formulate policy incentives. *The Provisional Regulations on the Management of Reward Funds for Heat Metering and Energy Efficiency Retrofitting of Existing Residential Buildings in Areas with Heating in Northern China* (N°. 957 [2007]), issued by the Ministry of Finance, regulates the awarding of funds for energy efficiency retrofit work on the basis of climatic region, and the nature and progress of the retrofit;

• Establish technological standards. *The Technological Guidelines for Heat Metering and Energy Efficiency Retrofitting of Existing Residential Buildings in Areas with Heating in Northern China, and the Heat Metering Technological Guidelines*, both issued by the Ministry of Housing and Urban-Rural Development, provide technological assistance for the development of this project;

• Innovate retrofitting models. The government encourages all regions to explore methods of financing that are suited to local practicalities and to mobilize the full force of all sectors of society, including heating companies, property management companies, property rights holding units, energy service companies, and local residents, to carry out retrofitting;

• Strengthen evaluation. This project has already become an important aspect of the State Council's evaluation system in the achievement of provincial government energy conservation targets, and constitutes an important means by which provinces, autonomous regions and municipalities directly under the Central Government can meet energy conservation and emission reduction targets.

2.3.3. Examples from Different Regions

Best Examples of Government Support

By formulating laws and regulations, and issuing policies, regions have been able to introduce rules and requirements for the energy efficiency retrofitting of existing residential buildings. The *Shanxi Provincial Regulations on Energy Efficiency of Civilian Buildings*, issued by the Shanxi Provincial Government, included a chapter with 7 articles dedicated to the "energy efficiency retrofitting of existing civilian buildings". This sets

out rules concerning the principles of energy efficiency retrofitting of existing buildings, its goals, sphere, content, implementing bodies, responsible departments and cost-sharing. The *Suggestions for Accelerating the Promotion of Energy Efficiency Retrofitting of Existing Buildings, issued by the Shanxi Pro-vincial Government, and the Notice on the Transmission of the Plan for Implementation of Heat Metering and Energy Efficiency Retrofitting of 13 Million m² of Existing Residential Building Stock Drawn up by the Financial Bureau of the City Construction Committee*, printed and distributed by the Tianjin Municipal Government, outline the guiding principles and thoughts behind energy efficiency retrofitting of existing buildings, and clarify its goals, duties and safeguards.

Regions have also increased the effectiveness of retrofitting by improving evaluation and strengthening public awareness of it. Municipalities such as Beijing and Tianjin have included energy efficiency retrofitting of existing residential buildings as part of their cities' key social engineering projects. Shanxi and Liaoning Provinces have signed responsibility pledges with local governments of municipal status and above concerning the energy efficiency retrofitting of existing residential buildings. The Ningxia Autonomous Region has incorporated energy efficiency retrofitting into the provincial government's system of evaluating relevant construction departments, and treats it as an indicator of the capacity and achievements of the construction departments of municipal governments.

Principle Examples of Fund-Raising

Drawing together provincial and municipal level complementary funds can be one of the most powerful means of driving work forward. Offices of the Inner Mongolia Autonomous Region and the Shanxi Provincial Government have issued notices requiring provincial finances to match Central Government finances one-to-one, and to draw up provincial level complementary reward funds for energy efficiency retrofitting.

Support may also be provided through the introduction of instruments to set up funding channels such as dedicated funds for encouraging retrofitting. Issued by the Office of the Ningxia Regional Government, *the Office of the People's Government of the Autonomous Region's Notice on the Printing and Distribution of Suggestions for Financial Support from the Autonomous Region for Energy Conservation and Emissions Reduction Work*, calls for the promotion of energy efficiency retrofit engineering, and the support of energy efficiency retrofitting by residents. Provincial and municipal finances of Beijing, Tianjin, Qinghai, Hebei, Heilongjiang, Sha'anxi, Henan, and Shandong have also provided financial support for energy efficiency retrofitting projects through measures such as dedicated funds, municipal funds for integrated retrofitting, and fiscal loans. All regions have actively mobilized individuals and groups such as heating companies, property management companies, property rights holding units, energy service companies, and local residents to take part in retrofitting, and tap into multiple channels for raising private funds to invest in retrofitting.

Principle Examples of Model Innovation

Different regions have actively innovated new models of retrofitting, adopting models organized around various individuals and groups such as property rights holding units, property management companies, heating

companies, energy service companies, or local residents. These have kick-started interest groups into action and raised private funds for investment in retrofitting. Meanwhile, focus has been placed upon synchronizing the implementation of other refurbishment work. Energy efficiency retrofitting of existing residential buildings can be made an integral part of compound renovation, including seismic renovations, or the refurbishment of old towns and urban villages.

2.3.4. Major Existing Problems

Insufficient Enforcement at Provincial Government Level

Many provincial governments have not incorporated this project as an integral part of their energy conservation and emission reduction work. They have focused, instead, on industrial energy conservation, leaving it up to departments in charge of construction to promote energy efficiency retrofitting of existing buildings. Government support at the municipal and provincial levels is simply not strong enough.

There is a shortage of the complementary policies necessary at the regional level. Until now, only Shanxi Province and the Inner Mongolia Autonomous Region have introduced fiscal policy incentives that complement exactly those of the Central Government. The fiscal support from a number of provincial level financial departments is insufficient, if at all existent. Many construction departments have had to rely solely on the funding of Central Government in order to carry out their work, making such a task extremely difficult.

Many evaluation mechanisms have yet to be set up. Except for Shanxi, Liaoning and Ningxia, the other provincial level governments have not included energy efficiency retrofitting of existing buildings as part of their evaluation systems for municipal energy conservation targets. Without binding mechanisms, ascertaining responsibility is unclear.

Obstacles of System Mechanisms

Reform in the area of heat supply systems lags behind and this has affected the progress of retrofitting. Heat metering retrofitting is a focal point of this project and is aimed at increasing residents' awareness of energy conservation by bringing into force consumption-based heat billing. However, under such a system, the profits of heating companies are bound to decrease after energy efficiency retrofitting has been carried out. This has meant that a number of heating companies have opposed the implementation of heat metering. Moreover, due to the slow progress of heat supply system reform in many regions, many areas still do not use cost-based heat pricing, meaning the installation of heat meters in such places could end up being wasteful and the meters themselves nothing more than decoration.

Relevant departments do not work in coordination with one another, hindering the progress of retrofitting. The heat metering and energy efficiency retrofitting of existing buildings is dependent on the cooperation and support of heating, energy conservation and construction departments. Energy conservation offices are primarily responsible for energy efficiency retrofitting, and heating offices for network management and the implementation of heat metering. However, depending on local organizational structures, energy conservation offices may come under either the local Development and Reform Commission, or the Economic Commission,

with the heating office coming under the Housing Bureau. This can cause systemic issues with the local Construction Commission and Construction Bureau. With each respective body looking after its own duties, it makes smooth coordination very difficult and unified implementation of retrofitting impossible, inevitably causing project work to suffer.

In addition, the cost-based heat pricing mechanism has yet to be truly formed, which has limited the implementation of heat metering. The potential for energy efficiency retrofitting to bring about energy saving behavior has also yet to be realized. It has been very difficult to motivate heating companies to carry out retrofitting. Because the payback period for retrofitting is often quite long, and in conjunction with the rapid increase in energy prices of recent years, heating companies' profits have already been tightly squeezed, with some even showing losses, making it very difficult for them to find the capital to fund energy efficiency retrofitting.

Financial Guarantees Have Become the Greatest Obstacles

Firstly, local fiscal support is insufficient. In areas where the growth in retrofitting has been quite promising like Inner Mongolia and Shanxi, local fiscal support has, at the very least, matched the amount allocated to the regions by the Central Government, allowing for sufficient funds to organize the implementation of retrofitting. In areas where such complementary financial support has not been forthcoming, progress has invariably been slow. Secondly, the mechanisms needed for multi-channel fund raising have yet to be established. Looking at the situation in various locations shows us that the development of this project is still fundamentally reliant on funds awarded by the Central Government. Fund-raising channels such as heating companies, residents, property management companies, energy service companies and financial institutions are yet to set up appropriate mechanisms. In addition to this, there is a lack of start-up capital. Central Government fiscal funding is granted as a form of supplementary capital, awarded after the work has been started. Thus it is very difficult for it to meet a project's initial requirements. The most crucial area of retrofitting work is having start-up capital to begin the whole project. If the Central Government's funds could be awarded on a different basis, it would certainly help to develop the retrofitting sector a great deal more.

Finding a Model of Retrofitting that Suits Nationwide Promotion Still Requires Exploration and Refinement

Regions have already explored various modes of retrofitting and means of financing that take local conditions into consideration, including the government-led promotion model, the heating company investment model, the proprietor investment model, and the energy contract management model. However, despite this, there remains to be found a model of energy efficiency retrofitting that is systematic, easily reproduced and that can drive the retrofitting movement on a national level. This would be one that incorporated clearly defined means of fund raising, retrofitting organs and repayment methods, and one in which all parties were actively involved and able to share in the common benefits.

2.3.5. The Next Stage and Recommendations

Increase Recognition, Clarify Mandates, Enforce Responsibilities

Energy efficiency retrofitting of existing buildings should be used as a foothold to broaden domestic demand, ensure growth, carry out restructuring, and improve people's livelihoods. It is an important means of developing low energy consumption and green building. The responsibility of carrying out retrofitting should be enforced through people, policies, standards, projects, and checks.

Be Goal-Oriented, Insist on Principles, Progress Scientifically

Energy efficiency retrofitting of existing residential buildings is, from start to finish, aimed at improving residents' heated environment, cutting down locals' heating costs, and limiting energy consumption. All the while, during this process, attention must be paid to legal procedures, planning guidelines, project selection, ensuring the quality of engineering, and carrying out energy-efficient evaluations properly.

- Establish a baseline. Complete a sound evaluation of energy consumption. Define very clearly the level of energy consumption and characteristics of existing local residential buildings;
- Investigate properties. Listen to ideas of relevant parties, and grasp what hopes they have from retrofitting. Do your best to meet their demands;
- Formulate a plan. Based on the quantity of retrofitting projects and their distribution, and in view of the overall urban plan, scientifically draw up an energy efficiency retrofit plan;
- Draw up an annual plan. On the basis of project characteristics and location, incorporate the foundation laid by earlier work to formulate an annual retrofitting plan involving gradual implementation of more and more challenging projects;
- Clarify projects. An integrated approach must be used to consider elements such as building lifespans, potential energy savings, and investment returns. Scientifically analyze residential building projects that are worth retrofitting;
- Respect procedures. Go into the housing estates and streets to hear the ideas of local stakeholders and gather expert evidence. Retrofit projects must be designed, carried out, inspected, and evaluated in accordance with construction procedures;
- Strengthen checks. Provincial level governments should incorporate energy efficiency retrofitting of existing buildings into their evaluation systems for municipal energy conservation targets. Completed retrofit projects should appoint energy efficiency evaluation agencies to carry out post-retrofit energy consumption and workload evaluations;
- Strengthen capacity. Coordinate the active cooperation of relevant authorities such as departments of finance, and development and reform. Organize the training of management, technical and construction personnel, which will improve the quality of service and ensure high-level, high quality retrofitting.

Innovate New Mechanisms, Overcome Obstacles, Open Up Opportunities

Innovation is needed in five areas of energy efficiency retrofitting: innovation of its mechanisms; innovation of its systems; innovation of

its financing; innovation of its technology, standards, and products; as well as innovation of the modes of retrofitting itself. Second, is the need to overcome three kinds of obstacles faced by such work:

- Systemic obstacles. When developing new energy efficiency retrofit projects, there are a number of complementary aspects to deal with outside of the system itself such as in development and reform, city management, and telecommunications. This requires the formation of a system of multi-disciplinary meetings. Within the system, the power of various departments such as overall planning, housing, and construction must be mobilized together to promote the work of energy efficiency retrofitting;
- Mechanism obstacles. The goal of energy efficiency retrofitting is to save money, and saving money can provide room for mechanism innovation. Heating companies, property management companies, and ESCOs etc. should be spurned into action to explore new modes of retrofitting that carry common benefits;
- Financing obstacles. The dependency of mechanisms on government fiscal subsidies for retrofitting needs to be broken. Governments, banks, societies, companies and individuals should dare to apply the funds available to them, such as maintenance funds, heating guarantee funds, and structure reform funds, to invest in retrofitting.

Advertise Well, Listen to the People, Foster an Atmosphere

Experience must be taken stock of constantly in order to read developmental trends accurately. Common problems must be dealt with efficiently, regulations adhered to, and the most advanced examples promoted. Exchange and learning between regions must be strengthened through mutual communication via conferences and symposiums. Training of personnel at the local level should also be improved. In bodies of State administration, technology companies and construction industries related to energy efficiency retrofitting, dissemination training should be initiated, thus improving their business capacity for retrofitting.

Dissemination work should be intensified. By increasing the re-cognition of energy efficiency retrofitting among local residents, heating companies, and other concerned parties, support and opportunities in all levels of society will be created.

Enforce Standards, Tighten Regulation, Carry Out Sound Evaluation

National standards, directives, plans and guidelines must be strictly adhered to in the development of energy efficiency retrofitting. Supervision and management must be strengthened at each stage, from project feasibility, through design, construction and completion acceptance. In accordance with the requirements of the *Regulations on Evaluation of Heat Metering and Energy Efficiency Retrofitting of Existing Residential Buildings in Areas with Heating of Northern China*, agencies that have been commissioned to carry out energy-efficiency evaluations must evaluate projects one by one, and link the findings directly to the payment of Central Government funds, granting the most energy-efficient retrofit projects with reward fund subsidies.

Conférences
& Séminaires

2.4. International Experience: Energy Efficiency in Buildings in France

Mr. Michel Hamelin, Deputy Director, International Affairs Division, ADEME (French Environment and Energy Management Agency)

2.4.1. A Rapidly Evolving Situation

Environmental Constraints

The most recent report released by the Intergovernmental Panel on Climate Change (IPCC) confirmed that the average temperature of the Earth's atmosphere would rise by 1.5 to 6°C by the end of the century. The actual extent of the rise will primarily depend on the scope of public policies implemented by the countries that consume the greatest amounts of energy and the dates upon which those policies are introduced.

Global warming has already caused disturbances to our climate, with extremely serious repercussions for humankind, and the future looks even bleaker. To limit these repercussions and guarantee the sustainable development of our societies, it is now generally agreed that world greenhouse gas emissions must be halved by 2050, with reference to the 1990 level.

A Firm Political Objective

"By virtue of the principle of shared but differentiated responsibility", **industrialized nations need to reduce their emissions by a factor of four or five within the next fifty years**. France has already adopted this objective as part of its National Strategy for Sustainable Development introduced in June 2003 and its Climate Plan introduced in July 2004, and incorporated in the Energy Policy Act in July 2005.

Meeting this objective will enable us to maintain tolerable concentrations of greenhouse gases in our atmosphere, calculated at 450 parts per million (ppm), compared to today's 380 ppm and some 280 ppm during the pre-industrial era.

Consequences for the Building Sector

In the building sector, average annual energy consumption is currently close to 400 kWh of primary energy per heated m^2. With the urgent call to reduce CO_2 emissions, combined with the inevitable energy cost increases caused by the gradual depletion of resources, the average primary energy con-sumption of operational buildings needs to be reduced to approximately 100 kWh per m^2 by 2050, including some 50 kWh per m^2 of primary energy for heating the premises and providing hot water.

The Building Sector: Pulling its Weight

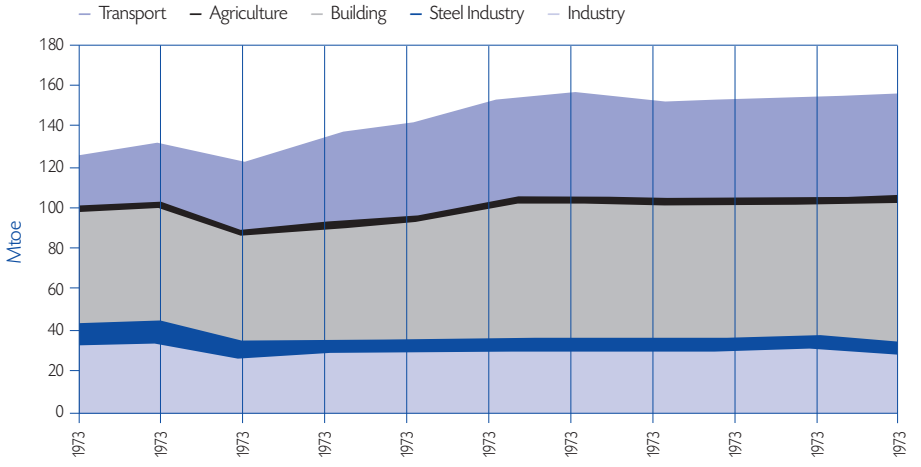
The Biggest Energy Consumer

In France, the building sector is the biggest energy consumer across all economic sectors, consuming some 70 million tons of oil equiva-

lent (toe). In other words, this represents 43% of total final energy, and 1.1 tons of oil equivalent is consumed annually by every French citizen.

Figure 25

Energy Consumption by Sector in France



Source: ADEME, Key Figures for the Building Sector, 2009.

The consumption of this energy produces 120 million tons of CO_2 emissions, representing 25% of France's emissions nationwide and 32.7 million tons of carbon. This quantity is of the same magnitude as the amount of building-site and household waste, and is equivalent to one-half ton of carbon released into the atmosphere every year for every French citizen. All of these figures need to be reduced by 75% by the year 2050.

A Slow Developer

However, the annual volume of new construction (300,000 housing units and 14 million square meters of heated commercial and office buildings), the current stock of buildings (nearly 30 million residential units and over 814 million m^2 of heated commercial buildings) and their extremely long service life are, in general, negative factors for rapid progress in the sector.

While the sector's rigidity and inertia have long been considered handicaps compared to more dynamic sectors like industry and transport, the building sector is now considered in a much more favorable light.

New Horizons for the Building Sector

A Key Player

The building sector is now set to play a significant role in tackling the troubling environmental challenges that we are now facing.

Just recently, it has come to light that this sector may be the only one capable of making sufficient progress to enable France to meet its national commitments with regard to reducing greenhouse gases.

Paths of Development

The paths of development in the building sector can be much more easily identified now than in previous years thanks to a greater understanding in various areas:

- Buildings may draw on several energy sources, including energy from renewable sources. These energy sources can be combined. In fact, in some cases energy sources may change several times over the life of the building;
- Improvements to the energy performance of buildings can be scheduled over several years. Each new development increases the value of the property;
- A building's occupants engage in relatively constant behavior over time. Their needs tend to evolve over long cycles, without sudden changes, and can be reasonably well anticipated.

2.4.2. The Grenelle Environment Forum: Reducing Emissions by 75% is an Achievable Objective

The Grenelle Act confirms that France has undertaken to reduce its greenhouse gas emissions by a factor of four by the year 2050, in keeping with legislation enacted in the Energy Policy Act of July 13, 2005, which sets energy policy guidelines (stipulating a reduction in greenhouse gas emissions of 3% per year). This long-term political commitment presupposes a collective effort, at least within the European Union.

This objective was inspired by the work of the Intergovernmental Panel on Climate Change (IPCC) and reflects a convergence objective at global level to succeed in reducing emissions to two tons of CO_2 per inhabitant by 2050. France is rather well positioned in comparison with its European neighbors: emissions per inhabitant are lower than the average and it will likely be one of the only European countries to respect the commitment it made in the framework of the Kyoto Protocol.

In France, the "factor 4 objective" (dividing 1990 emissions by 4) is achievable. First, consumption must be decreased; second, energy from renewable sources must be developed to further reduce greenhouse gas emissions stemming from the country's energy production. The revival of an energy efficiency policy, accompanied by the massive development of energy from renewable sources, will be sufficient to meet the challenge. Moreover, France is not working alone to meet this goal. The European Community has proposed concerted objectives in the framework of its energy package. It all comes down to reaching two specific goals: (i) reducing greenhouse gas emissions by 14% by the year 2020 (excluding negotiable permit systems), and (ii) producing 23% of total energy consumption from renewable energy sources.

Although at the European level decisions are currently focused on these two objectives, it should be noted that energy efficiency is an indispensable prerequisite to comply with these commitments.

Over the past 15 years – during which the particularly low energy prices worked against energy management policies – France saved nearly 10 Mtoe of energy. According to ADEME, using currently known technologies, it is possible to envisage sources of additional energy savings of the order of 35 Mtoe by the year 2020, apportioned between industry (10 Mtoe), buildings (15 Mtoe) and transport (10 Mtoe).

This progress will be possible – without sacrificing growth – through the development of new markets, the use of economic leverage, and the mobilization of society.

The "factor 4" objective offers perspectives for economic development and the conquest of markets in numerous rapidly growing activities which will generate strong job creation.

Energy management and the development of renewable energies currently represent a market of €33 billion and 220,000 jobs in France. According to studies conducted by ADEME, development perspectives for 2012 on the basis of the objectives of the Grenelle Environment Forum give reason to believe this market and related jobs will double by 2012, thus totaling €70 billion and 440,000 jobs.

The achievement of these objectives would thus have a positive effect on the economy (a two percentage point increase in GDP by 2020) even when the costs of implementation (shared between individuals, economic actors, and the central government) are taken into account. The positive impact of energy conservation on the exterior balance would favor growth and rekindle the ambition of reducing France's energy dependency. The development of rail transport, energy management in the building sector and biofuel production would offset economic and job losses in the energy sector by a large margin.

Over and above the exemplary nature of this project, economic and social interests alone are sufficient to justify its implementation. It should be pointed out that numerous studies (*e.g.* the Stern report and the reports of the IPCC) agree that the cost of doing nothing would be substantially higher than the cost of taking action: the ecological transformation of society is an obvious choice.

2.4.3. Energy Efficiency in the Building Sector: the First Priority

The Reduction of Energy Consumption in Buildings

The Environmental Stakes

The building sector is the sector that consumes the most energy in France. This sector alone consumes 70.6 million tons of oil equivalent (70.6 Mtoe), or 43% of total final energy. It is the second largest producer of GHG emissions, behind the transport sector, with 91 Mt of CO_2 equivalent emitted annually, or 25% of emissions nationwide.

Between 1990 and 2006, the building sector's GHG emissions increased by 14%. The transport sector's GHG emissions also increased (by 20%), while emissions due to industry, energy production, agriculture and waste processing went down.

Two-thirds of the sector's energy is consumed by residential units and one-third by the commercial (or tertiary) sector. Heating represents 70% of the building sector's energy consumption.

Currently, the average rate of consumption by existing buildings is 240 kWh of primary energy (kWhPe) per m^2 per year (but some buildings consume up to 400 or 600 kWhPe per m^2 per year) while the rate for new construction is between 80 and 110 kWhPe per m^2 per year. There is substantial room for improvement. For example, a French household consumes nearly 30% more energy than those in the highest rated countries, such as the Netherlands; for heating, consumption per m^2 – corrected for climate – is two times higher in France than in Norway, where buildings are particularly well-insulated.

Solutions Exist
and Can Be Implemented Immediately

Renovation solutions for existing buildings are not technically complex: they include insulation of attics and walls, replacement of windows, controlled ventilation, installation of energy-efficient boilers or heating via renewable energy, etc. In France, the number and quality of these renovations are insufficient in the face of what is at stake and in light of the potential, particularly when compared to other European countries. For example, less than one renovation out of 10 is considered satisfactory from the standpoint of energy efficiency.

The widespread renovation of existing buildings is where the major thrust of the work is required. There are currently 31 million residential units in France, totaling 2.7 billion m^2 (26 million main residences, three million secondary residences, two million vacant units; 17 million single-family dwellings and 14 million collective units) and 850 million m^2 of commercial or office buildings. The buildings that consume the most energy are those constructed during the "Glorious Thirty" (1945-1975). New buildings (430,000 new residential units in 2006 and 12 million m^2 of new commercial buildings per year) represent only about 1% of the existing stock.

If we are to act quickly, we must therefore take action on existing buildings. ADEME evaluates the potential energy savings at between 15 and 20 Mtoe by the year 2020, depending on the intensity of the support measures implemented between now and then.

The Economic Stakes

Building Renovation,
an Economic Sector in its Own Right

The building renovation sector represents estimated total revenues of €9.1 billion (not including renovation work on commercial and office buildings), growing by 9% between 2006 and 2007.

The sector employs nearly 100,000 people (in direct jobs, excluding commercial and office buildings, and new construction), an increase of 3% between 2006 and 2007.

Thanks to the Grenelle Environment Forum, the sector is set to gain momentum.

With the implementation of the Grenelle objectives, the sector's total revenues should more than double by 2012, reaching €18 to €22 billion per year.

The increase in revenue in the thermal efficiency sector, which is job-intensive and not conducive to relocation, will more than offset losses in the electricity production and fossil fuel distribution sectors. For residential and commercial work combined, the net gain between now and 2012 is estimated at almost 120,000 direct jobs.

Detailed Objectives of the Building Plan

The Objectives Are Ambitious...

For new construction, the goal is to continue to promote the widespread use of all available best practices by raising the energy performance objective, culminating in the construction of Low Energy Buildings (LEB) in 2012. These buildings are defined as buildings consuming less than 50 kilowatt hours of primary energy per m^2 per year for regulated uses (*i.e.* heating, hot water, air-conditioning, ventilation, auxiliary lighting and heating). Then, beginning in 2020, the goal will be the construction of positive energy buildings (which produce more energy than they consume).

For existing buildings, the twofold objective must be to:

- Maintain the current high number of small renovation jobs (in nearly three million residential units annually) while promoting the systematic use of the best performing equipment;
- Expand major renovation operations for the buildings which have the highest energy consumption (currently about 40,000 units every year), with the goal of gradually reaching 400,000 major renovations per year beginning in 2012.

But Realistic...

These objectives do not require technological breakthroughs: the equipment already exists and "model" operations are on the rise (*e.g.* new LEB buildings – consuming less than 50 kWh per m^2 of primary energy – as well as positive energy buildings and major renovations). The call for projects managed by ADEME in partnership with the French Regions under the label PREBAT Demonstration Buildings has resulted in the selection to date of nearly 300 demonstration buildings (including both newly constructed and renovated buildings) in seven pilot regions. By the start of 2010, there will be between 500 and 1,000 of these buildings in the 22 currently participating regions. The goal is not to invent the future with each new building, but to bring existing technologies into widespread use.

These objectives currently require an investment cost premium, which is recovered by savings on energy bills. For example, based on the initial projects, a new LEB building requires a cost premium of about 10 to 15%, which is offset in approximately 15 years (or in about 11 years after the Grenelle incentive measures). This additional cost can even be almost nil depending on initial design choices.

Concerning the renovation of existing buildings, the average cost of light renovation work is €3,800 and is depreciated over a three- to fifteen-year period (for attic insulation work, the investment payback period is reduced by 25% by Grenelle incentive measures; window replacement is depreciated over 15 years). The average cost of heavy renovation work is between €15,000 and €30,000 and is recovered over a ten- to twenty-year period without additional aid, while the Grenelle incentives reduce that time by four years.

Even though these investment payback periods may seem long, they are shorter than the service life of the investments, making them profitable in the long run. And though these service life spans are appropriate on a nationwide scale, there is a need for a more effective communication effort aimed at individuals.

It is important to point out that these payback periods are diminished as the cost of energy rises. For example, an exemplary work package (including exterior insulation, replacement of windows, hygro-adjustable controlled mechanical ventilation, condensation boiler with thermostatically controlled valves and solar domestic hot water) designed to totally renovate a single-family house heated with fuel oil costs approximately €24,000 on average. This work will reduce energy consumption by 64%. If the price of fuel oil increases by 3% per year, the net payback period for this investment is 13 years without public aid, 11 years with current subsidies and 9 years with the Grenelle subsidies (such as the already announced zero-interest-rate eco-loan). The latter payback period, including the Grenelle measures, is reduced to 6 years if the cost of fuel oil increases by

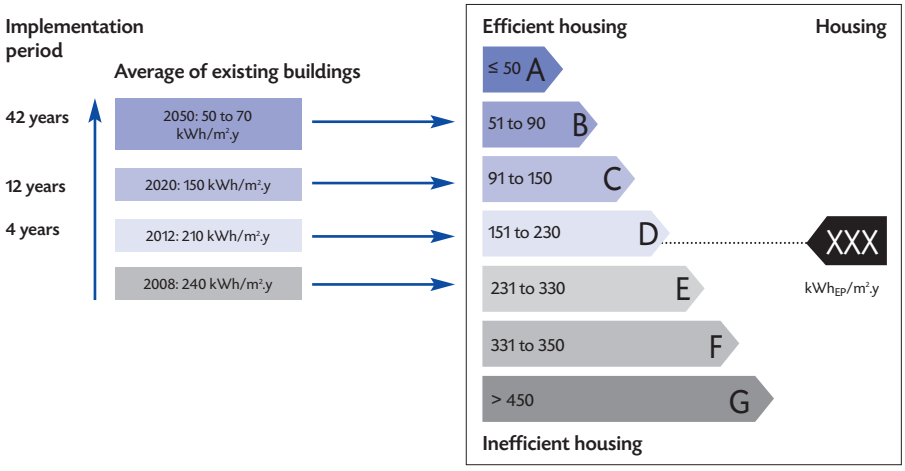
6% annually, and to less than 3 years if fuel oil increases by 12% annually.

The objective of 50 kWh in primary energy for regulated uses per m^2 and per year (*i.e.* the LEB building) is attainable by all the best energy techniques, including direct electric heating.

The goal of consuming less than 50 kWh per m^2 per year is a global criterion used to define a building's energy efficiency and can be attained by working to increase efficiency in several areas, including heating and hot water in particular, but also air-conditioning, ventilation and auxiliary heating and lighting, with careful attention to the integration of energy from renewable sources.

Figure 26

Upgrading the Energy Performance of Existing Buildings



Source: ADEME.

Primary Energy, Final Energy and the CO_2 Content of Energy

The comparison of heating systems in a building using different energy sources is generally performed in terms of primary energy in order to take into account the various conversion and distribution losses which affect each secondary energy sector, and which have an impact on the national energy balance.

When determining compliance with thermal regulations for buildings, the response to the building's energy needs is calculated as follows:

- For fossil energies used directly as a source of heat (*e.g.* gas): primary energy is equal to final energy, *i.e.* to the total volume of energy consumed and billed on a metered basis;
- For electricity used for heating, the computation is more complex since the electricity is produced from various sources (nuclear, hydraulic, fossil fuels, etc.). In France, the conversion factor between primary energy and final energy is 2.58 (source: MEEDDAT), which means that in view of the energy mix in France, 2.58 kWh of primary energy are

required to obtain 1 kWh of energy in the form of electricity. The rest (1.58 kWh) is accounted for by inevitable energy losses, primarily dissipated into the atmosphere, oceans or rivers by the cooling circuits of nuclear or fossil fuel power plants. The primary energy of electric heating thus corresponds to 2.58 times the electric energy consumed as measured at the building's meter (final energy).

Similarly, for the carbon content of energy, the physical reality of emissions produced by fossil energies is simple (the emissions are proportional to the physical quantities consumed), while the computation for electricity must take the production mix into account and requires conventional approaches. Although in Europe, France benefits from the lowest CO_2 mean emissions from power production (70g of CO_2 per kWh in France *vs* 370g of CO_2 per kWh on average in Europe) thanks to its reliance on nuclear and hydraulic production sources, this ratio conceals some very wide disparities, depending on the season or time of day. Two methodological approaches are used to determine the CO_2 content attributable to electric heating.

Conditions for Success: Structure Commercial Offers to Meet Growing Demand

Support for the Structuring of New Offers

The economic fabric of the building sector is characterized by the coexistence of a number of very large firms (including such global leaders as Bouygues, Vinci, and Saint-Gobain), about a hundred medium-sized equipment manufacturers (of electric heating appliances, boilers, solar energy systems, heat pumps, ventilation systems, windows, materials, etc.), and thousands of small businesses in the building and public works sector (performing insulation work, the installation of windows and heating equipment, etc.), as well as individual tradespersons and self-employed professionals (consultancy firms, architects and so on).

The sector's capacity for adaptation is a key success factor for the building plan. Professionals are aware of this and are rallying around this goal: the sector is more attractive and is endeavoring to respond to a dual challenge, which is both quantitative and qualitative.

In fact, there was a steady rise in the sector's workforce in 2007. Over 207,000 young people are currently in initial training in the building sector – a record figure that responds to the need for the injection of young blood into the profession's age pyramid.

From a qualitative point of view, best practices in the area of energy efficiency are still insufficiently develope, but the supply of new offers is expanding.

To support the planned strengthening of thermal regulations for new and existing buildings – and the introduction of required renovation work beginning in 2012 – incentive measures must be put in place to encourage renovation work exceeding current standards.

A certain number of tools are already in place, the main one being the tax credit to promote energy conservation and the use of renewable energies; another important resource is the Sustainable Development savings passbook, which has resulted in a tenfold increase in the supply of bank loans dedicated to the thermal improvement of housing. Thanks to the additional funds collected (over €10 billion), all French banks now offer loans specifically targeted to achieve this purpose

at a lower interest rate than traditional loans. On its website, ADEME offers Internet users the opportunity to compare these eco-loans.

Finally, it should be remembered that there are no additional financing measures for the commercial sector. Energy savings certificates would facilitate the sharing of efforts between the central government and energy distributors.

For the public sector, a decision is being held up by the complexity of public financing rules, which do not always permit an additional cost investment, even when such an investment is profitable in terms of total lifecycle cost thanks to the operational savings it generates. Recourse to Energy Performance Contracts ("Contrat de Performance Energétique" or CPEs) should therefore be facilitated, and administrative departments should receive more effective support in their technical negotiations with private operators.

A New Tool Aimed at Financing the Renovation of Public Buildings: Energy Performance Contracts (CPEs)

Germany's somewhat wider experience in this area can offer some lessons on CPEs: the contracts are entered into for a period of seven to twenty years, with guaranteed energy savings ranging from 10 to 25%. The building's minimum annual energy bill must amount to €75,000 to €100,000 (or €250,000 for a pool of buildings), which is equivalent to a minimum surface area of 5,000 m^2 in the commercial sector. The measures implemented primarily concern initiatives related to behavior, energy management and equipment; practically no measures exist for the renovation of the building's shell.

To support the development of CPEs in France, a variety of actions need to be implemented, including measures to inform and train contracting authorities on the details of these new contracts, actions to improve the reliability of the contractual framework, with the objective of developing high-quality CPEs, particularly in terms of the verification of guaranteed energy savings and evaluation procedures.

Energy Savings Certificates: a Major Financial Instrument

Transforming Energy Suppliers into Suppliers of Energy Efficiency Services

Energy Savings Certificates ("Certificats d'Economies d'Energie" or CEEs) were established by the Energy Act of July 13, 2005. This new plan is based on motivating energy suppliers to seek out potential energy savings in a variety of environments (currently in residential and commercial buildings):

- The State imposes an obligation of energy savings on these businesses (the obligees); they must comply with this obligation or face financial sanctions. The total obligation for the first period (2006-2009) was set at 54 billion kWh (54 TWh) cumac (*i.e.* accumulated and discounted ["cumulés et actualisés" in French]), amounting to a nationwide reduction in consumption of 0.2%;

- These obligees can conduct energy conservation programs for their customers and thus obtain CEEs. They also have the option of resorting to the market by buying CEEs from third parties (public bodies or businesses), which are also entitled to engage in these programs. They may also pay a penalty to release themselves from their obligation.

An Effective and Innovative Measure at Limited Cost for the State

In brief, the plan is a market mechanism based on an obligation of results: the public authorities determine the quantity of energy savings to be achieved, and the economic actors are then free to define their strategy and conduct their own programs.

The measure is designed to favor the most economically profitable sources of energy savings, without requiring budget resources. Moreover, it encourages the energy market to evolve toward the supply of services, which creates added value for these economic actors.

This type of measure is arousing keen interest at international level. The United Kingdom (which introduced such a plan in 2002), Italy and France are forerunners in this regard; and the Netherlands, Denmark, Ireland, Japan and the American State of California are closely studying the introduction of similar measures.

The first period, which will end on June 30, 2009, is a learning period for all the participants. Even though preliminary results recorded to date are modest in scope, they are very encouraging and confirm the effectiveness of this measure in actual practice.

It is now necessary to define the components of the plan for the second period (2009-2012). Compliance with the objective of the "Grenelle Environment Forum" will require a target 14 to 18 times as high as the previous one (*i.e.* 14 X 54 = 756 TWh cumac for the second period).

To facilitate the implementation of this measure, consideration is being given to extending the obligation concept, currently limited to energy suppliers, to major landlords and building owners in the commercial sectors. These businesses would be subject to an energy savings obligation on the basis of the energy consumption of all their property holdings, according to a "polluter-payer" type principle.

- The CEE plan could also be extended to the more diffuse field of transport, and to fuel suppliers in particular. The potential energy savings attainable in this sector are estimated at 216 TWh cumac, in line with the Grenelle objectives adopted.

The total obligation would thus be set between 756 and 972 TWh cumac

According to ADEME's estimates, this objective is attainable with a rather limited effect on energy prices if it is passed on to consumers (resulting in an increase of less than 5% distributed over three years). Instead of passing on this charge in the energy sales price, however, energy suppliers are proposing doubling the current obligation.

Special Measures for Lower-Income Households

Following the example of the British plan, where 40 to 50% of programs must be carried out in lower-income households, the French measure could include a social objective.

The application legislation could provide for bonus credits for energy-saving programs implemented in households in situations of instability regarding access to energy. However, this type of incentive measure would not provide a guarantee of results. It is also possible to set quotas: for example, focusing 10 to 20% of the total CEE obligation on this target group would enable 100,000 lower-income households to receive assistance in improving the energy efficiency of their dwellings.

Conférences & Séminaires

Part 3. Technical Issues Related to the Definition of an Energy Efficiency Retrofitting Program

3.1. Main Steps to Determine the Energy-Saving Potential, Investment Costs, and Cost Effectiveness of Different Energy Efficiency Retrofitting Strategies

Mr. Michel Raoust, General Manager,
TERAO Green Building Engineering

This presentation describes the adopted methodology to estimate the energy-saving potential of a large-scale thermal rehabilitation in the city of Wuhan to assess the corresponding investment costs and the cost effectiveness of typical rehabilitation strategies adapted to typical buildings.

The work exposed below describes the employed methodology and illustrates the steps with figures from the work of both Chinese and French partners.

3.1.1. Global Statistics

The approach first requires defining Wuhan's building stock, mainly in terms of floor area, types of buildings, construction products, and HVAC equipment.

This first step is about statistics. The floor area separates public buildings from housing and shows a proportion of 56% of housing and 44% of public buildings. That makes a total public building floor area of about 74.8 million m^2. Among these buildings, the distribution of floor area for different building types is also necessary. For instance, it was determined that administrative buildings represent 6.9% of public building surface area, but a later chapter about energy consumption will show they are not the most energy consuming type. Indeed, administrative buildings, as well as office building,s statistically consume less than 100kWh/m^2/year end-use energy. Hospitals represent 4.2% of public building surface area, but are identified as highly-consuming buildings, statistically above 200kWh/m^2/year.

Secondly, we have observed that construction products in Wuhan are not diversified. There was an evolution in the use of construction materials in past decades, but nothing related to the energy performance of the envelope. Therefore, the envelope quality in Wuhan is basically poor and this fact is observed in most cases. Buildings built before 1980 are mostly made of 240 mm brick wall. After 1980, the 190 mm hollow brick appears more and more. This change has some impact on the energy used for the fabrication

of materials and the amount of demolition waste. Regarding windows, 3-5 mm single pane type windows are widely used, leading to poor performance both in winter and summer. Most roofs are not insulated.

3.1.2. Energy Survey for Detailed Statistics

A more detailed study on a sample of 389 buildings was implemented so as to have a deeper knowledge of the energy consumption for different types of buildings and their HVAC equipment. The total area included in the survey is 3,963,497 m^2. 47% are administrative buildings with a floor area greater than 3,000 m^2 and 13.4% are large public buildings with floor area greater than 20,000 m^2 It shows that the energy consumption and type of HVAC equipment are quite diversified according to the type of building.

Table 1 *Energy Consumption of Different Types of Buildings*

Before such a program, awareness of energy efficiency in Wuhan was low. Therefore, within the survey sample, many figures were irrelevant. This is due to wrong reporting or missing data. As a result, 101 buildings were checked more carefully among the 389 that were initially considered. This enables us to remove meaningless data and improve the quality of the statistics. In this latter sample, 51 buildings are administrative buildings and 50 are large public buildings. It is meant to be representative of Wuhan's public building stock, except for the small-size buildings that are more likely to be destroyed than renovated.

	Total Consumption	HVAC Consumption	Cooling	Heating	HVAC Proportion
	kWh/m^2/year	kWh/m^2/year	kWh/m^2/year	kWh/m^2/year	%
Administrative	71.1	33.7	19.8	13.2	43.7
Multi-Function	83.8	38.2	22.4	14.2	42.6
Shopping Mall	239.2	85.9	73.7	10.2	35.4
Telecommunication	219.9	49.9	30.5	19.5	22.3
Hospital	198.8	87.5	16.9	70.5	42
Hotel	243.5	70.6	44.9	25.7	28.9
Office	77.3	28.3	16.6	11.7	36.6
Other	73	21.5	13.8	7.7	29.1

Source: University of Science and Technology of Wuhan.

We have noted that:

- office buildings consume less energy than shopping malls;
- administrative buildings tend to use decentralized HVAC systems, and large public buildings tend to use centralized HVAC systems;
- representative energy consumption is determined by building type.

Therefore, this step helped us identify energy-consuming buildings and the share of HVAC consumption in the total bill.

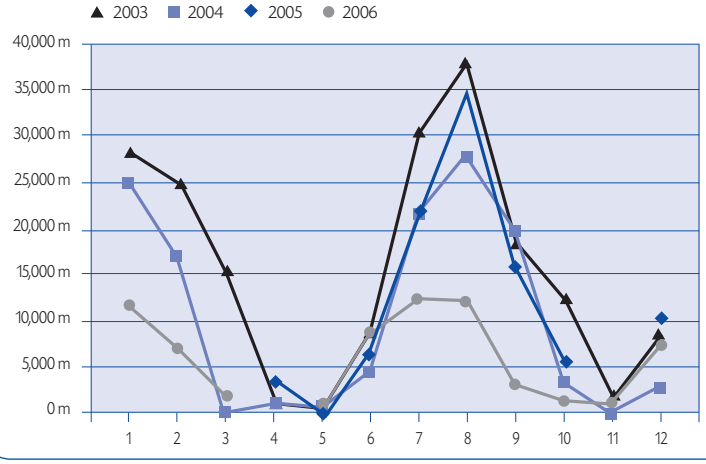
3.1.3. Energy Audits for Accurate Study of Energy Consumption

Energy audits have subsequently been carried out in order to confirm the results of the survey both in terms of energy consumption and type and performance of HVAC equipment used. Moreover, this survey facilitated the collection of information on possible maintenance and envelope quality issues. Owners, managers and occupants' interviews were also carried out.

The diagram below illustrates the changes in volumes of gas when the owner switched from coal gas to natural gas:

Figure 27

Changes in Volumes of Gas

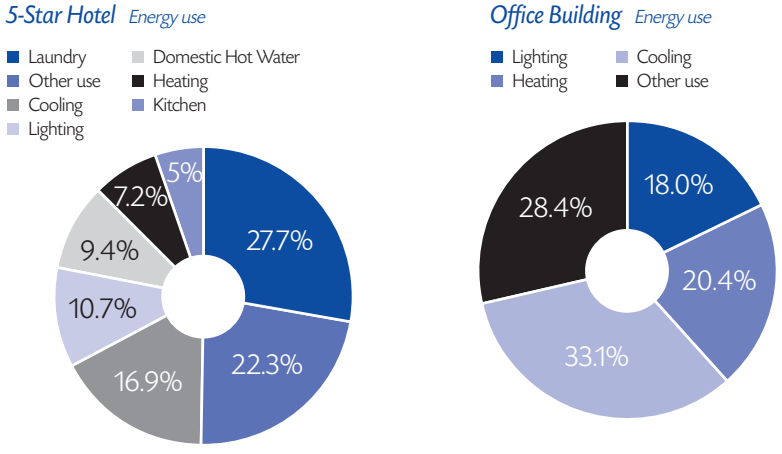


The effect of the use of natural gas is obvious here. Taking advantage of its superior specific heat, the volume of gas needed to satisfy the same heating needs is much smaller, contributing to great money savings for the building's owner.

Source: Synapse Ingénierie's report: « Assistance technique à la définition et la réalisation d'un audit énergétique à Wuhan dans la province du Hubei en Chine ».

A most important output of energy audits is the energy end-use profile that illustrates the typical repartition of energy consumption in each type of building. In the two profiles below, we can observe the huge difference in the proportion of energy use between an office building and a five-star hotel. In the office building, cooling accounts for about 33% of the total energy bill, whereas it is only 17% in the case of a hotel.

Figure 28/29 *Energy End Use Profiles for a 5-Star Hotel and an Office building*



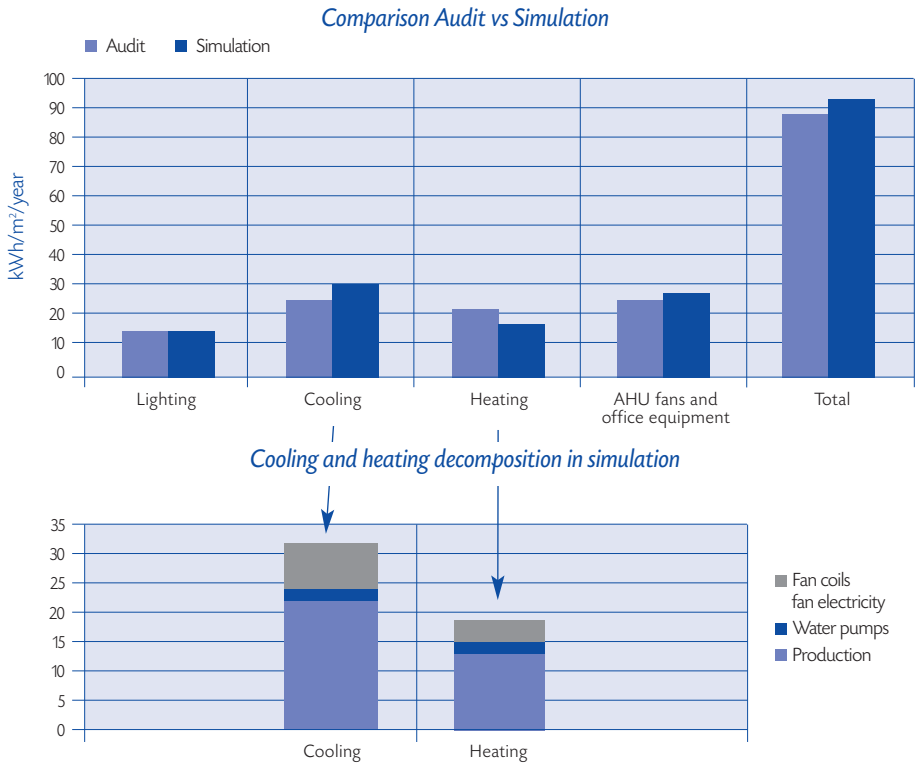
Source: Author.

These observations are extremely important in order to carry out a proper energy use diagnosis of the considered building and thus apply a consistent rehabilitation strategy. As we mentioned earlier, energy efficiency awareness is not high in Wuhan or it is recent. Therefore, even for building energy audits, some data can be missing or some information wrongly monitored. Therefore, it can be very useful to use simulation tools to confirm and/or complete the energy audit.

Thermal simulations can be complementary to energy audits to confirm and add more data to establish complete end-use energy profiles. In the case shown below, we can see that the simulation corresponds to the audit results with a 4% margin accuracy. Of course, this results from a careful verification and analysis of audit data, and complementary interviews of the owners if necessary.

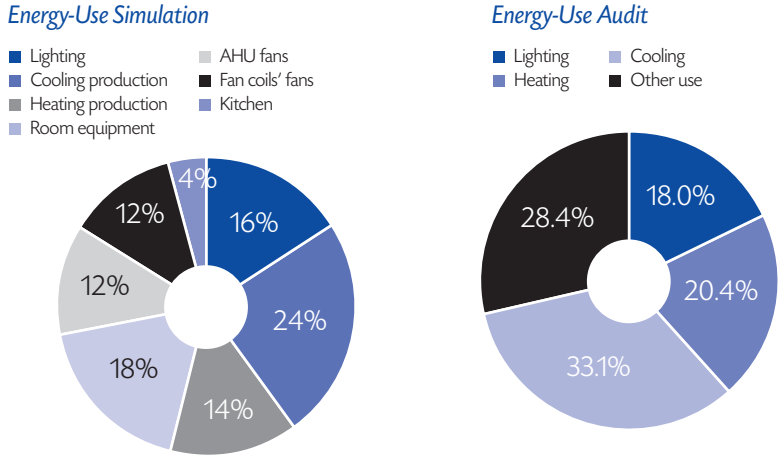
The second and maybe best advantage of simulations is the possibility to decompose further the energy-use profile. When not enough meters are present on site, it can be difficult to separate the consumption of water pumps, fancoils fan and lighting, and one should use the installed capacity and operation time. This can lead to some mistakes. The simulation can help accurately model existing HVAC systems and then calculate auxiliary systems' electricity use. Of course, these results should be coherent with audit information regarding installed power and operation time. The energy profiles on the right show how we could breakdown the audit energy profile into a more detailed distribution.

Figure 30 *Breakdown of the Audit Energy Profile*



Source: Author.

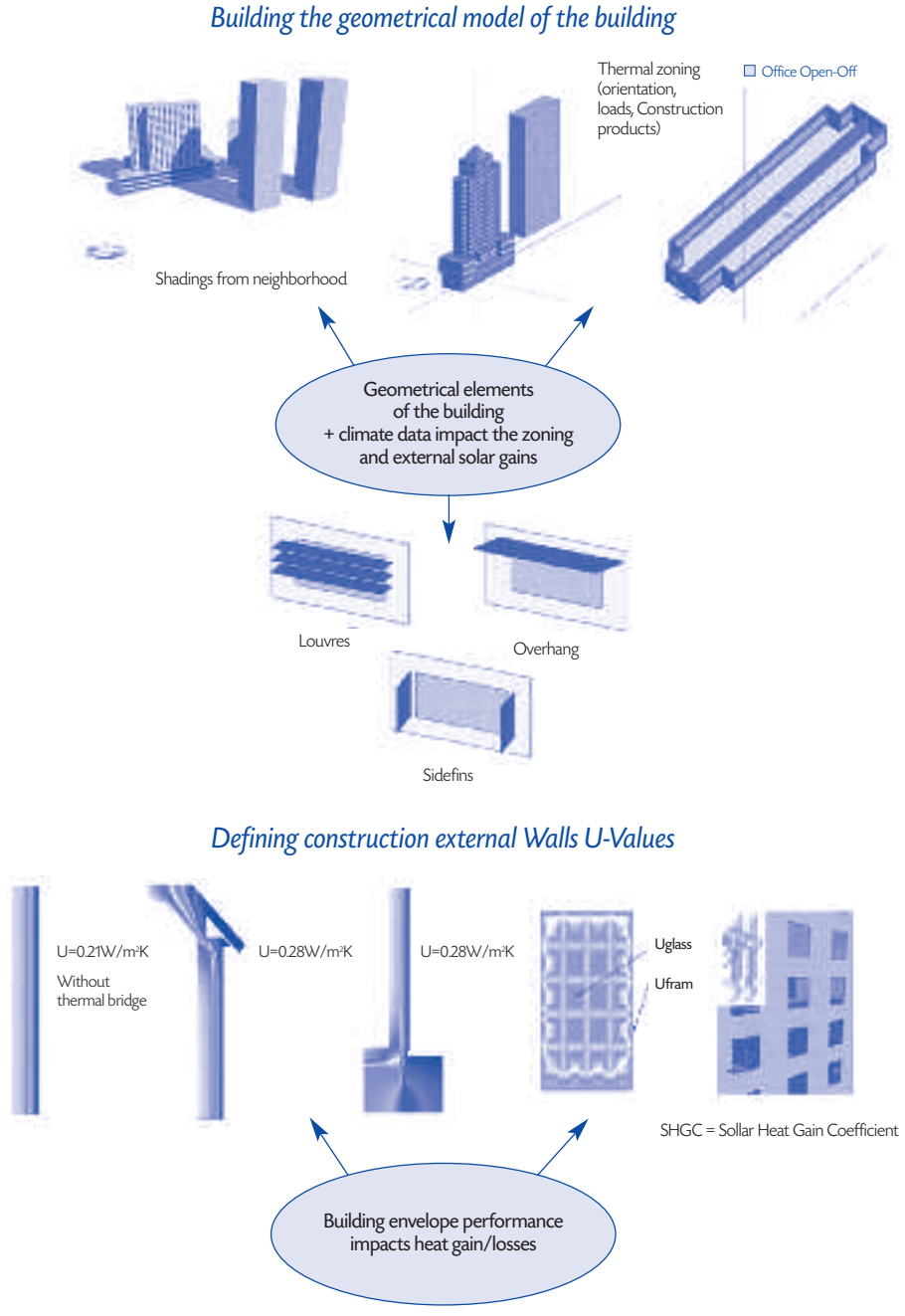
Figure 31/32 *Energy-Use Audit and Energy-Use Simulation*



Source: Author.

3.1.4. Estimates of Energy-Saving Potential

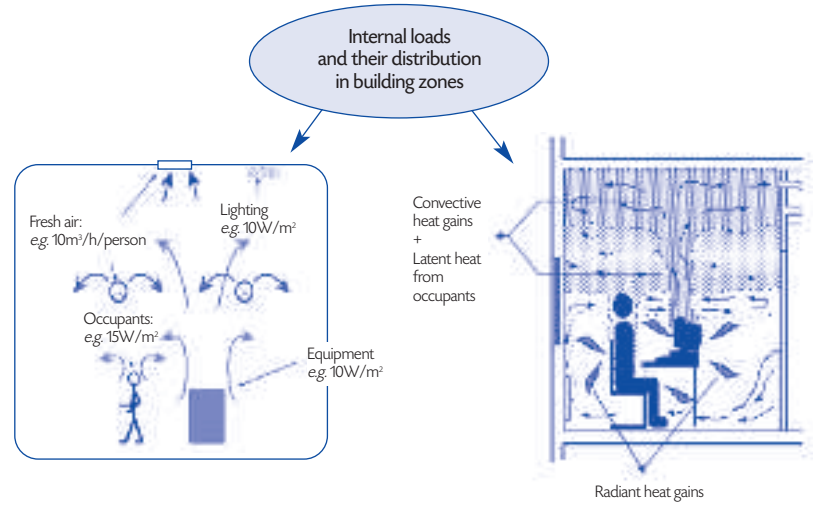
Figure 33/34 *The Different Elements that Impact a Building's Thermal Behavior*



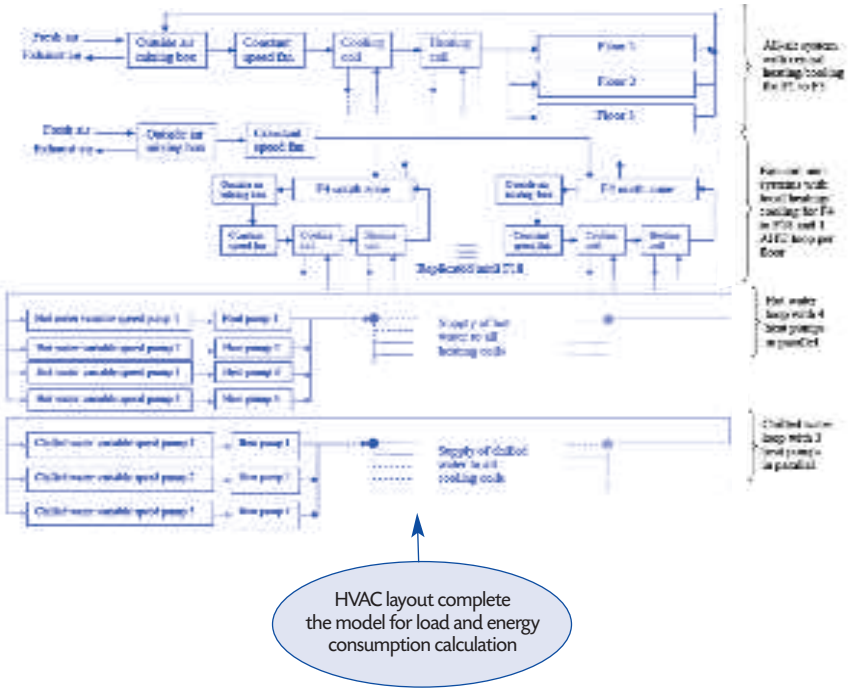
Source: Author.

Figure 35/36 *The Different Elements that Impact a Building's Thermal Behavior (contd.)*

Defining internal loads = what is inside the spaces and when



HVA layout after modification in energyplus



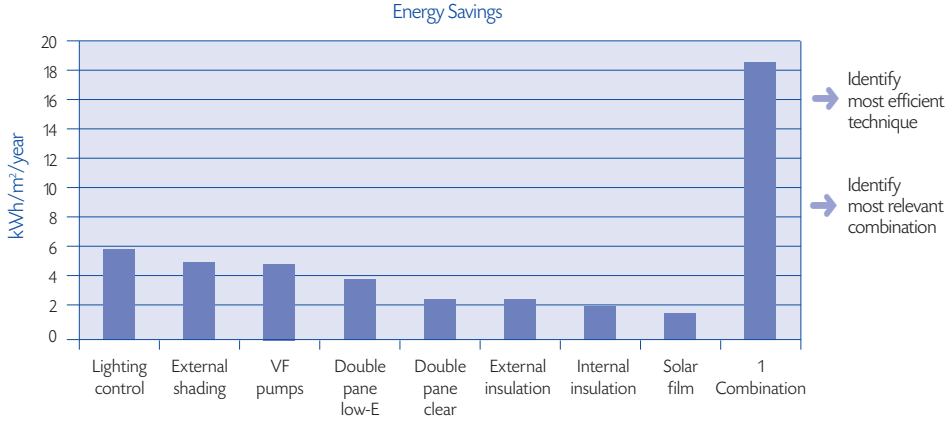
Source: Author.

Simulations also play a key role in the estimation of energy-saving potential. Indeed, as we mentioned earlier, they allow accurate modeling of the building's envelope and HVAC systems plus electricity use. Once the proper reference has been computed thanks to the energy audit, the next step is to calculate the energy savings due to different rehabilitation techniques (insulation, lighting control, variable frequency pumps, etc.). The pictures below illustrate the different elements that impact the thermal behavior of the building and that are taken into account in such practice.

Simulations are important to bring rationality into the decision process regarding building improvements. Their results allow one to sort out the most efficient rehabilitation techniques and their combination. Results should also comply with local expertise in terms of efficiency and savings: actions on existing HVAC equipment should save about 20% of HVAC consumption whereas envelope improvement could save up to 30% of HVAC consumption. Other savings can be achieved on the specific uses of electricity (lighting, lifts, etc.).

Figure 37

Energy Savings of Different Techniques and their Combination



Source: Author.

The available results can be quite detailed and allow one to classify the energy savings for different techniques and also for combinations of techniques in order to identify the most relevant combination for the building in question.

Simulation results are then compared to investment cost data to determine the most cost effective "rehabilitation package" for different types of buildings.

Investment costs analysis has identified representative costs as follows:

- Improvement of existing HVAC equipment: RMB45 to 90 /m^2;
- Improvement of electricity systems: RMB35 to 50 /m^2;
- Improvement of envelope: RMB190 /m^2.

Note: The above ratio all refer to m^2 of floor.

Basically, actions on HVAC equipment and electricity systems have a payback period of 5 years or less. Actions on the envelope alone have a payback period of 15 years or more.

Therefore, in Wuhan, the idea of a rehabilitation package is very important because it is only by combining the improvement of the building envelope with equipment that the payback period can be kept below 10 years. The example below shows the case of an administrative building. The rehabilitation package consists of internal insulation, use of external solar shadings, lighting control, and the use of variable frequency water pumps. The payback period is 9.8 years.

Table 2 *Rehabilitation Package for an Administrative Building*

Investment cost	RMB169 /m^2
Annual energy saving	18.5 kWh/m^2
Annual energy saving	31.2%
Annual savings	RMB17.2 /m^2
Payback period	9.8 years
Total area in Wuhan	3 million m^2 (4% of total building stock)
Investment	RMB507 million
Annual savings	RMB51.6 million

Source: Author.

Investment volumes and potential savings can be expressed to show decision-makers the importance and impact of thermal rehabilitation. Three main levels of thermal rehabilitation were determined, corresponding to 3 levels of investment and energy savings. These 3 levels are:

- Low cost: Existing HVAC equipment improvements only, RMB110 of investment per m^2, and a payback period of about 5 years;
- Medium cost: Existing HVAC equipment improvement + partial envelope improvement, RMB230 of investment per m^2, and a payback period of about 7 years;
- High cost: Existing HVAC equipment improvement + complete envelope improvement, RMB300 of investment per m^2, and a payback period of about 9 years.

These figures can be determined for Wuhan, Hubei Province and Yangtze River area as long as climate data and floor area statistics are reasonably similar.

We have also noted that these data are averaged on all building types within the category of the survey sample, *i.e.* administrative buildings and large public buildings. The presentation made about the extrapolations and the rehabilitation level shows that these values change from one category of building to another. Basically, the most energy consuming existing buildings give the best cost effectiveness of rehabilitation.

3.2. The Technical Characteristics and Energy Consumption Indicators of Existing Buildings in Wuhan

Dr. Li Yuyun, Professor, Wuhan University of Science and Technology

3.2.1. The Importance of Energy Retrofitting Existing Buildings

The Current Energy Situation in China

China ranks third in the world in terms of total energy reserves, but has more than 20% of the total world population.

Table 3 shows the energy consumption per capita at home and abroad. As we can see from the table, China's consumption per capita is less than half of the world's average level. With the improvement of people's living standards, China's energy consumption per capita will gradually increase. Consequently, the gap between energy supply and demand will become even more prominent.

Table 3 *Energy Consumption Per Capita at Home and Abroad (kg of standard oil)*

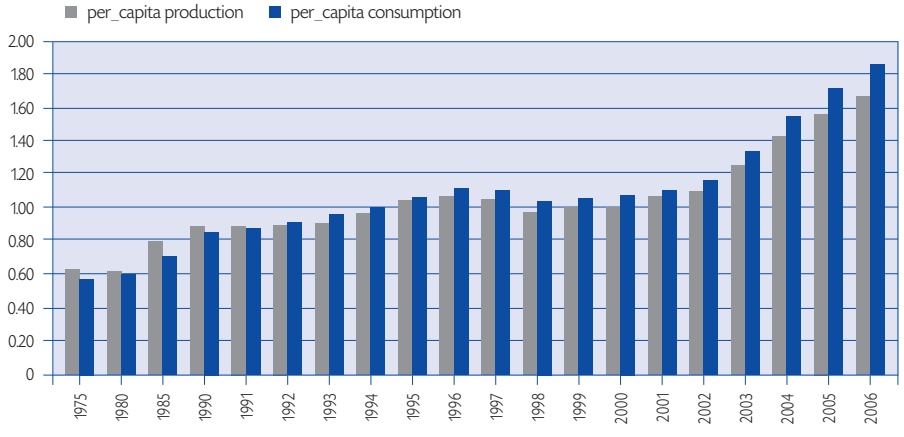
Year	1990	1995	1999	2000	2001	2002
China	428	495	451	448	453	473
USA	5,239	5,305	5,349	5,551	5,394	5,351
Japan	2,365	2,612	2,701	2,803	2,762	2,814
Germany	3,113	2,947	2,961	2,949	2,993	2,925
France	2,593	2,713	2,873	2,854	2,940	2,835
UK	2,526	2,597	2,755	2,740	2,749	2,670
Canada	5,786	5,980	6,136	6,203	5,932	6,093
Australia	3,402	3,553	3,694	3,752	3,761	3,622
World average	1,010	987	972	985	979	979

Source: calculated according to Statistical Yearbook of the domestic energy agency.

Figure 38 is a comparison between energy production per capita and energy consumption per capita in China, from 1978 to 2005. We can see from the figure that from 1993 onwards, China's energy consumption has been higher than its energy production.

Figure 38

Comparison of Per Capita Energy Production and Per Capita Energy Consumption in China



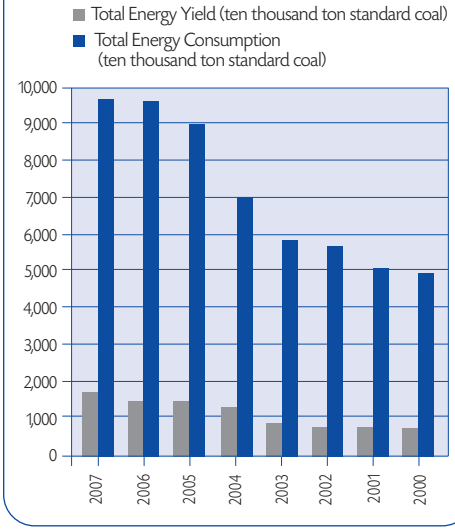
Source: China statistic annual, 2007

Energy Production and Consumption in Hubei

Figure 39 is an histogram comparing energy production and energy consumption in Hubei Province. As can be seen from the chart, there is a yearly growth in energy consumption in Hubei. Further calculations show that energy consumption in Hubei Province is 6.74 times energy production. Therefore, Hubei Province is a province with a great lack of energy.

Figure 39

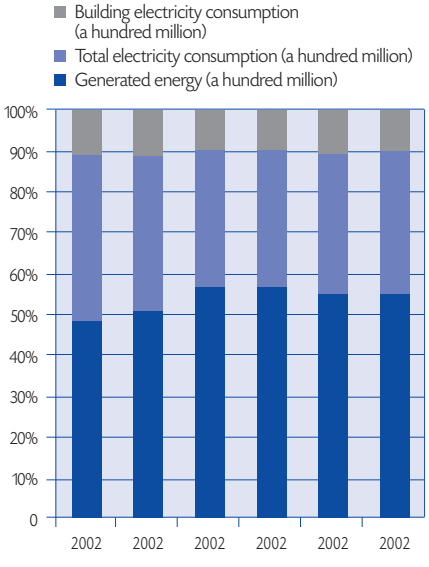
Comparison of Energy Production and Consumption in Hubei



Source: Hubei Provincial Statistics Bureau, Economic and Social Inquiry System.

Figure 40

Electricity Consumption, Generated Energy and Building Electricity Consumption in Hubei



Source: Hubei Province Statistics Bureau Economic and Social Inquiry System.

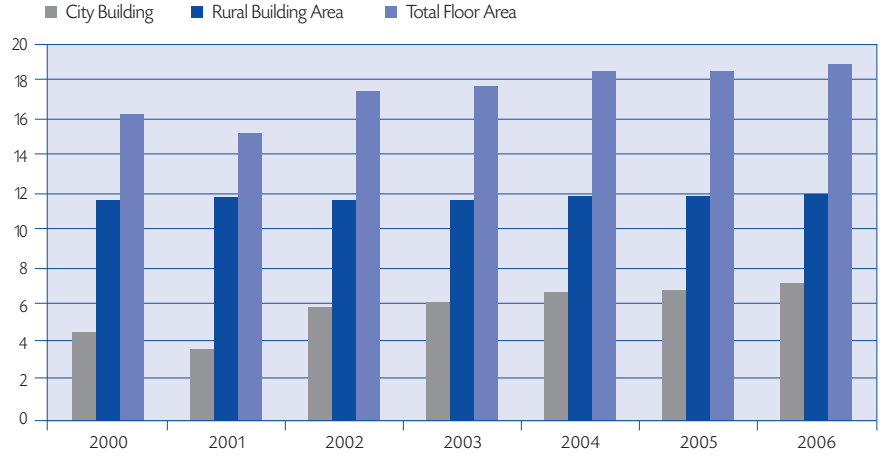
Electricity consumption (transportation, post and telecommunications industry + commercial and catering, material supply and warehousing + urban and rural residents' consumption) in Hubei Province from 2002 to 2007 is shown in Figure 40. From the figure we can see that in Hubei Province electricity production is 9.59% to 35.82% greater than electricity consumption; the yearly growth rate of electricity consumption is 13.48%.

The Growth Rate of Built-Up Areas

In 2006, China's built-up area had reached 40.054 billion m^2, urban construction areas accounted for 43.57%, with an average growth rate of 6.65%. The evolution of the built-up area in Hubei province is shown in Figure 41. From the figure we can obtain from further calculation that the average growth rate of built-up area in Hubei Province is 2.92%. As of 2007, the built-up area in the urban zone of Hubei Province is 757,841,300 m^2, of which residential buildings accounted for 65.15%.

Figure 41

Evolution of the Built-Up Area in Hubei Province /10 million m^2



Source: China Energy Conservation annual report 2008.

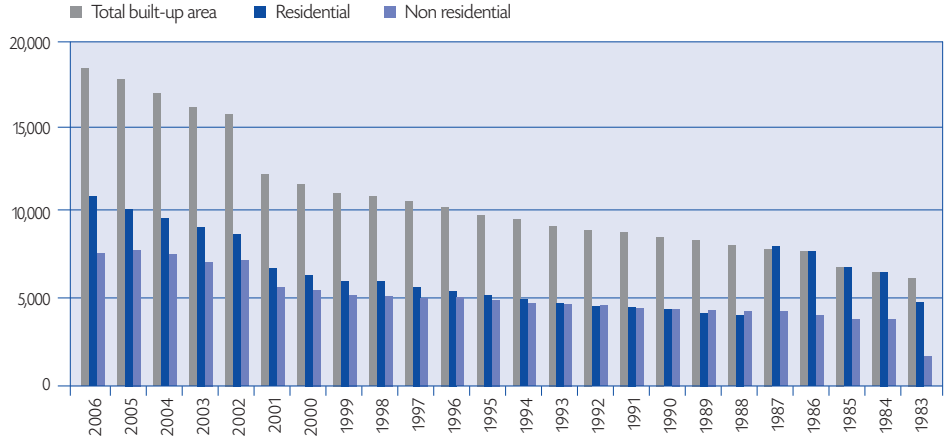
The Situation in Wuhan

Technical Characteristics of Buildings

According to statistics, at the end of 2007, Wuhan had 542,955 buildings in urban areas, with a total base area of 102,595,400 m^2, a total built-up area of 312,863,100 m^2, of which the built-up area in urban Wuhan was 191,505,800 m^2, residential built-up area of 113,532,100 m^2, and the surface area per capita was 26.86 m^2 per person. More than 95% of buildings were high-energy-consumption buildings; annual new construction was 8-12 million m^2, of which energy-saving buildings account for 10%. Figure 42 shows the evolution of the built-up area in Wuhan. Figure 43 shows the number of buildings in urban Wuhan. Figure 44 shows the built-up area in urban Wuhan.

Figure 42

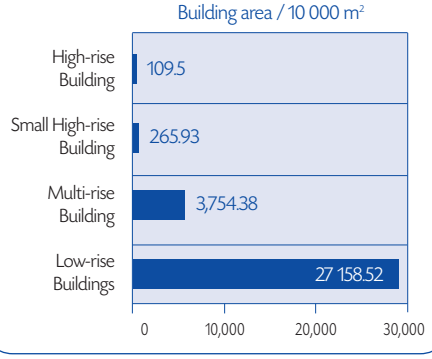
Evolution of the Built-Up Area in Wuhan



Source: Hubei Provincial Statistics Bureau.

Figure 43

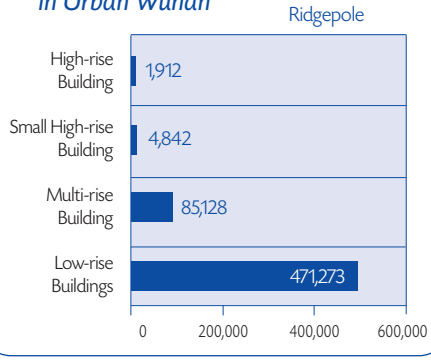
Built-up Area in Urban Wuhan



Source: Hubei Provincial Statistics Bureau.

Figure 44

The Number of Buildings in Urban Wuhan



Source: Hubei Provincial Statistics Bureau.

Table 4 *Percentages of Different Public Buildings in Wuhan in 2006*

Building Type	HVAC Consumption	%
Total Public Buildings	7,481.5	100%
Administration Buildings [1]	515.2	6.9%
Hospitals	312.6	4.2%
Hotels	174.1	2.3%
Education Buildings	2,141.3	28.7%
Shopping Malls and Other	4,378.7	58.5%

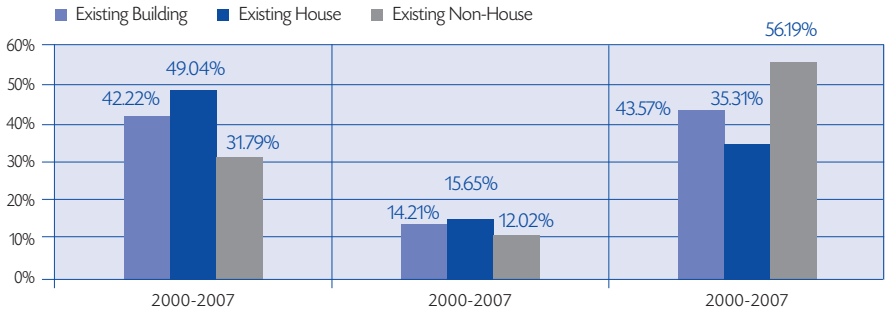
Source: Hubei Provincial Statistics Bureau.

According to the survey, among the existing public buildings in Wuhan at the end of 2006, the total area of administrative buildings was 515.2828 million m^2 (information provided by Wuhan Municipal Bureau of Finance), accounting for 6.9% of public buildings. Hospitals (125 in total) had a total construction area of about 3,126,012 m^2 (provided by Hubei provincial Department of Health), accounting for 4.2% of public buildings. University construction area was about 21,413,000 m^2 (Education Statistical Yearbook of Hubei Province, teaching buildings accounting for 35.8%, administration buildings accounting for 4.6%, residential buildings accounting for 37.5%, and residential buildings for teachers accounting for 22.1%), accounting for 28.7% of public buildings. Star hotels have an area of about 1,741,000 m^2 (provided by Wuhan Tourism Bureau and information on-line: there are currently 120 star hotels in Wuhan, of which 8 are five-star hotels, 23 are four-star hotels, 53 are three-star hotels, 43 are two-star hotels, and 3 are one-star hotels), accounting for 2.3% of public buildings. The distribution of different public buildings in Wuhan is shown in Table 4. The construction years for existing buildings in Wuhan City are shown in Figure 45. As can be seen, buildings constructed before the 80s of the last century account for 43.5 %, buildings constructed after the 20th century account for 42.22%. According to the census targeting 389 administration buildings and public buildings, frame structure is the main form of building structure in Wuhan City (See Table 5).

[1] Representative offices of provincial and central organisms in Wuhan are not included.

Figure 45

Construction Years of Existing Buildings in Chinese Wuhan



Source: Hubei Provincial Statistics Bureau.

Table 5 *Structural Forms of 389 Buildings*

Brick and Concrete	Frame	Frame-Shear	Steel	Unknown
143	202	3	3	38
36.76%	51.93%	0.77%	0.77%	9.77%

Source: Hubei Provincial Statistics Bureau.

Energy Consumption Characteristics

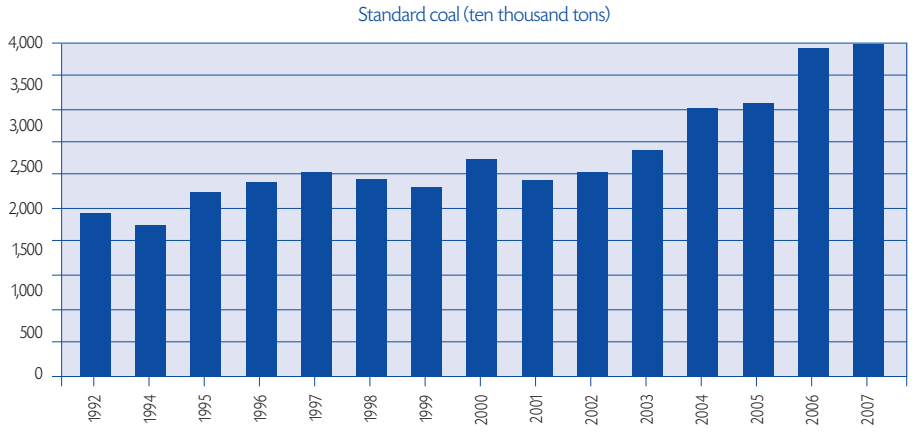
The city of Wuhan is a resource-dependent city. In 2006, the proportion of electricity consumption in buildings in total electricity consumption in Wuhan was higher than the national average, [2] reaching about 22.47%; [3] it reached 50% at peak times when air conditioners were being used (water storage air conditioners not included). The pressure of energy consumption in buildings on the energy supply of the whole city is becoming greater and greater. Energy consumption in Wuhan between 1992 and 2007 is shown in Figure 46. Electricity consumption in Wuhan is shown in Figure 47.

[2] In 2006, the proportion of building electricity consumption in total consumption was 21.4%, China Energy Conservation in buildings annual report, 2008.

[3] Obtained according to Statistical Yearbook of Wuhan; electricity consumption in buildings = transport, storage and postal industry + commerce, accommodation and catering industry + finance, real estate, business and residents service sector + public utilities and management organizations.

Figure 46

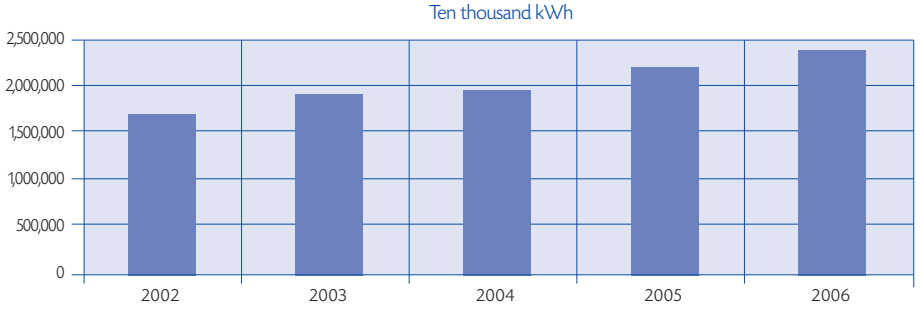
Energy Consumption in Wuhan 1992-2007



Source: Hubei Provincial Statistics Bureau.

Figure 47

Electricity Consumption in Wuhan



Source: Hubei Provincial Statistics Bureau.

Climatic Characteristics

Wuhan is located on the middle reaches of the Yangtze River in China. Its climate is characterized by high summer temperatures, heavy humidity and hot weather. It rains frequently in winter, with little sunshine and heavy humidity; cold lake effect is significant. Figure 48 shows the monthly average temperature and relative humidity in Wuhan.

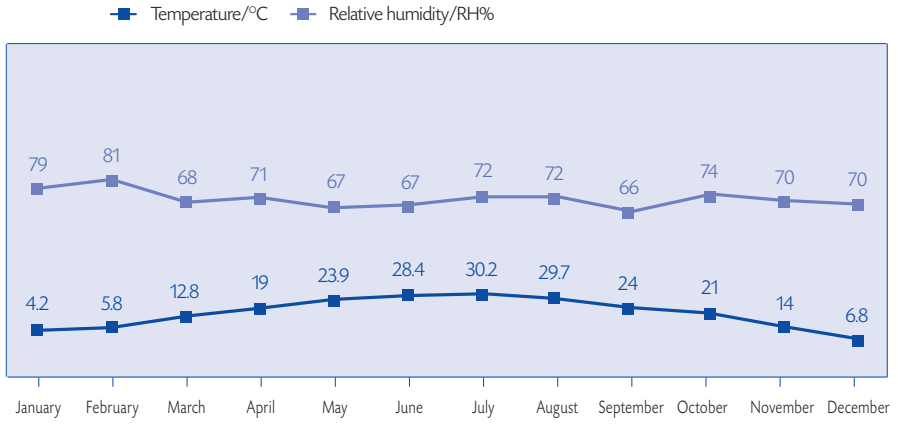
As can be seen from the figure, the monthly mean relative humidity in Wuhan is higher than the air conditioned comfort indicators (40 to 65%), and monthly average temperatures only in April, September, and October meet air-conditioning comfort scope (winter: 18°to 24°C, summer: 22°to 28°C).[4]

[4] HAVC design standards.

Outdoor Environmental Characteristics

Figure 48

Average Monthly Temperatures and Relative Humidity in Wuhan



Source: Hubei Provincial Statistics Bureau.

In 2006, the number of days reaching or better than grade II (for air quality) of 16 major cities in China was 307, while the number was 273 for Wuhan, which is lower than the average. Air pollution comes not only from industrial emissions: the burning of fossil fuel for heating in winter is also the main source of pollution in many regions. Energy used for air-conditioning in summer not only generates pollution, but the heat emitted increases the urban heat island effect, which results in temperatures 1.8° to 2° C higher in the center of the city than in suburban areas. Sometimes in summer, this gap even reaches 5.9° C.[5] Therefore, gas emissions and the heat island effect greatly harm the environment. Promoting energy efficiency in buildings will reduce energy use, pollution and the heat island effect, while improving the outdoor environment and providing multiple benefits.

3.2.2. Energy Consumption Measurement Methodology and Indicators for Typical Buildings in Wuhan

The vast Chinese territory results in large climatic differences between Northern and Southern China; accordingly, energy consumption characteristics in buildings and energy-saving potential vary considerably. In 2007 and 2008, the Research Group carried out three censuses and energy audits of the energy consumption of buildings in Wuhan. A total of 426 buildings have been investigated, of which 191 administration buildings larger than 3,000 m^2, 70 large public buildings larger than 20,000 m^2. Twenty-three buildings have been audited. Early in 2008, another energy consumption census was conducted in Wuhan, covering 934 residential buildings, 303 governmental administration buildings,

[5] http://www.sina.com.cn, 08:46, July 22, 2008. Hanwang.

156 small and medium-sized public buildings, and 76 large public buildings for a total of 1,469 buildings.

Energy Consumption Measurement Method

Energy Consumption Survey

Conducted mainly by survey questionnaire, including:

- Technical characteristics of the building;
- Measurement by watt-hour meter, gas meter, water meter, information from oil purchase bills;
- Equipment operation conditions, design conditions of energy systems.

Energy Audit

(1) Questionnaire:

- Technical characteristics of building;
- Measurement by watt-hour meter, gas meter, water meter, information from oil purchase bills;
- Equipment operation conditions, design conditions of energy systems

(2) Measuring:

- Indoor temperature;
- Indoor air quality;
- System operation state.

(3) Interview: to speak with the energy manager in order to know the real operating problems, etc.

(4) Energy diagnosis of systems

Energy Consumption Statistics Method

Total energy consumption: from the main energy meter.

Categories of consumption:

- From meters dedicated to one part of the building or the systems;
- Consumption = System capacity (kW) x operation time (h) x use coefficient.

Normalized Energy Consumption

Result of the Survey of 389 Buildings

Results of this energy survey show that the maximum electricity consumption is 5,283 kWh/m²/year for a building using split units, but we consider this value is not correct. Therefore, the maximum value of electricity consumption is 201.9 kWh/m²/year. It is 106.3 times the minimum consumption, 1.9 kWh/m²/year. The maximum electricity consumption in buildings using a AHU (Air Handling Unit) is 231.4 kWh/m²/year. It is 138.8 times the minimum consumption, which is 1.7 kWh/m²/year. Whatever the type of cooling system used, the maximum and minimum energy consumption appear in office buildings. Administrative buildings having a floor area greater than 3,000 m² consume between 18.3 kWh/m²/year and 111.7 kWh/m²/year, hence 6 times more. The average energy consumption of the 389 buildings is 87.32 kWh/m²/year, water consumption is 5.93 tons/m²/year.

The problems with this survey are:

- Since lots of information about urban heating, coal, fuel oil, etc. is missing, we only studied electricity, water and gas consumption;
- Since there is no energy meter in the building and considering that the energy managers' statistics knowledge is not sufficient, some statistical data are wrong, forcing us to eliminate some data.

Energy Consumption Verification of 106 Buildings

According to the survey of the 389 administrative and large public buildings, and considering the distribution of these buildings in the city of Wuhan, we selected 101 buildings for further examination. Among these buildings, there are 51 administrative buildings, 3 multi-function (office tower + shopping malls), 8 office buildings, 17 shopping malls, 12 hotels, 3 hospitals, 2 banks, 1 school, 1 library, 1 theater, and 2 telecommunication buildings. Most of this information comes from interviews, consumption data and technical data on the main systems.

Table 6 shows the energy use statistics for the 101 buildings. We see that the consumption of administrative buildings is between 20.15 and 168.8 kWh/m^2/year. There is a factor of 8.38 between the 2 extremes. The cooling consumption is between 1.62 and 73.4 kWh/m^2/year (factor 45). The heating consumption is between 0.14 and 57kWh/m^2/year (factor 407). The study of different types of buildings shows that the most energy-consuming type is the hotel, followed by the shopping mall and then by the office building. For HVAC system consumption, the most energy-consuming systems can be found in hospitals, followed by shopping malls.

Table 6 *Energy Consumption Statistics for 101 Buildings*

	Building Type	Building Area /m²	Energy Consumption/ m²/yr		HVAC /m²/yr		Consumption/m²				Water consumption t/m²/yr	HVAC / total %
							Cooling		Heating			
			kJ	kWh	kJ	kWh	kJ	kWh	kJ	kWh		
1	Admin.	656,134	8.33E+05	71.11	3.82E+05	32.66	2.32E+05	19.80	1.53E+05	13.14	2.03	43.74
2	Multi-function	194,800	9.81E+05	83.78	4.48E+05	38.23	2.65E+05	22.44	1.67E+05	14.22	1.11	42.58
3	Shopping Mall	211,643	2.77E+06	239.17	8.49E+05	85.85	8.63E+05	73.74	1.19E+05	10.18	1.44	35.38
4	Telecom	91,441	2.57E+06	219.85	5.85E+05	49.97	3.57E+05	30.50	2.28E+05	19.45	1.31	22.32
5	Hospital	127,100	2.33E+06	198.81	1.02E+06	87.45	1.99E+05	16.93	8.24E+05	70.50	5.29	41.97
6	Hotel	389,349	2.85E+06	243.52	8.27E+05	70.63	5.26E+05	44.91	3.01E+05	25.73	8.51	28.87
7	Office	352,023	9.05E+05	77.27	3.31E+05	28.27	1.95E+05	16.57	1.37E+05	11.66	0.38	36.57
8	Other	67,000	8.55E+05	72.99	2.51E+05	21.45	1.61E+05	13.75	9.00E+04	7.71	5.12	29.12

Source: Author.

Energy Audit of 23 Buildings

In order to have deeper knowledge of energy use in buildings in Wuhan, 26 of the 101 buildings were chosen for the energy audit. These 26 buildings have 3 levels of energy consumption. The shell structure of these 26 buildings are almost all framework type, 9% built before 1989, 39% before 1999, and 52% built between 2000 and 2005. Most of the buildings are high-consumption buildings.

(1) Normalized Consumption of Administrative Buildings in Wuhan

Table 7 shows normalized energy consumption of administrative buildings in Wuhan. We see that the primary energy consumption is 63.8 kWh/m²/year (25.78 kgce/m²/year). Average lighting consumption is 10.7 kWh/m²/year, office equipment is 7.49kWh/m²/year, and lifts 3.01 kWh/m²/year. End use energy is 79.82 kWh/m²/year, or 23.28 kgce/m²/year.

Table 7 *Normalized Consumption of Administrative Buildings*

Consumption Normalized by Person per Year			
Total Consumption/kgce	Total Cost/yuan	HVAC Consumption/kgce	Water Consumption/t
1,443.48	3,533.58	596.35	85.03
Consumption Normalized by m²/year			
Total Consumption/kgce	Total Cost/yuan	HVAC Consumption/kgce	Water Consumption/t
63.80/79.82	18.94	11.77	1.39
Costs Normalized by m²/year			
Total Cost/yuan	Cooling Costs/yuan	Heating Costs/yuan	Water Costs/yuan
62.62	18.5	14.02	2.33

Source: Author.

HVAC consumption is 49.24% of total building primary energy consumption, and 55.81% of end-use energy. Cooling energy use (7.4 kgce/m²/year) is greater than heating (4.87 kgce/m²/year) for primary energy. But for end-use energy it is the contrary (2.72 kgce/m²/year for heating and 2.56 kgce/m²/year for cooling).

Table 8 *Provincial Administrative Building Consumption*

Total Consumption		Total Consumption	
kgce/m²/year	kgce/pers/year	kWh/m²/year	kWh/pers/year
29.23	1,518.67	80.79	4,196.36

Source: Author.

Provincial administrative buildings consume 20% more than municipal-level administrative buildings. The main reason is that provincial buildings sometimes use coal boilers for collective heating. Their heating consumption is 12.02 kgce/m²/year. This is more than average heating consumption in Wuhan. We can say:

- Heating system efficiency is low;
- 50% of administrative buildings in Wuhan use air-to-water heat pumps. There is less distribution loss.

(2) Normalized Consumption of Office Buildings

Table 9 shows the consumption of offices. The primary energy for cooling (10.25 kgce/m²/year) is greater than for heating (6.56 kgce/m²/year). For end-use energy, heating consumption (4.36 kgce/m²/year) is greater than cooling consumption (3.12 kgce/m²/year).

In primary energy, HVAC consumption is 44.39% of the total bill and 52.66% in terms of end-use energy. Ventilation consumption is 8.98% of HVAC consumption of primary energy and 7.15% of end-use energy. Water consumption is 0.94 ton/m²/year. Water cost is RMB2.96 /m²/year. The total end-use energy is 118.21 kWh/m²/year.

Table 9 *Normalized Consumption in Offices*

	Cost		Consumption					
			Electricity		Equivalent Coal Primary Energy		Equivalent Coal End-Use Energy	
	yuan /m²/year		kWh/m²/year		Kgce/m²/year			
	With occupancy rate 85%-100%	Without occupancy rate	With occupancy rate 85%-100%	Without occupancy rate	With occupancy rate 85%-100%	Without occupancy rate	With occupancy rate 85%-100%	Without occupancy rate
Building	97.99	89.59	103.77	98.93	41.92 x /36.07	38.16	15.25	14.02
Heating	20.79	19.3	16.24	15.01	6.56	6.07	4.36	4.14
Cooling	22.85	21.09	25.37	23.36	10.25	9.44	3.12	2.87
Ventilation	3.94	3.35	4.45	3.78	1.8	1.53	0.55	0.54
Lift	5.15	4.51	5.84	5.11	2.36	2.07	0.72	0.63
Lighting + BA + Office Equipment	24.55	20.86	28.07	23.86	11.34	9.64	3.25	2.93
Pump and fans	20.71	18.64	23.8	27.81	9.61	9.41	3.25	2.91

Source: Author.

Table 10 shows the comparison between administration buildings and offices with regard to electricity consumption and average costs. We see the costs of consumption in offices are greater than in administration buildings. The main reasons are structure, operation and comfort requirements.

Table 10 *Comparison between Offices and Administrations for Consumption and Costs*

Building		Total	HVAC	Total	HVAC
		Without occupancy rate	Without occupancy rate	Without occupancy rate	Without occupancy rate
Office	Cost RMB/m²/y	89.59	43.50	97.99	47.15
Admin.		59.22	30.39	59.22	30.39
Office	Electricity/ kWh/m²/y	98.93	41.84	103.77	45.52
Admin.		63.80	30.36	63.80	30.36
Office	ce/x (standard coal) /m²/y	38.16	16.9	41.92	18.39
Admin.		25.78	12.27	25.78	12.27

Source: Author.

(3) Normalized Consumption for Hotels

Table 11 shows the consumption by hotels. Table 12 shows other consumption by hotels. For end-use energy, HVAC consumption is 30.9% of building consumption. For primary energy, HVAC is 34.58% of the total. Table 13 shows hotels' HVAC consumption including ventilation. We see that the cooling consumption is always greater than heating, both for end-use and primary energy. The main reason is that the operation time for cooling in hotels is longer than for offices and administrations. Especially for buildings using sealed windows, the cooling system is turned on at the end of March.

Table 11 *Hotels' Primary Energy Consumption Normalized by m²/year*

Occupancy Rate		Total	Usual	Heating	Cooling	Lift	DHW	Lighting	Kitchen	Other
Without	Cost/yuan	158.0	94.92	15.41	38.06	9.00	6.81	10.57	6.23	71.91
	Electricity /kWh	169.5	101.60	15.73	42.64	9.90	6.42	13.99	5.53	75.32
	Equivalent coal/kgce	68.01 /63.8	43.68	6.36	17.23	4.05	2.59	5.83	2.23	29.72
With	Cost/yuan	248.2	155.96	24.80	58.98	14.77	7.76	7.20	7.61	127.04
	Electricity /kWh	266.5	166.87	25.83	65.71	16.15	7.52	8.29	6.73	136.28
	Equivalent coal/kgce	107.0	70.93	10.44	26.55	6.59	3.04	3.35	2.72	54.35

Source: Author.

Table 12 *Other Consumption in Hotels*

Energy Cost/Turnover	Cost per bed/year	Consumption per bed/year (with occupancy rate)	Cost per bed/year	Water consumption per bed/year
6,821.29 kgce/bed/y	6,821.29 yuan/bed/y	10,598.9 kgce/bed/y	26,079.84 yuan/bed/y	474.73 t/m²/y

Source: Author.

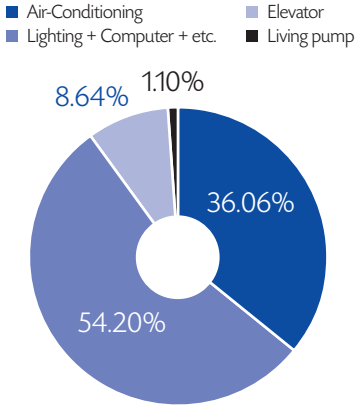
Table 13 *HVAC Consumption/kgce/m²/year*

Heating		Cooling		Heating/Cooling	
Primary	End-Use	Primary	End-Use	Primary	End-Use
6.36	5.13	17.23	5.24	3.04	1.19

Source: Author.

Figure 49

Profile of Electricity Consumption in Shopping Malls



Source: Author.

4) Normalized Consumption of Shopping Malls

Table 14 shows normalized consumption of shopping malls, and Table 15 shows other standard consumption figures. Figure 49 shows the profile of energy use in shopping malls. We see that lighting is the biggest proportion, then comes the cooling system with 36.16%. Among the audited shopping malls, only one is heated.

Table 14 *Normalized Consumption of Shopping Malls*

		Total	Cooling	Heating	Lift	Pump	Lighting
Per m²/year	Cost/RMB	195.66	72.26	28.65	8.21	1.09	102.64
	Consumption/kWh	214.92	79.44	29.05	9.29	1.26	113.02
	Equivalent Coal (primary)/kgce	86.83 /78.12	32.10	11.74	3.75	0.51	45.66
	Equivalent Coal (end-use)/kgce	26.65	9.76	4.52	1.14	0.15	13.89
/h	Cost/RMB	2,149.45	785.76	439.03	96.89	12.28	1,134.35
	Consumption/kWh	2,397.60	867.21	445.12	110.41	14.34	1,253.99
	Equivalent Coal (primary)/kgce	968.63	350.35	179.83	44.61	5.79	506.61
	Equivalent Coal (end-use)/kgce	298.30	106.58	69.24	13.57	1.76	154.12

Source: Author.

Table 15 *Other Normalized Consumption*

	Total Primary Energy		Total End-Use Energy
Per m²	214.92kWh/m²/year	86.83 kgce/m²/year	224.06 kWh/m²/year
	Water Consumption	Water Cost	Energy Cost
	2.89t/m²/year	9.42 yuan/m²/year	195.66 yuan/m²/year
	Building Consumption		Energy Cost
Per h	2,397.6kWh/h/year	968.63kgce/ h/year	2,149.65 yuan/h/year

Source: Author.

(5) General Building Survey

A general survey of 1,253 administrative and public buildings was done in early 2008. Table 16 shows the results of this survey for primary energy: 12.87 kgce/m²/year for housing, 24.89 kgce/m²/year for small and medium-sized public buildings, 50.19 kgce/m²/year for large public buildings. Table 17 shows the comparison with the audits and survey in 2007. We see that large public buildings consume 15.4% more than in this other survey. The main reason is that it was normalized by occupied area instead of total area.

Table 16 *General Survey in 2007/m²/year*

Building Type	Elec/kWh	Fuel/kg	Coal/kg	Oil/kg	Other/m³	Gas/m³	Natural Gas/m³	Liquid Gas/kg
Housing	16.404	0	6.543	0	0.006	0.698	0.753	0.74
Small and Medium Public Buildings	61.906	0.11	0.413	0.254	0073	0.048	0.704	0.441
Large Public Buildings	113.276	0.85	6.614	0	0	0.001	2.826	0.009

Source: Author.

Table 17 *Comparison between the Audit and the 2007 Survey*

	Shopping Malls	Hotels	Offices	Large Public Buildings	Administrative			Small and Medium Public Buildings	Housing
					Provincial	Municipal	Average		
Audit	78.12	63.8	36.07	59.33	29.23	23.28	26.26		
Survey	50.19							24.89	12.87

Source: Author.

(6) Normalized Consumption of Different Types of Buildings

Table 18 shows normalized consumption of different types of buildings.

Table 18 *Normalized consumption/(kWh/m²/year)*

Type	End-use	Primary
Administrative	79.8	63.8
Office	114.2	98.9
Shopping mall	217.7	214.9
Hotel	280.3	169.5
Housing	54.4	280

Source: Author.

We can see that:

- End-use energy: hotel > shopping mall > office > administrative > housing;
- Primary energy > shopping mall > hotel > office > administrative > housing;
- Administrative building consumption is lower because of:
  - structure - natural ventilation in mid-season;
  - limited consumption in administrative buildings;
  - low occupancy.
- Shopping mall consumption is greater because:
  - use of AHU and constant flow rate strategy for terminal units, the electricity consumption of the terminal unit is greater than chillers in hotels;
  - high occupancy rates and lighting density in shopping malls, creating a high cooling load.

3.3. Levels of Thermal Rehabilitation

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This presentation aims to define the three levels of thermal rehabilitation that have been identified in the research program. They represent three levels of investment costs and energy savings potential. Accordingly, they also correspond to three representative payback periods. This synthesis uses the results of studies performed by Terao, Wuhan University of Science and Technology, the Academy of Construction of Hubei and the Wuhan Bureau of Energy Efficiency. [6]

In order to define the savings generated by different techniques, we first would like to recall the representative energy consumption of different types of building. They are very different (from about 80 kWh/m^2/year for offices to 240 kWh/m^2/year for shopping malls) and therefore the energy savings potential will greatly vary from one category to another.

Energy audits give the following representative values:

- Administrative buildings: 71 kWh/m^2/year;
- Office buildings: 98 kWh/m^2/year;
- Star hotels: 260 kWh/m^2/year;
- Shopping malls: 240 kWh/m^2/year;
- Hospitals: 215 kWh/m^2/ year;
- Telecommunications: 220 kWh/m^2/ year;
- Multifunction: 80 kWh/m^2/ year.

The average value is 170 kWh per m^2 per year, and this is consistent with the national value. We note here that this average is not weighted by the floor area distribution since this value was not available at the moment of the work. This representative value is used to give energy savings in terms of percentage in the present study.

Statistics have highlighted that HVAC-related energy use is about 40% of the total energy bill. Specific uses of electricity also play a key role in energy efficiency in buildings.

Energy audits also helped to highlight that, with regard to total energy consumption, energy end-use profiles are very different from one type of building to another. As a result, energy efficiency strategies can differ from one building to another. In this first general approach, we do not focus on building specifically adapted technologies, but rather on whether or not the envelope plays a key role.

We distinguish two types of energy-saving techniques: building envelope improvements and HVAC/electricity equipment improvements. They are separated because they correspond to different ranges of investments. The different results available that led us to define a general course of action are described below.

[6] Unless otherwise indicated, all figures are end-use energy expressed per m^2 of constructed floor area.

3.3.1. Actions on Envelope

Actions on envelope are much less "popular" in this area of China because of the investment cost. Since in Wuhan it has been observed that construction products have quite uniform thermal properties, energy savings, and in absolute value, are less dependent upon the type of building than upon actions on the existing systems. Nevertheless, the interest of investing in envelope improvement can be stronger in some cases than others.

Dynamic Thermal Simulations

Work has been done on envelope energy-saving potential with dynamic thermal simulations. Some was done during the seminar held in Wuhan in March 2008, some by the Wuhan Science & Technology University, and some by the Hubei Academy of Construction. The different cases deal with offices, administrations, shopping malls, hotels and hospitals.

Shopping malls: Shopping malls seem to be the category where envelope has the smallest influence. The representative energy consumption of this type of building is high: 240 kWh/m^2/year.

According to simulation results, the energy savings from external wall insulation and the decrease of glazed areas' Solar Heat Gain Coefficient (SHGC) (mostly doors because shopping malls have only a small amount of glazed area) is 10 kWh/m^2/year of end-use energy. It is about 4% of the total energy bill (10% of HVAC energy consumption).

Hotels: Two simulations were done: the Shangri La hotel and the Hubei hotel. The first work was done on the Shangri La hotel by Wuhan University of Science & Technology, starting during the March seminar in 2008. At that time, the work done was limited to verifying the compliance of the simulation results with those of energy audits. Then, more simulations were carried out to calculate energy savings obtained with wall and roof insulation, plus a solar film on existing windows to lower the SHGC. Results show a saving of 14 kWh/m^2/year. Based on the reference consumption of 260 kWh/m^2/year, it is a saving of about 5% of the total bill, meaning about 13% of HVAC consumption.

Another simulation was done on the "Hubei hotel" by the Academy of Construction. This hotel initially consumes 122 kWh/m^2/year. Simulations show possible savings of up to 22 kWh/m^2/year. Rehabilitation includes wall and roof insulation, the use of double pane windows and external solar shadings. It is 18% savings of the total bill. We note that:

- This hotel is less energy-consuming than those considered for energy surveys and audits. Indeed, a wide variety of energy consumption can be observed within the hotel category since it depends on the number of stars, use, occupancy, etc;
- This hotel uses a very low-efficiency coal boiler to provide heating. The proportion of heating energy in this case is very high, 44%. Therefore, the energy-saving potential with envelope improvement is higher;
- Envelope improvement is more extensive than for the first hotel since it includes insulation, double pane windows, and external solar shadings instead of the less efficient combination of insulation and solar film.

If we study closely the energy savings achieved by type of techniques, we see in that case that insulation accounts for 60% of the total savings, with savings of 13 kWh/m^2/year. This

is consistent with the value determined in the case of the Shangri La hotel, 14 kWh/m²/year. Savings from double pane windows and external solar shadings are 9 kWh/m²/year.

The case of hotels suggests it can be convenient to consider two levels of envelope rehabilitation corresponding to two levels of investment costs:

- "Light improvement": Either the use of double pane windows with external solar shadings or wall and roof insulation with the use of solar film on existing windows;
- "Heavy improvement": Insulation, use of double pane windows, and external solar shadings.

In order to be consistent with the chosen sample for energy survey, we consider the value of 14kWh/m²/year as a representative value for the "light improvement" action on envelope. It is also consistent with the range of savings calculated for the Hubei hotel.

The slight increase in energy savings for hotels compared to shopping malls can be explained by the fact that hotels are mainly heated during the nighttime and that the set point temperature is usually higher because comfort requirements are more demanding than in retail spaces. Moreover, shopping malls have only little potential regarding savings due to the limitation of glazed area performance improvements.

Regarding the "heavy improvement" actions on envelope, hotels cases show quite a high value. Twenty-two kWh/m²/year can be considered as a representative value of energy savings in hotels for the addition of insulation, windows and shadings effects. Insulation of walls and improvement of glazed areas both have similar ranges of saving potential. We recall that, in this particular case, heating has a slight advantage because of the comfort requirement and the low efficiency of the coal boiler.

Office/Administrative Buildings: The use of insulation and solar film on existing windows or an internal additional simple pane saves about 7 kWh/m²/year, which represents about 10% of the total bill or 20 to 25% of HVAC consumption.

Simulations of the use of external solar shadings can increase savings up to 10 kWh/m²/year, which represents 12 to 14% of the total bill or 25 to 30% of HVAC consumption.

Once again, the work done suggests that we define two levels of envelope improvement. The difference between them is smaller than for hotels. However, we note that offices and administrations offer a much smaller energy-saving potential than hotels due to their smaller energy consumption. Also, these buildings all use electricity as their main fuel.

Hospitals: Simulations done by the Hubei Academy of Construction on three hospital buildings which have an average energy consumption of 140 kWh/m²/year show possible savings of up to 32 kWh/m²/year. This is 22.9% of the total bill. Rehabilitation includes external insulation, double pane windows, and external solar shadings.

In this example, the heat source is coal for both the boiler and absorption chiller. HVAC energy consumption is 70% of the total bill (much higher than the average 40% revealed by the energy survey, but this also includes vapor production for the sterilization process). As for hotels, the large energy-saving potential can be explained by the high comfort requirement and the very inefficient hot/cold production associated with coal technology.

When we study energy savings more closely and break them down by technique, we see that insulation accounts for 40% of the savings, meaning about 13 kWh/m²/year. The remainder is due to the use of double pane windows and external solar shadings, *i.e.* 19 kWh/m²/year. This important part is also due to the poor efficiency of the LiBr absorption chiller. Based on these data, we can consider the average value of 16 kWh/m²/year as a representative value of the "light improvement" action on envelope for hospitals.

The value of 32 kWh/m²/year is representative of the maximum energy-savings using insulation, double pane windows, and external solar shadings.

This example also suggests we define two levels of envelope improvement, and also shows the impact of comfort requirements and inefficient hot/cold production on the energy-saving potential of envelope improvement.

Load Distribution for Different Types of Buildings

The report released by the energy efficiency bureau of Wuhan gives some results regarding representative cooling/heating load distribution for different types of buildings (it does not take hospitals into account):

Table 19 *Representative Cooling/Heating Load Distribution for Different Types of Buildings*

	Lighting	Equipment	Occupancy	Fresh Air	Envelope
Administrative Buildings	15%	15%	20%	30-35%	15-20%
Shopping Malls	10-15%	–	35-40%	35-40%	< 10%
Hotels	10-15%		15-20%	40-50%	15-35%

Source: Research programme of the Commission for Construction of Wuhan.

The above table confirms that:

- The envelope is a weak factor in the total heating and cooling load in shopping malls. In these malls, we see that the main factors are occupancy (internal load) and fresh air;
- Fresh air in hotels is the dominant factor. The envelope has a variable weight in the total load depending on other factors. It is consistent with the fact that the hotel's category shows a wide variety of use profiles. Still, the envelope takes a significant part of the load and, therefore, it is technically consistent to improve it;
- In offices and administrations, we see that the different components of the load are quite uniform in terms of influence. Fresh air is slightly more impacting. But the envelope remains technically interesting to improve.

In order to illustrate the benefits of envelope improvement on the load, we consider here the mean energy consumption of each building category in the above table so as to have a representative value in kWh/m²/year of the envelope-related load and the proportion that is saved by envelope improvement:

- Offices/Administrations: the envelope-related load is between 15 and 20% of 80 kWh/m²/year, which gives between 12 and 16 kWh/m²/year. Calculated savings range from 7 to 10 kWh/m²/year. We can say that envelope improvement reduces the envelope-related load by half;
- Shopping Malls: the envelope-related load is less than 10% of 240 kWh/m²/year, which gives less than 24 kWh/m²/year. Calculated savings are about 10 kWh/m²/year. We can say that we decrease the envelope-related load by half;
- Hotels: the envelope-related load ranges from 15 to 35% of 260 kWh/m²/year, which gives between 39 and 91 kWh/m²/year. However, it is very likely that cases where the envelope-related load is 35% of the total load correspond to hotels that consume less energy than 260 kWh/m²/year (like the Hubei hotel described earlier). Calculated savings range from 14 to 32 kWh/m²/year. We can say that we save a little less than half of the envelope-related load. This can be explained by the fact that hotels usually already have better windows than average buildings in Wuhan.

Conclusions on Envelope Improvement and Representative Savings

The first thing to notice regarding building envelope savings is that the variations are small from one type of building to another compared to the variations in energy consumption. Indeed, these savings are first related to building envelope materials and climate characteristics. In reality, they will also depend upon building use and HVAC equipment efficiency because parameters like comfort requirements and boiler efficiency will affect the share of HVAC consumption in the total bill and therefore improve envelope savings potential.

Except for shopping malls, all the studied examples tend to define two levels of envelope improvement:

- Insulation + solar film on existing windows OR the use of double pane windows + external solar shadings (light improvement);
- Insulation + double pane windows + external solar shadings (heavy improvement).

These two levels are defined because in Wuhan it is not common to have proper investment to improve building envelopes. Therefore, an intermediate option has been proposed, corresponding to the light improvement defined above.

If we consider the first level, defined as light improvement, the synthesis of the energy savings calculated with a building dynamic simulation gives a representative value of 10 kWh/m²/year. This also corresponds to the representative value of **15% saving on HVAC consumption.**

If we consider the second level, defined as heavy improvement, the synthesis of the energy savings calculated with a building dynamic simulation gives a representative value of 18.5 kWh/m²/year. This corresponds also to the representative value of **25-30% saving on HVAC consumption.**

Noticeably, external solar shadings are very efficient in Wuhan. This is logical in such a climate, which is characterized by high solar irradiation and poor existing glazed area performance. However, in the case of high-rise buildings, they are likely to raise safety issues. The demonstration program has the great advantage of highlighting this kind of case-specific

problem. For instance, hospitals are usually not very high and can avoid such problems for external solar shadings.

Studies also show the influence of hot/cold production source efficiency on the potential savings of the envelope. These parameters tend to modify the proportion of HVAC energy-use in the total bill. Therefore, it also influences the potential energy savings of the building envelope.

To correlate this fact, results from the twenty-three audited buildings show a clear trend of increasing heating energy use as a function of the fuel, generally associated to a particular technology and efficiency: average heating energy-use is 25% of the total bill, whereas it is only 15% in the case of natural gas boilers or electric systems.

We can remember that buildings using only electricity might offer a smaller energy-saving potential and give advantage to window improvements. On the contrary, buildings using low efficiency heating production (coal, fuel oil) tend to have bigger energy-saving potential and give advantage to insulation. Of course, the best case scenario is to improve all these elements together.

3.3.2. Actions on Systems

Within this category of improvement, we include improvements to existing HVAC equipment and electricity systems.

This type of action includes: Lighting improvement, water pump improvement, existing HVAC installation improvement, and electricity transformer optimization. Different sources of energy-saving calculations have been crossed and we present representative energy savings below:

Lighting Improvement: This consists of the use of energy-efficient lighting, lighting control, removing oversized capacity, and optimization of natural daylight. The average energy savings in electricity is 4.7 kWh/m^2/year. The other representative value is 30-40% of savings for lighting electricity use;

Water Pump Improvement: This action consists of replacing the existing pumps with efficient and variable frequency ones. Savings regarding pump electricity consumption vary from one building to another. The reason is that pump electricity consumption is directly linked to building energy consumption (water carries the heating/cooling energy). Hence, we find that pump replacement can save about 10-12% of HVAC energy consumption;

Existing HVAC Installation Improvements: This includes numerous actions like cleaning pipes and filters (improving heat exchange efficiency), improved chiller COP, terminal unit control, part load control of oversized plants, etc. The savings from these actions can also reach about 10% of HVAC energy consumption;

Electricity Transformer: This includes improvements to the power factor cosφ, avoiding low partial load or zero load transformer operation. For instance this can save 3-4% of the total energy bill.

Basically, all these actions on HVAC and electricity systems have an effect that is proportional to the initial energy consumption of the building. For instance, equipment improvement will be more efficient in a shopping mall than in an office building.

Based on these results, the average electricity savings is 22 kWh/m^2/year. This represents about 13% of the representative total energy consumption.

To conclude, actions on existing HVAC equipment and electricity systems generate savings that are proportional to the reference energy consumption of the building. It is determined that 20% of HVAC and 30% of the lighting energy consumption can be saved with relatively low-cost actions (pump replacement, control, improvement of COP, etc.).

3.3.3. Synthesis of Energy-Saving Potential

Based on the work exposed above, we have identified three main representative values for energy savings:

- Energy savings due to HVAC equipment and electricity systems: 22 kWh/m^2/year of end-use energy (13% of the total energy bill based on the reference energy consumption of public buildings of 170 kWh/m^2/year; this includes 20% savings of HVAC consumption and 30% of lighting consumption);
- Energy savings due to "light improvement" of envelope: 10 kWh/m^2/year of end-use energy (6% of the total energy bill based on the reference energy consumption of public buildings of 170 kWh/m^2/year; this also corresponds to 15% savings of HVAC consumption);
- Energy savings due to "heavy improvement" of envelope: 18.5 kWh/m^2/year of end-use energy (11% of the total energy bill based on the reference energy consumption of public buildings of 170 kWh/m^2/year; this also corresponds to 30% savings of HVAC consumption).

The above values are representative when we consider the whole stock of administrative buildings and large public buildings. Of course, these values and percentages can vary from one category of building to another.

Based on the energy fuel use in the energy survey sample (78% electricity, 14% fuel oil, 8% natural gas), we can also express these savings in terms of primary energy using equivalent coal:

- Energy savings due to HVAC equipment and electricity systems: 8 kgce/m^2/year of primary energy;
- Energy savings due to "light improvement" of envelope: 3.2 kgce/m^2/year of primary energy;
- Energy savings due to "heavy improvement" of envelope: 6.2 kgce/m^2/year of primary energy.

We present below the illustration of energy savings for different types of buildings:

Table 20 *Energy Savings in kWh/m²/year of the Different Rehabilitation Techniques for Different Categories of Buildings*

Technical Rehabilitation	"Heavy Improvement" of Envelope	"Light Improvement" of Envelope	Lighting	Water Pumps	Existing HVAC Equipment	Electricity Transformer	Total: If "Heavy Improvement of Envelope" + Systems	Total: If "Light Improvement of Envelope" + Systems
Offices (ref. = 98 kWh/m²/y)	10 (10.2%)	7 (7.2%)	4.5 (4.6%)	3.9	2.9	2.9	24.2 (24.7%)	21.2 (21.6%)
Administration (ref. = 71 kWh/m²/y)	10 (12.8%)	7 (9.9%)	4.5 (6.3%)	2.8	2.1	2.1	21.5 (30.3%)	18.5 (26%)
Shopping Malls (ref. = 240 kWh/m²/y)	***	10 (4.1%)	4.5 (6.3%)	9.6	7.2	7.2	*** (not relevant)	38.5 (16%)
Hotels (ref. = 260 kWh/m²/y)	22 (8.5%)	14 (5.4%)	4.5 (1.7%)	10.4	7.8	7.8	52.5 (20.2%)	44.5 (17%)
Hospitals (ref. = 215 kWh/m²/y)	32 (15%)	16 (7.4%)	4.5 (2.1%)	8.6	6.5	x	58.1 (27%)	42.1 (19.6%)

Source: Author's construction.

3.3.4. The Investment Costs of the Different Actions

The data exposed below are representative of different rehabilitation actions. Quotations for envelope products are given as ratios per m² of walls or windows. Since there is a high diversity of shape coefficients and window-to-wall ratios among the building stock, we use four representative buildings to determine average costs as a ratio of m² of floor:

Table 21 *Building Surface Areas*

	Hospital	Hubei Hotel	Education Department Building	Finance Department Building
Floor Area (m²)	30,000	20,780	18,000	21,000
External Wall Area (m²)	15,000	8,000	3,296	6,300
Window Area (m²)	6,000	2,500	4,500	3,500
Roof Area (m²)	4,000	3,250	1,029	1,350
Number of Floors	5	12	18	21

Source: Academy of Construction of Hubei.

Investment Cost for Envelope Improvement

Wall insulation: RMB160 per m^2 of wall

Roof insulation: RMB30 per m^2 of roof

Window improvement:

Double pane clear: RMB500 per m^2 of windows + RMB15 per m^2 of windows for existing window removal = RMB515 per m^2 of windows;

Use of solar film on existing windows: RMB280 per m^2 of windows;

The choice of window improvement strategy has consequences on the investment cost.

Use of external solar shadings: RMB200 per m^2 of windows.

The investment cost related to envelope improvement varies greatly according to the options we chose. We can see that wall insulation and the use of double pane windows have a strong impact on total investment cost.

If we use the area table above to calculate ratios in terms of m^2 of floor, we obtain:

Table 22 *Investment Costs in RMB per m^2 of Floor*

Costs in RMB/m^2_floor	Hospital	Hotel	Education Department	Finance Department	Average
Wall Insulation	80	62	29	48	55
Roof Insulation	4	5	2	2	3
Solar Film on Existing Windows	56	34	70	47	52
Double Pane Clear Windows	103	62	129	86	95
External Solar Shadings	40	24	50	33	37

Source: Author's construction

From these economic data, we have determined two investment costs, corresponding to the two levels of envelope improvement that we defined earlier in the energy-saving potential chapter:

Light improvement of envelope:
Either insulation + solar film:
RMB110/m^2_floor
Or double pane clear window + external solar shading: RMB132/m^2_floor
The average cost for this level of improvement is **RMB120/m^2_floor.**

Heavy improvement of envelope:
Insulation + double pane clear + external solar shadings: **RMB190/m^2_floor.**

Investment Cost for Systems Improvement:
Existing HVAC equipment:
RMB45 to 90 per m^2
Lighting and electricity systems improvement:
RMB35 to 50 per m^2.

Improvement of both HVAC equipment and electricity systems belong to the same category of investment (low cost and short payback period). It ranges from RMB80 to 140 per m^2. We define the average value, **RMB110 per m^2 of floor**, as a representative cost for this level of improvement.

3.3.5. Definition of Thermal Rehabilitation Level

These actions can then be combined to define the 3 levels of thermal rehabilitation. Indeed, a thermal rehabilitation level is defined as a package of techniques that corresponds to a level of investment cost. As a result, different thermal rehabilitation levels give different ranges of payback period and different ranges of energy savings.

Low Level of Investment and Fast Payback Period:

The lowest level of investment includes actions focused only on:

- Existing HVAC equipment and electricity systems: pumps with variable frequency, maintenance operations, part load control for COP improvement, and terminal emitter regulation with thermostats;
- Electricity systems: remove oversized capacity, use of energy-efficient lighting and lighting control + electricity transformer management (mainly avoid zero load operation).

Based on the energy savings exposed earlier, the total savings of these actions can go up to 22 kWh/m^2/year of end-use energy, which is 13% of the total energy bill (average value 170 kWh/m^2/year).

The breakdown of investment costs given above defines a representative investment cost at RMB110 per m^2 of floor.

Based on these data, the payback period is 5.4 years. We can define 5 years as a representative value and it matches local knowledge of the cost effectiveness of such improvements.

Medium Level of Investment and Intermediate Payback Period:

This level of investment includes all actions described above (lowest level of investment's actions) in addition to those contributing to the "light improvement" on envelope defined earlier. So there are two sets of techniques possible for the same representative cost:

First set of techniques:

- Low level of investment actions;
- Thermal insulation of external walls (internal or external according to building height and decorative materials);
- Insulation of roof and ground floor;
- Limited window improvement consisting of applying a solar film to existing windows to lower SHGC.

This first package might be more efficient with buildings using inefficient heat production plants and that have high heating requirements (like hotels and hospitals).

Second set of techniques:

- Low level of investment actions;
- Replacement of windows by double pane type for better U-value and SHGC;
- Use of external solar shadings.

This second package might be more efficient with buildings using only electricity since glazed area improvement would greatly decrease cooling load.

In any case, it is important to note that in such a climate zone, glazed area is the most important element of the facade design since it will influence both winter and summer energy performance.

Based on energy savings exposed earlier, the total savings of these techniques reach 32 kWh/m²/year of end-use energy, which is about 20% of the representative total bill.

The investment costs described above define a representative cost for this level of rehabilitation at RMB230 per m² of floor.

Based on energy savings and costs, the payback period is 7.7 years. The representative value of 7 years was chosen since it also matches local knowledge of cost effectiveness.

High Level of Investment and Longer Payback Period:

This level of investment includes all actions described above (lowest level of investment's actions) in addition to those contributing to the "heavy improvement" on envelope defined earlier:

- Low level of investment actions;
- Thermal insulation of the envelope;
- Use of double pane windows;
- Use of external solar shadings.

Based on energy savings described earlier, the total savings of such a package can reach the representative value of 40.5 kWh/m²/year, which is about 25% of the representative total bill. The latter might be a little too high compared to reality. Therefore, in many cases, the savings can be up to 30% and more.

The cost of such a package can be defined at about RMB300 per m² based on the economic data exposed earlier.

As a result, the payback time is 8 years. However, based on local knowledge and since values here are average and representative, we chose the value of 9 years to represent the cost effectiveness of such actions.

3.3.6. Conclusions

We sum up these three levels of action in the table below:

Table 23 *Cost, Savings and Payback Time for Each Level of Action*

	Low Level	Medium Level	High Level
Investment Cost	RMB110/m²	RMB230/m²	RMB300/m²
Primary Energy Savings	8 kgce/m²/ year	11.2 kgce/m²/year	14.2 kgce/m²/year
Payback Time	5	7	9

Source: Author's construction.

These values are representative and average for the different categories of buildings included within the stock of large public and administrative buildings. According to the type of building, investment, savings and payback times will vary around these averages.

More options can be considered, such as significant improvements in COP by replacing existing heat pumps and chillers with new models. In addition, new energy-efficient models of fancoils and all-air systems should be considered as well, since fans use a significant amount of electricity.

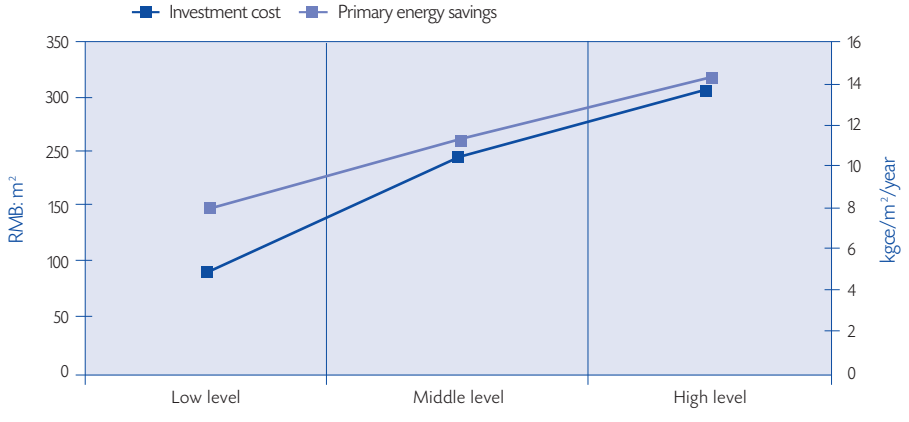
Actions on internal loads are also to be considered very seriously. For instance, the choice of computers has a big impact both on the electricity bill and cooling loads.

Also, it is important to consider strategies that can improve the economic balance of the rehabilitation when it involves the envelope. Changing fuel (from fuel oil to gas) can save a lot of money. The same effect applies to cold storage. These savings can compensate part of the over-cost due to envelope improvement.

A last point to consider is the perspective for the future. This is an area of China where heating is spreading very fast and the quality of building envelopes cannot be seen as a "bonus" anymore. Moreover, energy efficiency can take part in the improvement of the overall quality of buildings in this area. Indeed, it has been observed in China that standards compliance is higher in the north than in the south and one suspected reason is the difference in energy efficiency practices of the envelope due to climate differences that do not call for the same caution regarding comfort issues.

Figure 50

Investment Costs vs Energy Savings



Source: Author's construction.

3.4. Building Energy Audit and Rehabilitation Feasibility Study of Typical Buildings

Mrs. Ke Ying, Engineer, Institute of Architecture Science and Design of the Hubei Province

3.4.1. Background

Government office buildings and large public structures are areas of high energy consumption. With the development of the economy, the high energy consumption of these buildings is becoming an increasingly serious problem. In China, the area of large public buildings is less than 4 percent of the total area for urban buildings, but the power consumption constitutes more than 22 percent of the national total. The power consumption per unit area is 70-300 kWh/m^2 per annum, which is about 10-20 times that of ordinary civil buildings and 1.2-2 times that of countries in Europe, Japan and elsewhere. The work to improve energy efficiency in government office buildings and large public structures is extremely important in achieving energy-saving targets during and after the 11th Five-Year Plan.

In October 2007, the Ministry of Construction and Ministry of Finance jointly promulgated the "The Implementation Opinions on Energy-Saving Management for Government Office Buildings and Large Public Buildings" referred to as file [2007]245. As one of the country's 15 demonstration provinces, Hubei needed to complete energy audits of at least 20 office buildings in 2007 and publish the results.

3.4.2. Building Energy Audits

A building energy audit is a process for assessing how much energy a building consumes and evaluating what measures can be taken to improve energy efficiency performance. Professional auditors are assigned the task by the government or building owners. The objective of energy audits is that, through inspection, survey, and analysis of energy flows in a building, the government can enhance supervision of the energy dynamics of the system and improve energy efficiency.

Energy audits play an instrumental role in the energy-saving management of government office buildings and large public buildings. The audits can be used to research and establish systems on energy-consumption, energy-use standards, energy-consumption limits and price mark-up for consumption above quota, and further promote rehabilitation mechanisms including energy service and Energy Performance Contracting (EPC) in public buildings.

3.4.3. Building Energy Audits in Hubei Province

The Hubei Provincial Construction Department mandated the Hubei Provincial Building Research & Design Institute to complete energy audits on government offices and public buildings. So far, they have finished audits on 47 buildings including 44 govern-

ment office buildings, 2 complexes (offices + hotels), and 1 hotel.

Basic Building Information

Year of Construction

Of the 47 buildings, 19 were built before 1990, 19 between 1991 and 2000, and 9 after 2001. China started implementing energy efficiency in buildings later than developed countries. The Design Standards for Public Buildings on Energy Saving did not come into force until 2005. Most of these audited buildings, built before the enactment of these standards, were inefficient/low energy efficiency buildings.

Table 24 *Building Distribution by Year of Construction*

Year of Construction	Before 1990	1991-2000	After 2001	Amount
2007	4	13	7	24
2008	15	6	2	23
Amount	19	19	9	47

Source: Institute of Architecture Science and Design of the Hubei Province.

Building Floor Area

Of the 47 buildings, 7 had floor surface areas above 20,000 m^2, 18 between 10-20,000 m^2, and 22 had floor surface areas of less than 10,000 m^2.

Table 25 *Building Distribution by Building Floor Area*

Building Area	< 10,000	10-20,000	> 20,000	Amount
2007	7	12	5	24
2008	15	6	2	23
Amount	22	18	7	47

Source: Institute of Architecture Science and Design of the Hubei Province.

Energy-Saving Measures Taken

As many of the buildings were built a considerable time ago, very few included energy-saving measures in their building envelopes. Three buildings use thermal insulation in the outer walls; 9 have double-glazed windows; only 2 use low-E glass; most windows use steel and aluminum alloy frames; and a small number of buildings use plastic-steel frames. Most use interior shading, few use exterior shading.

Table 26 *Building Energy-Saving Techniques*

Energy-Saving Methods	Thermal Insulation	Double-Glazing	Low-E Glass
2007	2	7	1
2008	1	2	1
Amount	3	9	2
Percentage	6.4%	19.1%	4.3%

Source: Institute of Architecture Science and Design of the Hubei Province.

HVAC

In terms of air-conditioning (AC), out of 47 buildings, 23 use split AC, 24 use central AC (including 14 water coolers, 6 air source heat pumps, 3 LiBr absorptions, and 1 VRV). In terms of heating, 18 use centralized heating, 17 use boilers (including 1 electric boiler, 5 oil boilers, 5 coal boilers and 6 gas boilers), 9 use central AC, and the other 3 use split AC.

Table 27 *Building AC Type*

AC	Split AC	Central AC			
		Water Cooler	Air Source Heat Pump	LiBr	VRV
2007	8	10	3	2	1
2008	15	4	3	1	0
Amount	23	14	6	3	1
Percentage	48.9%	29.8%	12.8%	6.4%	2.1%

Source: Institute of Architecture Science and Design of the Hubei Province.

Table 28 *Building Heating Type*

Heating	Split AC	Centralized Heating	Central AC			Boiler			
			Air Source Heat Pump	LiBr	VRV	Electric Boiler	Oil Boiler	Coal Boiler	Gas Boiler
2007	0	10	3	1	1	1	5	2	1
2008	3	8	3	1	0	0	0	3	5
Amount	3	18	6	2	1	1	5	5	6
Percentage	6.4%	38.3%	12.8%	4.3%	2.1%	2.1%	10.6%	10.6%	12.8%

Source: Institute of Architecture Science and Design of the Hubei Province.

Building Energy Consumption

Energy Type

The energy used in these 47 buildings is electricity, coal, oil and natural gas. The distribution is as follows:

Table 29 *Energy Type Distribution*

Energy Type	Electricity	Oil	Gas	Coal
2007	24	5	1	2
2008	23	0	7	3
Amount	47	5	8	5
Percentage	100.0%	10.6%	17.0%	10.6%

Source: Institute of Architecture Science and Design of the Hubei Province.

Building Energy Consumption

The 47 audited buildings include 44 government offices, 2 complexes, and 1 hotel. The energy consumption and HVAC systems in these buildings are as follows:

Average Energy Consumption

The minimum energy consumption of these buildings is 27.7 kWh/m^2; the maximum is 160.2 kWh/m^2, which is 5.8 times the minimum. The energy consumption of the different types of buildings is set out in the table below.

Table 30 *Energy Consumption 1 (kWh/m^2)*

Type	Amount	Maximum	Minimum	Average
Government Office	44	151	27.7	84.9
Complex	2	160.2	128.2	150.2
Hotel	1	122.1	122.1	122.1
Total	**47**	**160.2**	**27.7**	**89.3**

Source: Institute of Architecture Science and Design of the Hubei Province.

As the table shows, the average energy consumption is 84.9 kWh/m^2 for government office buildings, 150.2 kWh/m^2 for the complex, and 122.1 kWh/m^2 for the hotel. This assessment is more reliable for the energy consumption of government office buildings than the two complexes and hotel because, in this survey, the majority of the buildings audited were government office buildings. More samples of the other types of buildings are needed.

Different HVAC systems have a significant impact on a building's energy consumption. Because it is difficult to compare energy consumption of all types of systems, a distinction is made as to whether the building has centralized heating or not.
The table below shows the energy consumption of the two general types of systems.

Table 31 *Energy Consumption 2 (kWh/m²)*

Government Office	Amount	Average Energy Consumption (kWh/m²)
Centralized Heating	18	77.3
Non-Centralized Heating	26	87.7

Source: Institute of Architecture Science and Design of the Hubei Province.

The energy consumption of buildings with centralized heating is lower than those without for two reasons. First, most centralized heating buildings use split AC, which makes it easy to control temperature. In this way unnecessary waste can more easily be avoided or prevented altogether. In contrast, buildings without centralized heating use inefficient boilers, which have high energy consumption.

Energy Consumption of HVAC Systems

Wuhan is extremely hot in summer and cold in winter. For almost 8 months, air-conditioning or heating is required; therefore HVAC energy consumption is high.

Table 32 *HVAC System Energy Consumption and Percentage (kWh/m², %)*

	AC		Heating		HVAC			AC		Heating		HVAC	
N°.	kWh/m²	%	kWh/m²	%	kWh/m²	%	N°.	kWh/m²	%	kWh/m²	%	kWh/m²	%
1	11.6	18.4%	28.0	44.4%	39.6	62.8%	23	16.4	22.6%	20.6	28.2%	37.0	50.8%
2	15.3	21.9%	33.8	48.3%	49.1	70.2%	24	7.02	25.4%	9.54	34.5%	16.56	59.8%
3	25.2	20.3%	51.2	41.4%	76.4	61.7%	25	10.7	11.6%	47.2	49.8%	57.9	61.4%
4	7.3	13.7%	30.7	57.6%	38.0	71.3%	26	11	21.2%	7.4	14.3%	18.4	35.5%
5	19.4	20.2%	51.4	53.3%	70.8	73.5%	27	32.2	23.8%	53.3	39.3%	85.5	63.1%
6	26.3	22.5%	29.5	25.2%	55.8	47.7%	28	41.2	27.4%	31.1	20.7%	72.3	48.1%
7	8.2	17.0%	25.1	52.2%	33.3	69.2%	29	16.3	17.3%	48.7	51.6%	65	68.9%
8	12.5	13.6%	41.2	44.7%	53.7	58.4%	30	9.8	21.1%	12.3	26.4%	22.1	47.5%
9	3.6	6.2%	40.5	68.9%	44.2	75.0%	31	19.1	22.1%	18.4	21.4%	37.5	43.5%
10	10.4	14.3%	9.3	12.9%	19.7	27.1%	32	18.3	14.7%	7.2	5.8%	25.5	20.5%
11	19.6	24.2%	15.6	19.3%	35.2	43.4%	33	20.7	19.1%	31.1	34.3%	51.8	53.4%
12	21.5	29.2%	18.1	24.7%	39.6	53.9%	34	13.9	21.2%	22.5	34.5%	36.4	55.7%
13	9.6	18.3%	5.0	9.5%	14.6	27.7%	35	9.2	12.5%	40.2	54.8%	49.4	67.3%
14	19.4	29.1%	7.3	11.0%	26.8	40.1%	36	13.8	12.4%	32.6	29.3%	46.4	41.7%
15	7.8	13.4%	7.7	13.1%	15.5	26.5%	37	20.9	16.0%	35.3	27.1%	56.2	43.1%
16	24.7	22.0%	34.8	31.1%	59.5	53.1%	38	18.5	18.8%	39	39.6%	57.5	58.4%
17	16.2	15.4%	46.4	44.3%	62.6	59.7%	39	27.7	28.8%	28.9	30.1%	56.6	58.9%
18	18.9	32.5%	23.0	39.5%	42.0	72.0%	40	32	26.9%	11	9.2%	43	36.1%
19	16.0	12.1%	58.8	44.3%	74.9	56.3%	41	30.3	18.4%	28.5	17.4%	58.8	35.8%
20	5.9	6.7%	59.5	68.0%	65.4	74.7%	42	31.5	24.6%	29.8	23.3%	61.3	47.9%
21	28.2	28.6%	19.2	19.5%	47.4	48.0%	43	20	16.3%	40.3	33.0%	60.3	49.3%
22	14.0	15.1%	18.7	20.1%	32.7	35.2%							

Source: Institute of Architecture Science and Design of the Hubei Province.

The average consumption of HVAC systems is shown below.

Table 33 *Investment Costs in RMB per m² of Floor*

System	Percentage			Energy Consumption (kWh/m²)		
	Maximum	Minimum	Average	Maximum	Minimum	Average
AC	29.2%	6.2%	20.1%	41.2	3.6	15.5
Heating	68.0%	5.8%	27.2%	59.5	5	21.1
HVAC	75.0%	20.5%	41.0%	85.5	14.6	36.6

Source: Institute of Architecture Science and Design of the Hubei Province.

The average energy consumption of HVAC systems is 36.6kWh, about 41.0 percent of total energy consumption. As the table shows, in a hot summer and cold winter area, HVAC is the most significant factor in energy consumption. Improving energy efficiency here is instrumental to savings.

Indoor Air Quality Evaluation

Indoor air is intrinsic to people's daily living environment. It not only affects people's health but also determines their work efficiency. Indoor air quality is evaluated according to Audit Technique Standards.

Parameters

Indoor air quality has been tested in the process of auditing. The tested items include temperature, humidity, light and CO_2 concentration.

Evaluation Standards

Under the Audit Technique Standards, indoor air quality is normally evaluated according to Indoor Air Quality Standard GB/T18883-2002. However, since this document only provides requirements for temperature, humidity and CO_2 concentration, the CIE luminance (light) standard was adopted here.

Table 34 *Indoor Environment Evaluation Standard*

Parameters	Unit	Standard value	Note
Temperature	°C	22-28	cooling
		16-24	heating
Relative Humidity	%	40-80	cooling
		30-60	heating
CO_2 Concentration	%	≤ 0.1	ppm ≤ 1000
Luminosity	1x	200	hall
		500	office
		50	traffic area
		750	meeting room

Source: Institute of Architecture Science and Design of the Hubei Province.

Results

Below is the evaluation of the 24 buildings' indoor air quality.

Table 35 *Meeting Standard Rate*

Parameter	Temperature	Humidity	CO_2 Concentration	Luminance
Office	75%	75%	95.8%	20.8%
Meeting Room	78.3%	91.3%	91.3%	0

Source: Institute of Architecture Science and Design of the Hubei Province.

Conclusion

The results show that some office buildings' indoor air quality failed to meet standards. This should be taken into consideration and resolved through retrofit measures. The evaluation also partially explains why these buildings' energy consumption is not the same as other buildings' of the same type.

Problems Found During Audits

During the audits, four problems emerged in terms of building energy efficiency.

First, energy-saving awareness needs to be raised and good energy-saving habits should be developed. For example, lights or air-conditioning left on in an empty room; doors or windows open when air conditioners are still in use; the air handling unit working 24 hours a day, etc.

Second, in some instances a complete set of technical records for a building could not be provided. Some buildings do not even have construction blueprints.

Third, the measurement system is not perfect. There is no separate measurement equipment in some buildings; most buildings are equipped with only one meter; no machine for sub-measuring can be found in some departments and sections of a building; and worse, meters have not been used since they were installed.

Fourth, experts on energy management are urgently needed. Some buildings have no professional energy management personnel. In particular, HVAC system management technicians are hard to find.

Conclusion

Compared with advanced office buildings, energy consumption in government office buildings is not high. However, this does not mean they are energy-efficient, and energy efficiency management is essential to develop their potential to save energy.

3.4.4. Feasibility Studies of Typical Existing Buildings' Rehabilitation

At present, existing building floor space in China totals 45 billion m^2 (19 billion m^2 are located in urban construction), of these buildings more than 99 percent are not energy-efficient buildings. Approximately 2,000 million m^2 of new construction are added every year, 95 percent of which are also high energy consumption buildings. Heating energy consumption is 2-3 times that of buildings in developed countries. Today, China's housing construction is still in the peak period, and 30 billion m^2 are expected to be added by 2020. Of the new buildings, just 320 million m^2 of urban housing are energy-saving buildings, with the rest still high energy consumers. These buildings will cause increasing amounts of waste in the future.

Of the different ways to save energy, building energy efficiency is the most direct and effective. It is also one of the most effective ways to handle the energy crisis and to solve the contradiction between socio-economic development and the shortage of energy supply. To decrease the unit GDP energy consumption by 20 percent, required by the national 11th Five-Year Plan, focus must not only be placed on energy conservation in new buildings, but also on the rehabilitation of existing buildings.

Retrofitting Existing Buildings

The retrofitting of existing buildings incorporates three parts: behavior, the building envelope, and building energy systems and equipment.

Behavior

Energy conservation awareness should be enhanced and people educated in developing good habits such as reducing computer standby time, lights-on time, and closing windows when the air-conditioning is on. The energy systems of a building should be checked and upgraded regularly, energy-saving facilities should be well managed, and the metering system should be improved constantly. All these measures can help save energy.

According to statistics, if people follow these simple energy-saving guidelines, energy-use in a building can be reduced by nearly 10 percent.

The Building Envelope

The aim of an efficient building envelope is to improve indoor comfort, reduce the cold and heating loads of the HVAC system, and reduce energy consumption. Building envelope energy-saving technology includes thermal insulation, efficient doors and windows, and shading.

Systems and Equipment

Since energy utilization systems are directly and closely connected with energy consumption units, retrofitting these systems has obvious effects. It improves energy efficiency in the lighting system, AC efficiency, heating efficiency, and electrical system efficiency, as follows:

Lighting system: high-efficiency lights, lighting controls, etc;

AC system: high-efficiency pumps, heat recovery, cold storage, frequency conversion, regeneration energy, etc;

Heating system: highly efficient boiler, heat net retrofit, etc;

Electrical system: power-saving, high-efficiency transformer, circuitry alteration, lifts, energy return equipment, etc.

Feasibility Studies of Typical Buildings in Wuhan

Feasibility Study 1

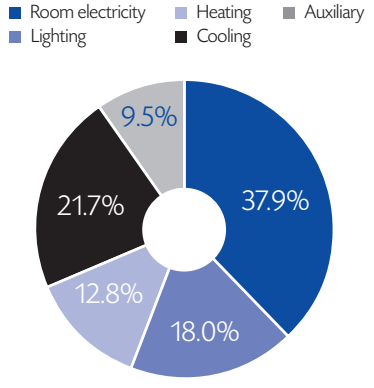
Building Information

Building 1 is a north-facing 18,000 m^2 office building with 18 floors above ground and 2 floors below ground. It was built in the 1990s. It has a frame structure, the outer wall is filled with aerated concrete block, and the roof has 40 mm expanded perlite for thermal insulation. The windows are single-pane aluminum alloy, and the glazing ratios are 55.8% (south), 46.5% (north), and 6.9% (east & west). The building uses ordinary fluorescent lights and a few high-efficiency lights in some public areas. The hot-and-cold source of the HVAC system is air-to-air heat pumps.

The energy consumption of this building is 73.5 kWh/m^2 per annum as follows:

Figure 51

Building 1 Energy Consumption



Source: Author.

Analysis of Energy-Saving Potential

Building Envelope

The Energy-Saving Potential of Each Measure

The building envelope includes walls, roofs, floors, doors and windows. The energy-saving measures involve exterior insulation, double-glazing, low-E double-glazing, film, and shading. Once each measure is tested, conclusions can be made about its potential for saving energy. The building envelope influences the HVAC system's cold load, heating load, and energy consumption. The table below sets out the performance of each measure in energy efficiency, including cold load, heating load, total cold load, total heating load, and the system's total consumption. After the simulation of a single measure, some packages of energy-saving measures can be decided based on practical conditions and circumstances.

Table 36 *The Energy-Saving Potential of Individual Techniques for the Building Envelope*

Energy Efficiency Technique & Parameters	Exterior Insulation	Interior Insulation	Film	Double-Glazing	Low-E Double-Glazing	Exterior Shading
	Outer wall EPS 30 mm roof XPS 50 mm floor EPS 50 mm	Outer wall EPS 30 mm roof XPS 50 mm floor EPS 50 mm	SC=0.475	K=2.8, SC=0.76	k=2.8, SC=0.40	Roll medium opaque only for
Cold Load	-15.9%	-13.4%	-7.7%	-1.2%	1.0%	-23.8%
Heating Load	-14.6%	-14.7%	-2.5%	-16.3%	-19.3%	0.0%
Cooler	-2.8%	-0.8%	-18.3%	1.1%	-12.4%	-25.7%
Heat Generation	-25.3%	-26.5%	15.8%	-25.9%	-22.4%	-1.9%
HVAC	-8.8%	-8.1%	-4.4%	-7.0%	-12.6%	-13.2%
Total Energy Consumption	-3.9%	-3.6%	-1.9%	-3.1%	-5.6%	-5.8%

Source: Author.

The exterior insulation will destroy the decor of the wall and increase costs. The cost of exterior insulation is RMB150 per m^2, interior insulation is RMB80 per m^2, but the energy-saving impact is almost the same. Interior insulation is therefore the preferred economic choice.

The best techniques for windows are double-glazing and removable outside shading. As low-E glass is too expensive and does not achieve a good effect in both summer and winter, ordinary double-glazing plus removable outside shading for windows is a good choice. Double-glazing inside existing windows is also a good measure, and removable shading between will have a satisfactory energy-saving effect.

As a result, interior insulation plus ordinary double-glazing plus outside shading are often used in building envelope retrofits.

Table 37 *Total Energy-Saving Potential of the Building Envelope*

Energy Efficiency Technique	Interior Insulation + Ordinary Double-Glazing + Outside Shading
Cold Load	-44.6%
Heating Load	-38.2%
Cooler	-27.1%
Heat Generation	-62.9%
HVAC	-31.7%
Total Energy Consumption	-14.0%

Source: Author.

After retrofitting, a building can reduce the cold load by 44.6 percent, the heat load by 38.2 percent, total HVAC system consumption by 31.7 percent, and total building energy consumption by 14 percent.

Lighting System

Lighting system retrofits use high-efficiency lights and lighting controls.

High-efficiency lights: the building used T8 lights. If these are changed to T5 lights, 40 percent of energy consumption on lighting could be saved. Lighting density could be decreased in the model.

Lighting controls: there are step controls and linear controls in the software. Here the 3-step control was chosen.

Table 38 *The Energy-Saving Potential of the Lighting System*

Energy Efficiency Technique	High Efficiency T5 Lights	3-Step Control	Combination
Cold Load	-1.5%	-1.3%	-1.9%
Heating Load	0.0%	0.0%	0.0%
Cooler	-4.1%	-3.1%	-5.8%
Heat Generation	1.9%	2.5%	3.0%
HVAC	-1.5%	-0.8%	-2.0%
Total Energy Consumption	-8.3%	-6.9%	-11.9%

Source: Institute of Architecture Science and Design of the Hubei Province.

Using high-efficiency lights and lighting controls has a significant energy-saving effect, with a possible reduction of energy consumption of almost 11.9 percent.

AC System

The AC system is fan coil with isolated fresh air. The cooling and heating source is air-to-air heat pumps. Since there is no air return duct, and the fresh air unit is not used frequently, the air system will not be retrofitted. However, as the water system in air conditioners has high energy consumption, the cold water pumps need to be replaced with high-efficiency ones.

The existing pumps will be replaced by high-efficiency warm pumps to increase efficiency and save energy. With the same flow rate and speed, each pump can save nearly 20,000 kWh per pump (8 months per year, 9 hours per day), for a total of RMB74,400 per year.

Electric System

During the audit, the power of the electricity distribution system was found to be quite high in the building. However, after using the capacitance, it reduced to 0.95. Thus, the electricity distribution system will not be retrofitted except for the elevators.

Energy return equipment will be added to the elevators to save energy by returning the electricity stored in the capacitance to the electricity net. This retrofit has a significant electricity-saving effect, with a rate of 25-30 percent. The lift's electricity consumption can be reduced by about 45,000 kWh per year, with the investment being returned within a year.

Total Energy-Saving Potential

Table 39 *Building 1 Energy-Saving Potential*

Energy-Saving Technique	Building Envelope	Lighting	AC	Lift
Energy Savings	186,741.3	152,175.8	80,000	45,000
Total Energy Savings	451,949.9			
Percentage	34%			

Source: Institute of Architecture Science and Design of the Hubei Province.

By retrofitting the building envelope, lighting, AC and lift, this building will reduce its energy consumption by 34 percent, about 451,950 kWh per year.

Investment Analysis

Table 40 *Building 1 Energy-Saving Retrofit Investment Analysis*

Energy-Saving Technique	Building Envelope	Lighting	AC	Lift
Energy savings (kWh/year)	186,741.3	152,175.8	80,000	45,000
Economy (RMB/year)	173,669.4	141,523.5	74,400	41,850
Investment (RMB)	2,679,058	596,061	80,000	49,740
Payback Period (year)	15.4	4.2	1.1	1.2
Energy Savings (kWh/year)	451,949.9			
Economy (RMB/year)	420,313.4			
Investment (RMB)	3,404,859			
Payback Period (years)	8.1			

Source: Author.

The total required investment is about RMB 3.4 million. The retrofit can save 34 percent of overall energy consumption and 0.45 million kWh of annual electricity consumption, or RMB0.42 million in electric charges (calculated at the current rate of RMB0.93 per kWh) per year. The initial estimate shows that the payback period is about 8.1 years.

Environmental Effect

While saving energy, the retrofit can significantly reduce the release of greenhouse gases and atmospheric pollutants. It is calculated that 0.45 million kWh of electricity can be saved each year, or 164 T of coal, and considerably reduce the emission of 429 T of CO_2, 1.39 T of SO_2 and 1.21 T of NOx.

Feasibility Study 2

Building Information

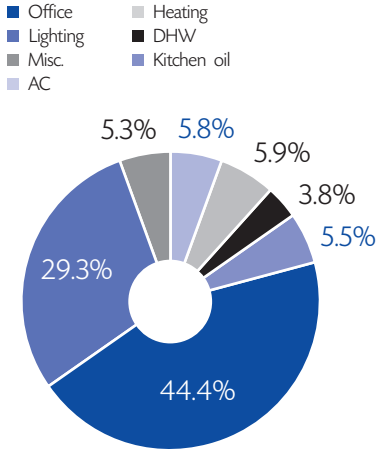
Building 2 is a north-facing hotel that has 14 floors above ground and 1 floor under ground. The total floor area is 20,780 m^2. It has a shear wall structure – the outer wall uses aerated concrete blocks, and the windows are aluminum alloy with single-layer ordinary glass.

This building uses a water cooler and a coal boiler as cold and hot sources. The boiler also supplies the kitchen and the laundry with steam.

The unit energy consumption is 54.1 kWh per m^2 of electricity, 32.09 kg per m^2 of coal, and 1.16 kg per m^2 of oil. Total energy consumption is 1,22.1 kWh per m^2 per year.

Figure 52

Building 2 Energy Consumption



Source: Author.

Energy-Saving Potential

The rehabilitation program is described below:
Building envelope: exterior insulation, double-glazing, outside shading;
Lighting: high efficiency light (T5 light);
AC system: high-efficiency pump, transducer;
Heating system: gas boiler;
Electric system: high-efficiency transformer, circuitry alteration.
The energy-saving potential is obtained through simulation and calculation.

Table 41 *Building 2 Energy-Saving Potential*

Energy-Saving Technique	Building Envelope	Lighting	AC	Boiler	Electric System
Electricity Savings (kWh/year)	95,749	63,220	50,429	0	168,758
Electricity Savings (kWh/year)	378,156				
Percentage (%)	34%				
Coal Savings (T/year)	152	0	0	256	0
Coal Savings (T/year)	331				
Percentage (%)	49%				

Source: Author.

Investment Analysis

Table 42 *Building 2 Energy-Saving Retrofit Investment Analysis*

Energy-Saving Technique	Building Envelope	Lighting	AC	Boiler	Electric System
Electricity Savings (kWh/year)	95,749	63,220	50,429	0	168,758
Coal Savings (T/year)	152	0	0	256	0
Gas Savings (m^3/year)	81,456	0	0	137,485	0
Economy (RMB/year)	317,124	58,794	46,899	384,959	156,945
Investment (RMB)	3,178,000	200,000	100,000	1,400,000	1,000,000
Payback Period (years)	10.0	3.4	2.1	3.6	6.4
Electricity Savings (kWh/year)	378,156				
Gas Savings (m^3/year)	194,505				
Economy (RMB/year)	896,299				
Investment (RMB)	5,878,000				
Payback Period (years)	6.6				

Source: Author.

The total investment is about RMB5.9 million. The retrofit can save RMB0.9 million per year, and the payback period is about 6.6 years.

Environmental Effect

It can save 396 T of standard coal, and reduce CO_2 by 1036 T, SO_2 by 3.36 T and NOx by 2.93 T.

Feasibility Study 3

Building Information

Case 3 is a hospital. The hospital consists of three buildings, which were built around 1982. These buildings serve the in-patient and out-patient departments and administrative offices. The floor area is 29,777 m^2; the outer wall is 240 mm brickwork with single-layer plastic windows. The HVAC system uses a LiBr absorption unit and coal boiler as the cold and heating source. The boiler also provides hot water and steam for other uses.

Energy-Saving Potential

The rehabilitation program is set out below:
Building envelope: exterior insulation, double-glazing, outside shading;
Lighting: high-efficiency light (T5 light);
AC system: high-efficiency pump, transducer;
Heating system: gas boiler, heat net insulation retrofit;
Electric system: high-efficiency transformer, circuitry alteration.
The energy-saving potential is obtained through simulation and calculation.

Table 43 *Building 3 Energy-Saving Potential*

Energy-Saving Technique	Building Envelope	Lighting	AC	Boiler	Electric System
Electricity Savings (kWh/year)	0	103,371	109,594	0	286,276
Electricity Savings (kWh/year)	499,240				
Percentage (%)	35%				
Coal Savings (T/year)	303	0	0	530	0
Coal Savings (T/year)	674				
Percentage (%)	26%				

Source: Author.

Investment Analysis

Table 44 *Building 3 Energy-Saving Retrofit Investment Analysis*

Energy-Saving Technique	Building Envelope	Lighting	AC	Boiler	Electric System
Electricity Savings (kWh/year)	0	103,371	109,594	0	286,276
Coal Savings (T/year)	303	0	0	530	0
Gas Savings (m^3/year)	162,727	0	0	284,638	0
Economy (RMB/year)	455,636	96,135	101,922	796,986	266,236
Investment (RMB)	6,650,350	230,000	200,000	1,697,000	1,500,000
Payback Period (years)	14.6	2.4	2.0	2.1	5.6
Electricity Savings (kWh/year)	499,240				
Gas Savings (m^3/year)	398,547				
Economy (RMB/year)	1,580,225				
Investment (RMB)	10,277,350				
Payback Period (years)	6.5				

Source: Author.

The investment is about RMB10.28 million. The retrofit can save RMB1.6 million a year, and the payback period is about 6.5 years.

Environmental Effect

It will save 711 T of standard coal, and reduce CO_2 by 1862 T, SO_2 by 6.04 T and NOx by 5.26 T.

3.4.5. Conclusions

The following conclusions can be drawn from these audits and feasibility studies.

The average energy consumption of audited buildings is 89.3 kWh per m^2.

Government office buildings consume 84.9 kWh per m^2, complexes 150.2 kWh per m^2, and hotels 122.1 kWh per m^2.

The average energy consumption of the HVAC system is 36.6 kWh per m^2, about 41 percent of total energy consumption.

The retrofits can efficiently reduce building energy consumption. The energy-saving potential is more than 30 percent. The investment in retrofits will be returned in 10 years.

The payback period for a building envelope retrofit is 10-15 years.

The payback period for updating an energy system is comparatively short – usually less than 5 years.

3.5. Stakes and Extrapolations from Wuhan to Hubei and the Yangtze River Area

Mr. Aymeric Novel, Consultant, TERAO Green Building Engineering

The methodology applied at the scale of Wuhan to determine the energy-saving potential, its corresponding investment costs, and payback periods, has been successful. We have obtained numerous estimates for the considered portion of the building stock: administrative buildings and large public buildings. Based on the results obtained in Wuhan, we have extended investment cost volume, energy and money savings, and reductions of CO_2 emissions to the scale of Hubei province and all the Yangtze river area within the limit of reasonable similarities of climate and building floor area statistics (Hubei, Hunan, Jiangxi and Anhui).

This work has been carried out to show decision-makers and investors the stakes related to large-scale programs of thermal rehabilitation of the public building stock. This was done for 3 geographical scales and 3 levels of thermal rehabilitation corresponding to 3 levels of investment and energy savings.

Wuhan Scale

We synthesize here results obtained **at Wuhan's scale** for average energy consumption and energy savings for the 3 levels of investment and performance for building thermal rehabilitation. The considered building area for large public buildings and administrative buildings is 37.4 million m^2 (half of the public building stock):

- Low-cost rehabilitation: RMB4.1 billion invested, 0.3 Mtce per year of primary energy and 0.8 Mt CO_2 per year saved;
- Middle-cost rehabilitation: RMB8.6 billion invested, 0.42 Mtce per year of primary energy and 1.1 Mt CO_2 per year saved;
- High-cost rehabilitation: RMB11.2 billion invested, 0.53 Mtce per year of primary energy and 1.4 Mt CO_2 per year saved.

Hubei Province Scale

This second part shows the results at Hubei Province's scale. These are based on comparisons of statistics between Wuhan and Hubei and the assumption that Wuhan is representative of Hubei's climate.

To do this extrapolation, we consider that building's properties and energy issues are similar. Therefore, we only need to estimate the building floor area that is concerned by the rehabilitation of public buildings.

According to statistics, public building floor area in Hubei Province is 263 million m^2. Without more accurate statistics, we will consider the same assumption as in the case of Wuhan: we apply rehabilitation packages on half of this area. Therefore, the considered area for building rehabilitation is 131.5 million m^2, and that leads to the stakes below:

- Low-cost rehabilitation: RMB14.5 billion in-vested, 1.1 Mtce per year of primary energy and 2.9 Mt CO_2 per year saved.
- Medium-cost rehabilitation: RMB30.2 billion invested, 1.47 Mtce per year of primary energy and 3.8 Mt CO_2 per year saved.
- High-cost rehabilitation: RMB39.5 billion invested, 1.9 Mtce per year of primary energy and 4.9 MtCO_2 per year saved.

The Yangtze River Area Scale

Finally, we have extrapolated results obtained in Wuhan and Hubei to the entire Yangtze river area. In this area, we can identify a certain amount of provinces, which could be included in our extrapolation. The 2 important questions to answer in order to do this are climate similarity and building floor area statistics.

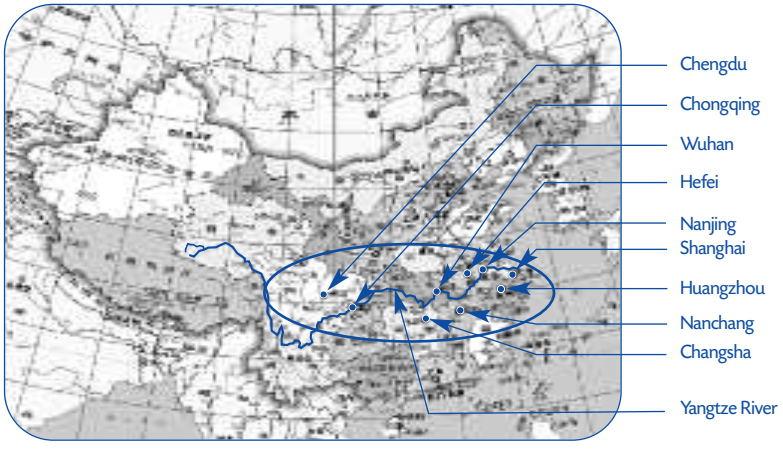
We have first addressed these issues for 9 provinces located around the Yangtze River. Weather data are illustrated by each of these provinces' capital. They are listed below:

- Shanghai (City of Shanghai);
- Hunan (City of Changsha);
- Hubei (City of Wuhan);
- Jiangxi (City of Nanchang);
- Anhui (City of Hefei);
- Chongqing Shi (City of Chongqing);
- Sichuan (City of Chengdu);
- Jiangsu (City of Nanjing);
- Zhejiang (City of Hangzhou).

The map below illustrates these locations around the Yangtze River:

Figure 53

Map of Locations in the Yangtze River Area



Source: Map of China Internet Version of State Bureau of Surveying and Mapping.

Climate Similarities

We have analyzed the weather data of the cities on the map above. As with Hubei and Wuhan, we can consider the weather data of a province's capital as being representative of the province's climate. Weather data come from the sources listed below:

China Climate Data 2007

CSWD: Chinese Standard Weather Data (developed by Tsinghua University and the Meteorological Bureau of Beijing);
SWERA: Solar and Wind Energy Resource Assessment (developed by the United Nations for wind and solar resources assessments in developing countries);

IWEC: International Weather for Energy Calculations (developed by ASHRAE for thermal calculations in buildings).

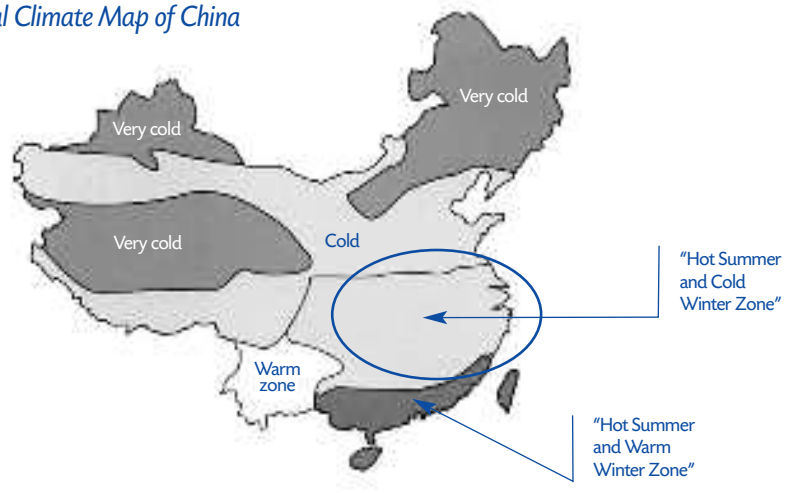
We present the results of the comparison of weather data below:

- Climate Classification: According to Köppen and ASHRAE classifications, the cities considered all belong to the same climate zone: "humid subtropical" according to Köppen (type Cfa) and "mixed-humid" according to ASHRAE (type 4A). These classifications are widely used for climate classification and considered to be reliable.

This agrees with the official climate map of China seen below:

Figure 54

Official Climate Map of China



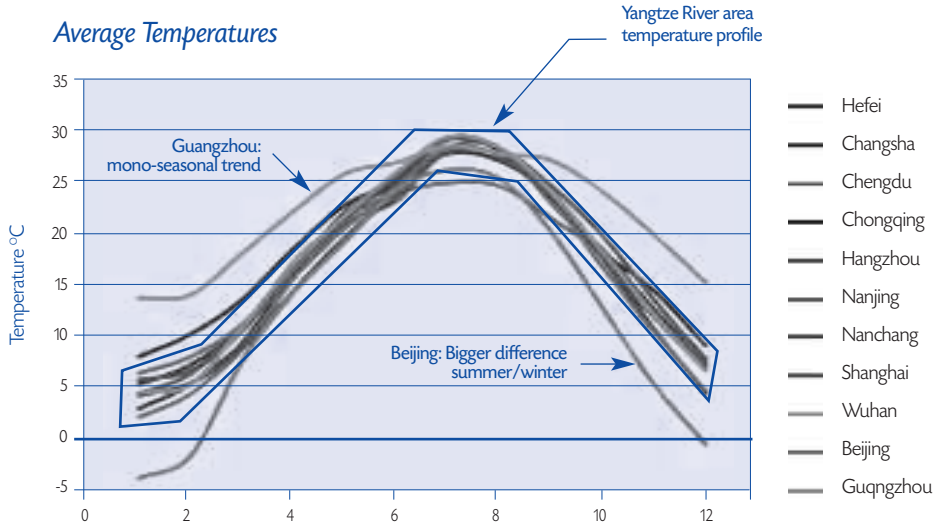
Source: Lawrence Berkeley National Laboratory.

The climate zone named "Hot Summer and Cold Winter" includes all the Yangtze River area. It tends to confirm that this part of China has a quite homogeneous climate pattern, as does the Yangtze River area.

- Monthly Mean Temperatures: For monthly and yearly mean temperatures, 7 cities are similar. A difference of about 2.6°C for monthly temperature and 2°C for yearly temperature is observed. The 2 cities that

have slightly different data are Chengdu and Chongqing. Chengdu is colder in winter and Chongqing is hotter in summer. In the graph below, in order to illustrate the "climate package" better, we used Beijing and Guangzhou data to highlight differences.

Figure 55



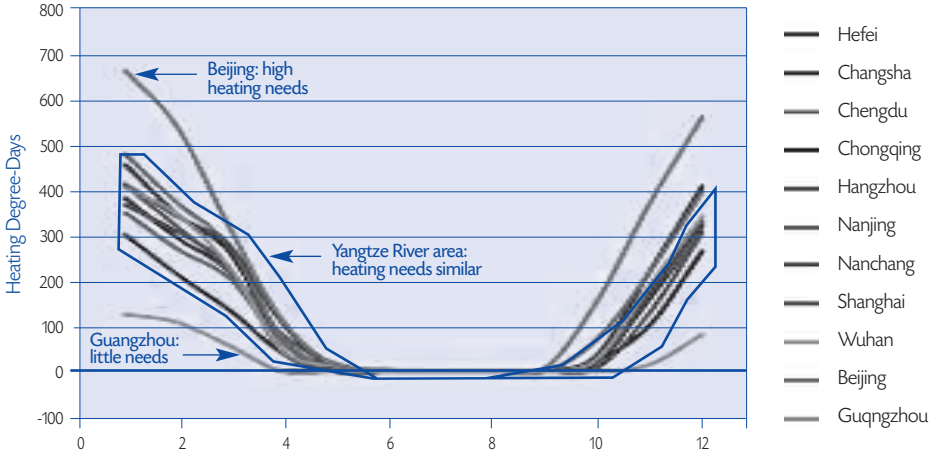
Source: Author's construction.

- Extreme Temperatures: The difference between yearly maximum temperatures in cities other than Chongqing is 2.2° C. The difference between yearly minimum temperatures is 5° C. According to "China Climate Data 2007", the difference in maximum temperatures is 2.1° C and the difference in minimum temperatures is 4.6° C. In both cases, the data are very similar. The difference in minimum temperature is a little large. However, if we remove Nanchang from the sample, it drops to 2.6° C, which is in agreement with the average difference of 2° C within that climate area. To give an idea of these extreme temperatures, in Wuhan, the maximum temperature is 37° C and the minimum temperature is -5.8° C.
- Relative Humidity: We observe differences of about 10.5% if we consider cities other than Chongqing and Chengdu.
- **Degree-Days**:* We present here an analysis of degree-days (DD) based on 18° C. The difference in heating degree-days is about 50 DD. The difference in cooling degree-days is about 33.8 DD. If we use Wuhan as the reference city and remove Chongqing from the package, the difference in heating degree-days between Wuhan and other cities is 3%. Heating needs are therefore quite similar. The difference in cooling degree-day is 13%. In other words, energy needs in these cities are quite similar.

[*] Degree-days: Sum of the differences between interior and mean daily exterior temperature [illegible] Taking 18° C as a base means θint=18° C.

Figure 56

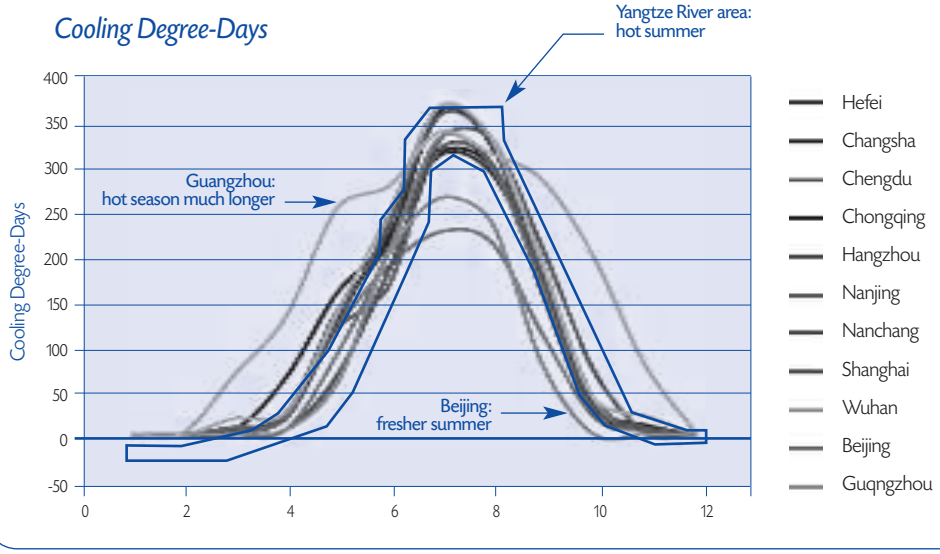
Heating Degree-Days



Source: Author's construction.

Figure 57

Cooling Degree-Days



Source: Author's construction.

- Solar Irradiation: For global horizontal irradiation, the difference is about 1000 Wh per m^2 even if we remove Chongqing and Chengdu. This is a significant difference. However, these data are of limited reliability since most of them are calculated instead of measured. Therefore, they depend on the chosen calculation algorithm.

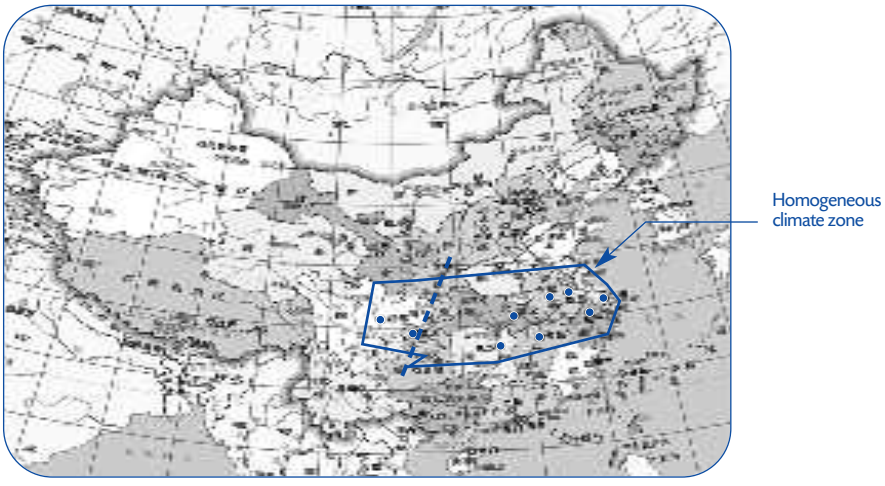
Conclusions on Climate Similarities

We can say that Shanghai, Nanjing, Hangzhou, Hefei, Nanchang, Wuhan and Changsha are quite similar in terms of climate. Solar irradiation is a particular parameter and data vary too much from one source to another to use it as a relevant comparison point.

Chengdu and Chongqing are a bit different from this "climate package" because they are more western cities, close to the edge of the climate zone named "cold winter":

Figure 58

Homogenous Climate Zone



Source: Map of China Internet Version of State Bureau of Surveying and Mapping.

As a result, this study excludes Sichuan and Chongqing from our extrapolation. These two provinces are within the transition area of two climate zones.

To conclude, we can consider that the climate around the Yangtze River is quite homogeneous by comparing several important weather data parameters.

Thus, energy consumption and energy-saving potential analyses conducted in Wuhan might be applied, as a first approximation, to estimate savings and costs in surrounding provinces, except for Sichuan and Chongqing.

Climate similarities tend to prove that performance, quality and building design approaches are similar in all these regions. It is likely that building stocks will show similar characteristics as those observed in Wuhan in terms of energy efficiency and energy-saving potential.

Building Floor Area Statistics

In the book *China Statistical Yearbook on Construction 2008*, we obtained the built floor area in 2008 for the 9 studied provinces. It is given in the table below:

Table 45 *Built Floor Area in 2008 for the 9 Provinces around the Yangtze River in million m²*

Province	Total	Industry	Proportion of Industry	Public Non-Industrial	Proportion of Public Non-Industrial	Housing	Proportion of Housing
Shanghai	60.9	22.5	37%	12.8	21%	25.6	42%
Jiangsu (Nanjing)	349	73.8	21%	72.6	21%	202.6	58%
Zhejiang (Hangzhou)	340.9	108.1	31%	74.5	21.9%	158.3	47.1%
Anhui (Hefei)	72.1	11.3	15.7%	15.4	21.4%	45.4	62.9%
Jiangxi (Nanchang)	45.7	5.2	11.4%	11.5	25.2%	29	63.4%
Hubei (Wuhan)	84.3	14.4	17.1%	17.1	20.3%	52.8	62.6%
Hunan (Changsha)	82	8.8	10.7%	23.4	28.5%	49.8	60.8%
Chongqing	57.5	5.1	8.9%	10.3	17.9%	42.1	73.2%
Sichuan (Chengdu)	96.3	9.6	10%	18.6	19.3%	68.1	70.7%
Total	1,189	258.8	21.8%	256.5	21.6%	678.7	56.6%

Source: China Statistical Yearbook on Construction.

In general, we see the same proportion of housing to public buildings in these provinces as in Hubei and Wuhan – about 60/40. In the case of Hubei and Wuhan, the proportion of the yearly built area between public buildings and housing was quite close to the proportion within the total building stock. Since we do not have explicit statistics for other provinces, we assume that this is also true for them.

We also observe that Jiangsu and Zhejiang provinces have different statistics. These provinces build many more buildings than the others. They are located near the east coast, around Shanghai. Statistics show that urban development is different in these provinces compared to more central provinces. Noticeably, industrial buildings comprise a much bigger part of the built floor area.

For these reasons, we consider that the extrapolations of studies made in Wuhan should be applied only to provinces that have similar building sector dynamics because we want to estimate the total floor area based on yearly built area.

In the table below, we sum up the remaining provinces. We also remove Sichuan and Chongqing because of the climate analysis.

As a result, we only apply the extrapolation to Anhui, Jiangxi, Hunan and Hubei provinces:

Table 46 *Extrapolated Built Floor Area*

Province	Total	Industry	Proportion of Industry	Public Non-Industrial	Proportion of Public Non-Industrial	Housing	Proportion of Housing
Anhui (Hefei)	72.1	11.3	15.7%	15.4	21.4%	45.4	62.9%
Jiangxi (Nanchang)	45.7	5.2	11.4%	11.5	25.2%	29	63.4%
Hubei (Wuhan)	84.3	14.4	17.1%	17.1	20.3%	52.8	62.6%
Hunan (Changsha)	82	8.8	10.7%	23.4	28.5%	49.8	60.8%
Total	284.1	39.7	14%	67.4	23.7%	177	62.3%

Source: China Statistical Yearbook on Construction.

For the statistic study in Hubei, we found:
Total building floor area in urban areas: 758 million m^2, including:

- Housing area: 495 million m^2;
- Public building area: 263 million m^2.

In Hubei in 2008, the total built area* was 84.3 million m^2. It corresponds to 11.1% of the existing building stock in urban areas. If we apply this idea to housing and public buildings, we find respectively 10.6% and 12% of newly built floor area.

The idea is to apply this rate of building floor area renewal per year to the four provinces considered as mentioned above.
We apply these percentages to the 4-province total:
Total building floor area in urban areas: 2.56 billion m^2, including:

[*] Area refers to floor space area.

- Housing area: 1.67 billion m^2;
- Public building area: 890 million m^2.

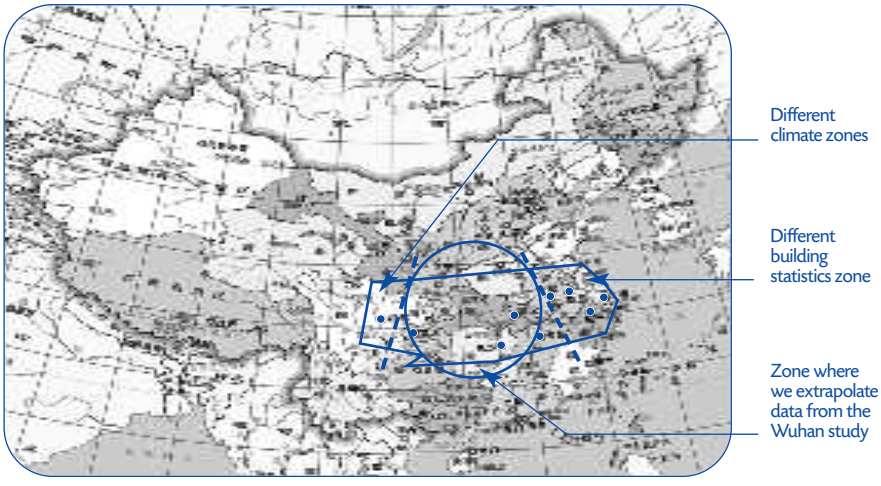
As for Wuhan, we consider that thermal rehabilitation is applied to half of the public building stock. Therefore, the considered area is **445 million m^2**.

Remember that these values are only for urban areas. The obtained value also correlates the value of 3 billion m^2 of building floor area in the Yangtze River area that we find in the report of the energy efficiency bureau for thermal rehabilitation. Since the considered provinces are not mentioned in this report, we can only conclude that all the information we have is consistent with itself.

The map below shows the zone around the Yangtze River where we apply the extrapolation of the results obtained in Wuhan:

Figure 59

Map of the Extrapolation Area



Source: Map of China Internet Version of State Bureau of Surveying and Mapping.

Results of the Extrapolation on the Considered Area

As was shown before, 3 other provinces (Hunan, Jiangxi and Anhui) can be used for larger extrapolation since their climates and building floor area statistics are very similar to those in Hubei. The considered area is 445 million m^2:

- Low-cost rehabilitation: RMB49 billion invested, 3.6 Mtce per year of primary energy and 9.5 Mt CO_2 per year saved;
- Medium-cost rehabilitation: RMB102 billion invested, 5 Mtce per year of primary energy and 13.1 Mt CO_2 per year saved;
- High-cost rehabilitation: RMB134 billion invested, 6.3 Mtce per year of primary energy and 16.4 Mt CO_2 per year saved.

In comparison, 445 million m^2 is half of the French public building stock and 16.4 Mt CO_2 is more than 15% of France's building sector CO_2 emissions! We can see that large-scale thermal rehabilitation in the Yangtze River area could have significant impact.

Further extrapolations in other provinces require additional studies based on the methodology we have exposed in this seminar. Indeed, climate data in Sichuan and Chongqing Shi are different. Moreover, building floor area statistics for the east provinces around Shanghai are also different. However, the techniques to be used are probably similar.

Conférences
& Séminaires

3.6. Focus: Administration Buildings and Large Public Buildings in Wuhan – Study on an Energy Savings Monitoring System

Mr. Tong Mingde, Chief Engineer of the Architecture Committee, Energy-Saving Office of Wuhan

Ladies, gentleman, and experts: good morning. I think we can safely say that after yesterday's discussions, our experts have managed to reach a consensus on how to advance energy efficiency retrofitting of existing buildings. This is primarily a consensus on the need to set up a market-based mechanism to serve as a foundation for progress. Adopting such a market-oriented approach will require some very important work be done – measurement of energy savings and supervision of energy conservation operational management.

This requires us to use a scientifically accurate way of calculating energy savings, thus providing itemized and operational supervision.

Experts in our economic team have done research on this kind of system for the office buildings of State organs and large public buildings. I would now like to give a simple presentation of the overall situation we have encountered.

The presentation will include the following aspects: first, a basic introduction to the buildings in Wuhan Municipality; second, research on an energy savings supervisory system; third, the safeguard measures we have adopted; fourth, our energy-saving targets and an ongoing economic analysis; and finally, a brief introduction to a case study on setting up a supervisory platform for energy savings.

And so we turn to the situation in Wuhan Municipality. Yesterday, a lot of experts from our scientific team gave a very detailed introduction to everybody about this so, in order to save time, I will not go into detail.

In the process of calculating energy consumption, we felt that there was currently a very important issue to resolve: none of the buildings of State organs or large public buildings have the equipment for taking itemized measurements. As a result, we believe that enhancing the market behavior of operational mechanisms would not be beneficial as the next step, and that the issue of itemized measurements should be resolved first. At the same time as resolving this issue, we must also set up a system of close supervision. I would now like to move on to the second item on the agenda.

Research into a supervisory system for energy savings. Our mayor actually gave us all a brief introduction to this system in yesterday's plenary session. It includes five aspects: (1) calculation of energy consumption; (2) audit-

ing of energy resources; (3) keeping the public informed of energy efficiency; (4) energy consumption quotas; and (5) guidelines on price increases for exceeding quotas.

The main thoughts on how to ensure supervision is that these five systems need to be established. A prerequisite condition for their establishment is that we set up an energy consumption platform. Such a platform would allow for the aforementioned work to continue.

The aim is to construct a platform to monitor energy consumption. There appear to be the following few ways of doing this in Wuhan Municipality. First, we should set up an administrative center that looks at the office buildings of State organs and large public buildings. This center will manage energy consumption monitoring of the public building stock (over 20,000 m^2) in Wuhan Municipality. This is one of our aims.

The second aim is to introduce measures of itemized measurements in existing buildings. This includes measures concerning what we have just been discussing: systems for rationing heating and air-conditioning, lighting, office systems (including electricity, water, gas, etc.). Through such itemized measurements, the data would then be entered into our supervisory platform. This supervisory platform would perform powerful calculations, analyzing energy consumption as well as the good and bad areas of our management of energy conservation. It would perform a powerful analytical, statistical and even partial auditing function.

So, setting up a supervisory platform has in fact three aspects. We first need to study how to formulate a method of evaluating energy consumption analysis for the office buildings of State organs and large public buildings. Such a method must, of course, comply with relevant State procedural rules and regulations. The second study should involve the formulation of a new set of quota standards. We require this kind of market mechanism to complement the energy efficiency retrofitting of existing buildings. In fact, other than discussing financing mechanisms, there is another incredibly important task at hand – economic policy incentives. I believe that a financing mechanism without economic policy incentives is never enough. As a result, it is imperative that we introduce energy consumption standards and they must be adapted to the different categories of buildings. The energy consumption quotas should, for example, be different for government office buildings, shopping centers, office buildings, hotels, etc. Professor Li from the Wuhan University of Science and Technology gave us all a presentation yesterday that highlighted the huge differences in energy consumption even in the same kind of shopping centers. This included the energy consumption of Wuhan Shopping Center and Qingshang Shopping Center. The difference in annual energy consumption per m^2 is very large, but does this mean that if a shopping center has high energy consumption it is unreasonable? Does Wuhan Shopping Center's high energy consumption, therefore, make it unreasonable, and Qingshang's low consumption make it reasonable? I do not believe it is so simple, and thus formulating energy consumption standards is an extremely complex process. We cannot simply look upon high annual energy consumption per m^2 as unreasonable and low annual energy consumption per m^2 as reasonable. It is just not that simple. Formulating energy consumption standards is thus an extremely crucial step.

The third aspect is to set fixed cost standards for the price increases for exceeding quotas. If we allow a building to consume a certain amount of electricity and this amount is exceeded, then a set system of price increases must be adopted. This is a very important aspect of establishing a market mechanism as it will allow us to benefit from carrying out energy efficiency retrofitting.

As part of current national implementation plans for energy conservation and emissions reduction, including those of the Ministry of Construction, Wuhan Municipality has been nominated as a demonstration city for the establishment of a system to supervise and control the energy conservation in State organ office buildings and large public buildings. We have thus managed to acquire funding from the Ministry of Finance. We have so far received payment of the first two installments of this funding. Meanwhile, Wuhan Municipality has also provided us with some funding to support the construction of a supervisory platform for energy conservation. I will not go into precise details of this funding with everyone right now.

The construction of a supervisory platform of energy conservation also involves a statistical element. We have drafted guidelines on gathering statistics in a scientific and rational way. I believe that this is key. If your statistical methods are irrational then it is very possible that the calculations will not reflect the true energy consumption of buildings scientifically. This is why we formulated guidelines on collecting energy statistics in Wuhan.

Energy data is the second aspect. How energy data is gathered is also extremely important. The Ministry of Construction has statistical guidelines for energy audits. I had a look at these guidelines and felt that, for climatic areas like our own that are hot in the summer and cold in the winter, further relevant research was still needed. As such, our research group formulated the *Wuhan City Regulations on Energy Auditing of State Organ Office Buildings and Large Public Buildings* in accordance with the Ministry of Construction's guidelines. These basically state how auditing can be done in a scientific and rational manner.

Meanwhile, we began energy audits on 23 buildings in Wuhan. This has primarily been carried out by students and teachers, led by the research team of Professor Li from the Wuhan University of Science and Technology.

The third aspect is that of keeping the public informed, which ignites public debate. We can thus let the public supervise the high energy consumption of buildings. We have drafted the *Administrative Regulations on Public Energy Information on State Organ Office Buildings and Large Public Buildings in Wuhan Municipality,* which states how to go about making such information public. Energy-inefficient buildings have primarily been made public through the use of government websites and newspapers. I would now like to share with everyone the safeguard measures for this supervisory system.

There is a leading group charged with the supervisory system of State organ office buildings and large public buildings. Below the leading group is an office, which is responsible for this area of work. Constructing a supervisory platform is mainly the work of our testing center, run by Wuhan's Kangcheng Science and Technology Development Company, Ltd., and Wuhan University of Science and Technology. Energy consumption statistics

are currently being compiled by universities, the departments of the Housing Bureau, as well as local government offices. Wuhan Municipality energy statistics have not only been gathered on State organ office buildings and large public buildings but also across its districts. Last year, we gathered statistics on 5,600 buildings in Wuhan municipal districts. This was done by groups from 20 residential committees that carried out door-to-door energy consumption checks in the evenings. Our statistical data confirms the situation that the mayor presented us with in yesterday's meeting.

Energy auditing was carried out by the Wuhan University of Science and Technology and related work units, including the Investigation Academy. Informing the public is primarily the responsibility of the construction committee. For constructing the supervisory system, there was a tender for bids, resulting in the work currently being granted to the Wuhan Kangcheng Science and Technology Development Company, Ltd. With the system in place, we will be capable of very good energy-savings analysis. The supervisory system should give us a very good picture of the level of energy consumption before and after retrofitting.

I would now like to present you with a case study. We have already begun taking itemized energy conservation measurements in the building of the Wuhan Municipal Supervision Bureau. Meanwhile we have set up the Wuhan Municipal Urban Window–our supervisory platform. The significance of this is clear to all. As I have just mentioned, there are four main targets to be met. The first is to set up a supervisory system for monitoring fluctuations in energy consumption of the Supervision Bureau. The second is to establish a large-scale statistical system for State organ office buildings and large public buildings. The third is auditing. The fourth is managing checks on energy conservation in such buildings throughout Wuhan Municipality. There is one main framework for this. Statistical data is taken from itemized measurements of electricity, water and gas, and transferred to our data collection center. Once analysis has been carried out on this data, we have a basic idea of the energy consumption of the system or building. This can then provide our operational, management and policy-making levels with analytical information on which to base their decisions. This data can also be reported to the next administrative level up, including the Provincial Construction Office and Ministry for Construction. If anyone is interested, we could go to the Wuhan City Supervision Bureau to give you a demonstration of how this interface works.

This is the basic supervisory platform and in the process of monitoring, it became incredibly clear what the energy consumption of the building was. For example, we discovered that in the evening, after office hours, many offices left their lights and even their computers on. We carried out some analysis and studied this straight away and adopted measures concerning the operational management of the Supervision Bureau. The situation is currently as follows: after eight months of operational management, we have saved 14kW of electricity. The buildings cover an area of around 6,000 m^2. Everyone can have a look at our interface. The management of our air-conditioning interface has been particularly strictly enforced. This has primarily involved regulating the compressors, cold drinking water and water pumps. By regulating the air-conditioning, we resolve an important

issue – that of a large horse being used to pull a tiny cart,[7] and help to reduce the overall operational energy burden. We think that there are two problems with our centralized air-conditioning system that must be resolved. You have just been presented with the main functions of the supervisory system as well as how the policy-making, management and operational levels might go about enforcing operational management.

First, we collected data from itemized measurements in the Supervision Bureau. There were many data collection points within the building. Once this was finished, the data was sent to us. As you can see, we collected a huge amount of data on energy consumption from August 2008 until April of this year, which we used to draw a prognostic chart. From this you can see that on each floor of the building was a work unit, and on each floor we carried out itemized measurements. The head of the construction committee for each floor has now acquired the good habit of looking to see whether or not the energy consumption for their floor has gone up or gone down when they enter the building. I will not go into the details of this any further for the time being. There is a very clear interface showing how much electricity has been used for general purposes such as lighting, and how much for high voltage consumption. This is the state of electricity consumption on April 2 in the Supervision Bureau building. Each hour of energy use is labeled. Everyone can see that it was actually during midday that the highest electricity consumption was recorded. This is some of the equipment that is used to take itemized measurements, including data transfer equipment. Meanwhile, we have also established a public information board. For the first, second, third, fourth, fifth floors, etc., each floor is shown with its corresponding energy consumption per m^2. This is available for everyone to look at. Even the energy consumption for the first floor is quite high. And look here, this is the energy consumption per person. We have compiled statistics on the basis of area and per person. This is the total energy use. In actual fact it is the seventh floor that shows the highest energy consumption. If any of our experts here today are interested, I invite you all to visit our regulatory building to see how our supervisory platform really operates.

[7] Translator's note: a Chinese expression implying that more energy is being used than necessary to power something.

Conférences & Séminaires

Part 4. Toward the Definition of a Financial Mechanism Meeting Existing Institutional Constraints

4.1. Interested Parties' Interests and Obstacles in the Energy Efficiency Retrofitting of Existing Buildings

Dr. Wang Bing, Professor, College of Public Administration, Huazhong University of Science and Technology

This report covers four parts: first, the overall benefits of the energy efficiency retrofitting of existing buildings; second, the interested parties involved in energy efficiency retrofits; third, analyses of the motivation and obstacles facing these interested parties; and fourth, some conclusions and policy suggestions put forward in this research.

4.1.1. Overall Benefits of the Energy Efficiency Retrofitting of Existing Buildings

The economic benefits of energy efficiency retrofitting of existing buildings come from the reduction of energy consumption after renovation. The users of the buildings will see the largest benefits. "Social benefits" refers to the improvement of air quality by reducing energy consumption, a benefit shared by all members of society. "National security" refers to lowering the nation's dependency on energy by lowering energy consumption, which is increasingly important against the backdrop of China's necessary rising energy imports and expanding strategic energy reserves. This will benefit the government and the people. "Ecological benefits" refers to the protection and improvement of the ecological system by reducing energy consumption, and this benefit is shared by all members of society and generations to come. Apart from economic benefits, all other benefits cannot be quantitatively measured.

Investment in energy efficiency retrofitting of existing buildings has the potential to generate enormous benefits that will exceed the costs. Society as a whole should be motivated to be part of the undertaking. Nevertheless, as the benefits are not simply economic, and the cost of renovation falls on certain economic entities while the benefits are shared by society as a whole, this energy efficiency retrofitting is essentially work that needs government interference in the event of market malfunctions.

4.1.2. Interested Parties in Energy Efficiency Retrofitting of Existing Buildings

There are various interested parties involved. At least 10 main actors can be identified, namely, the central government, local governments, government functional departments, property owners, property management companies, energy service companies, sup-

pliers of energy-saving products, research institutes, financial intermediaries, and energy supply companies. In addition, many parties might be indirectly involved, such as foreign governments and institutions.

4.1.3. Analyses of Motivation and Obstacles

The following focuses on the motivation and obstacles facing the 10 interested parties in the energy efficiency retrofitting of existing buildings.

The Central Government

The Central Government represents the interests of all members of society. Global warming is becoming a critical, urgent crisis, and as a major player in the international community, China should assume its responsibility. In China, with its rapid economic growth, environmental issues and ecological imbalance are constant issues. Thus, energy saving and environmental protection are essential to sustainable social and economic development, and essential to national security concerns. There are many ways of saving energy and protecting the environment, one important component of which includes demand-side management, where building energy retrofits play a significant part. One popular notion argues that energy savings and environmental protection will undermine economic growth, but this is erroneous. The theory ignores the benefits that cannot be measured in terms of currency, while energy savings and environmental protection can create green job opportunities and lead to more comprehensive economic growth, such as a so-called low-carbon economy and output by energy service companies.

From this perspective, the Central Government should be motivated to push energy-saving renovation for existing buildings. In fact, energy savings and environmental protection are among its top priorities.

Local Governments

The situation is more complex with local governments than with the Central Government, as goals are much more complex, particularly with regard to the conflict between pressing local economic growth and environmental protection, which in turn is magnified by the office terms and work evaluation systems currently in effect. Compared to the Central Government, local governments have limited public funds where priorities must be set. They are more inclined to target projects with smaller investments, swifter results, and more noticeable short-term benefits. Most energy-saving renovation projects for existing buildings do not fall into this category. As a result, local governments' motivation comes mainly from pressure from the Central Government.

Government Departments

Energy-saving renovation involves many government departments, at both national and local levels. For example, at the State level there are the Ministry of Construction, the State Development and Reform Commission, the Ministry of Finance, the State Bureau of Environmental Protection, and the State Science and Technology Commissions. At the local level, there are the Department of Construction, the local Development and Reform Commission, and the Department of Finance, with more complex divisions within these bodies.

For example, in an instance where the office building of the municipal Party committee needs renovation, the relevant Party committee leader must make a demand to be discus-

sed by the municipal government and at Party committee meetings. If it needs Wuhan budgetary funds, it has to be submitted to the municipal people's congress for examination and approval, after which the funds can be allocated by the municipal Bureau of Finance. If it needs State budgetary funds, an application has to go through the provincial Development and Reform Commission to the Division of Investment under the State Development and Reform Commission, after which the funds can be allocated by the Ministry of Finance. If State budgetary funds are not needed and capital is provided by energy service companies and banks, with funds saved from the reduction of energy expenditure, payment for the energy service companies must also be authorized by relevant State organs under the current fiscal system.

This process involves many government organs that have very different objectives. Some might give strong support while others might not, and coordination between them is difficult. To some government departments, energy efficiency retrofitting of existing buildings is still handled on a case-by-case basis, without fixed regulations. To effectively coordinate the various departments, a high-profile, long-standing "leadership committee on energy-saving overall management" should be set up.

Property Owners

Property owners are the most important interested group. The types of existing buildings are complex. They can be roughly divided into public buildings and residential buildings. Property rights are also complex, but they can be roughly divided into single or collective ownership of a building unit. In terms of property rights, China differs from other countries in that there are many apartment buildings with collective ownership, which raises difficulties for renovation. Energy bill payment varies greatly. For government buildings, some have full financial budgets, some partial, and some manage revenue and expenditure themselves. Motivation and financing schemes obviously differ to a large extent for different types of buildings.

From a property owner's perspective, the owner will first be motivated by profit, that is, a reduction in energy costs, secondly by energy-saving renovation during the retrofitting period, and thirdly, by administrative pressure.

Owners of different types of buildings will inevitably have different levels of motivation. The typical obstacle is the large initial investment and long recovery period, with a conflict between short-term and long-term interests.

The levels of motivation for building energy retrofits can be described as such: commercial buildings have the strongest, followed by self-run entities such as hospitals and schools, then residential buildings (agreement is difficult to obtain when they are collectively owned). Fully-funded buildings managed directly by the government come last as this renovation can only be done by pushing through administrative measures. Thus, energy-saving renovation for existing buildings should target mainly the first two types of buildings.

Property Management Companies

Property management companies are emerging along with the development of China's real estate markets. They manage the collect-

ive property rights of residential communities and some privately owned public buildings. They provide services in security, landscaping, cleaning, as well as invoicing for water and electricity costs. They can communicate fully with property owners, and participate in energy management contracting.

One such case is the Shanghai Children's Hospital, which has engaged a property management company for its energy management service that is responsible for managing water and electricity and sharing the profits of any energy consumption reduction.

Property management companies should be reasonably motivated for the energy-saving renovation of existing buildings, but as new market entities, without mutual trust and cooperation with property owners, they will have difficulty actively participating.

Energy Service Companies

Energy service companies are also emerging enterprises, providing energy management services with a view to helping customers cut energy bills and share the benefits of reducing energy consumption. They represent new economic growth points, are capable of generating profit, tax revenues and job opportunities, and are fully encouraged by the government to develop. The higher the energy waste, the more potential they have to survive.

Of all the interested parties, energy service companies are the most strongly motivated to carry out building energy retrofits. In fact, a number of energy-saving renovation projects for existing buildings are currently operated by this type of company. Nevertheless, there are obstacles to their development. Being in their infancy, they do not receive the State's special treatment of tax deduction or exemption, and promotion and advertising demands large amounts of capital.

Suppliers of Energy-Saving Products

Suppliers of energy-saving products are upstream enterprises in the energy service industry, and are also strongly motivated for building energy retrofitting as they need to sell their products and services. But there are obstacles. This type of product costs more than ordinary products, which means more initial outlay from consumers. Meanwhile, in China's flawed bidding system, purchasing costs are considered when inviting bids without considering future reduced energy consumption by using energy-saving products. A case in point is the Broad Air Conditioning Co. Ltd., which complains it is in a worse position in government purchasing, even though its products are more energy-saving. There are also loopholes in China's system of energy-saving product labeling. This is affected by the general social credit system and cultural mindset, as consumers lack confidence in energy-saving products. Even given reliable statistics on the investment recovery period of energy-saving products, statistics are not trusted.

Research Institutes

Research institutes include colleges and institutes that conduct research in fields such as the environment, ecology and energy. They engage in basic research or applied research, the application of research findings, and policy consultation.

They are reasonably motivated for energy efficiency retrofits, but the channels between academic fields, industry, and government are not fully open. Theoretical research and industrial application are not on the same page.

Financial Institutions

As providers of funds and risk takers, financial institutions play an important part in building energy retrofits. These include domestic commercial banks, non-commercial banks, risk investment companies, and international loan institutions. They are mostly profit-driven, but also participate in some non-profit projects.

They are reasonably motivated for the energy efficiency retrofitting of existing buildings. The obstacle is risk evaluation to ensure gains, or at least a balance of profit and loss. But the obstacle is easily overcome, as market competition and banking expertise will drive these institutions to evaluate risks accurately.

Energy Supply Companies

For Wuhan, electricity consumption accounts for 60 percent of the total energy consumption of buildings, thus as far as energy savings from existing buildings is concerned, energy supply companies refer to power companies. Their motivation in energy-saving renovation is complex. On the one hand, they expect users to increase electricity consumption to make more profits. On the other hand, as the difference between peak and off-peak demands on the power network tends to widen at home and abroad, from a perspective of upgrading power grids and installing new power stations, power companies are motivated by the renovation of existing buildings.

China lags behind in electric power system reform. After 2006, there was a new round of investment in the energy-saving field. Many new companies wanted to carve up this market and yet the five major power companies remain motivated to expand and invest. But in building energy retrofits, energy supply companies will not be able to exert direct influence.

From the above analyses, the levels of motivation for the energy efficiency retrofitting of existing buildings can be described as follows: energy service companies and suppliers of energy-saving products have the strongest motivation, followed by the central government, financial institutions and owners of commercial buildings, and then local governments, research institutes and property management companies. Energy supply companies and owners of fully-funded government-run properties have the weakest motivation.

Meanwhile, the levels of capability to renovate existing buildings to save energy must be determined: in other words, who is capable of playing a role when some have the motivation but lack capability? From the strongest to the weakest, the Central Government, local governments, research institutes, financial institutions, owners of commercial buildings, owners of fully-funded government-run properties, energy service companies, suppliers of energy-saving products, property management companies, and finally energy supply companies.

4.1.4. Conclusions and Suggestions

Energy efficiency retrofitting of existing buildings involves a complex market with various participating interested parties. Although there are enormous overall benefits, these are not distributed evenly across the parties. Thus, motivation and capability for retrofitting differs greatly. The overall benefits cannot be realized when there is a lack of public policies or poor implementation.

Our suggestions are to: first, target those with high-energy consumption and promote selectively with administrative measures; second, establish long standing and high-level "leader-

ship committees on energy-saving overall management"; third, categorize thoroughly, identify key targets, and formulate corresponding financing schemes; and fourth, endeavor to raise people's awareness of the cost-return effects of completed renovation projects, and generate stronger motivation for the benefits among society as a whole.

4.2. Promoting the Energy Performance Contracting (EPC) Mechanism, Accelerating ESCO Development & Implementing Energy Efficiency Building Retrofitting Projects

Mr. Shen Longhai,
Director of the Energy Service Companies (ESCO)
Committee of the China Energy Conservation Association (EMCA)

At the beginning of this century, the Chinese government outlined a vision for the country with a scientific development outlook. Saving energy and reducing emissions were defined as the primary national strategy. The target is to reduce energy consumption by 20 percent per GDP, and major pollutant emissions by 10 percent. Some achievements have already been made.

To advance our energy-saving and emissions reduction, we need to create new mechanisms and overcome financing difficulties. Saving energy and reducing emissions are paramount for "increasing domestic demand, maintaining economic growth and adjusting economic structure". Meanwhile, we need to strive to achieve the energy-saving targets set out in the 11th Five-Year Plan.

4.2.1. The Pattern and Demonstration of the EPC Mechanism

Energy Performance Contracting (EPC) is an investment and management model that allows us to divert funds that would be spent on energy bills into investment in energy-saving projects. Energy Service Companies (ESCOs) sign contracts with customers and agree on energy-saving targets and business operation models for energy efficiency projects. EPC is an innovative financing technique that uses cost savings from reduced energy consumption to repay the cost of installing energy-conservation measures.

An Energy Service Company is a specialized company that uses the EPC mechanism to implement energy efficiency projects, with profits as their direct motive. (The most common acronym is ESCO although in China they are referred to as EMCOs).

The three basic types of EPC contracts are:

- Share savings contract. ESCOs share energy-saving profits with customer enterprises according to their contract;
- Guaranteed savings contract. Both ESCOs and host enterprises can invest in the projects. The host enterprises are the main investors. The ESCOs guarantee energy efficiency performance and promise a certain percentage of energy savings;
- Outsourcing contract. The host enterprises commission the ESCOs to conduct operational management and retrofitting in an energy system, and pay trusteeship fees to the ESCOs according to their contracts. The ESCOs are responsible for the management of the operation and maintenance of the whole energy system.

The China Energy Conservation Promotion Project, officially launched in 1998 and supported by the World Bank and the Global Environment Facility (GEF), is a key international cooperation project between the Chinese government, the World Bank and the GEF in energy efficiency fields.

In the first phase of the project, three Pilot ESCOs were established in Beijing, Liaoning and Shandong. By the end of June 2006, these three pilot ESCOs had applied the EPC mechanism and in total implemented 475 energy efficiency projects for 405 customers. The total investment was RMB1.331 billion, the net income was RMB420 million, and customers' profits were 8-10 times those of the ESCOs.

The main achievements of the pilot project in the first phase involved the introduction and dissemination of the EPC concept, successful experience of implementing EPC projects in China, and the acceptance and popularization of the EPC mechanism. It transpired that ESCOs have a big market and a bright future in China.

4.2.2. Principles, Streamlining and Potential of ESCOs

Principles

1. In line with the EPC mechanism, ESCOs sign EPC contracts with customers, implement energy efficiency projects for them, and guarantee energy-efficient performance as well as energy-saving benefits;
2. In terms of accountability, ESCOs implement energy efficiency projects in accordance with the contracts and cooperate with customers to obtain a win-win outcome;
3. ESCOs should enhance their own capacities, establish a one-stop service, and evolve from operating simple energy efficiency projects into running comprehensive and integrated energy efficiency projects.

Streamlining

1) Energy audit/energy conservation diagnosis;
2) Feasibility study reports and energy efficiency retrofit project design;
3) Negotiating and signing EPC contracts;
4) Procurement of raw materials and equipment;
5) Construction;
6) Operation and maintenance;
7) M&V and energy efficiency performance guarantee;
8) Share energy-saving profits between ESCOs and their customers.

Potential

The ESCO Committee of the China Energy Conservation Association (EMCA) was founded in April 2004, and its members had increased from 59 to 317 by the end of 2008. Of these, 246 were ESCOs that had implemented EPC projects. In 2008, there were 65,000 employees working for ESCOs. According to incomplete statistics from 2008, 221 EMCA members implemented 505 EPC projects, with a total investment of RMB 8.59 billion. The annual energy-saving capacity reached 5.8435 million tce, and the annual CO_2 emission reduction amounted to 4.1578 million tC.

- Since energy efficiency is still low in China, there is potential for saving energy;
- From the perspective of energy consumption per unit of output value, the energy consumption per RMB10,000 of China's GDP was 1.06 tce in 2007, twice that of the USA, 4 times the EU's, and 8 times Japan's;
- From the perspective of energy-utilization efficiency, China's is 10 percent lower than the international advanced level;
- From the perspective of energy consumption per unit of product, consumption per unit of 8 major high-consuming products was on average 40 percent higher than the international advanced level.

The enormous energy efficiency market is the foundation for China's development of ESCOs. Chinese people need a deeper understanding of the EPC mechanism and governments at all levels need to provide more support for its implementation and for the development of ESCOs. China's ESCO industry is taking shape and growing rapidly. A great number of well-developed ESCOs will be the backbone of China's ESCO industry in the future.

4.2.3. The Practical Experience of ESCOs in the Energy Efficiency Building Sector

Energy efficiency in buildings is still low and there is a big potential to save energy in China.

In the urban area of Northern China, annual energy consumption in heating is 130 million tce, or 14-25 kg of standard coal per m^2. This is 2-3 times that of developed countries.

China has the arduous task of saving energy in buildings.

In the 11th Five-Year Plan, a target of saving 100 million tce in energy efficiency building projects was set out, and is one of the Ten Key Energy Conservation Projects.

In 2008, 150 million m^2 of heating measurement and energy efficiency retro-fitting was planned to be completed by 2010. However, in 2008, only 40 million m^2 had been retrofitted, so the task ahead will prove difficult.

In the second phase of the China Energy Conservation Promotion Projects, more and more ESCOs implemented energy efficiency projects in construction. According to 2008 data, there were 505 EPC ESCO projects, with a total investment of RMB3.26 billion. Of those EPC items, 224 projects were about energy efficiency in construction, accounting for 44.4 percent, with RMB84.4 million of investment, about 25.9 percent of the total.

Energy efficiency in construction includes designing and building new buildings according to energy efficiency building standards, and retrofitting existing buildings. To promote energy efficiency in construction, the following points should be focused on:

First, the published energy efficiency building standards, policies and measures should be strictly implemented, governments at all levels should keep revising incentive policies and measures (including an energy efficiency building management system), and offer more support for energy efficiency in building sectors.

According to Article 22 of the revised Chinese Energy Conservation Law, the State encourages the development of energy-saving service organizations and supports ESCOs to provide services including energy-saving consultation, design, evaluation, measurement, audit and certification; carry out energy efficiency knowledge dissemination and technology training; disseminate energy efficiency information; and offer demonstrations and other public welfare services. With the enforcement of the Energy Conservation Law, the ESCO industry will develop rapidly in China.

The "Ordinance of Civil Building Energy Saving and the Ordinance of Public Organization Energy Saving" promulgated by the State Council on October 1, 2008, should be strictly implemented. In the Ordinance, Article 26 in Chapter 4 "Energy-Saving Measures" stipulates that public organizations may use the EPC mechanism and commission energy-saving service organizations to conduct energy-saving diagnoses, design, financing, retrofitting, operation, and management. These legal documents have created favorable conditions for ESCOs and contributed considerably to the implementation of energy efficiency in the building sector.

Second, public organizations should take the leading role in energy conservation. Governments, energy consumption enterprises, ESCOs, and financial institutions, etc. should work together to push forward energy efficiency in the building sector.

Energy consumption in public organizations is comparatively high – the rate of consumption is rapidly growing while energy utilization efficiency remains low. Government agencies should play the leading role in energy conservation and set a good example for society by improving energy efficiency performance in their buildings.

Retrofitting existing buildings to improve energy efficiency includes the building envelope, heating system, cooling system, lighting equipment, and hot water supply facility. It means that these programs require joint efforts from ESCOs as well as governments, energy consumption enterprises, and individuals.

The central and local governments should promulgate policies and regulations related to financial subsidies and technical support in this area. The government will not only augment official investment, but also integrate its financial support with social investment and include more funds from society and individuals. The problem of auditing energy-saving practices will also have to be solved as soon as possible, and by doing so, energy consumption enterprises will be mobilized to support energy saving.

Third, ESCOs not only need to carry out energy efficiency projects, but must also continuously innovate their business models. ESCOs are expected to handle comprehensive energy efficiency building retrofitting projects and provide integrated energy efficiency retrofitting solutions.

Most energy efficiency building retrofitting projects managed by ESCOs now use the EPC Shared Savings model, with only a small number using outsourcing. Other models should be further explored, such as financing leasing models.

The energy efficiency building retrofitting projects in China are mostly programs in which only one single type of technology or energy-efficient product is used, such as lighting, central air-conditioning, various frequency speed motors, ice storage, water storage, geothermal heat pumps, or automation. Only a few projects integrate multi-energy efficiency technology in their construction. Judging from some ESCOs' experiences, integrated energy efficiency building projects are more profitable and therefore would attract a higher percentage of customers.

4.2.4. Broadening Energy Efficiency Financing Channels

The first phase of the China Energy Conservation Promotion Project, funded by World Bank loans and GEF grants, was launched in 1998 to implement EPC projects. In the second phase, the ESCO Commercial Loan Guarantee Program was set up to assist ESCOs in obtaining loans from commercial banks and carrying out EPC projects.

This new market-based EPC mechanism was introduced by developed countries. In the pilot project and promotion stage, capital from international financial institutions was used, and a special loan made to guarantee funds for ESCOs. Meanwhile, more energy-saving credits came from domestic commercial banks and enterprises' self-financing.

The three pilot ESCOs established in the first phase mainly made use of a World Bank loan (IBRD US$63 million) and implemented energy efficiency technology to retrofit in terms of the EPC Shared Savings model. They have achieved great success and their experience shows that this new EPC energy-saving mechanism is feasible in China and should be further promoted and applied.

In the second phase, the ESCO Commercial Loan Guarantee Program was established. This program was granted US$22 million by the GEF. A special guarantee risk fund was established to exercise the insurance function through the China investment insurance company IEtG, which provides credit guarantees for ESCOs to implement EPC projects in line with the contracts signed with commercial banks for the loans. More opportunities will be created for ESCOs to obtain loans from commercial banks.

By the end of 2008, IEtG had established cooperative relations with more than 10 banks, including Beijing Bank. Over the past five years, IEtG has guaranteed 127 energy conservation projects for 41 ESCOs. The total loan principal has been RMB501 million; insurance volume has amounted to about RMB454 million; and total investment has reached RMB790 million, which is about 7 times the reserve fund of US$16.5 million (at RMB6.84 = US$1). These energy efficiency projects saved 439,000 tce and reduced CO_2 emissions by 283,000 tons a year.

Banks are increasing loans for energy-saving programs. More and more commercial banks are entering energy efficiency fields.

- IFC and some commercial banks in China, including the Industrial Bank, signed the Energy Efficiency Loan Agreement, and by the end of 2008, IFC partner banks had accepted more than 200 projects and approved 97, with a total loan amount of more than RMB3.3 billion;
- The World Bank has initiated its energy-saving on-lending loan businesses in the Huaxia Bank and the Export and Import Bank, each of which is responsible for onlending US$100 million and its own disposable loans of US$100 million for projects

in energy saving and emission reduction. These loans are used to fund energy efficiency projects implemented by ESCOs, and the development of China's ESCO industry;

- Huaxia Bank signed a strategic partnership agreement with the China Energy Conservation Investment Corporation. It will provide a RMB5 billion intention agreement to strengthen cooperation on financial products in energy saving and environmental protection, such as green credit;
- Some domestic banks have started to use factoring financing for EPC projects by selling the accounts receivable of EPC projects to commercial banks. In this manner, ESCOs turn "future money" into "today's money". In addition, domestic banks have already granted green credit, and more and more banks are entering the energy efficiency field by increasing their loans in this industry.

The Chinese government is increasing funding for the energy efficiency industry, and attracting more social investors to the energy efficiency field.

- In 2008, the Central Government invested RMB42.3 billion to support the Ten Key Energy Conservation Projects and environmental protection facilities;
- In order to cope with the international financial crisis, the Chinese government implemented a significant strategy, namely, "expanding domestic demand, maintaining economic growth and adjusting economic structure". The central government also mapped out a revitalization plan for ten key industries, and added RMB100 billion to the investment in the fourth quarter of last year. Of the increased financial input, RMB12 billion was for energy saving, emission reduction and ecological projects;
- RMB4,000 billion, of which RMB1,180 billion comes from the central government, is for the Livelihood Project. The project involves energy savings and environmental protection. The budget for energy saving, emission reduction and ecological projects is about RMB210 billion, and the budget for structure adjustment and technology updating amounts to RMB370 billion.

International financial institutions are increasing their input in energy conservation, and more and more international funds are entering the Chinese energy efficiency field.

- In addition to the World Bank and IFC, ADB aided the energy efficiency Power Plant project in China and recently announced another Energy Efficiency Financing Program in China. Under this program, ADB will invest RMB800 million as a loss-sharing mechanism to support the energy-efficient performance of tall buildings in China;
- AFD provided China with €60 million as Intermediate Credit in the form of a sovereign loan. This program has officially entered the implementation phase. AFD has completed on-lending loans of €20 million to three commercial banks: the Huaxia Bank, Pudong Development Bank, and Merchant Bank.

Other energy efficiency financing channels and ways include:

Some ESCOs are small and medium enterprises. They seek cooperation with domestic large-scale consortia to realize equity financing through corporate restructuring, or attempt to acquire financial support from their parent companies by direct financing or guaranteed financing:

- Using venture capital or equity financing for ESCOs;

- Cooperating with financing leasing companies;
- Using CDM and DSM funds, etc.; and
- Financing from the capital market through listing.

4.2.5. Conclusions

The market-based EPC mechanism is applicable in China and needs to be further promoted and applied widely.

EPC is not only an operation pattern, but also a means of investment for ESCOs. We should consider Chinese circumstances, explore and initiate new EPC models, continuously broaden the channels for energy efficiency financing, and promote close cooperation between investors and ESCOs.

Many energy service companies in China need more support from the government because they are small and medium enterprises with weak competitive power. The Guiding Suggestions on Accelerating the Development of China's ESCO Industry are expected to go in force as soon as possible so that governments at all levels are directed to support ESCOs and implement more energy efficiency projects in public and government organizations.

It is still salient to mobilize social resources to fund the energy efficiency industry, though central and local governments are increasing their financial support for energy conservation and emission reduction. Individuals, markets and non-government organizations are all indispensable for energy service companies to attract more investment and gain more financing channels.

In addition to advancing the implementation of individual energy efficiency projects, promoting the implementation of comprehensive energy efficiency retrofitting projects and integrated energy efficiency retrofitting solutions should be emphasized, especially in construction. It is also paramount to push forward energy saving in public organizations and encourage ESCOs to carry out more energy efficiency building projects.

More focus should be put on the measurement and verification of energy savings or energy-efficient performance.

It is essential to scientifically measure and verify energy saving or energy efficiency performance, especially in comprehensive energy efficiency retrofitting projects and integrated energy efficiency solutions. The government is expected to assist the growth of some qualified organizations or companies as the third parties to carry out measurements. The IPMVP from other countries should be learned, and in line with Chinese conditions, a methodology developed that is applicable and practical in China for measuring energy savings or energy efficiency performance. The goal is to determine a set of parameters that are measurable, assessable and reportable.

International exchange and cooperation will be strengthened. The revised Energy Conservation Law maintains that the State should encourage the installation and utilization of renewable energy, such as solar energy, in the energy efficiency retrofitting of new as well as old buildings. Solar energy and geothermal energy, and so on, have already been integrated into some projects.

International cooperation will be strengthened in China. The cooperation involves integrating renewable energy with energy efficiency buildings, setting parameters for renewable energy utilization in new buildings, and using renewable energy technologies, such as solar energy and geothermal heat pumps, in updating the energy efficiency of old buildings.

Developed countries have advanced technologies and experience in energy efficiency building, whereas developing countries, such as China, are catching up in this field. China is in great need of management expertise and experience concerning advanced and applicable energy efficiency building technologies and services. In the future, information exchange in energy efficiency building will be enhanced and more training programs offered to facilitate relevant organizations. More efforts will be made to push energy saving and to provide sufficient support and training programs in China's rural areas, especially in the middle and western regions.

4.3. Energy Efficiency Retrofitting: a Bank's Viewpoint

Mr. Zhang Jian, General Manager,
Senior Vice President, Corporate Banking Department
of China Merchants Bank in Shenzhen

4.3.1. China Merchants Bank GoFortune Corporate Finance System

Introduction to China Merchants Bank

China Merchants Bank was founded on April 8, 1987. It was the first shareholding commercial bank in China whose shareholders were all corporate entities. Its headquarters are based in Shenzhen. Since its inception, China Merchants Bank has issued stock to raise capital four times. In March 2002, it succeeded in issuing 1.5 billion normal shares, and was the first domestic bank using international accounting standards to be listed on the Shanghai Stock Exchange (share number: 600036) on April 9 of the same year. The bank's total financial assets ranked within the top 100 in the UK-based The Banker magazine's latest "Top 1000 Banks in the World".

In just over twenty years, China Merchants Bank has gone from being a small local bank in the once remote area of Shekou in Shenzhen, to becoming a large, powerful nationwide commercial bank. Initially based in Shenzhen, it has spread throughout China and is now aiming toward institutional systems and business networks abroad. Branches have been established in over 30 major cities nationwide and Hong Kong, forming a network of over 700 offices. There is a representative office in the USA and over 900 banks have become representatives of the bank in more than 70 countries worldwide. In recent years the domestic and international media have heaped praise on China Merchants Bank, hailing it as "China's Best Local Commercial Bank", "China's Most Respected Company", and one of "China's 10 Best Listed Companies".

China Merchants Bank is committed to a developmental strategy that "promotes banking through science and technology" but is firmly rooted in the demands of the market and its clients. Through the huge advantage that comes from using a bank-wide electronic platform, a pioneering series of high-tech financial products and services has been developed, along with a stream of renowned financial brands, which have contributed to the public recognizing the bank as a leader in technology.

China Merchants Bank has adopted "We are here just for you" as its operational principle, improving all kinds of pioneering client services for the domestic market. Through its dedication to providing effective, convenient, considerate, and people-friendly services to its clients, a revolution in the domestic concept of banking service has come about, bringing banks and their clients closer together.

On the back of sustained and rapid growth, China Merchants Bank upholds the strategic guiding principle of "effective, quality and scaled coordinated development". It strives to create a management culture based on risk and standardized business management that is universally recognized by regulatory institutions both at home and abroad. Relative to the domestic banking sector, China Merchants Bank was very early in practicing assets-liabilities ratio management, loan origination and approval separation, a five-tier loan system, and establishing a good internal auditing system. Meanwhile, the bank has encouraged quality checks on savings and accountancy across the board, and became the first Chinese commercial bank to be awarded the ISO 9001 quality management system certification from BSI Pacific Ltd. and CCS Certification. China Merchants Bank has among the highest quality of assets of any domestic bank in China, which are constantly being improved thanks to its concern for risk-prevention.

Faced with the opportunities and challenges brought about by economic and financial globalization, China Merchants Bank aims to "become blue-chip stock and found a long-standing merchants bank". Innovative reforms will expedite adjustments in business strategy and the internationalization of management, strengthening our competitiveness, and with hard work China Merchants Bank will be established as a well-known, modern commercial bank of outstanding repute. Ultimately, this will maximize the long-term interests of shareholders, clients and employees.

China Merchants Bank

GoFortune | Corporate Finance System

In 2003, China Merchants Bank became the first bank in China to promote the corporate banking brand, **GoFortune**. It has since become an influential and comprehensive brand in the wholesale banking sector. In order to adapt to changes in the external economic environment and to the demands of a rapidly innovating internal business, as well as new development models and switching strategies of wholesale banking, China Merchants Bank have remodeled their GoFortune brand with the client at its center. An entire restructuring of all brands, products and commercial behavior for wholesale banking has been under way in order to recreate a representative brand for China Merchants Bank's comprehensive wholesale banking services: GoFortune Corporate Finance.

China Merchants Bank's GoFortune corporate finance service is guided by clients' demands, and through innovative products and services, provides companies with specialized, made-to-measure innovative solutions, increasing clients' wealth. By using modern financial know-how, instruments, and technology, it grows with client companies, helping them become model corporate citizens.

Wisdom Creates Value

"The highest excellence is like that of water"; "A true gentleman only gains his wealth in the right ways".

– extracts from Laozi's Tao Te Ching

"Wisdom Creates Value" is the principle of harmonious financial services advocated by China Merchants Bank's GoFortune brand. The "wisdom" in one sense signifies the bank's and a company's reasonable and positive use of finances in order to create a harmonious financial mode of operation; in another, it signifies choosing together the correct means for advancing harmoniously toward becoming qualified business citizens.

"Wisdom Creates Value" suggests that companies should make full use of modern financial services to solve the many financial difficulties faced in development, as well as to realize their growth targets and optimize their value. It also suggests that banks should make full use of financial innovation to provide expert knowledge and financial services for enterprise development, and to encourage the harmonious progress of society. This embodies the vision China Merchants Bank has of forging a new form of relationship with companies. China Merchants Bank looks on social responsibility as its starting block, advocating the establishment of a harmonious financial environment where wisdom creates value for an advancing society.

What GoFortune Means

Modern enterprises not only have the need for traditional commercial banking services, they also require individualized, integrated financial service solutions that are capable of embedding themselves in the heart of company operations. China Merchants Bank's GoFortune system is founded on having a sound understanding of the needs that corporate clients have of banks. It is aimed at providing for clients' needs in 6 areas: settlement services, cash management, loan financing, international operations, asset management and investment banking. It searches for the right way to grow through wise use of finances with the client, dedicating itself to refining products and integrating financial solutions for clients on 12 product lines: on-line enterprise banking, cash management, corporate financing, SME financing, trade financing, international settlements, overseas operations, intra-sectoral finances, asset trusts, enterprise annuities, corporate financial management, and investment banking.

As China Merchants Bank grows, the specialized services it offers will extend beyond the list of 12 lines of innovative products and services mentioned above. As trading partners, growth consultants, experts in acquisitions, and financial consultants, China Merchants Bank's 700 offices and 3,000 client managers and product management teams keep a constant watch on the needs and experiences of their clients in the hope of collectively creating a harmonious financial environment and helping "wisdom create value".

4.3.2. China Merchants Bank's Green Finance Service

The Important Practical Significance of Commercial Banks Implementing Green Finance Strategies

"Green Finance", as it is known, refers to the restructuring of the financial industry from an environmental perspective, including its operational principles, management policies, work procedures, credit structure, and product innovation. Optimizing the allocation of economic resources can further the sustainable growth of the social economy. Implementing a green finance strategy is a response to the objective demands on commercial banks faced with a deteriorating global environment and need for sustainable development. It is also a subjective requirement of commercial banks to perform self-regulated social responsibility.

To start with, implementing green finance strategies is a necessary direction for the development of the modern financial sector to take. The *Kyoto Protocol*, signed in December 1997, stipulated that all signatory nations must establish and operate "carbon trade" and "carbon funds" between 2008 and 2012 in order to meet targets in the

reduction of greenhouse gas emissions. In June 2003, 10 major global banks from 7 countries announced that they would implement the "equatorial principle", managing social and environmental issues related to project financing accordingly. Innovation in green finance products has flourished with the popularization of its principles. Its concessional prices and environmental tag have been the primary factors that have attracted customers. At present, green finance is gradually embedding itself in every aspect of banking and financial institutions, whether in terms of management principles, developmental strategies or product innovation, making it a current trend of the modern financial industry.

Secondly, implementing green finance strategies is a pressing demand in constructing a harmonious society. Constructing a harmonious society has become a fundamental developmental strategy of China. Accommodating the harmonious co-existence of man and nature is an important part of this. At the hub of socio-economic activity, commercial banks cannot shirk their responsibility to lead socio-economic resource allocation, promote ecological construction, and bring about the harmonious co-existence of man and nature. Chinese banks have for many years granted numerous loans to energy-hungry and polluting industries, which has had a serious negative environmental impact. It does not suffice to rely upon the public appeals of the Ministry of the Environment or the policy mechanisms of regulatory bodies to deal with pollution and carry out environmental protection. Rather, it should fall to economic levers, the restructuring of corporate finances, credit quotas, and guiding socio-economic resource allocation to bring about healthy economic and social growth. It is in exactly this respect that promoting and developing green finance has become the core content of China's commercial banking's practice of social responsibility.

Thirdly, implementing green finance strategies is beneficial to the healthy growth of commercial banks themselves. The healthy and sustainable development of commercial banks is reliant upon a stable macro-environment, good client relations, effective risk management, and the expansion of profit growth points, all of which are equally related to green finance strategies. To begin with, implementing green finance strategies can help change the "pollute first, treat later" model of development. It encourages sustainable economic and social development, providing a good external environment for commercial banking operations. With sustainable development comes fundamental gains for all industries. Furthermore, implementing green finance strategies helps raise a company's profile and establish a company brand. As public consciousness of the company rises, its image in society becomes increasingly scrutinized, turning into one of the deciding factors of consumer choice. Additionally, implementing green finance strategies helps to improve a commercial bank's risk management capacity. As the country pays more and more attention to environmental protection, the environmental risk rate becomes increasingly high. A great number of projects have to be stalled or abandoned due to environmental issues, meaning they have no way of repaying their bank loans. Besides all of this, changes in government industrial policy or related environmental policy can transform the developmental prospects or profit estimates for different industries, thus changing the credit risk structure of commercial banks.

Practicing green finance and carrying out environmental credit risk evaluations complies with the needs of commercial banks for steady business and risk control. Finally, by strengthening support for green industries through the innovation of new businesses and products, a commercial bank's business scope can be broadened, tapping into new profit opportunities and ultimately driving their own healthy and rapid growth.

China Merchants Bank's Green Finance Implementation Measures

Green Credit

At the end of July 2007, China Merchants Bank released the *Guidelines on Strengthening Credit Risk Management of High Energy Consuming and Highly Polluting Industries* in order to support sustainable social, economic and environmental development. Using industrial quota instruments, conditions of acceptance can be tightened, thus strengthening the credit risk management of "Two Highs and Resources" [1] industries. In one respect, this involves China Merchants Bank controlling the total volume of credit granted to high energy consuming and highly polluting industries, by placing proportional quotas on loans to parts of the electricity, steel, coal, non-ferrous metals, cement, and chemicals industries. In another, it involves refining industrial credit policy, raising acceptance standards, choosing only the best clients and being cautious of granting new credit. For example, granting new credit to thermal power companies is limited to units of at least 60 MW capacity; granting new credit to steel companies is limited to companies with a production volume of over 5 million tons, and with relatively high iron ore percentages and sheet metal ratios; support is given to the 12 nationwide cement enterprise groups and 48 regional cement companies that qualify for key support from the State. In contrast, support has been resolutely withdrawn from companies with low levels of productivity, high production costs, backward technology, or that are highly polluting.

In order to speed up the restructuring of industrial credit and to bring the business strategy of China Merchants Bank closer in line with the requirements of State industrial and environmental policy, the bank carried out in-depth research on "Two Highs" industries including those of coal, steel, non-ferrous metals and electricity generation. Because of the essential nature of these major industries to the national economy, China Merchants Bank chose to strengthen acceptance requirements, tighten lending conditions and ensure that the debtor company's production rate was high, its pollution level low, and its overall benefit far greater than its cost to society.

Meanwhile, China Merchants Bank has listed the environmental industry in the rubric of key support industries. Target clients for loans include: (1) companies involved with urban sewage treatment, rubbish incineration, and waste-heat generation; (2) manufacturers of equipment for air pollution prevention, water pollution prevention, and solid waste treatment, especially those with products featuring in the *Directory of Environmental Protection Equipment (Products) Whose Development is Currently Encouraged by the State.*

[1] In France, the cost of thermal rehabilitation in buildings for the part of the building stock that corresponds to housing is estimated at some €600 billions.

By making companies or projects meet environmental standards and undergo evaluations in order to meet basic lending conditions, China Merchants Bank is already leading and encouraging its clients to have a better awareness of their environmental and social responsibilities to support sustainable socio-economic development.

Product Innovation

By developing innovative products in the field of green finance based on traditional financial products and services, our bank hopes to put into practice the principles of green finance and increase the promotional power of its green finance services. They include:

1) International Finance Corporation and Foreign Government On-Lending:

Our bank has signed a Sino-French energy efficiency project intermediary credit agreement with the Chinese Ministry of Finance and Agence Française de Développement. As one of three beneficiary banks, our bank stands to receive €20 million for on-lending to dedicated investment in renewable energies and energy efficiency projects in China.

2) Risk-Sharing Mechanisms:

Our bank is currently in negotiation with the International Finance Corporation to set up, in the near future, a risk-sharing mechanism in the field of effective energy use. This is designed to increase investment in renewable energies and energy efficiency.

3) Cooperation with Shareholding Investment Funds and Investment Banks:

Other than directly providing financing services, our bank is also actively exploring models for cooperation with shareholding investment funds and investment banks. We plan to develop cooperation with private shareholding investment funds at home and abroad, attracting shareholding investment funds involved with energy conservation and emissions reductions. Through cooperation with both Chinese and foreign investment banks, we will provide domestic and international IPO services to energy conservation and emissions reducing companies.

Inclusion in the United Nations Environmental Program Finance Initiative

On October 11, 2007, China Merchants Bank held a symposium on green finance in Beijing, where their inclusion in the United Nations Environmental Program Finance Initiative (UNEP FI) was publicly announced. The main aim of the UNEP FI is to promote and popularize green finance, supervise and urge financial institutions to practice sustainable finance, and by becoming part of the organization, encourage exchange and cooperation.

By becoming a member of this organization, China Merchants Bank has been able to perform self-regulation in accordance with international banking principles and conventions, and strengthen its implementation of green finance concepts. It has been able to learn advanced principles of finance and gain management experience from well-renowned international banks. It has also received technical assistance from international organizations aimed at improving standards in the bank and expanding its international impact. Looking into the incorporation of the risks and opportunities brought about by environmental, social and corporate management into the development of financial risk prevention and new forms of financial products has also become possible. For example, the innovation and development of financial derivative products for energy efficiency projects and the emissions reduction trade, or how to evaluate

the impact of environmental change on future industry risk, and so on. By becoming a member of this organization, the bank's green finance development has been able to accumulate a wealth of experience, which can be used to explore new models for the sustainable development of China's financial sector.

4.3.3. China Merchants Bank's Acknowledgement of Energy Efficiency Construction

The Importance of Energy Efficiency Construction

In face of today's global energy challenges, the importance of the energy efficiency retrofitting of existing buildings is becoming increasingly pronounced, and this work will be the major undertaking of the next twenty or thirty years. With the building domain already accounting for around 40% of total energy consumption, energy efficiency construction is of great urgency.

Studies show that in China, 99% of existing buildings are energy inefficient buildings, with 35% of total energy consumption being accounted for by buildings. Energy efficiency construction has already become an important measure in ensuring national energy security, protecting the environment, improving people's quality of life, and promoting an economizing society. Energy efficiency in existing buildings is a large part of the work in energy efficiency construction and the task of energy efficiency retrofitting of existing buildings requires urgent attention in China in order to avoid wasting energy and to improve people's living and working conditions.

China's energy use per unit of building surface area is 2 to 3 times that of buildings with similar climatic conditions in developed nations. During the 11th 5-Year Plan, China plans to enforce energy savings of 50% in residential and public buildings, amounting to potential energy savings of at least 50 million metric tons of carbon equivalent (MMTCE).

Energy use in lighting accounts for 13% of national energy use, meaning huge potential energy savings, estimated at 29 billion KWh per year. Typical technological measures include: energy-saving fluorescent light replacement of normal incandescent lights (1:2.6); electronic ballast replacement of inductor ballasts, with electricity savings of 20-30%; use of LED lights, which last 5-10 times longer than normal light sources and are often used in floodlighting of buildings and large screens, etc.

Potential Types of Clients and Projects

Potential types of clients and projects include the energy efficiency retrofitting of buildings and energy-using equipment, and the use of new technology, new energies and renewable energy sources.

Of these, the energy efficiency retrofitting of buildings primarily refers to the refurbishment of building envelopes (including walls, windows, flooring, and roofs); energy efficiency retrofitting of energy-using equipment refers to air-conditioning and water pumping systems, heating systems, ventilation systems, lighting systems, lifts, and other energy-using appliances and equipment; new technology and new energies primarily include the operation of solar energy power generation in buildings as well as using solar-powered water heaters in homes.

Having said this, energy efficiency retrofits of buildings can vary in accordance with the type of building, differences in the energy-

using equipment present, and the kind of proprietor of the building. Providing financial services for such varying projects requires designing financing products and mechanisms that are based on actual conditions and that are able, to the greatest extent possible, to satisfy clients' demands.

4.3.4. China Merchants Bank Energy Efficiency Construction Service Plan

Financing Energy Service Company Projects

- Over 8% internal rate of return during the energy service contract term;
- Less than 5 year payback period on investment;
- Over 150% pre-tax debt recovery coverage;
- Mortgage registration after project and equipment loan; rights to levy fees on items in the energy service contract are pledged; closed management practiced for payment and settlement accounts.

Green Equipment Buyers Credit

- Over 8% internal rate of return within equipment use deadline;
- Less than 5 year payback period on investment;
- Over 150% pre-tax debt recovery coverage;
- Mortgage registration after project and equipment loan and sellers' buy-back guaranteed, etc.

End-User Energy Efficiency Special-Purpose Loan

- Over 8% internal rate of return when the increase in cash flow from the energy efficiency project's cost savings is the company's main source of loan repayment;
- Less than 5 year payback period on investment;
- Over 150% pre-tax debt recovery coverage;
- Mortgage registration after project and equipment loan; closed management practiced for payment and settlement accounts. When energy conservation is not the end user's main business, the income from the closed management part of a company's settlement account must be higher than the amount of interest a company needs to repay on their debts each term.

Special-Purpose Loans to Green Equipment Manufacturers to Increase Production

- Over 8% internal rate of return during the energy service contract term;
- Less than 5 year payback period on investment;
- Over 150% pre-tax debt recovery coverage;
- Mortgage registration after project and equipment loan; the income from the closed management part of a company's settlement account must at least be higher than the amount of interest a company needs to repay on their debts each term.

Leasing Loans

- Over 8% internal rate of return on projects;
- Less than 5 year payback period on investment;
- Over 150% pre-tax debt recovery coverage;
- Mortgage registration after project and equipment loan; closed management practiced for payment and settlement accounts.

Carbon Trading

- For clients looking to reduce emissions, international CDM buyers will be sought and CDM trading actively facilitated;
- China Merchants Bank has established a strategic cooperation relationship with Peony Capital, a company of which Bill and Melinda Gates are founding partners;

- China Merchants Bank has established cooperative business links with the International Finance Corporation (IFC).

Asset-Backed Commercial Paper (ABCP) Business

- This is an innovative kind of debt financing tool using public placement on the interbank market to supply companies with a stable cash inflow for a certain period of time ahead. Financing time limits are very flexible, in general lasting 5 years, making it an excellent form of medium- to long-term financing;
- China Merchants Bank is discussing with relevant institutions the possibility of setting up an energy efficiency investment company, specifically investing in greenhouse gas emission reduction projects. It would subsequently practice rolling investment by issuing ABCP.

4.3.5. Agence Française de Développement Green Credit Lines

By way of a sovereign loan, Agence Française de Développement has made €60 million of intermediary loans available to the Chinese Ministry of Finance to be used specifically in promoting investment in energy efficiency and increasing credit lines for renewable energy projects. These concessional loans will be granted by three banks, including the China Merchants Bank, at below market rate loan conditions to applicant companies. The sovereign loan has a term of 10 years.

Chosen projects must aim for energy savings of 20%, or strive to reduce energy use by 20%. To this effect, the French Global Environmental Facility has organized the provision of free and focused technical assistance for the bank and its clients from experts of the China Energy Institute and French energy company research association, Capenergies. This team of experts will perform energy efficiency analysis of projects, confirm their eligibility, and make technical suggestions on how projects may advance.

Over the next two years, as part of this intermediary loan project, cooperating banks will receive high quality and active technical assistance to strengthen the banks' ability to evaluate energy conservation projects and help the banks to train an in-house team to work in the green banking system. This promises to have major and long-lasting significance for China's green business development and meeting greenhouse gas emissions reduction targets.

4.4. Thermal Retrofitting of Buildings: Macroeconomic and Financial Issues

Mr. José Lopez, Director,
International Consulting on Energy (ICE-Group Burgeap)

4.4.1. Macroeconomic Stakes

Macroeconomic Stakes at the International and Country Level

On average worldwide, the building sector accounts for 40% of energy consumption. In France, it accounts for 37% of total energy consumption. In China this percentage is lower (30%), but the building sector's share in the country's total energy consumption is continuously growing.

Energy forecasts show that the building sector may have the potential for major energy savings and GHG reductions. This potential may reach 300 Mtoe in 2030, which would be equivalent to 700 Mt of CO_2.

Macroeconomic Stakes at the Regional Level

The research program team has conducted audit and feasibility studies to determine the optimal combination of thermal rehabilitation measures for different categories of building at Wuhan city level: administrative, office, shopping malls, and hotel buildings.

Based on the results of these studies and simulations of possible cost effective technical measures, the research program team has defined two options for investment packages covering the above mentioned categories and the overall Wuhan building stock. The first investment package addresses only the upgrading of the buildings' energy systems, while the second deals with the upgrading of the buildings' energy systems and their envelopes.

For the above-mentioned categories of building stock, annual savings range from 0.2 Mtoe (energy system retrofit) to 0.37 Mtoe (energy system + envelope retrofit). The corresponding energy bills will be reduced respectively by 13% and 24%. These savings require an investment from RMB4.1 billion (system retrofit) to RMB11.2 billion (system + envelope retrofit). The investment payback period ranges from 4 years for hotels' and shopping malls' system retrofits to 8 years for system retrofits in offices, 13 years for office system and envelop retrofits, and 18 years for administration building system and envelope retrofits.

In addition to direct energy savings, such a large-scale rehabilitation program will bring other benefits at Wuhan city level:

- Between 14,000 and 40,000 full-time equivalent jobs over a 4 year program implementation period;
- Better comfort for building users;
- A boost for the construction material, HVAC, engineering markets; and
- Additional budget resources for the local, provincial and central governments through economic activity taxation.

This reference thermal rehabilitation program designed at Wuhan city level could be replicated at Hubei province level and then at the Chang Jiang river basin scale (covering the Hubei, Hunan, Jiangxi and Anhui provinces).

The corresponding savings and investment requirements have been calculated for the same typologies of buildings and the same packages of thermal rehabilitation measures.

Box 1 *Hubei Province Savings and Investment Requirements*

HUBEI PROVINCE LEVEL

FOR LARGE PUBLIC BUILDINGS AND ADMINISTRATIVE BUILDINGS

- Annual energy-saving potential: 1.1 Mtce to 1.9 Mtce (0.76 to 1.3 Mtoe)
- Investment requirements:
- RMB14.5 billion (system retrofit)
- RMB39.5 billion (system + envelope retrofit)

IMPACTS

- Construction material, HVAC, engineering market development
- Employment (full-time year equivalent jobs created): 52,000 to 143,000
- Direct: from 30,000 to 82,000
- Indirect (construction material sector): from 22,000 to 61,000
- Better comfort for building users, reduced energy bills (by 13% to 24%)
- Additional budget resources (from taxation of economic activities) for local, provincial and central governments.

Box 2 *Chang Jiang River Basin Savings and Investment Requirements*

CHANG JIANG RIVER BASIN SCALE (*Hubei, Hunan, Jiangxi, Anhui)*

FOR LARGE PUBLIC BUILDINGS AND ADMINISTRATIVE BUILDINGS

- Annual energy-saving potential: 3.6 Mtce to 6.3 Mtce (2.5 to 4.4 Mtoe)

INVESTMENT REQUIREMENTS

- RMB49 billion (system retrofit)
- RMB134 billion (system + envelope retrofit)

IMPACTS

- Construction material, HVAC, engineering market development
- Employment (full-time year equivalent jobs created): 177,000 to 486,000
  - direct: 102,000 to 280,000
  - indirect (construction material sector): 75,000 to 206,000
- Better comfort for building users, reduced energy bills (by 13% to 24%)
- Additional budget resources (from taxation of economic activities) for local, provincial and central governments.

International Comparisons

Table 47 *International Comparisons*

	Germany	France
Factor 4 investment requirements (in billion €) – residential	920	461
Investment per m^2	277	206
Annual investment to 2030	38.3	19.2
Annual investment to 2050	20.9	10.5
Direct employment generated per year	920	461
to 2030	722 ,42	362,420
to 2050	349,340	197,680

Source: Climate Change and Employment, report, European Trade Union Confederation, 2007.

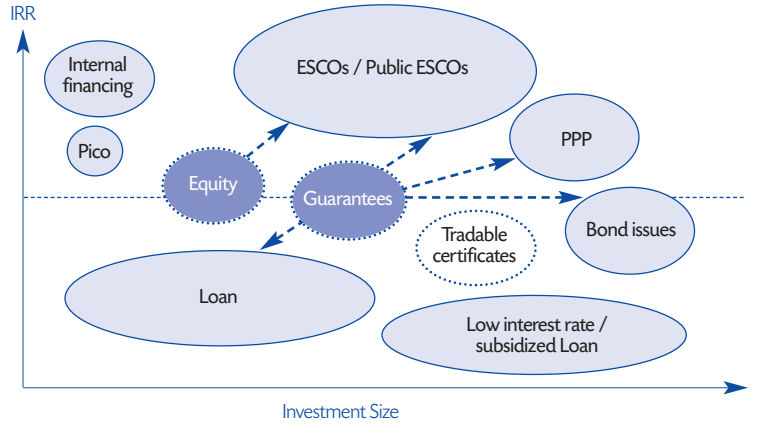
In the building sub-sectors selected for the program, the magnitude of financial resources required is very significant. At international level, building thermal rehabilitation under the Factor 4 objective entails similar financial needs. The above table presents the financial requirements and the employment impacts of large-scale programs in another building sub-sector, the housing sector.

4.4.2. Financing Issues

Adequacy between Financing Tools and Project Profiles

Figure 60

Financing Tools vs Project Profiles (general)



Source: ICE

The technical and economic feasibility of developing such large-scale investment programs is recognized by, and raises interest among, the public authorities. However, as in OECD countries, key stakeholders (such as the municipality of Wuhan, or the Hubei Province Construction Commission) face difficulties scaling-up investments in this sector. This is due to a lack of internal expertise to technically design the projects and/or to limited financial resources to pass from pilot and demonstration projects to large-scale programs.

The private sector (engineering and building construction companies, local financial institutions in particular, and well-established and emerging ESCOs) see the thermal rehabilitation market as an opportunity to expand business and/or compensate for the relative decline in the new building construction market. In the meantime, large-scale thermal rehabilitation projects in the building sector present financial and risk profiles that limit or prevent private sector involvement. More particularly, these projects:

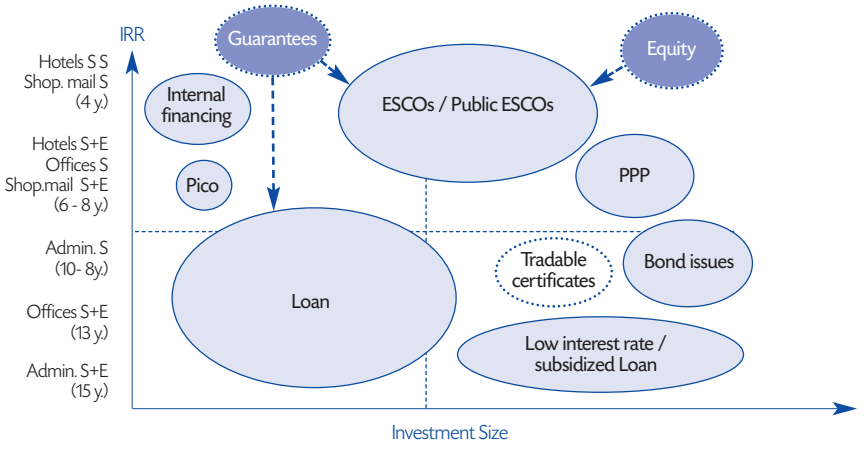
- Compete with more traditional easy investments such as power plants and industrial expansion projects;
- Are perceived to be more risky than supply-side projects because the expected savings may be negatively influenced by the quality of the rehabilitation works and equipment used, but also by the behavior of the building users. In addition, due to the legal status of the buildings (publicly owned and or multi-owner buildings), those investments are often non-asset based;
- Present lower profitability ratios and longer payback periods than investments in other sectors.

Consequently, it appears that building technical and financial engineering skills, removing policy barriers, and providing local stakeholders with experience in financing investments are some of the key measures needed to actually promote large-scale thermal rehabilitation programs in the building sector.

In that respect, the research team has highlighted the fact that, depending on the buildings' thermal and activity profiles, different types and combinations of financial resources may be required. Therefore, the structuring of a first large-scale rehabilitation program would have to address the adequacy and attractiveness of the financial resources for the project sponsors (building owners), as well as for the construction and energy service companies.

Figure 61

Financing Tools vs Project Profiles (research program)



Source: ICE

The typology of buildings considered in the research program shows different profitability ratios and/or payback periods. Whereas rehabilitation investment measures targeting the energy systems in hotels have a payback period of 4 years, which allows a project financial structure based on a combination of internal financing, medium-term commercial loans and/or third-party financing schemes, administrative buildings would require long-term financing with low interest rates.

Guidelines for Structuring a Financing Scheme

Large-scale rehabilitation programs at Wuhan and Hubei levels will entail:

- Tapping a large range of building categories;
- Addressing different energy-saving potentials with various technologies and equipment;
- Coping with different investment profiles (size, rate of return, risk, etc.);
- Involving different stakeholders (owners, tenants, users, local government, etc.);
- Attracting project sponsors and to make EE in the building sector an attractive business; and
- Raising finance at a level that is consistent with an ambitious program, *i.e.* to make commercial, project and corporate finance available for the program.

The research team has come to the conclusion that, regarding the financial component of large-scale rehabilitation programs, not one but several financing tools with strong coordination, or better, a financing scheme broad enough and flexible enough to meet the above expectations, would be required.

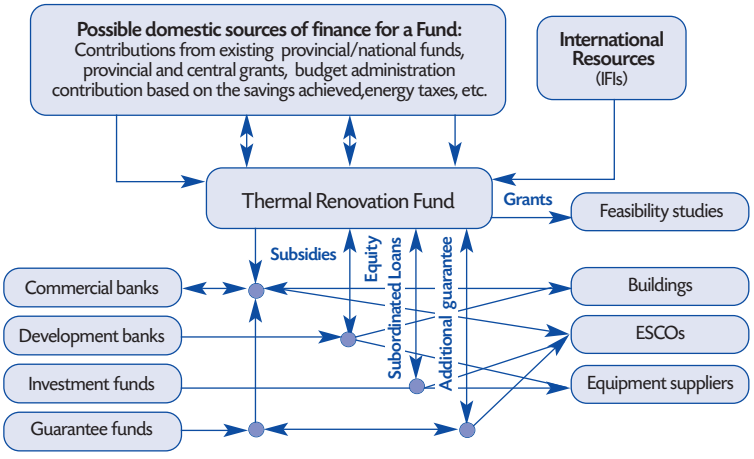
Based on a review of international case studies, a draft scheme to support the development of rehabilitation programs using a combination of public and private financial resources has been drawn up.

Basically, the envisaged scheme consists of placing provincial/national public resources from established public funds, city and pro-

vince budgets, taxes etc. in a Thermal Rehabilitation Fund managed by the Wuhan and Hubei authorities. The resources collected will be combined in the form of subsidies, complementary guarantee schemes, equity, and subordinated loans with commercial financial resources in order to improve the attractiveness of the current market financial resources (basically loans and equity) as well as the feasibility of innovative financing schemes such as the third-party financing scheme developed by ESCOs.

Figure 62

Draft Scheme Proposal



Source: ICE

Tailoring a Thermal Renovation Fund at Wuhan City Level

Table 48 *Reference Program Value: €0.4 billion (RMB3.6 billion)*

Sources of finance: Primary distribution	Reasonable market share of the different sources of finance	Values M€	Comments	Secondary distribution	Values M€
Escos	20%	80	of which 20% through equity and 80% through debt finance	Equity	16
Banks	65%	260		Debt	324
Self-financing	10%	40		Self-financing	40
Public budget support	5%	20		Public budget support	20
Total	100%	400		Total	400

Source: ICE

On the basis of the scheme envisaged above, it was possible to determine the size of a Thermal Renovation Fund dedicated to providing financial support to a reference program corresponding to the one designed by the research team at Wuhan city level and representing a total investment value of €0.4 billion over a four-year period.

The RMB3.6 billion investment value is distributed among the main possible primary sources of financing: public budget support, internal financing, bank loans, and financing provided by Energy Service Companies (ESCOs) under performance contracting schemes. The estimated respective market share of these primary sources is: 5%, 10%, 65%, and 20%. Regarding the specific contribution of ESCOs, we have considered that 20% of the performance contract value will be financed through equity and 80% through loans.

This intermediate calculation allows us to determine the secondary distribution of financial resources required to supply the program's financial needs:

- Public budget support: €20 million;
- Internal financing: €40 million;
- Banks loans: €324 million;
- ESCOs: €16 million.

Table 49 *Reference Program Value: €0.4 billion (RMB3.6 billion)*

Products / tools	Level of contribution to the market needs	Corresponding value
Grants for feasibility studies	for 50% of the feasibility studies up to 5% of the project cost	10
Support to ESCOs	max. 35% equity/subordinated loans participation	6
Soft loans	20% of the overall debt requirements (debt finance for projects + debt finance for ESCOs)	65
Subsidies for loans	10% of the loans and max. 20% subsidles	6
Complementary guaranties	coverage for 20% of the ESCO market	2
Total resources to be provided by the TRF over a 4-year period		**88**
of which: Grants/subsidies Revolving finance		 16 72
Annual TRF financial requirements		**22**
of which: Grants/subsidies Revolving finance		 4 18

Source: ICE

We have considered the Thermal Renovation fund would have to provide two types of support:

- Grants to facilitate the development of the feasibility studies that a large-scale renovation program would require; and
- Subsidies and blended financial resources to be combined with the above commercial sources of finance (bank loans and ESCOs) to increase their attractiveness in terms of cost and maturity.

The table shows the distribution of the Thermal Renovation Fund resources among the different financial products and tools. A significant part of the Thermal Renovation Fund contribution would come through the form of soft loans (€65 million) as a revolving source of finance. This particular resource could be provided by the government or the province and/or from a credit line provided by one or several financial institutions.

As a result, considering the leverage effect of the public resources, a €0.4 billion program would require a total contribution of the Thermal Renovation Fund of €88 million, of which €16 million through grants and subsidies and €72 million through revolving finance. Yearly, this contribution would be €4 million through grants and €16 million through revolving finance.

The approach proposed above has been developed following the analysis of several dedicated financial tools implemented at international level and combining public and private financial resources. We present a selection of those experiences below.

4.4.3. Case Studies

Case Study 1: The Thermal Modernization Fund in Poland

The fund was set up in 1998. It addresses the housing and district heating sectors. The fund provides grants up to 25% of the total project costs for energy efficiency investments implemented by owners and heat suppliers on the condition that a minimum of 25% energy savings is achieved.

The eligibility and disbursement procedure is as follows:

- Audit by an independent expert who defines the optimal investment program;
- Investment; then
- Grant directly disbursed to the bank account as part of the loan reimbursement.

The key fund stakeholders are:

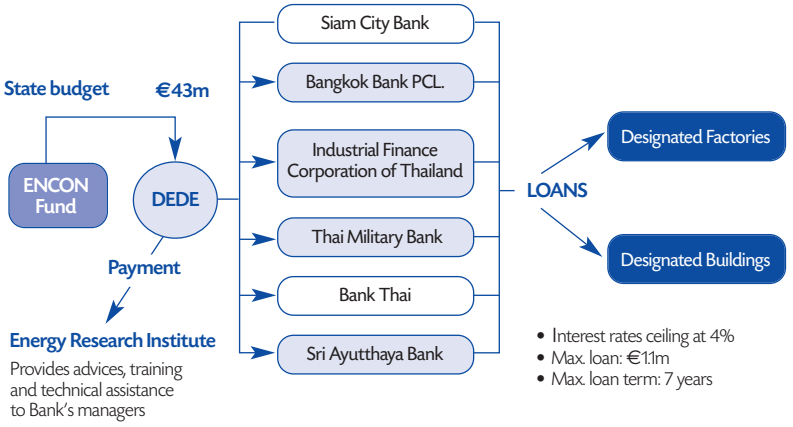
- The Ministry of Finance (provides the Fund resources);
- The Nation Bank for Economy (manages the fund); and
- The Ministry of Infrastructure (monitors the procedure and the results).

In 2007, the Fund provided grants to 4,200 loans for an amount of €73 million, and the total investments that could be reached with the support of the Fund was approximately €500 million.

Case Study 2:
Low Interest Rate Loans – The Thai Revolving Fund for Energy Conservation

Figure 63

The Thai Revolving Fund for Energy Conservation



Source: "Comparison of best practices in developing and managing financial mechanisms that support energy efficiency projects", Study for ADEME, José Lopez and Eliane Métreau, International Consulting on Energy (ICE), 2004.

In 1992, the Royal Thai Government passed the Energy Conservation Promotion Act (ENCON Act) to promote energy conservation and set up related regulations regarding funding and resources to support energy efficiency and renewable energy. Under the ENCON Act, the Department of Alternative Energy Development and Energy Efficiency (DEDE), which is a department of the Thai Ministry of Energy, is responsible for the Compulsory Program for Designated Factories and Buildings. These designated facilities have to comply with government regulations requiring them to manage their energy use, and conduct energy audits and establish energy conservation targets and plans.

In 2002, the budget allocated from the ENCON Fund to the Revolving Fund for Energy Conservation was approved.

The agreement with the financial institutions was signed in January 2003, marking the start of the scheme's implementation. The scheme is fixed for a period of three years, after which an agreement could be signed again with the ENCON Fund Committee. However, the idea is that this type of financing become "self-functioning", *i.e.* without public intervention.

The DEDE has received approval from the ENCON Fund Committee to use 2 billion baht (approximately €43m) to set up an EE Revolving Fund. The ENCON Fund is a special fund created by the Encon Act 1992 by collecting small taxes from the use of benzene, diesel, fuel oil and kerosene. At present, the Fund has gathered an amount of around 17 billion baht (approx. €365m).

A couple of people from the DEDE are assigned to manage the Fund and cooperate with participating financial institutions. As for the financial institutions, they manage risks related to loans, carry out book-keeping activities, credit checking, and customer selection.

Beneficiaries: Buildings and factories classified as "designated facilities (buildings and factories)" according to the 1992 ENCON Act. They are defined as facilities that have an installed capacity of 1175 kVA of transformers and have a peak demand of 1 MW and above, consume 20 million MJ or more of electricity annually, and use steam power and other non-renewable energy sources. These designated facilities have to comply with government regulations requiring them to manage their energy use, including lighting energy, air-conditioning energy, and the building envelope.

Projects: Improvement in fuel combustion efficiency, reduction of energy losses, recycling of energy waste, substitution of one type of energy for another type, more efficient use of electricity through improvements in power factors, use of energy-efficient machinery or equipment as well as use of operation control systems and materials that contribute to energy conservation, etc.

Term of Loan: Not more than seven years and/or the simple payback period (SPP) shall not be more than seven years.

Maximum Loan Size: 50 M baht per project (€1.1 M). No minimum size for the investment projects has been set.

Maximum Interest Rate: Not more than 4% per year (amount charged by financial institutions to the borrower). This interest rate is intended to cover the financial institutions' management fees and the risks associated with the loan.

Costs Included in the EE Loan: Equipment and installation costs, consulting fee for design, supervision, and guarantee of savings (*e.g.* for an energy service company, or ESCO), construction of a gas pipeline from the main pipeline to the designated factory or building, transportation and deconstruction costs, import duties and taxes, and value-added tax (VAT) for the above costs.

Interested owners of designated facilities need to request a loan application form from a participating financial institution. Financial institutions approve the EE project loans according to their regular lending criteria and perform an initial financial analysis of the project. The DEDE considers and approves projects according to its criteria and conditions.

Among the eight banks that declared their interest in participating in the scheme, six commercial banks were selected. They are responsible for providing loans. These banks are: the Industrial Finance Corporation of Thailand, the Bank Thai, the Bangkok Bank PCL., the Sri Ayutthaya Bank, the Thai Military Bank and the Siam City Bank. The DEDE is in charge of distributing the money between the six banks. The share is defined according to each bank's potential. Nevertheless, the budget for each bank is redefined every six months and adjusted (lowered or increased) according to the bank's dynamism in the field of energy conservation. Each bank's manager of the fund receives training on energy efficiency issues and technical assistance from consultants paid by the DEDE. The basic mechanisms such as Energy Performance Contracting, energy savings, ESCOs, etc. are explained to them. They can phone and get

advice from the DEDE. The DEDE is assisted by the Energy Research Institute regarding communication, information and advising activities.

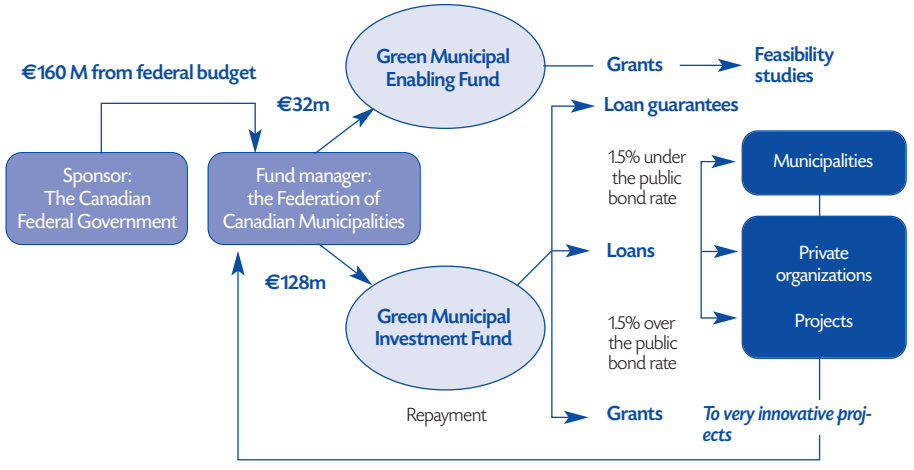
With regard to the above criteria, the actual interest rate and maturity of the loan depend upon the agreement reached between the bank and the borrower. However, the interest rate ceiling is 4% and the loan term cannot exceed 7 years.

The borrower makes repayments to the ENCON Fund via the bank and will also submit a report on the project's energy savings.

Case Study 3: Low Interest Rate Loans – The Canadian Green Municipal Fund

Figure 64

Canadian Green Municipal Funds



Source: "Comparison of best practices in developing and managing financial mechanisms that support energy efficiency projects", Study for ADEME, José Lopez and Eliane Métreau, International Consulting on Energy (ICE), 2004.

On the initiative of the Federation of Canadian Municipalities (FCM), the Canadian Federal Government (the Department of the Environment, the Department of Natural Resources and the Department of Finance) signed an agreement with the Federation of Canadian Municipalities in 2000. In this agreement, the Government has committed itself to bringing CA$125m (around €80m) to Green Municipal Funds (GMF). The endowment was doubled to CA$250m in the 2001-2002 federal budget year.

The FCM manages the Green Municipal Funds through its Center for Sustainable Community Development (20 people). The agreement with the federal government imposes a limit on annual administrative costs of CA$5m (€3.2m). They are financed by interest rates.

Beneficiaries: The Funds are open to all Canadian municipalities (even those not belonging to the federation) and their public-sector or private-sector partners. The partnership between a municipality and a private organiz-

ation has to be clearly stated either by the financial participation of the municipality in the investment, by its participation in the input (for instance by procuring land for a wind farm project), or by its participation in the output (by contracting a long-term renewable electricity purchase agreement with the firm, for example).

Projects: The five eligible sectors are: energy and energy services, water, solid waste management, sustainable transportation services and technologies, and integrated community projects. The project must significantly improve environmental performance or energy efficiency in these areas of municipal infrastructure.

Applications are reviewed by a Peer Review Committee of two or three independent experts in the field to which the project belongs. These experts come from government, institutions and/or the private sector. Each project is given a mark according to a grading system ranging from 0 to 1000. Criteria such as environmental improvement (150 points), replication possibilities (100 points), partnership quality, innovation (230 points) intervene in the grading system. Most of the time, projects with a mark superior to 600 points are recommended for financing by the Review Committee. Recommendations from the FCM staff are made to the 15-member Green Municipal Funds Council. The Council includes representatives from the Government of Canada (one-third), the FCM (one-third), and non-governmental institutions and the private sector (one-third). The council supports or rejects staff recommendations. Final approval rests with the FCM's Board of Directors. In theory, not more than 30% of the fund can be allocated to one of the 5 eligible activity sectors.

In practice, two types of funds with similar objectives and criteria are managed:

The Green Municipal Enabling Fund (GMEF) provides up to CA$100,000 (€64,000) to cover half the cost of feasibility studies for innovative environmental projects. The fund helps the Canadian municipalities and their public or private-sector partners to determine the technical, environmental and/or economic feasibility of municipal projects. The total amount of GMEF is CA$50m (€32m). The government should stop providing the fund in 7 or 10 years.

The Green Municipal Investment Fund (GMIF) has two main products: the primary product is loans and the secondary product is grants. Green Municipal Funds Council decided as a policy to direct half of the Fund's capital in loans to municipalities and the other half towards the private sector. The total federal government contribution to the GMIF is CA$200 m (€128m). It is revolving and fixed for an undetermined period. There are three types of loans:

- Direct loans to municipalities with very low risk at the preferred interest rate of 1.5% below the Government of Canada bond rate (which is the Country's lowest rate: currently 4.8% per annum for a 10-year term);
- Corporate loans to private-sector partners; and
- Project finance through loans. This type of loan is more risky as, in case of project failure, the project promoter is not bound to reimburse the loan. The interest rate is therefore higher.

The average of the interest rates for the loans to companies and for the loans to projects is an interest rate of 1.5% above that of the Government of Canada bond rate. As the

fund shares loans equally between municipalities and the private sector, the average interest rate for GMIF loans is the same as the bond rate.

The GMIF finances up to 25% of the capital costs of a qualified project. The GMIF can also provide loan guarantees. Loan payback periods may range from four to ten years.

If money from the interest rates is still available after covering administrative costs, it is dedicated to the allocation of grants for GMIF Pilot Projects: environmental projects that are highly innovative but have a payback period of more than 10 years. Special grant funding contributes to structuring these projects in ways that offer acceptable payback periods and risk levels.

After approval of the project, a standardized agreement is signed between the GMIF and the municipality (or private organization) in which a few conditions are settled. Among them, the municipality has the obligation to sign a "Project Results Reporting Agreement" in which it commits to creating a monitoring system, tools to check the results of the project and to report one year after the project achievement. A grant of CA$30,000 (€19,000) is provided by the GMIF for this purpose. Staff from the GMIF is especially assigned to the supervision of the evaluation process.

The Fund is constantly seeking to develop new loan products to overcome barriers to the implementation of valuable projects. For example, it is developing two other special tools:

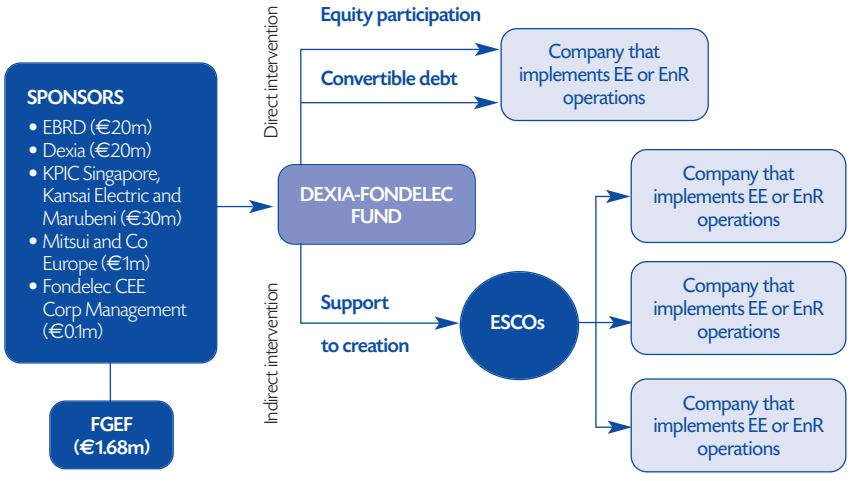
"Emission Reduction Rights–based financing": Loans will not be reimbursed by financial flows but by transferring to the GMIF the carbon credits gained thanks to the project's emission reductions. The GMIF will then sell those credits to reimburse the loan and the interest rate. The remaining proceeds from the sale of the credits are for the project sponsor;

"Reinvestment loans": The Fund can lend to projects which are not *a priori* innovative if the municipality commits itself to placing the economic savings earned by the difference between the GMIF's interest rate and another financial institution's interest rate into small but very innovative projects.

Case Study 4: Equity – Dexia-FondElec Fund

Figure 65

The DEXIA-FondElec Fund



Source: "Comparison of best practices in developing and managing financial mechanisms that support energy efficiency projects", Study for ADEME, José Lopez and Eliane Métreau, International Consulting on Energy (ICE), 2004.

The purpose of the Fund is to promote investments in energy conservation and renewable energy in the countries of the former Eastern Block and to contribute to the reduction of greenhouse gas emissions. The fund's investment strategy includes the valorization of these emission reductions in the form of carbon credits.

The Fund was set up to operate during the period 2000-2010, with the possibility of a 2-year extension. For the fund manager, this period corresponds to 2 phases of activity: a 4-year investment period and a 6-year exit period.

The Fund sponsors are specialized investors. The minimum investment share in the fund is €1m. The investors in the fund are:

- The European Bank for Reconstruction and Development (EBRD), with €20m (28% of the capital);
- DEXIA (*via* its subsidiary company Dexia Public Finance Bank), with €20m (28% of the capital);
- KPIC Singapore, Kansai Electric and MARUBENI Corporation, with €10m each (14% of the capital for each);
- Mitsui & Co. Europe, with €1 m; and
- In addition to the capital committed by the investors, FondElec C.E.E. Corp. management, as fund manager, with €0.1 m.

The French Global Environment Facility (FGEF) supports the fund by covering part of the additional costs of operation arrangements in

a region that, although advancing on the economic and legal levels, still remains difficult for private companies to access.

The management of the Dexia-FondElec fund is ensured by FondElec Clean Energy Efficiency Management Corp. FondElec Group Inc. is a private equity investment firm with five funds under management and more than US$250m of investment capital. The FondElec Group is a global energy, communications and technology investor. The firm was founded in 1992 to develop its business on the rapid growth of worldwide electricity, utility, technology and communications markets.

The beneficiaries of the Fund are projects of small and average size, for which investments range from €1m to €10m, and that:

- Improve energy efficiency in existing plants and equipment, *e.g.* plant retrofits and fuel conversions, heat recovery systems, electric transmission grids, gas and district heating system improvements, illumination, other public facilities and industrial energy efficiency enhancement; and
- Promote the use of renewable energy.

The projects in which the fund intends to invest are presented to DEXIA and the EBRD (the principal investors in the funds) for their opinion. The two sponsors have fifteen days to express their opinion. If the opinion is favorable, the project is submitted to the Investment Committee. If it is negative, the fund manager can nevertheless present the project to the Investment Committee but with the mention "project refused by the sponsor".

The fund can invest either directly in an energy conservation project or a renewable energy production project (heat network, industrial process, etc.) or through equity participation in (existing or new) companies specialized in the realization of this type of project (ESCOs). The fund, through an ESCO, enters into contracts with individual companies or municipalities to provide the capital, project build-out, and ongoing technical monitoring for specific projects. The increased income resulting from the installation of new equipment, as mandated in the energy service contract, will be split in a manner that allows the fund to receive a return on its investment.

Example of Direct Investment: In Poland, in the town of Gorlice, the fund invested in the retrofitting and optimization of the heat production infrastructure of the district heating company, EC. Gorlice. The fund brought €3.7 m in capital and €3.3m in convertible debt to the company. These resources allowed the realization of energy conservation operations on the heat generating stations, the commissioning of a 7-Mwe turbine and a cogeneration plant, as well as the extension of the heat network to new industrial and residential customers.

Example of Investment through Specialized Companies: In December 2000 in Hungary, the fund repurchased the consulting and engineering company in energy technology, EETEK Limited. This company was then capitalized and transformed into an energy service company (ESCO). EETEK is now able to reach potential customers, lead feasibility studies for the realization of energy efficiency projects or renewable energy valorization projects, finance and carry out investment operations identified in a turn-key approach, and refund them on the energy savings realized. On this basis, EETEK developed a project portfolio in the private and public sectors (industry, hospital, street lighting, heating networks, etc.).

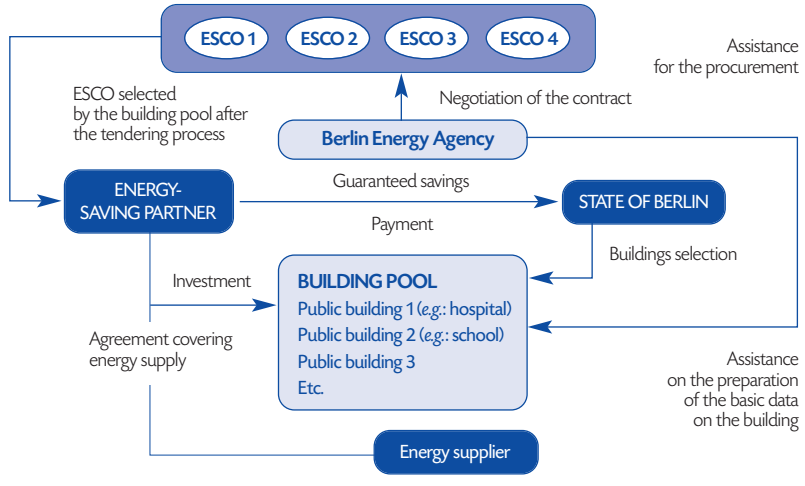
At the level of the fund management, the decision-making process relies on an extremely "compact" method: the president and the general manager of FondElec intervene personally on the ground. They ensure a continuous presence in Poland and Hungary, as well as in the other countries where the fund seeks to develop operations. In Poland and Hungary where most of the investment operations were carried out, FondElec detached an associate who, from day to day, ensures the follow-up of the projects at the administrative and financial level. This restricted team makes all decisions relating to the management of the investment operations carried out and new investments, and organizes the work and the studies canvassing new investment opportunities. The canvassing work of the manager in the countries where the funds has not yet invested can involve external consultants. From the end of the year 2001, subsidiary companies or representations of the ESCO EETEK Hungary (developed by the fund) were created in Bulgaria, Croatia, and Slovakia. In 2003, such structures were installed in Poland and Romania.

At the level of the projects in which the fund invested (projects in existing companies like Gorlice or ESCO creation projects), the fund relies on a highly qualified local "management" (experienced in working at international scale, excellent level of English) and generally young people. If the people in charge of the technical directions are specialists in the energy sector, the recruitment base for the posts of the development, investment and finance management is diversified.

Case Study 5: Third Party Financing – Berlin Energy-Saving Partnerships

Figure 66

Berlin Energy-Saving Partnerships



Source: "Comparison of best practices in developing and managing financial mechanisms that support energy efficiency projects", Study for ADEME, José Lopez and Eliane Métreau, International Consulting on Energy (ICE), 2004.

The sponsors are the State of Berlin and the districts that pay the Berlin Energy Agency's fees for consultancy.

The Berlin Energy Agency (BEA) is the project manager. It assists the municipality from the tendering process to the supervision of the contracts. The Agency is paid by a basic consultant fee, half by the State of Berlin and half by the district concerned by the project.

Beneficiaries: Public buildings (school centers, swimming pools, museums, etc.).

Type of Projects: Heating systems (central control systems, optimization of individual control tasks, distribution network, adaptation of thermal installed load, etc.) and electrical application (peak load management, efficient drives, ventilation and cooling techniques, lighting control systems, etc.).

Basic Principle: The client (for example the local authority) is responsible for the upkeep of various buildings, such as nursery schools or offices. It is bound by contract to energy suppliers who deliver electricity and heating (*i.e.* gas or oil). In order to reduce energy costs and damaging levels of carbon dioxide, the client transfers the financing, planning, implementation, and control of energy-saving measures to a private energy-saving partner– the "contractor" (an ESCO). The successful contractor undergoes a tendering process. The existing contracts between the client and the energy suppliers covering the delivery of electricity and heating are not affected by the project. The contractor, however, agrees to adopt the necessary technology and supply with the energy suppliers.

Building Pools: Energy-Saving Partnerships are not only applied to energy saving in large building complexes. The Berlin model is a conscious effort to pool smaller projects and create "building pools." In order to reduce transaction costs, the buildings are pooled as the tender procedure is quite similar with one or 20 buildings. In addition, for organizational reasons, all buildings constituting one pool have to belong to one fully responsible administration.

Energy-Saving Guarantee Contract: The ESCO signs a contract to guarantee the client a minimum level of energy savings. The contractor only receives his agreed earnings if the stipulated energy savings are reached.

The investments carried out by the contractor are re-financed through the savings. Any remaining savings are shared by the partners according to a ratio system agreed upon in the contract for the duration of the project. The contractor remains responsible all this time for the maintenance and service of the systems. The client benefits from all cost savings once the contract has expired.

In order to ensure long-term quality, the cooperation has to be based on a balanced contract. The Energy-Saving Guarantee Contract ensures the highest possible degree of reliability. It takes all the specific demands of the project into account and legally guarantees the client's interests. The contract includes all details regarding technical measures, the nature and extent of any investments made by the contractor, as well as the duration and level of savings. The contractor is responsible for the performance of the technical systems and therefore also for any risks caused if the systems break down. He also guarantees the client a minimum level of targeted energy savings and bears any financial risk– if interest rates rise, for example.

Project Cycle:

- *Preparation:* project definition, technical data-collection, creation of building pools if necessary, check of potential, technical economic objectives;
- *Tendering process and award:* announcement of the process and/or identification and choice of the target group for tenders, invitation for tender, negotiation of the tenders, recommendation for award;
- *Energy-Saving Contract;*
- *Contract Preparation Phase:* fine planning, index of planned performance, conception and financing, installation, transfer of property; and
- *Main Performance Phase:* optimization of the operation, parameterization, proof of savings, maintenance.

The BEA's Missions:
All municipal institutions are allowed to address the experts of the BEA to get their EPC projects defined and to get assistance for procurement. The BEA creates a Steering group in the administration to explain the modalities of an EPC to the staff. It elaborates on the basic data on the buildings and the energy consumption baselines. The preparation of the documents for the tendering process, the negotiations, the final recommendation as to the contractor, and the assignment of the contract are carried out by experts. Finally, the BEA can intervene in the supervision of the contract.

Example: Building Automation Systems in Pankow:
The Berlin District Pankow entered an Energy-Saving Partnership with a contractor in 1998. The successful bidder for the pool of 55 buildings was the company Johnson Controls JCI Regelungstechnik GmbH. The District decided to set the focal point of the contract on high investments with a duration of less than 15 years: investments of roughly €1.8m were therefore calculated for the contract with a duration of 14 years. The contractor guarantees more than 24% (€502,000 guaranteed savings and 2,500 CO_2 tons/year). In addition to other technical measures, JCI installed building automation systems in order to lower energy consumption and a central building control system in the building pool in Pankow. This enables all buildings to be optimally supplied with heating according to their types and times of usage.

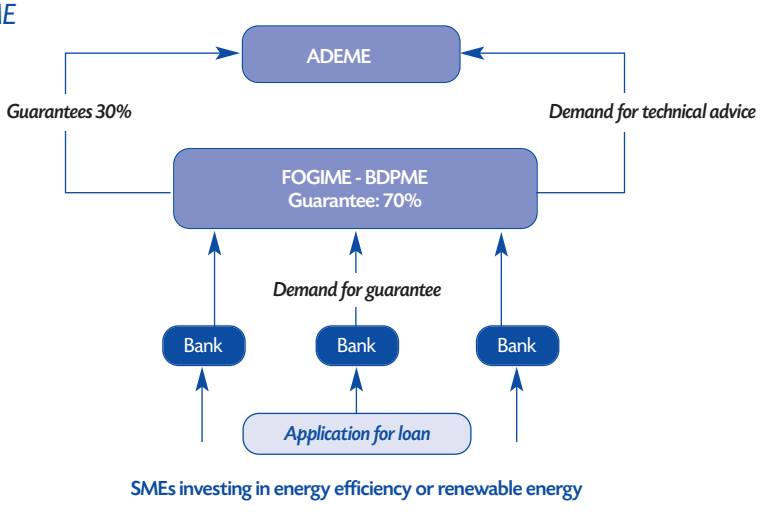
Other Examples of Projects:

- Individual Temperature Control for the Berlin District Friedrichshain (a pool of 30 buildings) / Total investment: approx. €940,000 / Energy-Saving Guarantee: 20%/Energy Partners: ARGE, MVV Energie AG, WFM GmbH & Co;
- Conversion from coal to gas in Steglitz-Zehlendorf (41 buildings) / Total investment: approx. €920,000 / Energy-Saving Guarantee: 22%. Energy Partner: SFW GmbH;
- High energy savings in Berlin's Public Baths (11 swimming-pools) / Total investment: approx. €4.9m / Energy-Saving Guarantee: 33.5% / Energy Partners: Landis & Staefa, Siemens Building Technologies GmbH.

Case Study 6: Guarantee – FOGIME

Figure 67

FOGIME



Source: "Comparison of best practices in developing and managing financial mechanisms that support energy efficiency projects", Study for ADEME, José Lopez and Eliane Métreau, International Consulting on Energy (ICE), 2004.

FOGIME was set up to support SMEs' investments in favor of energy conservation by guaranteeing the loans they have contracted with banks.

This fund was set up in 2001 by ADEME in partnership with the Bank for the Development of SMEs (BDPME) through its subsidiary company SOFARIS, EDF and Charbonnages de France.

The Fund Guarantee manager is SOFARIS. Held mainly by the State and the Caisse des Dépôts et Consignations (CDC), BDPME directly or indirectly controls the majority of the capital for the SME equipment credit. By creating BDPME, the authorities wanted to have a specific instrument which carries out a general interest mission for SMEs and shares the risk of their financing.

Beneficiaries: Companies in existence for more than 3 years with turnover of less than €40m that employ less than 250 people, whatever their sector of activity or legal form.

Eligible Projects: The eligible investments are in particular those relating to the equipment indicated in the list of materials devoted to energy conservation published in the Official Journal:

- High-performance material and equipment;
- Modifications of existing facilities and processes;
- Renewable energies; and
- The production of efficient equipment in the environment and energy sectors.

The FOGIME is a mutual guarantee conferred by BDPME-SOFARIS and ADEME provided to banks granting medium- and long-term loans. The FOGIME makes it possible for SMEs to benefit from a reinforced guarantee: 70% against 40% provided by the National Guarantee Fund for the development of SMEs, the additional 30% being financed by ADEME. The Fund guarantees a maximum of €750,000 per company. It also guarantees leasing operations for SMEs.

The successive stages in the implementation of the guaranteed loan are as follows:

- The SME applies for a short- or long-term loan to its bank, or for a leasing in order to finance an energy conservation investment;
- The bank makes a request to BDPME-Sofaris to receive the guarantee;
- BDPME-Sofaris addresses the project to the regional ADEME Delegation concerned for a technical opinion. This advice is simplified when the investment follows a decision-making aid financed by ADEME;
- In case ADEME agrees, the bank extends the loan. In the event of refusal, the project remains eligible for the National Guarantee Fund for the development of SMEs in which up to 40% of the loan is traditionally guaranteed.

4.5. A Case Study of Financing for Energy Efficiency Retrofitting of Existing Buildings in China

Dr. Ma Yanlin, Professor and Associate Dean,
College of Public Administration, Huazhong University of Science and Technology

4.5.1. The Expense Apportioning Mechanism Currently in Effect and its Obstacles in Application

Article 30 in the *Regulations on Energy Conservation of Civilian Buildings* issued by the State Council on October 1, 2008, stipulates that:

- Energy retrofitting expenses for government office buildings shall be incorporated by the People's Government at or above county level into the financial budget at the same level;
- Energy retrofitting expenses for residential buildings and public buildings used by such public undertakings as education, science, culture, public health and sports shall be de-frayed jointly by the government and their property owners;
- The State encourages investment in existing building energy retrofits from social capital.

The obstacles that Hubei is facing in implementing this apportioning mechanism are:

- First, the government's financial capacity is limited.

As of the end of 2007, total building space was 758 million m^2 in Hubei Province, 490 million m^2 of which are residential buildings and 260 million m^2 public buildings and government office buildings. The spending needed for the renovation of public buildings and government office buildings is projected at more than RMB39 billion.

The financial status of Hubei Province and Wuhan Municipality is as follows: the local fiscal revenue of the province was RMB133.8 billion in 2008; for Wuhan the figure was RMB37.6 billion.

- Second, public buildings such as middle and elementary schools are fully funded by the government. There are subsidization policies for the renovation of residential buildings in northern China, but none for residential buildings in southern China.

4.5.2. Analyses of Financing Practices in China

The central and local governments all attach great importance to energy-saving renovation. Practices differ from province to province. Generally speaking, they include: government full funding, government subsidization, payment by property owners, energy management contracting, bank loans, multi-party fund-raising, government-guided operation, and market-oriented operation.

Government Full Funding: Pilot Projects in which Energy-Saving Renovation is Funded by the Government's Financial Budget

The General Laboratory Building of the Liaoning Research Institute of Building Sciences was put into use in 1992, without any energy-saving insulation measures. It was a typical energy-inefficient building, hot in summer, cold in winter, with high energy consumption. In December 2007, as the first energy retrofit pilot project for buildings of Shenyang, its renovation was funded by the municipal government. After the project was completed, the building's energy-saving rate rose to more than 50 percent, since its exterior walls were enclosed by polyurethane heat preservation layers and composite panels. With this envelope, the heat transfer coefficient of the building decreased from 1.51 W/m^{2}K to 0.38 W/m^{2}K.

Characteristics: Pilot projects can be funded by the government, but it is impossible for all renovation projects to be funded this way. Long effective financing mechanisms should be established to push market development.

Government Subsidization: Energy-Saving Renovation Projects for Residential Buildings Mainly Paid for by Individuals and Subsidized by their Employment Units and the Government

Replacing windows: Window replacement in existing buildings in Nanjing has achieved significant results. In May 2007, Nanjing drafted *Advice on Energy-saving Renovation of Old Windows of Existing Residential Buildings in Nanjing Municipality*. Windows that were targeted were those in apartment buildings built in the 1980s or later and not earmarked for demolition, whose ownership was clear in the 11 districts of the city proper. The original solid (or hollow) steel windows of the 25, 32 and 35 series were replaced with new energy-saving windows.

Expenses for the replacement of energy-saving windows were mainly defrayed by property owners who have benefited from them, and government subsidies and welfare subsidies provided by beneficiaries' employment units were added. The municipal government allocated RMB10 million as a subsidy for the project, with a subsidization standard of RMB100 per m^2 of window space. Governments at district level also provided some subsidies, and the renovation expenses of families receiving minimum social welfare support and families with Livelihood Guaranteed in Five Aspects were covered.

Energy-saving bulbs: On January 10, 2008, the Ministry of Finance and State Development and Reform Commission jointly issued *Interim Measures for the Administration of Financial Funds in Subsidizing the Promotion of Energy-saving Lighting Products* (Ref. N°. File [2007], N°. 1027). The State indirectly subsidizes the application of these products by providing funds to the enterprises who have won the bid, who in turn sell the products to customers at the bidding prices minus the subsidies. The ultimate beneficiaries are clients making large purchases, and urban and rural residents.

Strong points: Quick results, uncomplicated operation;
Weak points: Suitable for the promotion of single energy-saving products, unsuitable for the energy-saving renovation of whole units.

Energy Retrofitting Payment by Property Owners: Hotels with Independent Accounting

The Shangri-La Group operates according to its triple goals of lowering operation costs, honoring enterprises' social responsibility, and

projecting a sound corporate image. Under these goals it has proposed an energy-saving target of 12 percent. To meet the target, its branches have actively participated in the design and implementation of plans that suit their conditions. The Shangri-La Wuhan is no exception, and it has taken many energy-saving renovation measures since opening for business.

As the Shangri-La Group has a strong financial capacity, these renovation projects have in most cases been funded by the Group, without financing from outside sources. Considering the risks posed by technological advancement (the technology currently in use is devalued by the emergence of better, more advanced and less expensive technology within the investment recovery period), the investment recovery period of these projects was limited to 2 years so that upgrading could be carried out regularly and appropriately.

The Howard Johnson Hotel Wuhan is a five-star hotel owned by the Wuhan Municipal Railway Bureau, and managed by the Howard Johnson International Group. Currently, the hotel's Engineering Department has drafted a *Renovation Plan for the Hot Water System of the Howard Johnson Hotel Wuhan*, to be approved by its owner.

As the hotel has only been open for business for a short time, and the initial investment has not been recovered, the head of the Engineering Department commented that in a short period of time the hotel would not raise enough funds for its energy retrofitting project. An application for a bank loan is not feasible because (a) it is economically unsound to use bank loans for renovation due to the high cost and heavy liabilities, and (b) banks would not approve an application due to the high risks of an enterprise that has not repaid its initial debts.

The head of the Engineering Department, who is well conversant with China's energy-saving industry and technology, also argued that there are obstacles in opting for the ESCO (Energy Service Company) mode.

"Chinese energy service companies have limited expertise in service and design, and are unable to fully satisfy enterprise demands for an overall energy-saving service. Furthermore, China's energy service industry is in its infancy, lacking in mature market operation mechanisms, and energy service companies generally have a low level of credit, which means high costs and risks of soliciting service."

In conclusion, the hotel will not easily opt for an ESCO financing mode.

Thus the hotel hopes that the energy retrofitting can be designated as a pilot project by the government, with funds mainly from government investment or subsidization, supplemented by a small amount of capital raised by the company itself.

Characteristics: Applicable to commercial buildings with high energy consumption with abundant capital and independent accounting. For example, the Shangri-La Group is highly motivated to renovate and has a strong financial capacity, while the Howard Johnson Hotel Wuhan is motivated but lacking funds.

Conclusion: Corresponding financing mechanisms should be established.

Energy Management Contracting

The Wushang Asian Trade Plaza Shopping Center is in the Wuchan District of Wuhan, with 119,660 m^2 of building space. The building is

owned by Wuhan Asian Trade Plaza Co. Ltd.,[2] with floors 1 to 5 and two underground floors leased to the Wuhan Wushang Group Co. Ltd. for the Wushang Asian Trade Plaza Shopping Center. The leased space takes up 60,116 m^2, with 50,000 m^2 for business. In 2002, the two parties signed a leasing contract with a term of 12 years, which stipulates that Wuhan Wushang Group pays an annual rent of RMB35 million for the Wuhan Asian Trade Plaza. The current equipment management and maintenance responsibilities of Wushang Asian Trade Plaza Shopping Center are assumed by Wushang Group's Property Management Department.

So far, energy-saving renovation measures have been taken by the installation of energy-saving bulbs and a cooled water storage system in the shopping center. As installing energy-saving bulbs did not require a very large investment, it was funded by the company. As for cooled water storage, the ESCO financing mode was adopted, in partnership with Beijing PowerU Technology Co. Ltd. The energy efficiency contract signed by the two parties stipulates that Beijing PowerU Technology is responsible for the investment in energy-saving renovation, and is entitled to a certain percentage of benefits from energy saving. Beijing PowerU Technology is also responsible for equipment maintenance should any malfunction arise. Three operators of cooled water storage equipment are on the payroll of Beijing PowerU Technology, with a monthly salary of RMB800 per person, paid for 5 months a year (from June to October).

The head of the Property Management Department of the Wushang Asian Trade Plaza Shopping Center (Wushang Group) commented that, in considering the investment and contract risks,[3] leasers do not normally make large-scale investments in buildings' renovation and energy-consuming equipment, but they would consider energy retrofitting if the ESCO financing mode with third-party investment was adopted.

Characteristics:

- First, effective in renovating energy-consuming systems, while unsuitable for renovating building envelopes, which demands a long investment recovery period;
- Second, the credit system is immature, with great difficulty in liabilities financing and high costs in negotiation.

Property Owners Applying for Bank Loans

The Wuhan Railway Central Hospital planned to carry out overall energy retrofitting in 2008. Energy management contracting was considered for the project. Due to limited capital, this energy service company planned to finance with bank loans, targeting transferred loans from AFD through China Merchants Bank. During the application process, the hospital purchased a set of medical equipment, which resulted in high liabilities for the hospital and insufficient credit for a loan application. Without a guarantee, bank loans could not be provided in an expeditious way, and the project was suspended. The hospital is now renewing its efforts to obtain bank loan approval.

[2] Wuhan Wuchan Group Co. Ltd. is a State-controlled enterprise, its State-owned assets are currently managed by the State Asset Regulatory Commission (SARC). Daily business decisions (including energy-saving reforms) are made independently– the enterprise being responsible for its own profit and loss– therefore a request relating to this issue does not have to be filed with the SARC .

[3] Here, contract risk means that during the service life of the equipment, the lease contract may expire or be modified.

Characteristics: Ideal financing means, but due to information asymmetry and a lack of guarantees, loan approval is not easy to gain since application terms are difficult to meet.

Conclusion: Government policy backing is needed to provide incentives to commercial banks.

Market-Oriented Operation under Government Guidance

In 2006, Harbin initiated energy retrofit pilot projects for existing buildings at municipal and district levels. The plan at the municipal level included 19 buildings along the Airport Road in a re-roofing project, and the community at Jingwei Shierdao Avenue in which additional stories would be added to the buildings. The district-level government could target buildings along main streets to carry out pilot projects. Renovation projects include replacing flat rooftops with sloping roofs, energy-saving renovation, and an overall improvement of the communal environment, with the option of adding a storey or a penthouse to the buildings. The exterior walls of residential buildings were renovated for heat preservation, and windows were also targeted for energy-saving renovation. The exterior of the buildings was also cleaned and renovated for a new look, and staircase walls were whitewashed. Roadways, green areas and lighting facilities inside the communities were improved. As a result, the comfort, exterior, and energy consumption levels were comprehensively improved. The project was carried out under a market-oriented operation under the theme "government organizing, joint operation at municipal and district levels, policy guiding, and enterprise participating."

The renovation project where flat rooftops were replaced by sloping roofs was funded jointly by governments at municipal and district levels and property-owning units, while funds for adding a story or a penthouse to the buildings were collected through market-oriented operations. Sellable houses built in the project were sold first to top-floor residents or residents of the same buildings at a discount, then sold to outside buyers at market prices.

Characteristics: 7 percent of buildings could have a story added, and considering various factors such as architectural structure, 2 percent of buildings were suitable targets for this kind of project. The scope was therefore very limited.

Establishing Special Funds: Special Funds for Energy-Saving Renovation of Office Buildings and Large-Scale Public Buildings

On October 24, 2007, the Ministry of Finance issued *Interim Measures for the Administration of Special Funds for Energy-saving Renovation of Government Office Buildings and Large-scale Public Buildings* (Ref. N°. File [2007], N°. 558). The Interim Measures stipulate that "Special Funds for Energy-saving Renovation of Government Office Buildings and Large-scale Public Buildings" refer to funds allocated by the State financial budget especially for the purpose of energy retrofitting government office buildings and large-scale public buildings. The funds can be utilized in the following areas. First, expenditure in establishing buildings' energy-saving monitoring systems, including energy consumption monitoring platforms (measuring devices and data networking), energy consumption statistics collection, energy auditing, and energy efficiency data publication. Second, costs of subsidizing interest rates of energy-saving renovation of buildings. Third, other expendi-

ture related to energy retrofits to government office buildings and large-scale public buildings authorized by the Ministry of Finance. The Interim Measures also specifies application and approval procedures of expenditure in energy-saving monitoring systems of buildings, costs of subsidizing interest rates of energy-saving renovation of buildings, and other related expenditures. The *Interim Measures* also covers the administration of these funds, but at the moment this is still not in effect.

Characteristics: Sound experiment, but there are many issues to be addressed in the operation process.

4.5.3. Overseas Practices

Experiences from Picardy, France: Property owners apply for bank loans and the government subsidizes interest rates.

Picardy is a region close to Paris (Ile-de-France region) (the regions are similar in size to Chinese provinces), with an area of 2 million hectares and a population of 2 million. The capital, Amiens, is a relatively small city, with a population of 130,000. In 2004, when Picardy began energy retrofitting residential buildings, the Picardy government adopted direct funding as the financing means, *i.e.* it allocated at least €1,000 for energy retrofitting per property. Its finances were soon depleted from this appropriation of funds, and renovation progress was slow. As a result, along with the local office of ADEME, the Picardy government opted for an energy retrofitting financing mode in which small amounts of public funds were injected to promote large-scale social investment.

Financing methods: The Picardy government, the European Union and the ADEME subsidized interest payments; Bungua Salfea, Domo Finance and the Minsheng Bank provided loans. Agreements signed by the Picardy government with these 3 banks stipulated that the 3 banks provide loans for energy retrofitting, while the Picardy government paid the interest and property owners only repaid the principal on the loans.

The Picardy government prescribed that a loan amount of €5,000, with a maximum of €6,500, could be solicited for a property, with a loan term of 7 years. Energy retrofitting projects that used renewable energy were further provided with incentives. For example, in the case of using terrestrial heat, interest-free loans could be applied for (but using underground water was not recommended); in the case of using wood-based boilers, the loan amount could be raised to €20,000 with an extended loan term; in the case of using solar energy for heating water, subsidies at €230 per m^2 were provided in full. It is estimated that using solar energy for heating water can reduce energy use by 5 percent.

The Picardy government conducted a survey on the energy-saving potential and loan repayment ability of property owners. They found that for an ordinary detached property with building space of 100 m^2, if the building envelopes are of low heat insulation levels, an annual amount of €1,500 would be spent on heating. At an energy-saving rate of 30 percent, €1,500 to €2,000 are needed for renovation, and with energy consumption reduction at €375 to €400 a year, investment could be fully recovered in 7.5 years to pay off the loan.

Home-owners can apply for interest-free loans and repay in installments. A tax credit is also applicable, as 40 percent of personal taxes can be exempted by purchasing energy-saving materials.

The new energy-saving renovation financing mechanism has been in effect for more than 2 years. During the first year, more than 500 houses underwent this renovation. Today, financing channels for residential buildings are fully open, and residents actively participate in loan applications for renovating their homes.

The implementation of energy-saving renovation for residential buildings in Picardy has spurred other industries on to develop. For example, enterprises specializing in design, construction, quality supervision, and construction material manufacturing have been drawn to Picardy, which brings revenues (such as the tax on corporate personnel training) for the government. The Picardy government takes these opportunities to boost the development of local industries. For example, it encourages using solar energy and offers €230 per m^2 of subsidy for installing solar energy water heaters in order to assist the expansion of the solar energy water heater market within the construction industry. This market has taken shape, and the government plans to cut the subsidization standard by half and, in the future, cancel it if the market is mature enough.

Considering the economic effects of the financial budget, providing funds at subsidized rates is 5 to 8 times more effective than directly appropriating funds.

Energy Retrofitting of Public Buildings in Berlin: Energy efficiency contracting is adopted and the government does not contribute anything.

In this type of project, public buildings or public building complexes sign energy service contracts with energy service companies. Energy service companies (ESCOs) are responsible for a series of services, provide construction technology, and bear the risks of project implementation. In the project, an energy institution (Berlin Energy Agency) plays a role in assisting public institutions by collecting data, negotiating with ESCOs, and following up on project progress.

Investment comes from ESCOs or third-party financial institutions, and is recovered by a reduction of energy consumption.

Energy efficiency contracting is a new financing mechanism in which investment in energy retrofitting is recovered by the costs saved from the reduction of energy consumption. Contracts signed by ESCOs and clients normally fix a certain energy-saving rate. This kind of mechanism enables clients to reap benefits from saving energy without increasing initial investment, as investment in energy retrofitting (energy auditing, feasibility research, and investment) is made by the ESCOs, and is recovered by sharing the benefits of the clients' consumption reductions. Meanwhile, in this kind of mechanism, the clients only have to deal with the other party of the contract in the whole process of project implementation (including auditing, financing, constructing, and operating), which lowers transaction costs to a large extent.

In Germany, many energy efficiency contracting projects have been carried out in Berlin. Between 1995 and 2001, 318 public buildings in Berlin were divided into 12 groups and each of these signed energy efficiency contracts with private investment institutions that promised an average energy-saving rate of

23 percent. Investments totaled €24 million, and public institutions saved €1.7 million each year, while contractors reaped €5.9 million from the reduction in energy consumption each year. In the Berlin case, the Berlin Energy Agency played an important role in coordinating the activities of public administrative departments and ESCOs. It assisted the municipal government in the work, from project bidding to contract execution and supervision.

4.5.4. Conclusion

Renovation of single or separate projects can be guaranteed, but financing mechanisms must be established to support long-term, large-scale energy-saving projects for existing buildings.

4.6. The Difficulties of Financing Energy Efficiency Retrofitting of Existing Buildings and Ideas on their Resolution

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4.6.1. The Content and Significance of Energy Efficiency Retrofitting of Existing Buildings

Content

The aim of energy efficiency building is to implement energy efficiency standards and policies during the building design, construction, and use phases. This means using energy-efficient building materials, tools and products, and raising the thermal insulation and air-tight properties of buildings in order to increase the operating efficiency of heating and air-conditioning systems, and reduce energy-consuming activities. According to internationally used definitions, energy efficiency building covers energy consumption in civil buildings during post-construction use, most importantly including consumption of energy resources for heating, ventilation, air-conditioning, lighting, electrical appliances, power, cooking, elevators, water drainage and water heating. Energy efficiency building mainly includes the two areas of energy efficiency in new buildings and energy efficiency retrofitting of existing buildings.

Energy efficiency retrofitting of existing buildings refers to the reduction of energy-consuming activities per unit area of existing buildings. This is carried out through the retrofitting of existing building envelopes and energy-using equipment on the basis of energy audits. Currently, most retrofit plans mainly cover improvements to the energy efficiency of areas such as building envelopes, windows, roofs, and energy-using equipment. Some retrofit plans have already reached a mature level in terms of techniques and technology, but in reality they are often hard to realize during the operation process due to system and funding issues.

Characteristics

Energy efficiency retrofitting of existing buildings possesses positive externalities. The externalities lie in people's self-interest and the public nature of society, as value is realized through the combined help of people or groups. The public environment and public resources are non-exclusive, which determines the degree of free nature of their use, therefore causing externalities. During the process of energy efficiency retrofitting, the self-interest motivated behavior of carrying out retrofits and investment in retrofits of customers or enterprises does not only reward individuals and proprietors with a certain level of benefits (increased comfort and energy-saving benefits), but also results in a positive effect for society. Energy efficiency building reduces the energy use of society as a whole and also reduces air pollution, so that other people in the surrounding area will also receive some environmental benefits. In addition to this, it also drives the development of energy efficiency related industries, and advances the development of the economy. However, despite the social benefits, people who have not adopted energy efficiency methods will also receive the benefits and therefore, at the moment, the future social benefits of energy-efficient behavior are greater than the individual rewards for the parties involved. Therefore, positive externalities exist in the energy efficiency building activities of customers and enterprises.

In the field of energy efficiency building, the expected investment income of customers is less than the increase of investment input. Moreover, the increase of investment in energy efficiency is inevitably less than the comprehensive benefits to society, such as the reduction of energy consumption in buildings, improvement of environmental quality and contribution to economic growth. Therefore, if the cost of investment in energy efficiency retrofitting [4] is to be fully covered by the main building users themselves, according to current energy price levels, it would take at least 5 to 8 years to recover the costs. Such a long period of return on investment is fundamentally unattractive to customers. Some commercial buildings have carried out energy efficiency retrofits of energy-using equipment, but mainly in cases where the economic motivations were driven by the incentive of fast returns.

From an overall perspective, the work of energy efficiency building in China is currently still in its infancy. There is an insufficient supply of high quality technology, materials and products, and energy efficiency building capabilities are lagging behind. In the past, energy efficiency in buildings has been driven solely by the self-motivation of developers and consumers in conjunction with obligatory standards and this has not produced substantial results. The fundamental reason for this is that there is "market failure" in the field of energy efficiency building. Practice has proven that this field cannot develop spontaneously, but must first have the intervention of the government, through national laws, to make clear regulations for energy efficiency building.

The externalities of energy efficiency building do not only have an effect on other people in the areas surrounding projects, but also continue to effect people for generations. The main energy sources used by mankind are

[4] Overall energy efficiency retrofitting includes retrofits to building envelopes and energy-using systems, etc.

non-renewable resources such as coal, oil and natural gas. These non-renewable resources can produce serious environmental pollution, and there will be a day when they dry up. Therefore, the use of resources without planning and consideration of future consequences will have serious effects on the sustainable development of the next generation. According to the experience of developed nations, the proportion of energy directly consumed by buildings will reach about 35% of the energy consumption of society as a whole. This will result in a heavy energy burden on society and cause serious environmental pollution.

In conclusion, the existence of externalities can lead to market failure in the field of energy efficiency building, and the market's allocation of energy-efficient and non-energy-efficient building will not be able to reach an optimum level for society.

The Significance of Energy Efficiency Retrofitting of Existing Buildings

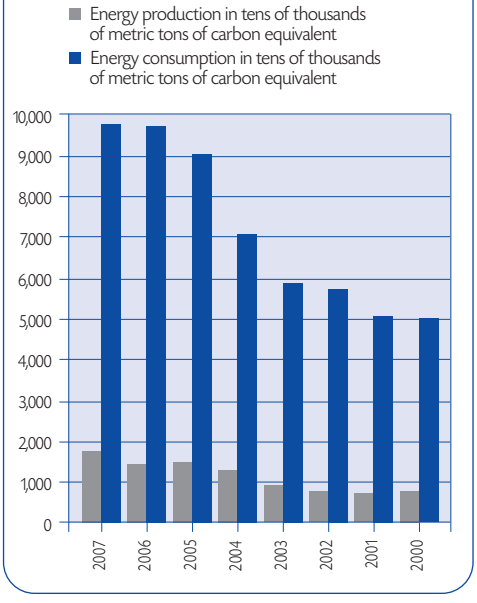
The Relation of Energy Efficiency Retrofitting to the Security of National Energy Resources

China has relatively low energy resources, particularly when compared to the energy resources in other major nations of the world. The country's resources are not only lower than developed nations such as the USA and Japan, but lower than those of other developing nations such as Brazil and India. Energy inefficient technology not only wastes large amounts of resources, but also contributes considerably to environmental pollution.

Energy consumption in Hubei province, for example, has risen from year to year (although electricity use in construction [5] in the province only rose by 13.48% during the 2002–2007 period). By the end of 2007, energy consumption was 6.74 times higher than energy output, turning Hubei Province into a prime example of a large province that is energy deficient (Figure 68).

Figure 68

A Comparison of Energy Production and Consumption in Hubei Province



Source: Hubei Province Statistics Bureau Economic and Social Inquiry System.

[5] Including energy consumption for communication and transportation, post and telecommunication industries, commercial catering, materials supply and storage, and the energy consumption of urban and rural residents.

China is currently undergoing rapid industrialization and urbanization; international experience has shown this to be a stage of high energy consumption. China not only faces insufficient energy resources, but the country has accepted industry transfers in the last two years from developed nations, thereby increasing the pressure on domestic resources. Therefore, in promoting energy efficiency building against the background of energy resource shortages in China, the advancement of energy efficiency retrofitting of existing buildings would have very real significance. It is an important measure that would mitigate energy security issues in China.

Energy Efficiency Retrofitting is Beneficial to Environmental Protection

Air pollution does not only come from industrial waste gases, but also from fossil fuel-fired heating in winter. In recent years, sulfur dioxide and smoke emissions in China have increased from year to year, residential-related emissions accounting for 16.14% of sulfur dioxide emissions, and 19.87% of smoke and dust emissions. Air quality in the 16 largest cities in China has reached or been above Level 2 standard on an average of 307 days per year, with Wuhan City dropping below average at 273 days.

In extreme weather areas with hot summers and harsh winters, the energy consumed by air-conditioning in the summer not only creates pollution, but the heat emitted also increases the urban heat island effect. For example, the urban heat island effect has made the average air temperature of the center of Wuhan 1.8 ° to 2 ° C higher than the outskirts of the city. In the summer, the temperature of certain areas in the city center can at times be 5.9 ° C [6] higher than areas outside the center. The urban heat island effect combined with exhaust emissions cause serious damage to the environment. Improving the energy efficiency of buildings will reduce energy usage, pollution and the urban heat island effect, and will improve the outdoor environment. This is an outstanding achievement.

The Benefits of Energy Efficiency Retrofitting for Living Standards

The energy efficiency standards for the building envelopes of existing buildings in China are very low compared to those in areas with a similar climate in developed nations. The average thermal insulation standard is only a half or a quarter of the standard at similar latitudes in northern Europe. When comparing the heat current transfer coefficient of 50% of civil buildings in China set by energy efficiency design standards with that of developed nations, buildings in China that have strictly enforced the energy efficiency design standards are still a certain degree behind those of developed nations. This results in a very low level of comfort in China's existing residential buildings and poor living conditions. Energy efficiency retrofitting of existing buildings will raise efficiency, and lower the total level of energy consumption of society, contributing to the nation's energy security. In addition, it will also improve living conditions and raise comfort levels.

Wuhan City is located in the middle of the Yangtze River Delta, and has harsh winters and hot summers, but it is not an area with heating. The climate is characteristically hot in summer with high temperatures and high humidity, and the winter is generally cloudy

[6] http://www.sina.com.cn July 22 2008, 08:46.

with few sunny days and a high level of moisture. In the winter, there is an obvious cold lake effect, which makes it feel colder than other areas with a harsher winter. In the winter it is like living in an ice cave, and the summer is like being inside a steamer. The city has very low comfort levels for long-term residents. Wuhan's monthly average relative humidity is higher than comfortable air-conditioning target levels (40%-65%). Only in the months of April, September and October is the average relative humidity within comfortable air-conditioning target levels of 18° to 24°C in winter, and 22° to 28° C in summer.[7]

Although the use of air-conditioning has continued to increase in conjunction with the rise in people's income levels, residents' thermal comfort conditions are still poor in comparison with other regions and other nations. Hubei Province's building stock is mainly made up of existing buildings. At the end of 2007, there were 757,841,300 m^2 of structural buildings in the province's cities and towns, of which 65.15% were residential. In the Wuhan City urban area, structural buildings accounted for 191,505,800 m^2, of which 59.28% were residential. Ninety percent of existing buildings are high energy consumers, and it is clear that this building stock requires energy efficiency retrofitting to reduce energy consumption and raise living standards.

Advancing the Sustainable Development and Technology of the Building Industry

The energy efficiency building industry impacts the work and lives of everyone in the modern-day world. Since the fossil fuel resources we use today are finite, our long-term energy efficiency behavior is a vital contributing factor. Energy efficiency building includes two key parts: the innovation of building materials to strengthen the thermal insulation capability of building envelopes; and saving energy in energy-use systems. The main insufficiencies in energy efficiency technology in China can be seen in the failure of an economic, usable and reliable technology system to reach energy-saving standards. For example, in the area of renewable energy buildings, there are a number of problems: there is a lack of core technologies with their own independent intellectual property rights; in terms of technology there are still deficiencies in the areas of reliable, effective, low-energy consumption heating and air-conditioning, heat measuring techniques, variable flow pipe network distribution and other energy related technologies, as these still do not meet the energy efficiency requirements for buildings. In terms of building envelopes, economic, safe, energy-efficient, long-lasting wall structure building materials still need continued research and development, etc.

Driving Industry Development and Encouraging Domestic Demand

There is a high degree of correlation and a long industry supply chain between the building industry and other industries, which can spur on the development of tens of other industries. Energy efficiency in buildings helps drive the development of related industries and the sustainable development of the economy, and will hugely promote the development and use of new energies in buildings. It will also promote energy-efficient technologies and the use and development of energy-saving products, thereby providing considerable business opportunities to the market and spurring on industrialization. These business

[7] Heating Ventilation and Air-Conditioning Design Standards

opportunities mainly include: thermal insulation wall structure materials, energy-saving windows, doors and glass curtain walls, exterior shades, green lighting, variable-frequency equipment, automatic control systems, heat pump hot water systems, solar-powered hot water, heating and refrigeration systems, and solar-powered electricity generators, etc. These business opportunities will be able to drive structural adjustments and technology upgrades for the whole building industry, the building materials industry, and the real estate industry. They will create job opportunities, increase domestic demand, ensure growth, and create new areas of profit for the nation's economy. According to a report on energy trends published by the State Statistics Bureau, the scale of the energy service industry in 2007 had reached RMB7 billion.[8] Therefore, energy efficiency building will contribute to the sustainable development of China's building industry.

Driving scientific development and constructing Wuhan are two key issues that can be significantly addressed by energy efficiency retrofitting. Its significance is far reaching, and will produce incalculable benefits for the economy, society and the environment.

4.6.2. Funding Difficulties for Energy Efficiency Retrofitting of Existing Buildings and Causal Analysis.

Funding Difficulties

According to the construction expert, Professor Tu Fengxiang, currently in China about 43,000 m^2 of existing buildings are fundamentally not energy-efficient. For the buildings to meet energy efficiency requirements, they need to be retrofitted in the following areas: building envelope and window renovation, provision of sun shades, roof renovation, and the replacement of energy-efficient equipment.

Funding Supply and Demand Conflicts

"Before 2020, China will reduce energy consumption in buildings by about 350 million metric tons of carbon equivalent, of which a target of 110 million tons should be reached during the 11th Five-Year Plan", Minister Chou Baoxing from the Ministry of Construction pointed out. He also added that "energy efficiency retrofitting of existing buildings needs a minimum investment of RMB1.5 trillion". This is a huge funding project. Following the principle of "whoever benefits should invest", the property rights holders and the users of the properties should be the main investment group for the energy efficiency retrofitting of existing buildings. According to the State-initiated principle of "whoever benefits should invest", construction enterprises or building users should bear the large part of the cost of investment. However, there is an obvious conflict between the funding needs to renovate existing buildings and the investment wishes of the main investment groups. According to statistics from the Ministry of Construction's "Building Energy Efficiency Survey" published in 2005, residents have the following attitude to the energy efficiency retrofitting of existing buildings: 58% were very willing, 8% unwilling, 15% would decide after seeing energy efficiency results, 19% would decide based on seeing government policy. Regarding the costs of retrofitting, 6% were willing to pay over 20% of the cost, 74% were

[8] China Building Energy Efficiency Network, www.k211.com

willing to pay up to 10%, and 20% were willing to pay 10-20% of the cost. In the case of public owners of existing buildings, the figures were as follows: 43% were willing to pay RMB200 or more per square meter, 36% were willing to pay up to RMB100 per square meter, and 21% were willing to pay RMB100-200 per m^2. Looking at individual cities, there is also a very noticeable conflict between the needs of retrofitting investment for existing buildings and investment attitudes. For example in Wuhan, a city of hot summers and harsh winters, 160 million m^2 of existing buildings are non-energy-efficient. According to expert predictions, building envelope retrofits alone (not including energy-use system retrofits), would cost about RMB200 per m^2 to reach a 30% energy-efficient result. This would require a total investment of over RMB300 billion. In 2008, Wuhan city's fiscal revenue was RMB791 billion so it is clear the budget will not meet funding requirements. Furthermore, fiscal budget allocations do not cover energy efficiency programs.

The research group carried out a survey in December 2007, in which they randomly questioned 100 residents and 50 public welfare and commercial public construction enterprises. The results revealed that if residents do not have to bear any of the costs, 100 of them would support renovation work. Residents who were willing to bear only part of the cost accounted for 83%, and 17% of users were not willing to pay the costs individually (as a family). The public building survey was completed by managers with decision-making authority. The results showed that 48% of commercial public building property owners or users thought that energy efficiency retrofits should be carried out, 38% were not sure if energy-saving methods should be used, 14% would depend on government policy, 5% thought that renovation costs could be paid independently, 77% were willing to use energy contract management methods to carry out renovations, and 18% were not willing to bear the costs. In buildings with multiple proprietors, many enterprises would wait to see the results of decisions of other main groups and then decide (in one building on average 63% of enterprises had a wait-and-see attitude). In public welfare buildings, 76% of users thought that energy-saving methods should be used, however since the units' funds are allocated by the finance department they have very little decision-making control over allocating funds for retrofitting, and are reliant on the upper levels making a decision. The places in Wuhan city that have gone through energy service companies (ESCOs) and energy contract management methods to pool funds to implement the process of energy efficiency retrofitting are mostly profit-driven commercial centers or hotels. However they are few in number, not more than 20 at the current date, and their retrofitting projects have been limited to energy-use system retrofits and light sources.

Single Finance Channels Lack Effective Methods of Implementation.

Finance channels generally include business owners' self-raised funds, government funding, and market funding. Under current practices in China, funding mainly comes from the government, through subsidies, discounts and incentives, and in most cases it involves a single demonstrative project. Another way is to apply for loans from commercial banks, but these are limited. Banks only extend loans to projects where calculable energy savings can be achieved. International investors are keen to inject capital into the energy efficiency

market, but only a small part of it can be effectively used in the energy efficiency retrofitting of existing buildings. Mainly these funding methods are successful with one-off projects, and cannot be extended to the majority of other green renovation projects.

An Analysis of the Reasons for Funding Difficulties

The High Cost of Energy Efficiency Investment Opportunities, and Long Periods of Investment Return

As energy resources in China are decoupled from energy market fluctuations, costs have been kept comparatively low. Therefore, when comparing profits from traditional production investment with the profits generated by energy efficiency building retrofits these appear low as well as slow, due to the unique characteristics of the use of energy in buildings. Therefore, the opportunity cost is relatively high, and the return period on investment is relatively long. According to current figures, in China the average living space per person is 28 m^2 with the average household being composed of 3 people. The average family dwelling measures 84 m^2. Taking the calculated cost of RMB200 per m^2 for the energy efficiency retrofitting of existing buildings in Wuhan city, for a normal family the input cost would be RMB16,800. Currently in Wuhan city, the cost of electricity for residents is RMB0.573 per kWh. For an equivalent consumption of 29,319 units of electricity, existing non-energy-efficient buildings would on average consume 200 units of electricity more per month, so that the cost of renovation would cover the cost of 12 years of electricity. Taking the example of energy efficiency retrofits to Hubei Province Education Offices, if comprehensive renovations are carried out on areas such as external walls, lighting systems, air-conditioning and elevators (so that the retrofitted building will satisfy Public Building Energy Conservation Design Standards GB50189-2005), with a target of 50% energy efficiency, the whole process of retrofitting would require a capital investment of about RMB3.2 million, calculated according to current electricity fees of RMB0.93 per kWh, the equivalent of 3,449,860 electricity units. If this building does not carry out the retrofit project, it will consume an extra 406,615 electricity units per year, of which the cost of renovation is enough to pay the cost of 8.4 years of electricity.[9] It is clear that the cost of investment opportunities for the energy efficiency retrofitting of existing buildings and the periods of investment return are not attractive for investors resulting in insufficient investment interest.

Irrational Cost-Sharing Mechanisms

The energy efficiency retrofit sector possesses economic externalities. As a public product where multiple parties share the benefits, according to the market trading principle that whoever benefits should invest, the cost should be shared among the parties who benefit. But in reality, energy efficiency retrofitting to existing buildings only possesses shared benefits, and lacks a system for sharing the costs. The main part of the investment activity creates an energy-saving result by replacing energy-inefficient building materials with energy-efficient ones. This not only provides benefits for the investment parties involved by boosting energy efficiency and

[9] Hubei Architectural Design and Research Institute, Wuhan Leading Solar Technology Ltd. Co., Hubei Provincial Education Department Building Energy Efficiency Feasibility Report, July 29, 2008.

raising comfort levels, but the process also reduces energy consumption and air pollution for society and drives the development of related industries. It will increase work opportunities for society and advance the nation's economic development, thereby benefiting the government and society as a whole. Also, according to expert predictions, every kilowatt of energy saved will reduce investment in energy production supply by RMB9,200. In addition to this, because of the marked highs and lows of electricity and natural gas supply in China, energy efficiency construction methods can effectively alleviate this issue and reduce operational costs, benefiting energy suppliers. Therefore, from the perspective of an analysis of the whole energy supply chain (from energy production to use to supervision), energy efficiency in existing buildings can benefit the whole system, not just the energy end-users (*i.e.* the buildings' users) but also the government and energy production suppliers. However, the current system of division of costs is not designed from the perspective of the parties who benefit from the whole energy flow, and has lost rationality.

Additional reasons for the difficulties of sharing investment costs also include problems in calculating the quantity of energy used and the quantity saved. Currently, the methods of calculating energy consumption, the calculation equipment, and the reliability of calculation results in China are still not able to satisfy the needs of energy management. For example, because central heating in buildings is centrally metered, it is difficult to individually calculate the energy savings of each property owner.

- The Legacy of Housing Reform

Under the current housing system in China, there are still a large number of properties established under housing reform. According to the regulations governing these houses, the personnel only have property rights to the inside of their housing. The corridors and stairs are collectively owned by the work unit. According to the principles of demarcation of responsibilities under property rights, personnel are responsible for the cost of energy renovations in the interior part of the housing, and the work unit should bear the cost of the renovation of the public part of the building. According to the principle of whoever benefits invests, the main party that directly benefits from renovations are the personnel. Therefore, the cost of renovation of the public part of the building easily leads to conflict.

- The Problem of Rental Properties

In terms of rental properties there is also conflict between the letting parties and tenants. Proprietors invest in the energy renovation of the housing, which can improve the thermal capability of the housing, increasing its usage value, thus increasing the rental value of the property. The letting parties of the properties will reap the benefits of renovation, and therefore should bear the costs. However, after the letting parties and tenants have signed a rental contract, the benefit to the letting party has already reached its optimum value, if they then carry out energy-efficient investments they will have to reduce their profits. Also, rent will increase, possibly reducing the rental capacity of the property for the letting party. During the period that the tenant is renting the property and investing in the energy retrofitting, they will save energy and improve the thermal comfort of the housing, but there

exists the problem of positive externalities, and a problem of a loss of investment for the party bearing the costs.

The Conflict of Diversification of Property Rights Holders and Renovation Process Integration

Currently, housing in China, particularly urban housing stock, is mainly located in apartment buildings, and the existence of a variety of property rights is very common. Commercial and office buildings with diverse property rights holders are also very common, such as Ruitong Square in Wuhan, the Wuhan Municipal Bureau of Land Resources and Housing Management Building, and the Wuhan Science and Technology Bureau Building. The diverse nature of building property rights has decentralized the decision-making powers in terms of retrofitting investments, so it is not easy to make a united investment decision. In December 2007, the research group randomly chose 10 high-rise apartment buildings in Wuhan to survey the attitudes of residents towards energy efficiency retrofits. The survey produced the following results: in one building, 63% of residents were indecisive, 17% were in favor and 20% were not in favor of retrofits. In addition to this, in order to initiate the energy retrofitting project, raise funds, invest in energy efficiency services and carry out the renovation, the whole building needs to unite unanimously behind the project. The conflict between the diversified investment intentions of property rights owners of existing buildings and the unified nature of the renovation project can easily create a "hitchhiking" phenomenon. For example, due to the complex property rights structure of the Wuhan Science and Technology Bureau Building, it is very difficult for the different rights holders to unite behind a decision and they have therefore been unable to pass a decision to carry out a retrofitting project.

The Weakness of the Energy Services Market

Specialized energy services are an effective method and channel for solving funding issues. Outside of China, the energy service industry has developed an energy contract management system whereby energy service companies apply for loans from banks to meet the funding needs of renovation projects, and specialized leasing companies address the funding needs of large scale equipment procurement, creating the perfect funding management system. The development of the energy service industry in China is lagging behind; it is in its infancy, small-scale and low standard. The companies on the market do not have the experience or capability to implement energy services according to a contract energy management system, and the industry has not established a means of meeting the increasingly pressing financing needs of implementing energy efficiency measures. For example, the three pilot energy service companies in Beijing, Liaoning and Shandong, supported by the World Bank/Global Environment Facility Fund for China Energy Conservation Advancement, established in 1996, have now been running for over 10 years. After using loans from the World Bank and international organizations, their survival and development has been challenged as access to finance is not easy and there is competition for funds. The energy service market in Hubei Province started even later, establishing the Hubei Rich States Industry Investment Co. Ltd. in 1999. By the end of 2008, this had developed into seven energy service enterprises. Most of them promote a single technology (product), and there are not many that can provide comprehensive energy services.

Faults in the Finance Market Support Mechanism

China's four State-owned commercial banks and 12 joint-stock commercial banks are relatively large banks. According to the current financial operating mechanism, loans are mainly given to large-scale enterprises. When compared with large-scale enterprises, the loan amounts for energy service enterprises are not high, so the per unit operating costs and supervision fees of bank loans are high. As bank loan work units' operating and supervision costs are high, these types of loans are therefore not profitable enough for commercial banks. The energy service industry is hampered for various reasons: low level assets, low quality standards, low credit ratings, insufficient credit and loan conditions, and difficulty fulfilling commercial banks' security regulations and, therefore, an inability to use assets to guarantee loans from commercial banks. Energy efficiency retrofitting of existing buildings concerns small individual technological projects, so the scale of investment is not that big, and various different types of projects mean that the strength of specialization is diluted. Therefore, project evaluation methods are difficult to reproduce and banks cannot build on experience gained from investing in other energy efficiency projects. With no learning curve to speak of, the costs of getting involved in the industry are high (project evaluation, assessment, approval and supervision) and therefore economies of scale do not apply. When there is not enough competition in the loan market, and banks make the final decisions, it is very difficult for energy service companies to get access to finance through bank loans.

Performance and Quality Risks

Energy efficiency retrofit projects of existing buildings need very mature and workable technologies and products to support them. Currently in China there are several problems in this area, such as the fact that the energy efficiency building industry has had a relatively late start, that the overall standard of technology is not high enough, that innovation is relatively weak, and that there is low public confidence in the product technology. Such problems mean that the key parties involved, including developers, business owners and guarantee agencies, all take on a certain level of risk for the quality, effectiveness and lifespan of existing building energy retrofits. Existing buildings are the product of different generations, and all have very different structures, levels of quality, geographical conditions, and climates. There are also many differences in owner preferences and a diverse range of energy efficiency retrofitting evaluation approaches, so there is a high level of uncertainty in this field.

Due to a lack of data and significant pilot projects, there is no way for business owners to have a clear view of the quality, effectiveness, benefits, or increased thermal comfort levels of retrofitting work on existing buildings. All of these factors undermine decision-making and influence potential stakeholders' motivation to invest.

4.6.3. The Challenges of Financing the Energy Efficiency Retrofitting of Existing Buildings

Insufficient Supply of Effective Mechanisms

The People's Republic of China Renewable Energy Law, implemented on January 1, 2006, and the *Energy Conservation Law of the People's Republic of China,* revised in 2008,

have not set out any clear provisions for energy efficiency retrofitting of existing buildings. Chapter 3, Article 30 of the *Regulations on Energy Conservation of Civil Buildings* implemented on October 1, 2008, states that the energy efficiency retrofitting costs of national organs' offices should be incorporated into the finance budgets of county-level governments or above. The cost of energy efficiency retrofitting of public buildings used for education, science, cultural, health, sports and residential purposes, should be shared between the government and the property owners. The State is encouraging society to invest in energy efficiency retrofitting of existing buildings. *The Energy Conservation Regulation for State-Funded Institutions* implemented on October 1, 2008, provided clear provisions for the energy-saving work of public agencies. It stipulates that the management systems of the State Council and local government organs above county level should join together with related departments of a similar level to draw up energy consumption quotas according to the combined energy consumption levels and features of public organs in the different industries and systems under their jurisdiction. Financial departments should then decide expenditure levels for energy consumption based on those quotas. At a local level, in March this year, Hubei Province issued *Regulations on Energy Conservation of Civil Buildings in Hubei Province*, in which Chapter 2, Article 3 states that the People's government at levels higher than county level should draw up preferential policies to encourage society to use capital in various ways to invest in energy efficiency retrofitting of existing buildings, and to provide energy efficiency building services. Investors then have the right to a share in the benefits of retrofits according to agreed terms. This is currently the most recent significant legal basis for developing financing methods for energy efficiency retrofitting of existing buildings. However, although in principle the text sets out clear demands, at the implementation stage it is clear that obstacles are numerous.

In reality, if the cost of energy efficiency retrofitting national agency office buildings is completely incorporated into the financial budget of the relevant agency, and the cost of retrofitting buildings used for public benefit is to be shared by the government and the property owners, this will create a huge financing gap. This will inevitably affect the comprehensive implementation of energy efficiency retrofits to existing buildings. According to the studies carried out by the research group, systematic arrangements are needed to enable the transfer of benefits and capital from society to the individuals carrying out retrofits. This is an effective process for internalizing the externalities of the field of energy efficiency building, and it has the power to stimulate and direct a large proportion of society's capital into the energy retrofitting field. This kind of policy would impact considerably on changing financing patterns. However, the Chinese government has not as yet implemented these kinds of policies. Regarding the retrofitting of residential buildings, in 2007, the Ministry of Finance introduced *Finance Incentives for Heat Metering and Energy Efficiency Retrofits of Existing Residential Buildings of Heating Zones in North China*. These incentives are aimed at encouraging energy efficiency retrofits and heating metering in existing residential buildings in heating zones in north China; however the incentives are not adapted to southern China or to public buildings. Due to a lack of effective mechanisms, it is difficult to create a highly effective financing system. The expe-

rience of different countries in the area of energy efficiency in buildings shows that a comprehensive use of financial incentives, tax breaks, and special funds in order to diversify financing, can effectively increase financing channels for energy efficiency retrofits. For example, Japan has introduced tax benefits for different types of energy-efficient equipment from a catalogue of energy-efficient products, which provides tax deductions of 7% of the total cost of equipment, to encourage the use of highly effective energy-efficient products in buildings. Countries such as Denmark, Finland, Korea and Poland have provided financial incentives for energy efficiency retrofits to existing buildings. France and the USA have implemented measures to accelerate the depreciation of parts of energy efficiency equipment, and tax deductions to encourage the use of energy efficiency products to raise energy efficiency.

Current price levels coupled with lack of stimuli have created an environment that motivates neither businesses nor residents to carry out retrofitting work. In addition, because of a lack of incentives, it is also very hard for other investment bodies to find good reasons to provide investment. This means that the few powerful developers that dare to be innovative and far-sighted and that are actively trying to explore new methods will often give up after a short period.

The Lack of a Support System for the Development of the Energy Efficiency Industry

The energy efficiency industry includes energy service industries and energy-efficient material manufacturers. The development of the energy service industry in China is lagging behind; it is in its infancy, small-scale and low standard. The companies on the market do not have the experience or capability to implement energy services according to a contract energy management system. It cannot satisfy the increasingly pressing demands of energy efficiency financing and technology supply. The energy service industry is hampered for various reasons: low level assets, low quality standards, low credit ratings, insufficient credit and loan conditions, difficulty in fulfilling commercial banks' security regulations and, therefore, an inability to use assets to guarantee loans from commercial banks. Energy efficiency retrofitting of existing buildings concerns small individual technological projects, so the scale of investment is not that big, and various different types of projects means that the strength of specialization is diluted. Therefore, project evaluation methods are difficult to reproduce and banks cannot build on experience gained from investing in other energy efficiency projects. With no learning curve to speak of, the costs of getting involved in the industry are high (project evaluation, assessment, approval and supervision) and therefore economies of scale do not apply. Because of this difficulty in getting bank loans, and the high level of pressure on funding, there are significant challenges to the survival and development of energy service companies.

The key production sectors in this field include the manufactures of energy-efficient products and manufacturers of new energy-efficient materials. On the one hand, because the cost of production of energy-efficient products is higher than ordinary products – in some cases considerably higher – a price disadvantage exists when the products reach the market. Furthermore, product performance is not well known to consumers who are already wary due to the high quantities of fake or poor quality products on the market,

and all these factors are detrimental to the free circulation of these kinds of products.

The initial development phase of the energy efficiency market can particularly benefit from the support of government policy. There is even more need to increase the stimulus of preferential policies when consumer demand is not a driving force. For example, funding allocation support policies, policies for establishing appropriate security systems, policies for reducing the production costs of energy efficiency products, and policies supporting the enlargement of the industry's share in the market, are needed to help create mechanisms for increasing returns to scale as soon as possible. Otherwise, it is very difficult for the industry to mature to meet the long-term, large-scale needs of energy efficiency in buildings.

Ineffective System Arrangements for Reducing Transaction Costs in the Energy Market, and the Inefficiencies of the Energy Efficiency Market

Currently in China, the determinants of transaction costs [10] are in widespread existence within the energy efficiency building field, which has led to low efficiency in the energy efficiency market. First, because of opportunism and the limited rationality of human beings, there is an obvious lack of motivation for businesses and customers to invest in energy efficiency building, and local government has not as yet introduced a clear set of comprehensive policies to promote the local development of energy efficiency in buildings. Second, a lack of credible product authentication systems, energy consumption labeling systems and energy consumption notification systems means that energy market information and reports are not coherent. Third, the system only includes positive rewards and does not include punitive measures, which leads to a lower cost of activities outside of the system, contrasting with the higher costs of business within the system. For example, *The People's Republic of China Energy Conservation Law* and the *Civil Energy Bill* relating to energy efficiency in buildings both "support," "encourage" and "promote" new building materials and buildings technology, but the texts lack concrete mandatory measures, and there are no specific terms for constraints. Therefore, changes to designs and even violations of building energy efficiency standards can occur after design completion. Fourth, there is a lack of supportive policies for efforts to develop energy-efficient intermediary service institutions. Specialized energy efficiency intermediary service institutions can provide a widespread level of service to society. They can provide such services as energy auditing, energy efficiency testing and labeling, and energy efficiency design, which can reduce transaction costs and raise efficiency, providing an important guarantee for the effective operation of the market economy. At present, specialized energy efficiency intermediary mechanisms in China are either attached to local government, or are under the control of industry associations. Currently consumer willingness to invest in energy efficiency is low and the credit system is inadequate, so that the opportunity for independent development of intermediary mechanisms is very small and has therefore never been developed properly, resulting in an inefficient energy efficiency market.

[10] According to Williamson, the determinants of transaction costs are frequency, specificity, uncertainty, limited rationality, and opportunistic behavior.

Financial intermediaries are the institutions that direct savings towards effective investment. Since the field of energy-efficient retrofits for existing buildings needs huge amounts of funding, the role of financial intermediaries is even more important. However, because of the limiting characteristics of energy efficiency in buildings and the limited rationality of financial institutions, there is a strong tendency for opportunistic behavior in finance in this field. The lack of relevant policies for the establishment of a financial intermediary platform, and the lack of incentive policies to reduce the risk for financial institutions, such as a corresponding guarantee system, means that there are large opportunity costs and conflicts of interest, and high coordination and monitoring costs. This creates a barrier to financing channels, and a lack of protection when in operation on the market. For example, in August 2008, Wuhan City Railway Hospital started to make a plan for energy-saving retrofits to the hospital buildings, and actively used the intermediary credit services of AFD to carry out financing. However, the project was stopped at the end of 2008 because it failed to get approval from China Merchants Bank's Loan Approval Committee, the main reason being that in 2007 the cash flow financial indicator assessment fell short, and could not satisfy the loan conditions of the China Merchants Bank. However, because of the special characteristics of the hospital retrofit project, it should be classified as a project supported by government policies, and therefore should not have to submit to commercial loan standards. However, because of the lack of appropriate incentive policies and guarantee systems, the project could not be approved for bank loans and the financing issue was a barrier. AFD[11] and Hubei Urban and Rural Environment Energy Engineering Co., Ltd. (an energy-saving enterprise) have on many occasions discussed the project with the China Merchants Bank, but to no avail.

4.6.4. Solutions for Financing Difficulties

Theoretical Foundations

Correcting Externalities

From an economic point of view, the presence of externalities results in society becoming distanced from the most efficient production conditions, resulting in the market economy mechanism being unable to properly realize its basic function of optimization of resource allocation. The fundamental idea of resolving externalities is to let externalities become internalized, that is, to make the social benefits of costs created by the economic activities of the main economic parties become individual benefits or costs through systematic arrangements. There are three typical strategies: taxes and subsidies, business amalgamation, and demarcation of property rights. According to the characteristics and realities of energy efficiency building work, we should focus on the first approach to eliminate externalities in the energy efficiency building area. As mentioned earlier, energy efficiency retrofits to existing buildings are considered a typical area of market failures. Externalities can be corrected and market

[11] In July 2007, AFD provided €60 million of intermediary credit to the Chinese Ministry of Finance in the form of a sovereign loan to be used specifically to encourage investment in energy efficiency and finance renewable energy projects. Companies could then apply for loans through the China Merchants Bank, Huaxia Bank and Shanghai Pudong Development Bank at below-market interest rates.

failures overcome through effective government mechanisms, and therefore government intervention is essential.

System and Mechanism Innovation

Construction of a "Two-Oriented Society" is a social engineering project involving the creation of a system mechanism and development methods. It involves many participants, and every participant has a different role, function and responsibility in both types of social construction. At the same time they also have different interests and behavior. There must be a rational mechanism or system to allow different types of participants to fully carry out their functions, perform their duties, and fulfill their responsibilities.

Specialization

The level of efficiency of a complex market should also be derived from specialization. In classical economic theory, specialization can raise productivity and increase sources of national wealth. In this complex system of energy efficiency retrofits to existing buildings there are many stakeholders, and the only way for the main parties to attain a win-win situation and form a positive cycle of growth is on the basis of specialization.

Mechanism Principles

A government-led finance mechanism is a large-scale, long-term form of mechanism. It fully embodies the leadership of the government, and should promote the self-development of the market and a positive cycle of self-improvement. When specifically extended to the field of energy efficiency retrofitting of existing buildings, government-led content should help the market to complete the process of profit generation. It should lead to the design of a type of profit generation mechanism, and pass this on to the market to create a foundation for market operation and development. The establishment of a profit generation mechanism includes setting new ideas and integrating these into financial practice. This mainly includes: economy of scale systems, cost-effective evaluation systems, credit support systems, cost-sharing systems, and information platforms. Taking into account the special nature and complexity of energy efficiency retrofits to existing buildings, we believe that a more effective means of achieving these should be: acting on a policy basis, using entity promotion as an important breakthrough for important uses of "rules, planning, supervision, enlightenment, and demonstration".

Specific Ideas

Establish a Business Construction Concept, Coordinate Planning and Debt Financing, Third-Party Financing and Equity Financing

According to the fundamental principles of economics, resources that will bring future economic benefits for the relevant economic parties are defined as assets. From this perspective, buildings are assets that possess huge potential value. Energy efficiency building projects will not only provide the economic benefits of continuous reduction in energy costs for future building owners or users, they will also provide comprehensive benefits such as reductions of energy consumption for the whole of society and improvements in environmental quality. Therefore, buildings are an asset that can provide benefits of significant value to relevant beneficiaries.

The process of energy efficiency building must be guided by business principles for it to be able to realize its optimum value. The key characteristic of assets is that they must go through effective business operations

to optimize their value, and buildings are no different. The business of construction should be oriented to the market, so that buildings are seen as assets capable of bringing added value. Sustainable growth in value can be achieved through the efforts of people and funding, and by using advanced technology and management tools to target the physical characteristics of construction and develop their potential (fundamentally different to the concept of the real estate business). The core idea of the building business is to highlight the characteristics of building assets, at the same time as emphasizing market mechanism operations, focusing on efficiency, and placing effectiveness at the top. Establishing the concept of building energy management includes two levels of understanding. Firstly, we should identify and understand the characteristics of construction assets. Secondly, we should harness the motivating forces of the key market bodies and use price signals to guide and optimize the allocation and rational use of resources in order to achieve value growth and value maximization.

From a financing perspective, business means choosing one optimum financing strategy that is capable of giving full play to the advantages of debt financing and equity financing. It should fully use the advantages of the situation and minimize disadvantages. In this way, both financing tools combined can reach the optimum situation, *i.e.* to enable operation risks and finance costs to be as low as possible and gain an optimum level of benefits.

The Requirements of Debt Financing to Leverage Energy Efficiency Building

Because of the special characteristics of market failure in the field of energy efficiency building, the initial stages of positive guidance by the government should use the supply and demand of building funding as the specific tool to create an "access platform." There are several possible models to choose from, such as energy efficiency project management mechanisms that can be used to attract idle funds from the market to the energy efficiency building market. This will effectively activate the demand for energy efficiency building, and leverage the development of the energy efficiency building field.

Using Third-Party Financing to Accelerate the Marketization of Energy Efficiency Building

Financing based on the contract energy management method is a typical type of third-party financing. Under this financing model, specialized energy service companies can provide a comprehensive advantage through measures such as professional technical services, system management, and financing during the process of implementing energy efficiency projects. Clients and ESCOs can build a new win-win mechanism to provide the intrinsic motivation needed for the implementation of energy efficiency projects, which can also ease parts of the market failure problem and accelerate the pace of the energy efficiency building market.

Using the Energy Efficiency Industry Supply Chain to Release Equity Finance

From the perspective of the whole industry supply chain, it is important that both upstream and downstream industries should be highly integrated with the energy efficiency retrofitting of existing buildings. This should include sectors such as specialized energy service companies, new energy-efficient materials, new products and new-technology enterprises. If this can be established on the foundation of the specialization of labor and with capital management at its core, it will be able to release the full power of equity finance.

4.7. Research on Financial Mechanisms for the Energy Efficiency Retrofitting of Existing Buildings

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4.7.1. Characteristics of Financing Energy Efficiency Retrofitting of Existing Buildings

Energy efficiency retrofits of existing buildings, due to fundamental engineering differences, can be divided into energy-use system retrofits and building envelope retrofits. Certain characteristics of these energy improvements result in different models of financing.

Characteristics of Financing Energy Efficiency Retrofitting of Existing Buildings

Financing Energy Efficiency Retrofitting of Energy-Use Systems

Energy-use system proprietors have much clearer benefits to gain from equipment system improvement. However, the positive externalities of equipment improvements are fewer than for building envelope improvements and the internalized costs quite low. More specifically, with currently available technology, data can be gathered that will accurately record the energy consumption of equipment systems along with respective post-retrofit energy savings. As a result, carrying out techno-economic evaluations and calculating cost effectiveness and payback periods is relatively easy. It is therefore possible to make a detailed assessment of the costs and benefits of a retrofit. Having the benefits and payback period clearly laid out makes retrofitting more easily acceptable to homeowners and other market entities. Therefore, in terms of finding financing, this kind of retrofit is well-suited to market-based solutions (namely banks and other financial institutions).

Internationally, there is currently a quite well-developed market practice for banks and other financial institutions to grant commercial

loans to energy service companies (ESCOs). Energy service companies provide comprehensive professional energy services to their customers (providing them with services to upgrade or replace energy-consuming equipment), and ultimately recover their costs and make a profit through the energy savings they make. This method is known as "contract energy management".

Characteristics of Financing Energy Efficiency Retrofitting of Building Envelopes

Building envelopes, in general, form the public part of buildings. With the diversification of buildings' property rights, their upkeep and refurbishment is now a public matter. Bringing with it strong positive externalities, the internalized costs are also very high. Even in the case of distinct property rights (to a sole owner), using the technology currently available, it remains very difficult to measure and calculate the energy savings and degree of comfort that would result from building envelope retrofitting. It is not yet possible to carry out an accurate appraisal of the costs and benefits. This lack of precise information on the benefits and payback period of building envelope retrofitting coupled with reasonably high outlays means homeowners and other market entities are wary of this kind of retrofitting. As a result, market-based solutions to finance such projects are not as well-suited as for "contract energy management".

Owners of existing building stock lack enthusiasm for undertaking building envelope retrofitting, as do energy service companies. Under current institutional policies and techno-economic conditions, and based upon accurate evaluations of the costs, risks and efficiency of such projects, commercial banks and other financial institutions are still unsure of financing projects involving building envelope retrofitting. As a result, they require financial investment from governments (such as direct investment and subsidies) as well as relevant policies aimed at users, banks and energy service companies (including mandatory regulations, tax incentives and the establishment of an energy quota system).

The Advantages of Financing Energy Efficiency Retrofitting of Existing Buildings

Low Investment Risks, Steady Gains

There is enormous potential for energy efficiency retrofitting in China due to the sheer scale of the country's existing building stock. With the advances in technological know-how, refurbishment projects can show sustainable cash flows and steady profits.[12] Precisely because of this, and in the foreseeable future, there will be strong demand for energy efficiency retrofitting of existing buildings, which will accelerate growth of the entire market and industry, creating a propitious investment environment. Meanwhile, energy efficiency retro-fitting of existing buildings complies with China's State policy on property and the State's overarching strategic goals for energy saving and emissions cuts. The policy curve will become steeper and steeper with the release of a stream of technical standards and incentives regarding industries connected with energy efficiency building. Financial support will strengthen as financial funds gradually draw in more and more investment, signifying a lowering of investment risk in

[12] For a concrete data analysis, see the research group's reports, the *Technological and Economic Analysis of Energy Efficiency Retrofitting of Existing Buildings in Wuhan City,* and the *Energy Audit and Potential Energy Savings for Hubei Provincial Government Office Buildings Study.*

this area. In general, the payback period for a building envelope retrofit is longer than that of an energy use system retrofit. Taking office buildings as an example, surveys show that the average payback period for a building envelope retrofit is 23.9 years, and an external window retrofit 22.3 years (only fitting outside sunshades is paid back in 9.42 years). This compares with around three years for frequency conversion and air-conditioning main unit retrofits, one or two years for lighting, and between two and three years for energy-efficient installations . The benefits of energy conservation in hotels are even more evident where a building envelope retrofit has an average payback period of 10 years.

Running and Maintenance Costs are Lower than for Other Energy Efficiency Retrofit Projects

The energy efficiency retrofitting costs of a building are not very high and the works program is relatively short for both retrofitting the building envelope or the energy use system. Compared with energy efficiency retrofitting in other fields, the post-retrofit running and maintenance costs are very low, with generally no extra operational costs. Moreover, a rise in the thermal capacity of buildings and compliance with energy efficiency standards can increase their value. Comparatively speaking, running and maintenance costs after an energy efficiency retrofit in the industrial sector are always high, with additional operational costs involved. Take the desulfurization of an electric power plant, for example. Once the initial work has been completed, there remains the high cost of operating the desulfurization equipment. As a result, some plants do not use their desulfurization units on a regular basis, choosing only to do so when being inspected by the Ministry of Environmental Protection. Consequently, the equipment's work rate drops and becomes operationally ineffective.[13]

The Drawbacks of Financing Energy Efficiency Retrofitting of Existing Buildings

The main barriers to financing the energy efficiency retrofitting of the existing building stock are as follows: projects tend to be dispersed; property rights can be complicated; the management systems of different types of building stock vary; and it is very difficult for proprietors to finance it themselves. With projects quite sparse and individual projects quite small, the majority of them require less than RMB10 million of investment, and therefore applying for traditional forms of financing such as bank loans is more difficult. Secondly, complicated ownership rights make policy-making more challenging and the process longer. Not only can different kinds of building stock have alternative management systems, but within the same kind of building stock the management systems can vary from project to project, all of which can impact the policy-making and financing processes.

[13] In order to solve this issue, the National Development and Reform Commission and the Ministry of Environmental Protection released *Experimenting with Franchising for Developing Flue Gas Desulfurization in Thermal Power Plants* in January 2008. The paper called for the development of flue gas desulfurization in thermal power plants. Led and organized by concerned ministries and on the foundation of favorable policies surrounding a desulfurized electricity price, desulfurizing facilities were to be constructed, operated, maintained and managed on a daily basis by a specialized desulfurization company charged with reducing sulfur dioxide emissions.

4.7.2. Potential Channels for Financing Energy Efficiency Retrofitting of Buildings in China

Establishing Dedicated Funds for Dedicated Construction Investment, Subsidies, Discounts, and Guarantees

Funds can refer to both financial and organizational aspects of the term. In terms of finance, funds represent capital that is used to serve specific ends and that enjoys independent accountability. Among these are the pension funds, retirement funds, relief funds, and educational scholarship funds that are found the world over, as well as the dedicated financial funds, collective staff welfare funds, major energy and communications construction funds, and budget regulation funds that are specific to China. In terms of organization, funds are aimed at institutions or organizations that specially manage and operate capital with specific goals. Such a fund may be a non-corporate body, an institutional body or a corporate organization. The funds mentioned in this paper refer to the financial sense of the word. In construction, the electrical power funds, environmental funds, dedicated housing maintenance funds and structural alteration funds that have previously been established in China have all had a positive impact in specific fields. Currently, China has yet to set up funds for the energy efficiency building sector. Based on the experience of establishing and managing electrical power funds, dedicated housing maintenance funds and structural alteration funds, as well as drawing on international experience, dedicated funds should be set up in order to push forward energy efficiency retrofitting of buildings.

In the *Wuhan City Cluster "Two-Oriented Society"* Experimental Region Master Plan, the Hubei Provincial Government clearly states that it is planning to establish a business and industry investment revolving fund worth RMB20 billion, with an initial phase investment of RMB5 billion. Speeding up energy efficiency building work is an important part of creating a two-oriented society. In this way, the Hubei Provincial Government will be a precursor in establishing a "dedicated fund for energy efficiency building." Establishing a revolving fund for energy efficiency building projects will support the implementation of long-term, large-scale energy efficiency retrofitting of existing buildings.

Financing Debts: The Involvement of Financial Institutions

On July 30, 2007, the Ministry of Environmental Protection, the People's Bank of China and the China Banking Regulatory Commission jointly announced the concept of "green credit" to be brought about through the use of environmental regulation and financial levers. By introducing environmental thresholds for accessing financial credit, new construction projects that do not reach these thresholds will not be eligible for credit support. All forms of newly increased credit for such unenvironmentally friendly projects should be withheld and measures taken to recuperate any previously granted loans. By cutting off the cash flow, it is hoped that this kind of energy-hungry, polluting industry will be severely restricted. These measures will prevent lawbreakers from accessing capital, thereby curtailing their investments whilst mitigating environmental issues as well as initiating a restructuring process in the industrial sector through the provision of credit. In this context, the China Development Bank has been vigorously pursuing "green loans", setting up special-purpose loans for energy-saving and emissions cuts in 2007. They

have helped to bring industrial pollution under control, encouraged the treatment and reclamation of urban wastewater and the disposal of urban solid waste, and promoted comprehensive clean-up operations of key water-based environments such as Taihu and Chaohu. In 2008, the China Development Bank began studying special-purpose loans aimed directly at energy efficiency building. As the current threshold for medium- to long-term loans to single projects is set at RMB10 million per project, currently the China Development Bank does not consider loans to individual energy efficiency building projects, primarily focusing its attention instead on collaboration with municipal governments. Considering projects in their entirety, municipal governments serve as a platform for loans (the debtors). Therefore, municipal governments can tie together projects in energy efficiency retrofitting of buildings by borrowing money from the China Development Bank to support them.

According to information gathered on the EU, France, Germany, Japan and the USA provided by AFD, the central banks of developed nations abroad play an active role in financing energy efficiency building. In this field, the funding for large-scale energy efficiency retrofits of existing buildings is generally engineered through cooperation between commercial banks and development banks. The types of loans can be classified as follows: (1) direct loans to energy service companies,[14] and (2) direct loans to proprietors. The ratio of individual residences to the total number of residences is quite high abroad, reaching 56% in France. As a result, the cost of energy efficiency retrofitting is often undertaken by the homeowners themselves. If homes in a certain city or administrative region wish to carry out energy efficiency retrofitting, the government will carry out research and evaluations and design plans with the help of energy efficiency information services. Once the entire implementation plan has been approved, the government, the energy services intermediary, and the commercial bank will enter into consultation to agree upon an energy efficiency retrofit project for the administrative region. The government will then directly appropriate interest subsidies to the appointed commercial bank, from which homeowners will ultimately be able to apply for financially subsidized loans to carry out a retrofit.

It is possible for commercial banks abroad to play a contributing role in the energy efficiency retrofitting of existing buildings thanks to the developed nature of their system of credit, people's relatively high awareness of energy savings and environmental protection, and the level of governmental support. Credit is seen as a second lifeline by all the stakeholders: individual homeowners, businesses or government institutions. As such, the proportion of loans repaid in full is very high. Second, as greater emphasis is placed on quality of life in developed countries, residents' support of energy savings and environmental work is quite high, and they are therefore receptive to energy efficiency retrofitting of buildings. Third, foreign governments often have policy incentives such as subsidizing the interest on loans to commercial banks, or

[14] Because energy service companies are already well-developed abroad, the amount of jobs and the client base are relatively stable and the profits well-documented. In the USA, most of these service companies have already come through their initial stages, and have established a certain degree of credit. With the global growth of the energy savings and environmental sector expanding constantly, commercial banks are now actively willing to grant them loans.

reducing business taxes in order to encourage commercial banks to get involved with energy efficiency building.

Equity Financing

Equity financing [15] primarily involves the attraction of direct investment and stock flotations. Public-private partnerships [16] are being used more and more widely in engineering projects as they are a quite good form of equity financing to attract direct investment.

Equity financing is characterized by not carrying the burden of fixed interest; fund-raising and financial risks are low; there are no deadlines on loans; there are no repayments; it can be used by a company for a long time; and restrictions on its use are very few.

Equity financing can also provide the public with useful information. If small– and medium–sized enterprises (SMEs) are able to finance their own developmental needs through equity capital, they obtain an optimal capital structure and thus establish a healthy management structure. This can strengthen the company's economic power and encourage more efficient use of their resources enabling SMEs to reach their targets and improve their company image. Outside investors are then more likely to have confidence in the company's management and future growth, investing more capital, which may be used to improve management systems further, improving results and generating further profits for stakeholders. [17]

Equity financing is able to distribute control in a company rationally and optimize its management structure. If a company wants to grow, it must establish a sound capital structure and create an effective corporate management structure in order to strike a balance between the incentive and supervisory mechanisms of its managers. In modern financial economics, stock options play a very important role. They act as a corporate reward system with long-term incentives, granting a company's managers the right to purchase a certain number of company shares at a predetermined price during certain periods. Within this set period of share purchasing, even if the market price of shares exceeds that of the grant price, managers may exercise their right to purchase them at the lower price, thus making a profit on the difference between the two prices. Conversely, if the market price drops, they may opt not to exercise their right to purchase shares. This therefore provides a system for companies' managers to have a guaranteed profitable trade in which they cannot lose. In maximizing their own individual interests, the interests of the assignee company are also maximized, thus limiting the company's representation costs and reducing any agency of agreement issues for the company. In this way, this kind of system can encourage managers to work harder and increase the value of the company, as their personal interests are also served.

[15] Equity financing works by expanding a company's equity by attracting new investors, new share offerings and additional investment, rather than transferring equity or selling shares. Selling or transferring shares is a form of assignment and does not increase equity. One consequence of equity financing is that the control wielded by the original investors is diluted.

[16] When social capital (civilian capital) is involved in infrastructure development and public works it is generally known as a Public-Private Partnership (PPP).

[17] Rose, Stephen A. *et al. Corporate Financing,* Vol. 6, p. 329.

Financial Leasing

Internationally, financial leasing [18] is a common form of industrial financing, a means of financing facilities, and an effective way of promoting both investment and consumption demand. For many years, China's financial leasing sector has remained mismanaged and unbalanced. Three kinds of leasing companies have emerged. The first are financial leasing companies overseen by the China Banking Regulatory Commission, the second are joint-venture leasing companies overseen by the Ministry of Commerce (by the end of July 2008, there were already 90 foreign-owned leasing companies), [19] and finally, the third are domestic leasing companies (numbered at more than a thousand), also regulated by the Ministry of Commerce. To different degrees, all of these companies have developed a financial leasing business, including traditional financing, leasing, sub-leasing, sale and lease-back transactions, joint-venture leasing, etc. In developed countries, along with bank credit, securities, trusts and insurance, financial leasing is one of the big five financial tools and has penetrated all aspects of economic life. Seen as a "sunrise industry", it has become the second largest channel of financing for companies after bank credit. Almost one-third of global investment is currently completed with financial leasing, and it has a 30% market penetration. In China, that figure falls far short of developed nations at only 1.3%. These figures clearly show that market potential for financial leasing to become an effective form of financing in China is huge. There are currently many industries in China in which the leasing market is flourishing including telecommunications, medical services and printing, and it is fast developing in the areas of engineering tools, machine-tools, energy conservation, transportation, and shipping. The market functionality of financial leasing is improving day by day and new products are constantly being created.

In the energy efficiency building sector, proprietors and energy service companies have a huge need for equipment. In order to ease the financial difficulties of retrofitting, the financial leasing sector is emerging as a sector with great prospects. The replacement of energy-consuming equipment accounts for a large share of the invested capital in an energy efficiency retrofit of an existing building's energy use system. Using financial leasing to implement a retrofit may be an effective way of reducing costs for the proprietors and promoting the use of new technology. At the CPPCC on March 10, 2008, CPPCC member and Department Head of the Department of Science and Technology of the Ministry of Construction, Lai Ming, called for the "need to innovate a new development model, which promotes energy-saving services". He recommended that the Ministry of Construction and the Banking Regulatory Commission facilitate the development of energy efficiency building services by supporting the

[18] Financial leasing refers to the leasing of equipment of a financial nature and change of ownership rights. Namely, a lessor, according to the specifications, model, and function required by the lessee, leases out equipment to the lessee. During the contractual period, the ownership rights of the equipment still belong to the lessor, while the lessee only has user rights. Once the contract has finished and the rental fee is paid, the lessee has the right to purchase the equipment at scrap value in order to obtain its ownership rights. Financial leasing is a financial service in the insurance industry, which satisfies clients' need to "circulate finance" by "circulating equipment".

[19] Among these, Huazhong International Leasing Ltd. and Rongzhong International Leasing Ltd. were set up in Wuhan in 1985 and 2008 respectively.

investment of large companies in this domain. He also emphasized the need for equipment manufacturers to set up financial leasing companies in order to provide energy-efficient equipment through financial leasing programs. It is evident the financial leasing of energy-efficient equipment will emerge as a new market.

Guarantees

Guarantees[20] serve as leverage that, compared with other forms of policy-based financial support such as discounts, tax exemptions or fund allocations, are able to satisfy greater needs with fewer resources and can help policy-based funds have a greater impact in accelerating economic development. Meanwhile, credit guarantee mechanisms that serve SMEs in making up their credit shortfalls, can resolve financing difficulties and not only bring economic benefits to themselves but also, more importantly, have far-reaching benefits such as expanding employment opportunities, increasing tax revenue, boosting the economy, and stabilizing society. Credit guarantees are already an established and effective means for national governments worldwide to accelerate the growth of SMEs and create employment opportunities.

Establishing a credit guarantee system for SMEs is a common way for countries around the world to help support the growth of SMEs. In general, large banks do not provide ample, or even rudimentary, financial support to SMEs and so credit guarantees become necessary. Because of the Chinese capital markets' long-term focus on supporting large companies, and in order for banks to avoid risk, loans have tended to be granted to large State-owned enterprises (SOEs) and conglomerates. This has created a number of difficulties for financing energy service companies, entities at present generally quite small. A credit guarantees system is therefore one of the keys to helping SMEs finance their growth. International experience shows that even the market economies of developed nations need to provide policy-based credit guarantees for SMEs. While developing nations are in their "catch-up period", the importance of credit guarantees is even more pronounced. Establishing a credit guarantee system for SMEs eases their financing bottlenecks whilst improving their financial strength, it bolsters the power of financial organizations to provide loans to SMEs, and it is also a very important means of optimizing the overall financial environment. Perfecting the credit guarantee system will accelerate the healthy growth of SMEs, help to increase employment opportunities within them, push forward technological innovation, and increase fiscal revenue.

China's first use of credit guarantees for SMEs occurred in 1998. In ten years, the government has introduced a number of policies aimed at supporting the rapid development of guarantee agencies, and by the end of 2007, their number had grown to 3,729. In terms of their character, there are policy-based guarantee agencies, commercial guarantee agencies, and agencies that display a combination of the two. In terms of their organization, there are government-administered institutions, State-owned as well as privately-owned share-holding companies, and various sorts of fund management companies

[20] Guarantees are legal measures that serve as a guarantee for debt. From a Chinese legal perspective, a debt guarantee should be founded on the assets of the person (or party) concerned in order to keep a check on the obligations of the debtor and protect their use of credit. Guarantees generally fall into one of five kinds: bonds, mortgages, pledges, liens, and deposits.

along with corporate mutual guarantee agencies. Most of the capital for China's initial phase of guarantee agencies was provided by the government but non-governmental capital has now grown to account for more than 60%. More and more guarantee agencies are operating under market conditions and commercial management is gradually driving China's guarantee sector away from government-led growth to market-led growth. Experience has shown that the establishment of agencies specialized in SME loan guarantees eases access to finance thereby resolving, in a practical way, the difficulties faced by many SMEs' due to their lack of collateral. Guarantee agencies act as bridges between banks and SMEs.

With the help of the World Bank and the Global Environment Facility (GEF), the China National Investment & Guaranty Co. Ltd. took the lead in providing the first loan guarantees to the energy conservation sector for implementing energy conservation projects using the "contract energy management" mechanism. The Asian Development Bank has, through the Standard Chartered Bank, also provided partial credit guarantees to China, supporting energy efficiency building projects in the south and east of the country. It is easy to see that in step with the rapid development of China's guarantees sector, loan financing obstacles that SMEs in the energy efficiency building sector currently face will gradually be removed.

Tax Remits

Western developed nations place great emphasis on the use of tax incentives in the construction sector. There are many different forms of tax incentives, generally including tax reductions, tax exemptions, export tax rebates, preferential tax rates, tax reimbursements, tax deductions, accelerated depreciation, and tax-deductible expenses.

China has already implemented a series of measures using tax incentives aimed at improving energy savings and emissions cuts. According to the most recently promulgated enterprise income tax law,[21] the earnings of companies involved in environmental protection or energy and water conservation projects that meet the prescribed conditions, are exempt from State tax, and qualify for business income tax deductions. A certain proportion of the money invested by companies to purchase specialized equipment for environmental protection, energy savings and water conservation and work safety, etc. is tax exempt. For energy efficiency techno-

[21] Chapter IV, Article 25 of the *Enterprise Income Tax Law*, promulgated in 2008, stipulates that important industries and projects whose development is supported and encouraged by the State shall enjoy preferential treatment in relation to enterprise income tax. Article 27 stipulates: "As regards the following incomes, the enterprise income tax may be exempted or reduced: (1) The incomes generated from the engagement in agriculture, forestry, husbandry and fishery; (2) The incomes generated from investment in and business operations of the important public infrastructure projects supported by the State; (3) The income generated from the projects of environmental protection, energy and water saving and satisfying the related requirements; (4) The incomes generated from transferring technologies and satisfying the related requirements; and (5) The income as provided for in Paragraph 3, Article 3 of the present Law." Article 28 stipulates: "As regards a small meager-profit enterprise satisfying the prescribed conditions, the enterprise income tax shall be levied at a reduced tax rate of 20%. As regards important high-tech enterprises needing to be supported by the State, the enterprise income tax shall be levied at the reduced tax rate of 15%". Article 32 stipulates: "In case an enterprise needs to accelerate the depreciation of any fixed asset by virtue of technological progress or for any other reason, it may curtail the term of depreciation or adopt a method for accelerated depreciation". Article 34 stipulates: "As regards the amount of an enterprise's investment in purchasing special equipment for protecting the environment, saving energy and water, work safety, etc., the tax amount may be deducted at a certain rate".

logical retrofitting, financial rewards are granted on the basis of how much energy is saved.

Fiscal taxation policies are a government's primary means of managing and regulating energy in a market economy. In the 1980s, China drafted a series of fiscal taxation policies to promote energy efficiency, but almost all of them were abolished in the institutional reform of fiscal taxation begun in 1994. For example, as early as 1981, the State established an energy-efficient technology refurbishment dedicated fund, offering 50% reductions on interest for energy-saving project loans. This fund was abolished in 1998. In the 1980s, energy-saving infrastructure project loans were given preferential interest rates, from 1991-1993 differential interest rates were implemented where energy-saving infrastructure projects were granted 30% lower interest rates than commercial loans. Such differential rates were abolished in 1994. At the beginning of 1991, the State began levying a fixed assets investment orientation regulatory tax, but in sectors such as thermoelectric cogeneration and energy efficiency building the tax rate was zero. Since January 1, 2000, this policy has been suspended.

Overall, except for the budgeted direct fiscal support for research and development and technological refurbishment in energy-saving projects, China lacks alternative policies in its fiscal expenditure. Regarding preferential tax policies, policies towards energy saving, the use of sustainable resources and environmental protection are all mixed up together. Specific tax exemptions and deductions for energy efficiency retrofit companies are necessary. The lack of government tax incentives is the main obstacle to China's energy efficiency movement. Today, the conservation of natural resources has finally been integrated into China's fiscal taxation reform, and the government is actively seeking to develop tax incentives that would suit China's current situation as well as further new mechanisms to promote energy conservation. Among these, electrical power demand management, energy service companies, and energy efficiency standards have already demonstrated impressive progress. The government's investment has already begun and some regional governments are also trying out new mechanisms for energy conservation such as energy efficiency non-profit foundations. Since 1998, through international cooperation, almost all energy efficiency mechanisms have been brought to China. Some incentive policies have been highly successful in experimental projects such as guaranteed loans for energy efficiency projects, energy efficiency information services and consumer subsidies.

The Ministry of Finance is currently studying relevant fiscal taxation policies including formulating a "Directory of Energy-Efficient and Emissions Reducing Equipment Qualifying for VAT and Income Tax Deductions". Companies that purchase equipment listed in the directory would be entitled to VAT reimbursements. Studies are also being conducted with a view to formulating a policy of VAT reimbursement on the purchase of electric and thermal power produced from waste such as agricultural straw, bark residue and sludge, and another for the use of bio-diesel made from used animal and vegetable oil, as well as one relating to energy-saving lighting. Studies into extending the incidence of tax on heavily polluting products and resource-wasting products are also underway. The opportunity is here for a plan to reform resource tax, and to levy environment and fuel taxes.

In terms of the building energy efficiency retrofit market, the effect of preferential tax policy is primarily demonstrated in the following two areas: in encouraging homeowners to undertake energy efficiency retrofitting through the use of tax deductions, exemptions, and tax credits; in cultivating the energy efficiency services market, thus promoting the growth of energy service companies in China. A concrete analysis follows:

• Tax Credit: 10% of the total amount invested in specialized equipment for use in energy efficiency retrofitting (as set out in the "Directory of Specialized Equipment for Environmental Protection Qualifying for Preferential Enterprise Income Tax" or the "Directory of Specialized Equipment for Energy and Water Conservation Qualifying for Preferential Enterprise Income Tax") can be offset against taxes due by the company that year or over the next 5 years if necessary.

• Tax Deductions: Buyers who have purchased energy-efficient buildings may receive a deduction on their property tax after it has been collected. According to Articles 25,[22] 27,[23] and 28,[24] of Chapter IV of the *Enterprise Income Tax Law*, promulgated in 2008, energy service companies should qualify to receive key support for their development from the State,[25] and as such all projects working towards environmental protection and energy saving should benefit from preferential income tax policies; for companies engaged in the energy efficiency retrofit of existing buildings, starting from the end of the first year in which the project has made an operating income, for the first three years they will be exempt from enterprise income tax. Between the 4th and 6th years they will be exempt from half of the enterprise income taxes levied. ESCO certified high-tech companies[26] will benefit from a 15% deduction in the enterprise income tax rate; those engaged

[22] "Important industries and projects whose development is supported and encouraged by the State shall enjoy preferential treatments in enterprise income tax."

[23] "As regards the following incomes, the enterprise income tax may be exempted or reduced: (1) The incomes generated from the engagement in agriculture, forestry, husbandry and fishery; (2) The incomes generated from investment in and business operations of the important public infrastructure projects supported by the State; (3) The income generated from the projects of environmental protection, energy and water saving and satisfying the related requirements; (4) The incomes generated from transferring technologies and satisfying the related requirements; and (5) The income as provided for in Paragraph 3, Article 3 of the present Law."

[24] "As regards a small meager-profit enterprise satisfying the prescribed conditions, the enterprise income tax shall be levied at a reduced tax rate of 20%. As regards important high-tech enterprises needing to be supported by the State, the enterprise income tax shall be levied at the reduced tax rate of 15%."

[25] *The Management Regulations on Civilian Energy-Efficient Buildings*, enacted on January 1, 2006, clearly stated the Ministry of Construction's intent to promote growth of energy-efficient building technology and products, respectively: new forms of energy-efficient walls and roof insulation technology and materials; airtight technology for insulating doors and windows; central heating and joint thermal, electric and cooling technology; heat regulation for heating systems and individual household thermostat technology and installations; technology and equipment harnessing renewable energies such as solar power and terrestrial heat; energy-saving lighting technology and products; energy-saving air-conditioning technology and products; the eight main high-tech industries.

[26] The "Guidelines for the Administration of the Recognition of Hi-tech Enterprises", released by the Ministry of Science and Technology, Ministry of Finance, and State Administration of Taxation, stipulate that the eight main high-tech industries that conform to regulations will enjoy preferential taxation. The eight key State-supported high-tech industries are as follows: electronic information technology, biological and new medicinal technology, aeronautics technology, new materials technology, technological service sector, new energies and energy-saving technology, resources and environmental technology, and high-tech renovation of traditional industries. These guidelines came into force on January 1, 2008.

in energy efficiency retrofitting that have achieved a certain standard in energy use in construction qualify for housing tax deductions and land use taxes; deed tax may be annulled in the event of relevant transactions.

• Identification of Taxes Due: The current tax system has put an excessive tax burden on energy service companies. When energy service companies provide services in the market they are benefiting the whole of society by choosing to install energy-efficient equipment for their clients. Nevertheless, China's State Administration of Taxation has always viewed energy service companies as normal retailers of energy-efficient equipment, considering that the ESCOs profit by selling the equipment and viewing the energy efficiency contracts as mere equipment sales agreements. This has meant that the Administration of Taxation has applied standard VAT regulations as if they were standard retailers of energy-efficient equipment and therefore charged VAT instead of the lower service tax, thus creating a tax burden.

Energy service companies' main operational revenue comes as a share of their clients' gains from energy savings, not through the manufacturing or selling of energy-efficient equipment. As such, these companies firmly believe that they should be viewed as a service industry, not as a manufacturer or retailer and therefore should not have to add VAT to their service fees.[27]

• Fixed Assets Investment Orientation Regulatory Tax: China previously had regulations including "a fixed asset investment orientation regulatory tax rate of zero for energy-efficient housing, or 5% for non energy-saving housing", but this was suspended on January 1, 2001. The government has yet to establish any new economic incentive policies for energy efficiency building, meaning that there is no longer any economic policy control over energy conservation in construction. As constructors of high-energy-consumption buildings are not penalized through restrictive taxes, this is detrimental to the green building movement. It would be advisable for the government to revert to its "Fixed Asset Investment Orientation Regulatory Tax" or rename it "Building Energy Use Tax", providing a zero tax rate for energy-efficient construction;

• Accelerate Depreciation: Any enterprise undergoing energy efficiency technological retrofitting may curtail the term of depreciation of energy-wasting equipment, or adopt a method for accelerated depreciation;

• Levy Energy Tax: It is recommended that energy tax (environment tax) and fuel tax be levied as soon as possible.

Energy Efficiency Retrofitting Capital Return: Learning from the Ukrainian PICO Model

Public Internal Performance Commitment (PICO) is a common form of funding the energy efficiency retrofit of public buildings abroad. It operates in the following manner. A specialized department in public administration (that is, for instance, the Department of the Environment) is made responsible for the overall plan, cost calculation and implementation of the PICO scheme. This department carries out energy efficiency evaluations, and economic and technological analyses of other governmental departments

[27] According to regulations: "Any company or individual selling goods or providing processing, repair or replacement services or importing goods within the borders of the People's Republic of China is deemed a taxpayer of VAT".

(pictured as client departments), and signs them up for PICO agreements. Ultimately, the Department of the Environment is responsible for all energy efficiency retrofitting of its client departments. Subsequently, the Department of the Environment may use its own workers or external contractors, including ESCOs, to complete the energy efficiency retrofit for their client departments. During the refurbishment process, the Department of the Environment may use its own expertise to provide technological assistance and supervision of the work. Capital for such projects is sourced from revolving funds (initial investments for revolving funds may be from governments' fiscal budgets, international aid loans or social finance). Energy efficiency retrofitting brings about a decrease in energy consumption and costs for client department buildings and thus a reduction of governmental expenditure and use of annual budgets. This saving can then be reinvested in the revolving fund, providing capital for the energy efficiency retrofit of the next client department and so on, allowing for a single initial investment to reap benefits multiple times.

For PICO schemes to be feasible, the following conditions must be present: (i) government policy support–political support primarily lies in granting a specific department the right to manage energy efficiency retrofitting of government office buildings and in putting pressure on client departments to carry out energy efficiency retrofitting; (ii) the presence of a technical department, such as the Department of the Environment in the diagram – this department is at the heart of any PICO funding scheme and its role includes pre-refurbishment economic and technological evaluations, signing PICO contracts with client departments, being responsible for the renovation work (even including signing contracts with ESCOs), and supervising the evaluation of post-refurbishment results; and (iii) the implementation of fiscal policies – namely that in each government department's budget there is an independent energy-use category, allowing for all energy savings to be transferred into the revolving fund.

The implementation of PICO schemes in the current Chinese system is faced with the following obstacles:

(i) A lack of specialized departments – relevant departments that are currently charged with the energy efficiency retrofit of existing buildings in China are extremely limited. In Wuhan Municipality for example, such work is the responsibility of the Energy-Saving Office under the Wuhan City Construction Committee. The Energy-Saving Office is a second-tier unit of the Wuhan City Construction Committee and therefore it would have difficulty in taking on the role of the specialized department in a PICO scheme either in terms of its administrative category or technical know-how.

Recommendation: A principal department of provincial governments should take on the responsibility for such schemes.

(ii) Budgetary constraints – currently energy saving is not yet an independent item on government budgets, with daily energy consumption being accounted for by operating costs such as electricity and heating. Investment in refurbishment equipment can be counted as broader renovation costs such as maintenance (repair) costs and leasing fees. Government office buildings have, for a long time, adopted the "claim for what you spent"

payment system, meaning that it has been the finance departments who have paid energy providers directly for the energy costs of each respective work unit. Under such a system, there is little motivation for independent work units to be energy efficient and the savings from an energy efficiency retrofit are also not easily transferable directly to revolving funds.

Recommendations: (i) introduce incentives and penalties to motivate departments to carry out energy efficiency retrofits so that energy efficiency can become part of regular departmental checks; and (ii) energy savings should be made an independent item on budgets, specifically drawing on the method used in the "establishment of small- and medium-sized enterprise item on municipal fiscal budgets" from the "Method of Wuhan Municipal to Implement the *Law of the Peoples Republic of China on Promotion of Small and Medium-sized Enterprises* (Draft)".

4.7.3. Financial Mechanisms for Energy Efficiency Retrofitting of Existing Buildings in Hubei Province

Macro Strategies

Fostering Building Management Principles, Overall Planning Debt Financing, Third-Party Financing and Equity Financing

According to the basic laws of economics, resources that are able to bring economic gain to the concerned party in the future are called assets. Analyzing it from this perspective, buildings are hugely valuable assets. An energy efficiency retrofit can not only bring continual future savings on energy costs to the proprietor or resident of the building, it can also serve wider society in reducing energy consumption and improving the quality of the environment. Consequently, buildings are assets that are able to bring about very valuable capital inflows to interested parties.

The process of energy efficiency building must be guided by management principles for it to be able to realize its optimum value. One of the most important characteristics of assets is that only through their effective management can their value be optimized, and buildings are no exception to this. The business of construction should be oriented to the market, so that buildings are seen as assets capable of bringing added value. Sustainable growth in value can be achieved through continual labor, material and financial investments, and by using cutting-edge technology and management tools to tap the latent potential of a building's physical characteristics (fundamentally different to the concept of managing real estate). The core of building management is making a building's assets stand out, while at the same time emphasizing the operation of market mechanisms, concentrating on efficiency and placing effectiveness on top. Fostering principles of energy efficiency in building management should work on two levels: first, the characteristics of a building's assets must be identified and understood; and second, we should harness the motivating forces of key market bodies and use price signals to guide and optimize allocation and rational use of resources, in order to achieve value growth and value maximization.

In terms of financing, good management means choosing the best financing strategy that can play to the strengths of both debt and equity financing. With an ideal synthesis of both financing tools in place, risks will be as small as possible and financial costs at a minimum, resulting in maximum profits.

Designing Financing Mechanisms

Designing financing mechanisms for retrofitting projects in terms of their financial sources and uses complies with the principles of building management and can maximize a project's effectiveness. As such, financial mechanism design involves debt financing, third-party financing, equity financing, and subsidized financing.

Debt Financing

- Definition:

Debt financing is one of the primary forms of externally sourced financing. Primarily, it involves one of commercial credit, deposits, guaranties or pledges to the external creditor in order for them to lend the required capital;

- Strengths:

The Effectiveness of Interest Tax Credit: The greatest strength of debt over equity is that it may result in preferential taxation for the company as interest on debt can be deducted from pre-tax profits, meaning a reduction of the income tax due and hence an increase in value of the company. China's "Provisional Regulations on Enterprise Income Tax" also clearly stipulate, "Interest that a taxpayer pays to a banking institution on a loan he has borrowed during the term of production or business operation, shall be deducted by the actual amount". Once the interest rate on debt and the rate of income tax have been established, the more corporate debt grows, the more effective interest tax credit becomes;

The Effectiveness of Financial Levers: Because creditors are only able to receive a fixed amount of interest, with any surplus profits going to shareholders, increasing the profit of each share is effective financial leverage on debt. However, one must retain that financial leverage is only effective after-tax because profit from both debt capital and equity capital is all liable for enterprise income tax. When the interest rate on debt and the rate of income tax have already been fixed, and the debt is of an appropriate scale and corresponding level of taxation, the higher the profitability of debt capital, the greater the effectiveness of financial leverage. When this profitability is equal to the interest rate on debt, financial leverage will be zero, and when it is less that the interest rate financial leverage will be negative. Whether or not an enterprise is able to benefit from the effect of financial leverage depends upon the correlation between the profitability of debt capital and the interest rate on the debt.

Controlling rights are not reduced – owners retain fairly strong controlling rights over their enterprises.

- Drawbacks:

Sustained growth of debts will eventually cause a crisis of financial capital. Debt puts more pressure on companies because the payment of this money and interest is a contractual obligation that the company must bear. If the company has no way of making its repayments, it may face financial crisis. This may increase the company's costs and reduce its cash-flow.
Satisfying certain credit requirements. Creditors pay close attention to debtors' credit situation and failing to meet creditors' minimum requirements makes it very difficult to obtain capital.
Satisfying profit demands. The cash-flow or profitability of a project must meet debtors' demands;

- When to use Debt Financing and Existing Problems:

From the perspective of financing bodies, proprietors and energy service companies are

the most suited to adopting a debt financing strategy for the energy efficiency retrofit of existing buildings.

Debt Financing by Building Proprietors

- Almost no residential buildings;
- Public buildings: Only very few managed public buildings such as guest-houses and hotels are forced through outlay pressures to carry out an energy efficiency retrofit, which they may finance through debt.

Debt Financing by Energy Service Companies (also known as third-party debt financing)

Based on the research groups' findings, energy service companies in Hubei Province are not only few in number (about ten), but their projects are also extremely limited in scale. In a credit environment with such adverse conditions where ESCOs cannot meet the threshold per project for external lending, access to financing is virtually impossible.

- Designing Paths to Debt Financing:

Due to the fact that the energy efficiency building market is not yet streamlined, the initial stages of energy efficiency building are under the proactive guidance of the government. To establish a financing platform, debt financing is the financing method of first choice. In order to take full advantage of the superior leverage of debt financing, a few workable models have been chosen such as dedicated funds, financial investment platforms and energy efficiency building project management offices. By injecting cash flow into energy efficiency building, idle funds on the market will be attracted towards the energy efficiency building market, spurring demand for its services and kick-starting the growth of the energy efficiency building industry.

Equity Financing

Equity financing is an exchange of money for a share of ownership. Equity financing shares the rights to profits of a company with its investors, encouraging them to take on respective risks and management responsibilities. Investors share company profits through bonuses. In one respect, Wuhan City is in the middle of establishing a two-oriented society, providing it with an opportunity to embark on bold new developmental initiatives, innovative system mechanisms, whilst promoting economic and social scientific and harmonious development. On the other hand, energy efficiency building is a concrete manifestation and support of the idea at the heart of the construction of a two-oriented society. It should stress the development of the energy service sector which has so many potential economic, environmental and social benefits. The research group believes that Hubei Province (Wuhan City) can play to its favorable status across the whole industrial chain. It can establish quite strong degrees of association between energy efficiency retrofit engineering of existing buildings and industrial links up and down the chain, for example specialized energy service companies, energy-efficient new materials, new products, and new technology companies based upon specialized work, with operational costs at the center, releasing the power of equity financing.

- Definition:

Equity financing is an exchange of money for a share of ownership. Equity financing shares the rights to profits of a company with its investors, encouraging them to take on respective risks and management responsibilities. Investors share company profits through bonuses.

• Strengths of Equity Financing:

First, capital raised through equity financing is permanent, without an expiration date and with no repayment requirements. Project capital is the minimum requirement for a project to guarantee capital and is the fundamental prerequisite to sustain a project's long-term steady growth.

Second, there is no pressure to make fixed repayments with deadlines. Whether dividends are paid out, and at what price, is determined on the basis of actual operational results and so the financial burden and financing risks of the project are relatively small.

Third, it is at the basis of debt financing. Equity financing is the most fundamental resource of capital for a project. It is a sign of the strength of the project and the basis for other means of financing, especially in providing creditors with a guarantee and strengthening the company's debt-raising capacity.

• Drawbacks of Equity Financing:

First, fund-raising costs are quite high. Fund-raising costs are higher than for debt financing.

Second, controlling rights are diluted. Many investors hold equity in the company thereby acquiring the right to share the company's operating profits. The more investors a company has, the less control each investor has over the company, which equally weakens the influence of corporate decisions.

Overall, equity financing has come out of the establishment of energy efficiency building industry links. Based on Hubei Province's comparative advantage in training personnel, transport, advanced manufacturing, and concentration of scientific research institutions, advantage has been taken of the "construction of a 'Two-Oriented Society' in the Wuhan City Cluster" to create an energy efficiency building industry supply chain. As conditions have continually matured, the industry supply chain has gradually broadened, unleashing fully the potential of equity financing and turning around the development of the energy efficiency retrofit of existing buildings sector into a real engine of economic growth.

The industry supply chain currently includes upstream enterprises (energy-efficient materials, energy conservation scientific research), midstream enterprises (energy-efficient products, the manufacture of energy-efficient equipment), and downstream enterprises (which include ESCOs, specialized intermediary organizations, etc.). Playing the important role of linking these together are logistics and storage industries, etc.

Subsidized Financing

Guided by management principles, investors use their initiative, when circumstances allow, to choose external or internal sources of financing to subsidize debt and equity financing.

• Sustainable Financing Systems:

- Government-Led Financing Mechanisms:

Establishing an "energy efficiency building revolving fund" initially serving to repay collective capital and subsequently to expand rolling growth.

First, establish a fund. Through various uses of such funds, generate effective energy savings with minimal energy consumption. Second, effective use of the fund can push forward the development of energy conservation work, in particular the development of energy-efficient and renewable energy technology. Third, the use of funds has proven that developing the energy efficiency retrofit of existing buildings can effectively engender

industrialization of the energy efficiency sector. For example, in the Picardy Region of France, in order to encourage local residents to carry out energy efficiency retrofits, the Regional Government, the EU, and the Environment and Energy Agency jointly established a fund. The Regional Government then signed a cooperative agreement with three banks, Banque Solfea, Domo Finance and Banque Populaire for them to provide loans to residents to carry out residential energy efficiency retrofitting. The fund subsidized the interest on the bank loans so the proprietors only had to repay the capital, not the interest. Since this incentive package has been implemented, huge numbers of residents have applied for loans to carry out energy efficiency retrofitting on their homes, which has led to real growth in this sector. Many companies specializing in design, construction and supervisory work, and material retailers have since come to Picardy, bringing new sources of tax for the local government. The regional government has taken full advantage of these incentives to spur on industrial growth in the area. To encourage the use of solar power, subsidies have been granted for the installation of solar powered water heaters (€230 per m^2), the objective being to expand the integration of solar-powered water heating into buildings. The economic benefits of industrialized growth are evident.

In the usual developmental path, first the funds are created primarily to repay the initial capital and provide dedicated capital. In this way, the market for the energy efficiency retrofit of existing buildings is effectively started by way of subsidies, interest deductions, rewards and guarantees. This brings with it wider-spread social capital invested in the energy conservation sector, developing into the second phase. The funds should now enjoy independent accountability, and through operational management of assets, payback on energy efficiency improvements will continually strengthen the fund and ultimately lead to further industrial growth.

Establishing energy efficiency retrofit project management agencies to carry out the leading role of the government in the overall management of projects.

Under the authority and supervision of a functional government department, energy efficiency retrofit project management agencies are specialized agencies that undertake the responsibility of independently managing energy efficiency retrofit of existing building projects. Their primary responsibilities are: overall project planning, control and supervision, and the raising of batch funds. In general, when dedicated funds have been newly established, an energy efficiency retrofit project management agency can first be set up, the agency then has overall management within certain boundaries, drawing in policy loans or funds that already exist internationally for energy conservation and emissions reduction. Once the dedicated fund has been set up, the agency can become the fund's (or dedicated fund's) coordinated management organ. Based on experience in China, project management agencies that carry out such a role have been quite successful.

Building a "Financing Platform for Energy Conservation and Emissions Reduction", substantiating operations: a gradual transition to market-led business.

As the energy efficiency building retrofit sector is so diverse, when funds move into their second phase of operation, it is possible

that the project offices acting as functional government departments will no longer be able to meet the demands of large-scale energy efficiency retrofit projects, and that therefore they will need to build a platform for financing, meaning substantiating their business operation.

Building up a platform for financing should be planned in accordance with modern enterprise principles and suited to the growth of the production chain. It could be established on the group enterprise model,[28] made up of a State-owned assets management limited company, a technology service limited company, and a logistics service limited company. According to Article 12 of the *Provisional Administrative Regulations on the Registration of Enterprise Groups*, the parent company of enterprise groups must be approved by the State Council or the Provincial Government in order to become an authorized investment institution of the State or provincial government, or an exclusively State-owned enterprise. Therefore, Hubei Provincial Government could support the "project office" in establishing a State-owned assets management limited company, as the parent company, and a technology service limited company and a logistics service limited company as subsidiary companies linked by capital, forming an enterprise group that incorporates a non-profit operating fund with a market-oriented space for profit. This would bring about growth in the energy conservation/emissions reductions production chain, driving internal demand, boosting employment and ultimately help reach the economic, social and ecological targets of energy conservation and emissions reductions.

Setting up State-Owned Assets Management Limited Companies: It can be an investment holdings company that, by making use of policies and using debt and equity financing, can enlarge and strengthen its assets, increase its interests investment, management and operational capacities, standardize corporate organizational systems, financial investment systems and project supervision processes. The energy conservation/emissions reduction sector will accumulate a wealth of industrial investment experience from such work.

Establishing a Technology Service Company: A technology service company, established through investment holdings of the State-owned assets management limited company, while responding to market needs, should open up the technology service sector. This should involve dominating the market and leading technological service standards in energy evaluations, refurbishment project design, information, energy construction and supervision work.

Establishing a Logistics Service Company: The growth of energy-saving work will offer huge commercial opportunities in the distribution of energy-efficient material. Wuhan City has an advantageous geographical position – human resources and also logistics and communication networks converge here. A logistics service company set up by a State-owned assets management limited

[28] *The Provisional Administrative Regulations on the Registration of Enterprise Groups,* defines an enterprise group as a joint entity of enterprise legal persons that has a definite size; regards the parent and its subsidiary companies, which are primarily linked by capital, as the principal body; takes the group articles of association as standards for joint activities; and is constituted by a parent company, subsidiary companies, mutual shareholding companies and other member enterprises or institutions. An enterprise group does not have enterprise legal person status.

company could meet market demands and bring about and standardize a healthy, ordered development of the energy-saving products logistics industry.

- Market-Led Financing Mechanisms:

Phase one, angel investors get involved. Angel investors are well-educated individuals with high incomes and substantial wealth, substantial business success and particular interest in the initial stages of an enterprise. They are able to invest their own personal capital directly in the newly-founded business. Angel investors are very valuable because they are willing to embark upon relatively small investments. The threshold for entering such a company is quite low. This is one of the main forms of private capital involvement.

Phase two, attract venture capital. Venture capital is capital from venture investment companies who invest in newly-founded enterprises as well as small companies with exceptional growth potential. The benefits of attracting venture capital financing are: (1) venture investment capital is generally greater than that of angel investors, and (2) venture capitalists are very well-connected in the business world and can provide a great deal of help besides their investment, such as valuable business strategy advice. Drawbacks: the venture investment industry expects high returns; venture capitalists' investments are subjective and extremely narrow. Venture capitalists are cautious and they tend to focus on a very small portion of innovative growing companies.

Phase three, initial public offering (IPO). Another source of equity financing is selling shares to the public through an initial public offering. Despite there being many benefits to a company being listed, it is also a very complex and costly process. While being able to raise a huge amount of capital, the company must also undergo public scrutiny.

To conclude, the first two phases require strong government support and impetus, whilst the third phase is primarily dependent on the support of market forces. In accordance with the rules of market investment, this can generate strong growth.

- Coupling-Up the Two Mechanisms:

On the back of powerful government impetus for energy efficiency retrofitting of existing buildings, healthy market growth has established and extended the energy service industry supply chain, driving the market and supply chain to initiate a self-developing, self-improving cycle.

Government intervention should initially play a leading role to boost the market, before switching to providing the complementary services needed by a mature energy efficiency of existing buildings market and industry, allowing the two to work in harmony with one another.

4.8. Focus: Constructing Models of a Financial Service System for Energy Efficiency Building in China

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China Architecture Design and Research Group,
China Building Design Consultants Corporation, Beijing

4.8.1. Introduction

Energy conservation and emission reduction have become focal points of the international community due to increasingly serious environmental pollution and shortages of resources and energy. A certain amount of success has already come from the nationwide development of energy efficiency building as part of the overall implementation of the scientific outlook on development, the spirit of which is exemplified in documents such as *The Energy Conservation Law of the People's Republic of China, The Renewable Energy Law of the People's Republic of China, Regulations on Energy Conservation of Civil Buildings, as well as the Decision of the State Council on Strengthening Energy-conservation Work (N°.28 [2006] of the State Council), Opinions of the State Council Concerning Accelerating the Development of the Service Sector (N°.7 [2007] of the State Council), and the Notice of the State Council on Printing and Distributing Arrangements for Energy Conservation and Emission Reductions.* But in contrast to such success is the underdeveloped state of the construction of a financial service system for energy efficiency building, resulting in many obstacles to project development. The shortages in financial capital for energy efficiency building and insufficient guarantees make achieving set targets in energy efficiency building particularly challenging. Consequently, bolstering construction of a financial service system for energy efficiency building has become a key element in promoting the sector's development. In today's turbulent international financial market, instabilities in the international economic environment have markedly increased. At the Executive Meeting of the State Council that opened on October 17, 2008, Premier Wen Jiabao made it clear that in light of the current economic situation, the following measures should be taken: work in energy conservation and emissions reduction should be advanced; investment in the energy sector should be increased; the guarantee system for SMEs should be improved; and financial institutions should be encouraged to

grant more loans to SMEs. At the Executive Meeting of the State Council that opened on December 3, policies aimed at encouraging economic growth with finance, such as insurance companies investing in infrastructure and energy by means of equity, or the creation of new means of financing, were once again highlighted. *Several Opinions of the General Office of the State Council on Providing Financial Support for Economic Development* (N°. 126 [2008] of the State Council), released on December 13, articulated further the creation of new means of financing and the expansion of corporate financing channels, providing an excellent opportunity to develop the financial service system for energy efficiency building. Consequently, this study is aimed at designing a financial service system for energy efficiency building. By strengthening government leadership and supervision, and effectively using price, tariff, taxation, fiscal, and banking levers, a healthy market mechanism of financial services for energy efficiency building could be established. This would unlock the internal dynamism of financial services to drive growth in energy efficiency building itself.

4.8.2. Factor Analysis of Domestic and International Financial Service Systems for Energy Efficiency Building

A financial service system for energy efficiency building refers to an organizational system in which both the suppliers and demanders of funds for energy efficiency building use financial instruments to finance all kinds of energy conservation. It is a constituent part of the social finance system that, established through modern communication facilities, combines the financial instrument system, and complementary systems related to financing activity. A factor analysis looks at characteristics of financial systems in China and abroad in terms of their organizations, financial instruments, and complementary systems.

Organizations

Organizations of financial service systems for energy efficiency building include any form of entity that is involved with financing the energy efficiency building market. On one side there are the suppliers of funds, providing and granting loans to those in need of funds for energy efficiency building, or purchasing securities and other financial instruments issued by energy service companies; on the other, there are demanders of funds for carrying out energy efficiency building. Of these, depending on the various channels of financing, financial organizations of energy efficiency building primarily include: banking institutions, non-bank financial institutions and governments. Banking institutions' main form of financing is by providing more bank credit to energy service companies and individuals. Non-banking financial institutions mainly finance energy service companies and individuals through share offerings, bonds, investment trust funds and other financial instruments. Governments play a dual role in the financial system for energy efficiency building. On the one hand, the government is there as a supplier of funds, on the other, it functions as a regulator of the financial service system. The government's role as regulator is seen in their macroeconomic and political control of the energy efficiency building financial market, their support through government interest subsidies, etc., and their use of government credit to provide guarantees for secured loan organizations and ensure the growth of the secured loan and securities markets.

Governments took on a leading role in the initial development of the financial service system for energy efficiency building abroad. Through the formulation of relevant laws and regulations, dedicated funds for energy efficiency building were set up and administered and financed by energy efficiency building financial service organizations. In 21 states of the USA, for example, there were previously no non-profit foundations for energy efficiency. Funds for foundations were hence raised by increasing the cost of electricity by 2% to 3%. Public service commissions in each state are responsible for their administration. Japan has also set up energy efficiency foundations, granting specialized organizations the responsibility of raising, administering and allocating the funds. The UK's energy efficiency building foundation provides between £2-3 million a year in subsidies for residents to buy energy-saving gas-fired boilers. Following the growth in energy efficiency building, a number of commercial banks and development banks such as Poland's Gospodarstwa Krajowego Bank (BGK), KfW and the International Bank for Reconstruction and Development (IBRD) have become important suppliers of funds.

In China, the central government has set up a "Dedicated Fund for Renewable Energy Buildings", a "Dedicated Fund for Energy Efficiency in State Organ Office Buildings and Large Public Buildings", and a "Reward Fund for Energy Efficiency Retrofitting and Heat Metering of Existing Residential Buildings in Heated Northern Areas", but their support for them is limited to demonstration projects. The China Development Bank has set up a "Special-Purpose Loan for Energy Conservation and Emissions Reduction", and commercial banks have set up variously named new energy funds, but they are yet to be drawn upon for any concrete projects. It can thus be seen that organizations for the financial service system for energy efficiency building in China have yet to mature fully.

Financial Instruments

There are very few financial instruments specifically designed for financial service systems for energy efficiency building. However, well-developed financial instruments already on the market can also be used. One kind are those common to all financial systems, such as shares, securities, notes, working capital loans, trust loans, and loans by consignment. Another kind are specific to the real estate financial system, such as mortgages, real estate project bonds, real estate investment trust funds, foreign real estate financing, and housing mortgage obligated securities.

The first steps in creating a system of financial instruments that combines governmental and market-oriented practices have already been taken in the drive to develop energy efficiency building abroad. A number of methods have been drawn upon, including fiscal support, bank loans, mortgages, and asset securitization, but the vast majority have combined complementary financial instruments used in housing construction development. For example, the USA introduced economic policy incentives, including cash subsidies and tax exemptions, and gradually increased the fiscal budget for energy efficiency building, which was accompanied by market-based funding support, including low-interest loans and energy contract management. The Swedish government introduced financing for energy efficiency housing construction, providing long-term, low-interest or subsidized-interest loans for housing construction capital. Poland put into practice a complete set of financial measures for energy efficiency building, including the first 20% of

energy efficiency retrofitting being assumed by the homeowner, with the remaining 80% being covered by a bank loan from BGK, who manages State construction funds.

At present there is only one kind of financial instrument available to China's financial market for energy efficiency building. It must rely upon fiscal and economic policy incentives at every governmental level. This means beneficiaries are relatively few and the level of support quite limited, resulting in slow growth in the energy efficiency building sector. Consequently, financial instruments must be designed that are specifically adapted to the financial service system for energy efficiency building in China.

Complementary Systems

Putting in place financial systems requires the support of other related complementary systems including energy efficiency building laws and regulations, technical standards, macro regulatory and supervisory measures by the government, intermediary service providers such as energy efficiency building evaluation organs, guarantee agencies and credit rating bodies, etc.

Foreign governments have formulated policy measures that standardize the energy efficiency building market in terms of both legal and technical norms. The USA has, for example, enacted the Energy Policy and Conservation Act of 1975, the Federal Energy Policy Act of 1992, the Energy Policy Act of 2005, and set up the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. Japan has instituted an Act of the Rational Use of Energy, as well as the Comprehensive Assessment System for Built Environment Efficiency (CASBEE). The UK, for their part, established the world's first green building standard, BREEAM.

China has, more or less, already established the legal framework for the field of energy efficiency building with the enactment of The Energy Conservation Law of the People's Republic of China, The Renewable Energy Law of the People's Republic of China, Regulations on Energy Conservation of Civil Buildings, and the Regulations on Energy Conservation of Public Institutions. Initial steps have been taken to create a system of technical standards for energy efficiency building through the formulation of technical standard guidelines covering each respective climatic region, a bulletin on energy efficiency information, and measures for green building evaluations. Economic policy incentives have also been drawn up for demonstration projects in energy efficiency building. Having said this, these kinds of complementary policies still lack cohesion and their effect on the financial service system for energy efficiency building is yet to be felt.

From a comparative factor analysis of financial service systems in China and abroad, it has become clear that such a system has yet to be properly established in China. Despite a relatively high market demand for capital, the corresponding supply guarantees have not materialized. Consequently, it is of immediate urgency that the internal links in demanders of funds are clarified, and that models for the construction of a financial service system for energy efficiency building are reorganized.

4.8.3. Links and Categories of Demanders of Funds

Feature Analysis of Demanders of Funds

An analysis of the needs and degree of satisfaction of various demanders of funds on the energy efficiency building market in China has been conducted.

It looked at their motivation for seeking funds, their project content, the amount of capital involved, their ability to repay loans, and the corresponding risk, focusing on both macro and micro characteristics. It divided them into three levels: governmental, corporate and individual. Detailed results can be seen in Table 50.

Table 50 *Level, Motivational and Featured Analysis of Demanders of Funds on the Chinese Energy Efficiency Building Market*

Level and Nature of the Demander of Funds		Reason for Demand	Features of Demand	Extent to which Demand Has Been Met
Government Level	Central Government	Public Supervision of Energy Efficiency Building	Emphasis on Macro Planning, Small Amounts, Repayments Unnecessary	Partly Met
	Local Government	Coordinate the Public Supervision of Energy Efficiency Building	Comprehensive Local Supervision, Relatively Small Amounts, Repayments Unnecessary	Slightly Met
Corporate Level	Property Developers	Energy Efficiency Building Project Development, Implementation	Relatively High Demand for Capital, Quite Strong Repayment Capacity, Quite High Risk	Slightly Met
	Equipment Producers	Production of Equipment for Energy Efficiency Building	Relatively High Demand for Capital, Quite Strong Repayment Capacity, Medium Risk	Unmet
	Energy Efficiency Building Service Companies	Providing Services for Energy Efficiency Building	High Demand for Capital, Strong Repayment Capacity, Medium Risk	Unmet
	Owners of Public Buildings	Carrying Out Energy Efficiency Retrofits of Public Buildings	Relatively High Demand for Capital, Quite Strong Repayment Capacity, Quite High Risk	Unmet
	Property Rights Holding Units	Energy Efficiency New-Builds or Energy Efficiency Retrofitting	Relatively Low Demand for Capital, Quite Strong Repayment Capacity, Quite Low Risk	Unmet
Individual Level	Residents	New-Build Energy Efficiency or Energy Efficiency Retrofitting	Relatively Low Demand for Capital, Quite Strong Repayment Capacity, Quite Low Risk	Unmet

Source: Author.

From the above analysis, the demand for funds on the energy efficiency building market in China can be said to have the following features:

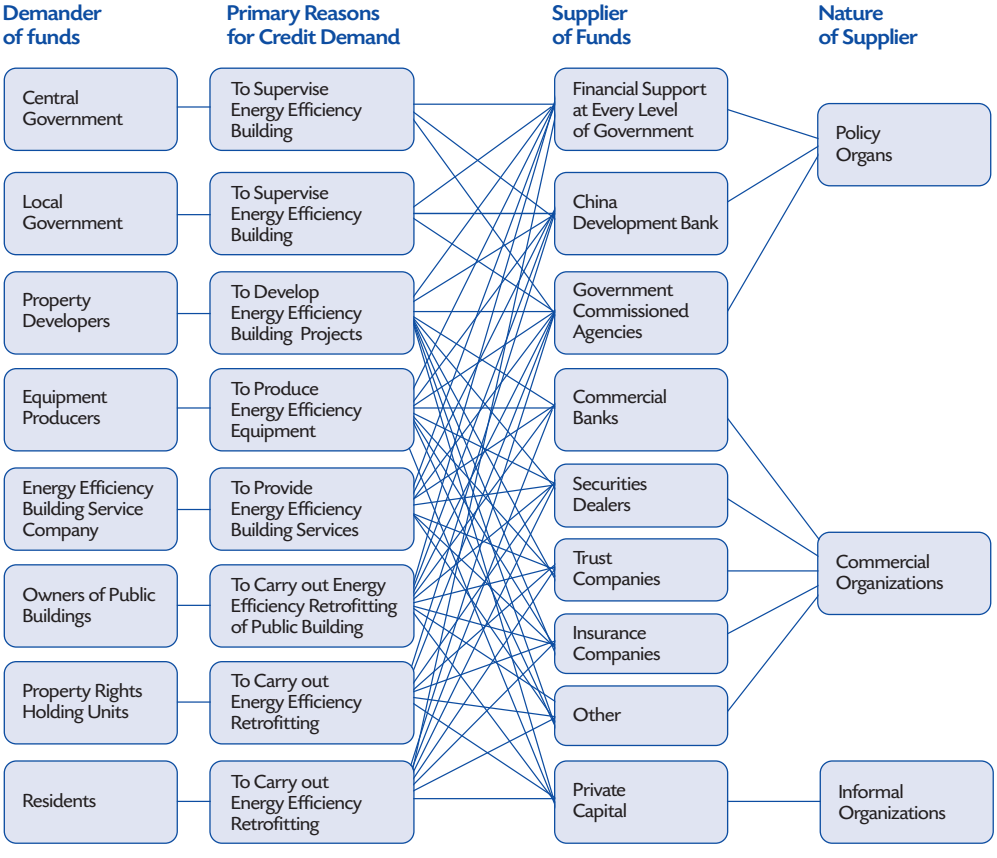
There is a big demand for funding, on many levels. Any party related to housing, from the government down to residents, has, to a greater or lesser extent, a demand for funding energy efficiency building. As a result, the sums of capital involved are quite large and the demand quite diverse;

Few needs are being met. The government has already set up dedicated funds for renewable energies, and energy efficiency retrofitting of large public and existing residential buildings, but so far these have only provided funds for demonstration projects and their level of support limited, leaving the demand for funding largely unmet.

Categories of Suppliers and Demanders of Funds

To meet the credit requirements of different demanders of funds, capital must be obtained from corresponding suppliers of funds, but under many circumstances, the responding links are not simply one to one. As a result, the complex network of links shown in Figure 69 has arisen. Suppliers of funds for energy efficiency building can be divided into the following: policy organs, commercial organizations, and informal organizations, where policy organs include government institutions and policy banking organizations.

Figure 69 *Categories and Links of Suppliers and Demanders of Funds*

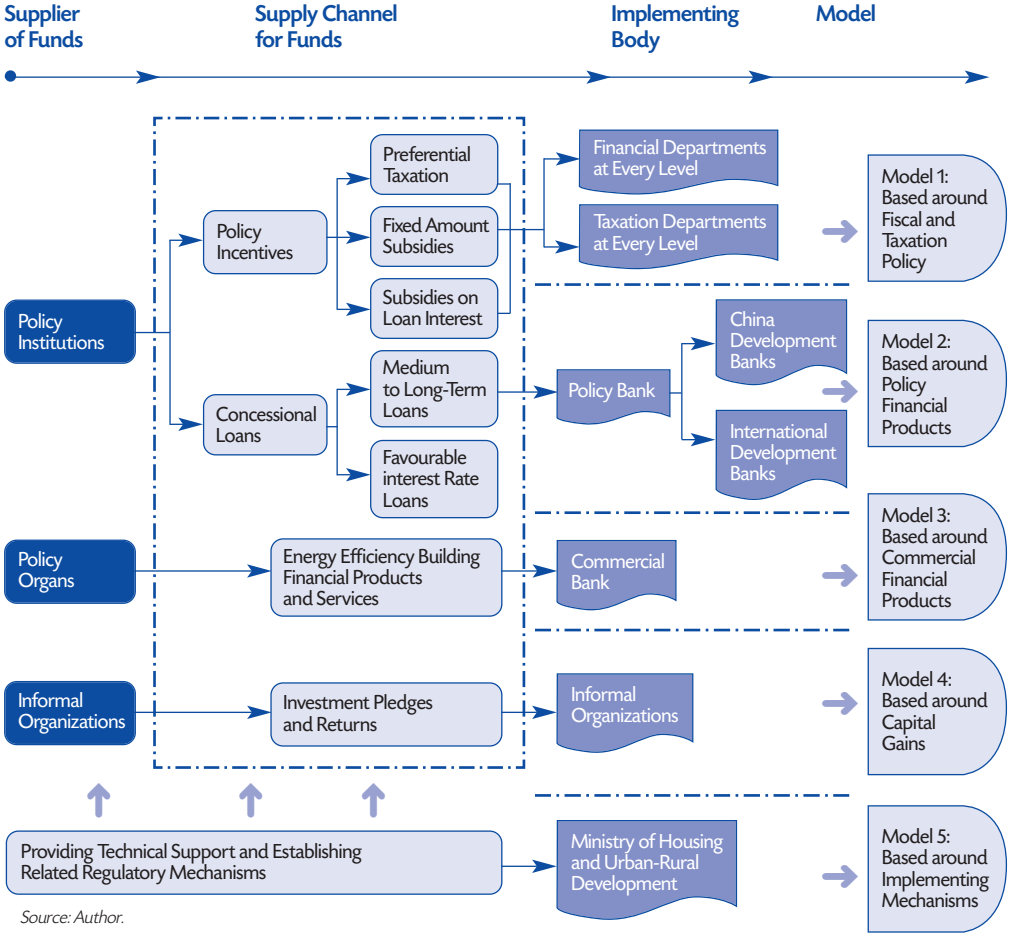


Source: Author.

4.8.4. Model Framework for a Financial Service System for Energy Efficiency Building in China

An analysis of the features, links and categories of suppliers and demanders of funds in the financial service system for energy efficiency building in China shows that certain suppliers often correspond to specific funding channels, which ultimately have corresponding implementing bodies to release the funds. This forms an initial stage of financial service system construction, as shown in the developmental model in Figure 70.

Figure 70 *Construction Models of a Financial Service System for Energy Efficiency Building*



Source: Author.

Financial Model for Energy Efficiency Building Based around Fiscal and Taxation Policy

The main organizations involved in this kind of model are fiscal and taxation departments at all levels, while the primary financial instruments are fiscal and taxation economic policy incentives that relate to energy efficiency building. Fiscal policy includes fiscal subsidies, and subsidies on loan interest payments, etc., whilst preferential taxation includes policies that offer preferential tax rates and tax exemptions to all parties involved in the energy efficiency building market. Such a model is well suited to the early stages of development of a financial market for energy efficiency building, where fiscal levers can effectively resolve funding shortages in an immature market. However, there are currently not very many economic policy incentives of this nature in China, and those that do exist are not part of an organized system. More systemic fiscal and taxation policy should thus be formulated.

Financial Model for Energy Efficiency Building Based Around Policy Financial Products

The main organizations involved in this kind of model are policy banks providing financial support for energy efficiency building in China, including the China Development Bank and various other domestic and overseas development banks. The primary financial instruments available to this model are the selection of financial products offered by such banks. These include long-term soft loans, dedicated funds for energy conservation and emissions reduction as well as industrial investment funds, all of which are capable of providing financial support for energy efficiency building, but in reality still lack the experience of putting it into practice. Financial products specifically customized to energy efficiency building are still required.

Financial Model for Energy Efficiency Building Based Around Commercial Financial Products

The main organizations involved in this model are all the various kinds of commercial banks, and the model's main financial instruments are commercial financial products. The commercial model will probably become the primary financial model for energy efficiency building in the future but currently has relatively few financial instruments available for its use. Until now, there have only been a small number of experimental guaranteed loans granted to energy service companies. In the future, the financing of energy efficiency new-builds should consider merging more with the financing of the real estate market, while that of energy efficiency retrofitting of existing buildings could focus more on designing its own independent financial products.

Financial Model for Energy Efficiency Building Based Around Capital Gains

The main actors involved in this kind of model are high net worth individual investors and corresponding investment organizations, with various kinds of loans and flexible means of investment as its main financial instruments. China currently has a very active private capital market, with idle funds in abundance. These funds could be attracted to the energy efficiency building market if its profit models could be scaled up and stabilized. This kind of financial model has yet to be applied in practice but the financial profitability of the energy efficiency building market should allow for it to become a future model for growth.

Financial Model for Energy Efficiency Building Based Around Implementing Mechanisms

The main organizations involved in this kind of model are policy institutions that ensure the growth of the financial system for energy efficiency building. The guarantees and implementing mechanisms they provide are the primary financial instruments available. Despite being unable to bring about direct cash inflows, this model is able to attract investment in energy efficiency building from the suppliers of funds mentioned in the four financial models. It does this by providing technical assistance and regulation of guarantee agencies, such as regulating relationships between market entities, clarifying potential profit models, enforcing supervisory and risk avoidance mechanisms, and carrying out energy consumption checks. It is thus able to serve as a preceding element in the development of the other four models.

4.8.5. Conclusion

The financial market for energy efficiency building constitutes an important part of China's financial markets. Complementary policy systems should be established to strengthen financial service system guarantees and open up and develop the R&D on corresponding financial products that will ensure the security of the financial system for energy efficiency building. The need to increase security and lower risk is particularly crucial given the current international economic situation. This paper has looked at features of financial service systems for energy efficiency building in China and abroad. Construction models for China's financial service system for energy efficiency building have put forward our corresponding thoughts and suggestions, with the hope that they may go some way towards developing the provision of financial support for China's energy efficiency building sector.

Conférences & Séminaires

Part 5. Way Forward

5.1. Role and Objectives of a Demonstration Program

Mr. Michel Raoust, General Manager,
TERAO Green Building Engineering

This presentation deals with the necessity of implementing a demonstration program as a logical extension of the work done until now, which is analytical and theoretical, albeit based on a careful assessment of existing buildings. As we could see in previous presentations, the data obtained from statistics and audits have been used to their full extent to provide a clear picture of investments and energy savings potential, as well as of environmental impacts involved in a large-scale thermal retrofit program.

What do studies allow us to conclude?

We identified 3 levels of thermal rehabilitation. Each level corresponds to a range of investment costs and energy savings. Accordingly, it also corresponds to a representative payback period.

Then, we used the data obtained at the level of Wuhan city to extrapolate stakes in terms of investment costs and energy savings to Hubei Province and even to the Yangtze River area (Anhui, Jiangxi, Hubei and Hunan).

It was shown that building types (use) and equipment (fuel and efficiency, local, centralized, etc.) have a strong influence on the definition of the optimized rehabilitation package. However, we were able to determine the main guidelines with reasonable accuracy. It allows us to guide the decision-making process by giving a framework of performances and costs that are representative of different types of buildings.

What are the limits of such a study?

Since the study was based on statistics and samples, its accuracy is necessarily limited.

The relevant solutions for envelope rehabilitation are hard to generalize since it is a function of building types, fuels and equipment. Even if we were able to define typical rehabilitation programs, it is obvious that detailed programs can only be done on specific buildings.

A demonstration program is necessary to go beyond the scope of exploration, be more accurate in terms of savings and investment potential, and determine the most relevant rehabilitation packages corresponding to real cases.

Going from Studies to Practice

A demonstration program calls for feasibility studies. These studies allow the adjustment of energy-saving packages to each real case. Among other improvements, it is the occasion to consult product suppliers for more accurate information on technologies and prices. It is also where one can raise technology-specific issues. For instance, external insulation for high-rise buildings can be difficult to

implement. And in addition to the technical difficulty, some buildings have expensive external coatings for decoration. In such cases, the owner may be reluctant to choose external insulation and would rather go for internal insulation.

For most cases, it is very likely that a complete rehabilitation of the envelope is too expensive. Therefore, in such cases, envelope improvement might occur only partially. The choice to improve either insulation or windows and shades is a function of the building and its HVAC equipment. Indeed, these factors will influence the importance of HVAC energy consumption within the total energy bill and therefore the energy-saving potential of the envelope.

Regarding the systems, specific technologies apply to specific buildings. In the case of shopping malls, we have highlighted that fresh airflow rate is the most impacting factor on energy demand (up to 40% of the load). Therefore, heat recovery AHU (air handling units) for shopping malls can be a very efficient strategy to save energy.

In hotels, fresh airflow rate is also an important part of loads and might call for optimized airflow rate regulation. Also, heating demand is higher in such buildings than in offices. Moreover, hotels are typically very demanding in terms of domestic hot water (DHW). Therefore, combined heating/cooling and domestic hot water heat pumps for hotels can be a very efficient strategy.

The demonstration program is also necessary to assess the building owner's motivation and interests. It can tell us why the owner is reluctant to go for rehabilitation. It is necessary to have a better knowledge of the levels of rehabilitation that can be acceptable in terms of investment for him or his bank. In addition, it is very common for owners not to be aware of the potential energy savings and other advantages, like increased comfort, that improve employees' productivity.

Most importantly, owners and investors need to see something operational before taking a financial risk!
As an example, in Harbin (northern China), 5 residential buildings were retrofitted in 2006 as part of a demonstration program. As it was a success, the following years the city of Harbin went on to retrofit 100,000 m^2 of residential buildings with the same techniques.

The demonstration program enables one to adjust the techniques on site, monitor real performances, test the reliability of calculation methods, and have the owners realize the full scope of benefits they can have.

It is necessary to reach the goal of this research program – the design and implementation of financing mechanisms – by dealing with the real actors involved in the financial side of thermal retrofitting projects. There-fore, the demonstration program should be applied on a sufficient scale for such financing mechanisms to be applied.

To conclude, this demonstration program is a necessity in order to fully reach the objectives of the research program, come out with possible improvements, and overcome the current implementation difficulties. The support of decision-makers is thus needed for large-scale implementation. It is also necessary to have practical examples in order to come up with the best financing mechanisms applied to small-, mid- or large-scale programs.

5.2. Energy Efficiency Policy Implementation

Dr. Bernard Laponche, Independent consultant and international expert in energy and energy efficiency policies

5.2.1. Implementing Energy Efficiency Policies

Two Essential Conditions

Political determination is the first condition required to develop an energy efficiency policy in every sector. Producers and suppliers of energy hold strong positions in the economy and have an undeniable influence on politicians and policy-makers. Energy efficiency does not have the same economic power because it is dispersed between all sectors of activity, which is why it needs constant, high-level political support.

The second condition is the price of energy products at the consumer level. The price of energy must reflect the cost of a well-managed energy system and gradually incorporate the cost of externalities, such as environmental degradation. Price increases, whether the cause is internal or, as is more frequently the case external, do not lead to energy efficiency unless specific policies and appropriate means are in place to capitalize on the stakes and potential. However, if consumer prices are kept artificially low, efforts to increase energy efficiency are apt to be in vain.

A Set of Complementary Tools and Instruments

Implementing an energy efficiency policy requires the setting up of a series of major tools and instruments that are complementary:

- Institutional Capacity Building for conceiving, organizing and supporting efficient energy programs and projects;
- Legislation and Regulations related to energy efficiency;
- Information, Communication and Training to increase consumers', enterprises' and decision-makers' awareness and competence; and
- Financial incentives from the government and financing mechanisms adapted for use in energy efficiency projects.

Institutional Capacity Building

Energy efficiency programs will be successful only if they are designed and executed with the full agreement and cooperation of all the economic agents concerned. The implementation of projects is a decentralized and diversified activity. Responsibility for it lies with the enterprises – either concerning their own energy use, or in the manufacture or sale of efficient equipment – local authorities, government services, and households.

To motivate this network of partners, inform them on the best practices and instruments, train professionals, prepare energy efficiency regulations, elaborate and launch new programs, and promote energy efficiency through financial incentives there is a need for appropriate entities. The public service of energy

efficiency promotion and animation is of a new type compared to the traditional role of government services or regional and local administrations: it must be entrusted to specific and competent organizations.

With varying positions and status, public bodies charged with promoting, facilitating and implementing energy end-use efficiency policies and programs exist in most OECD countries, and in particular in all countries of the European Union at national and often at regional levels.

The main tasks of these "Energy Efficiency Agencies" (which are often also in charge of renewable energy development) are as follows:

- Integrate the objectives of energy efficiency into the economic, industrial, R&D, building, transport and energy policies of the country (or the region);
- Design, in cooperation with the concerned partners, a national (or regional) energy efficiency program for the short, medium and long terms;
- Elaborate and propose decisions regarding regulations and standards;
- Organize and promote energy audits, demonstration operations, dissemination of efficient techniques;
- Organize and coordinate information and training programs on energy efficiency;
- Organize and coordinate financial incentives and develop innovative financial mechanisms for energy efficiency projects; and
- Participate in international cooperation.

The great advantages of building permanent and specific institutions devoted to energy efficiency are the coherence of approaches and the capacity to follow through and implement an energy efficiency strategy in the long run. The prerequisites for the success of agency action are political determination at the highest government level, freedom of action and autonomy of management, the employment of high-qualified personnel, and stable financial resources.

In parallel to national or regional initiatives, another fundamental arena for energy efficiency implementation is the city or town.

The city occupies a strategic position in the implementation of programs of action in the fields of energy efficiency and environmental protection:

- It is often the producer and distributor of energy in its territory;
- It consumes energy (in its own buildings and facilities, in the urban transportation system, in households, industries and tertiary activities);
- It is, to a large extent, in charge of urban planning and regulations in the field of buildings and urban development;
- It also has an important role in providing incentives or subsidies for social activities.

Developing energy efficiency and environment protection programs at city level requires a certain number of capacities and instruments to be created to collect and deliver information, analyze energy consumption and pollutant emissions, propose new transportation schemes, implement demand-side management projects, etc.

Legislation and Regulations

Legislation and regulations represent a very powerful way to improve the efficiency of new equipment and buildings, especially in sectors in which there are a multitude of consumers who are not always aware of energy costs.

Although initially the use of regulations was mainly reserved for new buildings or equipment, it has also been considered in some countries to impose maintenance on existing energy-consuming equipment (buildings, boilers, vehicles).

The most widely used regulations are on buildings, electric appliances, and energy audits.

The Building Sector

Thermal regulations for the construction of new buildings have been promulgated since the mid-1970s in all OECD countries and are being drawn up in a number of developing countries (for instance in the Maghreb countries). These regulations have a considerable effect over a long period and are cost-effective given the technical progress made in building methods and the quality of building materials. In France, for instance, the quantity of final energy needed for heating a given dwelling has been cut in two over the past thirty years.

Standards and Labels for Electric Appliances

Standards and labels do not affect the market in the same manner. While standards set a minimum value for energy efficiency and ban from the market appliances which consume too much energy, labels inform the consumer on the energy efficiency of a product and enable him to compare between the various models available. In some cases, in particular for widely used appliances (refrigerators), the two approaches are combined: labels are accompanied by a ban on the less efficient models.

In most countries (and for the European Union as a whole), both standards and labels have been issued for domestic electrical appliances.

The introduction of a label must be accompanied by consumer information.

Mandatory Regular Energy Audits

In industrial plants, large tertiary sector buildings (hospitals, hotels, etc.) and transportation fleets, energy audits allow one to identify the technical and economic measures necessary to achieve energy savings.

As a general rule, good maintenance measures alone, without heavy investment, can reach savings of 15 to 20%.

In many countries, energy audits are compulsory (and partly subsidized by the State) for large energy consumers.

Information, Communication and Training

Information

Information is usually the first type of measure to be considered since it requires less preparation and smaller budgets than other types of measures. The bodies in charge of promoting energy efficiency are the most likely coordinators of information programs, ensuring that a coherent message is delivered by the many different actors in the energy efficiency scene. They can also initiate information campaigns themselves, when needed.

General information is useful to create and maintain consumer awareness of energy efficiency. It often targets energy-saving potential which can easily and immediately be mobilized through a change in the behavior of the population. Thus, information campaigns have targeted primarily private residential and transport consumers: sometimes industrial and commercial consumers have been included.

Targeted information campaigns are often indirect: they pass through professional and consumer organizations or industrial organ-

izations. This type of campaign often has a stronger impact on consumers than general information campaigns because such organizations are usually considered trustworthy by their members. It is thus often more interesting to organize targeted information campaigns than general ones when funds are limited.

Another way of providing direct information to consumers is to have them monitor their consumption. In most countries, schemes, methods and software have been proposed to large companies and certain municipalities to incite them to monitor their consumption; in a few countries, this has even been made mandatory for the largest consumers, usually with the obligation of reporting to the energy administrations.

Informing consumers of the energy efficiency of new appliances, or even new buildings, is another common measure of information, usually referred to as labeling (which we presented above).

Comparative information can also be provided to consumers so as to indicate how he relates to a standard consumer or to the most efficient consumer.

Promotion is another way of providing information, the idea being to disseminate information on the actual results obtained with new technologies, or efficient vehicles, equipment or buildings. The experience shows that the demonstration of the feasibility of new technologies remains limited if it is not followed by real advertising campaigns to make the potential client of such technologies aware of their potentialities.

Energy Audits

Providing information on the energy consumption characteristics of the energy consuming equipment probably has a greater impact. **Energy audits** fall into that category. They include a detailed survey of the energy used in an industrial firm, in a transport company or in a building, and an indication as to what actions can be done to reduce the energy bills: reduce consumption (energy efficiency actions), shift to another fuel (energy substitution), or introduce tariff variations (so as to modify consumption patterns, for instance through load management). In some countries the approach has been to have the energy efficiency agency undertake the surveys free of charge or at a limited cost; in other countries, the audits have been left to private sector firms; in that case the role of the administration is to contribute financially to the cost of the audit. In Europe more recently, electric or even gas utilities have been proposing energy audits to their large customers.

Training

Training is another important measure that can concern all types of professionals involved in the design (architects, engineers), construction (workers, technicians), operation (drivers, pilots, technicians), and control (auditors, consulting engineers) of energy-consuming equipment, vehicles or buildings. All energy efficiency agencies, energy administrations or international organizations have supported various types of training. At all levels training is fundamental. The most efficient vehicles can loose part of their efficiency gains if the drivers are not properly trained in energy-saving driving, or if the vehicles are not properly maintained. For a new technology, it is important that all professionals involved from design to operation are trained; if one link is missing, part of the potential gains may be lost. To be efficient, training must also be well-targeted

Financial Incentives

Direct Financial Incentives: Subsidies

The most widespread incentive is the **grant or direct subsidy to the consumer**. This grant was either defined as a fixed amount, or as a percentage of the investments (with a ceiling), or else as a sum proportional to the amount of energy saved. This system faced difficulties due to public budget limitations, lack of information for the consumers, and a heavy administrative burden. To correct these problems, grants can be better targeted to limit the consumer population that could benefit from a grant (*e.g.,* targeted on low-income households like in the British Fuel Poverty Strategy), or be restricted to certain types of investments.

Another form of incentive is the **tax reduction or tax credit**. In the first case (tax reduction), the investment is deducted from taxable income; in the second case, part of the investment is directly deducted from income tax. Such incentives can be easily implemented at low operational cost. The main problem again is that of informing consumers, since the presentation of the tax reduction or tax credit mechanism is not always easy to understand and is difficult to pass on to most consumers.

All the limits discussed above should not condemn these types of measures, but lead to their more careful use, taking into account their side-effects and real effectiveness. These economic incentives should be viewed as a temporary measure to mobilize consumers, prepare a regulation, or promote energy-efficient technologies by creating a larger market than would exist with market forces alone; one direct result may be a cost reduction for such techniques, as experienced with efficient electrical bulbs in Europe

Financial Mechanisms for Promoting Investment

The implementation of energy-efficient programs leads to a significant potential reduction in the running costs for companies and institutions, and helps governments achieve their greenhouse gas reduction goals. However, the difficulty in obtaining the necessary financing all too often constitutes a major barrier to the achievement of energy conservation projects:

- Energy efficiency projects compete for capital with more traditional investments such as power plants and industrial expansion;
- Energy efficiency projects are perceived to be more risky than supply-side projects because they are often non-asset-based investments;
- Many energy efficiency projects and ventures are too small to attract the attention of large multilateral financial institutions;
- Finally, energy prices do not generally reflect the real costs of energy, and are often too low to attract potential investors in energy efficiency.

These barriers highlight the need to search for the appropriateness of new financial mechanisms.

Involving the Private Sector

If tax subsidies and other incentives are very useful to stimulate investments in energy efficiency, they are very dependent on the State's direct intervention. In the context of energy market liberalization, many governments seek to increase the role of the private sector in financing energy efficiency operations in order to integrate energy efficiency in a market perspective.

The State can encourage the intervention of financial operators, like the banks, by collaborating with them to develop soft loans, whose interest rates are some points (a few %) below the market rate, for the consumers wishing to undertake energy efficiency works. The capital is mobilized by the banking structure according to traditional methods on the national (for example, issuing of bonds) or international market. In general, if loans with softer interest rates are considered, the authorities take care of the financial cost related to the subsidy.

Leasing consists of renting one or several pieces of equipment for a duration determined by a contract. The rents paid by the tenant are registered in the running costs and the rented equipment does not appear in the assets of the company's balance sheet (or in the investment budget of a local community as the leasing option is increasingly used by municipalities and public enterprises), which alleviates it in proportion.

In the guaranteed results contract procedure, an energy user negotiates a general contract covering the financing and risks of the energy efficiency investment. The guaranteed results contract is particularly well-suited to cases where the manager has neither the time nor the analytical data necessary and cannot or will not cover the cost of the project. Although leasing contracts do have a number of advantages, their application is limited to circumstances where the need for a specific energy system is well-defined.

Third-party financing is proposed by specific companies who are interested in developing energy efficiency projects, with no financial interest in selling equipment or operating the system. Under this arrangement, the third-party investment company finances and executes the project aiming at making operational savings, and is repaid up to an amount of the savings actually made each year over a limited period. Hence the company provides a three-fold service covering financing, technical execution and guaranteed results.

The third financing company is either a financial operator (generally a bank) whose role is only limited to the supply of capital and its recovery on the project depreciation, or an ESCO ("Energy service company") which proposes, for its part, the "turn-key" implementation of energy efficiency projects. The ESCO, as a supplier of energy services, manages and coordinates all the phases of the project, including the design, establishment, follow-up and financing, while being remunerated on the basis of the energy savings generated by the project over a determined period.

Innovative Funds Compared to "Classic" Funds

Establishing energy efficiency funds is not recent: many governments have had recourse to them to finance specific projects and programs.

The primary objective of a "fund for energy efficiency" should be to create a favorable climate for energy efficiency investments by stimulating the development of a market for energy efficiency and ESCOs that would reduce the need for public funding. What we call "innovative funds" are funds that:

- Use tools traditionally dedicated to private sector investments (loans, equity participation, venture capital, etc.);
- Seek the participation of private investors, such as banks or private companies (ESCOs);
- Have the long-term objective of developing a market for energy efficiency that would be "self-sustaining," meaning functioning without a public intervention; and

- Have the short-term objective of obtaining a good return on investments that will reimburse the money put into energy efficiency projects.

5.2.2. Key Lessons from International Experience

A certain number of lessons drawn from best-practice analysis of international experiences in energy efficiency, notably in European Union countries, are useful for designing an energy efficiency strategy.

A Wide Range of Complementary Tools and Measures

There is not one single tool or measure that works best. All successful programs in various countries illustrate the importance of having solid architecture and coherent organization, and using a wide range of tools that mix incentives with proven offers and innovative means.

The Importance of Institutions and Regulations

Countries that develop successful energy efficiency policies, especially in Europe, use a wide range of means to control the supply and demand of energy, and respect the Kyoto Protocol agreements. In each country, regulations are a powerful tool, and are increasingly determined at the European Community level. Institutions dedicated to controlling energy at the national, regional and local levels are very important, although their form and responsibilities vary from one country to another. Generally speaking, local authorities, energy operators and financiers have more responsibility to set up and run energy efficiency projects, while the role of the State regulator is one of making market rules that permit the development of energy efficiency projects.

The Increasing Role of Local and Regional Initiatives

Regional and local initiatives are of increasing importance. That is particularly true in countries where decentralization and citizens' initiatives have a long tradition, and where local and national decision-makers facilitate initiatives that control energy use. The evolution of a decentralized system means that local authorities support the creation, training and coordination of local teams. It also implies a growing use of information exchanges and networking at national and international levels.

A Remarkable Diversity of Financial Incentives

The use of very diverse financial incentives has accelerated in recent years, with a growing trend towards using partnerships and funds dedicated to support investments in different forms. New forms of financing that give a larger share to private operators join traditional investment instruments. In fact, as European markets are in the process of being liberalized – especially energy markets – Member States are trying to increase the role of the private sector in financing energy efficiency to make it competitive. Some of the new forms of financing include leasing or third-party financing through "Energy Service Companies", the development of investment funds or guarantee funds, or subsidized loans from the public sector or private banks.

But a Lack of Energy Efficiency Policies in the Transport Sector

Efforts for improving energy efficiency have mostly focused on industry, and residential and tertiary buildings. As a general rule, in the European Union and its Member States, very little has been done in the transport sector. And this, despite its near-total dependency

on petroleum products and an increase in energy consumption and the nuisances it engenders, especially in terms of greenhouse gas emissions. There are certainly examples from cities that are taking the lead in developing urban mass transit systems, but progress is very slow. Furthermore, rail freight continues to lose market share to trucking.

The Characteristics of the Most Successful Programs

The most successful programs have the following characteristics:

- A clear definition of the group targeted for action and coherent measures to achieve objectives;
- Costs shared in the right measure between private stakeholders and the State;
- Flexibility, administrative simplicity, information quality, awareness-raising, stakeholder participation and motivation;
- Continuity through the establishment of policies that are structured, planned and sustainable; and
- Substantial environmental benefits.

5.2.3. Energy Efficiency in Buildings

Energy efficiency in both residential and tertiary buildings is based on the same technologies. The three key technical aspects are: insulating for both heat and cold; using energy-efficient appliances and equipment; and choosing the right energy type, such as solar hot water heaters or cogeneration.

However, while residential buildings are relatively homogenous in terms of their energy use, tertiary buildings have vastly different uses and types of activity. The methods used for motivation, partnerships and incentives are very different depending on the activities performed.

New Buildings

The main action required for new buildings is thermal regulation and equipment efficiency. In order for planned systems to be truly efficient, they should be accompanied by:

- An intense information, motivation and incentive program: Information should be provided to construction professionals as well as the general public; precise assessments of cost increases should be done; and appropriate, accessible financial incentives put into place;
- Research and development of construction alternatives: Bioclimatic architecture is a field where Chinese researchers could contribute a lot for each climate zone that requires its own zone-appropriate solution. Research programs should lead to the more generalized construction of highly energy-efficient buildings over time;
- An energy efficiency-oriented national and provincial industrial policy to produce energy-efficient construction materials, heating and cooling systems, and electric appliances.

Existing Buildings

Energy consumption in existing buildings will very likely increase given peoples' desire to live in increased comfort. Without action, the increase will waste energy in heating and cooling because of the poor insulating properties of existing buildings. It is necessary to put a renovation program in place for tertiary and residential buildings. However, the payback period of such an investment at present energy prices is not very attractive for the building owner, even if the public's interest is clear. Because of this, it is necessary to provide owners with financial incentives to upgrade their buildings by offering grants or loans. Consultation between concerned owners,

authorities and policy-makers should lead to the best solution. At some point, an obligation to "thermally renovate" all buildings with heating and/or cooling systems may be envisaged.

Electricity Savings in Buildings

To reduce electricity consumption in residential buildings, four uses need to be targeted: lighting; kitchen appliances, especially refrigerators and freezers; air-conditioning; and standby modes on kitchen appliances and audiovisual equipment.[1]

There are two main ways to act on the energy consumed by these uses to get the same or superior service. One is to modify the consumer's behavior, and the other is to improve the appliance's energy performance through legal regulations and financial incentives:

- Behavior: Consumer's behavior can be modified through information and awareness-raising campaigns that affect usage habits, such as turning off lights, and purchasing habits, such as buying energy-efficient appliances and thinking about one's real needs. Product choices, economic interests, and the consequences of their choices can be highlighted for the consumer-citizen, leading to changes in behavior. The effect of awareness-raising campaigns can be reinforced by regulatory and financial incentives.
- Regulations: The most effective measure is to set standards for maximum energy consumption for each type of appliance, and to define relative performance between appliances with certified labels.[2]

Refrigerators, for example, would have both energy consumption and volume standards. The certification and labeling process should also be applied to other types of appliances, such as individual air-conditioners, hot water heaters, lamps and lighting fixtures, washing machines, dryers and combination machines, dishwashers, ovens, irons, television sets, and monitors.

The control for the proper application of the rules and the type of incentives are essential elements for success.

There is a link between behavior modification and technical improvements. The latter can sometimes make up for the deficiencies of the former, but it would be an illusion to think that energy efficiency is essentially a technical problem. Policy choices about development and planning as well as the citizens' attitudes to consuming goods and services are critical elements.

Information and Incentives for the Tertiary Sector

Technical solutions for tertiary buildings are similar to those for residential buildings. Information and incentives need to be fine-tuned to the target.

Each tertiary activity sub-sector has specific needs, so it is important to tailor energy efficiency programs to each one. It would be possible to develop projects for individual buildings or a series of buildings by working with representatives of each sub-sector. An energy audit could provide an opportunity to reinforce the capabilities of a tertiary building's technical team through training and information.

[1] The production of sanitary hot water by solar water heaters should also be considered.

[2] Once a process for certifying energy use exists, the suppression of low-performance equipment can be considered. The best way of suppressing the least efficient appliances is to slide the certification scale toward higher levels to accommodate new, higher-performance products.

It is easy to identify ways to rationalize energy use and increase efficiencies in a group of similar buildings or in a sub-sector with several buildings that share the same characteristics. This is especially true for lighting and cooling equipment, as well as audiovisual and computer equipment such as televisions, monitors, and computers. Planning for bulk purchases of equipment leads to cost savings, and energy efficiency as well as price can be criteria for procurement tenders. In the case of privately-owned buildings, such investments should benefit from financial assistance.

The key to being able to go from intention to action following an energy audit or discussions with sector representatives lies in the financing capacity of the building owners, as well as the administrative rules governing public buildings. One option that is particularly attractive for tertiary buildings is to use a specialized, third-party "energy services establishment" that makes the investment for the building owner. Often, the building owner lacks technical expertise (which industrial owners generally have) that the energy services establishment has. The owner may also lack adequate funds to invest in rational energy or substitution programs, even though the programs provide a good return over time. Using a third party would be valuable for any building owner, such as a hospital, who could repay the initial investment out of money saved in the operational budget because of lower energy bills.

5.2.4. Conclusion

The Research Program launched jointly by the Hubei Construction Department and the Research Department of AFD on "Energy Efficiency in Buildings" has already successfully achieved the main steps necessary for the implementation of a large-scale investment program:

- The typology of the existing building stock and its various categories has been established;
- A large number of energy audits have been achieved, leading to the assessment of the energy consumption and thermal simulation modeling exercises;
- The energy efficiency techniques and their combination for optimal projects have been identified and investigated;
- The investment costs have been evaluated for different types of buildings;
- Various possibilities for financing mechanisms to facilitate the investment have been explored;
- The evaluation of the potential has shown, by extrapolation of the local results, the enormous energy, economic and environmental gains of energy efficiency in buildings not only for the city of Wuhan but also for the Hubei Province and the Chang Jiang area.

The foundations are here and ready for a change of scale.

The next steps resulting from this research phase should develop through demonstration operations, both for technical, economic and financial assessment, based on detailed feasibility studies, as an introduction to widespread investment programs.

In order to succeed in these new operational phases, it is of paramount importance to build the convergence of two lines of force:

- The mobilization of the local and regional authorities and all the actors of energy efficiency in buildings: building owners and occupants, construction enterprises, engineering companies, architects and designers, equipment manufacturers and retailers, financial institutions and banks, etc;
- The strong support of national authorities both in terms of political backing for these programs and in terms of financial intervention.

Conférences & Séminaires

Concluding Remarks

Concluding Remarks

Dr. Bernard Laponche, Independent consultant and international expert in energy and energy efficiency policies

We have all listened to the very comprehensive presentations in the plenary sessions, and then taken part in the two series of workshops that provided the opportunity for more detailed, more concrete exchanges, the main lines of which were relayed back to all of the attendees. The substance of the interventions and exchanges was extremely rich, and touched on a wide variety of subjects: so much so that any attempt to now "summarize the summaries" would overly impoverish the contributions to this conference and narrow their scope.

I shall, thus, not venture to conclude these two days by summing up the presentations and debates, but would rather share with you some thoughts on what I feel is the spirit of both the actual theme of this conference, energy efficiency in buildings in Hubei Province, and the three-year research program, the results of which have been presented here. What did strike me was the fact that both the subject of the study and the method used to carry it out have matching approaches and characteristics and, to talk about this similarity, I shall use four key words, in the hope that each has a corresponding Chinese character. These four key words are: convergence, complementarity, articulation, and diversity.

Convergence is apparent in several ways and in different areas. To begin with, as the presentations in the first plenary session showed, there is a convergence of constraints and needs: the obligation to simultaneously deliver economic and social development, energy security, and protection or improvement of the local and global environment, at local, provincial and national levels. These obligations, which are subject to strong constraints of resources, prices, population needs, converge towards the absolute necessity for energy efficiency in all sectors: transport, industry and especially buildings, which are becoming the primary consumers of energy, in particular electricity. This means that energy efficiency stands as a priority measure at the crossroads of development obligations and energy and environmental constraints.

Next, comes the convergence of interests. First at international level, which is far from being the case in other energy-related sectors. Be it in China, California, Hubei, France, India, Indonesia, South Africa – in short, everywhere in the world – in rich and poor countries alike, the power exporters or importers, individually and together, all have an interest in improving their economy's energy efficiency. Thus, a convergence of interests that, in turn, is a powerful factor for international cooperation, which has materialized in the high quality of work carried out jointly by the research program teams.

Finally, the convergence of interests at different levels: national, provincial or municipal authorities, individual consumers, companies, universities, financial bodies, etc.

Complementarity is vital not only within the research program itself but also, in parallel, for implementing a program and large-scale projects. At the level of research, given that multiple elements are at stake, there is a strong temptation – and this is what generally happens – to deal with each question separately, one after the other, and then assemble the results only at the very end. Thus, the engineers look after the technical questions, economists evaluate costs, then come the institutional and organizational questions, and finally the financial questions. The fundamental importance of policy guidelines is often overlooked (they are sometimes even described as "claptrap" since they do not use the same logic as engineering sciences, but everyone here has rightly understood their determining role).

The complementarity overarching this research program has certainly resulted in – or has at least done the utmost to result in – the implementation of a process through which the different expert groups worked in parallel, and then shared their progress and findings at each step, so that the viewpoints and choices of each and every one was being heard and taken into account at each stage. For instance, the technician will tell us that "the best solution is this one; this is what we need to do". And the interdisciplinary dialogue will reveal that there is simply not enough money to implement this solution and that the choices have to be reviewed in the light of financial or political decisions.

An energy efficiency project may be technically feasible and economically advantageous, meeting energy and environmental constraints: in a word, it has everything going for it. And yet, it will not come to fruition if the organizational and financial conditions are not met. This is complicated because we are replacing the wealth of energy resources by intelligence, imagination, organization, technical and financial innovation. It is certainly a complex matter, but it is also what gives the cutting edge to energy efficiency as a choice instrument for sustainable development.

Energy efficiency is not a vertical problem that can be solved by a logical and linear approach. It is a horizontal problem involving all disciplines: this is why it is difficult to address and why complementarity and interaction between disciplines are vital for success.

We have also understood that it is a domain where means of action are complementary and that it is necessary to bring a set of tools into play. A program's success will not depend on a "single solution" but rather a consistent and well-balanced combination of political will, legislation and regulation, information and training, organized partnerships, financial incentives, and the implementation of specific financial mechanisms.

Articulation: Knowing how to "grease the wheels". This means organizing and driving complementarity and getting it to function harmoniously. This is often the most neglected aspect, as if somehow "it were taken for granted". And yet, someone has to do it.

It is not enough to say that everything stems from the government and that, on this basis, everyone must follow. That does not work. On the other hand, we cannot consider that

everything comes from the market and that the market, through some mysterious workings, will solve everything. This also leads to disastrous situations.

The key most certainly lies in articulation: on one side, as we have already seen, the articulation between the various activities and disciplines and their interactions and, on the other side, the articulation between the different forms of power and decision-making centers. Political power at government, regional and local authority levels, industrial power (companies in construction, building materials and equipment business), the power of research and expertise (universities, design offices, energy service providers), financial power (government finance, banks, investment funds, ESCOs, etc.). Each time, for each project or program, it is the combination and harmonization of each contributor's skills that will guarantee the quality of the work. Articulating the different responsibilities (and being sure that each will be properly assumed) is the key to success.

Diversity of situations and diversity of solutions, which I shall illustrate with a few examples.
Depending on the type of building, the kind of owner or the activities accommodated, the solutions in terms of energy efficiency programs will be different. The same building, depending on whether it is used as offices, a hospital, a large store or housing, has different energy requirements and types of energy use. Although the technical solutions may be the same – to varying degrees – the financial solutions will be almost always individual. In the case of a prestigious or emblematic building, for instance, the national budget will directly provide the financing required to make it into a model low-energy building (a "showcase") or a pilot operation. In most cases, the best solution has to be found either in the form of a soft loan or through intervention from an ESCO, etc. Addressing these questions means having an open mind and not saying *a priori* "this is the solution": there are in fact three, four possible solutions! The broad diversity of solutions found for financing energy efficiency investment in the building sector was clearly evidenced in the presentation of international experiences.

There is also diversity at the level of power and decision-making. The question underlying all the discussions on this theme is that of the balance between the government and the market, and of how the various tasks and responsibilities are shared out. The government clearly has the responsibility of legislating and regulating. But one cannot stop their saying: "I make the law and it must be applied". This would mean that the essential task of informing and facilitating is forgotten: "I make the law and set up a framework enabling and facilitating its application. I draw up thermal regulations and ones for the efficiency of equipment and appliances, and I create the means for informing, training and incentivizing so that architects, designers and companies can build, renovate and equip low-energy buildings." Public authority has no direct responsibility to "get things done", except where its own assets are concerned, but it is responsible for creating the conditions to ensure that "things get done". And, in a symmetric and complementary fashion, market players must also organize themselves and acquire competences so as to be capable of responding to the collective interest. One cannot say "I'm private sector, so I do what I like" and then the next day request a grant or advantageous legislation.

The art of governing lies precisely in the ability to know and understand this diversity and ensure that it serves society as a whole.

To conclude this brief overview on a more concrete note, I will say a few words about the logical follow-on from this research program.

We have seen that most tasks have made good headway and all together the presentations have shown us what was more or less fruitful and what was still lacking.

With respect to the technical and economic questions, two recommendations were formulated during the discussions regarding demonstration operations and feasibility studies. To ensure the quality of the investigation and calculation methods, it seems vital that we carry out demonstration operations on a small number of representative buildings. This is not just for the satisfaction of checking that we have worked well, but to provide solid ground for the following phase of feasibility studies, and to gain the confidence of the project owners. Feasibility studies for large-scale programs can be carried out for example by ESCOs, if these are called on to intervene, or directly financed by project promoters. It would seem indispensable to encourage such studies, as well as energy audits, which constitute the first phase of these studies, through public financial incentives, in order to create a dynamic for implementing large-scale programs.

A twofold need has emerged with respect to institutional and financial questions.

On the one hand, it seems necessary to re-discuss and clarify the way in which public authorities can play their role in terms of promotion and organization by setting up a "platform" bringing together the public and private stakeholders of a program for energy efficiency in buildings.

On the other hand, the conditions for implementing specific financial mechanisms tailored to different types of projects need to be streamlined by organizing a dialogue between the project owners, energy service providers and financial institutions around projects targeting concrete results.

Knowing and understanding diversity and turning it to advantage, organizing articulation and encouraging initiatives, ensuring the complementarity of powers and responsibilities, and making convergence a success: this is the challenge.

Thank you.

Conférences & Séminaires

Acronyms and Abbreviations

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AC	Air-conditioning
ADB	Asian Development bank
ADEME	French Environment and Energy Management Agency
AFD	*Agence Française de Développement* (French Development Agency)
AHU	Air handling unit
BAU	Business as Usual
BEA	Berlin Energy Agency
BGK	Gospodartswa Krajowego Bank (Poland)
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CC	Climate Change
CCS	Certified Coding Specialist
CDM	Clean Development Mechanism
CEE	Energy Savings Certificate *(French acronym)*
CIE	International Commission on Illumination *(French acronym)*
CO_2	Carbon dioxide
COP	Coefficient of performance
CPE	Energy performance contracts *(French acronym)*
CPPCC	Chinese People's Political Consultative Conference
Cumac	Accumulated and discounted *(French acronym)*
DD	Degree-day
DEDE	Department of Alternative Energy Development and Energy Efficiency (Thailand)
DSM	Demand-side management
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EPC	Energy Performance Contracting
EMCO	Energy Services Company in China
EMCA	The China Energy Conservation Association
ENCON	Energy Conservation Promotion
ESCO	Energy Services Company
EU	European Union
FCM	Federation of Canadian Municipalities
FGEF	French Global Environment Facility
GEF	Global Environment Facility
GHG	Greenhouse gases
GDP	Gross Domestic Product

GMEF	Green Municipal Enabling Fund
GMIF	Green Municipal Investment Fund
GMF	Green Municipal Fund
HVAC	Heating ventilation and air-conditioning
IBRD	International Bank for Reconstruction and Development
IEA	International Energy Agency
IFC	International Finance Corporation
IPCC	International Panel on Climate Change
IPO	Initial public offering
IPMVP	International Performance Measurement & Verification Protocol
Kgce	Kilogram of standard coal equivalent
kW	Kilowatt
kWh	Kilowatt-hour
kWhPe	Kilowatt-hour of primary energy
LEB	Low-Energy Buildings
LEED	Leadership in Energy and Environmental Design
MW	Megawatt
MEEDDAT	French Ministry of the Environment, Energy, Sustainable Development and Town and Country Planning
MMTCE	Million metric tons of carbon equivalent
MTCE	Metric tons of carbon equivalent
Mtoe	Million tons of oil equivalent
OECD	Organisation for Economic Cooperation and Development
PICO	Public internal performance commitment
PPP	Public private partnership
RMB	Renminbi or yuan (Chinese currency)
SHGC	Solar Heat Gain Coefficient
SME	Small and medium enterprise
SO_2	Sulphur dioxide
SOE	State-owned enterprise
tce	Ton of standard coal equivalent
toe	Ton of oil equivalent
TWh	Terawatt-hour
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Program Finance Initiative
USA	United States of America
VAT	Value-added tax
VRV	Variable refrigerant volume

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What is AFD ?

AFD stands for Agence Française de Développement. AFD is a public development finance institution that has worked to fight poverty and support economic growth in developing countries and the French Overseas Communities for almost 70 years. AFD executes the French government's development aid policies.

Through offices in more than fifty countries and nine French Overseas Communities, AFD provides financing and support for projects that improve people's living conditions, promote economic growth and protect the planet: schooling, maternal healthcare, help for farmers and small business, water supply, preservation of tropical forests, and fighting climate change, among other concerns.

In 2009, AFD committed more than €6.2 billion to financing aid activities in developing and emerging countries and the French Overseas Communities. The funds will help vaccinate 1.8 million children, improve drinking water access for 7.3 million people and support 900,000 private sector jobs, while energy efficiency projects save nearly 5 million tons of carbon dioxide emissions per year.

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Implementing Large-Scale Energy Efficiency Programs in Existing Buildings in China

Collected papers of the conference organized by Agence Française de Développement and the Commission of Housing, Urban and Rural Development of the Hubei Province, in Wuhan (China), on May 12-13, 2009

In the context of climate change and continuously growing dependence on imported energy, the Government of China has set the ambitious objective of reducing the energy intensity of the Chinese economy by 20% between 2006 and 2010.

Although energy efficiency, especially in the fast growing building sector, appears critical to all Chinese Provincial Authorities in reaching this objective, the novelty of the subject raises many issues. How can large scale energy efficiency retrofitting programs be carried out in the short run? Which technical solutions shall be implemented? How much would they cost? Which institutional set up should be put in place? Which financing tools or mechanisms should be developed?

The papers presented during the Wuhan conference attempted to provide answers to these difficult and topical questions, which constitute some of the most burning issues for all governments aiming at reducing their greenhouse gas emissions worldwide. These papers summarize the results of a three-year research program carried out by the Commission of Housing, Urban and Rural Development of the Hubei Province and Agence Française de Développement, with the support of the French Agency for Environment and Energy Management.

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