# Organic Renewal of Urban Buildings in China Driven by Green Development

Johnson Controls

## Introduction

In the era of reform and opening, China has experienced accelerated urbanization alongside rapid economic development. According to data released by the National Bureau of Statistics, China's percentage of permanent urban residents grew from 17.92% at the beginning of reform and opening to 59.58% in 2018, and while the total urban population has increased by 4.8 times[1]. 18th National Congress of the Communist Party of China announced a "new urbanization" strategy, giving this process a new momentum. In the 2020s, China's urbanization is shifting towards a people-first focus that balances scale and quality. This transition poses new challenges for current models of urban development.

The new urban population has increased energy consumption, and current city development models create unnecessary pressure on energy resources. In 2016, China's urban areas consumed up to 85% of the country's total energy consumption, nearly 16 percentage points higher than the global average. As the primary setting of work and everyday life, buildings are the heaviest contributors to urban energy consumption.

In recent years, governments and industry players have forged a new consensus that places intensive, smart and low-carbon practices at the core of sustainable development. As a result, new requirements and standards for the new urbanization strategy have

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[1]National Bureau of Statistics: Series Report on the Achievements in Economic and Social Development at the 70th Anniversary of the Founding of the People's Republic of China (II), [July 8, 2019], http://www.xinhuanet.com/politics/2019-07/09/c_1124729131.htm

emerged. Efficient resource utilization and green upgrading of urban agglomerations are key components of this. As the introduction of new policies supporting these objectives speeds up, the need to explore green, low-carbon city renewal grows stronger.

Johnson Controls has led the world in building equipment since 1885 and is now a world-leading provider of innovative solutions for smart buildings. Since entering China 30 years ago, Johnson Controls has been committed to the promotion of energy efficiency for industrial buildings. Johnson Controls now provides full-cycle services from energy-efficient retrofit design to efficient operations maintenance for a diverse range of buildings and facilities, including office buildings, hospitals, schools, airports and commercial complexes, to support the green development of Chinese cities.

Based on its successful and practical experience in China and the rest of the world, Johnson Controls has developed an operable and universal proposal of "**organic city building renewal in China**". Using the **energy-saving retrofitting of existing buildings** as its starting point, the proposal aims to promote green development and accelerate the high-quality transformation of Chinese cities.

In this report, Johnson Controls will analyze China's current urbanization and introduce global experiences of city building renewal. Based on its extensive industry experience Johnson Controls puts forward the following three policy suggestions for the promotion of organic city building renewal in China.

1. Promote the use of technologies including Internet of Things (IoT) and cloud computing in energy-efficient building retrofitting, advancing the digitalization and agile transformation of cities;

2. Expand existing industry standards for building renewal beyond result standardization to process standardization;

3. Introduce policies that encourage the development of the energy performance contracting (EPC) model, and expand related multi-party cooperation.

## I. Organic renewal of urban buildings driven by energy-saving retrofitting

### (I) Proposal background

The developmental model of large-scale demolition and reconstruction used in China's early urbanization is out of date. It is no longer applicable to the technological and environmental requirements of the modern era, as it goes against the concept and needs of green development. At the same time, the economic and practical feasibility of the model has diminished as China's urbanization has advanced. The demolition and reconstruction process would incur huge costs, not limited to the relocation of building users and businesses, waste disposal, and significant carbon emissions.

China's urbanization enjoys a shorter history and the cities are therefore younger than their foreign counterparts, which were often built over a century ago. Renewing buildings in China have different requirements – problems are rooted less in physical aging, but rather functional deficiency and energy inefficiency. At present, the average design life span for the main body of a building is over 60 years, but energy-consuming systems have shorter service lives. For example, heating, ventilation, and air conditioning (HVAC) systems lose energy-efficiency over 15 to 20 years. However, high maintenance costs and upgraded energy-saving standards have sped up the pace of equipment upgrade and replacement.

In 1989, leading Chinese architect Wu Liangyong proposed the “organic renewal” theory for city development[2]. He argued that a city can be understood as a living organism, with all of its parts - the city itself and its individual buildings - organically connected and coexisting in harmony. In this sense, urban construction should conform to the internal order and law of the city as an organism. During renewal, it is necessary to properly consider the relationship between present and future based on intended alterations and requirements. Such an approach allows for city renewal based on sustainable development, improving the overall quality of the city.

Just as buildings are part and parcel of a city, the equipment, systems, management platforms and occupants are all part and parcel of buildings. The theory of “organic renewal” is therefore also applicable to the practice of building retrofitting. Like city renewal, building retrofitting needs not only to respect the connections and interactions between the organic parts of each building but also to adapt to each building’s internal logic and laws of development. Johnson Controls believes that, instead of demolition and reconstruction, organic renewal of existing buildings to improve energy efficiency is the most effective way to implement urban green development, thus giving birth to a new era of urban development. Such a new era is already emerging in cities worldwide.

## (II) Global organic building renewal practice: The Empire State Building in New York City

According to data from the C40 Cities Climate Leadership Group (C40), carbon emissions from buildings account for above 30% of annual city emissions. In developed cities, such as London, the proportion of carbon emissions from buildings can reach 80%.

[2] Wu Liangyong (1989), Way to Renew Residential Areas in Old Beijing – Organic Renewal of Urban Cells and Exploration of “New Siheyuan”, *Architectural Journal*, 7, pp.7-14.

By focusing on city buildings as a bottleneck for emission-reduction breakthroughs, countries have widely adopted energy-saving retrofitting to boost sustainable urban transformation.

| City | Country | Transportation | Waste | Residential Buildings | Commercial Buildings |
|---|---|---|---|---|---|
| Buenos Aires | Argentina | 38% | 6% | 38% | 18% |
| Rio de Janeiro | Brazil | 49% | 19% | 7% | 3% |
| Johannesburg | South Africa | 31% | 37% | 31% | - |
| Berlin | Germany | 17% | 6% | 50% | (Commercial and Residential Buildings) |
| London | United Kingdom | 21% | - | 37% | 42% |
| Seoul | Republic of Korea | - | 5% | 15% | 26% |
| Tokyo | Japan | 20% | 13% | 28% | 36% |
| Paris | France | 50% | 1% | 23% | (Commercial and Residential Buildings) |
| New York | United States | 21% | 5% | 74% | (Commercial and Residential Buildings) |
| Los Angeles | United States | 37% | - | 9% | 13% |

Picture 1: Carbon Emission by Sectors of C40 Countries[3]

In 2013, the Empire State Building's energy retrofitting project became a pioneer and model for urban building renewal. Constructed in 1931, the 102-story skyscraper on Manhattan's Fifth Avenue long held the record of the tallest skyscraper in the world. Despite the building's status as a symbol of American urban culture, its aging facilities and excessive energy consumption had prompted a significant number of occupant complaints.

In 2008, the Empire State Building began working with Johnson Controls, Jones Lang LaSalle(JLL), the Clinton Climate Initiative, the New York State Energy Research and Development Authority among other public and private institutions to establish an upgrade plan for the repositioning and utilization of the skyscraper. To maintain its appearance and function, the energy-efficiency retrofit was launched with an investment

[3]GHG Interactive Dashboard Data 2017. London, UK: C40 Cities Climate Leadership Group. https://www.c40knowledgehub.org/s/article/C40-cities-greenhouse-gas-emissions-interactive-dashboard?language=en_US

of around CNY 35 million. A three-step strategy was adopted to complete the overall retrofit.

**Step 1**: Johnson Controls carried out an energy-consumption assessment. The findings were used to develop a reasonable energy-saving target and retrofitting plan based on the needs of owners and occupants. Based on this plan, the feasibility, economic and ROI cycle of the project was then fully communicated with investors, and adjustments were made according to their expectations and budget.

**Step 2**: Johnson Controls executed the construction portion of the retrofit plan by batch, step and area, minimizing the impact on occupants and visitors while maximizing efficiency and cost performance. Building hardware was updated with thermal insulation materials, including the replacement and upgrading of primary energy-deficient equipment. A smart building management and control system was installed to improve the comprehensive and synergetic energy management of the building, collecting data indicators that can support real-time control and regulation of the building's energy use.

**Step 3**: Johnson Controls maintained efficient operations maintenance, digital platforms, and tenant-coordinated space and building energy management to ensure that long-term energy efficiency targets were achieved.

Picture 2: Energy-saving Retrofit of External Structure

Picture 3: Intelligent Upgrade of Internal System

The renewal project enabled the Empire State Building to reduce energy consumption by 38.4%, decrease annual energy costs by CNY 30 million, and cut annual carbon emissions by 105,000 tons, a reduction equivalent to 20,000 fewer cars in New York each year. The spillover effects of the retrofit project were also obvious as it became a replicable business model strongly demonstrating the benefits of energy-saving. Such models can effectively motivate tenants and building stakeholders across the country and the world to carry out and promote green renewal projects.

The Empire State Building renewal project proves the technical and economic feasibility of renewing large, aging buildings. Through its reasonable investment costs and demonstrable benefits, the project created a replicable model for organic renewal that has now been applied in over 4 million commercial buildings in the United States.

## II. Challenges and solutions for China's urban building renewal

### (I) Solid demand on urban building renewal

In 2016, buildings contributed almost 20% of China's total primary energy consumption, and 25% of China's greenhouse gas emissions. Air conditioning and heating usage were responsible for the majority of this energy use, with air conditioning alone around 50%. As large and medium-sized public buildings increase in number, and the Chinese urban quality of life improves, energy consumption is increasing, expanding the amount of wasted energy. Large public buildings occupy less than 4% of urban areas but contribute over 20% of total building energy consumption 10-20 times more than residential buildings[4].

[4]Building Energy Conservation Research Center, Tsinghua University, Annual Development Report on Building Energy Efficiency in China (2018), [April 1, 2018], Beijing, China Architecture & Building Press.

Take Shanghai as an example, the city's building energy consumption is increasing at an annual rate of approximately 6%. Against the backdrop of rapid development in the modern service and construction industries, surging demand for public buildings and limited land resources, renewal and upgrade of existing buildings through energy-efficient retrofitting is necessary to achieve macro-level goals of green development.

To better understand the inefficient energy use of Chinese city buildings, in 2019 Johnson Controls conducted a research survey targeting three major stakeholder groups: property owners, property operators, and property reconstruction & optimization service providers. Receiving 275 replies, the survey identified six major challenges that building renewal faces in China.

### Six Major Challenges to Organic Renewal of City Buildings

**Challenge 1:**
**There is an urgent need for retrofit.**
Enterprises are dissatisfied with a building's current energy consumption due to high operating costs, and their equipment is aged and prone to failure. Urgent upgrades are therefore required.

**Challenge 2:**
**Economic obstacles are obvious.**
Energy-saving retrofitting requires significant investment and has a long cycle for ROI. It can also be difficult to quantify new energy efficiency. Enterprises therefore worry about not being able to recover costs.

**Challenge 3:**
**Incentive policies require stronger promotion**
There is an urgent need for the promotion of government incentive policies for energy-saving retrofit projects. Policy implementation thresholds are high and application processes are complex.

**Challenge 4:**
**Energy consumption cannot be diagnosed.**
The origins of energy inefficiency cannot be identified, and energy consumption cannot be diagnosed with existing software and hardware.

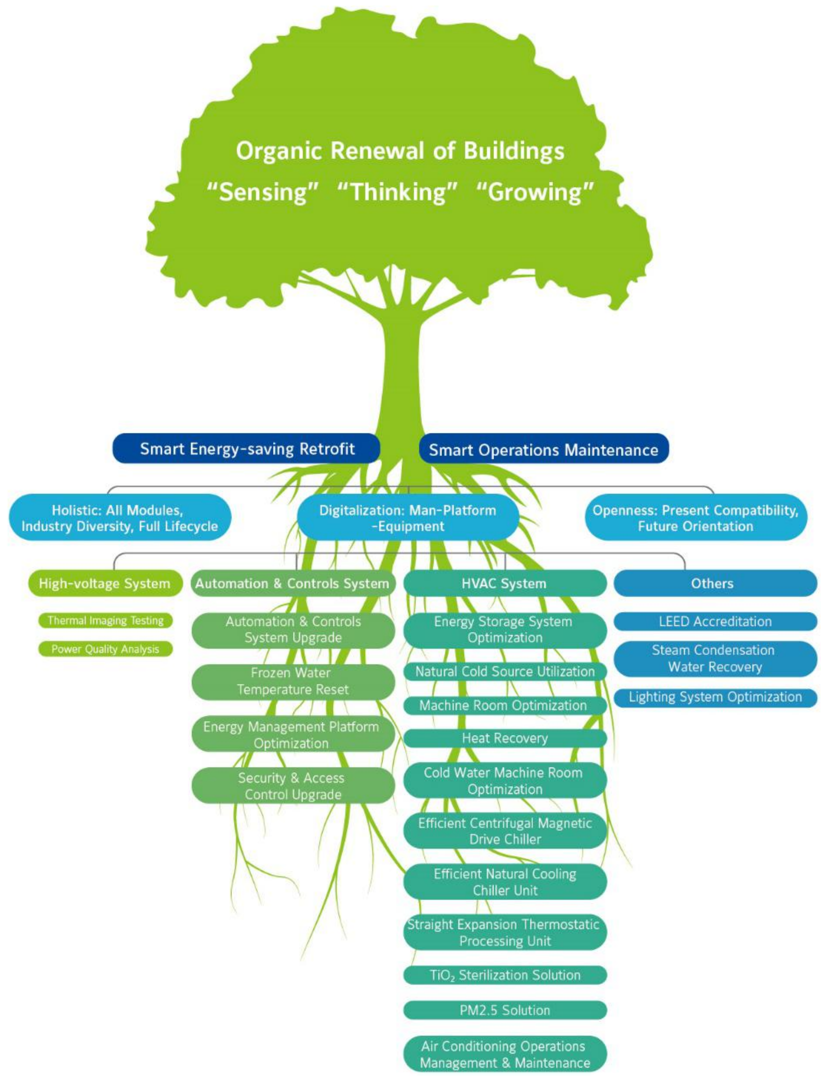
**Challenge 5:**
**Energy inefficiency problems are wide-ranging.**
As building energy management is a complex issue with many parts, upgrade and energy efficiency needs cannot be met by simple equipment replacement.

**Challenge 6:**
**Post-retrofit services are required.**
Post-retrofit installation, debugging, continuous optimization, and support for maintenance of building facilities and systems are implemented over the long term, raising concerns about the final energy-saving effects and after services.

## (II) Solutions

Johnson Controls has responded to and resolved these six challenges through its “organic renewal of city buildings” model. The core of our city building renewal practice is the development of feasible plans for future buildings and urban development.

Energy-saving retrofitting projects should have three characteristics. They should be holistic, smart and digital, and compatible and open. Projects must take into consideration existing hardware and current software resources, using technological development to achieve sustainable improvements in building energy efficiency. Through such practices, city buildings can become organisms that “sense”, “think” and “grow”.




Picture 4: Schematic Diagram of Building Organic Renewal Model

## 1. Holistic approach: Focus on the building's full lifecycle

Building renewal should take a holistic view that considers all building systems and modules while coordinating the mobilization of existing resources to comprehensively improve energy efficiency. Following the retrofit, building occupants should be able to communicate with internal equipment through software platforms. This process can better realize the positive integration of man, platform and equipment.

An organic renewal plan should also begin from the full lifecycle of the building and its equipment. It should identify breakthrough points for energy-saving and incorporate energy-saving targets into the retrofit design. Following the retrofit, buildings can achieve long-term improvements in energy efficiency through continuous operations maintenance, technical services and real-time optimization of energy management strategies.

**2. Digitalization: a smart, simple people-oriented approach**

Digitalization refers to the widespread adoption of industrial IoT, cloud computing and artificial intelligence (AI) by the contemporary construction industry. However, digitalization is not the fundamental purpose of organic building renewal. Instead, the omni-directional approach of digitalization can improve energy efficiency by enhancing user ability to monitor energy usage through simple, intuitive interfaces.

Digital solutions can display transmission equipment energy use data in real-time, making energy consumption visible and quantifiable. Platforms can collect, integrate, process and analyze data from building equipment and systems, producing insights for managers that support the optimization of energy management. Digital systems can further incorporate management experience with the real-time optimization of equipment and system operations in response to the ground situations.

**3. Open: open to expansion and compatible with future platforms**

Organic renewal plans should also meet the needs for horizontal expansion of equipment and systems, alongside the vertical development of technology. Designs for improvement of energy efficiency must be compatible with existing equipment and solutions from different suppliers, while avoiding waste of existing resources. Organic renewal plans must also consider the future. The ability to incorporate larger-scale equipment and the absorption of new technologies is important as enterprises scale-up their buildings' operations.

## III. Policy Suggestions

Johnson Controls proposes the following three suggestions based on organic renewal theory. We believe that these suggestions can drive green urbanization development and upgrade, and promote the vision of "sensing", "thinking" and "growing" buildings in China.

### (I) Use 5G, IoT and cloud computing technologies to realize digital building upgrades and promote the smart transition of Chinese cities towards universal access

The rapid development of 5G, IoT and cloud computing technologies has created new opportunities for upgrade and transformation across different industries and application areas. These new technologies should be applied to specific industries to resolve specific issues, thus creating social value. Digital renewal plans add a nervous system to each building, synergizing individual units and connecting single buildings to the "Internet of Everything (IoE)" ecology.

Digital building renewal is an important component of smart city development, as digitization can help fulfill energy conservation commitments for renewal projects. For city governments, smart buildings can be a strategic foothold in an integrated urban energy-saving system. The successful installation of digital upgrades can also affect other key areas (including smart healthcare, transportation and security), becoming referential experiences that advance the all-round transition towards smart cities.

With building digital renewal as an example, we list the practical principles and unique advantages of this approach as follows:

**1. Visualize and quantify energy-saving effects**

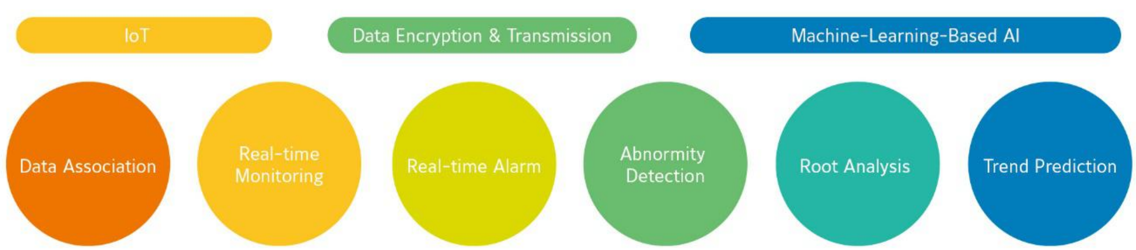
By collecting, analyzing and presenting energy consumption data, digital systems enable users to access a clear picture of building energy performance. The comparative analysis of equipment operations before and after the retrofit quantifies energy-saving results. Building users can also provide feedback on energy-saving effects, promoting adjustments and improvements to the retrofit that ensure long-term energy-saving.

Johnson Control's Structure Energy Efficiency Dashboard (SEED) is a prime example of this. The SEED collects real-time data on building energy consumption (including power consumption, gas consumption, water consumption, cooling and heating capacity) and automatically provides energy consumption reports, trend analysis, and consumption rankings, among other results. It further presents the energy consumption status and indicators of buildings and equipment through multi-angle analysis and visual presentation. In addition, it offers a before-and-after comparison of building equipment, calculating energy and costs saved. These features ensure that users can optimize energy-saving solutions in real-time in accordance with their targets, better-achieving energy conservation and cost reduction.


Picture 5: Working Interface of Structure Energy Efficiency Dashboard

## 2. Save manpower and improve efficiency and accuracy

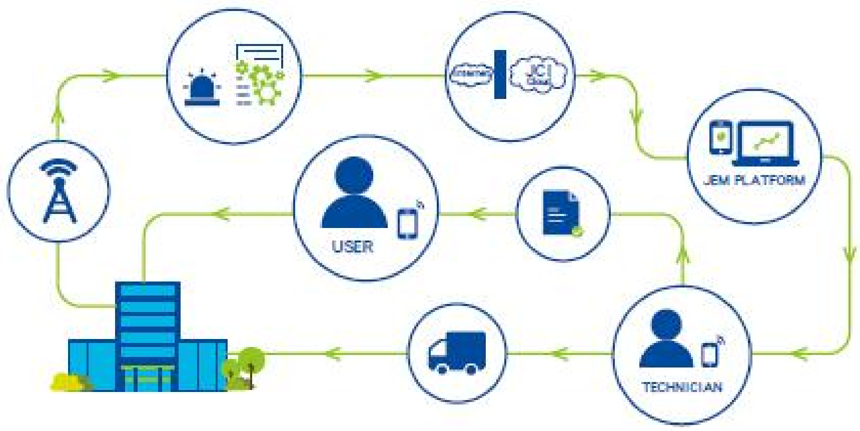
Cloud-based smart building energy management systems support remote equipment monitoring, improving communication and execution efficiency. Together with AI technology, such systems help complete energy-saving operations through pre-programmed modes. Smart automation and control systems also incorporate best practices in building energy management, allowing users to transfer manual operation experience into implementable management strategies. Overall, these systems improve operations accuracy and reduce the risk of human error in judgment and execution.




Picture 6: Operation Mechanism of Digital Building Energy Management System

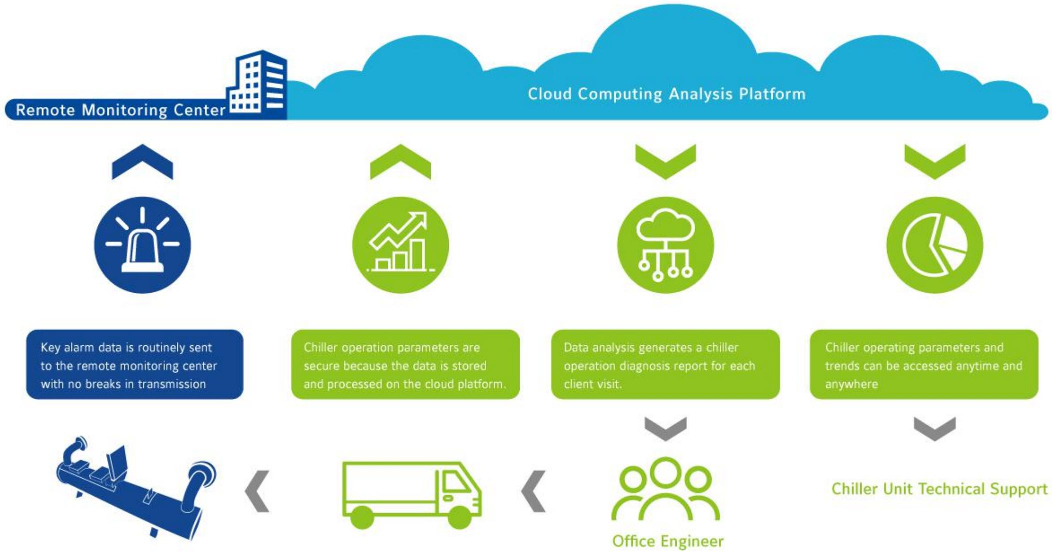
### 3. Dynamic adjustment and optimization of equipment operations

Smart systems continuously monitor and analyze environmental data. With this data, they optimize real-time operations based on the control logic of different equipment and modules, facilitating the achievement of energy efficiency objectives.




Picture 7: Digital Man-Platform-Equipment Organic Interaction Mechanism

Take chiller units as an example. As the heart of the HVAC system, chiller units play a key role in ensuring comfort and productivity. Data from the units transmitted through the internet makes real-time management possible. Building managers and operations maintenance personnel can assess operating status and parameters at all times, allowing them to smoothly diagnose problems, analyze trends and take proactive protection measures in advance. Johnson Control's smart-connected chiller unit reduces abnormal downtime by 66%, saving substantial labor costs otherwise incurred from equipment repairs and equipment failure.




Picture 8: Operation Mechanism of Cloud-based Remote Smart Connected Chiller Unit

In its triple identity as an investor, manager and practitioner, the government plays an irreplaceable role in promoting the digital renewal of buildings.

**As an investor**: Central and local government efforts to accelerate the construction and improvement of basic networks and infrastructure inter-connectivity provides a material basis for adding smart systems to existing buildings and achieving remote man-equipment interconnections. The widening adoption of 5G networks and technology can effectively facilitate the ecological formation of smart buildings and communities, enabling the application of digital energy-saving beyond the workplace.

**As a manager**: Central and local governments should adhere to concepts of openness and flexible supervision, and organize information silos between buildings, enterprises, industries, and regions. The data generated by IoT systems can subsequently be fully collected and analyzed as a database for machine learning, serving as a foundation for energy management and best practice adoption in building renewal and efficiency upgrades.

**As practitioner**: Local governments can approve demonstration projects and implement relevant policies to create higher market demand and recognition for energy-saving retrofitting of city buildings. Local governments can also use public-private-partnerships (PPP) to purchase energy-saving retrofit projects for local public buildings, thus incentivizing private sector participation in building renewal and urban green development.

**(II) Expand existing building renewal standards from result standardization to process standardization**

China's existing building renewal standards mainly center on the results of energy-saving retrofits of buildings. Industry guides including *Technical specification for energy efficiency retrofitting of existing residential buildings* (JGJ/T129-2012) [5] and *Guidelines on Verification of Energy Conservation of Public Buildings*[6] provide compliance parameters for post-retrofit energy efficiency, but lack standardized guidance for the project implementation process.

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[5]Ministry of Housing and Urban-Rural Construction (2012), including Technical specification for energy efficiency retrofitting of existing residential buildings (JGJ/T129-2012), http://www.mohurd.gov.cn/wjfb/201301/t20130106_212475.html.

[6]Ministry of Housing and Urban-Rural Construction (2017), and Guidelines on Verification of Energy Conservation of Public Buildings, http://www.mohurd.gov.cn/wjfb/201707/W020170727111040.doc.

The professionalism and quality of building renewal project services vary. Unqualified final parameters and subsequent needs for rework can cause additional costs and waste. A lack of thorough planning in the early stages is a major factor in increasing costs from partial modification and correction.

We suggest that relevant government authorities and industry associations supplement existing standards and produce **project implementation guides covering the full lifecycle and modules of buildings**. Such guides can refine processes and ensure energy efficiency for renewal projects, while reducing manpower, waste of material resources, and post-delivery operational risks.

Johnson Controls has summarized a proven project implementation process from its experiences in hundreds of successful building renewal projects for reference and professional discussion. To effectively prevent any omission in a building energy retrofit project, from planning to implementation, this implementation proceeds along two lines: one based on the full lifecycle of buildings, and the other based on energy-consuming units within buildings.


Picture 9: Project Implementation Process Covering Full Lifecycle and All Modules of Buildings

**1. Organic renewal based on full building lifecycle**

At each step of the process of retrofit design, feedback and adjustment, there should be aware of energy efficiency. It is also necessary to understand the sources of energy inefficiency through detailed audits and realize long-term energy-saving commitments through continuous maintenance of smart operations.

**Before Renewal**: Pre-renewal activities can be divided into two areas. The first is the evaluation and diagnosis of existing equipment based on energy audit results. This helps confirm the feasibility and cost of the retrofit, including LEED accreditation and energy-saving building standards for the renewal plan. The second is an analysis of the building's life stage and the operating duration of its equipment. This helps set energy-saving indicators and targets for the retrofit. The enterprise or building operator is thereby guided to consider energy-saving retrofitting in a planned way that ensures efficient allocation of existing capital and human resources, and ultimately, maximization of economic benefits.

**During Renewal**: Building facilities and systems are upgraded as necessary. Important measures can include adding variable frequency drives or waste heat recovery systems, making full use of natural cooling resources, and the optimization of control logic. Data from high and low-voltage power facilities is concentrated through the energy management platform for the convenience of management and use.

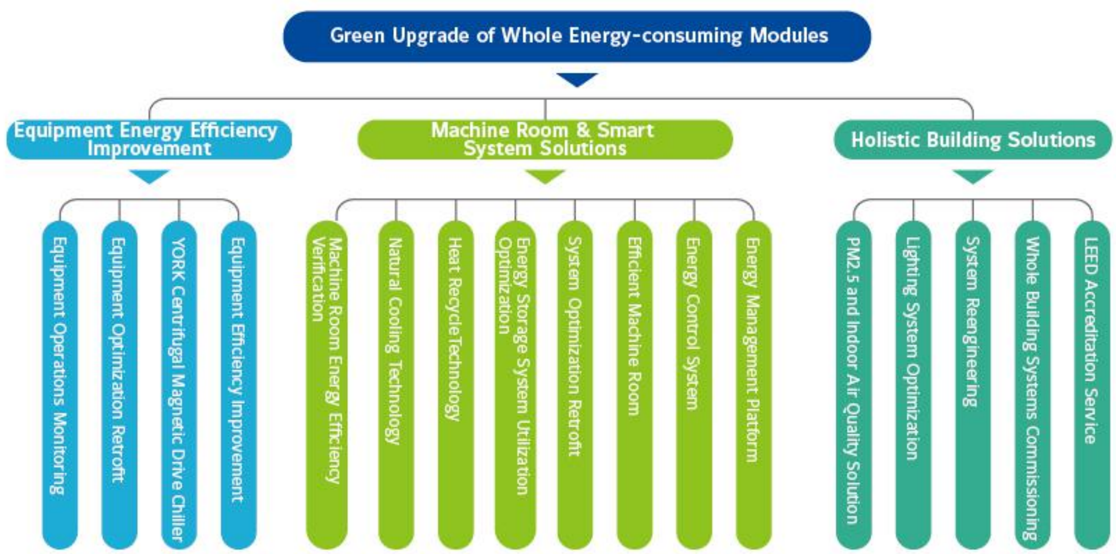
**After Renewal**: Energy-saving is quantified and presented through the management platform. If energy-saving does not meet requirements, systems can be readjusted and optimized to ensure the full effectiveness of EPC services for users.

The building plan's service solutions can guarantee successful project implementation and achievement of energy-saving effects.


Picture 10: Schematic Diagram of Building Lifecycle-based Renewal Project

**2. Organic renewal based on whole energy-consuming modules**

Organic building renewal uses holistic methods that fully respect the history and life of each building. Previous solutions relied on energy-inefficient systems or pieces of equipment, including the upgrade of components or device replacement. However, energy inefficiency does not have a single cause. Building equipment comprises an entire system with overlapping relationships. Organic building renewal must therefore be executed holistically, covering all energy-inefficient units and the entire control module system. It must also consider the interactive relationships between pieces of equipment, proceeding from point to whole in consideration of the entire system.




Picture 11: Schematic Diagram of Energy-saving Retrofit of Whole Energy Modules

**(III) Use flexible policy measures and encouragement of multi-party cooperation to activate and innovate Energy Performance Contracting (EPC)**

Energy performance contracting (EPC) is a business model that can improve energy efficiency, reduce energy costs, alleviate investment pressure and boost energy-saving benefits. Since its introduction to China in the 1990s, EPC has greatly improved the development of domestic energy-efficient (EE) enterprises. Many EE enterprises have transitioned from simple manufacture of energy-efficient equipment towards investment in energy conservation, speeding up their development while boosting energy conservation and emission reduction. At the same time, third-party energy service companies specializing in EPC have emerged, adapting EPC to China's domestic energy environment. However, the development of this model now faces a bottleneck.

Controversy remains over the energy-saving effects and benefits of some building retrofits. Common problems include a limited guarantee of return on investment, a lack of financial support policies, and inflexible measurement standards for tax relief. These obstacles have prevented the further popularization of EPC in China's building energy retrofit market. At the same time, some EPC practitioners have bucked the trend through model innovation.

Together with Guolian Group, Industrial Bank and the Wuxi Metro, Johnson Controls established the joint venture Guolian Johnson Controls Green Technology. Through the joint efforts of its parent collaborators, Guolian Johnson has developed a successful model of "building energy-saving retrofit benefit sharing" + "efficient trusteeship of building energy systems". With this model, it has completed dozens of EPC projects, serving a total area of 1.5 million square meters. These projects have earned over CNY 2 billion in energy service income and helped make annual energy savings equivalent to over 30,000 tons of coal.

One of Guolian Johnson's most successful EPC model projects was an energy-saving retrofit of Three on the Bund in Shanghai. Following its completion in 2019, it generated considerable energy-saving benefits and received the ESCO Committee of China Energy Conservation Association (EMCA)'s **2019 Excellent Demonstration Project**. Guolian

Johnson's success in EPC projects demonstrates the promise of EPC model innovations in the Chinese market.

Based on the success of this joint venture and the challenges encountered by Guolian Johnson in business development, we propose the following suggestions for the government to enhance EPC innovation and promotion in China.

**1. Encourage innovative forms of cooperation in which multiple parties are involved and risks and benefits are shared**: Parties with professional backgrounds, including technology and financial service providers, should be involved in EPC project design and execution. Building renewal service providers can utilize their technology and experience to increase user demand for energy efficiency. After project completion, technology providers can provide continuous operations maintenance services for energy facilities and equipment, and reduce disputes over energy efficiency through contracts for energy use indicators.

Generally, EPC companies obtain project loans by mortgaging assets and future rights to income, weakening their overall financial capacity. EPC requires high levels of investment for gradual returns, so flexible financial services are necessary to lower transaction costs, and an innovative investment risk-sharing framework and standardized investment terms are required to break bottlenecks in project financing and investment.

Using Guolian Johnson as an example, Guolian Group plays a fundamental role as a state-owned enterprise. It finances the joint venture's operations and participates in the implementation of engineering projects, ensuring that the company can operate stably while Johnson Controls advances world-leading energy technology and products. Local engineers provide long-term operations maintenance support and training services that ensure the achievement of energy efficiency targets. Industrial Bank provides lines of credit and support using its financial service expertise and experience.

EPC’s success is also helped by innovative energy investment. Guolian Johnson designs and plans the building renewal and completes the investment required for each project. It is also responsible for the results of the energy renewal, addressing owner concerns about the costs and benefits of renewal and supporting more aggressive upgrades. Following the completed renewal, Guolian owns the renewed equipment and systems. However, after a limited, pre-agreed period, it transfers ownership to the client at a low price and rescinds energy-sharing profits, enabling the client to achieve profitability and energy conservation.

**2. Use laws and policies to regulate market order and systematically optimize the bidding process:** The maintenance of good market order can encourage EPC stakeholders to invest in building renewal. The market order can be advanced through improvements to the existing legal framework, increased penalties for breaches of contract, and protection of the interests of building owners and energy retrofitting service providers in obtaining project funding or meeting energy-saving targets.

Under current industry bidding procedures, EPC enterprises are required to adopt the same technical proposal for simultaneous bidding on the same project. To support further innovation of the EPC model and related technology, the government should transition towards encouraging differentiated competition in the EPC market and diversified ROI portfolios. Furthermore, bidding processes for state-funded projects are often lengthy, affecting the implementation processes of city renewal and large-scale energy efficiency upgrade projects. The government can address this issue through simplification of the bidding process, or enhanced negotiation for project implementation.

Enthusiasm and motivation for further innovations in EPC project implementation can be enhanced through several measures. These include effective regulation of market order, encouragement of differentiated competition, simplification of bidding processes, and other policy drivers.

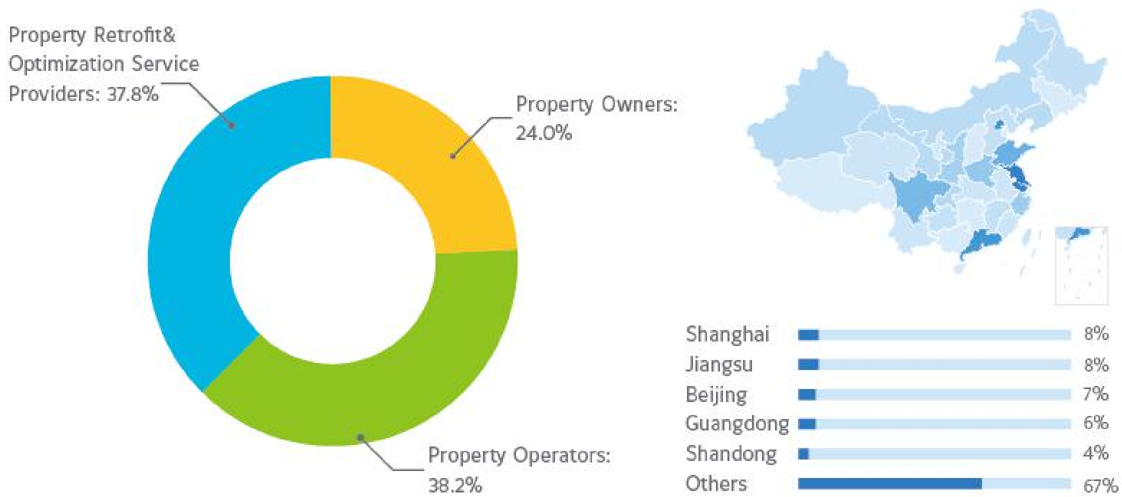
**3. Provide greater flexibility when assessing eligibility for government subsidies for EPC and add preferential financing interest rates as means of financial support**: We suggest that taxation and other administrative departments can judge whether EPC is effective and should meet exemption policy requirements according to its ability to realize energy efficiency while reducing burdens for service companies. We also suggest the implementation of project filing and pre-examination systems for EPC. Measures such as flexible identification procedures and audits can incentivize enterprises to innovate new EPC forms, and develop channels and methods to improve building renewal and efficiency upgrades. Due to the capital-intensive and long return cycle inherent in the EPC model, financial support requires increased preferential financing interest rates on top of existing financial and tax incentives for promoting the development of organic city renewal. Guiding support from the state in providing lower financing rates for EPC projects can greatly alleviate capital pressure and financing costs for energy retrofit and city renewal projects. This could in turn encourage energy enterprises to make larger-scale investments, realizing the quantitative and qualitative improvement of urban green development.

**Appendix:**

## A Survey Report on Building Energy Management Status in China

In 2019, a Johnson Controls research team worked with a third-party company to design a survey questionnaire targeting three major stakeholder groups: property owners, property operators and property retrofit and optimization service providers. The survey studied and analyzed existing problems in building energy management, energy-saving retrofit demand, and challenges faced in China.

The survey received a total of 275 valid responses, including 105 from property operators, 66 from property owners, and 104 from property retrofit and optimization service providers. The samples covered most Chinese provinces. Shanghai, Jiangsu and Shandong in central and eastern China, Guangdong in southern China, and Sichuan in southwestern China had the highest sample density.



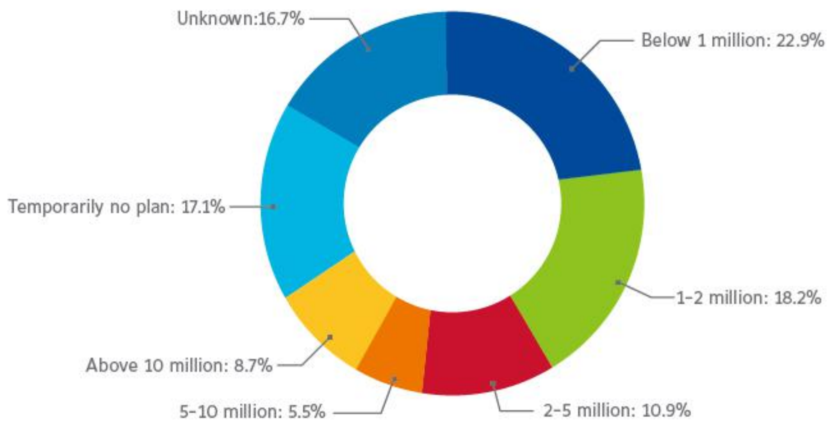

Appendix-Fig. 1 Questionnaire Survey Sampling

The data provided the research team with the following six key insights.

**Insight 1: The concept of energy-saving retrofit of buildings needs to be further promoted,**

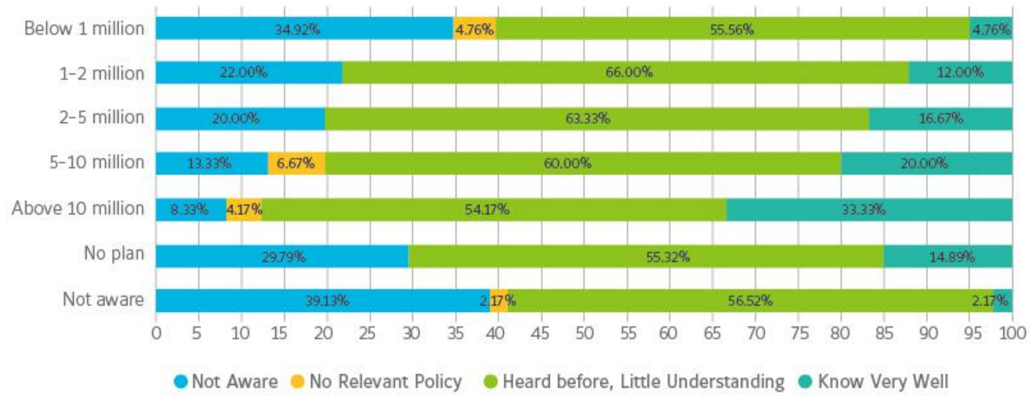
- 30% of enterprises still had no budget for energy-saving retrofits.
- Compared with building energy efficiency accreditation, promoting and popularizing relevant incentive policies could significantly enhance the willingness of enterprises to engage in building energy-saving retrofitting.

The survey found that more than 60% of enterprises have a budget for energy-saving retrofits of buildings they own or manage, and nearly 40% of enterprises have a budget of more than CNY one million. However, nearly one-third of enterprises still have no budget or plan for energy efficiency retrofitting. These enterprises are not demand-free but have not developed retrofitting plans due to a diverse range of concerns. Relevant departments should further advocate the benefits of retrofitting to these enterprises to advance energy-saving efforts.




Appendix-Fig. 2 Amount of Budget for Energy-saving Retrofit

The Chinese government currently promotes energy-saving retrofits through two main approaches. The first approach is improvements to the green building accreditation system. The second approach is the provision of fiscal incentives for enterprises to invest in energy-saving retrofits. The survey found that, compared with the promotion of building energy performance ratings, fiscal incentives have a bigger role in enhancing enthusiasm for energy efficiency retrofitting. Through cross-correlation analysis, the survey found a positive correlation between the budget set by enterprises for energy-saving retrofit and their familiarity with corresponding incentive policies. This implies that enterprises familiar with incentive policies are more likely to invest in energy-saving retrofits.

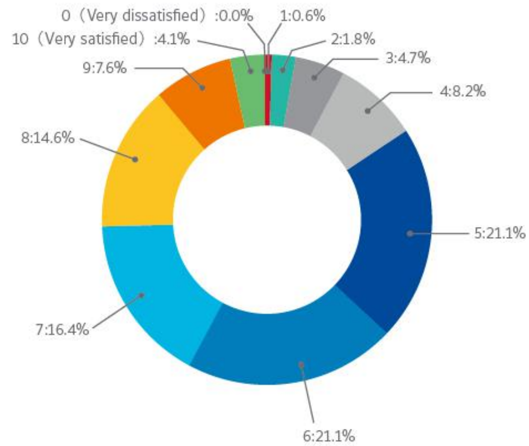



Appendix-Fig. 3 Cross Analysis of Familiarity with Incentive Policies and Retrofit Budget Amount

**Insight 2: Most enterprises are dissatisfied with their building's current energy consumption. Excessive energy consumption and energy-inefficient equipment are the main factors driving enterprises to choose energy-saving retrofits.**

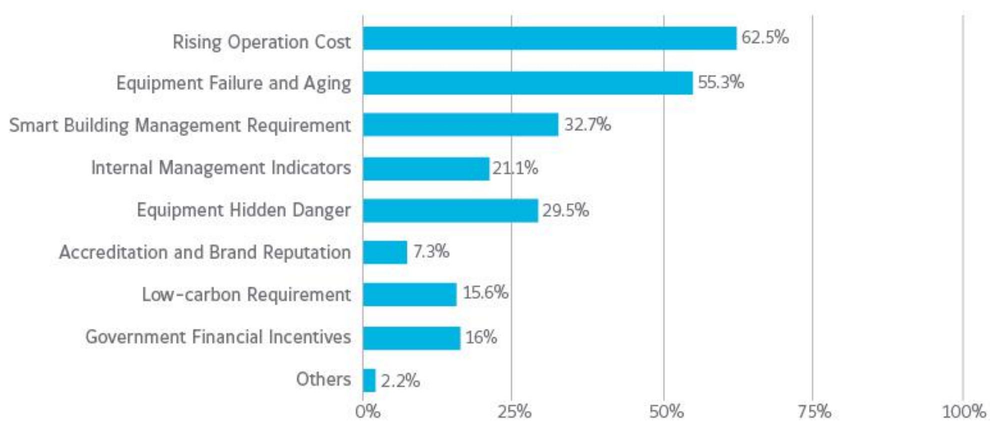
- Most enterprises are dissatisfied with their building's energy consumption, with an average satisfaction score of only 6.22.
- Rising operating costs and energy-inefficient equipment were the two main factors driving enterprises to choose energy-saving retrofits.

Less than 5% of enterprises were very satisfied with their building's energy management. Most enterprises were dissatisfied with their building's energy management, and more than 50% only gave passing or low scores. The average score of 6.22 (out of 10) shows a low level of satisfaction in current building energy management.




Appendix-Fig. 4 Distribution of Scores for Satisfaction with Current Building Energy Consumption Status

Lower levels of satisfaction with energy efficiency management propelled enterprises to seek corresponding energy-saving retrofit plans. Cost and hardware were the two most common drivers for enterprises, with rising operational costs and aging equipment top answers. In addition, requirements for smart building management and malfunctioning equipment were frequently cited. Helping enterprises improve operational efficiency, cut operating costs, prolong the equipment lifecycle and increase equipment benefits are the keys to designing a good energy-saving retrofit plan.



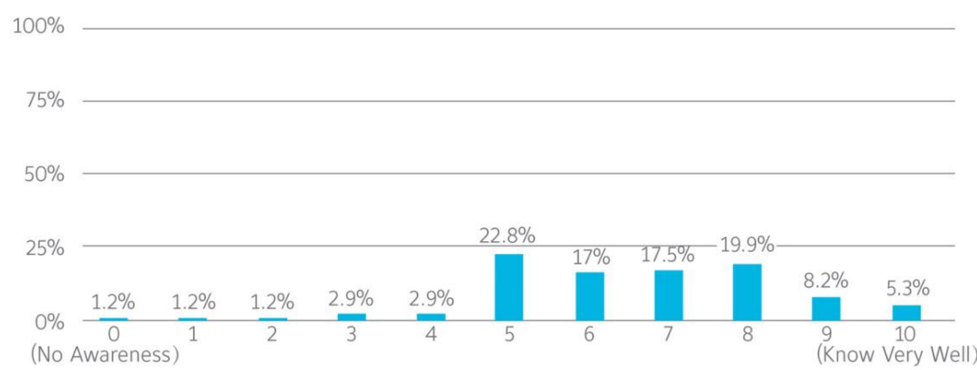

Appendix-Fig. 5 Drivers for Energy-saving Retrofit

**Insight 3: For enterprises willing to choose energy-saving retrofits, the first step is clarifying the reasons behind energy inefficiency. However, obstacles still persist.**

- Most enterprises did not know the reasons behind building inefficiency and expressed a willingness to carry out energy diagnosis and evaluation.
- Some enterprises gave up energy diagnosis and evaluation due to high costs, lack of qualified professionals and an inability to assess results.

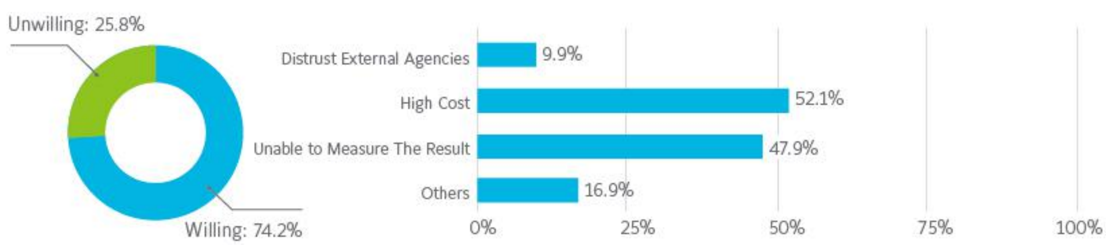
Most enterprises were dissatisfied with their current building energy management, but nearly 90% of enterprises could not identify the causes of energy inefficiency in buildings they owned or operated. Just 5% of enterprises were clear or aware of the causes of energy inefficiency.

Assisting enterprises to identify the reasons behind energy inefficiency should be the first step in promoting the energy-saving retrofit of existing buildings. When enterprises are dissatisfied with their building's energy management but unaware of the causes of energy inefficiency, they may be reluctant to sanction the large cost of an energy-saving retrofit. This can hold up efforts to retrofit existing buildings on a greater scale.




Appendix-Fig. 6 Knowledge about Causes of Building Energy Consumption

Given this problem, many energy-saving retrofit service providers have begun offering building energy performance diagnosis and evaluation services. After collecting the relevant data, they employ professional equipment and personnel to help enterprises understand the causes of energy inefficiency and subsequently design appropriate retrofitting plans. While most survey participants expressed a willingness to accept and purchase such services, one-fourth held negative opinions of such services. These enterprises lacked corresponding professionals that can measure and verify energy diagnosis results, making it difficult for them to understand the value of such evaluations. High service costs were also a factor discouraging the purchase of energy performance evaluation services.



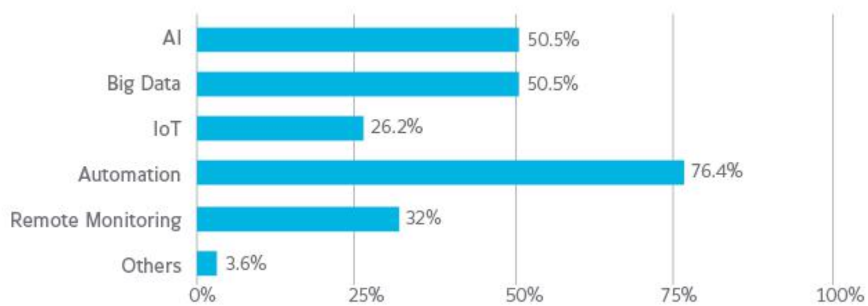

Appendix-Fig. 7 Willingness to Purchase Energy Diagnosis and Evaluation Service

**Insight 4: Building energy management requires a holistic aproach, so simply replacing hardware and equipment cannot meet the energy management needs of enterprises.**

- Problems in early-stage design, equipment, system, and personnel among other issues resulted in enterprise dissatisfaction with energy management.

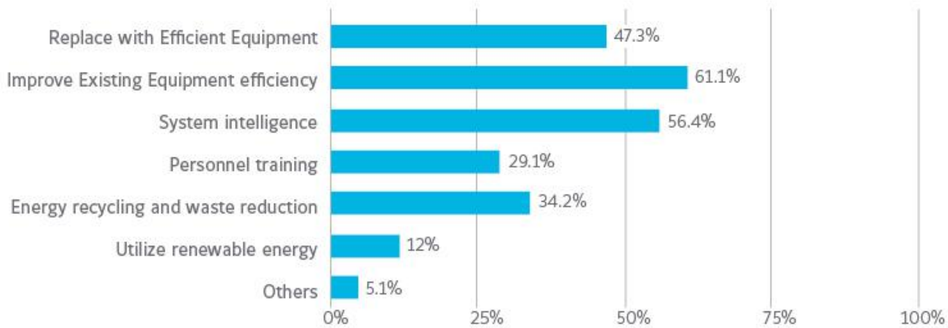
- Beyond improving existing equipment efficiency and replacing aging equipment, most enterprises considered big data and smart management systems to be the best method of improving building energy efficiency.

Insight 2 shows that equipment energy inefficiency is one of the most important drivers for enterprises when investing in an energy-saving retrofit. Improving equipment efficiency and replacing inefficient equipment are the first considerations for enterprises choosing energy retrofitting plans. However, many enterprises have realized that hardware upgrades cannot completely resolve energy inefficiency, with over 55% of enterprises believed that smart building systems are essential to resolving energy management problems.




Appendix-Fig. 8 Technical Solutions to Improve Building Energy Efficiency

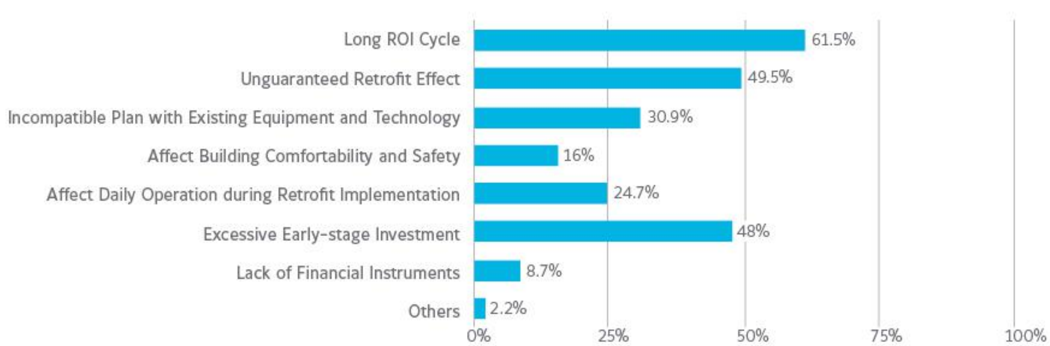
More than half of respondents believed that, in addition to smart building automation and control systems, Big Data and AI are key technologies for improving energy management. This result indicates that more enterprises are realizing that building energy management is a project requiring a holistic approach beyond the mere optimization of facilities and equipment. These enterprises understand the necessity of building automation and control systems alongside Big Data and AI technologies to ensure that equipment can realize optimum results for energy-saving.




Appendix-Fig. 9 Approaches to Improve Building Energy Efficiency

**Insight 5: Expensive investment, long ROI cycles and uncertain outcomes are the main factors discouraging enterprises from carrying out energy-saving retrofits.**

The survey found expensive required investment, prohibitively long ROI cycles and uncertain outcomes are the main factors preventing enterprises from carrying out energy-saving retrofits. Such worries are not unfounded. Investments of over a million dollars are often required, and ROI cycles can last several years. These concerns are exacerbated by the uneven quality of service providers. Even where enterprises are willing to set aside a large budget for an energy-saving retrofit, they cannot be guaranteed that providers can deliver on their desired results.

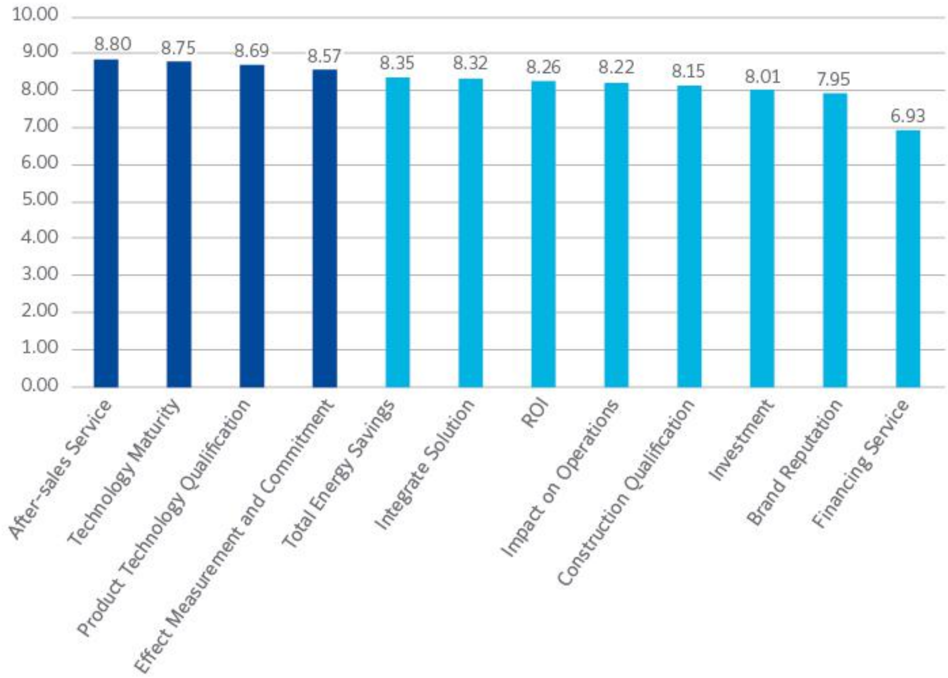



Appendix-Fig. 10 Main Factors Preventing Enterprises from Energy-saving Retrofit

**Insight 6: After deciding to retrofit, enterprises care most about a supplier's technological maturity, commitment to the final retrofitting results and follow-up services.**

Prior to the retrofit, enterprises often raise various concerns, especially regarding the required investment. However, once the decision to retrofit has been made, costs are no longer a primary factor in their assessment of a supplier and their plans. When selecting a supplier, enterprises focus more on products and the maturity of its technology, its commitment to delivering strong outcomes through the retrofit and follow up services following project completion.

Follow-up services are often the first consideration when selecting a supplier. Post-retrofit installation, debugging, optimization and operations maintenance support are required in the long-term. If energy performance fails to meet an enterprises' original targets, the supplier is responsible for adjustments until the contractually agreed level is reached. Even where targets are achieved, continuous optimization and operations maintenance support are needed for the full lifecycle of the retrofit. Enterprises are therefore more focused on the technical strength and service levels for the latter stages of a retrofit when choosing a supplier.




Appendix-Fig.11 Considerations in Choosing Energy-saving Retrofit Suppliers