Federal Ministry
for Economic Affairs
and Climate Action

中德能源与能效合作
Energiepartnerschaft
DEUTSCHLAND - CHINA

# Potential Analysis: Retrofitting Large Public Buildings for Energy Efficiency


EESIA

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

# Imprint

The report “Potential Analysis: Retrofitting Large Public Buildings for Energy Efficiency” introduces the current situation of energy consumption in large public buildings in China as well as the main potential for energy saving in public buildings. It also discusses key energy efficient technologies and the central factors affecting the exploi-tation of energy saving potential.

The report is published in the framework of the Sino-German Energy Partnership between the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and the National Development and Reform Commission of the People’s Republic of China (NDRC). As the central dialogue platform on energy between two countries, the main objective of the partnership is to foster and advance the far-reaching and profound energy transitions ongo-ing in both countries by exchanging views, best practices and knowledge on the development of a sustainable en-ergy system, primarily centered on improving energy efficiency and expanding the use of renewable energy. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH implements the project under commission of BMWK. As a German federal enterprise, GIZ supports the German government in the achievement of its goals in international cooperation for sustainable development.


**Published by**

Sino-German Energy Partnership
commissioned by the German Federal Ministry for Economic Affairs and Cli-mate Action (BMWK)

Tayuan Diplomatic Office Building 2-5, 14 Liangmahe South Street, Chaoyang District
100600 Beijing, P. R. China

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# Executive Summary

China's buildings account for more than 20% of the country's total energy consumption. Large scale public buildings, such as hospitals, schools, office buildings, shopping malls, etc. are the building type with the highest energy consumption per space unit. Against the background of China's Dual Carbon Goals, relevant policy requirements towards building energy management are picking up pace to promote building energy saving and carbon reduction. Major market opportunities arise alongside this development for manufacturers of energy and carbon saving technology, energy service companies (ESCOs), construction companies, building owners, etc.

The Sino-German Energy Partnership of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), in cooperation with the Energy and Environmental Services Industry Alliance (EESIA), set up a research team to conduct a research project with the title "Potential analysis: Retrofitting Large Public Buildings for Energy Efficiency". The goal of this project is to investigate the development direction and potential for enhancing energy efficiency in large public buildings in China, gain insight from global cutting-edge expertise and management, and encourage communication and collaboration between energy and energy efficiency businesses in China and Germany.

The research project consisted of three phases:

In the first phase, the research team designed a research questionnaire on the main issues of energy efficiency in large public buildings with the help of relevant enterprises (see annex). The survey was circulated along Chinese and German ESCOs, building owners, construction engineering enterprises, equipment manufacturers etc. Totally, over 300 entities participated in the survey.

In the second phase, the research team co-organized a Sino-German Business Roundtable with the topic "Enhancing Energy Efficiency in Public Buildings", in which more than 20 industry experts and representatives of Chinese and German building energy saving enterprises were invited to exchange views and discuss the outlook and direction of the Chinese energy saving market in public buildings, as well as related problems and challenges.

In the third stage, the team analyzed the research results, combined the views of experts and enterprise representatives in the Sino-German Business Roundtable, conducting in-depth research on the status quo and future direction of energy saving renovation of large-scale public buildings in China.

This report is the result of this research. It analyzes the current situation of energy consumption in large public buildings in China as well as the main potential for energy saving in public buildings. It also discusses key energy efficient technologies and the central factors affecting the exploitation of energy saving potential.

# 1 Energy Consumption in Large Public Buildings: Status Quo

Public buildings are buildings for public services, where people carry out a variety of public activities. Single buildings with a gross floor area of over 20,000$m^2$ are considered large public buildings. They generally include office buildings, commercial buildings, school buildings, tourism buildings, medical buildings, sports buildings, communication buildings, transportation buildings, etc. . Among them, government buildings, schools and hospitals, are collectively referred to as public institutions.

According to a study by Tsinghua University, the gross floor area of China occupies 67.8 billion $m^2$ in 2021, of which 30.5 billion $m^2$ are accounted as urban residential area and 22.6 billion $m^2$ are accounted as rural residential area. 14.7 billion $m^2$ are identified as public floor area, accounting for 22% of the national floor area[1] (Figure 1.1).

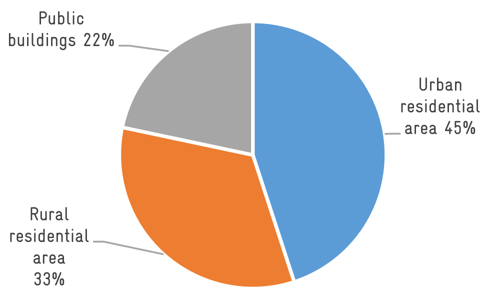
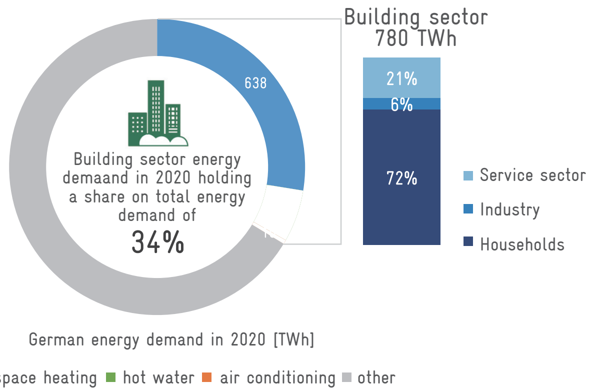



**Figure 1. 1 Distribution of the gross floor area into different area types in 2021**

In 2020, the energy consumption of operating China's buildings accounted for 1.06 billion tons of coal equivalent (tce). The operational energy consumption of public buildings sums up to 420 million tce, which is 39.6% of the total operational energy consumption of all buildings (Figure 1.2). Regarding carbon emissions, the operation of public buildings emits 2.16 billion tons of CO2, representing 38.4% of the total national carbon emissions in the building sector[2] (Figure 1.3). Public buildings cover 40% of energy consumption and carbon emissions, while occupying only 20% of the gross floor area.

**Hence, advocating for energy conservation and efficiency in public buildings is crucial in achieving the broader objectives of energy savings and carbon reduction within the entire building sector.**

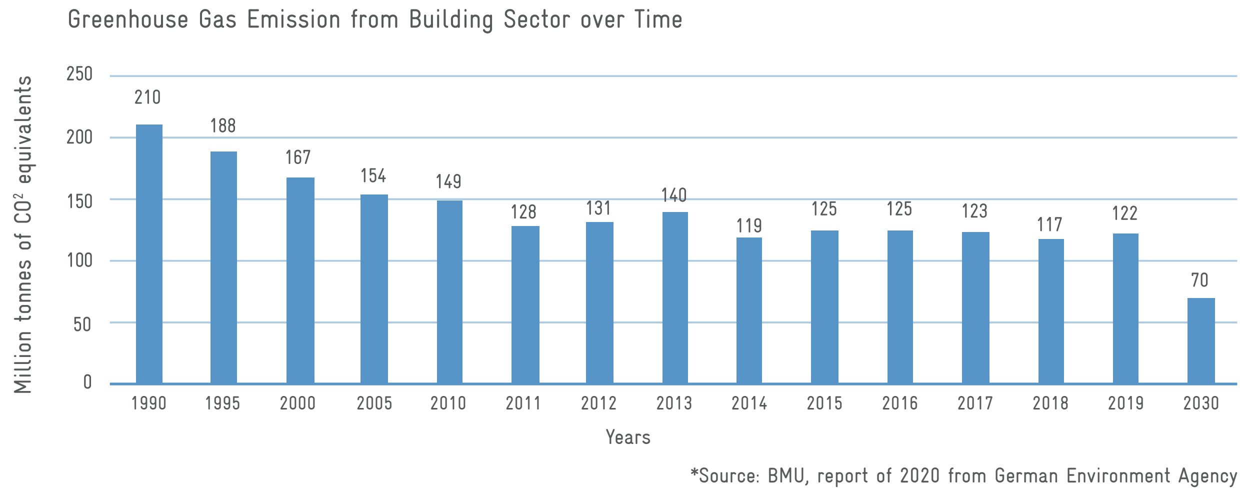



Source: Based on Data from German Federal Ministry of Economics and Climate Protection, 2021c

Data from Germany shows that the energy demand for buildings in Germany accounts for 34% of the country's total final energy demand. Correspondingly, the greenhouse gas emissions of the German building sector are 122 million tons of carbon dioxide equivalent in 2019. In comparison to 210 million tons in 1990, emissions reduced by 42%.[3] Concurrently, Germany has continuously and effectively reduced its carbon emissions in the building sector for the past three decades, thanks to the government and building industry's unwavering support for enhancing building energy efficiency. There are various valuable experiences to learn from, both at the policy or technical level.

1 According to "China Building Energy Efficiency Annual Development Research Report 2023" by Building Energy Efficiency Research Center of Tsinghua University

2 According to the Specialized Committee on Building Energy Consumption and Carbon Emission Data of China Building Energy Efficiency Association, "2022 China Urban and Rural Construction Sector Carbon Emission Series Research Report".




# 1.1 Development Status of Public Buildings

## 1.1.1 Office and Shopping Malls as Main Types of Public Buildings

Over the last twenty years, China has experienced a tremendous growth in its public building area stock, which has expanded from roughly 3.8 billion m2 in 2001 to about 14.7 billion m2 in 2021. At present, office buildings and shopping malls make up the majority, representing 34% and 23% as of 2020. Schools account for 16%, while hospitals and hotels constitute smaller proportions of the total, with 5% and 4% (Figure 1.4).

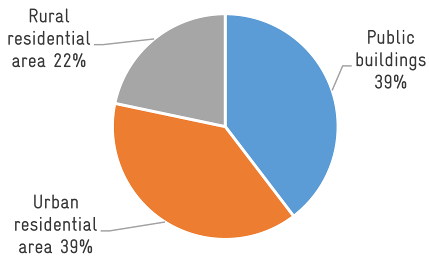



**Figure 1. 2 Share of operational energy consumption by building type in 2020**

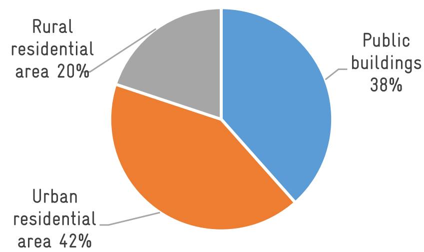



**Figure 1. 3 Share of operational carbon emissions by building type in 2020**

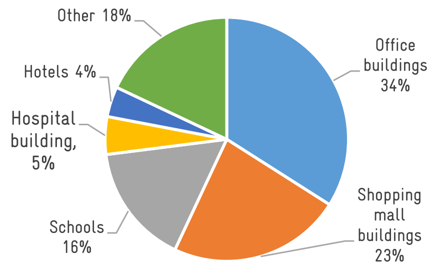



**Figure 1. 4 Share of public floor area of buildings in China 2020**[3]

## 1.1.2 Upward Trend of Hospital and School Floor Area

With China's growing urbanization rate, the spatial occupation of public buildings has slowly decreased each year since 2016, with annual completions falling from approximately 850 million m² to about 750 million m². **Among them, offices, shopping centers, and hotel buildings**

3 According to Tsinghua University's Annual Development Research Report on Building Energy Efficiency in China 2022

**have shown a continued decline in annual completions since 2016. However, hospitals, schools, and other types of public buildings have maintained an upwards trend.** According to Tsinghua University, China's urbanization rate will continue to grow, and future public building development will shift away from office buildings, shopping malls, and hotels. The "13th Five-Year Plan" places significant emphasis on the growth of schools, education buildings, and healthcare facilities. These types of public buildings are key areas for improving energy efficiency in public buildings.

### 1.1.3 Markets for Public Buildings are Surging

Public buildings such as transportation hubs and cultural and sports venues have experienced rapid growth in recent years. Taking newly commissioned urban rail transit stations as an example, the number has surged from 2,236 (in 2015) to 5,343 (in 2021). The annual addition of urban rail transit stations has also shown an increasing trend, growing from 435 in 2016 to nearly 700 in 2021. Due to their special climatic requirements and therefore higher potential for energy savings, public buildings in the cultural and sports venue category require more attention. For instance, newly constructed sports venues such as those for the Winter Olympics adhere to high construction standards, with substantial configurations for heating, cooling, power supply, HVAC systems, and electromechanical systems. Despite their infrequent usage, these buildings commonly experience prolonged operation at low capacity, resulting in lower operational energy efficiency and substantial untapped energy saving potential.

## 2.1 Energy Consumption Characteristics and Current Status of Energy Saving Technology in Public Buildings

### 2.1.1 Distribution of Energy Consumption of Public Buildings

Public buildings come in various types, each with their own unique energy consumption characteristics. Even buildings of the same type can exhibit differences in their energy consumption distribution due to variations in their energy systems and the climates of their respective regions, making it challenging to generalize (see Table 1.1). However, approximately 50% to 60% of the annual energy consumption in public buildings is dedicated to heating, ventilation, air conditioning, and domestic hot water, with 15% to 20% allocated for lighting (see Figure 1.5).

**Table 1.1 Characteristics of energy consumption in different types of public buildings**

| Type of public building | Energy consumption characteristics | Main features |
|---|---|---|
| Government office buildings, commercial office buildings | Office systems, lighting equipment, air-conditioning systems, elevators, etc. | Energy consumption is related to workdays, electricity consumption (mainly for air-conditioning systems) varies with the season |
| Shopping centers | Air conditioning system, lighting system, elevator system, domestic water pumps, etc. | Air-conditioning systems are more demanding and seasonally variable, while other systems are relatively stable |
| Hotel | Domestic hot water, lighting equipment, air-conditioning systems, elevators and domestic water pumps, etc. | Highly affected by occupancy rate and tourism peaking seasons, hot water systems account for a large proportion of energy consumption |
| Healthcare buildings | Specialized medical equipment, fresh air units, water treatment equipment, lighting equipment, air-conditioning systems, elevators, and domestic water pumps | Energy consumption is more persistent, energy consumption focuses on specialized equipment |
| School buildings | Lighting equipment, research office equipment, air-conditioning equipment, domestic water pumps, etc. | Energy consumption strongly correlates with the duration of educational activities, displaying intermittent patterns, with electricity usage (mainly for lighting and air conditioning systems) varying with the seasons. |

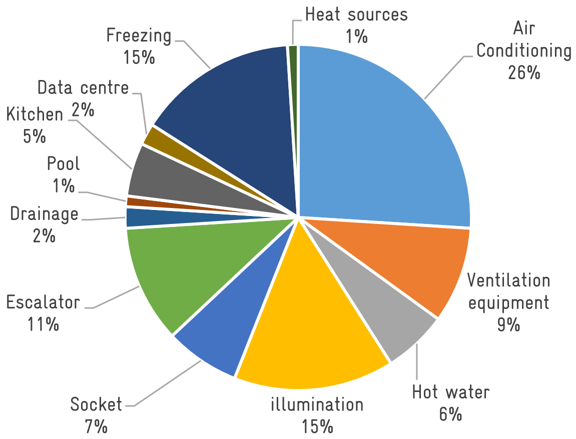



**Figure 1. 5 Energy consumption of a typical public building**[4]

## 2.1.2 Current status of Energy Efficiency Improvement in Public Buildings

According to the implementation experience of Chinese demonstration projects, the China Academy of Building Research summarizes that the main applications of technology for improving the energy efficiency of public buildings involve six major categories comprising 28 items. These categories include heating, ventilation, and air conditioning (HVAC) systems, power supply and lighting systems, intelligent control and sub-metering systems for energy consumption, renewable energy and domestic hot water systems, and building envelope retrofitting. The items are outlined in Table 1.2.

**Table 1.2 Application of Energy Efficiency Improvement Technologies in Public Buildings**

| Affiliated systems | Subsystems | Single technology |
|---|---|---|
| Heating, ventilation and air conditioning systems | Heating and cooling | Cooled water (heat pump) unit upgrade |
| | | Energy saving controls for refrigeration stations and water systems |
| | | Cooling tower energy saving retrofit |
| | | Heat recovery |
| | | Boiler upgrade |
| | | Steam system upgrades and energy efficiency retro-fits |
| | Distribution system | Pump upgrades |
| | | Pump variable flow control |
| | End equipment | Ventilation unit upgrades |
| | | Fan frequency conversion |
| Power supply, distribution and lighting systems | Power distribution system | Energy saving retrofit of power distribution system |
| | Illumination | Lighting source upgrade |
| | | Lighting energy saving control system |
| | Escalator | Escalator energy meter |

4 According to the keynote speech of the Sino-German Roundtable Seminar “Analyzing the Key Direction and Potential of Energy Saving and Carbon Reduction in Large Public Buildings in the Context of Dual Carbon”, Yu Zhen, Institute of Building Environment and Energy Research, China Academy of Building Research (CABR)

| Affiliated systems | Subsystems | Single technology |
|---|---|---|
| Intelligent control and sub-metering of energy consumption | Heating and air conditioning systems | Intelligent control of building equipment systems |
| | | HVAC system configuration |
| | Sub-measurement of energy consumption | Sub-metering of building energy consumption |
| Renewable energy and domestic hot water | Solar energy use | Solar thermal water heating system |
| | | Solar photovoltaic applications |
| | Air energy utilization | Air-to-water heat pump |
| | Shallow geothermal power | Ground source heat pump applications |
| Envelope modification | Facade and window upgrade | Renewal of glass curtain walls and windows |
| | | Sunshade conversion |
| | Changes on non-transparent building envelope | Roof and wall insulation retrofit |
| Other | Water conservation | Water saving appliance replacement |
| | Kitchen stoves and exhaust systems | Upgrading of kitchen stoves |
| | | Installation of intelligent control systems for smoke exhaust fans and supply air fans |
| | Data room | Optimization of airflow organization in server rooms |

**Excerpt 1: Opinions from the Sino-German Business Roundtable**

"Currently, the development of the domestic real estate industry has entered a bottleneck period. The ongoing energy saving retrofitting of existing buildings relies on the urban renewal process. The relatively easier parts of energy saving retrofitting have been largely completed, and the exploration of the remaining potential faces significant chal-lenges. There is a clear trend of extended return on investment periods. I don't think that at present (from a techno-economical perspective) en-ergy efficiency in buildings can increase more than 20-30%. However, the dual carbon goals by the Chinese government present a favorable opportunity to enhance the comprehensiveness of energy saving ser-vices. Figuring out how to actively confront and leverage this trend is a matter that requires careful consideration."

**Excerpt 2: Opinions from the Sino-German Business Roundtable**

"Public buildings have a high energy consumption density and com-plex equipment. In the construction of new public buildings, energy consumption can be reduced by improving the thermal performance of building envelopes, using high-efficiency electromechanical equipment, and utilizing renewable energy. However, for existing public buildings in operation, feasible energy saving measures are often constrained by factors such as the difficulty of modifying existing struc-tural conditions and the inability to affect normal building operations. In such cases, energy saving measures are more reflected in intelligent optimization control and refined operation settings."

## 3.1 Central Policy Developments for Energy Efficiency in Public Buildings

With the basic completion of the dual carbon "1+N" policy system[5], the construction industry has also introduced numerous related policies and plans.

In March 2022, the Ministry of Housing and Urban-Rural Development issued the "14th Five Year Plan for Energy Efficiency in Buildings and Green Buildings Development". The document proposes that by 2025 all new buildings in cities and towns will be green buildings. Energy efficiency in buildings will continuously improve and the distribution of energy consumption will be gradually optimized. Further regulation for energy consumption and carbon emissions in buildings will be issued. It also proposes to improve the quality of green buildings, raise energy efficiency standards of new buildings, boost the green transformation of existing buildings, promote the application of renewable energy, implement building electrification projects and share new green construction methods and other key tasks.

In July 2022, the Ministry of Housing and Urban Rural Development and the National Development and Reform Commission jointly issued the "Implementation Plan for Carbon Peaking in the Urban and Rural Construction Sector". It proposes that by 2025, all newly constructed government-funded public buildings and large public buildings should achieve a rating of one star or above in the green building rating system. Energy consumption monitoring and statistical analysis and gradually implementing energy consumption management should be further advanced. It also advocates for the integrated construction of solar photovoltaic systems in buildings, promoting additional solar photovoltaic systems on roofs, promoting intelligent photovoltaics and the comprehensive electrification of new public buildings. The document suggests the region-specific promotion of geothermal energy and biomass energy, various types of electric heat pump technologies, efficient direct current appliances and equipment, the application of intelligent microgrids, cold and heat storage systems, flexible load adjustment, virtual power plants, intelligent control technologies for electrical equipment and so on.

**Table 1.3 Policies and priority objectives for the construction sector in a dual carbon context**

| Timing | Deal | Sectoral | Focused work objectives |
|---|---|---|---|
| 03.2022 | The 14th Five-Year Plan for Building Energy Efficiency and Green Building Development | Ministry of Housing and Urban Development (MOHURD) | By 2025:<br>- Completion of energy saving renovation of existing buildings with an area of more than 350 million m2<br>- Construction of more than 0.5 billion square meters of ultra-low-energy and near-zero-energy buildings<br>- Assembled buildings accounted for 30% of new buildings in cities and towns in the year<br>- Nationally, more than 0.5 billion kilowatts of solar photovoltaic capacity have been installed in new buildings<br>- Geothermal energy building application area of more than 100 million square meters<br>- Renewable energy substitution rate of 8% in urban buildings<br>- Electricity consumption in buildings exceeds 55% of energy consumption |

5 China's central policy system for achieving the dual carbon goals.

| Timing | Deal | Sectoral | Focused work objectives |
|---|---|---|---|
| 2022.7 | Peak Carbon Implementation Program for the Urban and Rural Construction Sector | Ministry of Housing and Construction, National Development and Reform Commission | By 2025.<br>- Roof photovoltaic coverage rate of new public institution buildings strives to reach 50 percent<br>By 2030.<br>- All key cities above prefecture level have completed the renovation tasks, and the overall energy efficiency has been improved by more than 20% after the renovation.<br>- 20% electrification in new public buildings<br>- Enhance the overall energy efficiency of the electromechanical systems in public buildings by 10% from the current level. |

The introduction of relevant policies is not only a directional guideline for the future of energy saving and carbon reduction in buildings, but also puts forward several medium- and long-term requirements in a goal-oriented manner (Table 1.3). The analysis and interpretation of the policies will support the key areas of the future construction sector and its market potential to be further analyzed in consideration of Table 1.3, the current policies in the construction sector shows the future direction and primary goals of the Chinese government regarding building energy efficiency and carbon reduction. The enhancement of building energy efficiency (green building and energy efficient retrofitting of existing buildings), the application of renewable energy in construction (geothermal energy, air energy, distributed photovoltaics, wind power, etc.), and adjustments to end-use energy structures (electrification) are targeted.

# 2 Analysis of the results of the questionnaire survey

In addition to industry literature and data research, this study aims to collect frontline market information. The research team has formulated a questionnaire with around three categories and 16 questions, studying the potential for energy efficiency in public buildings, key focus technologies, and issues and obstacles in energy saving efforts. The team designed a survey questionnaire and jointly conducted surveys with major stakeholders such as energy service companies and property owners to gather insights.

## 2.1 Basic information of the questionnaire research

As of the end of July 2023, the research team recovered a total of 381 valid research questionnaires. The survey participants include various entities such as energy service companies, project owners, equipment manufacturers, engineering companies and design units. The energy service companies depict the main force of the energy saving renovation work and accounts for 40% of the participants ( Figure 2.1 ).

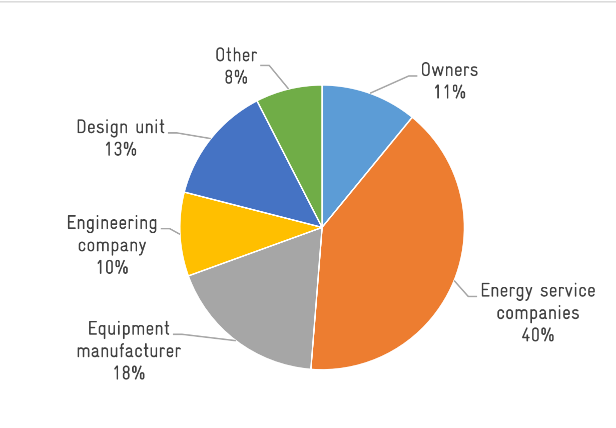



**Figure 2. 1 Distribution of subjects participating in the questionnaire survey**

## 2.2 Key areas for energy savings in large public buildings

### 2.2.1 Features of different building types

The survey conducted this time focused on the statistics of various entities' participation in energy saving projects for various types of public buildings. The results show that among energy service companies, those involved in the energy saving renovation of government office buildings, shopping malls, and hospitals accounted for the highest proportion, at 63.1%, 58.2%, and 53.2%, respectively. Next are school buildings, commercial office buildings, and hotel buildings, accounting for 46.8%, 46.1%, and 41.8%, respectively. On the other hand, entities engaged in energy saving projects for cultural and sports venues and transportation buildings have a relatively lower proportion, accounting for 29.8% and 18.4%, respectively (Figure 2.2). Overall, it can be observed that the percentage of companies involved in energy saving projects for different types of public buildings is somewhat correlated with the proportion of each building type in the total area. For major building types such as office buildings, shopping malls, and schools, which have a relatively large proportion of the total area, more than half of the energy service companies have participated in related energy saving projects. With small differences in proportions, buildings with a public institutional nature marginally improved in terms of energy saving efforts.

In recent years, driven by energy saving policies for public institutions, government office buildings, hospitals, and schools have been more actively involved in energy saving initiatives compared to general commercial buildings. Despite hospitals accounting for a relatively small percentage of the overall building area (approximately 5%), they have a higher participation rate due to their complex functions, the relatively extensive energy systems, longer operating hours, and higher energy intensity. Additionally, with continuous advancements in medical technology, regular updates of diagnostic and treatment equipment, and the continuous expansion of additional services, the energy consumption of hospitals has shown a growing trend. There is an urgent need for energy conservation. Given the relatively stable returns and the pressing demand for energy conservation in hospitals, many energy service companies consider hospitals as preferred entities for conducting their business. As a result, the proportion of service companies that have implemented energy saving projects in hospitals is relatively high.

In recent years commercial complexes have sprung up with urban advancement in large numbers within cities and the proportion of building area to the total public building area is already very high (23%). Simultaneously, due to their large volume, complex space, and many factors affecting operational energy consumption, building energy intensity increased tremendously, created the necessity for energy conservation initiatives. Consequently, the focus of energy service companies shifts towards energy saving renovation for these buildings. The proportion of energy service companies participating in the energy saving renovation for these buildings also grew.

Transportation buildings, as well as cultural and sports venues, have experienced rapid development. However, compared to other types of buildings they still account for a relatively low proportion in terms of quantity and area. Consequently, the proportion of energy service companies involved in energy saving renovations for these types of buildings is the lowest compared to other building categories. As depicted in Figure 1.4, the respective proportions of cultural and sports venues, as well as transportation buildings, are still likely to be less than 4%. Given this baseline, there is still a significant participation in energy saving initiatives of approximately 20% to 30% within the energy service companies. This suggests a relatively widespread attention on the energy saving potential of these building categories.

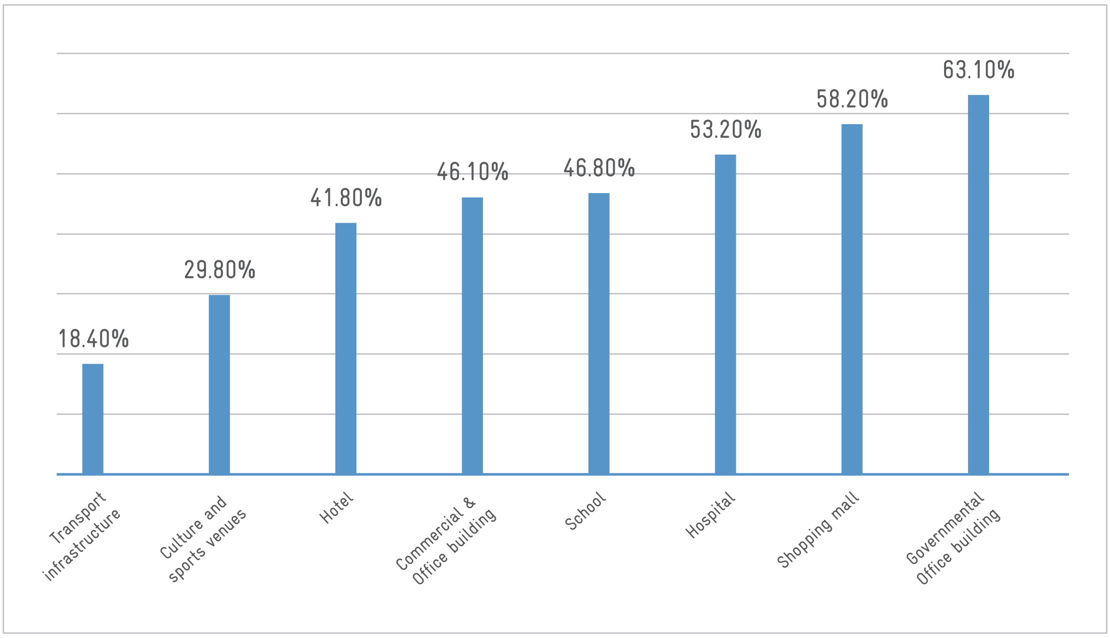



**Figure 2. 2 Share of energy efficiency retrofits for different types of public buildings**

### 2.2 .2 Distribution of potential in different areas

According to over 60% of the surveyed entities believe that the main potential lies in the Heating, Ventilation, and Air Conditioning (HVAC) field. Entities perceive development potential in new energy and energy storage systems (56.3%) as well as in intelligent energy consumption monitoring and management systems (44%). Elevator systems, building materials and structures receive the least attention in terms of interest (Figure 2.3).

Based on the general characteristics of the energy consumption distribution within public buildings, approximately 50% to 60% is consumed by heating, ventilation, air conditioning and hot water systems. As HVAC constitutes a primary area of energy consumption, there is generally a consensus that it is a key focus for exploring energy saving potential. As energy saving efforts shift from individual equipment to overall system improvements, there is a continuous increase in the demand for the automatic monitoring, control and optimization capabilities of energy consumption systems. The establishment of efficient smart operation and maintenance systems for integrate a concept of fine management of building energy efficiency is widely recognized. Given the rapid development of new energy and especially of energy storage systems in recent years, there is significant attention and expectation from a considerable proportion of entities regarding the role these technologies can play in energy saving and emission reduction efforts in large public buildings.

With the development of society, public demands for comfort within public buildings have further increased. The application of hot water systems in public buildings has become more common and the energy saving potential in this area has received a certain level of attention. On the contrary, the attention to elevator systems is relatively low due to their low proportion of energy consumption. Areas such as building enclosure systems have lower rankings in terms of attention, primarily influenced by the type of research participants. In this survey, energy service companies constitute a significant proportion of the surveyed entities. When energy service companies undertake energy saving renovations for existing public buildings, they often employ methods such as contract energy management, focusing on the transformation and operation of major energy consuming equipment and facilities. However, renovations related to building enclosure structures and materials, although effective in energy savings and cost-effective, tend to be more suitable for one-time engineering projects. This approach is not within the business scope of most energy service companies, resulting in a relatively lower level of attention in this research.

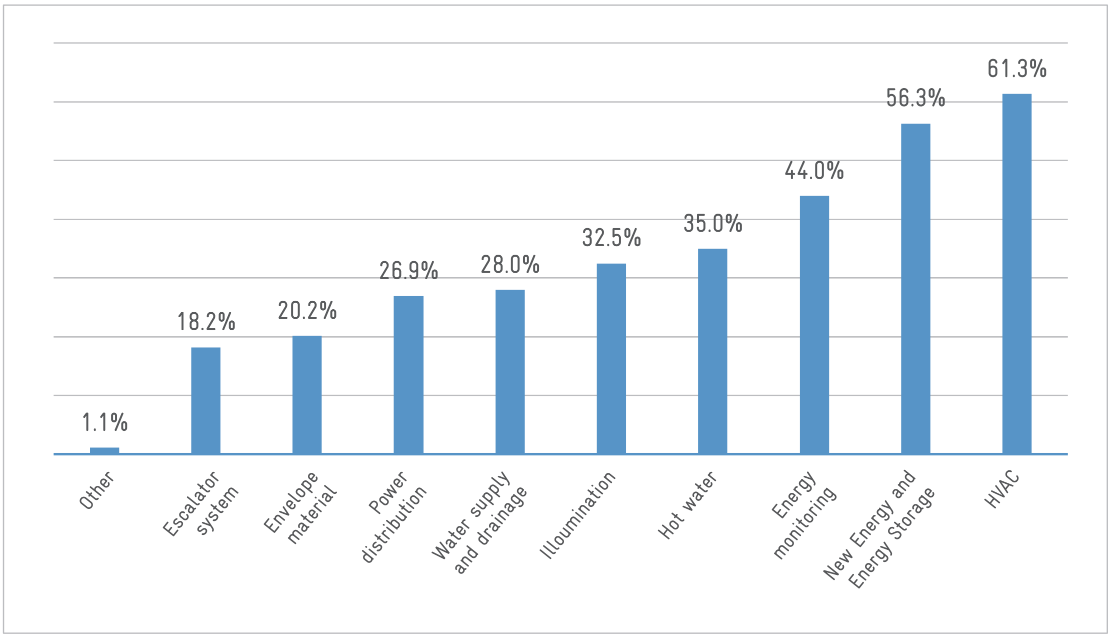



**Figure 2. 3 Level of interest in potential areas of energy efficiency in large public buildings**

According to the questionnaire statistics, this study about the overall energy saving potential of large public buildings shows a basic consensus about an achievable energy saving potential exceeding 10%. Nevertheless, significant variations in the energy saving potential ranges can be observed. Among the respondents, the majority (37.8%) believe that the energy saving potential falls within the 10-20% range, followed by 30% who believe the potential lies within 20-30% and ultimately 26.3% who believe it exceeds 30% (Figure 2.4).

**Excerpt 3: Opinions from the Sino-German Business Roundtable**

"In the field of construction, there is still a potential for 20-30% energy savings that can be realistically harnessed. Among these, passive energy saving measures can achieve 10-15% (utilization of low energy thermal insulation in buildings). In terms of active energy saving enhancements, optimizing the use of equipment and devices can result in 5-15% savings. With precise operational methods, effective monitoring, and timely measures, an additional 2-8% can be achieved."

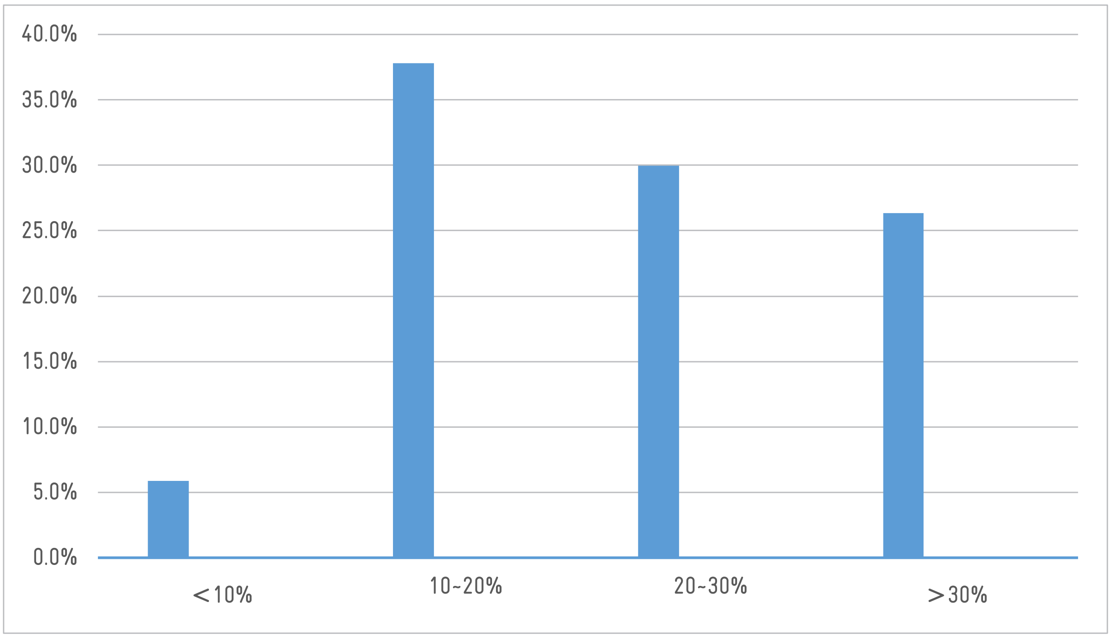



Figure 2. 4 Estimation of future energy saving potential within large public buildings

### 2.2.3 Key Energy Saving Technologies for Large Public Buildings

Regarding the key technologies currently focused on by various entities, the results of this questionnaire survey show significant differences in the level of attention to critical energy saving technologies. In their midst the most highly regarded technologies are smart management technology and efficient cold storage system solutions which accounts for 36.7%. Other key technologies with relatively high levels of attention include new energy storages (35%), efficient chillers (34.7%), efficient water pumps (30.8%), and thermal storage/energy saving hot water systems (29.7%). Energy saving technologies with attention levels below 20% include elevator optimization control, efficient doors and windows, structural improvements, electrification upgrades, power distribution and operation and lighting control technology (Figure 2.5).

In the initial design of the questionnaire regarding key technologies, a corresponding breakdown and listing of technologies were conducted after identifying the key potential areas. Therefore, there is a significant correlation between the energy saving technologies of each surveyed entity and the distribution areas of energy saving potential mentioned earlier. Within these, the smart management technology needed in the intelligent energy consumption monitoring and management system holds a high level of attention. In the HVAC field, efficient cold storage system solutions and efficient chiller technology are the most keenly observed. In the area of new energy and energy storage systems, there is a certain difference in the level of attention on different technologies, with energy storage technology ranking high and distributed photovoltaics ranking in the middle to lower positions. This suggests that the attention to the potential of "new energy and energy storage systems" mentioned earlier is largely influenced by new energy storage technologies

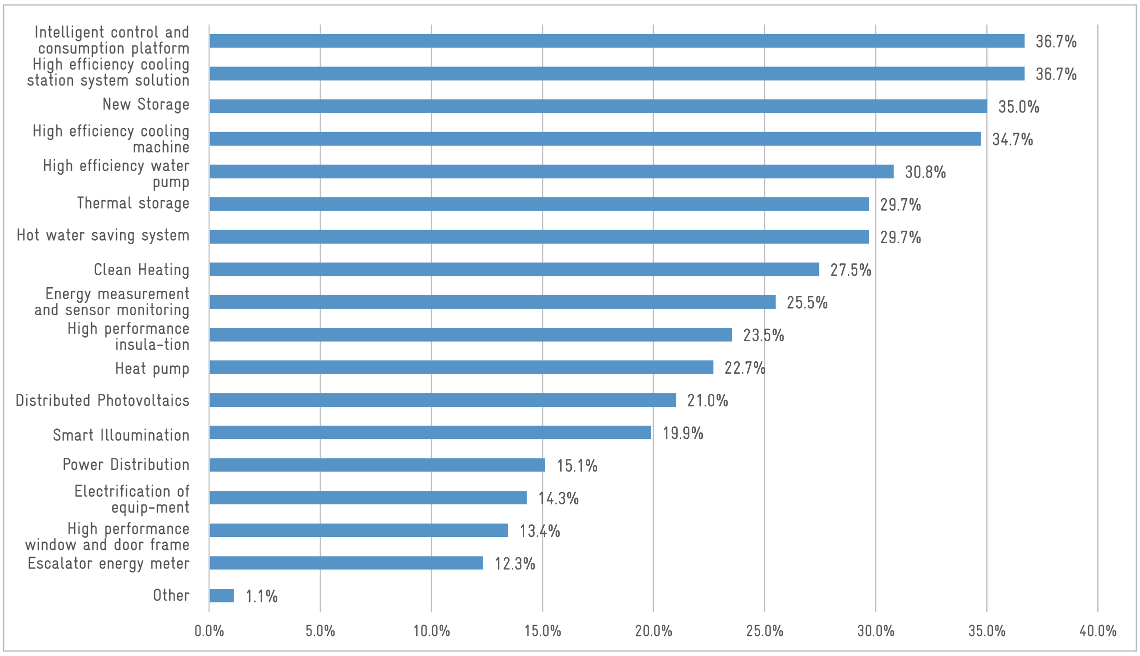



**Figure 2. 5 Energy efficiency technologies of interest**

From the perspective of ESCOs and property owners, high-efficiency cooling systems, cold storage systems, and new energy storage are of interest for both. Their opinions differ regarding thermal energy storage technology, intelligent management technology and heat insulation material technology. ESCOs pay the highest attention to intelligent management technology and relatively low attention to thermal insulation material technology. Property owners, on the contrary, pay the highest attention to thermal insulation material and less attention to intelligent management technology and cold and heat storage technology (Figure 2.6., Figure 2.7).

According to the experts of Sino-German Business Roundtable, about 20%~50% of the energy consumption of HVAC and hot water systems in public buildings is consumed by heat transfer through the building envelope. It is of great significance to improve the thermal insulation of building envelope to reduce the energy consumption. As mentioned above, due to their limited involvement in building envelope materials and structures, ESCOs tend to pay less attention to insulation material technology. However, from the perspective of property owners, insulation materials play a significant role in improving building energy efficiency, as they require low maintenance and personnel costs.

Thermal energy storage technology requires large amounts of space, which is challenging for many existing buildings to accommodate. Even when utilizing firefighting pools, there may be additional costs related to safety concerns and regulatory approvals. According to the research team's findings, the current market penetration of thermal energy storage technology is not high, possibly indicating a lack of awareness among property owners.

ESCOs and property owners place different emphasis on intelligent management technology. Intelligent information technology can effectively improve the effects of retrofitting and operation for ESCOs that employ contract energy management, thus increasing revenue. However, the energy saving benefits are not immediately apparent to property owners, and the adoption of intelligent management technology adds a certain level of technical complexity to building operations and maintenance.

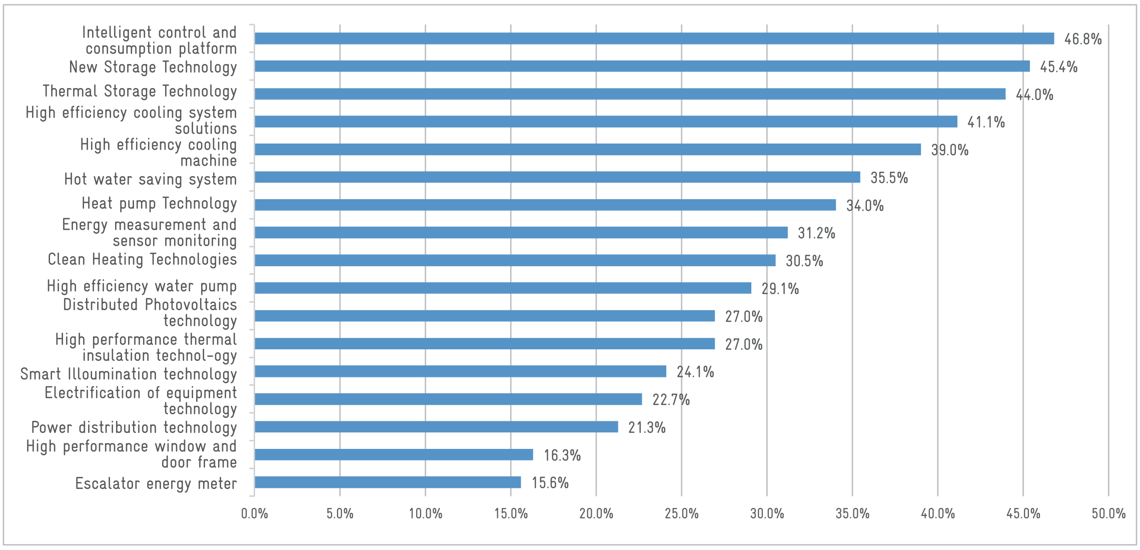



**Figure 2. 6 Energy efficiency technologies of interest (ESCO perspective)**

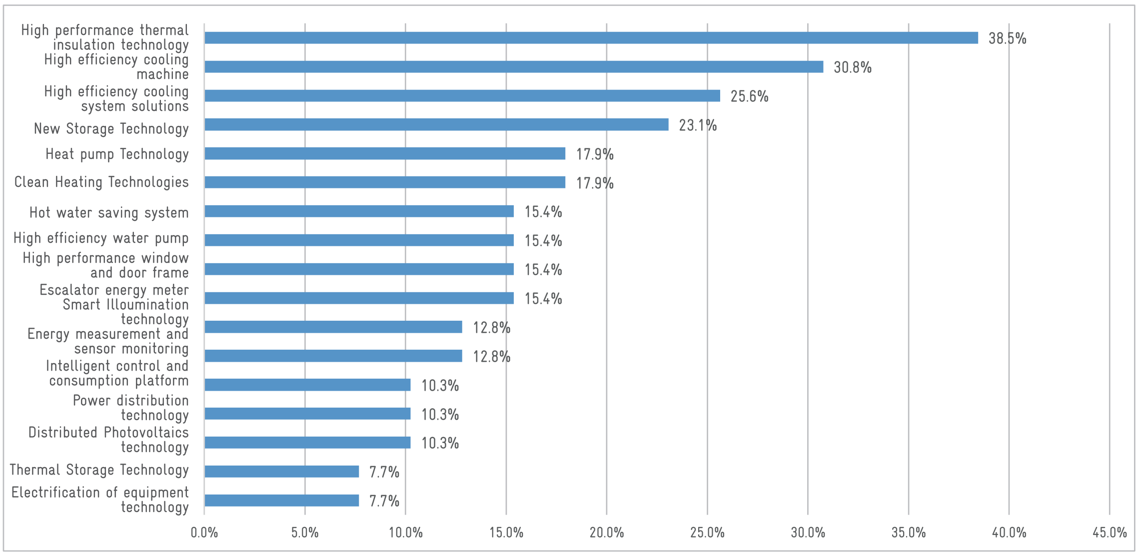



**Figure 2. 7 Energy efficiency technologies of interest (owner's perspective)**

Note: The number of property owners involved in this research is relatively small. The statistical results may be biased due to insufficient sample size.

**Excerpt 4: Opinions from the Sino-German Business Roundtable**

"In the energy consumption of heating, ventilation, air conditioning, and domestic hot water in public buildings, approximately 20% to 50% is attributed to heat transmission through the building envelope. (In regions with warm summers and mild winters, it's around 20%; in regions with warm summers and cold winters, about 35%; in cold regions, around 40%; and in extremely cold regions, about 50% ). Additionally, 30% to 40% is consumed for the treatment of fresh air. Based on the current analysis, there is significant energy saving potential in public buildings related to the building envelope, heating, ventilation, air conditioning, domestic hot water, and lighting."

## 3.1 Analysis: The Competitive Advantages of German Companies and Products

### 3.1.1 The Chinese Market's Attitude towards Foreign Brands

The cooperation between the Sino-German Energy Partnership of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Energy and Environmental Services Industry Alliance (EESIA) aims to promote exchanges between Chinese and German energy efficiency companies. Therefore, the questionnaire survey addressed the attitudes of the participants towards foreign brands when choosing energy saving technology. The results of the survey show that the participants' willingness to choose foreign brands is relatively high, with 65% of the subjects willing to choose foreign brand technology (Figure 2.8). Participants willing to choose foreign brands mainly focus on advanced technology (36%) (Figure 2.9), while the main reason for refusing to use foreign brands of technology services are the costs (51%) (Figure 2.10).

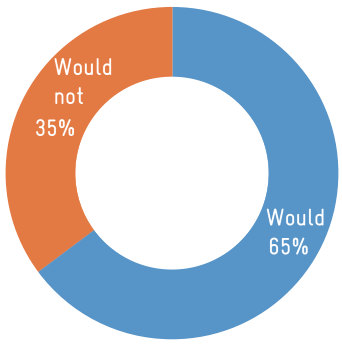



Figure 2. 8 Willingness to choose foreign brand products

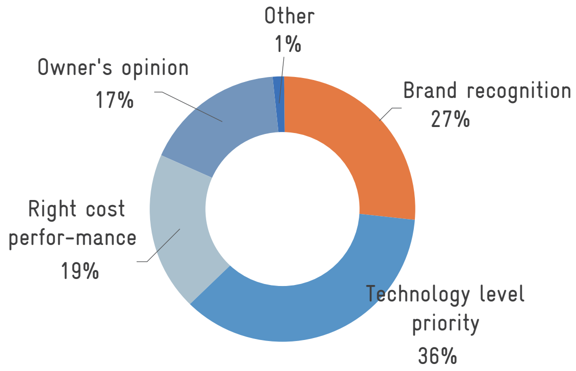



Figure 2. 9 Reasons for choosing foreign brands

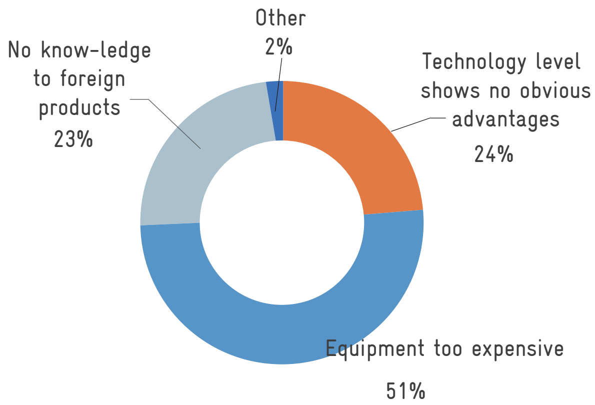



Figure 2. 10 Reasons for refusing to choose foreign brands

### 3.1.2 Analysis: The Advantages of German Technology Products

Foreign brands, especially German products, maintain a strong advantage in most energy efficient products, energy equipment, and energy saving and carbon reduction solutions compared to domestic brands. They have gained widespread recognition in the Chinese market for their advanced technology. However, regarding general equipment and products, Chinese technology, such as air-source heat pumps, intelligent systems, metering instruments, renewable energy equipment components, etc., also have a strong market competitiveness. For instance, exports of photovoltaic components and air source heat pumps have grown steadily in recent years. In the fields of energy information technology and instrumentation, numerous large-scale and publicly traded enterprises emerged. Therefore, regarding general equipment and products, German manufacturers face challenges in promoting their products due to the relatively higher prices.

On the one hand, the research team believes that German companies should focus on differentiated market strategies. The high-end market still presents opportunities, especially in sectors like public institutions and high-end commercial residences. These types of clients tend to prioritize product quality while being less sensitive to pricing. There is potential to further consolidate and expand the market within these customer segments. On the other hand, German manufacturers can leverage their technical advantages by concentrating on and enhancing specialized solution designs for specific scenarios. This may include specialized applications such as distributed photovoltaic technology for unique scenarios, regionally based intelligent energy technologies leveraging multiple complementary sources, and advanced solutions for energy storage and energy efficiency in data centers. By offering irreplaceable solutions, they can offset cost disadvantages.

For the future, it is worth mentioning that prefabricated construction will occupy a significant share of new buildings. Representative companies such as Broad Homes (远大住工), Sumitomo, and Shanghai Construction Group (上海建工) have already emerged in this field. Prefabricated construction involves integrating various systems, including the building envelope and electromechanical systems, during the production phase of the building material. This trend represents an important potential for German technology manufacturers in the construction industry to closely monitor in the future.

## 4.1 Analysis of Factors Affecting the Exploitation of Energy Saving Potential

The research team interviewed several stakeholders within the large-scale public building sector to learn about their opinions on policy mechanisms, markets, and objective conditions. By incorporating their opinions and the results of the survey, the team identified and compiled some typical factors influencing the exploitation of energy saving potential. The factors are discussed below.

### 4.1.1 Policy Factors

Energy saving work in large public buildings is greatly influenced by government policy. According to the results of the research, 88% of the participants have a certain degree of understanding of the policies in the building sector (Figure 2.11). Incentive policies play a crucial role in driving energy saving efforts in large public buildings, with 84% of the surveyed entities considering such policies as a decisive factor influencing their work (Figure 2.12).

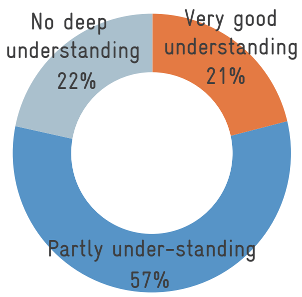



**Figure 2. 11 Knowledge of policies in the building sector**

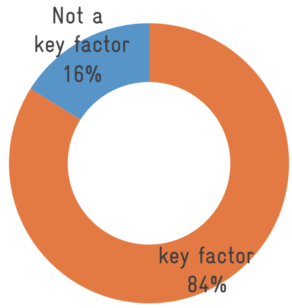



**Figure 2. 12 Degree of impact of incentive policies**

**(1) Public Procurement**

*There is a conflict between the bidding and procurement policies of public organizations and the business model of energy saving renovation, as indicated by 49.3% of the participants.* Public institutions heavily rely on government funding, and when purchasing services from external providers, they often stipulate a maximum contract renewal period of three years. However, the prevailing business model in the market for energy efficient renovation projects typically requires contract durations of 8-10 years to ensure the economic viability and motivation of service providers. Currently, various regions are progressively introducing relevant policies to promote energy conservation through market mechanisms, encouraging public institutions to engage in energy saving initiatives. For instance, in places like Shandong and Shanghai, policies explicitly state that the contract period for 'contract energy management projects' in public institutions generally should not be less than 5 years and not exceed 10 years. However, regions lacking corresponding policy support still face limitations due to short contract duration.

**Excerpt 5: Opinions from the Sino-German Business Roundtable**

„The business model of energy outsourcing for public institutions is undergoing a developmental process, moving towards cost reduction, efficiency enhancement, and quality improvement. Energy saving is viewed as a process, not just an outcome, transitioning from equipment centric energy savings to system wide efficiency improvements. The current trend is towards holistic lifecycle services, although awareness of such services is not yet sufficient."

### (2) Contract Settlement

*There are issues with the settlement mechanism for energy service fees in public institutions, as reported by 42% of the participants.* In certain regions, such as Shanghai, it is explicitly stated that ‘public institutions implementing contract energy management projects shall further utilize the saved energy costs, if they are to be used for overall energy saving efforts.’ However, in areas without clear policy support, public institutions lack mechanisms to further utilize the saved energy costs. The savings in energy costs may indirectly impact the fiscal budget of public institutions in the following year, potentially affecting the motivation of some public institutions to engage in energy saving initiatives (Figure 2.13).

### (3) External Constraints

*Project implementation is restricted by the management norms of other external entities, answered 36.7% of the participants.* During energy saving initiatives, coordination with project stakeholders is essential, and compliance with regulations from external entities such as electricity and water providers is also necessary. Currently, there is a lack of targeted supportive policies for energy saving businesses in this regard (Figure 2.13).

One company mentioned that their plan to deploy an energy storage system and provide energy services to multiple public buildings faced challenges, because the electricity provider struggled with unifying the power supply for multiple buildings, which prevented them from proceeding.

**Excerpt 6: Opinions from the Sino-German Business Roundtable**

„The implementation of energy saving and comprehensive energy services is closely related to the local electricity pricing situation. Currently, electricity market reforms are still underway, and there are variations in factors such as peak and off-peak electricity prices in different regions. Consequently, the implementation of energy saving initiatives should also be tailored to account for these differences.“

**Excerpt 7: Opinions from the Sino-German Business Roundtable**

„In terms of external wall materials, in some regions with less strict regulation, there is a phenomenon of making blanket judgments on the quality of external walls, leading to the current insulation material industry being in a ‚cold winter phase.“

Another expert responded, “There are indeed certain issues with building envelopes, but they are not that severe. Relevant authorities actively engage in negotiations with local governments when promoting the import of external wall materials and related initiatives.“

### (4) Financial Implications

*53.3% of the participants believe that energy saving retrofitting is not a rigid demand, and that the implementation of energy saving work is largely influenced by budgetary considerations.* In the absence of mandatory policy requirements, companies may lack pressure for energy consumption management, and energy saving renovations are not considered necessary. Some companies state that even with sufficient funding, the lack of sensitivity from the client regarding the indirect benefits of building energy efficiency results in a lack of motivation to carry out related initiatives (Figure 2.13).

### (5) Labeling of Energy Efficiency Ratings

*50.7% of property owners state that the lack of clear energy efficiency labels of large public buildings leads to a lack of understanding of the energy efficiency level of the own building.* Consequently, there is a lack of awareness regarding the need for corresponding energy saving renovations. Although standards such as the ‘Standard for energy consumption of buildings’ (GB/T 51161-2016) can serve as a reference point for determining the energy efficiency levels of large public buildings, the absence of mandatory requirements for existing public buildings means that owners may lack the proactive motivation to clarify their own energy efficiency levels (Figure 2.13).

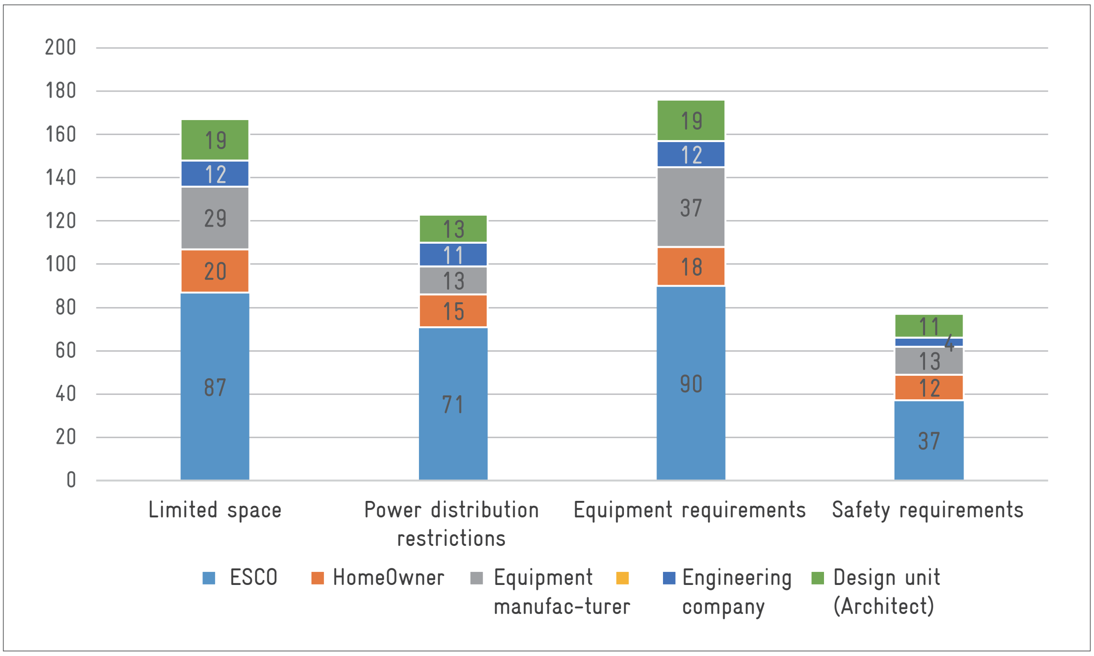



**Figure 2. 13 Selection of relevant policy factors**

## 4.1.2 Market Factors

**(1) Too many Stakeholders, Few Shared Incentives**

*More than 60% of respondents believe that energy efficiency in large public buildings involves too many stakeholders*, such as owners, building users, etc., and that the incentives for energy efficiency retrofits are not consistent among the parties involved. This makes it difficult to communicate with each other and hinders the project to a certain extent. In addition, even if a project is carried out, *the demand side is not willing to sign long term contracts (38.7%)* due to factors such as the duration of the lease contract and changes in the internal organization structure (Figure 2.14).

**(2) Judgment of Competence and Effectiveness**

On one hand, **demand side entities face challenges in discerning the technical capabilities and service offerings of product suppliers (41.5%)**. With numerous ESCOs in the market, demand side entities lack a basis for assessing an ESCO's technological capabilities. Inappropriate selection often results in energy saving renovations falling short of expectations. On the other hand, *the service provider lacks the ability to identify and judge the fulfillment capability of the demand side (32.8%)*. Energy service contracts have extended durations, and demand side entities may face challenges in meeting contract requirements due to their own operational constraints. Service providers need a thorough assessment of demand side entities' fulfillment capabilities in the early stages of project initiation. Moreover, in terms of determining energy saving effectiveness, there is a lack of a comprehensive energy saving verification system. *It is difficult for both parties to effectively reach a consensus based on the contract alone (45%)* (Figure 2.14).

**(3) Project Financing**

**Only 33.9% of respondents stated that there are difficulties in project financing and financing platforms.** The research team believes that the relatively low percentage of results does not indicate that the financial services in the field of building energy saving renovation are sufficient. The volume of building energy saving projects and businesses are of small scale in the first place, making it a less prioritized area for attention and support from financial institutions (Figure 2.14).

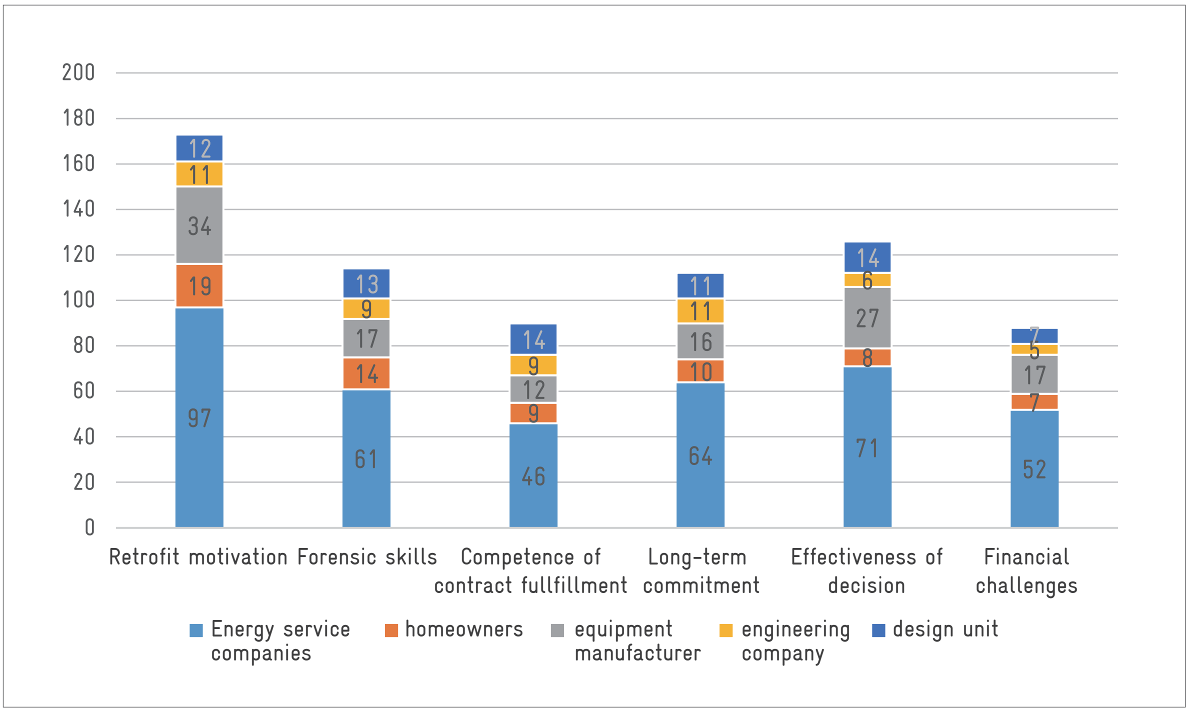



**Figure 2. 14 Selected relevant market**

### 4.1.3 Environmental Factors

**(1) Spatial Conditions**

**The limited space in existing buildings constrains the implementation of certain technologies, such as thermal storage, heat pumps, etc. (59.4%),** as these considerations were not adequately taken into account during the initial design (Figure 2.15)."

**Excerpt 8: Opinions from the Sino-German Business Roundtable**

„We believe that we are only at the beginning of energy saving efforts in the field of construction. The single stages of the construction industry's value chain, including planning, construction, and operation, are relatively isolated. Rather, the entire industry chain should be integrated, strengthening communication among relevant stakeholders from the planning stage onward. We maintain a positive outlook on the energy saving potential in the construction sector!"

**2) Supporting Conditions**

Another significant factor is the power distribution capacity. **The power demand for technologies like heat pumps cannot be promptly addressed due to limitations in distribution capacity (41.7%)** (Figure 2.15).

**(3) Poor Original Equipment**

*Inadequate original equipment conditions result in excessively high retrofitting costs or affects the retrofitting effectiveness (62.2%)* (Figure 2.15). In such cases, merely focusing on retrofitting specific equipment is insufficient to meet overall energy saving requirements. Strong technical service capabilities are often needed to provide comprehensive and systemic solutions, but the associated increased costs can harm project implementation.

**Excerpt 9: Opinions from the Sino-German Business Roundtable**

„Firstly, we believe there is a need to strengthen the reception of energy service providers. Secondly, we perceive the design phase in the construction industry as relatively ‚conservative,' partially resisting adopting new technologies. Therefore, we should engage in proactive discussions with designers, encouraging the early integration of advanced energy efficient technologies to promote the improvement of energy efficiency from the beginning."

**(4) Security Limitations**

*Some technologies face limitations in implementation due to rigid safety requirements (28%)* (Figure 2.15). Safety concerns act as an impassable boundary. All participants consider safety requirements before initiating projects, thereby reducing the impact safety limitations have on the actual execution of a project.

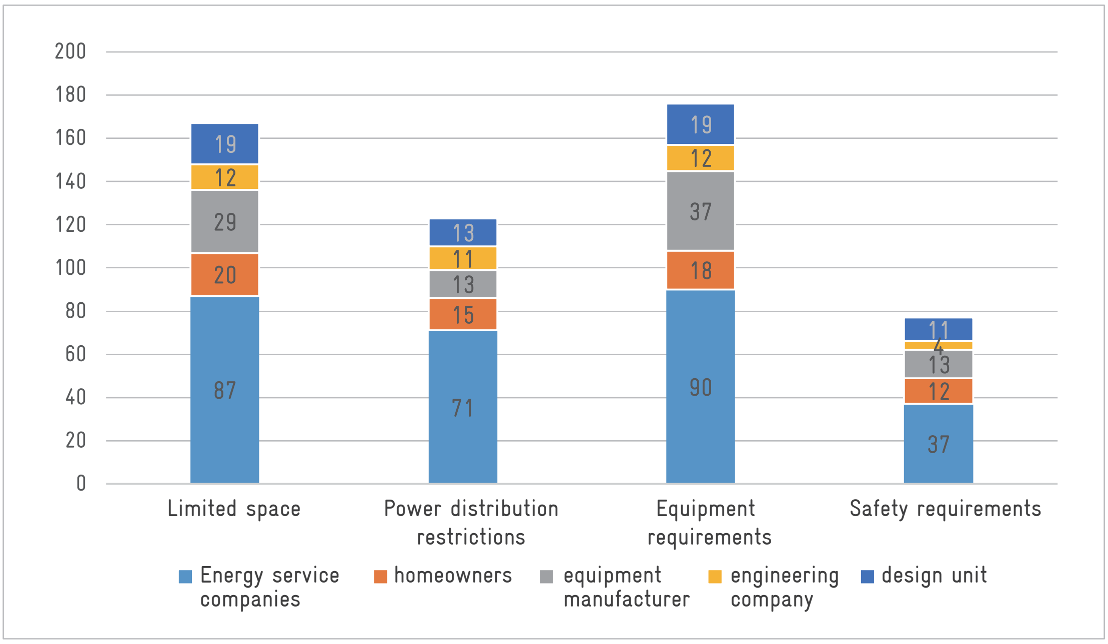



**Figure 2. 15 Selection of condition factors**

# 3 Outlook: Energy Saving Potential in Large Public Buildings

## 3.1 Stronger Policy Support – A Common Aspiration

In contrast to the energy saving renovations in residential and rural homes, which are mainly driven by government initiatives, the current stage of energy efficiency in large public buildings relies primarily on market forces. The progress in this domain still depends on strengthened policy support and various standards. Survey results indicate that, among the options of policy support, technological advancements, business models, and energy saving awareness, the highest percentage chose 'strengthened policy support' as the primary pathway for further improving energy efficiency in large public buildings. To a significant extent, stakeholders are anticipating increased support from incentivizing policies (Figure 3.1).

While there is also a relatively high percentage selecting 'improved energy saving awareness,' the research team believes that, in the current context of the dual carbon goals, there is already a strong foundation for the widespread awareness of energy saving and carbon reduction. Achieving a substantial leap in awareness in the short term is challenging. The motivation for building owners directly affects whether further energy saving renovations will be executed. In the absence of mandatory policies to clarify their buildings energy efficiency levels and energy saving obligations, relying solely on the awareness of building owners is insufficient to effectively advance energy saving renovations in existing public buildings.

Therefore, both incentivizing and mandatory policies are crucial influencing factors for driving future energy efficiency in buildings. If these policies are directed towards building owners, it can effectively stimulate their motivation for energy saving.

Regarding business models, the national and local governments have successively introduced policy recommendations encouraging public institutions to carry out energy saving work through methods such as contract energy management and energy outsourcing. According to discussions in the Sino-German Business Roundtable, the energy outsourcing management model has gained widespread recognition and is considered a crucial development direction for future business models in energy efficiency for public buildings.

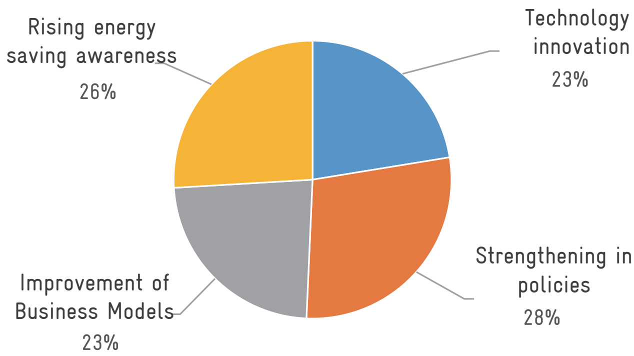



**Figure 3. 1 Future expectations of the participants**

**Excerpt 10: Opinion from the Sino-German Business Roundtable**

„Regarding business models for energy saving retrofitting of public buildings, the benefit-sharing model is relatively applicable in the industrial sector but is not feasible in the construction field. The biggest drawback of implementing energy saving work in this model is allowing Party A to fully grasp Party B's profitability. Therefore, the energy trusteeship model is expected to be the trend."

## 3.2 Policy and Market Align on Key Technologies and Areas

As of the current policy direction, the main objectives of the Chinese government's efforts towards energy efficiency and carbon reduction are:

1. The improvement of building energy efficiency (green buildings and energy saving renovations of existing buildings).

2. The integration of renewable energy in buildings (such as photovoltaics, heat pumps, smart energy storage, and thermal energy storage).
3. Adjustments in energy consumption structure (electrification).
4. Intelligent control (smart control technology for electrical devices).

The results of this survey to some extent reflect the market's attitude. In the field of energy consumption and emissions, energy efficiency and carbon reduction in the operation of large public buildings rely mainly on the improvement of the efficiency of electromechanical equipment and the implementing building information technology. With increasing application of renewable energy technologies in the construction sector, new energy storage and thermal storage technologies play a crucial role in accommodating renewable energy and ensuring the flexibility of distributed energy.

## 3.3 Existing Standards Require Mandatory Application

As mentioned in the previous section, energy efficiency in large public buildings is greatly influenced by policies. According to the research results, relevant energy efficiency policies in large public buildings are well disseminated. Incentive policies play a decisive role in driving energy saving initiatives for large public buildings. Currently, there are existing standards supporting the energy saving retrofitting of public buildings, including renovation standards (such as the "Technical Code for the Retrofitting of Public Building on Energy Efficiency"; JGJ 176-2009) and energy consumption standards (such as the "Standard for Energy Consumption of Building"; GB/T 51161-2016). However, according to expert opinions, these recommended national standards do not yet fulfil their intended role in practical implementation. There is still a need for mandatory mechanisms to guide and promote the application of relevant standards.

## 3.4 Public Building Energy-Saving to Transition to Dual Emphasis on Energy Efficiency and Carbon Control

With the introduction of the dual carbon goals and the requirements for carbon peaking in urban and rural construction, China officially initiated the development of the "Technical Standard for Zero Carbon Buildings" national standard on April 9, 2021. This standard aims to establish regulations on the relationship between zero-carbon buildings and nearly zero-energy buildings, the definition of zero-carbon buildings, carbon trading mechanisms, and other related aspects. On July 24, 2023, the Ministry of Housing and Urban Rural Development began soliciting public opinions on the national standard "Technical Standard for Zero Carbon Buildings (Call for Comments)." The new standard is set to guide energy saving efforts in China's construction sector with a dual track approach focused on both energy consumption and carbon emissions. This will create a new dual-control system based on these two indicators, providing the impetus for the development of technologies for carbon reduction and energy efficiency in large public buildings.

# 4 Summary

The field of construction is a key area for China to achieve its dual goals of peaking carbon emissions and achieving carbon neutrality. Energy efficiency improvements and changing the energy use pattern of existing buildings, especially existing public buildings, are crucial aspects in this domain. Clearly, energy saving efforts in public buildings play a significant role in promoting energy conservation, emission reduction, and addressing climate change in China. Through this survey and analysis, we have identified the following key points:

As for the technical aspect of energy efficiency in public buildings, HVAC remains as the most dominant influence. High-efficiency HVAC systems are crucial technologies of concern for both ESCOs and property owners. With rapid growth in the energy storage industry in recent years, great potential is expected in this area, although the application effects and business models are not yet mature in the field of public buildings.

Energy saving efforts are driven by both policy and market factors. While China has clear mandatory policy requirements for the energy efficiency levels of new buildings, the retrofitting of existing public buildings relies mainly on recommended policies and incentive-based subsidies, lacking mandatory requirements for energy efficiency. Relying solely on the energy saving awareness is not sufficient to achieve significant energy saving transformation in the vast stock of existing buildings.

At present, the energy efficiency transformation of public buildings is gradually shifting from equipment energy savings to system energy savings and further towards life cycle energy savings. Collaborative cooperation among stakeholders at different stages of the life cycle will become a trend in further promoting energy efficiency and performance improvement in large public buildings.

With the advancement of China's dual carbon goals, there will likely be a dual demand for energy saving and carbon reduction in the future, posing challenges for various stakeholders involved in large public building energy efficiency.

As the participants from the Sino-German Business Roundtable have pointed out, the real work on energy efficiency in large public buildings has yet to begin.

Finally, sincere thanks are extended to the experts and companies for their discussions and suggestions on questionnaire design, collection, and analysis of research results. Gratitude is expressed to all relevant stakeholders for taking the time to participate in the questionnaire for this research.

# Annex

## Annex 1: Survey Questions

**1. What is your type of business?**

☐ Building owner ☐ Energy service provider ☐ Equipment manufacturer

☐ Construction company ☐ Design agency ☐ Others

**2. For which types of public buildings do you provide energy efficiency equipment/services? (Select all that apply)**

☐ Government buildings ☐ Culture and sports facilities ☐ Hospitals ☐ Schools

☐ Shopping malls ☐ Office buildings ☐ Hotels ☐ Transport facilities £Others

**3. Which of the following have significant potential to improve a public building's energy efficiency? (Select all that apply)**

☐ Building envelope ☐ Renewable energy and energy storage ☐ Lighting ☐ Lifts ☐ Cooling ☐ Heating
☐ Ventilation □Water supply and drainage □Hot water □Electrical distribution system □Energy monitoring □Others

**4. Which energy saving technologies do you require most to improve the systems mentioned above? (Select all that apply)**

☐ High-performance thermal insulation materials ☐ High-performance windows and doors ☐ High-efficiency pumps ☐ Photovoltaic technology ☐ New energy storage ☐ Lighting control system ☐ High-performance lifts ☐ Energy efficient cooling ☐ Clean heating technology ☐ Heat pumps ☐ Energy efficient water heaters ☐ High-efficiency plantrooms ☐ Intelligent energy management systems ☐ High precision energy monitoring & metering, sensors etc. ☐ Operation and maintenance of distribution systems ☐ Thermal energy storage ☐ Electric upgrading □Others

**5. How familiar are you with the policies and standards related to energy efficiency in large public buildings?**

☐ Very familiar ☐ Moderately familiar ☐ Not familiar

**6. Are or were local government incentives a decisive factor in your decision-making?**

☐ Yes ☐ No

**7. What do you think is preventing large public buildings from getting more energy efficient? (Select all that apply)**

I. Policy factors

☐ Restrictions in procurement processes of public institutions

☐ Problems in the billing process of public institutions

☐ Project implementation in public institutions is restricted by other regulations (e.g., on water consumption, electricity consumption, etc.)

☐ Energy efficiency retrofitting is not considered an urgent need and its implementation depends on the availability of funding

☐ Insufficient energy performance labels for public buildings and lacking awareness of own energy performance

☐ Others

II. Market factors

☐ Too many stakeholders involved yet few shared interests for retrofitting, which hinders project development

☐ The demand side is unable to tell the product and service quality of suppliers

☐ The demand side is not willing to sign long term contracts

☐ Challenges in agreeing on the desired energy savings by contract

☐ Difficulty in financing projects and poorly functioning funding platforms

☐ Others

III. Environmental Factors:

☐ Limited space in existing buildings hinders the installation of certain technologies such as thermal storage technology

☐ Limited power distribution capacity in existing buildings hinders installation of technology with high power demand such as heat pumps

☐ Poor condition of existing equipment results in excessive retrofitting costs or unsatisfying retrofitting effect

☐ Safety and other mandatory requirements hinder the implementation of certain technologies

☐ Others

**8. How much energy savings can large public buildings achieve?**

☐ < 10% ☐ 10-20% ☐ 20-30% ☐ > 30% ☐ Other:____________%

**9. The average cost of your equipment/service for saving one tonne of standard coal equivalent is __ yuan.**

**10. Which of the following factors can most contribute to energy efficiency improvements in large public buildings? (Multiple choice)**

☐ Technology advancement ☐ Policy improvements ☐ Better business model

☐ Better awareness of energy efficiency ☐ Others_____________

**11. (Only asked to Chinese participants) Are you willing to choose foreign brand products or technical services for energy saving retrofitting:**

☐ Yes ☐ No

**12. (Only asked to Chinese participants) Why do you chose foreign brands (multiple choice):**

☐ Brand recognition ☐ Advanced technology ☐ Cost-effective ☐ Owner's suggestion ☐ Other

**13. (Only asked to Chinese participants) Why do you not chose foreign brands (multiple choice):**

☐ No significant advantage in technology level ☐ Cost

☐ Little understanding of foreign brands ☐ Other

Website

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www.energypartnership.cn