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Beijing and New York City: A comparison of building energy efficiency policies

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Abstract. Building energy efficiency is an important measure for reducing carbon emissions, and it plays a key role in the energy saving strategies all over the world. There is a growing global appeal to improve building energy efficiency due to the pursuit of sustainable development. Reducing building energy consumption and improving building energy efficiency are the main tasks of energy conservation work in China and the United States. We chose Beijing and New York City to highlight the current building energy efficiency policies in two cities. We then examine the differences between them. In New York City, there are more financial incentives, funding channels, participants, and public data available than in Beijing. Using the lesson learned from our investigation of New York City, we make recommendations for the development of Beijing's policies. To overcome barriers to creating energy-efficient buildings, Beijing should increase energy efficiency awareness, innovate with flexible and feasible incentive policies, and improve data disclosure policies.

1. Introduction

China and the United States are the world's two largest energy consumers and greenhouse gas (GHG) emitters. In 2017, the total energy consumption of China was 3105 Mtoe, accounting for 22% of the total energy consumption in the world; the total energy consumption of the United States was 2201 Mtoe, accounting for 16% of the total energy consumption in the world [1]. Because energy efficiency is the least-cost means of meeting new demand for energy, both countries have increasingly focused their policies on energy efficiency. With increasing urbanization and economic growth, building energy use has become a leading source of GHG emissions in cities—almost half of the emissions from the member cities of the C40 Cities Climate Leadership Group come from the energy consumed in buildings [2].

The building sector is the largest energy end-user in the United States. In 2016, about 39% of the total U.S. energy consumption was consumed by the residential and commercial sectors [3]. The building sector is a rapidly growing energy end-user in China. From 2000 to 2014, with the growth of the construction industry, energy consumption in the Chinese building sector increased significantly, from approximately 300 million tons of standard coal to 814 million tons of standard coal, an increase of 2.63 times the amount consumed in 2000. Chinese building energy consumption accounted for about 20% of the total energy consumption in 2015[4]. Reducing building energy consumption and

improving building energy efficiency are the main tasks of energy conservation work in China and the United States.

There are many differences in implementing building energy efficiency policies between China and the United States. For a more targeted analysis and comparison, we chose two cities as case studies: Beijing and New York City. The two cities were chosen for the following reasons. First, both cities are modern metropolises with a dense population and developed economy. Second, the rating of the building sector in terms of the total energy consumption in both cities is more than the average level of their respective countries. Third, both cities have made remarkable achievements in improving building energy efficiency over the last two decades. Fourth, both cities have clear building energy efficiency goals and building energy efficiency plans for the future. Since New York has a mature building energy efficiency market mechanism, we compared the differences in the building energy efficiency policies between two cities and summarized the feasible measures learned from New York City. The purposes of this paper are to provide insights into how New York's policies could be adapted for use in Beijing to overcome obstacles and promote the implementation of building energy efficiency tasks.

2. Status of building energy efficiency in Beijing and New York City

2.1. Beijing

The estimated population for Beijing in 2016 was 217.29 million residents. This reflects a growth of 21.1 million people, a 10.75% increase, since the 2010 census recorded 196.19 million residents. The land area of Beijing is 16,410 km^2, so the density of the population is 13,241 people/km^2. From 2000 to 2016, the construction area in Beijing increased from 69.96 to 227.21 million m^2, the average annual growth is 7.6% [5]. The increasing number of buildings also indicates that building energy consumption is growing. From 2009 to 2014, building energy consumption increased from 19.46 million tons of standard coal to 31.14 million tons of standard coal. In 2014, Beijing's building energy consumption accounted for 45.6% of the total energy consumption, more than the average level of 20% in China. However, officials in China have strengthened energy saving measures in an attempt to effectively control the intensity of energy consumption. In 2014, the energy consumption per unit area of urban civil buildings was 30.91 kg standard coal, which was a decrease of 9.2% from 2009 [6]. According to the Civil Building Energy Efficiency Development in Beijing, at the end of 2015, energy efficient buildings accounted for 74% of all civil buildings, while energy efficient residential buildings accounted for 92% of all residential buildings. From 2000 to 2016, Beijing built 471.27 million m^2 of energy efficient residential buildings and implemented the retrofitting of existing buildings so they could become more efficient. From 2011 to 2015, Beijing implemented the residential energy efficiency reform of 55.32 million m^2, investing RMB 34 billion Yuan, which benefitted more than 819,000 households. Beijing has completed public building energy efficiency reform of 6 million m^2 and large public building energy efficiency reform of 19.5 million m^2 [7]. Beijing has set goals to develop green and ultra-low energy buildings and comply with international building energy efficiency best practices. According to the 13th Five-Year Plan on Civil Building Energy Efficiency Development in Beijing, by 2020, Beijing aims to control the total energy consumption of civil buildings within 41 million tons of standard coal, ensure that green buildings account for more than 25% of the total residential area, and complete 300,000 m^2 ultra-low energy demonstration buildings.

2.2. New York City

The U.S. Census Bureau estimated New York City's population was 8,622,698, as of July 1, 2017. This figure represents an increase of 447,565 residents (or 5.5%) over the April 1, 2010 decennial census count of 8,175,133[8]. The land area of New York City is 777.93 km^2, so the density of the population is 11,084 people/km^2 [9].New York City is a dense city of buildings, and the energy used in these buildings accounts for nearly three-quarters of the citywide GHG emissions; addressing building energy performance is critical to meeting the goal of GHG emissions reduction. New Yorkers

consume more energy in buildings than Americans do on average, with 75% of GHG emissions coming from in-building activities such as lighting, heating, cooling, and running appliances. In the U.S., the energy used in buildings constituted just 39% of the GHG emissions in 2011 [10]. Energy consumption in New York City declined by 7.9% from 2005 to 2011. However, the rate of this reduction slowed in 2013. To lower GHG emissions, in 2014, New York City Mayor committed to reducing New York City's GHG emissions 80% below the 2005 levels by 2050 [11]. The plan titled "One City, Built to Last: Transforming New York City's Buildings for a Low-Carbon Future" includes a GHG reduction goal for municipal operations. New York City has invested more than $580 million in energy efficiency projects located in over 1,250 public buildings. These projects are expected to yield more than $68 million in annual energy savings and avoid approximately 187,000 metric tons of GHG emissions. The city is also supporting private building owners who pursue energy efficiency and clean energy projects with $16 million in city funding. These programs are currently assisting over 5,000 buildings to identify energy and water saving retrofit opportunities and connecting them to financial and technical resources [12].

3. Analysis of building energy efficiency policies in Beijing and New York City

3.1. Building energy efficiency standards

3.1.1. Beijing

In China, the government plays a crucial role in setting the framework for building energy efficiency. The Beijing government executed many regulations and policies to boost building energy efficiency [13]. Guided by national building energy standards, Beijing designed practical building energy standards at the city level, including *Design Standard for Energy Efficiency of Residential Buildings, Design Standard for Green Buildings, Standard for Green Construction Management, and Code for Acceptance of Green Building Construction* and so on.

Beijing is the first city in China to implement high level design standards for residential building energy efficiency and public building energy efficiency. On Jan. 1, 2013, the Beijing government executed the Design Standard for Energy Efficiency of Residential Buildings, which was published by the Beijing Institute of Architectural Design (BIAD) [14]. In the new standard, the energy efficiency rate reached 75%, which exceeded the energy efficiency rate of 50% in most cities. On November 1, 2015, the Beijing government executed the Design Standard for the Energy Efficiency of Public Buildings [15]. Under this standard, the energy efficiency level of new public buildings has been greatly improved. Beijing continues to promote the creation of green buildings. Beijing stipulated that new civil buildings should comply with green building standards from June 1, 2013. After reaching this goal, Beijing issued a new notice requiring new large public buildings to implement green building 2-star and above standards from October 1, 2017 [16].

3.1.2. New York City

In the United States, the federal government did not introduce building energy codes; instead, state or city governments introduced local building energy codes. Having originally adopted its standards in the 1980s, New York was one of the first states to adopt appliance standards after California paved the way in 1974 [17]. Building technology in New York City has always evolved at a fast rate. Although New York State's energy code has been amended numerous times to keep pace, New York City requires change on a faster scale to reach GHG emissions reduction goals. New York City's adoption of its own energy code not only allows the city to move forward in sustainability and energy reduction but also to implement the most broad, cost-effective energy improvements. On March 9, 2016, the New York State Fire Prevention and Building Code Council completed major updates to the State Energy Conservation Construction Code. New York City further adopted the Energy Conservation Construction Code of New York State as Local Law 91 of 2016, and the 2016 New York City Energy Conservation Code (NYCECC) was based on the State Code and further modified. The NYCECC

went into effect on October 3, 2016, and the scope of this code has been widened to encompass any renovation or alteration project.

3.2. Financial incentives

3.2.1. Beijing

Due to externalities and information asymmetry, mandatory building energy policies are difficult to implement at the main energy saving entities, but financial incentive policies can effectively promote building energy efficiency. Beijing has offered some financial incentives for new buildings or existing building retrofitting and innovative building technologies. For example, according to Beijing Interim Measures for the Reward Funds Management of Super-low Energy Consumption Building Demonstration Projects, the projects approved before Oct. 8, 2017 were rewarded with RMB 1000 Yuan/m2, and a single project could not exceed RMB 30 million Yuan. The projects approved from Oct. 9, 2017 to Oct. 8, 2018 were rewarded with RMB 800 Yuan/m2, and a single project could not exceed RMB 25 million Yuan. The projects approved from Oct. 9, 2018 to Oct. 8, 2019 were rewarded with RMB 600 Yuan/m2, and a single project could not exceed RMB 20 million Yuan.

3.2.2. New York City

In the United States, governments and utilities offer a variety of tax incentives and grants, rebates, and bond programs to encourage consumer investments in energy efficiency. There are many financial incentive types, including corporate depreciation, corporate tax credits, corporate tax deductions, corporate tax exemptions, grant programs, industry recruitment/support, loan programs, personal tax credits, personal tax exemptions, property tax incentives, rebate programs, and sales tax incentives [18].

New York State and New York City enacted legislation allowing municipal corporations to exempt green buildings from real property taxes. New York City set up the New York City Energy Efficiency Corporation (NYCEEC) that provides loans and alternative financing solutions for energy efficiency and clean energy projects, and passed legislation for Green Roof Tax Abatement and Solar Panel Tax Abatement.

3.3. Benchmarking and reporting

3.3.1. Beijing

Reporting energy performance data appears to be a major trend in building energy efficiency policy making. In many countries, most reporting and benchmarking programs target large buildings and mandate annual reporting of energy performance and GHG emissions data, with differing policies regarding the disclosure of the data [19]. In China, the central government introduced technical guidelines for building energy consumption monitoring systems on office buildings of state organs and large-scale public buildings in 2008, as well as a guideline for energy audits in public buildings in 2017. Beijing established an energy consumption monitoring system for office buildings of state organs and large-scale public buildings in 2010[20], and built the Distributed Energy Platform of Services for public building energy management in 2015. Since 2014, Beijing has set the electricity consumption limit for public buildings above 3000 m2. According to the Notice on Strengthening the Energy Efficiency Management of Public Buildings in Beijing, Beijing adjusts the electricity consumption limit of public buildings every year and reports the information of buildings exceeding 20% of the limit for 2 years [21].

3.3.2. New York City

In the United States, benchmarking and data transparency policies in different forms have been adopted by 8 states and 14 cities. New York City was one of the earliest cities to implement a benchmarking policy, introducing Local Law 84 in 2009, which required commercial and multifamily buildings above 50,000 ft^2 to disclose their energy use data [22]. Annual energy and water consumption

data are to be submitted for public disclosure annually by May 1 by owners of buildings. In 2017, New York City expanded the list of buildings required to benchmark for energy and water efficiency to include buildings 25,000 ft^2 and larger by 2018, adding another 340 million ft^2 into the coverage area. In order to ensure submitting Benchmarking Report, there are penalties for non-compliance. Failure to submit a Benchmarking Report by May 1 results in a penalty of $500. Continued failure to report usage by the next quarterly deadline results in additional penalties of $500 per violation, up to $2,000 per year [23].

4. Comparison of the building energy efficiency policies of Beijing and New York City

4.1. More financial incentives are provided in New York City

For many years, Beijing has been relying on the administrative instructions and financial appropriation from the governments to promote building energy efficiency. At present, Beijing aims to move from a government policy-driven model to a market-driven model. However, a mature building energy efficiency market mechanism has not yet been established. Therefore, there are few financial incentive programs and policies in Beijing. The financial incentives for building energy efficiency are mainly distributed through subsidy and loan discount programs, and there are very few other incentives. New York City officials have worked hard to encourage building energy efficiency upgrades and set up a mature building energy efficiency market mechanism. The local government introduced a series of operational, flexible, and convenient economic incentive policies. All kinds of economic incentive policies, including a rebate program, loan program, and tax reduction program, greatly promote energy conservation projects that execute energy conservation reform. In New York City, there are more financial incentive types and more flexible financial incentive policies than in Beijing.

4.2. More funding channels are chosen in New York City

In Beijing, the building energy efficiency funding channel is narrow, so most projects are financed through bank loans. A lack of new funding channels and the difficulties associated with obtaining third-party funding are major barriers to the growth of the building energy efficiency industry. In New York City, the government and state utility regulatory agencies initiated different types of programs to overcome barriers in building energy efficiency upgrades. Financial innovations were created to overcome the lack of capital available for energy efficiency upgrades. In addition to traditional financing options that include leases and loans, specialized energy efficiency programs and products were developed to encourage energy efficiency. Energy efficiency funding channels include leases, loans, on-bill financing and repayment, Property Assessed Clean Energy (PACE) financing, and savings-backed arrangements [24].

4.3. More information and data are publicly available in New York City

Data transparency is a serious problem in Beijing. It is extremely difficult to acquire building data from building owners. The lack of information awareness and data transparency leads to the public's inability to supervise the progress of building energy efficiency, and the inadequate communication between the supplier side and the demand side has hindered improvements in building energy efficiency. In New York City, numerous measures help to mitigate the data transparency issue. A benchmarking program helps building owners compare their building's energy usage with similar buildings. Making benchmarking data available to the public gives owners an incentive to enhance their buildings' energy and water performance, while also spurring data-driven decision-making in the real estate market. According to New York City's Energy and Water Use 2014 and 2015 Report, New York City's benchmarking data showed significant declines in large-building energy use and GHG emissions between 2010 and 2015. Over that period, emissions from more than 4,200 regularly benchmarked properties fell by almost 14%, while energy use fell by more than 10% [25].

5. Suggestions for promoting building energy efficiency in Beijing

5.1. Increasing energy efficiency awareness

Occupants' behaviour has a significant impact on the energy performance of buildings. In Beijing, building users and operation managers have a low enthusiasm for energy efficiency, citizens do not pay enough attention to building energy efficiency, and enterprises and institutions have little knowledge about energy efficiency technologies, energy efficiency transformation, and energy efficiency management. Thus, the government should increase occupants' energy efficiency awareness through education and training and encourage building users to implement energy efficiency behaviour actively and voluntarily.

5.2. Innovating financial incentive policies

The energy efficiency market can become self-sustaining only through the creation of a mature financial incentive mechanism that creates "win-win" outcomes for the stakeholders. The government's advocacy of the flexible finance incentives will provide new opportunities for the building energy efficiency market to go through this transition. Beijing's government needs to develop innovative financial incentives, adding new approaches, including tax deductions, loans, and grants, to promote participation in building energy efficiency projects. In addition, in order to promote a greater enthusiasm for implementing building energy efficiency initiatives, government and financial organization should provide energy efficiency companies with a variety of financing methods, including government subsidies, commercial bank loans, credit guarantees, financing leases, international funds, or loans from international financial institutions.

5.3. Improving data disclosure policies

Creating mandatory data disclosure policies in Beijing would provide benefits to building owners, but the Beijing government needs to develop solutions to mitigate data access issues. Improvements in the energy efficiency awareness and credit systems would create more business opportunities for building energy efficiency stockholders in Beijing, help consolidate the currently fragmented market, and provide building users with systemic and complete energy efficiency upgrade solutions. The market succeeds when data are available to inform program design and evaluation efforts and support contractors, investors, entrepreneurs, and other essential market actors in their business decisions.

In short, Beijing government has implemented many kinds of policies to motivate improvements in building energy efficiency. Beijing still faces enormous building energy efficiency tasks. In order to build a comprehensive supporting system for building energy efficiency stakeholders, Beijing government should develop flexible incentive policies and feasible energy efficiency programs as soon as possible.

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