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Articles

Shanghai's Commercial Building Energy Policies & Practices

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Abstract

Research estimates that Shanghai's commercial buildings stand to become a key challenge with regard to energy use and CO_2 emissions as compared with other major Asian cities. Large-scale commercial buildings, particularly, consume the most energy and CO_2 emissions per square meter among all types of buildings in Shanghai. This paper examines Shanghai's building energy policies and practices for large-scale commercial buildings and evaluates if they achieve the so-called "co-benefits" approach. To define and apply the co-benefits approach to the building case studies in Shanghai, building co-benefits analytical frameworks will be provided followed by two case studies, including Shanghai IKEA and Plaza 66. These are classified as significant large-scale retrofitting cases in Shanghai with advanced energy efficient technologies and building energy management mechanisms. Relevant building energy-saving policy instruments at national and local levels for commercial buildings are reviewed, to further explore policy drivers in the case studies. Moreover, detailed building energy savings, CO_2 reductions, and management cost reductions based on data availability and calculations are presented with the co-benefits approach. The paper additionally analyzes different interventions and factors that facilitate or constrain the implementation process of co-benefit effectiveness in each case building. Furthermore, a multi-scale analytical framework is employed to investigate relevant stakeholders that shape Shanghai's commercial building energy governance. Policy recommendations and implications are offered at the close of this paper.

Keywords: *co-benefits approach, large-scale commercial buildings, building energy efficient technologies, building energy management, multi-scale analytical framework*

Introduction

Challenges of Building Energy Governance in Urban China

China has experienced rapid and widespread urbanization at a scale never seen before in history. However, according to Lin (2002), China's urban structural change is a dual-track system of urban settlements integrating large city dominance at the top with rapidly expanding small cities and towns at the bottom. Although large and extra-large cities have declined relatively in terms of the growing urban population in China, massive built-up areas and infrastructure development among these large and extra-large cities along the eastern coast have reconsolidated the dominance of China's urban development pathway.[1] These cities contribute greatly to the Chinese national economy with massive commercial energy consumption and CO_2 impacts. Therefore, a better understanding of urban energy use in these advanced cities is essential for Chinese decision-makers at various levels in order to adequately address energy security, climate change mitigation, and local pollution abatement (Dhakal, 2009).[2] Moreover, China is experiencing an extraordinary building boom (Butera, 2008; Lang, 2004)[3]. Economic expansion and migration from rural areas to cities not only alter China's urban infrastructure and built environment, but also cause urban building energy governance challenges for Chinese cities. However, although building energy efficiency efforts have been pursued by the Chinese government since the early 1980s (Lang, 2004), the effectiveness of building energy efficiency policies and sustainable building initiatives is far from satisfactory (Zhong, 2005). The low local implementation rate of national and local policies reveals the barriers and the enforcement gap that exist for urban building energy governance in China (Zhong, 2005). Moreover, local regulation duplicates the content of national law, and does not provide rules and guidance specifically tailored to the local jurisdiction (Yao, Li and Steemers, 2005). Therefore, it is essential to investigate and evaluate existing building energy policies and practices to reduce energy consumption and strengthen low-carbon management in modern urban China.

Shanghai's Commercial Buildings

Under global and local forces, Shanghai has functioned not only as the most important center of the Chinese national economy, but also as the most attractive

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[1] Among all cities, large and extra-large cities (in the study, large cities refer to an urban population between 0.5-1 million; extra-large cities refer to an urban population of more than 1 million) received more than 60% of all fixed assets capital invested in cities in the 1990s. More than 63% of the fixed assets investment in cities was directed to the Eastern region. Among the special economic zones, open coastal cities, and open economic regions, Shanghai has been selected by the Chinese government as a new growth center, thus receiving the largest increase in fixed assets investment between 1990 and 1998 (Lin, 2002).

[2] Dhakal examined 35 cities in China that represent provincial capitals as well as cities mentioned in the national plan and found that they have a disproportionate influence on China's energy and economic activity. These highly urbanized and economically significant cities claimed only 18% of China's population but produced 41% of GDP, consumed 40% of commercial energy, and contributed 40% of national CO_2 emissions in 2006 (Dhakal, 2009).

[3] China's Ministry of Housing and Urban-Rural Development (MOHURD) estimates that China has 40 billion square meters of existing buildings and is adding an additional 2 billion square meters of floor area each year, a number almost half the global total (Asian Business Council, 2008; Li, 2007). Besides accounting for the world's largest construction market, more than one-half of these structures are being developed in cities (Lang, 2004). According to data from the World Bank (2001), more than one-half of China's urban residential and commercial building stock in 2015 will be post-2000 construction. The growth in urban building stock coincides with rising building energy consumption. In addition, urban households usually exhibit higher energy demand than rural households (Li, 2007).

locus for foreign investment in China. Since the implementation of China's open policy in 1979, the "oriental pearl" has quickly emerged as the most important locale for many multinational corporations to set up their regional headquarters in China. Meanwhile, Shanghai is engaged in constructing giant iconic buildings and large development projects, enhancing city branding, and regenerating a new city skyline for global competition. Figure 1 demonstrates the changing urban skyline of Shanghai from 1978 to 2009. Shanghai's building stocks are increasing exponentially.

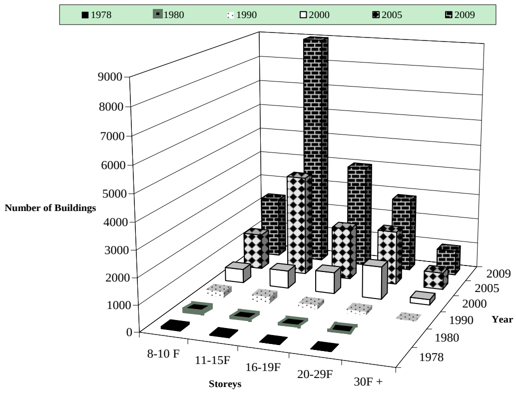

Figure 1: Changing Urban Skyline of Shanghai (1978-2009)

Source: Shanghai Statistics Yearbook 2010, Shanghai Municipal Statistics Bureau, 2010

Although the development of residential building construction has occurred rapidly in Shanghai, energy consumption from commercial buildings is occurring at a faster rate than that of residential buildings in recent years. Commercial buildings also account for a higher share of electricity consumption in Shanghai, while residential buildings account for a higher share at the national level (see Table 1). With only 37% of the total area, the commercial sector consumes around 70% of total energy in the whole building stock of Shanghai (Jiang & Tovey, 2010; Shanghai Municipal Statistical Bureau, 2008). Hence, it is urgent to investigate and assess existing commercial building energy policies and practices in Shanghai.

Table 1: Consumption by Shanghai's Building Sector

Building Category	Energy Consumption (10,000 tec)				Electricity Consumption (billion kWh)			
	China		Shanghai		China		Shanghai	
Commercial	10,932.6	36.2%	700.7	55.0%	1,534	40.7%	169.2	65.1%
Residential	19,268.4	63.8%	573.2	45.0%	2,238	59.3%	90.6	34.9%
Sum	30,201.0	100%	1,273.9	100%	3,772	100%	259.9	100%

Source: Yang & Tan, "Research on Building Energy Consumption Situation in Shanghai," 2006

When one further analyzes different building types, it becomes evident that China's large-scale commercial buildings account for 7.5% of total building area but are responsible for 20% of electricity consumption (Pan et al, 2010). Table 2 and Figure 2 both indicate that large-scale commercial buildings have the highest energy consumption per square meter (70-300 kWh/m^2.a) among all types of buildings. Therefore, large-scale commercial buildings have become major targets of action for both national and local energy saving agendas.

Table 2: China's Building Energy Consumption (BEC)

Building Type		Area (bm^2)	Annual Energy Consumption (10^4 tce)	kWh/m^2.a
BEC in Rural Area		24	19200	7.5 ~ 15
Heating in Northern Area		6.5	12740	57
BEC except Heating	Resid ential	10	7820	10 ~ 30
	Ordinary Commercial	5.5	9470	20 ~ 60
	Large Commercial	**0.5**	**1760**	**70 ~ 300**
	Urban Total	16	130 Mtce	52
Total		40	51730	30

Source: Lin, China Building Energy Conservation Report, 2008

Note: "tce" stands for tonne of coal equivalent and "bm²" stands for billion square meters

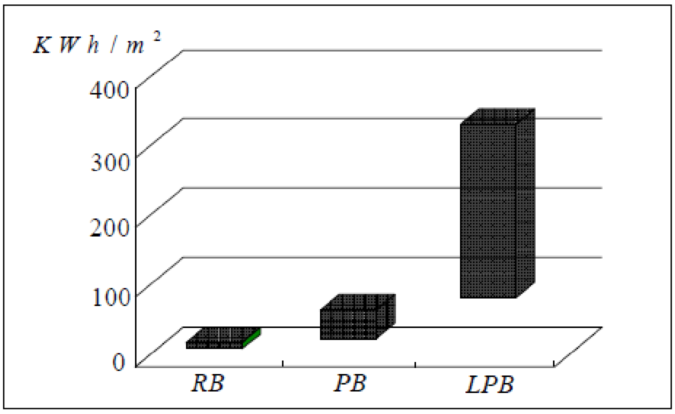

Figure 2: Electricity Consumption in Buildings

"RB": Residential Buildings; "PB": Public Buildings "LPB": Large-scale Public Buildings (Large-scale Commercial Buildings)[4]
Source: Cai, Lin & Feng, "Improving Energy-Efficiency in Public Buildings in China: Challenges and Solutions," 2009

4 China's building energy regulation system is divided into civil and industrial subsectors; the civil subsector is further divided into residential and commercial (public) buildings. China's commercial buildings include department stores,

In Shanghai, large-scale commercial buildings have been growing rapidly since 1990 (Li et al, 2005). Table 3 presents building energy consumption in Shanghai's large-scale commercial buildings. Among types of large-scale commercial buildings, average energy consumption is the highest in shopping malls (see Table 3). The following case studies select Shanghai IKEA and Plaza 66, for an investigation and assessment of their efforts on building energy saving measures with the co-benefits approach. Moreover, the paper further explores commercial building energy policies and practices at the city scale. Findings and policy implications are intended to facilitate commercial building energy governance in other fast growing second-tier or third-tier cities in China, and to further contribute to the general body of knowledge on urban building sustainability.

Table 3: Building Energy Consumption in Shanghai's Large-Scale Commercial Buildings

Building Type	Office	Hotel	Shopping Mall	Mix
Mean Energy Consumption (kWh/m^2)	114	169	229	154

Source: Xu et al, "Analysis on Energy Consumption Statistics Data of Large-Scale Public Buildings in Shanghai," 2010

Research method and Analytical Frameworks

The paper utilizes qualitative methodology in the form of the case study in order to explore, analyze, and evaluate commercial building energy policies and practices in Shanghai. The sources of data applied to this study include professional books, journal papers, official publications, and internet materials. Shanghai fieldwork and relevant interviews with national/local policy makers, professionals and researchers have been applied as background information and case study resources. As an introductory note, the authors of this paper would like to point out that Chinese researchers and officials traditionally perceive "operational building energy use" as "building energy use" (Zhong, 2005). Therefore, this research mainly focuses on the operational phase of the building life cycle in Shanghai's large-scale commercial buildings, which include those with more than 20,000 square meters of floor space. Below is a brief introduction of the three analytical frameworks adopted by the study.

Co-Benefits Approach

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supermarkets, rental offices, apartments, hotels, restaurants, banks, post offices, airports, rail stations, and buildings used for education, science, research, medicine, sports, and communication services (Lang, 2004).

The research model employed for this paper analyzes two case buildings with the co-benefits approach, according to data availability. Local climate change mitigation through building energy efficiency can not only reduce energy use and CO_2 emissions, but may also improve local and regional air quality, particularly in large cities. Beyond the general synergies between improved air quality and climate change mitigation, improving building energy efficiency can further improve economic efficiency through increased productivity and retail sales (WBCSD, 2011). Moreover, enhanced building energy efficiency can reduce local governments' energy consumption as well as energy bills for residents and firms. Such benefits can be a good incentive to retain business and development in a particular locale. Furthermore, improving end-use energy efficiency is among the top priorities for increasing energy security (European Commission, 2003). Therefore, additional co-benefits of improved building energy efficiency and building-integrated distributed electricity generation include improved energy security and system reliability (IEA, 2004; WBCSD, 2011). Besides the above benefits, building energy efficiency and renewable energy technologies can substantially improve indoor air quality, contributing to public health.

Building Energy Policy Instruments

This paper categorizes Shanghai's commercial building energy policy instruments into three policy types. "Regulatory and control instruments" include building codes and standards and other mandatory programs and policies. "Market-based instruments" and fiscal incentives include cooperation with energy service companies and financial support for the purchase of energy efficient appliances or green buildings, or subsidies for renewable energy applications. "Support, information and voluntary action" aims at persuading residents to change their behavior by providing information and examples of successful implementation.

A Multi-Scale Analytical Framework

In addition to static policy instruments, the research model discusses major factors that affect Shanghai's building energy governance. One factor pertains to a mayor's willingness and leadership. Another factor concerns the level of each city's local decentralization: Does city government have local autonomy on building energy governance or does the national government still exercise authority over local specific functions? In terms of interdepartmental relationships, which department or departments are in charge of commercial building energy-related issues? Also, are other policy actors in the private sector or the voluntary sector involved in Shanghai's building energy governance system? Does the city government participate in any transnational urban networks for regional and global interaction and cooperation on climate change mitigation that further bring positive influence to building energy governance? All of these factors are discussed in the following sections.

Shanghai's Building Energy Administration and policy instruments

Building Energy Administration

This section introduces Shanghai's commercial building energy administration and relevant policy instruments. China has a centralized building energy administration system. The Ministry of Housing and Urban-Rural Development (MOHURD) under the State Council coordinates and develops China's building energy policies and regulations. Although MOHURD is responsible for directing and supervising national building energy policies and regulations, policy enforcement is undertaken by local governments through their construction administration departments. The construction administration departments simultaneously report to the local governments and to the local branches of MOHURD. Local governments can choose to either comply with the national codes or adopt more stringent local codes (Lang, 2004). MOHURD supervises and oversees the Shanghai Municipal Urban and Rural Construction and Transportation Commission (URCTC) and the Construction Commissions of Districts and Townships. The Shanghai Municipal Government (SMG) and Shanghai Municipal Urban and Rural Construction and Transportation Commission (URCTC) need to follow MOHURD's policies and regulations. The District/County Construction Bureau and Township Construction Manager must follow URCTC's direction. A group of departments under the SMG explains the interdepartmental relationship characterizing Shanghai's building energy administration (see Figure 3). The URCTC plays the major role in Shanghai's building energy administration. The Finance Bureau initiates economic incentives and is responsible for energy use by financial institutions. The Education Commission accounts for schools, while the Tourism Association addresses hotels, the Health Bureau deals with hospitals, and the Commission of Commerce covers stores and shopping centers, etc. The State-Owned Assets Supervision and Administration Commission and the Government Offices Administration Bureau are in charge of public or municipality-owned buildings.

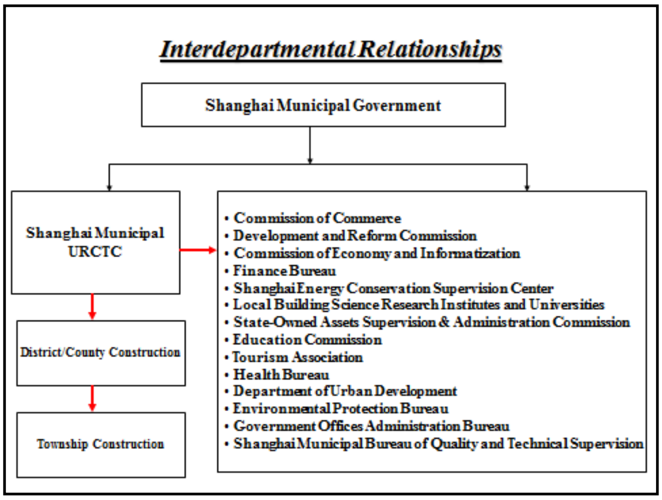

Figure 3: Shanghai's Building Energy Administration

Building Energy Policy Instruments

In terms of regulatory and control policy instruments, the SMG followed MOHURD's guidelines and initiated the same or more ambitious targets for its building energy policies and regulations. The SMG, in 2007, as part of the *Implementation Plan for Energy Conservation and Emission Reduction*, committed to a binding energy-saving standard for new buildings. The standard called for a 50% reduction in the energy used by new buildings that will likely become a 65% standard. New construction failing to meet the standard would not receive a construction permit. In addition, the *Shanghai Energy-Efficient Building Design Standards* guide encourages contractors to use energy-efficient materials and to adopt energy saving technologies for heating, cooling, ventilating, and lighting public buildings. Moreover, the SMG issued the *Administration Procedures of Shanghai Municipality on Building Energy Conservation* (Shanghai Procedures) to strengthen the administration of building energy conservation and to foster use of energy efficient materials for buildings. The Shanghai Procedures encourage mandatory energy conservation standards to be met in all stages of building construction, from design to supervision. The promotion of strengthened supervision and administration by municipal and district administrative departments of construction by the Shanghai Procedures demonstrates that Shanghai has sought to establish an energy efficiency supervision system for government office buildings and large public buildings (APERC, 2009). The newly released *Regulation of Shanghai Building Energy Conservation,* put into effect in 2011, includes the most comprehensive energy policies for the building sector in Shanghai. Meanwhile, in terms of economic and market-based policy instruments, Shanghai in 2008 launched its own marketplace for environmentally-related financial products. The Exchange initiates domestic trading schemes related to pollution discharge rights, starting with sulphur dioxide and chemical oxygen demand. The Exchange aims at expanding soon to include carbon dioxide under a voluntary trading scheme in a pilot phase, targeting the Building Sector. Further developments are likely under the 12th Five-Year Plan (World Energy Council, 2010). Moreover, the SMG has provided funding and subsidies for the development and application of renewable energy projects and energy efficiency technologies for buildings. Yet there remain limited commercial building energy regulatory/control instruments and market-based incentives, and the SMG has adopted many support/information/voluntary building energy instruments. Shanghai's building energy savings have caught the national government's attention since China's 10th Five-Year Plan[5]. The 11th Five-Year Plan touched on Shanghai's building energy saving management and eco-construction

[5] China's Five-Year Plans are a series of economic development initiatives shaped by the Communist Party of China through the plenary sessions of the Central Committees and national congresses. The 1st Five-Year Plan ran from 1953-1957. The 12th Five-Year Plan (2011-2015) was hailed as the "Greenest FYP in China's History," and contains one-third of the social and economic objectives relating to natural resources and environmental issues, aiming to build sustainable development practices into Chinese industries.

efforts. Moreover, in order to facilitate the promotion of energy efficiency, Shanghai was the first city in China to launch a “green standard” in construction. Shanghai also initiated the “Garden Lane” project, an urban renewal project based on energy efficiency building principles. Eighteen older factory buildings in the area were renovated with efficiency standards pursuant to the Leadership in Energy and Environmental Design (LEED) international green architecture standards and the Chinese 3A Green Building Efficiency Standard. The SMG also proposed a “Green Lighting” project for reducing electricity consumption for lighting in commercial buildings. In terms of renewable energy applications, the Shanghai Green Electricity Scheme offers electricity consumers in Shanghai the opportunity to “green” their usage by buying some amount of renewable electricity.

Overall, while the SMG has offered fewer control and regulatory building energy policy instruments, the recently passed and implemented Regulation of Shanghai for Building Energy Conservation reveals the local authority has paid close attention to this pressing issue and has started to take mandatory action. The SMG also took the lead on the clean development mechanism for the building sector in China. Moreover, many support and voluntary plans and demonstrations relate to building energy governance in Shanghai. Recently, SMG proposed different evaluation standards and incentives for the building sector to reduce energy consumption. Shanghai’s building evaluation standard will prioritize considerations not only for the actual energy reduction amount but also the social benefits regarding the demonstration/ diffusive effects from the building’s energy saving initiatives. Under a top-down governance model, Shanghai has autonomy for more ambitious building energy saving initiatives. However, the fragmented building energy administration under SMG needs better coordination and cooperation.

Case Analysis

This section presents relevant energy efficiency technology applications and building energy management measures in Shanghai from two case studies: the IKEA and Plaza 66. The paper asks how the role of private building management interacts with Shanghai’s government and civil sectors in relation to building energy sustainability to form multi-sector networks in the governance structure. Although both cases are classified as China’s large-scale commercial buildings, they represent different building structures and energy management measures for further examining Shanghai’s building energy practices.

Retrofit Projects	**Energy Reduction Benefit (MWh)**	**CO2 Emission Reduction Benefit (tCO_2)**
179 Metal Halide Lamp (400W) →Promise Light (200 W)	300	264.75

79 Metal Halide Lamp (250 W) →Promise Light (150 W)	38	33.54
2900 HID Spotlights (20W) → Halogen Spotlights (30W & 50W)	424	374.18
5 Escalator VVVF	196	172.97
Central Solar Hot Water Module on roof (17→40 tons/day)	170	150.03
4 HCU and ERV for HVAC System	60	52.95
Split Circuit for Lamp Wiring	8	7.06
Improve Natural Ventilation	100	88.25
Lighting Retrofit at Parking Lot	488	430.66
Light Control and Infrared Motion Sensor Switch for Lighting Retrofit	11	9.71
Total	**1657 MWh**	**1462.30 tCO_2**

Table 4 Co-Benefits Calculations (2009-2010)

Source: Shanghai IKEA (Weng, 2011)

Shanghai IKEA

At 35,000 square meters, Shanghai IKEA is located in Xu-Hui District. Influenced by the Netherlands' Owner- Stichting INGKA Foundation, the Shanghai store not only inherits the corporation's green and sustainable values but develops its building energy practices as led by its interior energy management team. Below are relevant building energy saving measures:

- IKEA Goes Renewable (IGR) Program
  IKEA has launched the "IKEA Goes Renewable (IGR)" program and has mainly focused on reducing energy consumption throughout the company by 25%, compared to the 2005 level by 2010. The long-term goal is to operate 100% on renewable energy.

- Energy Consumption Database
  IKEA followed a mandatory energy usage checklist introduced by headquarters in 2006 to raise awareness of current energy use, to monitor work, and to enable internal energy audits to be conducted. The checklist, also known as "Webess," makes it easier to compare energy usage among global IKEA buildings and to exchange experiences, and will be followed up on a regular basis (Evans, 2009)[6]. Electricity and heating costs are entered by the facility manager at each store, and comparisons are made over a three-year period. Store and facility managers review the information each month, with discussion at store meetings. The goal is to gain an overview on the regional level by examining IKEA buildings in a specific country, and on the global level, by comparing results of current consumption levels, challenges and possible improvements across

[6] Webess is an IT application used by IKEA buildings for reporting energy consumption and emissions, and for benchmarking with other IKEA buildings. Webess records electricity, fuel oil, gas, water and other types of energy consumption. It also provides information about how much renewable energy is used per cubic meter, as well as the level of carbon dioxide emissions caused by building operations.

IKEA buildings worldwide. A third-party European company, Vitech, runs the program for IKEA stores around the world.

- IKEA Building Standards
  IKEA has developed a building standards document for renewable energy use and for energy reduction in IKEA buildings. The aim of the building standards is to establish construction methods for new IKEA buildings that run solely on renewable energy. For existing buildings, the standards document offers suggestions on how to replace traditional heating and cooling equipment with equipment adapted to renewable energy requirements.

- Energy Efficient Technology
  From 2009-2010, Shanghai IKEA has initiated several retrofit projects to enhance building energy efficiency, including lighting, air-conditioning, and escalators. Table 4 represents project details and relevant energy reductions and CO_2 emission reductions.

- Renewable Energy Application
  A Central Solar Hot Water Module has been installed on the rooftop for dishwashing and employees' bathing needs.

- Internal Training and Education
  The energy management team has regularly held internal staff training and environmental education to raise employee energy saving awareness. In addition, the "IKEA Retail China Energy Efficiency Rewarding Program" as an interior incentive can promote each store's energy efficiency.

- Engage with NGOs and Local Community
  Shanghai IKEA has cooperated with the World Wildlife Foundation's low carbon projects and has actively participated in local community environmental protection activities and promotion, such as Earth Hour activity.

Because of the above retrofitted energy projects and energy management practices, Shanghai IKEA's energy consumption has decreased steadily from 2004-2009. Energy efficiency has improved, measured by the total energy use per sold cubic meter of product in stores. The less energy consumed per sold cubic meter, the more energy efficiency is improved. The growth rate of Shanghai IKEA's energy efficiency accordingly has increased from 16% to 33% (see Table 5).

Table 5: Shanghai IKEA's Energy Efficiency

Year	04	05	06	07	08	09
Electricity Consumption (10,000 kWh)	953	882	851	839	817	800
Energy Efficiency (kWh/m3 sold)	99	67	60	54	49	45
Growth Rate of Energy Efficiency (Base year: 2005)			16%	19%	27%	33%

Shanghai Plaza 66

At 327,000 m^2, Shanghai Plaza 66 is comprised of a shopping mall and two office buildings. Located in Jing-An District, Plaza 66 is owned and developed by the Hong Kong company Hang Lung Properties, with an interior energy management department. Relevant building energy saving measures are as follows:

- Corporate Value
  Hang Lung aims to build low-carbon and sustainable buildings. Senior management is actively engaged in determining and implementing corporate strategies for sustainable development. An "Environmental Project Team" (EPT) consisting of 40 cross-departmental representatives is set up to engage staff at different levels in environmental and energy efforts, including building energy efficiency.

- Energy Auditing & Monitoring System
  Plaza 66 has invited a local research institution - the University of Shanghai for Science and Technology - to conduct a comprehensive energy audit report. Relevant analysis ensures Plaza 66's sustainable development and helps to formulate an action plan to further reduce its carbon footprint. The company also set up guidelines and monitoring systems on using at least 20% recycled materials. Moreover, the target extends to the use of at least 20% locally produced materials in the construction process.

- Energy Efficient Technology and Management
  In order to lower management costs and maintain low carbon emissions, Plaza 66 has developed several energy saving initiatives (see Table 6). These programs include the use of energy efficient lighting as well as the replacement of air-conditioning systems with more efficient water-cooled versions. Plaza 66 also maintains indoor temperatures of the shopping mall within a range of 23 to 23.5 degrees Celsius, with office buildings between 25 to 25.5 degrees Celsius.

- International Benchmarks and Certification
  Hang Lung Property seeks a gold rating under the LEED core and shell certification issued by the U.S. Green Building Council, for all developments.

- "Green is All Around" Campaign
  Plaza 66 is one of the corporate buildings participating in the "Green is All Around" campaign, which aims at improving internal air quality while also providing tenants and shoppers with more pleasant and healthy surroundings. The building allocates at least 17% of its area to the development of green spaces.

- Staff Awareness Raising
  The corporation launched an internal "Energy Saving Competition" to promote sustainability and to look for innovative energy saving ideas among staff.

- Engage with NGOs and the Community
  Hang Lung Property supports work with relevant organizations such as the World Wildlife Fund and the Jane Goodall Institute through sponsorships of sustainability projects. It organizes and participates in a range of community events through a corporate sustainability program. In addition, the corporation joined the worldwide awareness campaign "Earth Hour," turning off the lights to help fight climate change.

  Government Relationships
- Hang Lung Property maintains ongoing dialogue with provincial, municipal, and district governments to enhance understanding in local regulations. Moreover, Plaza 66's sustainable practices have won the SMG's "Leading Project in the Advancement of Energy Saving Technologies in Shanghai" award, as the city's demonstration project.

Table 6: Co-Benefits Calculations

Retrofit Projects	Energy Reduction Benefit (kWh)	CO2 Emission Reduction Benefit (kg)
Adding Frequency Conversion of Chillers	765,336-803,023	535,735.2-562,116.1
Retrofitting Electric Heating System → Gas Boiler During Winter	1,083,184	758,228.9
Adjusting Frequency Conversion of Cooling Water Pumps	738,000-1,266,000	516,600-886,200
Regulating Water Flow	208,728	146,109.6
Retrofitting Lighting	3,321,000	2,324,700
Improving VMC System and Surrounding Condition of Chiller Cooling Tower	1,232,673	862,871.3
Total	**6,441,387-7,007,073 kWh**	**4,508,971-4,904,951 kg**

Source: Shanghai Plaza 66 (Liu, 2011)

As one of Shanghai's leading commercial landmarks, Plaza 66 is managed with sustainable building practices. Table 7 indicates CO_2 emission changes from 2005-2009.

Table 7: CO2 Emission Reductions in Plaza 66 (2005-2009)

Year	Building Area m^2	CO_2 kg/m^2	Emission Change %	Note
2005	200,000	161.83	-	Baseline
2006	200,000	170.03	+5.1%	
2007	310,000	135.38	-20.4%	* Retrofit projects began this year
2008	310,000	142.23	+5.1%	* All stores at the shopping mall full rent this year; Area of business function increased
2009	313,500	137.70	-3.2%	* Change of Building Function in 2009: changed the parking lot at the basement to the shopping stores. Business area increased, but efforts have continued for energy efficiency retrofit work to mitigate carbon emissions

Source: Shanghai Plaza 66 (Liu, 2011)

Results

Following the introduction of Shanghai IKEA's and Plaza 66's building energy practices, this section provides case analysis with the co-benefits approach according to data availability. Besides the actual co-benefits calculation, potential co-benefits are discussed as well. Moreover, relevant intervention and policy drivers and actors for the implementation process are discussed.

Co-Benefits Calculation

In terms of energy reduction benefits and CO2 emissions reduction benefits, IKEA adopted several retrofit projects from 2009-2010. Most are related to lighting, including energy efficient lighting replacement (promise lights and halogen lights) and lighting control systems. Lighting retrofit projects are responsible for more than 75% of total reduction benefits (1,261,000 kWh from energy reduction and 1,113,000 kg from CO_2 emission reductions, respectively). In addition, escalator retrofitting and solar hot water module installment on the rooftop also contributed a 366,000 kWh energy reduction and a 323,000 kg CO_2 emission reduction. Overall, total retrofit projects contributed to an energy reduction benefit of 1,657,000 kWh and a CO_2 emission reduction benefit of 1,462,300 kg, which are beneficial to local air quality and climate change mitigation. Moreover, in terms of economic benefit, relevant management costs savings were 1,022,369 RMB (see Table 8).

Table 8: Actual Co-Benefits from Case Buildings

Co-Benefits Effects	Economic Benefit	Energy Reduction Benefit	GHG Reduction Benefit
	Management Cost Reduction (RMB)	Energy Reduction (kWh)	CO2 Reduction (kg)
IKEA	1,022,369	1,657,000	1,462,300
Plaza 66	3,974,336~ 4,323,364	6,441,387~ 7,007,073	4,508,971~ 4,904,951

As for potential co-benefits, according to Shanghai IKEA's interior data, electricity consumption dropped from 9,530 MWh to 8,000 MWH. In terms of economic benefit, total energy use per sold cubic meter in Shanghai IKEA dropped from 99 kWh/m^3 to 45 kWh/m^3. This evaluation indicator, designed for measuring energy efficiency in each IKEA store, also presents Shanghai IKEA's enhanced productivity and retail sales. Furthermore, Shanghai IKEA has kept improving end-use energy efficiency through energy efficient technologies and energy management mechanisms, which could contribute to energy security benefits in the long run. Building energy efficiency and renewable energy technologies applied to the Shanghai store can substantially improve indoor air quality, as well.

Plaza 66, in the face of soaring energy bills and management costs, saw property management start and continue energy efficiency retrofit projects in order to reduce energy consumption, carbon emissions and management costs since 2007. Although the trend of total CO_2 emission reduction is not steady because of the completion and use of the second office building, the rental condition of office buildings, and an area increase of business function, CO_2 emissions per square meter still dropped from 161.83 kg/m^2 to 137.70 kg/m^2 from 2005-2009. In 2008, Plaza 66 undertook six retrofit projects, and actual co-benefits included 6,441,387~7,007,073 kWh of energy reduction, 4,508,971~4,904,951 kg of CO_2 emission reductions, and 3,974,336~4,323,364 RMB of electricity cost reductions (see Table 8). Similar to Shanghai IKEA, lighting retrofit projects contributed the most reductions, followed by VMC system and heating system improvements.

Besides the actual co-benefits described above, potential co-benefit effects of Plaza 66 could generate the following energy saving measures:

Table 9: Potential Energy Saving Measures in Plaza 66

Improving Air-Conditioning System • Add frequency conversion of chillers • Adjust frequency conversion of cooling water pumps • Improve frequency conversion of cooling water system • Improve surrounding condition of chiller cooling tower
Improving Heating System • Retrofit Electric Heating System in Winter
Improving Insulation • Glass Windows film

Indoor Green Space • Green Vegetation

Source: Shanghai Plaza 66 (Liu, 2011)

Energy security benefits and in-door air quality are potential co-benefits generated from Plaza 66's continuous building energy saving efforts.

Policy Drivers/Factors

Relevant policy drivers and factors will be analyzed in this section. At the micro level, the particular policy interventions and important factors implemented in the two case buildings will be discussed. The macro level will analyze the multi-scale governing framework that includes dynamic relationships that exist among relevant stakeholders who serve to facilitate or constrain the SMG's effectiveness on commercial building energy governance.

Micro-level

In terms of policy intervention, both IKEA and Plaza 66 were selected by SMG to install sub-meters in the buildings for further measuring and reducing building energy consumption. In addition, both buildings applied for energy efficiency special funding from SMG to subsidize relevant building energy efficient technologies. Moreover, IKEA has its own auditing system, "Global Webess," to facilitate the energy management team's recording of monthly energy consumption and periodic analysis of trends in energy use and CO_2 emissions. Plaza 66 cooperated with a local research institution to audit its building energy consumption and to provide energy savings and carbon reduction consultation. The IGR project also facilitates reducing IKEA building energy consumption and enhancing renewable energy use. Higher energy efficiency further benefits Shanghai IKEA's productivity and brings economic benefits along with energy/CO_2 emission reduction benefits. Plaza 66's "Energy Saving Competition" promotes sustainability and innovative energy saving ideas among staff.

The study also identifies important factors from the two case buildings that affect the implementation process of co-benefit effects. "Cost" refers to management costs (energy bills) and retrofitting costs (cost of energy efficient technologies). Property managers of both buildings pointed out that the major driver of their building energy practices was to lower energy management costs. Additionally, they will undertake more building retrofit projects if the cost of energy efficient technologies becomes more reasonable. However, "capacity and willingness of the energy management team" also plays an important role. Capable energy management staff can develop sound building energy practices. Their willingness is key to effective building energy practices. In China, still fewer property managers and energy management staff are actively and spontaneously working for building energy management. They are afraid of complaints from building users, in instances where some new technologies still are not mature enough or require a longer payback period. Therefore, "corporate value" and "leader support" become crucial factors for existing building energy practices in China. Both IKEA and Plaza 66 emphasize the value of sustainability and low-carbon practices to enhance their green branding. Relevant energy and environmental initiatives are from corporate top management. Moreover, both IKEA and Plaza 66 have engaged local environmental NGOs and research institutions to promote low carbon activities for local communities as their corporate social responsibility (CSR).

Macro-Level

Shifting from the micro-level analysis offered above, this section investigates relevant stakeholders (see Figure 4), with a multi-scale governing framework that includes the dynamic relationships that exist among relevant stakeholders who serve to facilitate or constrain the SMG's effectiveness on commercial building energy governance.

City Mayor's Willingness/Leadership:

Current Shanghai Mayor Han Zheng has announced a halt to the construction of projects with high energy consumption and the halting of electricity and water supplies to block high-energy consumption projects under operation. Han urges for energy saving buildings and fosters the use of a market mechanism to support energy saving services for the building sector. Under the stable governance of Mayor Han Zheng, who assumed office in 2003, SMG building energy policies are relatively predictable and long lasting, when compared with the experiences of some Chinese localities and mayors who have encountered varied institutional challenges within China's complex policymaking environment.[7]

Municipal Governance Capacity:

The competencies of municipal governments concerning their powers and duties are critical in shaping the capacity for urban energy governance (Betsill & Bulkeley, 2007). Shanghai is directly under the central government's rule as a level of government. The central government sets macro-policies and appoints top leaders under the hierarchy system. Overall, SMG has restricted authority in its jurisdiction's affairs. However, SMG has wide autonomy with respect to economic development, urban planning, infrastructure, civic facilities and budget. Being a leading city of China, the SMG has enough autonomy and support on urban building energy saving practices.

Public and Private Partnerships:

The SMG cooperated with Energy Service Companies (ESCOs) on large, existing office retrofit projects as successful demonstrations. However, it is critical to

[7] Although mayors are appointed to 5-year terms, many hold their post an average of just 30 months before moving on to their next assignment (Landry, 2008), making it difficult to sustain momentum on complex planning initiatives. This also forces mayors to focus on short-term victories, emphasizing progress on pressing daily challenges rather than strategies with a longer time horizon.

switch the government-led model towards a more market-driven mechanism. The SMG needs to provide more financial incentives to overcome financing barriers, in order to stimulate Shanghai's ESCO system towards a more market-driven one. Besides the promotion of the ESCO system, the private sector also provides technical support for Shanghai's green building and energy efficient projects through public-private partnerships.

Public and NGO Cooperation:

The World Wildlife Fund (WWF) launched a Low Carbon City Initiative in 2008, partnering with SMG to explore ways to marry economic development with the primary focus on improving energy efficiency in buildings (WWF, 2009). Some international environmental and energy NGOs cooperated and participated in building energy saving policies and projects in Shanghai.[8] The Shanghai Energy Conservation Supervision Center (SECSC), affiliated with the Shanghai Economic Commission, is the first non-profit energy conservation administration organization in China. The SECSC has taken an active part in the dissemination of energy conservation information, best practices, technological consultation and energy conservation training. The SECSC also has undertaken major activities regarding the development and implementation of Shanghai's building standards and regulations. Moreover, central and local building science research institutions and universities have provided significant technical support and assistance for reducing building energy consumption in Shanghai. Examples are the Shanghai Research Institute of Building Science and Tongji University.

Global City Peer Pressure:

After Beijing's Olympic Games, Shanghai's World Expo featuring the "Better City Better Life" slogan revealed its interest in the "green" wave of current global trends. In the process of holding the international event, Shanghai appeared more committed to building energy efficiency and energy saving regulations and supportive policies.

Transnational Municipal Networks:

Shanghai has joined the C40 and United Cities and Local Governments[9] for international cooperation and experience exchanges. Further evaluation is required on the effectiveness of joining these transnational municipal networks with regard to urban building energy governance.

[8] Those NGOs include the Energy Foundation; Natural Resource Defense Council; and Joint US-China Collaboration on Clean Energy (JUCCCE), among others.

[9] C40 is a group of global cities committed to tackling climate change. United Cities and Local Governments also has a climate change program for its member cities.

Other Stakeholders:

The relationship between landlord and tenant represents the common contradiction of "split incentives," meaning that the benefit of energy savings often does not go to the person who makes the initial investment.[10] Moreover, developers or investors who have the final decision-making authority on commercial buildings usually hinder the adoption of energy efficiency designs, technologies and practices because of cost considerations. They pursue short-term profit maximization and tend to emphasize the initial cost rather than the life cycle cost, because energy costs are irrelevant to them. A strict supervision system could create market opportunities for new, efficient technologies, while incentive policies could encourage developers to exceed the code. Therefore, the SMG should provide more incentives and policies to improve the common issue for tackling its growing commercial building energy consumption.

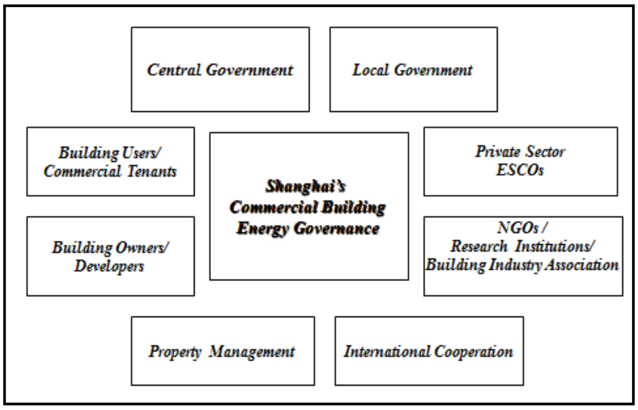

Figure 4: Relevant Stakeholders Analysis

Discussion and Conclusion

As China's leading global city, Shanghai has been under tremendous pressure to set an example in the areas of planning and development to meet emerging needs. As is characteristic of global cities, more and more large-scale commercial buildings are being constructed in Shanghai; these buildings are following the Urban North models with central heating/air-conditioning systems. Shanghai and other first-tier cities have different problems than the second-tier or third-tier Chinese cities, which have booming new construction projects. First-tier cities like Shanghai need to address significantly growing energy consumption and CO2 emissions from both new and existing commercial buildings. In particular, existing buildings comprise

[10] Landlords often purchase the heating and air conditioning equipment and other hard-wired equipment, while the tenant pays the utility bills. As a result, the landlord is typically not rewarded for investing in energy efficiency. Conversely, when the landlord pays the utility bills, tenants are typically not motivated to use energy efficiently.

the largest segment of this global city. Retrofitting existing commercial buildings, especially large-scale public or commercial buildings, becomes an important issue for Shanghai's building energy governance.

In general, Shanghai has established a good foundation towards better building energy governance. This status has led to more active public and private partnerships as well as cooperation between the public and NGOs. Moreover, retrofitting existing commercial buildings, especially large scale public or government office buildings, has become an important issue in Shanghai's building energy governance due to the large number of existing buildings in Shanghai. Therefore, the two case studies provide good examples in terms of building energy management in existing commercial buildings. The interaction among governmental agencies, private companies and civil society has not only shaped the two private companies' building energy management mechanisms, but has also brought positive momentum for Shanghai's building energy governance.

Some policy recommendations are provided for Shanghai's commercial building energy sustainability. In terms of regulatory and control policy instruments, the SMG basically followed the national government and the MOHURD guidelines. However, laws, regulations, standards and implementation rules with more stringent energy saving requirements could be issued and enforced by the SMG to address the enforcement gap in urban building energy governance. In addition, there are insufficient mandatory policies and regulations for existing buildings. The government should formulate corresponding reward and punishment mechanisms. Moreover, it is important to strengthen monitoring mechanisms among all levels of government for stricter compliance and enforcement.

Shanghai has limited municipal-led market-based incentives. Local demonstration projects often receive limited and unstable special funds and subsidies that have failed to promote long-term energy efficient building projects. Moreover, as mentioned above, developers, building owners, and building users have split incentives to improve energy savings and energy efficiency for buildings. Therefore, more market-based mechanisms are needed for Shanghai's commercial building energy governance. The growing energy conservation service industry should be encouraged continuously, and energy efficiency retrofit projects for large-scale public buildings should be kept a priority. Shanghai's proposal to set up a special fund (10 million RMB) for an interest subsidy should help to address this issue. However, it is even more important to create a new financing protocol with local banks and financial institutions to facilitate loans for energy efficiency projects.

In terms of building energy auditing in Shanghai, insufficient energy consumption statistics exist. Yet these statistics are required to enhance policy design and effectiveness and can be acquired through expanded surveys, monitoring and the establishment of meaningful baselines of building energy consumption and efficiency. Standardization of data gathering methodologies and greater public availability of data are needed to inform further policy design and monitoring. Moreover, building energy consumption data and data reporting methodologies should be made more transparent for better evaluation of policy progress, including analysis by outside independent organizations (Zhou et al., 2010). Also, the SMG needs to strengthen building energy efficiency inspection and supervision patterns to establish a more reliable building energy consumption database from Shanghai's commercial sector and further report to the national government. Correspondingly, capacity building for relevant staff and institutions is needed.

Moreover, the SMG should encourage comprehensive and integrated urban land-use planning, while reducing reliance on coal by promoting high energy efficiency technologies and renewable energy applications. Comprehensive and integrated urban planning also can have a positive influence on the commercial sector. Such an approach can take the whole building life cycle of energy consumption into account and further advance a more optimized total urban building energy system. For example, Hong Qiao district has been selected as one of the low-carbon commercial districts and already has built green commercial buildings which take the whole building life cycle into consideration.

The SMG has promoted energy efficient buildings and green buildings as successful demonstrations. Moreover, the SMG should continue to make a concerted effort to educate the public on energy management of large-scale public and governmental buildings. It is necessary to provide more commercial building energy saving training programs for relevant stakeholders and the general public for mobilizing public participation. The public should be more informed and motivated about the need to take individual and collective actions to reduce energy consumption and enhance energy efficiency in buildings. However, such a strategy takes time to change not only public consciousness but also attitudes and behavior. Both case buildings have engaged with local communities for low carbon initiatives. Although public consciousness about energy savings remains lagging and constitutes the most difficult obstacle for the SMG, efforts should continue to accelerate transformations of urban dweller mindsets toward a green mindset, the foundation of a low-carbon urban future.

Finally, compared with most local companies, international developers or external companies are keen to adopt new green technologies and innovative energy management. According to the interviews, more external companies focus on building energy efficient saving measures than local companies. Therefore, it is important to diffuse the international-led trend to develop localized and internalized low-carbon values throughout Chinese society. Future research could select buildings owned by domestic companies to investigate the differences between these structures and those owned by external companies. In terms of data classification and sharing, relevant building energy use data nation-wide and city-wide is cited in the paper according to secondary data from some significant research institutions domestically and internationally. Besides that, building energy consumption auditing and metering policies are still in the midst of the testing phase. Relevant data is not easy to access. Moreover, most building energy saving policies and mechanisms have been announced by the government recently or are still in the process of policy formulation. It is difficult to evaluate their effectiveness at this stage. Further detailed studies with better methodologies are important as a follow-up to these issues in the future (Dhakal, 2009).

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References

Asia Business Council. Building energy efficiency: Why green buildings are key to Asia's future. Hong Kong: ABC Publication; 2008.

Asia Pacific Energy Research Center (APERC). Understand energy in China: Geographies of energy efficiency. Tokyo: Asia Pacific Energy Research Center Publication; 2009.

Betsill, M., Bulkeley, H. Guest editorial: Looking back and thinking ahead: a decade of cities & climate change research. Local Environment 2007, 12: 447-56.

Bressand F, Zhou N, Lin J. Energy Use in Commercial Building in China: Current Situation and Future Scenarios. Stockholm: European Council for an Energy Efficient Economy; 2007.

Cai J, Lin Y, Feng Y. Improving Energy-Efficiency in Public Buildings in China: Challenges and Solutions. In Computational Intelligence and Software Engineering International Conference, Ganzhou, China, December 11-13, 2009.

Chen F. Research on Strategy of Low Carbon City: Shanghai Empirical Analysis. Beijing: Chinese Building Industry Publication; 2010.

China Council for International Cooperation on Environment and Development (CCICED). Energy Efficiency and Urban Development Beijing: CCICED Publication;2009.

Dhakal, S. Urban Energy Use and Carbon Emissions from Cities in China and Policy Implications 2009; 37: 4208-19.

Flavin C, Gardner G. China, India, and the New World Order. In: State of the World 2006: Special Focus, China and India, Washington DC: Worldwatch Institute Publication, 2006.

Jiang P, Tovey K. Overcoming Barriers to Implementation of Carbon Reduction Strategies in Large Commercial Buildings in China. Building and Environment 2010; 45:856-64.

Lang SW. Progress in Energy–Efficiency Standards for Residential Buildings in China. Energy and Buildings 2004; 36: 1191-96.

Lawrence Berkeley National Laboratory. China Energy Data Book. Berkeley: LBNL Publication; 2008.

Li J. Sustainable energy future in China's building sector. In: Energy System. Texas: Energy System Laboratory; 2007.

Li Z, Peng J, Wong B, Yan Y. Survey on Energy Consumption & Operation Management Status of Public Buildings in Shanghai. HV&AC 2005; 35:134-6.

Lin GCS. The Growth and Structural Change of Chinese Cities: A Contextual and Geographic Analysis. Cities 2002; 19:299-316.

National Bureau of Statistics of China (NBS) [Internet]. 2012. China's Total Population & Structural Changes in 2011; [cited 2012 Jan]. Available from: http://www.stats.gov.cn/was40/gjtjj_en_detail.jsp?searchword=urban+population&channelid=9528&record=5

Pan Y, Yin R, Lou Z. Energy Efficiency Investigation of 10 Large Public Buildings in Shanghai. HV&AC 2010; 40:152-6.

Pearce, F. Ecopolis Now. New Scientist 2006; 17:36-45.

Shanghai Municipal Statistics Bureau [Internet]. 2008. Shanghai Statistical Yearbook 2008-10,[cited 2011 March].Available from:http://www.stats-sh.gov.cn/2004shtj/tjnj/tjnj2008.htm.

World Energy Council. Shanghai Municipal Case Study. In: WEC Energy for Megacities Study. London: WEC Publication; 2010.

World Wildlife Fund[Internet]. 2011. Low Carbon City Initiative in China [cited 2011 March].Available from: http://www.wwfchina.org/english/sub_loca.php?loca=1&sub=96

Yang X & Tan H. Research on Building Energy Consumption Situation in Shanghai. In: Proceedings of the Sixth International Conference for Enhanced Building Operations, Shenzhen, China, November 6-9, 2006.

Yao R, Li B ,Steemer K. Energy policy and standard for built environment in China. Renewable Energy 2005; 30:1973-88.

Zhong P. Energy Efficiency Policies for Residential Buildings in China and Their Effectiveness. Wageningen University: MS Thesis; 2005.