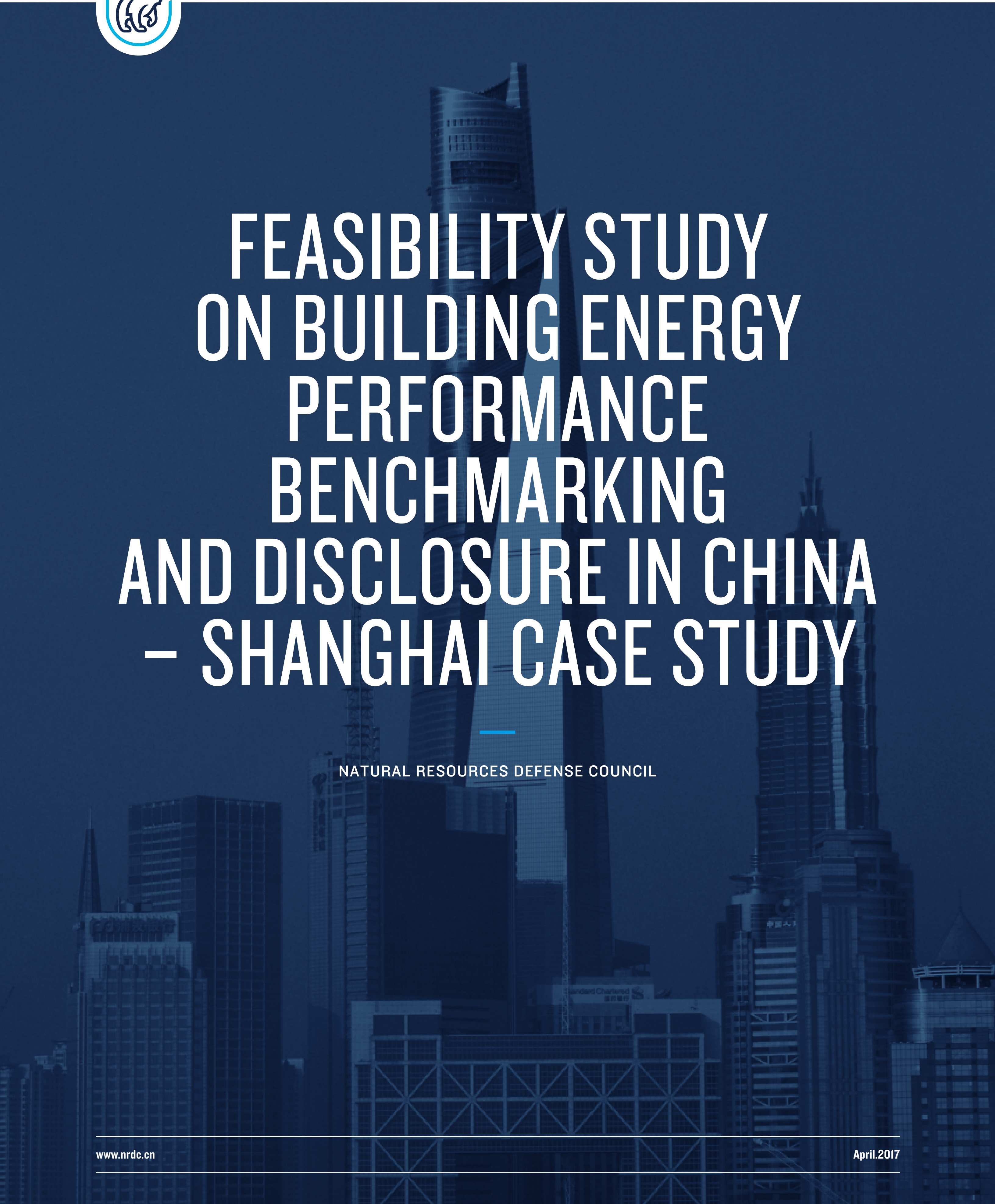

FEASIBILITY STUDY ON BUILDING ENERGY PERFORMANCE BENCHMARKING AND DISCLOSURE IN CHINA – SHANGHAI CASE STUDY

NATURAL RESOURCES DEFENSE COUNCIL

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EXECUTIVE SUMMARY

With the active participation and promotion of China, the Paris Agreement on climate change came into effect on November 4, 2016. Under the agreement, China committed to peak carbon dioxide emissions by approximately 2030. China's housing stock has reached to nearly 60 billion square meters, and with this growth, energy consumption has soared. Building energy consumption now accounts for nearly 20% of the national energy consumption. Improving energy efficiency in the building sector is essential for China to meet its Paris commitments. Effectively using market mechanisms in this process, particularly to retrofit energy intensive buildings on a large scale is a critical issue for Chinese urban sustainability.

Building energy performance benchmarking is the process of comparing or ranking the measured energy consumption of a building with others of the same type. Results can then be released to the public to offer owners, property managers, users, energy-saving consulting companies, financial institutions, and other relevant parties an accurate understanding of the building's energy performance. This secondary process, known in the field as building energy performance disclosure, give parties information to make energy efficiency retrofits and gives full play to the fundamental role of the market.

Benchmarking and disclosure have been adopted in many industrialized countries. So far, these mechanisms have not been adopted in China because their feasibility and potential effects remained unclear. This report makes the case for benchmarking and disclosure by introducing the policies' impact in foreign countries and summarizing the policies' global development trends. Turning to the Chinese context, the report uses Shanghai as a case, reviewing the city's building energy efficiency policies and analyzing opinion surveys of stakeholders to assess the feasibility of implementing benchmarking and transparency in China. By analysing international progress as well as a Chinese case, this report seeks to facilitate building energy performance benchmarking and disclosure pilot projects in China.

I. Benchmarking and disclosure: International progress

Benchmarking and disclosure have been widely adopted across the globe in recent years. The most noteworthy progress has been made in America where a rapidly increasing number of cities and buildings have adopted this policy and improved their energy efficiency. New York City took the lead in 2009, passing legislation requiring large buildings to report energy performance online and carry out energy performance benchmarking. The legislation also requires the municipal government to release benchmarking results annually. Since then, many cities have followed suit. As of January 2017, the total construction area covered by energy performance benchmarking and disclosure amounted to 10.7 billion square feet. To date, 38 regions have passed mandatory laws to conduct benchmarking and transparency. Results from three cities show that after adopting benchmarking and disclosure, the energy efficiency of buildings increased 2%-3% annually over the six years. The United States Department of Energy's assessment on the effects of the policy in New York City over the past few years shows that the energy intensity of benchmarked buildings decreased by 5.7 percent from 2011 to 2013. Similar results were seen in Washington, D.C. and San Francisco. As the policy has become more widespread, cities have improved the mechanism. For example, pioneering cities have begun using visualizations to view building data rather than using traditional data lists. By doing so, they have made the data accessible, easier to compare, and more comprehensible for the public. Federal and local governments have also introduced other initiatives to give users better access to disclosed data.

II. Exploring benchmarking and disclosure of existing LNRBs in Shanghai

Shanghai boasts a robust building energy consumption database and has made laudable efforts to promote building energy performance benchmarking and disclosure. The first effort Shanghai has made is making their building monitoring more comprehensive and robust. Shanghai is listed as the model city for the Building Energy Consumption Monitoring Platform established by the Ministry of Finance and Ministry of Housing and Urban-Rural Development. In late 2015, the "1 +17 +1" Building Energy Monitoring Platform for government buildings and large-scale public buildings was established (one primary platform, 17 district sub-platforms, and one public agency sub-platform, hereafter referred to as "monitoring platform"). The installation of sub-energy (lighting, air conditioning, power, plug) metering devices and remote data transmission equipment enables real-time tracking of electricity consumption in government office buildings with a single building area of over 10,000 square meters and large non-residential buildings (LNRBs) over 20,000 square meters. As of December 31, 2015, the cumulative monitored non-residential buildings reached 1,288, covering 57.196 million square meters of floor space. In addition, Shanghai has gathered the annual energy consumption data of various residential buildings and performed energy audits of some government buildings and LNRBs since 2007 under the requirements of Ministry of Housing and Urban-Rural Development, thereby accumulating a large dataset. From the perspectives of policy-making efforts, coverage, and depth, Shanghai is undoubtedly China's lead municipality in this policy area.

Beyond monitoring, Shanghai has also made an attempt in both benchmarking and disclosure. As early as 2008, Shanghai released some public building energy consumption data on government websites, which can be regarded as building energy performance data disclosure in a broad sense. Since 2014, Shanghai has released the Government Buildings and LNRBs Energy Consumption Monitoring Platform Annual Report for three consecutive years. In terms of benchmarking, no specific regulations or standards exist in Shanghai, but the annual energy consumption monitoring report has dedicated a chapter to "Energy performance benchmarking for buildings of typical types" since 2014. Their approach is to first calibrate the measured energy performance of all kinds of buildings in accordance with the guidelines for energy use for various types of buildings released by the Shanghai municipal government. These measurements are then converted to a "comparable annual comprehensive energy consumption," which allows them to be compared with the reasonable energy consumption and efficient energy consumption values for the same type of buildings given by the guidelines. Buildings above the reasonable value are identified as poor energy performers; buildings that consume less energy than the "efficient value" determined by the guidelines are regarded as being in the leading position in their class of buildings in terms of energy efficiency. This method of energy consumption calibration is similar to the ENERGY STAR Portfolio Manager system adopted in the US, which controls for variables so that buildings of the same type can be compared using the same standard as much as possible. Calibration parameters include the star hotels annual occupancy rate and sales per unit area of commercial buildings.

We believe that there are two main issues hindering benchmarking and transparency in Shanghai:

- The separation of disclosure and benchmarking, rather than benchmarking and disclosing data sequentially, makes the disclosed data difficult to comprehend by non-professionals, greatly reducing the practical transparency of the system.
- Currently, benchmarking is limited to individual typical buildings and remains at the research level. This is mainly because the existing data are not comprehensive, especially the indicators for results calibration, including a lack of information on office buildings, machine room area, shopping malls' annual turnover, star hotels occupancy rate, etc.

The lack of transparent energy use information has become a major obstacle to implementing energy efficiency retrofits.

Despite these challenges, the potential to decrease energy consumption in Shanghai's large buildings is considerable. We estimate that the 57.196 million square meters of LNRBs monitored by the platform alone can save 340,000 tons of coal equivalent annually in the coming five years after conventional energy efficiency retrofits, which equals the annual energy use of all residential buildings in Changning District. Referencing the quantitative energy savings from benchmarking and transparency in American cities, we further calculated that buildings currently monitored by the platform will save 30,000-50,000 tons of coal, and reduce carbon dioxide emission by 90,000-140,000 tons annually. That is equal to the annual energy use and emissions of five large commercial complexes each with a floor area of 300,000 square meters.

III. Opinion surveys of benchmarking and data disclosure stakeholders

Cooperating with Shanghai Twenty-First Technology Co., Ltd. ("Twenty-first company"), we selected four types of LNRBs in Shanghai—office buildings, shopping malls, hotels and integrated buildings—and conducted questionnaire surveys and interviews with stakeholders in five buildings of each type. We found that owners, property managers, and other groups have largely accepted building energy performance benchmarking and transparency but still have concerns. We surveyed nearly 40 owners and property management staff. Over half of the respondents deem benchmarking and transparency to be necessary. They also believe that energy performance data for the same types of buildings is helpful in identifying optimum energy efficiency levels and the relative energy use of their own building. Most respondents did not oppose the government releasing benchmark results and energy performance data from their own buildings, but have a wait-and-see attitude. Some respondents expressed concerns about how the government would use the benchmarking results, and how data disclosure could invade their commercial privacy.

IV. Thoughts on the feasibility of developing benchmarking and transparency in Shanghai

Stakeholders are primarily concerned about the design of the non-residential buildings energy performance benchmarking and data disclosure policy. Not only owners, property managers and other market players, but also government departments have concerns about benchmarking and transparency. In fact, the main concerns of market players and government departments are related. For example, the concern of owners and property managers that "disclosure may invade business privacy" decreases government motivation to promote benchmarking and disclosure. The lack of information on how disclosed data would be used raises concerns of owners and property managers about "being controlled," and even being fined for the poor energy performance. Learning from global practices and Shanghai's experience, we can gradually promote thorough and comprehensive building energy performance benchmarking and disclosure policies through the following strategies:

- Prizes and penalties should not be awarded based on benchmarking results. Owners and property managers will only support the policy if they are not being fined for poor benchmarking results. Compulsory participation in benchmarking and publicity can be enforced, and those who do not participate for no reason will be fined. Compulsion is the only way to achieve universal participation across all types of buildings, and thus more representative results from benchmarking and disclosure. Only those buildings that are suitable for benchmarking and disclosure would be required to participate. A policy of mandatory benchmarking and disclosure can potentially coexist with other policies that the Shanghai government is considering such as consumption quota management. Under the latter policy, some buildings that used excessive energy might be fined, but that fining would not be linked to benchmarking and therefore would not affect participation in the benchmarking and disclosure policy.
- Clarify the difference between benchmarking and disclosure and other mandatory regulations. Benchmarking and disclosure provide comprehensive energy performance information for the market whereas quota management and mandatory constraints quantitatively specify consumption limits for existing buildings and regulate the responsibilities of actors involved. They are complementary to each other rather than contradictory. The former guides, the latter promotes, and they jointly accelerate building efficiency. The two differ in the degree of data granularity, legal effects, barriers to implementation and so on. It would be much easier to first carry out benchmarking and transparency, and then gradually introduce energy consumption quota management.
- Data released should be accessible to the public so that the market can play its leading role. As many buildings as possible need to adopt benchmarking and disclosure in the long-term, since effective disclosure relies on widespread benchmarking. With more buildings, benchmarking results can be more instructive.
- Business privacy protection is not difficult to achieve. At present, there is no clear legislation in China regarding whether energy performance data disclosure is against business privacy. The argument that data could violate privacy is that commercial revenues are positively correlated with building energy consumption, and commercial competitors may infer income of a commercial building from its energy consumption data. However, our survey found that owners and property managers believe the occupancy/rental rate of commercial buildings can be disclosed, and that such information could be more directly related to revenue than energy consumption. Therefore, we believe that building energy consumption disclosure does not pose any threat to privacy; moreover, the disclosed benchmarking results are not all raw data. In addition, exceptions can be made for special buildings.

- Data quality can be improved during benchmarking and disclosure. The need to improve data quality should not be an excuse to postpone implementing a benchmarking and disclosure policy. International practices indicate that it is normal that data quality is unsatisfactory in a certain period and that time is needed for data quality improvement. It is more realistic to collect data and improve data quality in the process of benchmarking and disclosure.

- Equity is not a major challenge for benchmarking and disclosure. While it is impossible to absolutely equitably compare, and evaluate two buildings of the same type, using variables during calibration, as stated above, can improve the accuracy of benchmarking. Benchmarking and transparency enables the public and market actors to compare the energy consumption of buildings with a focus on providing information; building energy consumption quota management emphasizes rewards and punishment. The latter poses greater issues for fairness.

We believe that launching benchmarking and disclosure pilots in Shanghai is completely feasible since concerns from stakeholders can be effectively settled through reasonable policy design and steady promotion.

V. Suggestions for launching non-residential buildings energy performance benchmarking and disclosure in Shanghai

The current policy orientation, social awareness, and public opinion and economic environment provides a valuable chance to promote data-driven energy efficiency retrofits and sustainable operations for LNRBs and building energy use benchmarking and disclosure in Shanghai. In terms of overarching policy guidance, the state has been limiting total energy consumption in all industries, and promoting digitalization of energy as well as a performance-oriented approach. Benchmarking building energy performance was incorporated into the 13th Five-Year Plan for Housing and Urban-Rural Construction, which states that data-based urban building energy performance benchmarking should be implemented during the 13th Five-Year Plan period. Approaching building energy saving with emphasis on measured data has become the industry consensus. In terms of public opinion, the frequent occurrence of haze and other pollution incidents has caused an unprecedented increase in public awareness and participation in energy savings and emission reduction, which has led to a growing call for building energy use data. The combination of these demands has compelled the government to take action to accelerate energy efficiency. In terms of the financing environment, under the New Normal, China expects to see an economic slowdown and lower capital returns. As a stable investment with medium returns, building retrofits are gaining popularity in the new economy. In terms of the data foundation, electricity consumption of existing LNRBs in Shanghai is no less detailed than the counterparts in Europe and America, but more time-efficient, which has advantages in allowing for timely responses and better meeting needs of perform-oriented management. As for technical support, driven by the “Internet+” policy, the Internet and Internet of Things have developed rapidly, which lowers energy consumption monitoring costs, and makes immediate interactions among property owners, property managers and users unprecedentedly convenient. We suggest that authorities at the municipal and district levels should seize the opportunity to forge a solid foundation by passing laws, strengthening data collection, and boosting global exchanges so as to lead the nation and world in the new trend of building energy conservation:

- Pass laws to guide the steady promotion of benchmarking and disclosure. It is best to have legal support to carry out building energy use benchmarking and disclosure. Regulations should cover benchmarking and transparency and the quota management system, distinguishing between them in terms of their principles and rules, and clarifying their collaborative relationship. The use of benchmarking and disclosure to provide the market with building energy use information should be made clear. Further clarity is also needed to ensure that disclosure, the main content of which is benchmarking results, should come after benchmarking. Besides data privacy, surrounding

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issues should also be clarified. Shanghai can develop medium- and long-term strategies and roadmaps for energy efficiency retrofits of existing buildings and incorporate benchmarking and disclosure into its long-term strategy.

- Enrich the database through data stratification and automating data collection and analysis. Combine existing building energy consumption data, audit data, energy consumption of different items, and real-time monitored information to enrich the database. Adjust and complete corresponding indicators according to different demands from the benchmarking and transparency policy and quota management policy. Fully utilise different acquisition channels and improve accuracy. Establish guidelines for owners to submit energy performance data as soon as possible, so as to provide more information for the calibration of the benchmarks. Establish a long-term mechanism to improve data quality.
- Strengthen international cooperation. Benchmarking and transparency policy in China is on a long journey toward full maturity. Furthermore, how to effectively improve data quality, innovate data analysis methods, and identify energy saving goals based on performance data are challenges shared by Shanghai, New York City, and other large cities. Increased global exchanges make learning from one another more convenient, and in turn, practices in China can offer references and inspiration for other countries.

1

PREFACE

Greening China's building sector is a critical component of the country's effort to peak carbon dioxide emissions by 2030. According to research and practice over the past 30 years, improving building energy efficiency is one of the most direct and effective ways to save energy.[1] At present, building energy consumption accounts for about 20% of total energy consumption in China. Several factors will increase building energy consumption and its proportion of total energy consumption in the coming years. As China's economy shifts towards light manufacturing and services, which rely on the built environment, these industries will drive building energy consumption up. In addition, rapid urbanization will contribute to this rise. Given these projected trends, reducing building energy consumption, especially operational energy use, is of great importance to China and the world's ability to combat climate change.

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As China looks to meet more ambitious building energy efficiency goals, it can build on the progress the country has made in the past decades on building energy conservation. This year marks the 30th anniversary of the publication of China's first building energy efficiency standard in 1986. Learning from western countries has helped China formulate suitable building energy saving policies and identify key development areas. Since the Building Energy Conservation Ordinance was published in 2008, China has strengthened its focus on building energy efficiency. Recent improvements include the standardization of energy efficiency policy design, institutionalization of energy efficiency supervision for newly built buildings, and large-scale energy efficiency retrofits of existing residential buildings. In the "Twelfth Five-Year Plan" period (2011-2015) alone, the floor area of new green buildings exceeded one billion square meters and 990 million square meters of existing residential buildings completed heating measurement and energy efficiency retrofits.[2] The floor area of newly built energy efficient buildings exceeded ten billion square meters during the past decade.[3]

The gap in building energy efficiency between China and developed countries has narrowed quickly. In the future under Building Efficiency 2.0[1], the focus of building energy efficiency will move to digitalization, precision, and marketization.Through digitalization, energy consumption data can be used to assess building energy efficiency, thus shaping energy-saving evaluation and certification strategies. A focus on precision will promote the "spirit of the craftsman" in the construction process, leading to better results. Marketization is an urgent requirement at present. To realize marketization, direct subsidies must be replaced by indirect incentives and guidance. In the past, energy efficiency improvements have largely relied on government subsidies, which led to unevenness as areas with subsidies became more efficient while other areas in China did not receive the same level of support. The energy efficiency retrofits of existing residential buildings in the northern China serves as a typical example. Similar examples can be found in renewable energy applications in buildings and green buildings promotions.

By the end of 2014, the floor area of China's buildings amounted to 56.1 billion square meters, among which urban buildings represent 30.7 billion square meters.[4] Over ten billion square meters of urban buildings are

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energy efficient, leaving two thirds of existing urban buildings with unsatisfactory energy performance. Even among certified green buildings, only approximately 6% have an operational green label.[5] Many so-called green buildings, residential and non-residential, consume more energy than those without the label of "green building."[6]

Upgrading the energy efficiency of such a large amount of buildings in a short period with limited government subsidies presents a large challenge. Giving full play to the role of market is necessary. "Government guidance, market oriented" has long been the policy, but slogans are insufficient to motivate the market. Our "guidance" to the market may always be subjective and high-handed, which is more "leading" than "guidance." The "guidance" should come in the form of providing sufficient information. It is believed that energy performance benchmarking and data disclosure (hereafter referred to as "benchmarking and disclosure") are effective tools to engage market actors. Benchmarking energy consumption with buildings of the same type and then disclosing results and other related information is a kind of "guidance." The approach has great potential to be applied in existing buildings.[7]

The status quo of the building sector supports Premier Li Keqiang's remark, "more than 80% data stay in the hands of government authorities. Information hidden in the closet is a great waste." Without transparency, data cannot be accessed by the market. The shortcomings of lack of transparency in energy performance data have become increasingly prominent in the process of energy efficiency retrofits. The information asymmetry between the government and market actors leads to a low degree of participation and even resistance from the latter. Futhermore, the information asymmetry between contracted energy management companies and energy consumers has negative effects on the implementation of service contracts. Lastly, the information asymmetry between financial institutions and lenders makes financial institutions refuse to give loans due to the lack of information on energy-saving project credit or project profitability.

To promote the application of building energy performance data in China, we introduced the rationale and practices of mandatory benchmarking and disclosure policies adopted in the U.S. in *Benchmarking and Disclosure to Improve Building Energy Efficiency—*

Case Study of New York City in 2014. Since then, benchmarking and disclosure have gradually become the hot topics in forums and seminars in China. However, there is still insufficient understanding of benchmarking and disclosure. This report aims to shed a light on some of the key issues benchmarking and disclosure are facing. First, we summarize international benchmarking and disclosure progress and policy trends. We then present the results of a survey we conducted in Shanghai to assess stakeholders' attitudes toward the policy and its applicability in China. In that section, we will also introduce preliminary solutions we have created to address stakeholders' concerns. Hopefully, the insights from this survey can help policymakers effectively utilize this mechanism to advance energy efficiency in buildings.

2

BENCHMARKING AND DISCLOSURE: INTERNATIONAL PROGRESS

″Benchmarking” is a loanword from western countries. It was first introduced to China’s energy efficiency field by industrial companies to improve their energy efficiency by comparing their performance with domestic and international leading companies.[8] This use of “benchmarking” differs from building energy performance benchmarking in two ways. On the one hand, buildings compare their energy use performance with the pool of their peers which include but not limited to the leading buildings.

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On the other hand, the focus of buildings benchmarking, as stated above, is to help the maket get a sence of the energy use. While in the industrial setor, more emphasises are put on improving your energy efficiency and try to catch up with the most efficient company. Industrial practices like identifying leading models and using benchmarking to improve energy performance have not been applied as rigorously to the building sector. Therefore, the term "comparison," a substitute word, is suggested by some Chinese experts to be used in the building sector instead of "benchmarking" to avoid confusion and misunderstanding.

Building energy performance benchmarking and disclosure is not new, in fact, it has been widely used in European countries and the U.S., and there are multiple definitions and practices. However, the most influential and extensive application of the policy has been in American cities, especially New York City, which mandated energy reporting and benchmarking in large buildings eight years ago. This chapter and the following analysis will reference American practices as a model for Chinese cities.

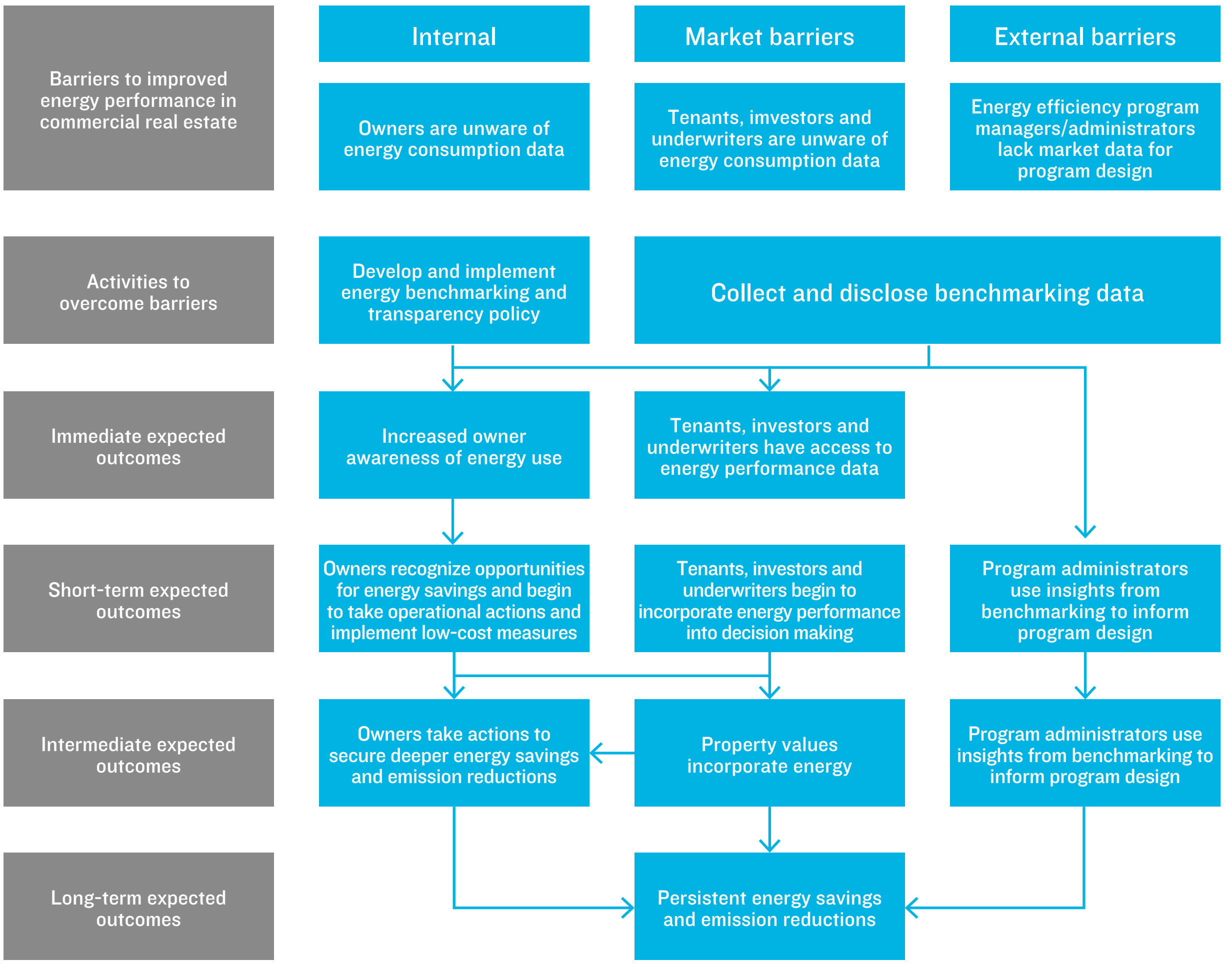
Energy performance disclosure policies were adopted in the U.S. to get a clearer picture of urban buildings' energy performance so as to facilitate building energy conservation. This policy was first promoted by developed cities where buildings accounted for the largest part of energy consumption and emissions. For example, buildings contribute up to 70% of total city energy consumption in New York City, Seattle, Chicago, Boston, and Washington,

Building energy performance benchmarking in this report is a way to evaluate building energy performance according to measured energy consumption. The core data is measured energy use of the building in a certain period (usually a year). After calculation and analysis of the core data and other related information such as building area, operation duration, and personnel density and so on, energy efficiency level of a specific building can be identified by comparing with others of the same type during the same period. Building energy performance disclosure is to release benchmark results and other closely related indicators to the public, so as to raise awareness of building energy performance. Benchmarking is an evaluation tool and a baseline; disclosure is a means to present benchmark results and other related information. Benchmarking is to convert absolute parameters (total energy consumption and etc.) to relative parameter to protect privacy and reduce resistance; disclosure in turn contributes to the promotion of benchmark results. Scientific benchmarking and effective disclosure facilitate owners, property managers, users, energy conservation services, financial institutions and even the public to clearly master the energy efficiency level of the building, give incentives to save energy and tighten supervision, and advance energy conservation towards owner-driven and market-driven.

*Note: Building energy consumption level closely relates to energy use method, which is decided to a great extent by building function (type). Theoretically, energy consumption of different buildings or systems should be roughly the same when they fulfilling the same function or offering similar services. Excluding individual characteristics and special functions, good benchmark results (less energy consumed) means better energy efficiency.

Figure 1

Benchmarking and transparency policy logic



Source: *Benchmarking &Transparency Policy and Program Impact Evaluation*, U.S. Department of Energy, May 2015

D.C. Despite that surveys conducted by the federal government have already shown the general energy consumption features of commercial and residential buildings and city-level greenhouse gas inventories showed the total energy consumption in the building sector and its annual changes, the information is not adequate. In order to realize precise guidance for building energy consumption at the city level, obtaining building-level data is essential. A city cannot effectively manage what it does not measure. Because local governments not the U.S. federal government are responsible for collecting energy consumption data, local government action is required to improve data collection. In 2009, New York City began leading the way in this effort. The municipal government proposed a local law requiring large building owners to report on energy consumption and water use data regularly. The government then must either disclose benchmarking results regularly or disclose data to buyers and tenants in transactions and leasing. As shown in Figure 1, this local law helps to eliminate various information barriers. Since the implementation of this law, benchmarking and disclosure policy has been continuously developed in America within an increasing number of cities, improving energy efficiency.

2.1 American leadership on benchmarking and disclosure policies

As of January 2017, the total area of benchmarked buildings in America was 10.7 billion square feet (see Figure 2), with New York City accounting for 2.8 billion square feet and California 2.4 billion square feet. Energy benchmarking policies have also been implemented in Chicago, Atlanta, Washington, D.C., Philadelphia, Seattle, Boston, San Francisco, Austin, Minneapolis, Portland, Cambridge, Montgomery County, Berkeley, California, and Washington and other cities and regions. So far, 38 regions have passed regulations requiring benchmarking and public disclosure, among which ten regions only target government buildings while others cover commercial buildings, multi-family properties, and single-family properties.[9]

The implementation of energy benchmarking and disclosure policies in New York City and other cities has lead an increasing number of regions to mandate such a policy. Cities implementing energy benchmarking range from coastal developed cities to developing cities in the Midwest. Moreover, the increasing public awareness of building energy benchmarking and disclosure policy has reduced resistance to implementing similar policies in the future and facilitated the passage of such policies in other cities. From 2007 to 2012, a total of eight states and municipalities mandated energy efficiency benchmarking. Ten more states, municipalities and counties implemented the policy from 2013 to June 2015, among which six cities (Cambridge, Berkeley, Atlanta, Portland, Salt Lake City, Kansas) and one county (Montgomery) implemented a benchmarking and disclosure policy after February 2014. This rapid rollout clearly shows the domino effect of lead cities and states influencing others to follow suit.

In addition to periodically tracking energy data, evaluating policy impacts, and releasing reports, leading cities are trying various ways to make data more accessible to the public. Strengthening data

Figure 2

Building Area Covered by Benchmarking Policies Across Major Cities by January 2017

Unit: square feet

Source: http://www.buildingrating.org

visualization, unifying data formats, and establishing direct communication with users are the typical examples of this trend that will be elaborated in the following sections.

2.2 Further improving energy efficiency in American cities

Several cities' results over the past seven years show that benchmarking and data disclosure policies helped to lower energy consumption by 2%-3% annually. The U.S. Department of Energy's *New York City Benchmarking and Transparency Policy Impact Evaluation Report* shows that from 2011 to 2013 the energy use intensity (EUI) of benchmarked buildings decreases by 5.7%.[10] The Benchmarking and Transparency Policy Impact Evaluation Reports of Washington, D.C. and San Francisco reveal that EUI decreased by 6% from 2010 to 2012 in Washington, D.C.[11] and EUI decreased by 7.9%[12] in San Francisco from 2010 to 2014 (see Table 1).

As shown in Figure 3, the median EUI of two main

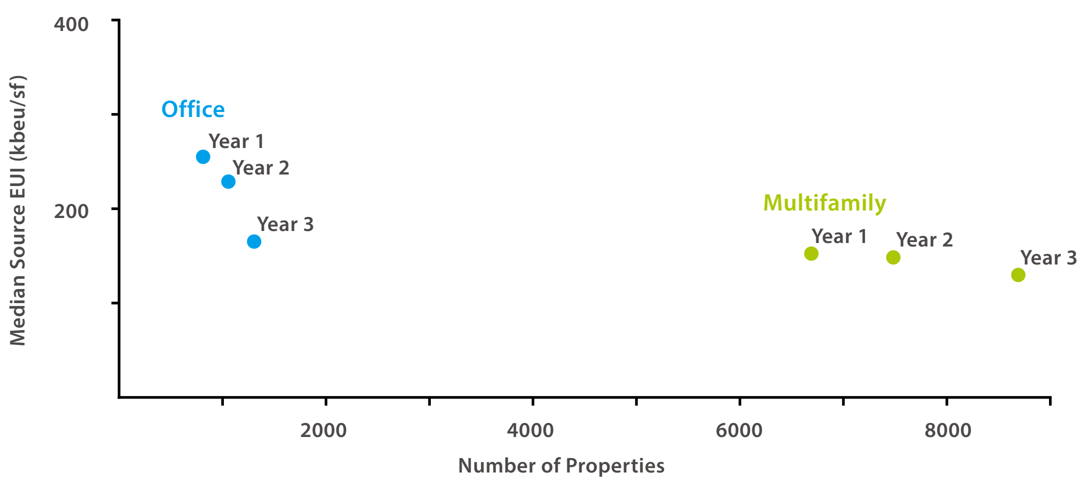
Table 1

EUI Decreases in Leading Cities

City	EUI decreased by	Assessment period
New York City	5.7%	2011-2013（2 years）
Washington, DC	6%	2010-2012（2 years）
San Francisco	7.9%	2010-2014（4 years）

Figure 3

Changes in EUI of Key Building Types in New York City from 2011 to 2013



Source: NYU and NYC Mayor's Office

building types (office and multifamily properties) in New York City fell continuously from 2011 to 2013.

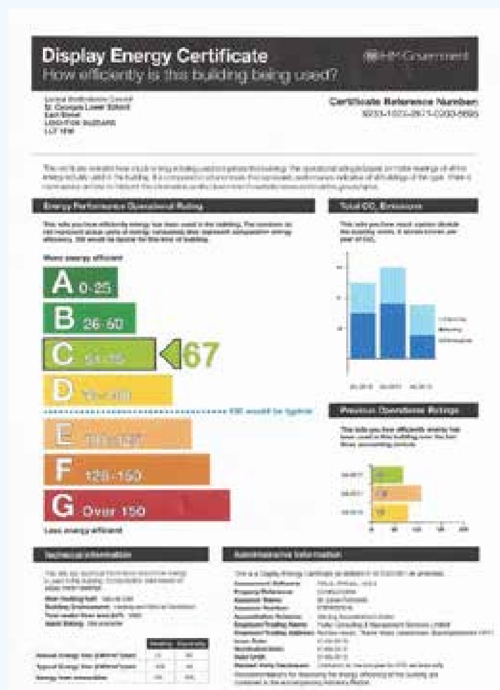
Another report on the effectiveness of benchmarking and transparency policies in resolving information failures focused on four leading cities: Austin, New York City, San Francisco and Seattle, and suggests that the policies resulted in a decrease in the energy cost per unit area of the covered buildings by approximately 3%.[13] The UK has also benefited from such decreases in operational cost. Researchers at University College London analysed 73,160 certificates of 31,802 buildings from 2008 through 2012 and found that 9 of the 14 building types with certificates annually renewed saw a continuous electricity consumption decrease and 13 saw a continuous decrease in fossil fuel consumption.[14]

Although benchmarking and disclosure policies are still in an early stage of implementation, there is clear evidence in the U.S. and the U.K. that the policies can effectively lower energy consumption. These positive signals should encourage more cities to implement similar policies.

UK Building Energy Disclosure Laws

In 2008, the UK government passed legislation requiring owners or users of public sector buildings over 1,000 square meters to permanently display a Display Energy Certificate (see the following picture) in a prominent place as well as possess a valid advisory report, making a detailed amendment to Energy Performance of Building Directive 2002/91/EC and 2010/31/EU of EU implemented in England and Wales. The Display Energy Certificate (DEC) rates CO2 emissions, which is calculated based on energy consumption of the specific building in the past year, using grades from A to G with A being the most efficient grade. Since then, the range has increased to cover more buildings. The regulation was revised and issued in 2013 and has lowered the threshold from 1,000 square meters to 500 square meters. From July 9, 2015, it was lowered further to 250 square meters. The advisory report must be dispensed by accredited energy assessors and offers practical suggests to enhance energy performance. Both DECs and advisory reports have certain validity period (see the following table).

Floor area (square meters)	DEC validity period	Advisory Report validity period
> 1000	1 year	7 years
501-1000	10 years	10 years
> 250-500	10 years	10 years



Source: UK Department for Communities and Local Government

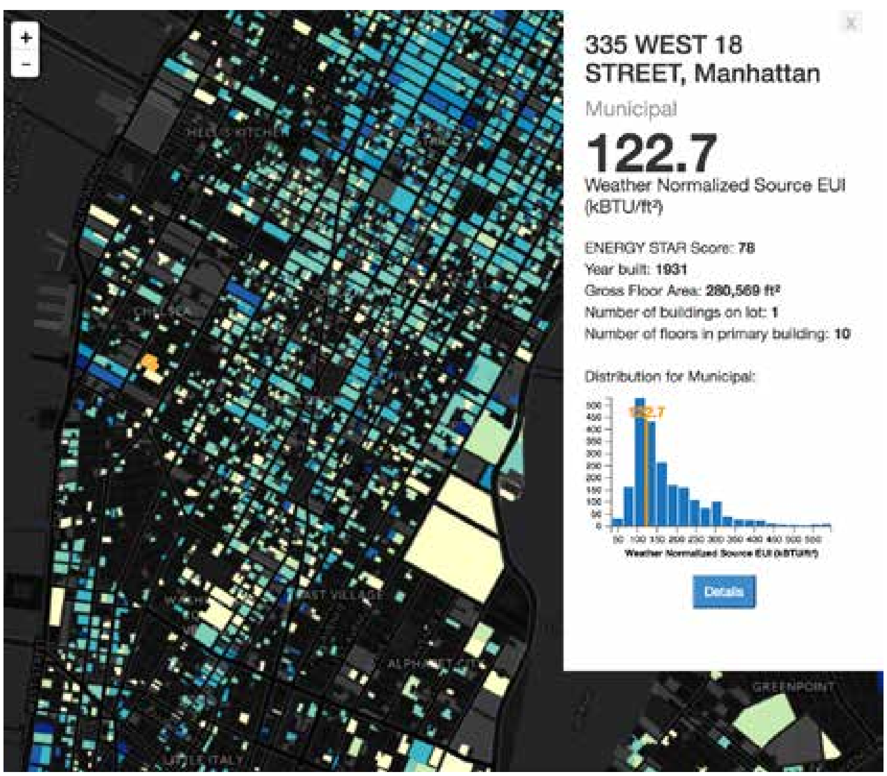
2.3 Best practices for building data presentation

The effect of data disclosure depends on the quantity of data disclosed, the quality of analysis, and how creatively the data is presented. Limited analysis and inflexible data presentation modes prevent stakeholders from fully using of disclosed data. The past several years witnessed various attempts from many cities in America to present data effectively. Boston, Chicago, Los Angeles, New York, Philadelphia, and Salt Lake City have enhanced data visualization by using geographic information systems (GIS) so that data can be presented based on location for convenient queries. In December 2015, New York City launched the New York City Energy & Water Performance Map (Map for short), as shown in Figure 4. The map colors[II] buildings based on EUI.[III] The darker the color is, the higher the EUI. This map marks significant advancement from cities' past efforts, presenting data more attractively and interactively including a search function and comparisons across multiple criteria. In addition, Urban Green, a local branch of USGBC, used public data to develop a website with more comparison and search options.[IV] New York City makes full use of free technical assistance from the Building Energy Exchange and other local non-profit organizations to support its public data search and presentation efforts.

This Map enables in-depth inquires and data integration. As shown in the sample search in Figure 4, the map displays the building-level data of benchmarked buildings in New York City (commercial buildings and multi-family properties over 4,645 square meters, and non-residential buildings over 929 square meters) between 2013 and 2014. It reveals basic information (location, building type); energy and emission intensity; water use intensity; and provides a visualization of how the energy intensity of the selected building compares with that of similar buildings. In addition, because the building locations are all disclosed, site visitors can use

Figure 4

Screenshot of New York City Energy & Water Performance Map



Source: NYC Mayor's Office of Sustainability

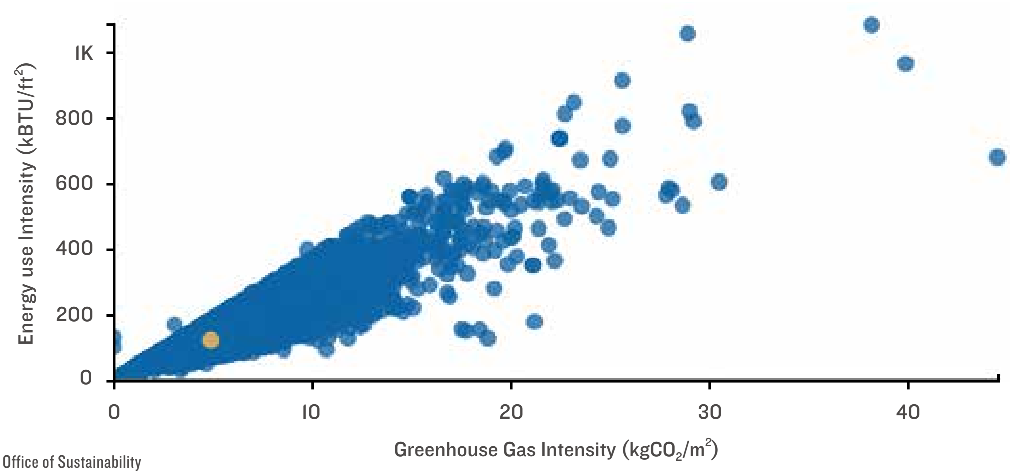
Google Street View and other open resources to easily obtain street view imagery of the building to identify it.

The above graph shows the energy and GHG intensity data for 2015 covering 10,819. Data points in the top right corner represent the buildings with the highest energy and GHG intensity. The building highlighted in yellow is an extreme outlier, with an energy intensity of 1095.2 kBTU/ft^2 (3450kWh/m^2) (Figure 6), while most buildings' EUI are lower than 600 kBTU/ft^2 (1890kWh/m^2).

Using the map, one can identify the building as the Mortimer B. Zuckerman Research Center. The research center containing the Memorial Sloan Kettering Cancer Center was built in 2009 including

Figure 5

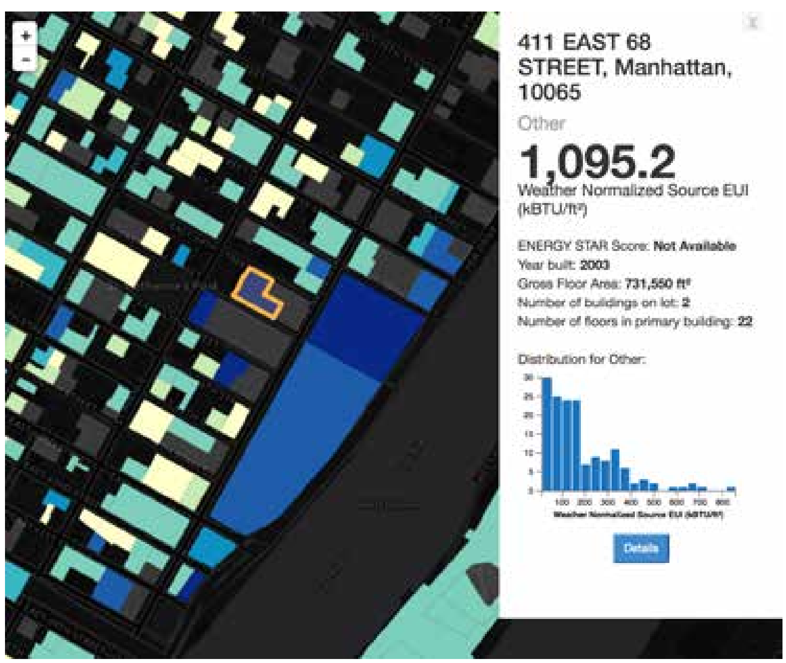
2014 New York City GHG Emissions Map



Source: NYC Mayor's Office of Sustainability

Figure 6

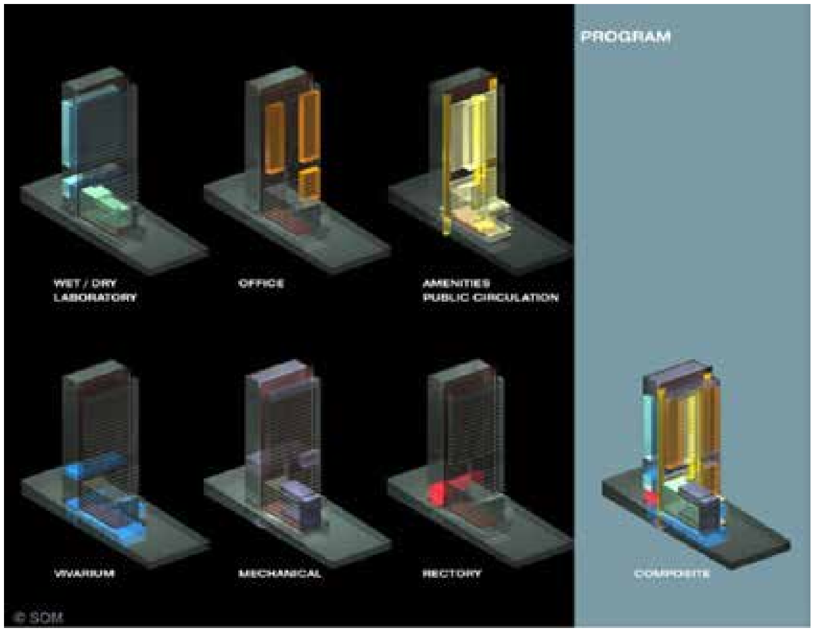
Energy and Water Use Data of a Specific Building in 2014



Source: NYC Mayor's Office of Sustainability

Figure 7

Memorial Sloan-Kettering Mortimer B. Zuckerman Research Centre Functional Sub-areas



Source: http://www.archello.com/en/project/memorial-sloan-kettering-mortimer-b-zuckerman-research-center

labs, offices, and accommodation. The map further reveals that the buildings was designed by Skidmore, Owings & Merrill LLP, and constructed by the Turner Construction Company as are design features and functional sub-areas (Figure 7) of the building. Although building names, designers, and builders are excluded from the energy and water performance map, they can be searched using the information offered by the map to better understand the building's history and purpose.

Disclosed information reveals that the building has used many green technologies to comply with the LEED assessment system, such as using recycled materials, local resources, and natural lighting, heat recovery. This stands at odds with its high measured energy consumption. It is not within the scope of this report to explore the reasons for this specific building's high energy consumption. However, as a result of the above sample searches, we can get a preliminary understanding of the energy performance of this building. Such information could motivate owners, property managers, and green consultancies to conduct further audits, find out the reasons behind its high energy consumption, and improve energy efficiency. Moreover, with disclosed information, researchers can follow the search method briefly displayed to obtain more information and details at low cost, making in-depth analyses and comparisons between this building and buildings of the same type possible. For example, it can be hypothesized that intensive high energy-consuming equipment, long working hours, and high indoor environmental standards may be the reasons for the building's high energy consumption. Researchers can examine each of these reasons to find patterns so as to improve energy efficiency more broadly, promote energy efficiency retrofits, and facilitate policy making.

2.4 Data integration and promotion

In addition to interactive, visual data presentation, U.S. federal and local governments have introduced many other initiatives to promote data dissemination. To help local governments make better use of building energy data to guide energy-saving projects, the U.S. Department of Energy recently worked with the Natural Resources Defence Council (NRDC), the Institute for Market Transformation (IMT), the National League of Cities (NLC), and the National Association of State Energy Officials (NASEO) to launch the Standard Energy Efficiency Data platform. The three-year collaboration with state and local governments will help governments at all levels better manage, standardize, and share large building energy efficiency data. In addition, the U.S. Department of Energy announced a collaboration with CoStar[V] on May 26, 2016 to display building energy consumption data on CoStar's online platform to promote transparency in real estate transactions and leasing.

Some cities have given energy efficiency data and benchmarking results directly to owners. Under the City Energy Project, Philadelphia holds building benchmarking and energy conservation competitions.[VI] Participating building operators receive free training and medals for outstanding performances. They also receive energy performance profiles (Figure 8) listing the detailed energy performance of the building to help owners learn about the energy efficiency gap between the building and buildings of the same type. Philadelphia plans to continue to provide such feedback to participating buildings every year. A study shows that delivering energy performance profiles to residential users for months continuously can effectively encourage users to save energy.[15] According to the study, energy consumption decreases sharply upon receiving profiles, but will gradually bounce back until residents receive the next profiles. But such fluctuation will not exist for a long time, since energy efficiency actions solidify into habits after a while.

Figure 8

Building Energy Performance Profile

Source: *Philadelphia 2014 Energy Benchmarking Report*. http://www.buildingrating.org/document/philadelphia-2016-energy-benchmarking-report, page 11

3

BENCHMARKING AND DISCLOSURE FOR LARGE BUILDINGS IN SHANGHAI

3.1 Background

Shanghai sits in the Yangtze River estuary, located in the middle of the arc-shaped eastern coastline of China. It is one of the largest cities in China, covering 6,340 square meters, eight times larger geographically than New York City and three times the size of Tokyo. Shanghai is China's economic center, contributing 3.7% of China's total GDP from only 0.06% of China's total area.

Shanghai has also been labelled as China's most significant industrial base and trade, finance, and cultural center. Recently, the adjustment of China's industrial structure has led to the growth of tertiary industry. In 2015, tertiary industry accounted for 67.8% of Shanghai's GDP, within which consumption constitutes an increasing percentage as almost 60% of Shanghai GDP.

Shanghai is a microcosm of China's rapid economic growth and urbanization. By 2015, Shanghai had a residential population of 24.2 million, within which non-local population amounted to 9.8 million and the local population amounted to 14.3 million. This large population promotes prosperity and creates value. According to the residential population and exchange rate of that year, Shanghai's per capita GDP reached USD 16,560 in 2005, equivalent to that of medium developed countries and regions; and the city's residential disposable income per capita reached USD 8,000 (RMB 49,867).

The *Shanghai Statistical Yearbook 2015* states that the total floor area of civil building [VII] is some 910 million square meters, within which residential building area is 610 million square meters and non-residential building area is 285 million square meters. Office and shopping malls together comprise the majority of non-residential buildings (Figure 9).

Shanghai consumed 110.8463 million tons of coal in 2014 and building energy consumption was approximately 20% of total energy consumption, increasing by 5.1% in the past decade. [16] Energy intensity per unit of building floor space stayed roughly stable, but the rise of building size led to the increase of the city's overall building energy consumption. As shown in Figure 10, non-residential building area has increased 2.3 times over the past decade in Shanghai. The rapid growth of energy consumption in non-residential buildings has contributed the most to the recent increase in building energy consumption.[17] In addition, energy consumption per unit of building area for non-residential buildings is much higher than that of residential buildings. Moreover, LNRBs (over 20,000 square meters) are mostly equipped with central air conditioning systems, consuming the majority of energy

Figure 9

Shanghai's Building Floor Space Distribution by Non-residential Building Types

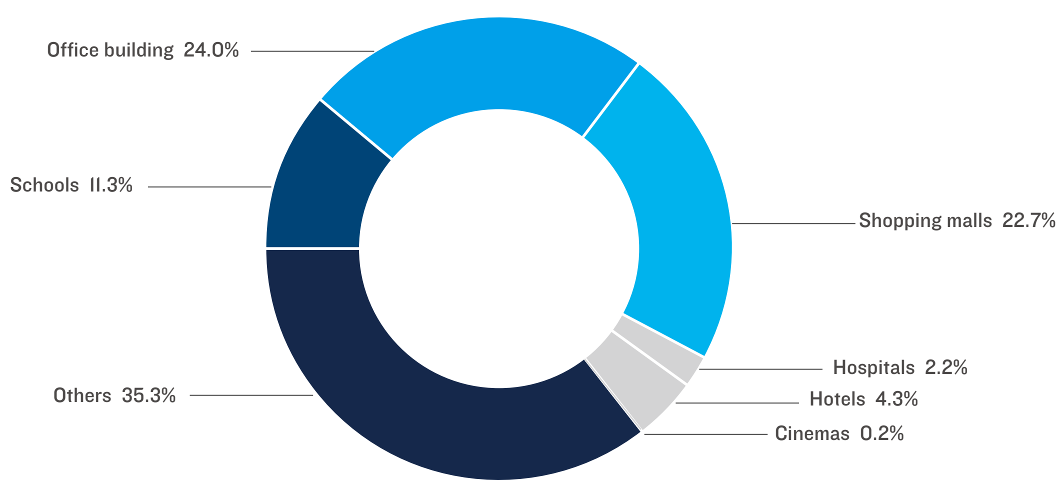
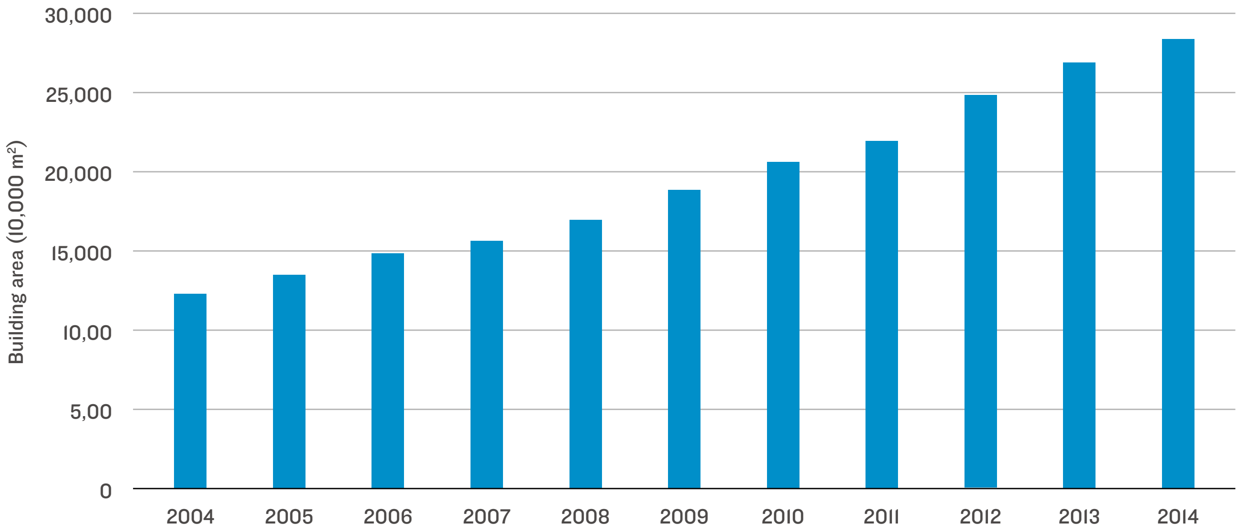


Figure 10

The total area of non-residential buildings in Shanghai



Source: *Shanghai Statistical Yearbook*

among non-residential buildings. Electricity consumption of LNRBs is 70-300kWh/(m^2.a), 10-20 times[18] higher than that of residential buildings. Therefore, LNRBs are the priority for energy conservation.

3.2 Shanghai's energy saving policies and programs

Shanghai started to promote building energy conservation in 2005. Initially, Shanghai focused only on improving insulation in newly built residential buildings, adopting the same strategy as northern China. Over the past decade, Shanghai's efforts have expanded to cover building energy efficiency policies, standards, technologies, management, and assessment. The focus of building energy conservation has also shifted from new buildings to the efficient operation and energy efficiency retrofits of existing buildings.[19] Improving the energy efficiency of LNRBs is the priority of the national Eleventh Five-Year Plan and Twelfth Five-Year Plan. Under the guidance of national policies, Shanghai has issued a series of decrees requiring energy efficiency upgrades for LNRBs. Since then, Shanghai has seen ground-breaking progress in data monitoring and energy efficiency retrofits for existing LNRBs as well as explorations on data disclosure and applications.

First of all, as the demonstration city of the Building Energy Monitoring Platform launched jointly by the Ministry of Finance and Ministry of Housing and Urban-Rural Development, the Shanghai municipal government issued the *Notice on Speeding up Establishment of Energy Consumption Monitoring System for Government Office Buildings and LNRBs* (Shanghai municipal government issued [2012] NO.49) in 2012. This notice explicitly announced that under the Twelfth Five-Year Plan period, Shanghai would establish a "unified, hierarchically managed, and connected" "1+17+1" Building Energy Monitoring Platform (one primary platform, 17 district-level sub-platforms, and one public agency sub-platform, hereinafter referred to as "monitoring platform"). The purpose of this platform is to promote data exchange and unified management between the municipal platform and sub-platforms scattered in districts and counties. This platform is undoubtedly more advanced than actions taken in other provinces and cities in terms of its policy execution, coverage and depth.

The monitoring platform in Shanghai also plays an important role in providing timely tracking of emission reduction progress for the municipal government. Back to the Eleventh Five-Year Plan period, the national energy saving and emission reduction targets were broken down and assigned to provinces and cities on a yearly basis by the National Development and Reform Commission. Assessment results have become a fundamental indicator linked to the promotion of cadres. Due to the lack of timely data, local authorities in the past had to rely on statistics to track jurisdictional progress. How, statistics is a poor source, it only provides out-of-date information. In contrast, the energy consumption monitoring system reports building energy consumption monthly through nearly real-time energy measurement, thus helping authorities to make timely strategic adjustments and active interventions to reach their overall annual emissions reduction target.

Energy monitoring has been rapidly implemented. At present, city and district level energy consumption monitoring platforms have been established. The installation of sub-energy (lighting, air conditioning, power, plug) metering devices and remote data transmission equipment enables real-time tracking of electricity consumption in government office buildings with a single building area of over 10,000 square meters and LNRBs over 20,000 square meters. As of December 31, 2015, a total of 1,288 buildings had installed energy consumption monitoring devices and connected to the the municipal platform, representing 57.196 million square meters. By June 30, 2016, the monitoring platform covered 1,402 buildings at a total of 60.949 million square meters. Among them, 174 government office buildings covered 3.573 million square meters, and 1,228 LNRBs covered 57.376 million square meters.[20] Basic asset information and energy consumption data from government office buildings and LNRBs have been collected.

The government has already undertaken surveys for samples of small and medium non-residential buildings (excluding government office buildings). More than 1,600 non-residential buildings were surveyed in 2015.[21] Although this method does not provide real-time data in the same way that the monitoring platform does for large buildings, it still allows the city to gather data on the total energy consumption of the building over the previous year. This survey method also covers a greater range of energy types and activities including electricity, gas, coal, LPG, central cooling and other forms of consumption. The statistical process has also fully mobilized all relevant sectors to ensure that the data is certified. For example, the basic information of an office building provided by the municipal housing bureau is reviewed by municipal authorities, and electricity and gas consumption data are collected and provided by municipal departments.[24]

Second, Shanghai was assigned as the key city for non-residential building energy efficiency retrofits in August 2012. Under this edict, Shanghai was required to retrofit 4 million square meters of non-residential buildings by August 2014 and to decrease energy consumption per unit area by 20%. In March 2013, the Shanghai Municipal Urban and Rural Construction and Transportation Commission, Shanghai Municipal Development and Reform Commission, and Shanghai Municipal Finance Bureau jointly issued a *Notice on Arranging and Declaring Demonstration Projects of Energy Efficiency Retrofits for Non-residential Buildings* (Shanghai municipal government issued [2013] NO. 311). According to the Notice, non-residential buildings that have or are decreasing energy consumption per square meter floor space by 20% or more will receive a total subsidy of up to 35-40 Yuan per square meter (including a national financial subsidy of 20 Yuan per square meter, and those that adopt Energy Performance Contracting shall receive another 20 Yuan per square meter). Municipal subsidies and national subsidies are allocated separately. The project undertaker must submit detailed materials including an energy audit report and project proposal. Once the project being approved by the designated department, 50% of municipal subsidy and 65% of the national subsidy will be allocated. After the completed project has been examined by designated audit institutions, the remaining 50% of municipal subsidy and 35% of the national subsidy will be granted. Subsidies allocated shall be recalled if the project fails to pass its evaluation. To this end, relevant departments have introduced a series of supporting regulations, covering project admission and energy-saving audit methods. Retrofit projects must install sub-metering and monitoring devices, and connect to the monitoring platform. Shanghai completed energy efficiency retrofits for 73 large buildings with a total area of 4 million square meters during the Twelfth Five-Year Plan period.[22] Among them, the Changning low-carbon demonstration area completed 23 energy efficiency retrofit projects for existing buildings, covering a floor area of 1,347,800 square meters by the end of 2015.

3.2.1 Early Data Disclosure Efforts

Authorities have gathered a tremendous amount of detailed government office building and LNRB information and energy performance data through the monitoring platform. In a broad sense, Shanghai began disclosing building energy consumption data early on although this did not include benchmarking. In response to national policies, the Shanghai municipal government released some buildings' energy use data on their official website as early as February 2008 (see Table 2).[VIII] This release included data from 16 government office buildings, six hotels, 10 shopping malls, and five schools.[23] Thenceforth, the government released several batches of data. Disclosed data includes building type, area, annual energy consumption and average energy intensity. Although there are some shortcomings, namely the time window to access disclosed data is too short, data is disclosed discontinuously, and data is over-generalized; however, such disclosure is an early attempt to improve data transparency and its application.[24]

Since the Shanghai municipal government's 2012 *Annual Report on Priorities of Energy Conservation and Emissions Reduction,* the government has required monitoring and disclosing the energy consumption of government office buildings and LNRBs. Take 2016 as an example, the report proposed to disclose the energy use data of 100 buildings. Based on the positive results of energy use monitoring, Shanghai has established an annual building energy use data analysis report series. Since 2014, the *Energy Consumption Monitoring Annual Report Based on Government office Buildings and LNRBs Energy Consumption Platform* (hereinafter referred to as Energy Consumption Monitoring Annual Report) has been released for three consecutive years. The annual report includes the progress made on monitoring the energy consumption of all government office buildings and LNRBs in Shanghai, the location of monitored buildings and their types, energy consumption data and other relevant information (see Figure 11 and Figure 12).

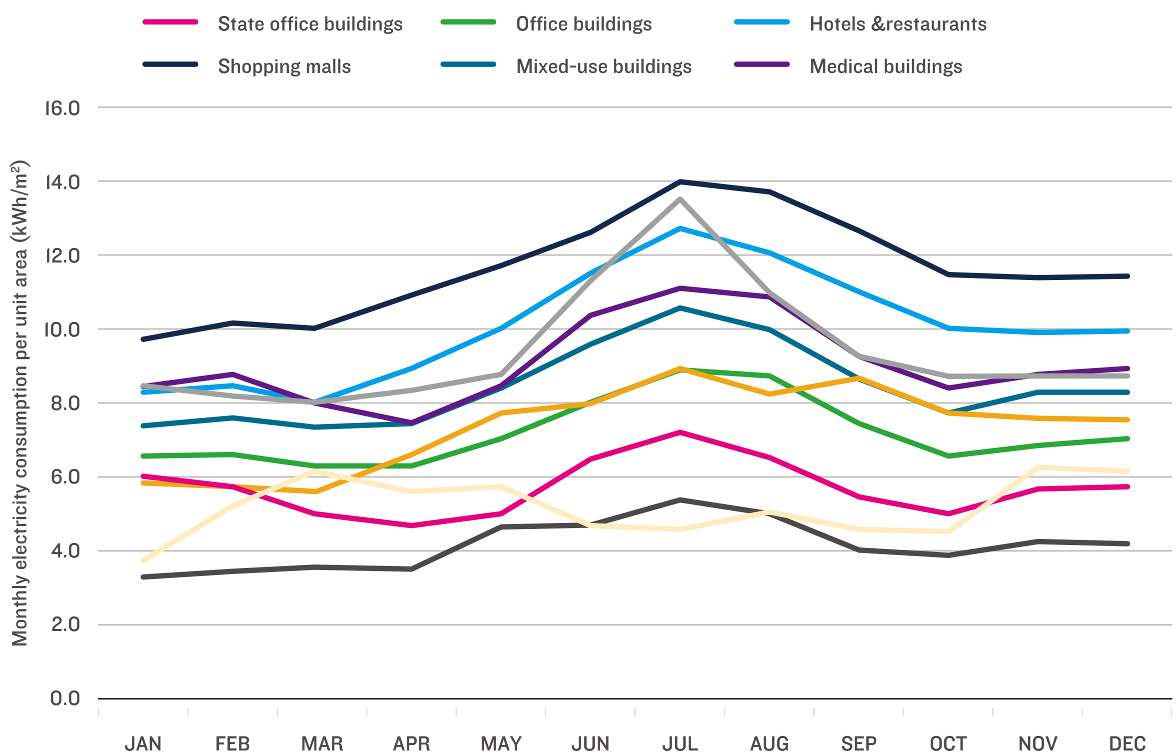
Table 2

Shanghai building energy performance data disclosure table (selected)

Name	Type	Area (m^2)	Annual Consumption (ton of coal)	Annual Consumption per unit area (ton of coal/m^2)
Shanghai Municipal Information Committee Building	Centralized office	18547.13	112.47	0.006
Shanghai Municipal Intellectual Property Bureau Building				
Shanghai Municipal Public Works Bureau Building	Combined office	7226	154.99	0.021
Shanghai Municipal Youth League Committee Building	Office building leased	3500	129.44	0.037
Ramada Pudong Airport Shanghai	Four-star hotel	34000	n/a	0.0244
Pinault Printemps-Redoute Huaihai Lu Department Store	Shopping mall	22214	2205.84	0.0993
Shanghai University	University	1098300	19931.36	0.490485

Figure 11

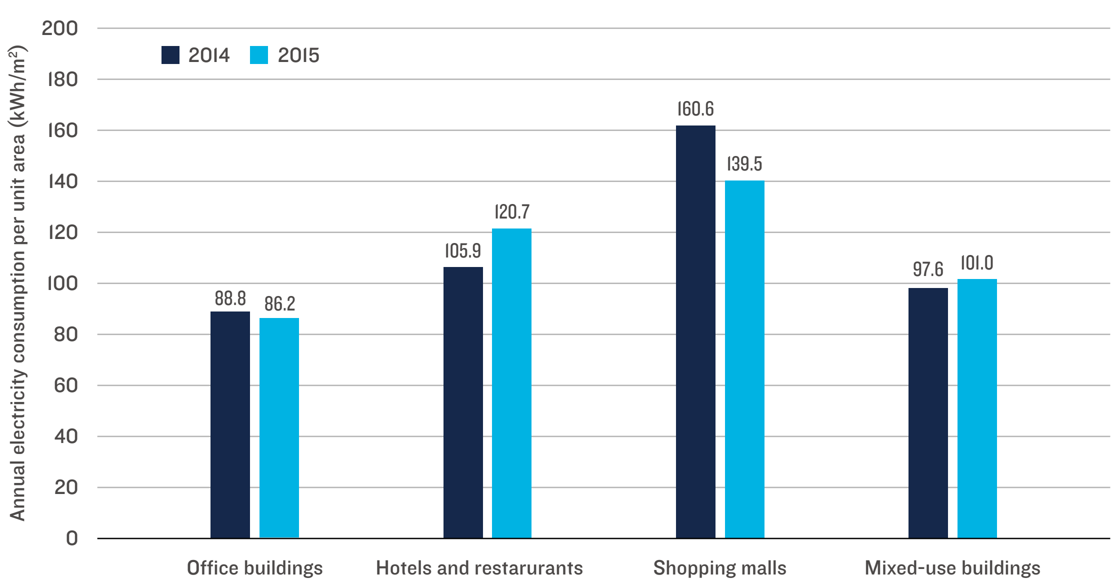
Monthly energy consumption of government office buildings and LNRBs in Shanghai in 2015 (Original legend only contains 6 entries)



Source: Shanghai Municipal Housing and Urban-Rural Development Commission. http://www.scca.sh.cn/shownews.aspx?id=8710

Figure 12

Annual electricity consumption per unit area of LNRBs in Shanghai from 2014 to 2015



Source: Shanghai Municipal Housing and Urban-Rural Development Commission

The above information is open to the public. In addition, the municipal-level monitoring platform (the first "1" of "1 +17 +1" platform) established a website where municipal energy conservation authorities can access the monitoring and analysis of energy performance for all building types. The municipal-level platform also regularly publishes the energy consumption data of buildings in districts and counties and sends an annual report to building owners.[25]

Based on these available statistics, audit and monitored data, Shanghai has carried out research on utilizing data, and released guidelines for the rational use of energy (hereinafter referred to as Guidelines). From 2011 to 2014, six guidelines for rational energy use were introduced:

- *The Municipal Agency Office Buildings Guidelines for Rational Use of Energy*
- *The Star-rated Hotels Guidelines for Rational Use of Energy*
- *The Large-scale Commercial Buildings Guidelines for Rational Use of Energy*
- *The Medical Buildings Guidelines for Rational Use of Energy*
- *The Comprehensive Buildings Guidelines for Rational Use of Energy*
- *The College Buildings Guidelines for Rational Use of Energy*

2015 saw the publication of *The Large-scale Public Cultural Facilities Guidelines for Rational Use of Energy*. New guidelines are being added, such as the upcoming *Primary and Secondary Schools Guidelines for Rational Use of Energy and Evaluation on the College Buildings Guidelines for Rational Use of Energy* etc.[26]

The guidelines offer authorities references for energy-saving policy making and a basis for a future energy consumption quota (setting ceiling energy amounts that building should not exceed); they also encourage owners, property managers and related actors to actively participate in energy saving. To this end, the guidelines have set a **reasonable value** and **advanced value** for the energy use of typical building types. The reasonable value is indicate the highest acceptable energy consumption level. Buildings exceed that value should be retrofitted. The advanced value sets standard for the ideal level of energy consumption, highlighting buildings with high energy efficiency. Approximately 75% of buildings operate at around the reasonable value while the advanced value

Table 3

Reasonable advanced energy consumption value of large commercial buildings

Type	Comparable comprehensive energy consumption per unit area (ec) kgce/(m^2•a)	
	Reasonable value	Advanced value
Shopping mall	◂90	◂65
Supermarket and warehouse	◂105	◂75
Family appliance store	◂50	◂35
Restaurant	◂150	n/a
Bathing center	◂110	n/a

Table 4

Calibration parameters for star-rated hotels in Shanghai

Star hotels rank	Calibration parameters			
	Annual room occupancy rate	Room density	Laundry equipment density	Parking area percentage
Five star	√	√	√	√
Four star	√	√	√	
One to three star	√	√		

Source: *The Star-rated Hotels Guidelines for Rational Use of Energy* (DB 31/T551 —2011)

is set to a level that only 25% of buildings can attain. Table 3 shows the two values from *The Large-scale Commercial Buildings Guidelines for Rational Use of Energy* (DB 31 / T552-2011):

Similar to the analysis method of ENERGY STAR, the identification of a reasonable value and advanced value normalizes the main non-controllable factors[IX], such as weather, that affect the actual energy consumption, in order to allow buildlings of the same type to be fairly compared.[27] For example, office buildings are calibrated in accordance with the form of air-conditioning system (central air conditioning or split air conditioning); star-rated hotels in accordance with the room occupancy rate, laundry equipment density, etc. (see Table 4); large-scale commercial buildings in accordance with sales per unit area and building area.[X]

Statistical data, audit data, and monitored data are used in the preparation of the guidelines. The statistical data comes from the aforementioned energy statistics for all buildings from 2007. Monitoring data refers to information gathered from the online monitoring platform for large buildings. Besides this, Shanghai has also conducted energy auditing for about 700 large buildings. Below is a high-level summary of what data points the three datasets offer respectively.

- Energy consumption statistical data: covering all fuel types including coal, natural gas, steam, gasoline, liquefied petroleum gas, heating and cooling, etc. Annual energy consumption (kgce/a), annual electricity consumption (kWh/a), total energy consumption per unit area (kgce/(m^2•a)) and total electricity consumption per unit area (kWh / (m^2•a)).
- Energy audit data: In addition to energy use, building information such as name, address, type, total area, form of air conditioning systems, building heating systems, and building envelope are recorded. Annual electricity consumption (kWh/(m^2•a)) and annual energy consumption (kgce/a), electricity consumption of per unit area (kgce/(m^2•a)), total energy consumption of per unit area etc are included.
- Energy consumption monitored data: It mainly monitors electricity consumption of LNRBs. It can provide annual, monthly and even 15 minutes interval electricity consumption (kWh/a), electricity consumption per unit area (kWh/(m^2•a) and electricity consumption for different type of usage (HVAC, plug load, lighting etc).

There is overlap between the three datasets , but some content, indicators, data formats, time duration and depth vary between them. The statistical data covers a greater range of energy types, but at a lower granularity; the monitored data is more detailed but only covers electricity consumption; audit data includes not only the building information and energy consumption but also some detailed information about the physical building. But audit samples are limited, and audits are not done every year. Much of the existing audit information is energy consumption data from before 2010, which does not reflect current energy consumption. Thus, the guidelines are based on audit data supplemented by monitored and statistical data.

3.2.2 Shanghai's emergent energy performance benchmarking system

At present, Shanghai has no specific regulation or standard on building energy performance benchmarking. But from 2014 on, a chapter of Energy Performance Benchmarking of Typical Building Types has been included in the *Energy Consumption Monitoring Annual Report*. As outlined in these reports, the basic method for benchmarking is to calibrate a building's measured energy consumption in accordance with the method given in the guidelines to obtain the comparable annual energy consumption. Then the building can be compared with the reasonable value and advance value set by the guidelines to identify the relative energy consumption level of the building. For example, those higher than the reasonable value are identified as poor energy performers and those lower than the advanced value can be regarded as having high energy efficiency among buildings of the same type. Based on this idea, Changning District is studying the rules to implement benchmarking and disclosure currently as a self-appointed pilot district. As shown in Table 5, benchmarking practices in Shanghai differ from those in New York City and other American cities.

The independence and degree of automation are probably the most notable differences between Shanghai and New York City's Bechmarking Strategy; the outline of the basic framework process in Figure 13 illustrates these differences. Take independence as an example: first, New York uses the

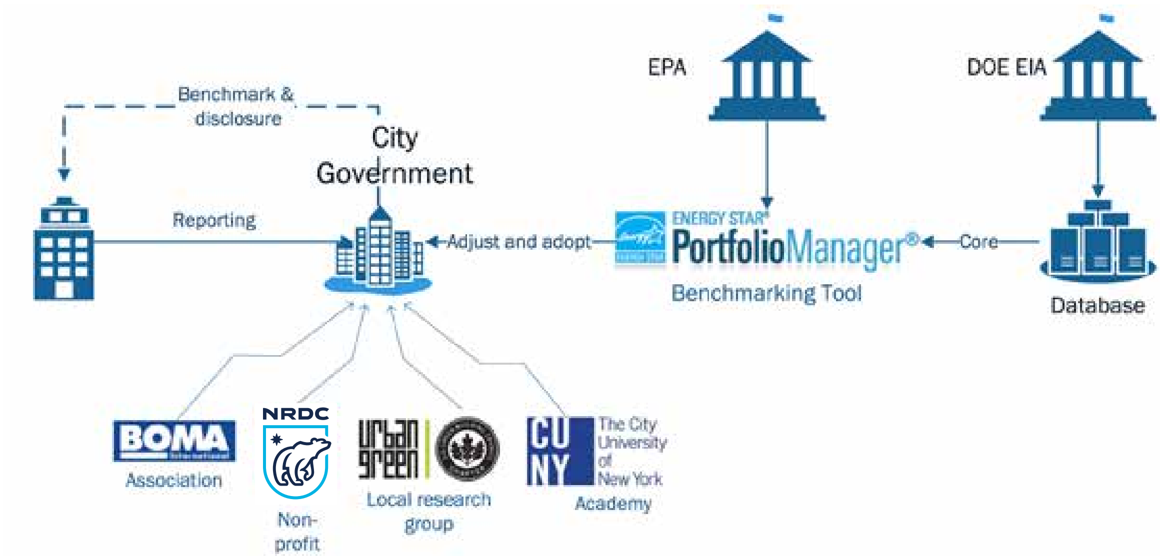
Table 5

Comparison between Shanghai and New York City Benchmarking Strategies

		Shanghai	New York City
Practices		Compare with reasonable value or advance value set in guidelines	Rank energy performance of a building among buildings of the same type, and show the ranking in percentage
Similarities		• Based on measured energy consumption • Obtain both absolute value of energy consumption and energy intensity • Regular updates to the building sample pool are needed [XI] • Exclude non-comparable factors to ensure fairness	
Differences	Forms	Whether building meets requirements of reasonable value or advance value (yes or no questions)	Present in grades on a scale of 1-100
	Relation to disclosure	Relatively independent	Benchmarking first, disclosure second
	Comparison basis	Energy audit and monitored samples	CBECS[XII] database etc.
	Benchmarking process	Professional involvement and manual calibration are needed	Owners upload building information and energy consumption data online; utilities add energy bill information; benchmarking results produced automatically
	Supporting organisations	Majority are data collecting and research institutions	Multiple organisations and institutions involved
	Challenges	Acquisition of information for calibration indicators	Access to tenants' energy consumption data
	Others	Specific calibration indicators, classification of buildings, data process methods	

Figure 13

New York City Building Energy Performance Benchmarking Workflow Diagram



ENERGY STAR Portfilio Manager. The tool is independently maintained by the US Environmental Protection Agency and free to states and municipalities to use and get support; second, the benchmarking tool uses samples from the CBECS database to identify the total amounts of buildings of a specific type, and the CBECS database is maintained by the Department of Energy Information Administration (EIA) independently. Moreover, the full mobilization of associations, utilities, non-profit organizations, research institutions and other external forces, further enhances the independence of benchmarking. Automation also manifests itself in many aspects of the process. For example, building information and energy consumption information is submitted by owners online, aggregated energy bills are uploaded by utilities directly in New York City, and benchmark results are also produced online. There is no need for professional manual calibration or third party validation.

It should be pointed out that some of the above differences (such as practices) are determined by the different situations of the two cities. It does not imply that one is better than the other. The purpose of such comparison is to learn from each other and improve both policies.

In addition, based on the guidelines, Shanghai is developing energy consumption quota system for non-residential buildings to set the maximum energy use for all types of non-residential buildings. [28] We will discuss the differences between the quota system and benchmarking in Chapter 5.

3.3 Challenges for benchmarking and disclosure in Shanghai

Section 2.2. introduced Shanghai's policy and progress in terms of benchmarking and disclosure. The comparison between the approaches of NYC and Shanghai show where improvements could be made in Shanghai. Two shortcomings are particularly noteworthy:

- Conducting benchmarking and disclosure separately: the separation of disclosure and benchmarking makes disclosed information difficult to be understood by non-professionals, thus greatly weakening the positive effects of disclosure.
- Benchmarking is not widely used and is limited to the research level: the current limitation is mainly due to incomplete data (especially the lack of parameters to calibrate benchmarking results such as the annual revenue of shopping malls, occupancy rate of star-rated hotels and other information).

In short, Shanghai's current approach to benchmarking and disclosure cannot effectively promote data transparency. In fact, the lack of transparency has become a major obstacle to energy efficiency retrofits. As shown in Figure 14, building owners or property managing companies should be responsible for energy efficiency retrofits and energy efficient operation. However, they often do not take initiative for various reasons. For instance, these activities may be beyond the scope of their power or they may be unaware of benefits and concerned about the potential risk of not recovering their investments. Therefore, they tend not to directly invest in retrofits, instead relying on external impetus and capital investment.

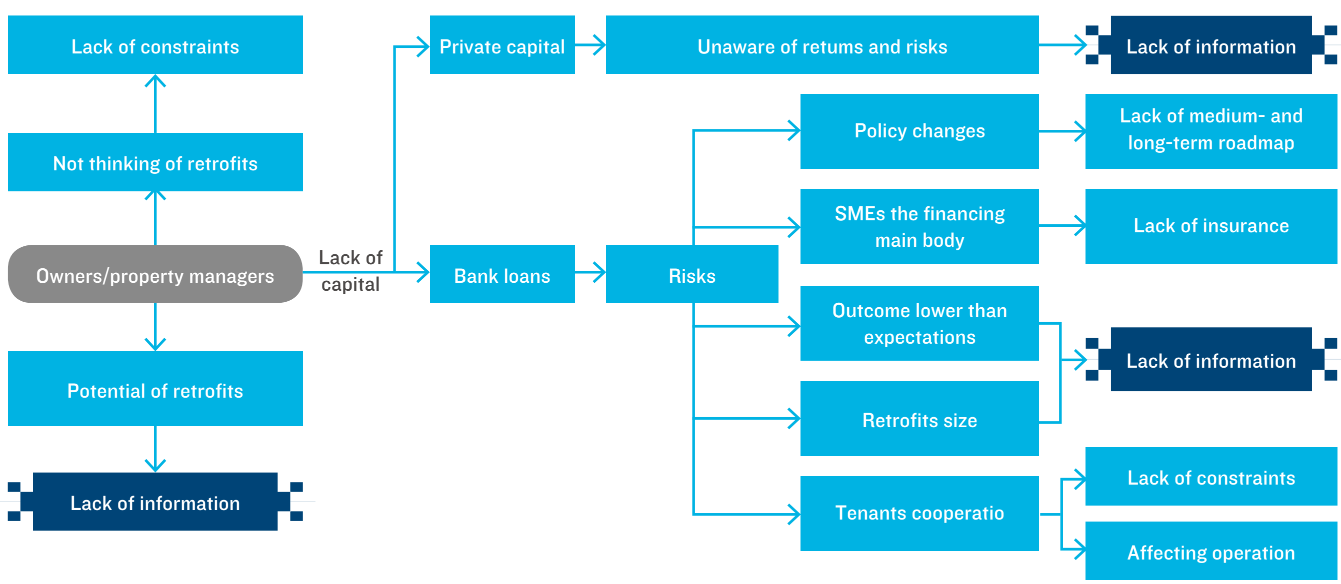
As shown in the figure, building energy performance data is not easy to access and the cost effectiveness of retrofits is not clear, thus private capital lacks confidence that they will profits from retrofits. This has left investors cautious and conservative. In contrast, seeking loans from banks seems to be a better choice. Many regions are trying to seek support from banks, insurance companies, and other financial institutions to complete retrofits.

The Shanghai Demonstration Project on Building Energy Efficiency and Low-Carbon City Construction attempted to help these projects overcome financial barriers. It was launched jointly by the World Bank (WB), Global Environment Facility (GEF), and the Chinese government in September 2013. Focusing on Changning District, the project demonstrates energy conservation strategies to promote large-scale investment in low carbon development. Energy conservation renovation of existing buildings is the project's priority and tackling the financing issue was the first step. The GEF provided $4.35 million in technical assistance, and the World Bank provided a loan of $100 million through Shanghai Pudong Development Bank and Shanghai Bank.

However, the amount of lending has been insufficient since the project started, which is indicative of a larger issue. The risk-return trade-off is one of the key factors banks consider when deciding whether to give loans. However, this creates a paradox: large companies with good credit and low risks in paying off loans are generally equipped with sufficient funds and do not need bank loans while the majority of small and medium enterprises (small and medium-sized energy conservation service companies) are in urgent need of financial support but cannot easily obtain loans because of their relatively high risk. They are ranked as high risk in paying off loans for several reasons. For instance,

Figure 14

Obstacles for energy efficiency retrofits of existing buildings



they are usually asset-light companies with low credits, lacking collateral for loans. In addition, small and medium enterprises quote policy subsidies in the repayment plan. Therefore, the potential policy instability becomes another risk as subsidies may be canceled during the repayment period. Besides, the need for building energy performance data transparency is another key reason smaller energy service companies struggle to obtain financing. The current energy consumption, characteristics, energy efficiency level and potential of the renovation project can allow banks to predict profitability and repayment capacity. In the absence of data, banks can only rely on predictions from loan applicants, who have incentives to exaggerate potential and profits. Thus projects' returns are usually much lower than expected.[XIII] Correspondingly, repayment capacity is unreliable. Information transparency is the fundamental issue without which financing or insurance cannot be secured.

3.4 Projection of energy savings potential from benchmarking and disclosure

Practices in the aforementioned American cities show that benchmarking and disclosure, as a means to mobilize market actors, have promoted energy conservation. Since benchmarking and disclosure have not yet been widely adopted in Shanghai, it is hard to assess the energy-saving potential of the policies in Shanghai. But with the monitoring platform, it is possible to study energy-saving potentials of the monitored government office buildings and LNRBs. Therefore, the energy-saving potential of the policy can be roughly calculated by assessing energy savings from retrofits (which the policies would motivate) so that decision makers can have a deeper understanding of the potential benefits.

Many have calculated the energy conservation potential for LNRBs in Shanghai, but these calculations are either outdated or too general, discussing energy intensity alone but ignoring the total quantity of buildings. The energy efficiency ratio of all building types are needed to make an accurate projection. According to public data, 4 million square meters of large public buildings in Shanghai completed energy efficiency retrofits from 2013 to 2015, with energy consumption per square meter decreasing by 20% or more.[29] Since information about retrofits or energy performance before and after retrofits is unavailable, we can only select common types of LNRBs from projects to make projections. We have used the Twenty-first company as the source for our study. As the kind of information provided for each project varies one to the next, inaccuracy is inevitable, thus we erred on the conservative side as much as possible in our projections.

Energy-saving potentials of existing LNRBs are mainly decided by lighting and air conditioning, which consume the most energy. For example, these buildings commonly use ordinary fluorescent lamps. Offices mainly use T8 fluorescent tubes as the ceiling lights. Corridors mainly use fluorescent tubes as the main light. These two are also common in shopping malls, although more emphasis is placed on their aesthetics. Hotels mostly use warm tone-based down lights, spot lights, and light belts. All of these can be replaced by LED lamps. LED light bulbs use 40% to 60% less energy than conventional lightbulbs. Energy efficiency retrofits can also be realized by reducing running time and controlling brightness. Using these measure, a building can reduce its lighting electricity consumption by 15%.

Currently, buildings also waste energy due to poor insulation, overuse of air conditioners, inefficient equipment and systems, deferred maintenance, and the low degree of automation. There is great potential to reduce air-conditioning energy consumption in different buildings: office buildings and shopping malls can reduce their energy consumption by 5%-15%, hotels by 5%-18%, mixed-use buildings by 5%-20%. The major energy-saving measures include condensation heat recovery, BTS automatic condenser cleaning ball, changing lithium bromide refrigeration to electrical cooling or cooling tower free cooling, variable frequency fan, heat exchanger, cold rooms equipment controllers, heating by oil to heating by gas or cooling by air-source heat pumps and chillers, installation of solar heating systems, updating steam boilers to hot water boilers, etc. Through the following cases provided by Twenty-First Company, we can get a better sense of the energy saving potential for commercial office buildings, hotels, shopping malls and mixed-use buildings.

3.4.1 Case 1: Commercial office building[XIV] retrofit

Built in 1999, the office building consists of two towers and an attached building. The total building area is 103,355 m^2 with 31 floors above ground and 2 underground. The building has a double glazed curtain wall and is mainly powered by electricity and natural gas. Energy performance data from 2011 to 2013 shows a stable energy consumption level for the building with an annual electricity consumption of 11.353 million kW/h and a natural gas consumption of 32,800 m^3, equivalent to 3,046 tons of coal and 36.9 tons of coal respectively. Natural gas only powers some kitchens in the attached building. Following energy efficiency retrofits (Table 6), 726 tons of coal equivalent have been saved annually, a 21.1% improvement in energy efficiency compared to previous years.

3.4.2 Case 2: Hotel retrofit

A five-star hotel was completed in August and commenced operation in October 2006. The hotel's total building area is 44,797.8 m^2 with a 42,297 m^2 main building, a 2,022 m^2 energy centre, a 405.3 m^2 wastewater treatment plant and a 73.5 m^2 building control station. The heating and air conditioning area amounts to roughly 42,300 m^2. Its height is 51m with 13 floors above ground and one underground. The underground area is around 5030 m^2, and the area above ground is 39,000 m^2. The first three floors of the attached building include the hall, dinning zone, entertaining zone, meeting rooms, gym and swimming pool. The basement floor is for equipment. The 13th floor contains guest rooms and pubs with an area of 60 m^2 rented to shops. The building is in good condition and the outside windows are made of double Low-E glass, which helps the building maintain a proper temperature.

The hotel is mainly powered by electricity, natural gas and diesel fuel,[XV] accounting for 62%, 6% and 32% of total energy

Table 6

Energy saved by energy efficiency retrofits of the office building

Energy consumption	Actions	Energy saved (ton coal)
Air-conditioning	Replacing heating boilers with air-source heat pumps and chillers	311.7
Lighting	Lights updated	391.1
Air-conditioning	Variable frequency water chillers	23.2
Total	-	726

Table 7

Energy saved by energy efficiency retrofits of the hotel

NO.	System		Actions	Energy saved (tce)
1	Heating	Daily hot water	Replacing natural gas boilers with absorption heat pumps+ solar energy	404.2
2		Heating	Replacing natural gas boilers with air-source heat pumps and chillers	83.1
3		Swimming pool	Replacing natural gas boilers with swimming pool heat pumps	67.14
4		Kitchen steaming	Replacing natural gas boilers with small steam generator	44.9
5	Lighting	Public area	Replacing spot lights and ESL with LED lights	276.5
6	Gas	Cooking	Update to energy saving hobs	48.1
7	Air-conditioner		Variable frequency air-conditioner updating in the hall	4.0
Total				927.94
Energy efficient ratio				27.14%

consumption respectively. Natural gas is mainly used for heating and hot water; diesel fuel is used in the kitchen. Energy consumption in 2010, 2011 and 2012 was equal to 3275.75tce, 3162.28tce, and 3419.52tce respectively. After energy efficiency retrofits adopted (annual energy consumption dropped to 927.94tce. Compared to 2012, energy efficiency improved by 27.14%. Table 7), annual energy consumption dropped to 927.94tce, a 27.14% improvement in energy efficiency compared to 2012.

3.4.3 Case 3: Shopping mall retrofit

The shopping mall studied has a total area of 60,000 m^2 with six floors above ground and one underground. Heating is need from the end of November to end of next March; cooling is used from the end of April to the the beginning of November. The mall's annual electricity consumption during the reference year was 11,800,000 kWh and its gas consumption was 1,625,000 m^3, equivalent to 4811.6 tce. Electricity consumption increased after retrofits by 473,000 kWh annually according to Table 8, but gas usage decreased by 128,000 m^3, a 11.5% improvement in energy efficiency compared to previous years.

3.4.4 Case 4: Mixed use building retrofit

This building includes an office, exhibition area, and shopping center with the total area of 284,651 m^2 and operation area 266,867 m^2. The building is 136.3m tall with 32 floors. It commenced operation in October 1999. The building's annual energy consumption in 2011 was 7980tce. It is mainly powered by electricity and diesel fuel; electricity use was 24,398,000 kWh, about 91.8% of total energy consumption. Electricity powers cooling, ventilation, lighting and office use. Diesel fuel consumption was 453.3tce, accounting for 8.2% of total energy consumption. Diesel fuel is mainly used by the heating boilers. Table 9 presents the energy consumption of different items in 2011.

Table 8

Energy saved by retrofits of a shopping mall

Item	Electricity saved (ten thousand kWh)	Gas saved (ten thousand m^3)	Energy saved (tce)
Air conditioning cooling facilities	-71.0	128.00	481.9
39 variable frequency air-conditioners	16.0		48.0
LED lights updating	1.8		5.3
Brightness enhancement film on advertisement lamps	6.0		18.0
Total	-47.3	128.0	553.1

Table 9

Energy consumption of different items of an integrated building

Item	Electricity consumption (ten thousand kWh)	Diesel fuel consumption (ton)	Equivalent of coal (ton)	Percentage
Ventilation	1213.35	0	3640	45.6%
Heating	177.36	453.12	1192	14.9%
Lighting	414.77	0	1244	15.6%
Comprehensive service	170.75	0	512	6.4%
Indoor equipment (including lifts)	463.57	0	1391	17.4%
Total	2439.8	453.1	7980.2	100.0%

It is calculated (Table 10) that annual energy savings reached 872.8 tce after retrofits, with annual electricity savings of 2586,000 kWh and annual diesel savings of 451 tons. Natural gas consumption increased by 431,000 m^3, a 10.9% improvement in energy efficiency compared to previous years.

As mentioned earlier, the data for the above cases may not entirely be precise. Even if the data was completely accurate, these cases cannot be used to project the exact energy savings potential for buildings of the same type in the same region. Differences between buildings of the same type could even lead to a wider energy savings potential gap than that of different types of buildings. However, the four cases do show that energy consumption can be reduced by 20%, and that this level of reductions is feasible. Research from the Twenty-first company on the LNRBs registered in the district-level sub-platforms of Changning District and Huangpu District shows that most buildings in the region were built before 2005 and have relatively high levels of energy consumption. At present, the public awareness regarding energy savings is increasing, and energy efficiency has become a priority for property managers. However, due to poor property management, there remains great potential for energy savings. These cases show that the energy saving potentials of office buildings is approximately 24%, 20% for shopping malls, 25% for hotels, and 20% for mixed-use buildings.

Table 10

Energy saved in an integrated building after retrofits

NO.	Item	Electricity saved (ten thousand kWh)	Diesel fuel saved (ton)	Natural gas saved (ten thousand m^3)	Equivalent of coal (ton)
1	Glass screen protector	6.606			19.8
2	Thermal insulation roof	0.945	4.552		9.5
3	Boilers heated by oil to natural gas		446.4	-44.5	72.4
4	Centrifuge replacement	8.36			25.1
5	Water system	12			36.0
6	Cooling tower	11.8			35.4
7	Fresh air machine of shopping mall	15.8		1.388 [XVI]	65.4
8	Aisle lighting	89.1			267.2
9	Garage lighting	35.54			106.6
10	BA system	27.31			81.9
11	Photovoltaic power generation system installation	51.13			153.4
12	Total	258.6	451.0	-43.1	872.8

Note: negative numbers mean that consumption increased.

Table 11

Estimated energy saving potential of LNRBs registered on the Shanghai monitoring platform

Type	Annual electricity consumption (kWh/m^2)	Average energy consumption(kgce)	Area (ten thousand m^2)	Assumed energy efficient ratio(%)	Potential (tce)
Government office buildings	68.2	20.5	334.6	15	10289
Office buildings	86.2	25.9	1906	21	103667
Hotels and restaurants	120.7	51.7	775	27	108182
Shopping malls	139.5	41.85	1102	20	92237
Integrated buildings	101	30.3	989	11	32963
Others (educational, recreational and sporting)	84	25.2	613	15	23171
Total			5719.6		370511

Notes: Values projected based on experience, and energy intensity and other data from the *Energy Consumption Monitoring Annual Report*.

Taking energy efficient ratio of the above sample cases as that of their corresponding building types, the monitored 57.196 million m^2 alone can save energy equivalent to 370,000 tons of coal. That is to say, monitored buildings can save 370,000 tons of coal annually (see Table 11).

If we do not divide buildings into sub-types such as hotels and shopping malls and instead give these large buildings an average energy intensity of 100 kWh/m^2 and an energy efficient ratio of 20%, then it can be calculated that the annual energy savings potential could reach 340,000 tons of coal. Whether the calculation results in 370,000 or 340,000 tons per year, it is an impressive amount. A survey conducted in four typical residential areas in Shanghai found that the average annual energy consumption of a typical residential area in Shanghai is some 1113 kgce/ (household). So to put the potential annual energy savings of buildings registered on the monitoring platform in perspective, the energy saved could power 300,000 households in Shanghai, which is more than the total number of households (258,700 households) in Changning District.

In general, improving the management of existing LNRBs can save 3%-5% of total energy consumption. Assuming that energy saving awareness of owners and property managers would increase greatly after benchmarking and disclosure, it can be projected that implementing benchmarking and disclosure policies has the potential to reduce coal use by 50,000-90,000 tons annually within the coming 5 years just within the buildings registered on the platform. Based on the effects of benchmarking and transparency policy in the U.S. (annual energy consumption reduced by 2%-3% on average), it is estimated that benchmarking and disclosure policies have the potential to save 30,000- 50,000 tons of coal every year in the currently monitored buildings alone.

The removal of information barriers and realization of energy savings potential relies on the timely and effective implementation of benchmarking and disclosure policies. As a market-oriented approach, benchmarking and disclosure policy requires the participation of market actors. That is to say, the degree of support and engagement from market actors will determine the success of the policy. To determine the wiliness of the market to participate in benchmarking and disclosure, we conducted a survey on views of stakeholders in Shanghai, the results of which will be presented in the following section.

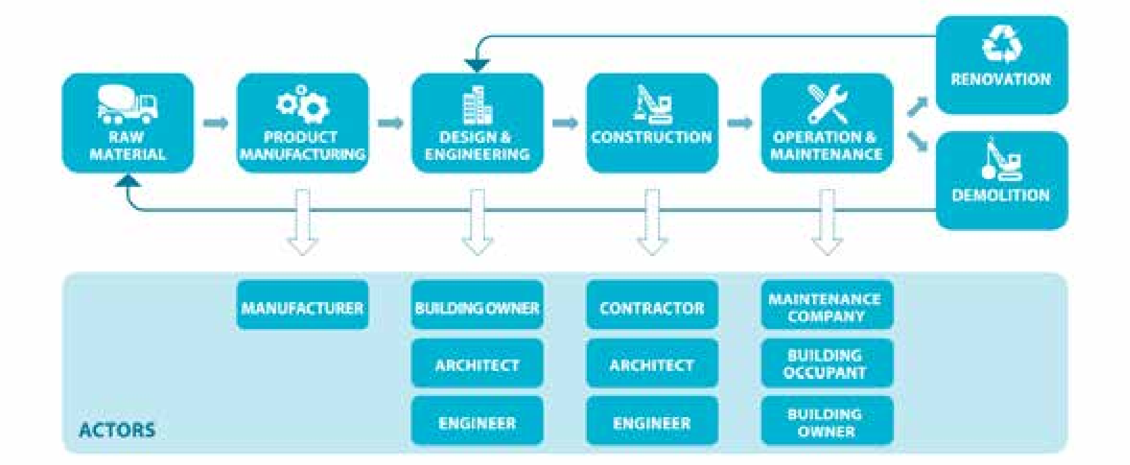
4

STAKEHOLDER SURVEY

Improving building energy efficiency is a systematic process involving design, material selection, construction, operation, and renovation or demolishing. Apart from the stakeholders described in Figure 15 below, common actors also include authorities, industrial associations, energy suppliers, energy consultancies, rating agencies, and financial institutions, energy conservation service companies. Concerning the operation phase alone, besides owners, tenants and property management staff, designers and construction workers are key stakeholders who, theoretically, should take long-term responsibility for project planning and quality.

Figure 15

The Construction Life-Cycle and Actors in Building Sector



Source: Buildings Performance Institute Europe (BPIE)

The survey collected key stakeholders' opinions on benchmarking and disclosure to learn about key issues such as whether they will accept such a policy and concerns they have. The survey results can provide policy-makers with insights and facilitate policy implementation. The directly related stakeholders, owners, and property management staff, were selected as key respondents. Contract energy management companies and other actors were not considered key respondents since similar surveys[30] have suggested that they are the main beneficiaries and supporters of benchmarking and disclosure. Because Shanghai does not provide large-scale central-heating, and much less waste is seen in the transmission and distribution of electricity and gas than those of hot water, heating and electricity suppliers were also not included in the survey accordingly.

The survey also focused on four types of LNRBs in Shanghai—office buildings, shopping malls, hotels and mixed-use buildings—and conducted questionnaire surveys and interviews with stakeholders in five buildings of each type. Government office buildings were not included in the survey. The government should lead by example and take the initiative to conduct energy benchmarking and disclosure; therefore, we did not find it necessary to gather feedback in this area.

Most people we surveyed are still unfamiliar with energy benchmarking and disclosure as it is a new concept to them. In order to determine their openness to the policy, we designed questionnaires with Twenty-first company and commissioned Twenty-first company to do the telephone and on-site surveys. The questionnaire asks for basic information, energy management information, and feedback about benchmarking and disclosure. Almost 40 respondents participated in the survey, and 32 valid responses were collected. The responses to eight key questions are briefly presented in the following section.

4.1 The potential to increase information transparency

Respondents were required to choose three determinants that they think affect energy savings among options. As shown in Figure 16, service quality ranks the highest while social responsibility and public opinion were not seen as significant barriers. This results are partly due to owners and property management staff's limited awareness. Because these stakeholders have always lacked information, they cannot recognize the importance of tenants' reviews, not to mention public opinion. Therefore, great potential is expected to be unlocked with respect

Figure 16

Factors affecting energy efficiency policies

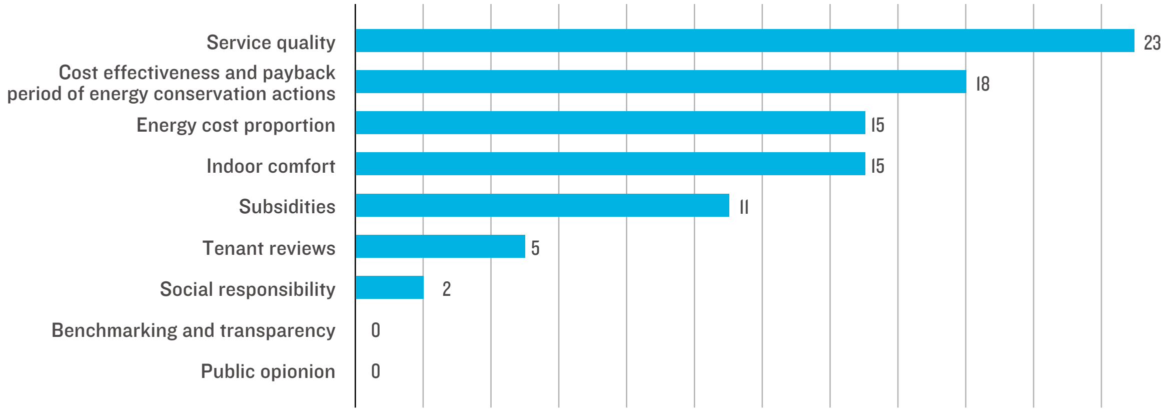
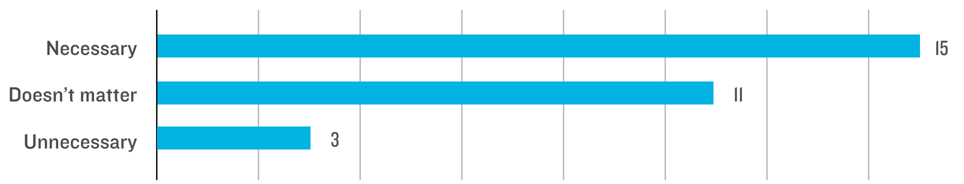


Figure 17

Feedback about “is it necessary to disclose your own building’s energy data”



to social responsibility and public opinion through benchmarking and disclosure.

4.2 Most people are in favor of data transparency

When asked about whether it is necessary to disclose energy performance data, more than half of 28 responses found it necessary, and only three deemed it unnecessary. This supports the belief that disclosing data, especially which of the same type buildings, helps to build a comprehensive understanding of a buildings’ comparative energy performance level, which can contribute to energy efficiency improvement. Opponents argued that differences among buildings leads to differences in energy performance, therefore other buildings’ energy information only providing a limited reference. Respondents who said “doesn’t matter” are not denying the positive impacts of information disclosure, but lack confidence in whether transparency would improve operation levels or whether authorities are able to overcome obstacles effectively and promote transparency steadily.

4.3 Most respondents willing to disclose their own building’s data

Owners’ and property management staff’s willingness to disclose data indicates the degree of resistance to such policies and thus is of great significance. The ideal scenario is, of course, that most are willing to disclose their “books” actively.

Figure 18 shows that the reality is far from the ideal scenario. Most respondents are not motivated to disclose their records on their own accord. Without data disclosure, only owners and property management staff know how efficient the building is, and hold the authority to interpret their own buildings’ energy performance and thus cannot gain an active comparative understanding. However, some respondents thought that benchmarking and transparency is too complicated to put into practice. Fortunately, very few respondents expressed resistance to the policies; most choose to wait and see. Therefore, providing incentives and mollify the concerns of the majority can fairly readily increase support.

Figure 18

Feedback about "are you willing to disclose your own building's energy consumption and performance data"

Figure 19

Feedback about "What's your biggest concern over disclosing the energy data of your own building?"

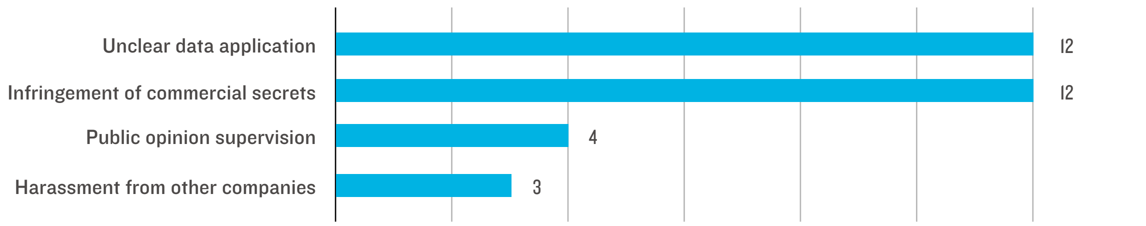
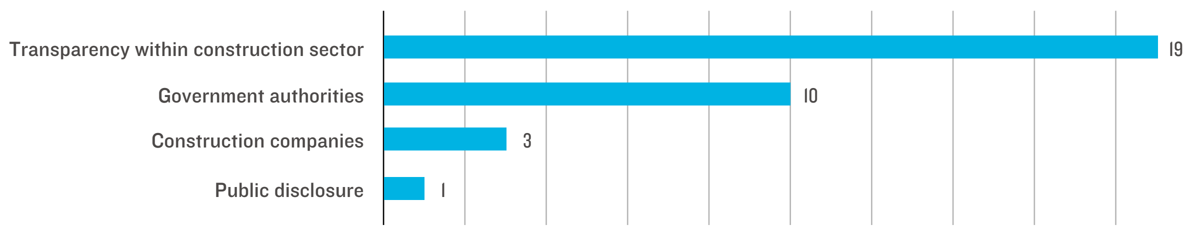


Figure 20

Feedback about "To whom should building energy performance data be disclosed?"



4.4 Concerns regarding data privacy

Figure 19 outlines respondents' concerns over benchmarking and data disclosure. "Infringement of commercial secrets," the most frequently mentioned topic in previous symposiums, unsurprisingly was also a top concern among survey respondents. Uncertainties regarding data usage were also widely expressed. Owners and property management staff worry that once data has been disclosed, more regulations may be imposed, although they can't identify any potential restrictions right now.

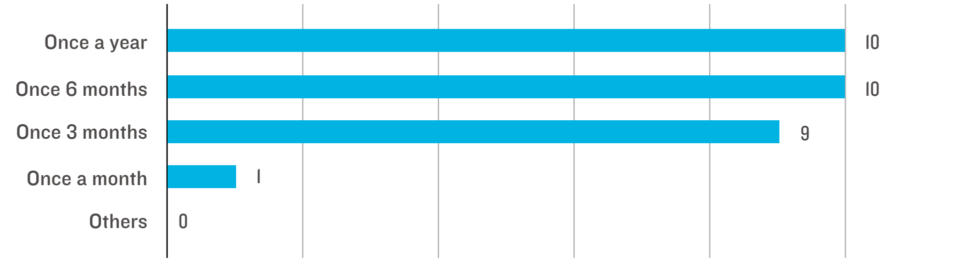
Concern about privacy infringement decreases government motivation to promote data disclosure. In addition, authorities are wary of being held accountable for issues and inconsistencies with data. Besides, in order to encourage more owners to participate in the energy monitoring system for LNRBs, some local governments have promised that energy data will not be publicly disclosed but only serve as references for policy making. All these factors result in a mentality of "better to avoid the trouble" among some local authorities.

4.5 Transparency within peer group is the main preference

As mentioned before, energy performance data can be disclosed to investors or tenants who are directly related to a specific building, to research institutes, or even to the general public. Most respondents support transparency within the construction sector, believing that only insiders

Figure 21

Feedback about "building energy performance data disclosure frequency"



care about building energy data and that peer comparison is the most effective way to improve energy efficiency.

4.6 Disclosure frequency can be increased

Taking timeliness into consideration, international best practices show that data should be disclosed no less than once a year. Under this prerequisite, different frequency has been set in different areas. Theoretically, disclosure times and frequency should be determined based on data types. However, currently no such data disclosure frequency system exists in China. Therefore, we can only use the survey to acquire a basic knowledge of respondents' acceptance and understanding of data disclosure frequency.

Figure 21 indicates that most respondents prefer data to be disclosed once a year or every six months. Considering practical difficulties, once a year may be more efficient.

4.7 Electricity consumption of different items received the most attention

As for what kind of data should be disclosed, the survey listed 23 options including basic information, energy consumption and efficiency, electricity consumption and distribution data. Their top five preference areas for data disclosure are the power system load, HVAC and lighting system load, building area, total electricity consumption, and plug load. Building area and total electricity consumption fall under general information while the other three are classified as electricity consumption distribution data. The ranking suggests respondents' priorities. Electricity consumption distribution data and total electricity consumption are key indicators when comparing energy performance among buildings and can provide references for policy making. Interestingly, half of the respondents believe that the leasing/occupancy rate should also be disclosed to the public. Not all respondents voted against the disclosure of data that seemingly directly related to business revenue.

4.8 Acceptance of current building energy consumption standards

China has established standards for Energy Consumption in Civil Buildings to regulate energy consumption of existing buildings, especially LNRBs. Shanghai also published a voluntary guide to proper use of electricity for six building types. By looking into respondents' understanding of these technical documents, one can infer his/her future response to the implementation of energy benchmarking and data disclosure.

Most respondents have acknowledged that the current standards and guides are helpful. However, there were more than 10 respondents who had little knowledge about the current standards and guides. Given the fact that these buildings have already been included in the energy consumption monitoring system, the respondents should have been more aware. Thus, encouraging owners and managers to actively get involved should be given more consideration in future policies.

In addition, the survey addressed to whom and where to disclose data as well. 26 respondents stated a preference for disclosing data on government websites, and two said they would like disclosure to take place on TV or radio. Newspaper and magazines received zero votes. As for who should be responsible for data disclosure, 29 respondents chose government departments plus owners' discretion, and two selected owners' discretion. No one chose government alone. At this very preliminary stage when the prototype of benchmarking and data disclosure policies in Shanghai has yet to be developed, these results can provide critical background knowledge in terms of stakeholders' attitudes and perceptions.

Figure 22

Feedback about "What kinds of data should be disclosed?"

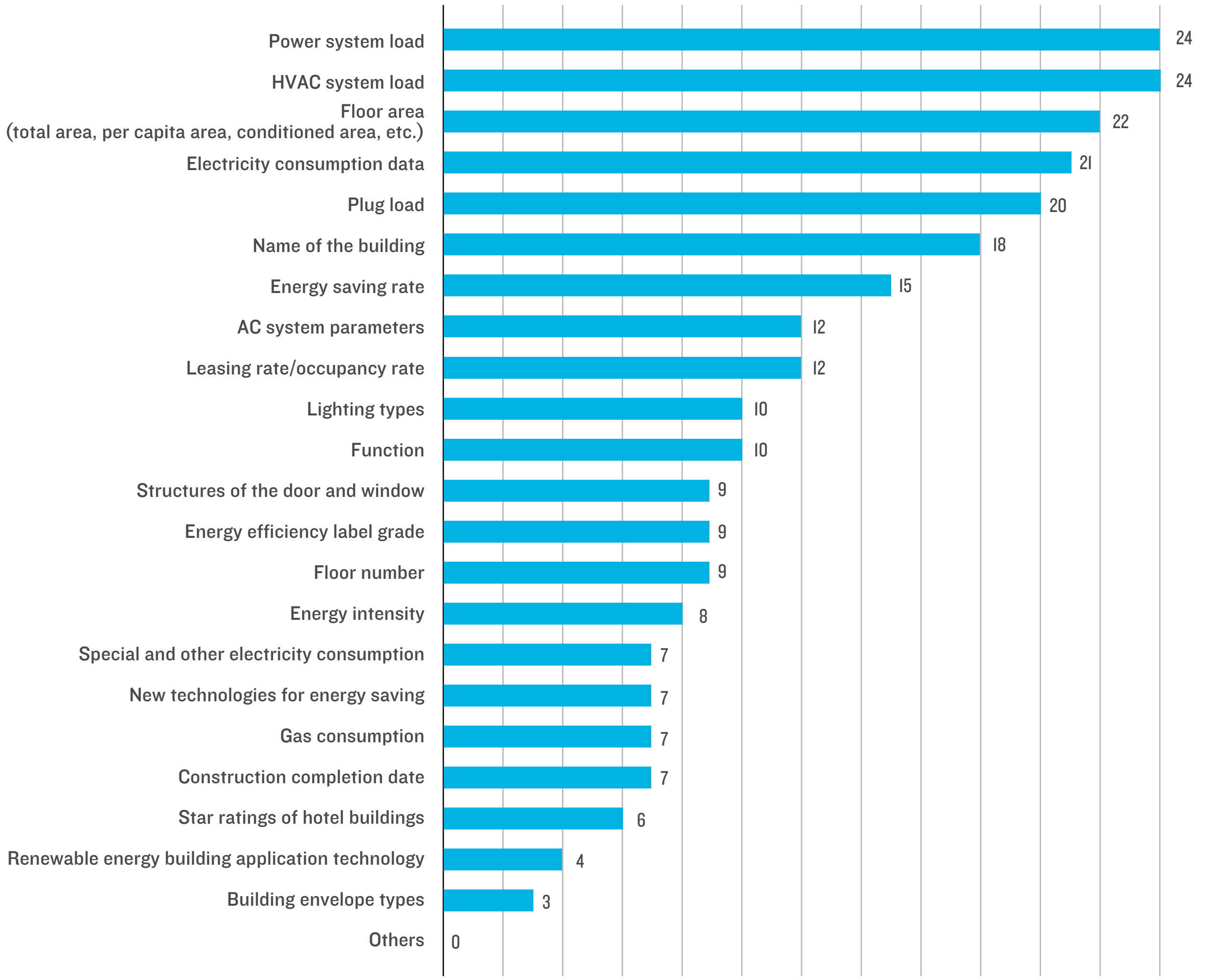
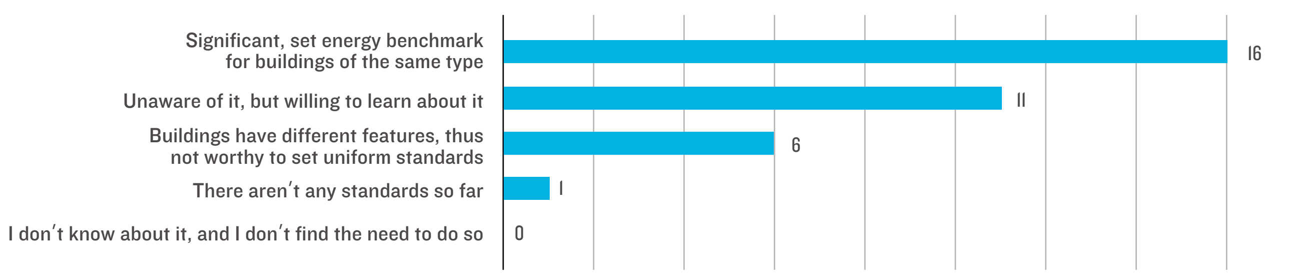


Figure 23

Feedback about "How do you view Shanghai's current building energy consumption standards?"



5

FEASIBILITY OF DEVELOPING BENCHMARKING AND DISCLOSURE IN SHANGHAI

Through the survey as well as communicating with insiders in the past two years, we have encountered different opinions on commercial privacy, data quality, and other issues. Although many issues were unearthed through our work in Shanghai, these lessons can also be applied to other regions. This chapter will analyze the most prominent issues.

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5.1 Is it worthwhile to implement benchmarking and disclosure?

Speaking of data disclosure, many would ask: what is the purpose, who is the audience, and what effect it can have on energy conservation for existing buildings? Answers to these questions vary. Some find it not worthwhile since it does not directly reduce energy consumption. Similar doubts arose when the UK launched its *Display Energy Certificate* program. Opponents argued that hiring accredited assessors to produce Display Energy Certificate costs money and data disclosure does not directly cut costs to compensate building owners.

However, the potential effects of benchmarking and disclosure should not be underestimated. Indeed, the ultimate goal is to improve energy efficiency and reduce energy consumption. Policies are only means to achieve this goal; without the goal, policies like benchmarking and disclosure would be meaningless endeavors. Strictly speaking, benchmarking and disclosure is not a method to reduce energy consumption, but more like a method to remove the obstacle to achieve this goal. The obstacle is that we are unaware of building energy performance, as we lack a comprehensive and extensive understanding of energy usage in existing buildings. Benchmarking and disclosure are to energy consumption reduction what blood tests are to cold treatment. Testing blood can neither relieve cold symptoms nor cure them, but these tests help doctors to come up with a targeted and effective remedy. Benchmarking and disclosure can have a much more profound effect on energy savings and low-carbon urban development than blood tests have on disease treatment. After all, blood test results can be only used for once, whereas benchmarking and disclosure have a long-term positive impact on energy-saving and low-carbon development. Moreover, data disclosure provides fundamental insights for energy conservation and the efficacy of policy implementation, addressing negligence and market failures, and thus contributes to energy conservation.

5.2 Penalties and awards for benchmarking and disclosure

Some proponents of benchmarking and disclosure think the policies are important, but the effect on promoting energy efficiency retrofits and lowering consumption is indirect and slow to manifest. Thus, in order to "effectively utilize" benchmarking and disclosure, they argue that penalties and awards according to benchmark results are necessary. For instance, buildings that rank low in benchmark results and have energy consumption levels higher than the reasonable values set by guidelines shall be renovated in an allocated period.

Such practices sound reasonable and effective, but they would render benchmarking and transparency impossible to carry out since they betray the intentions of benchmarking and disclosure. Benchmarking and disclosure are designed to eliminate information barriers and to encourage market players to participate in energy efficiency retrofits. This requires owners and property managers to be actively involved in the whole process, including accepting energy consumption monitoring and audits, submitting and collecting affecting factors, and reporting issues they meet. Imagine if owners and property managers received penalties after benchmarking and disclosure; they would be hesitant to abide by the policy. Even though they participated out of pressure, they might alter information to avoid penalties. A relevant analogy is to think of buildings of different energy performance levels as employees of different competence levels. In order to improve employers' abilities, the team leader encourages employers to expose their shortcomings themselves and then rank their competence. When an employee responds accurately to the proposal, detailing their shortcomings truthfully, resulting in an unsatisfying ranking, should the team leader praise their honesty and offer help or reduce salaries and demand improvement in a certain period or even dismiss the employer?

Moving from data disclosure to retrofitting takes time, even if it is just a simple action like adjusting a building's operational management strategy, or modifying air conditioner temperature. If government departments can patiently develop the spirit of ownership among market players and guide them to take action, resistance to benchmarking and data disclosure will be greatly reduced. It is not difficult to understand why the UK requires their advisory reports to be produced by accredited assessors, but does not force owners or occupants to take actions according to the report. The same principal of "fully informed, options provided, and choices self-made" has been adopted in the U.S. Despite the fact that many cities' benchmarking and disclosure legislations have specified compulsory responsibilities and retrofits deadlines, in the first few years of policy implementation, the government stuck to the strategy of "giving notifications and a certain period of extension" to owners who failed to submit data or conduct benchmarking on time. Penalties are always kept as a last resort. Another advantage of doing so is that it doesn't interfere with the fairness issue mentioned before. Benchmarking and disclosure must not rely solely on government regulations, but instead be an inclusive structure that encourages market development. In terms of policy making, benchmarking and disclosure should be made mandatory. Since a mandatory policy leads to extensive involvement and thereby samples can be more representative.[31] But such a mandate should only be to participate in benchmarking and disclosure. Those who participate should not be fined. This is not in contradiction with the building energy consumption quota management or other mandatory constraint policies (maximum energy consumption) which are been developing in Shanghai and many other regions.

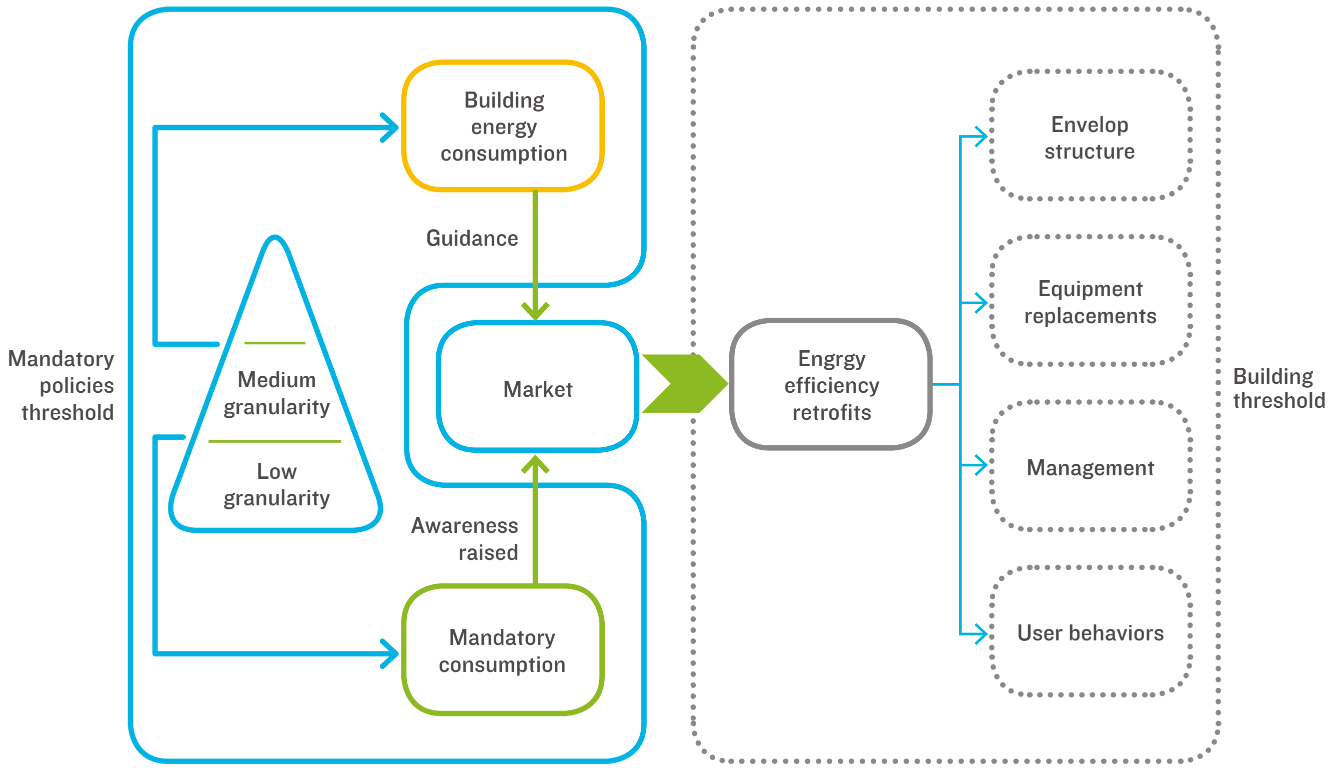
5.3 The relationship between benchmarking, disclosure, and mandatory constraint policies

Benchmarking and disclosure offer more detailed building energy consumption information, whereas quota management[XVII] and other mandatory constraint policies set quantitative parameters for existing buildings, clearly stating the responsibilities of related actors. The two are not contradictory to each other. The purpose of the former is to "guide," and the latter is to "push." If they are properly designed, they can reinforce each other and help owners and other market players to take energy conservation actions (Figure 24).

Differences between benchmarking and disclosure and quota management need to be clarified. First, in

Figure 24

Interactions between benchmarking and disclosure and mandatory policies



terms of data, benchmarking and disclosure are based on annual or monthly energy consumption along with a few calibration parameters to describe building energy performance; accuracy is not a top priority. Quota constraints, on the other hand, have legal force and therefore a greater level of accuracy and detail is required. Second, implementation difficulties differ. For Shanghai, in the short term, it is more practical to adopt benchmarking and disclosure and then introduce quota management. Benchmarking and disclosure can be applied widely and readily by further simplifying calibration parameters based on the *guidelines*. Then gathering and submitting related indicators for such parameters could be integrated into monitoring and audit regulations, facilitating the process for stakeholders. However, building a quota policy is more complicated no matter if it is designed based on past performance or comparing with buildings of the same type. If the policy is designed according to past performance, historical energy consumption data must be verified. If comparing with buildings of the same type, detailed categorization and large amounts of calibration are needed, otherwise doubts of unfairness may appear. A few factors contribute to the complexity, for example, various public building types and calibration parameters exist. Also, energy use characteristics and composition differ greatly for every type of non-residential building. Third, in terms of implementation strategy, quota management places greater emphasis on penalties, establishing minimum requirements for energy consumption and requiring those buildings with poor performance to improve. In contrast, benchmarking and disclosure should depend more on guidance. For instance, using energy efficiency challenges and other incentives, these policies can encourage owners and related actors to work together to achieve the highest level. Lastly, benchmarking and disclosure and quota management have different

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demands for timeliness. Benchmarking and disclosure can improve timeliness by using less data, although benchmarking results should be updated annually at least. Quota management can update data every three years since its process is complex and costly. With the full involvement of owners and other actors and an open system, benchmarking and disclosure require results to be updated faster so as to reflect the current situation and give feedback about owners' actions.

5.4 Relationship between benchmarking and disclosure

Due to differences in building energy data's basic conditions and acquisition approaches between China and the U.S., there are divergences in understanding regarding benchmarking, public disclosure, and the relation between the two as well.

The U.S. approach to benchmarking is that building owners submit the basic information and energy consumption information to a government online system, and the system generates benchmarking reports automatically. The online system is based on the benchmarking tool ENERGY STAR Portfolio Manger developed by EPA. Slight changes can be made to adapt to local conditions or requirements of the local government. Data collection is also completed during the process of benchmarking. With these data, policy makers can conduct other researches (such as the comparison of building energy consumption in regional level, the comparison of building energy consumption based on year built, etc.) apart from benchmarking.

In comparison, take Shanghai as an example, the collection of building information and energy data as well as energy performance monitoring for government office buildings and LNRBs are independent from benchmarking in China. Thus data collection is isolated from benchmarking. As long as data is collected, benchmarking has not been considered urgent at all or even unnecessary. A more general trend is to separate data disclosure from benchmarking, and to prioritize disclosure and the pressure brought from public opinion. Under the guidance of this idea, the main issue of disclosure shifts from how to disclose more effectively to which data points can be disclosed (avoiding commercial privacy infringement) and which cannot. From the perspective of audiences, addressing how to promote a more effective disclosure will naturally lead to benchmarking. Benchmarking is really about comparing energy performance among the same building type, and presenting results in a concise, accessible fashion. In other words, benchmarking is the prerequisite for effective data disclosure, and benchmarking results is a significant component of disclosed information. No matter if the purpose is to promote social awareness of energy consumption or to create pressure from public opinion, disclosing more information does not make goals easier to achieve. Disclosing data without any processing could not only result in concerns over commercial privacy exposure, but also lead to confusion, thus inducing failure. Therefore, data disclosure systems and processes should be carefully designed. Among various indicators and different approaches, energy consumption benchmarking is the most effective one. By benchmarking, one can easily locate the ranking of a specific building's energy performance and have a general knowledge of it.

5.5 Commercial privacy protection

Whether data disclosure invades commercial privacy has long been a heatedly discussed topic. Unfortunately, there is no definitive legislation concerning this issue. The most relevant law may be the *Anti-Unfair Competition Law* published years ago. However, there's no clear definition of commercial privacy in the law, resulting in confusions. Some owners from government departments who are not associated with building policy even regard energy consumption as "national secrets."[32].

When discussing such issues, the most important evidence brought forward by owners of commercial buildings, who advocated privacy in the survey, is that revenue is positively correlated with energy consumption. Given that, competitors might speculate about a company's revenue based on energy consumption. However, the survey showed that half of respondents believed that the leasing/occupancy rate of a building should also be made public, which means revenue would be exposed more easily than through the above method. Hence, it is groundless to hide revenue for the sake of commercial privacy protection. Besides, attaining competitive edges by hiding one's actual energy consumption seems to be against the law of fair competition. If such a general definition of commercial privacy is to be applied, then nutrition ingredients and contents should also be a secret to prevent recipe from being guessed by competitors. Of course, it is undeniable that, under some special circumstances, some detailed information, which might include energy consumption, is of critical importance to a company. It is also possible that some energy consumption information might involve greater interests, such as safety issues. However, even in such extreme cases, privacy can still be protected through technical methods. For one thing, most of the disclosed information is secondary and processed information, rather than detailed raw data. Benchmarking results are a typical example. The comparison is made among groups of the same building type, results of which can be either the qualitative judgement (whether it is energy-efficient), or shown in a rank or with a score. Also, according to different circumstances, some buildings can be exempted from disclosure provided applications are made and deemed reasonable after evaluation. The fact that benchmarking and disclosure policies have been implemented successfully in other countries proves that the policies do not pose a threat to businesses.

5.6 Data quality concerns

Low data quality also decreases government motivation to promote disclosure. Both technical limitations and organizational factors result in low data quality currently. For the energy monitoring system for LNRBs alone, technically, most existing buildings are not designed to be monitored by different items (lighting, air conditioning, power, plugs and so on). Usually one power wire is connected to multiple end users, and each may belong to different categories. Thus, clarifying the energy consumption of different items is no easy task. Second, metering of different items is not done directly by installing sub-meters but by binding transformer equipment and extracting secondary data. Sensor specifications, installing methods, on-site electromagnetism may all affect accuracy. Third, data distortion caused by hardware breakdowns of metering devices and sensor collectors, transmission network, electromagnetic interruptions and other factors is inevitable. Fourth, total electricity consumption of many buildings cannot be measured due to various limitations, thus data calibration cannot be processed and accuracy cannot be guaranteed. As for organizational factors, first, most existing buildings were built long ago. Electricity distribution adjustment, changes in property managing companies, and missing of electrical equipment blueprints make basic information about the item metering system difficult to ascertain. Second, cutting off the power of the item metering system or unexpected disconnection with network results in frequent data gaps. In short, with the unsettled technical difficulties and mismanagement, data quality collected from some buildings can be subject to high levels of inaccuracy. Once the disclosure has been made, such data will be questioned by insiders undoubtedly, which could reduce citizens' confidence in public bodies. Therefore, government agencies expect to verify data first and then move to disclosure to reduce pressures shouldered by authorities, and raise acceptance of disclosed data and the following-up policies.

In fact, domestic and global experience shows that data quality improvement requires a certain period of time. Many manual operations are required during data acquisition and transmission. Data quality, to some extent, relies on the competence of personnel who deal with metering devices installation, maintenance, and data interpretation. The more accurate the data, the more time required in the process and the greater the cost. Besides, without mandatory policies on benchmarking and disclosure and with the limited number of buildings involved and insufficient participation of shareholders, even the most detailed proposal could encounter unexpected challenges in implementation. Thus, it is suggested, based on the current situation, that data should be disclosed as early as possible. The following chapter will elaborate on the low data quality's effect on fairness. The New York City experience shows that the earlier the application is put into practice, the earlier defects are exposed, and the faster solutions are found. Policies adopted in New York City require owners to submit data, the quality of which was even worse than the current situation in China. Many owners were unclear of definitions and boundaries of building area. However, defects were identified in the following years, which helps to improve policies. Thereafter, accuracy has increased annually. In fact, even the inaccurate data at the very first two years helped authorities to better understand energy patterns, distribution and changes over time.

5.7 Benchmarking fairness

Even within the same type buildings, the differences in shapes, energy systems, operation strategies, distribution structures, personnel density, and many other factors can lead to a great difference in energy consumption. It is almost impossible to compare and evaluate two buildings of the same type absolutely fairly. However, this does not mean we cannot create an adequately fair policy. Fairness can be improved and has been improving. In the U.S., climate factors, personnel size, and operation duration are normalized in the ENERGY STAR Portfolio Manager tool. In Shanghai, sales of commercial buildings, bed numbers of medical institutions, star ranking of star-rated hotels were considered when developing its guidelines. Those are all steps toward better equity. More suitable indicators will appear and evaluations will be more transparent and reasonable over time.

Benchmarking and disclosure policies were not explicitly built to optimize for fairness. As stated earlier, the importance of fairness depends on the understanding and positioning of the effects of benchmarking and disclosure. If we jump from benchmarking to impose constraints on building

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energy consumption in haste, and link benchmark results directly with penalties, then fairness would undoubtedly become the focus. On the contrary, if benchmarking and disclosure are positioned as helping the public to better grasp the status of building energy performance and to raise awareness amongst market actors about energy consumption, solutions can be found.

6

POLICY SUGGESTIONS

The current policy orientation, societal awareness, public opinion, and economic environment provides a valuable chance to promote data-driven energy efficiency retrofits and sustainable operations for LNRBs and building energy use benchmarking and disclosure in Shanghai. In terms of overarching policy guidance, China has been limiting total energy consumption in all industries and promoting the digitalization of energy as well as a performance-oriented approach. Benchmarking building energy performance was incorporated into the 13th Five-Year Plan for Housing and Urban-Rural Construction, which states that data-based urban building energy performance benchmarking should be implemented during the 13th Five-Year Plan period[33]. Approaching building energy saving with emphasis on measured data has become the industry consensus.

In terms of public opinion, the frequent occurrence of haze and other pollution incidents has caused an unprecedented increase in public awareness and participation in energy savings and emission reduction, which has led to a growing call for building energy use data. The combination of these demands has compelled the government to take action to accelerate energy efficiency. In terms of the financing environment, under the New Normal, China expects to see an economic slowdown and lower capital returns. As a stable investment with medium returns, building retrofits are gaining popularity in the new economy. In terms of the data foundation, electricity consumption of existing LNRBs in Shanghai is no less detailed than the counterparts in Europe and America, but more time-efficient, which has advantages in allowing for timely responses and of performance-oriented management. As for technical support, driven by the "Internet+" policy, the Internet and Internet of Things have developed rapidly, which lowers energy consumption monitoring costs, and makes immediate interactions among property owners, property managers and users unprecedentedly convenient. We suggest that authorities at the municipal and district levels should seize the opportunity to forge a solid foundation by passing laws, strengthening data collection, and boosting global exchanges so as to lead the nation and world in the new trend of building energy conservation.

6.1 Establishing laws to guide the steady promotion of benchmarking and disclosure

It is best to have legal support to carry out building energy use benchmarking and disclosure. Regulations should cover benchmarking and transparency and the quota management system, distinguishing between them in terms of their principles and rules, and clarifying their collaborative relationship. The use of benchmarking and disclosure to provide the market with building energy use information should be made clear. Further clarity is also needed to ensure that disclosure, the main content of which is benchmarking results, should come after benchmarking. Besides data privacy, surrounding issues should also be clarified. Shanghai can develop medium- and long-term strategies and roadmaps for energy efficiency retrofits of existing buildings and incorporate benchmarking and disclosure into its long-term strategy.

Since district-level governments do not have legislative power, related regulations shall be issued by municipal government. But some districts which have already accumulated experience and practices, for example, Changning District, should undertake initiatives to explore implementation methods, attempt to optimize methods of benchmarking and disclosure, and to perfect benchmarking tools in accordance with regulations. To reduce difficulties, the policy should be steadily promoted because both owners or property managers need time to accept mandatory energy performance benchmarking and data disclosure.

Taking disclosure data point as an example, the following approach should be considered: starting with simple data points and indicators. This will encourage more involvement and reduce resistance, leaving time to perfect policies and improve accuracy. Then new data points and indicators should be gradually added. After the launch of the disclosure program, more indicators can be added every half year, for instance electricity consumption of different items, benchmarking results, etc. The selection of new indicators should align well with the goal of helping stakeholders to take action. In this regard, an Operation and Maintenance Index might be explored in the *Shanghai Energy Consumption Monitoring Platform Annual Report* in the future. [34] It is a ratio of measured energy consumption and simulated energy consumption. The simulation is based on real building physical characteristics rather than design concepts and calibrated with real climate factors when the building in put into use. Such indicators allow us to make the full use of both metering data and simulations and thus generate a better result.

The principle of gradual improvement applies to buildings covered by the policy and fuel types as well. The threshold of covered buildings should be lowered over time to regulate more building types, ideally covering all building types in the long run. It should be noted though, once a building type is included in the disclosure program, all buildings that fall under that

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category, except exemptions (listed in regulations), should participate in data disclosure. In terms of fuel types, better coordination is needed to integrate existing scattered statistical data with data from utilities so as to evaluate the energy performance level of a specific building more comprehensively.

6.2 Enrich the database through data stratification and automation data collection and analysis

By combining existing building energy consumption data, audit data, energy consumption of different items, and real-time monitored information, the database can be enriched. Corresponding indicators should be adjusted according to different demands from the benchmarking and transparency policy and quota management policy. Different acquisition channels should be fully utilized and improve accuracy. The following aspects are suggested as priorities:

(1) Establish guidelines for owners to submit energy performance data as soon as possible, to provide more information for the calibration of the benchmarks.

Missing benchmark calibration parameters has become the major technical barrier hindering energy performance benchmarking and disclosure in Shanghai. Taking practicality into consideration, values set in *guidelines* can be the benchmarking basis. Then, adding information of calibration parameters is of great importance. The monitoring platform has already accumulated large amounts of energy consumption data of buildings with different functions. But related information to energy consumption is still incomplete. Regulations should be established for owners to submit energy performance data. Such information cannot be collected automatically but calls for manual submission. Only owners and the commissioned property managing organisations have access to the most accurate information. User-friendly app for smart phones can be designed to facilitate data submission. The submission process is a good chance for owners to gain awareness about energy conservation. If owners can get timely access to benchmarking results after submission and learn about building energy performance of the same type, then twice the results can be achieved with only half the effort. It can also avoid disclosure becoming a show for the government itself.

In addition, benchmarking calibration parameters need to be simplified. Currently, calibration set in *guidelines* is highly technical and hard to put into practice. Some calibration information can hardly be obtained. Especially for buildings with diverse functions, more indicators are involved, the more difficult the calibration is. Therefore, it is necessary to simplify and revise such factors.

(2) Improve benchmarking and disclosure automation.

First, improve automation of data correction. Taking electricity consumption tracking on the monitoring platform as an example, a vast amount of data floods into the platform every minute. At the same time, new buildings are being included in the monitoring platform. Mistakes and missing messages are inevitable in data collecting and transmission. If mistakes are not corrected in a timely fashion, the growing issues will be extremely hard to settle. Data calibration (correction and recovery included) consumes great human resources. If automation of data correction is not in place, maintenance staff would be tied up, with no spare time to analyze and utilize data.

6.3 Revise *guidelines* to clarify benchmarking and establish a long-term mechanism to improve data quality.

If the *guidelines* will continue to be the basis for benchmarking, timely revision and updates to the values are necessary. The current energy consumption level defined by guidelines is inferred from energy performance data of previous years. Owners now have gained new understandings of energy conservation and emissions reduction, and the energy consumption level of LNRBs has been lowered greatly. Thus, energy consumption values set in guidelines are no longer suitable for the current building energy performance level. Besides, the economic slowdown in recent years has altered business operation forms. But the current guidelines updates infrequently and updates have not been institutionalized, imposing obstacles for the steady promotion of benchmarking and disclosure in the long run. It is suggested to institutionalize the database to achieve standardization of updating process and reduce difficulties in data updating.

6.4 Strengthen international cooperation

Benchmarking and transparency policy in China is on a long journey toward full maturity. Effectively improving data quality, innovating new data analysis methods, and identifying energy saving goals based on performance data are challenges shared by Shanghai, New York City, and other large cities. [XVIII] Increased global exchanges make learning from one another more convenient, and in turn, practices in China can offer references and inspiration for other countries.

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ENDNOTES

I. Building Energy Efficiency 2.0 is next generation energy efficiency as compared to the traditional period of Building Energy Efficiency 1.0. While Building Energy Efficiency 1.0 was just about design and construction, Building Energy Efficiency 2.0 will put more emphasis on quality and real savings during operation.

II. The author believes that colouring benchmarking results on maps facilitate users' understanding of energy performance and distribution of different building types. After communicating with NYC Mayor's Office of Sustainability, NYU Centre for Urban Science and Progress prepares this energy performance map and provides it to NYC. It doesn't represent NYC government policies.

III. Weather normalized source EUI. Convert energy consumption to source energy according to its acquisition, which incorporates losses in exploration, transmission, processing and delivery. In the US, electricity acquired from grid per kWh equals to 3.14kWh source energy. Conversion factor of photovoltaic power generation is 1, and central steam and hot water 1.2. Weather normalized energy intensity is the energy intensity in climate normal, making comparisons between buildings in different regions and different years fair and easy.

IV. http://metered.urbangreencouncil.org/

V. Costar has about 30 histories in building and maintaining the industry's most comprehensive database of commercial real estate information. It provides online database of commercial real estate information for U.S, London and other UK market.

VI. The City Energy Project is a joint initiative of the Natural Resources Defense Council and the Institute for Market Transformation. It initially created the campaign of building energy efficiency in 10 American cities and now the project has include 20 pioneering cities.

VII. Civil buildings refer to residential buildings, government office buildings and commercial, tertiary, educational, medical and other public buildings.

VIII. Regulations on Energy Conservation of Civil Buildings issued by State Council in 2008 regulates that local construction departments at and above the county level are responsible for the supervision and evaluation of state office buildings and public buildings electricity consumption within their administration regions. State office buildings and large public buildings heating, cooling, and lighting consumption data should be released to the public in accordance with laws, regulations and other provisions. On Strengthening State Office Buildings and Large Public Buildings Energy Conservation Management issued by Ministry of Housing and Urban-Rural Development on October 23, 2007 requires local government "discloses energy consumption data and auditing results on government official websites or designated websites and local mainstream media".

IX. There are two kinds of factors, objective and subjective, that affect building energy consumption. Climate is a typical objective factor. Others like building operation time, personnel density etc. are hard to change, to some extent, are non-controllable, thus should be excluded via calibration to ensure fairness. Subjective factors include building envelope structure, systems performance, operational strategies and etc. Such differences are to be settled by taking actions, thus should not be regarded as calibration parameters.

X. Guidelines apply only to Shanghai (regions of the same climate zone). Therefore, climate factors are not regarded as calibration parameters currently. However, note that when comparing building energy performance over calendar years, as shown in Figure 12, impacts of climate factors should be taken into consideration.

XI. The reasonable and advance values set by the guidelines should be updated regularly. The benchmarking tool adopted by New York City also needs to update database to reflect the latest energy efficiency levels of buildings of "the same type".

XII. Commercial Buildings Energy Consumption Survey

XIII. According to insider sources, an energy-saving service company professed energy consumption would lower 70% in the loan proposal. However, it was later found that consumption reduced less than 20%.

XIV. We can not provide the names for the buildings in this case compendium, however, each case refers to a real building in Shanghai.

XV. The hotel changed to use natural gas boiler at the end of 2011, used little diesel fuel at the beginning of 2012. Therefore, energy consumed in 2012 are mainly electricity and natural gas, among which, natural gas is mainly for heating, daily hot water and hobs. That is to say, .arency. But benchmarking and disclosure policy demands participationly and effectively implementation of bench

XVI. "According to manufacturers, the use of variable frequency reduces amounts of fresh air, and reduces energy consumption of air conditioner and boilers by some 4%". That is quoted from the proposal. The reduced fresh air eases the burden of indoor heat load, which is converted to energy consumption of cooling machines and boilers.

XVII. The government is considering implementing a quota management policy, but they have yet to do so.

XVIII. The New York City passes laws on building energy performance benchmarking and disclosure in 2009. 2012 witness the first completed benchmarking and disclosure. It has been performed 4 times. Currently, the primary stage of benchmarking and disclosure has been finished. Building energy consumption data transparency improved greatly. Look forward to the next stage, New York City faces the same challenges—how to promote retrofits, how to set constraint energy conservation goals to go with benchmarking and disclosure policy, how to strengthen data foundation to support awards and penalties.

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