Policy Roadmap to 50% Energy Reduction in Chinese Buildings by 2050

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ABSTRACT

Buildings use more energy than any other sector in the world. Total building energy consumption in China is expected to triple through 2050 as a result of increasing urbanization, improving standards of living, and economic growth. A three-year collaborative study *Reinventing Fire China: A Roadmap to China's Revolution of Energy, Production and Consumption to 2050* (Energy Research Institute et al., forthcoming) analyzed strategies to effectively reduce China's building energy consumption and carbon dioxide emissions by half at little or no cost. The strategies evaluated include use of prefabricated construction methods, integrative design and passive buildings, super-efficient appliances, smart controls, clean fuel technologies, and renewable energy. Barriers continue to limit rapid market adoption of these strategies even though China has adopted many regulatory policies including building and equipment standards and codes, building labeling programs, retrofit targets, and subsidies for both residential and commercial buildings. Innovative, cross-cutting policy solutions are needed that address multiple barriers.

This paper reviews the major barriers to adoption of cost-effective low-energy and low-emissions building designs and technologies in China, recommends policies to address multiple barriers, and presents a roadmap to achieving 50% energy reduction in Chinese buildings. The recommended policy solutions, which aim to lower energy usage while capturing the value of more efficient buildings, fall into four areas: disclosure and transparency, market forces, financing and investment, and codes and enforcement. Solutions are ranked according to their magnitude of impact and ease of implementation and identified as either "quick-win" or long-term approaches.

Introduction

Buildings use more primary energy than any other sector in the world, accounting for nearly 40% of energy-related global greenhouse gas emissions (IEA 2013). China's building energy consumption accounts for about 20% of total primary energy consumed in China;[1] in contrast, buildings in developed countries typically account for 40% of total primary energy consumption (Diamond et al. 2013). In 2010, the end-use energy consumption of China's building sector was about 546 million tons of coal equivalent (Mtce),[2] which represents approximately 771 Mtce of primary energy. Although China's building-sector energy consumption is large and has been increasing rapidly, energy intensity per unit of floor space and

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[1] In this paper, "energy use" refers only to commercial energy forms and does not include biomass energy consumption.
[2] Mtce is the standard unit for energy in China. 1 Mtce = 29.27 million GJ.

per capita is far lower than in many developed countries. For example, energy use per unit of floor space in China's urban buildings in 2005 was only about 33% of the level in the United States because. This difference results part from cultural differences in energy usage patterns, including China's higher indoor temperatures in summer and lower indoor temperatures in winter (GEA 2012). Steady economic development, urbanization, and population growth are anticipated in China, so building energy and carbon dioxide (CO_2) emissions will continue to grow. Continuing the current development model that relies largely on coal will not only damage the environment and contribute to climate change, but it could also cause substantial economic loss and hamper social and economic development.

China's path forward – a path that aims to urbanize 300 million people, grow the country's economy, and substantially advance the welfare of all citizens – cannot follow the same patterns that have prevailed during the past 40 years. This paper is part of a three-year U.S.-China collaborative research effort to develop a technologically feasible, economically viable, transformative pathway for China's buildings sector. This research effort focuses on developing a comprehensive and very detailed residential and commercial building energy end-use model that can distinguish among China's three major climate zones, existing and new buildings, and five different building efficiency vintages.

In this paper, we developed two distinct scenarios for evaluating potential energy and emissions reductions in the Chinese buildings sector from 2010 through 2050. In the *baseline business-as-usual (BAU) scenario*, only policies already in place by 2010 have continuing impact, and technological improvements are autonomous.[3] The *transformative scenario* represents the potential of accelerated, full adoption of four key strategies and associated technologies to save significant energy: use of passive and integrative building designs, super-efficient equipment, smart controls, and renewable and clean energy sources.

The results of this study indicate the need for significant policy changes, including the tighter building codes, a roadmap for regular code updates, and data transparency and disclosure for Chinese policy makers. The methodologies and assumptions used in the model described in this paper will be presented in a separate report along with detailed model results. This paper focuses on assessing barriers and recommending policy changes that will help to overcome these barriers and enable China to realize the full potential of adopting strategies for reducing building-sector energy use and greenhouse gas emissions.

Building Sector Development Status and Outlook

China's building sector is diverse and complex as one would expect given the country's geographic and economic diversity. Across regions, the availability of natural resources, level of economic development, and standard of living vary. For example, China's urban residential buildings in the cold northern region have central heating and meet internationally accepted standards for thermal comfort while hundreds of millions of people in the Yangtze River Valley still live in poor-quality housing with marginal comfort. Buildings in China also have relatively short lifetimes. Research has found that the average lifetime of urban Chinese buildings is 30 to 40 years; in rural areas, it is 15 years or less (Hong et al. 2016) although both are expected to increase over time. Short lifetimes result from use of inferior materials and poor quality control

[3] We assume 40% market share of today's highly efficient equipment by 2050.

in construction taking place in rapidly developing urban areas. These factors, combined with a general lack of long-term planning, mean that new buildings are not designed for high performance, and deep energy retrofits are rarely, if ever, undertaken in existing buildings.

Chinese buildings use less energy per square meter than buildings in many developed countries because of different usage patterns, which result partially from cultural norms and occupant acceptance of a larger expanded indoor temperature range than is typical in other countries. Historically, China's buildings are not automated; instead, these systems are operated during portions of the day, season, and year and thus consume less energy than continuously operating systems. However, typical buildings that comply with Chinese building codes and standards are not necessarily efficient. Envelope thermal integrity and infiltration are key problems in existing Chinese buildings, and appliance and equipment efficiency lag behind international levels. Many buildings are not metered or properly controlled. In addition, because few buildings are commissioned, it is common for buildings to consume more energy than specified in their design.

China is experiencing rapid national population growth and urbanization as well as unprecedented economic development. The urban population is expected to increase from 50% of total population in 2010 to 68% in 2030, adding 280 million people to cities; this is consistent with other international population forecasts (Zhou et al. 2014, UN 2015). In 2010, China constructed more than 2 billion square meters (m^2) of new buildings. Our stock turnover analysis (Hong et al. 2016) indicates that this rate of construction is expected to continue through 2020, averaging 2.1 billion m^2 per year over the 10-year time frame. As China's urban population increases, an average of 1.4 billion m^2 per year of new urban residential floor space will be added during the same time period, and we assume that the recent phenomenon of vacant buildings will disappear. In the future, residential energy use will continue to rise because of many factors including urbanization, growth in household income, growth in household size, and increased use of energy-consuming appliances. Commercial energy consumption is also growing as China's economic development shifts away from heavy industry to a service-oriented economy. This is driving an increase in total commercial building floor area and energy use intensity.

While the immense size and rapid growth of China's building sector is a challenge, it also presents opportunities for business initiatives to drive innovation and to realize social benefits such creating jobs, reducing pollution, and increasing living standards. The biggest opportunities lie in designing new buildings to be energy efficient and retrofitting the existing buildings that waste the most energy.

Vision and Goals for 50% Energy Reduction in Chinese Buildings

To reduce energy use by 50% by 2050, China's buildings need to become resilient and make use of the maximum available, technically feasible, cost-effective, energy-efficient technologies and renewable-energy supplies. Our economic analysis identified the best technologies available worldwide to arrive at a list of the most effective, technically feasible yet cost-effective technologies for China's buildings. Applying these technologies will produce high-quality buildings and improve occupant comfort, health, and productivity compared to current conditions. Pursuing this vision will achieve four key goals for the building sector:

Improved thermal comfort without increased energy consumption. Currently, only residential buildings in areas with district heating in China's northern cold climates meet internationally recognized indoor thermal comfort criteria during the winter. Future shifts to meet international comfort levels throughout the country will result in two- and three-fold increases in urban residential heating loads and cooling loads, respectively, under the BAU scenario.[4] Under the transformative scenario, improved thermal comfort will be achieved with no load increase due to improved building designs that incorporate passive strategies.

Urban planning, integrative design, and quality construction to reduce energy use. In the BAU scenario, rising per capita income and rising per capita residential and commercial floorspace, along with improved thermal comfort, increase building energy use. However, in the transformative scenario, planning, design, and construction strategies control building energy demand. These strategies include maximizing the use of each building and incorporating high-performance envelopes (MOHURD 2015), optimizing energy-using systems, manufacturing prefabricated buildings, and performing energy-saving retrofits on existing buildings.

Adoption of super-efficient equipment and smart management. By 2050, we assume that 100% of Chinese households and commercial buildings will use today's super-efficient appliances and equipment along with smart building systems that use sensors, controls, and analytics to increase access to performance data and facilitate intelligent building operations. Using smart systems will improve overall building energy efficiency, lower operating costs, and increase energy grid reliability.

Reliance on clean energy sources and infrastructure. The transformative pathway relies on clean energy sources and infrastructure to accelerate the move away from carbon-based fuels and associated emissions and thereby to improve air quality. This includes shifting away from heating with distributed coal systems and toward a growing share of electric heat pumps and renewable energy sources, such as biomass and solar thermal. The transformative scenario also includes installation of on-site solar photovoltaic (PV) systems on buildings and development of a distributed electricity grid.

Strategies for Reducing Energy Use in China's Building Sector

There are five strategies that, together, achieve the goal of reducing China's building energy use by 50% by 2050: using prefabricated buildings with longer lifetimes than current buildings, reducing building energy demand through integrative/passive design and retrofits, installing super-efficient equipment, employing smart systems, and switching to clean fuel sources for on-site building equipment and power generation. Successful execution of these five strategies under the transformative scenario results in annual primary energy use of buildings increasing to only 1,060 Mtce by 2050, which is 38% of the 2010 value of 770 Mtce. This contrasts with the outcome under the BAU scenario, in which 2050 primary energy would increase to 2,410 Mtce or 210% of the 2010 value. The primary energy savings for the buildings

[4] Average load increases based on urban residential load projections; actual value depends on climate zone and building type. Estimate is made by comparing China's 2050 per-capita gross domestic product (GDP) with the current Japanese per-capita GDP and estimating comfort and energy use intensity based on current Japanese data.

sector under the transformative scenario total 1,350 Mtce, as shown in Figure 1, with the largest savings resulting from integrative/passive design (440 Mtce) and super-efficient equipment/appliances (390 Mtce). Retrofitting buildings, prefabricating buildings with less materials waste, and employing smart systems contribute 150 Mtce, 130 Mtce, and 100 Mtce, respectively. Switching to clean energy sources for on-site equipment and power generation also accounts for 100 Mtce and 70 Mtce, respectively, of primary energy savings.

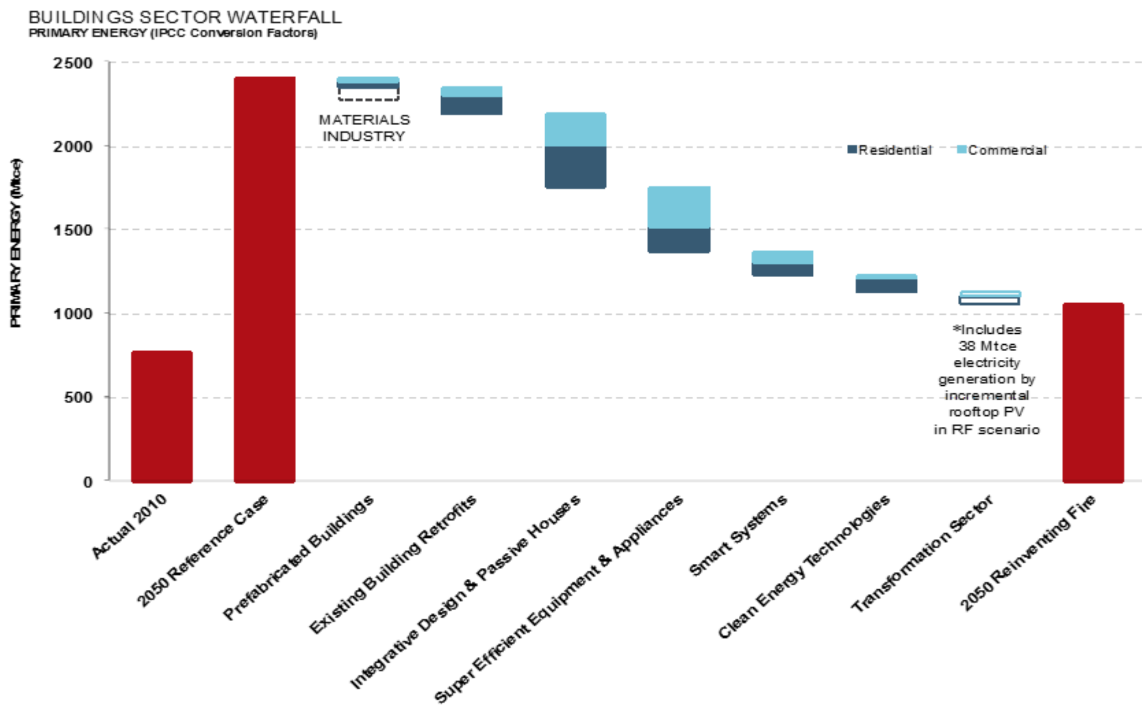

Figure 1. Potential 2050 Primary Energy Savings for the Reinventing Fire Alternative Scenario for buildings. Black dashed box indicates savings from less wasteful construction, accounted for as part of the Industry Sector. Blue outlined boxes indicate savings from cleaner power used by buildings, generated by the Transformation Sector. This figure is based on the authors' analysis.

The impact of the transformative-scenario strategies is even more pronounced on annual CO_2 emissions than on energy consumption. Under the alternative scenario, annual CO_2 emissions related to energy use in buildings are 1,050 $MtCO_2$ by 2050, which is 44% lower than the 2010 level of 1,900 $MtCO_2$. These projected emissions are 77% lower than the BAU scenario total of 4,500 $MtCO_2$ by 2050. Integrative/passive design, super-efficient equipment/appliances, and clean energy sources for on-site equipment account for the largest savings: 830 Mt CO_2, 800 Mt CO_2, and 710 Mt CO_2, respectively. Adopting clean energy sources for power generation, retrofitting buildings, and employing smart systems contribute 380 Mt CO_2, 330 Mt CO_2, and 300 Mt CO_2, respectively. Prefabrication accounts for 120 Mt CO_2, which increases to 250 $MtCO_2$ when reduction in construction material waste is considered.

Policies to Realize the Transformative Scenario in China's Building Sector

To realize the transformative scenario for Chinese buildings, policies are needed to overcome barriers to full adoption of the five strategies mentioned above (longer-life prefabricated buildings; integrative and passive design; efficient equipment; smart systems; and clean energy). Table 1 lists barriers, solutions, and metrics for each strategy. High-level metrics for measuring success at various points in time are also included.

Table 1. Barriers, Policy Solutions, and Metrics for Building Policy Focus Areas

Focus Areas	Barriers	Policy Solutions	Metrics
Longer Life /Prefabricated Buildings	• Rapid building demolition and cheap building construction • Lack of long-term urban planning • Lack of design for adaptability and flexibility	• National and local coordinated construction planning • Promotion of efficient low-waste prefabricated construction	• Rate of demolition and new construction • Percentage of prefabricated buildings
Integrative & Passive Design	• Lack of owner/developer awareness of opportunities • Non-supportive codes, lack of enforcement • Designers' and builders' lack of familiarity with methods • Upfront costs	• Stringent codes based on whole-building energy use • Legal basis for regular energy code improvements • Workforce training to reduce cost and risk • Building energy use transparency • Innovative financing mechanisms	• Residential and commercial building energy use intensity
Efficient Equipment	• Low efficiency standards and uneven enforcement • Lack of information on and consumer trust of energy label • Upfront costs	• World-class appliance standards • Increased education and awareness re: energy labeling • Energy-efficiency project financing	• Level of appliance standards • Super-efficient equipment percent market share
Smart Systems	• Historic use of inexpensive labor • Lack of skills to install and use • Distorted energy pricing and tariff structure	• Operator training in pro-active maintenance • Creation of market for demand response • Energy pricing and tariff reform	• Residential and commercial building energy use intensity • Percent share of buildings with smart meter/control and load flexibility
Clean Energy	• Upfront costs • Accessibility and availability of the resource • Lack of supportive policy on integration and tariffs	• Fuel-switching project financing • Feed-in tariff or net metering for on-site generation	• Share of biomass in rural residential, solar water heating in urban residential, heat pumps in all buildings • Percent of electricity supplied by on-site generation

These barriers and policies can be framed around major opportunity areas in different segments of the building sector. Figure 2 lists the areas and segments in order, from 1 to 4, of potential impact, with 1 indicating the largest impact. The opportunity area with the largest savings potential is construction of new low-energy-use buildings that can reduce peak electrical demand periods and incorporate the strategies of integrative and passive design, efficient equipment, and smart systems.

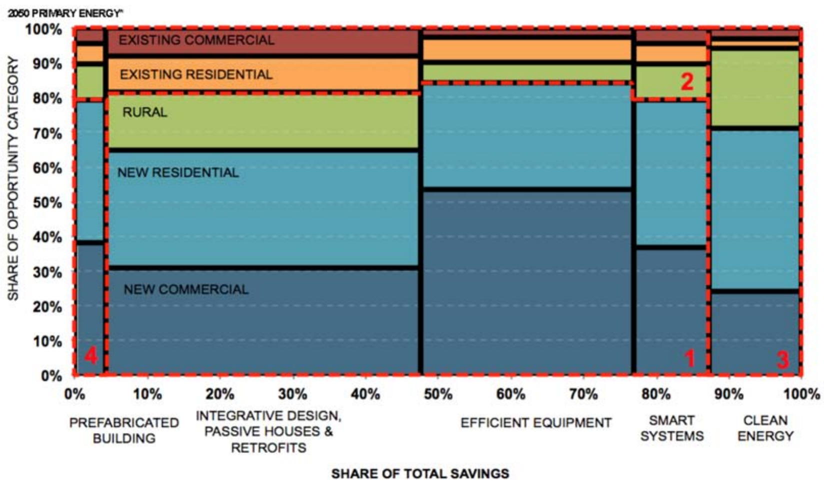

Figure 2. Building Sector Energy Savings Opportunity Share by Segment and Opportunity
This figure is based on the authors' analysis.

Roadmap

The policy roadmap for reducing China's building energy use by 50% by 2050 also aims to transform the development pattern of the building industry in both urban and rural areas. Fundamental reforms are needed in building energy consumption patterns to reduce energy consumption growth. Based on current conditions, national targets, climate change pledges, and the timeline for implementation of each of the five strategies described above, a roadmap could be implemented in three phases: short-term (2016–2020), mid-term (2020-2040), and long-term (2040–2050). Figure 3 shows a roadmap of possible goals for each of the three phases.

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		Preliminary shift in urban/ rural development; building energy-saving policies to control actual energy use		RF implementation with building ultra-low-energy building as the core		Efficient, clean and smart way of building energy use
		2010	2020	2030	2040	2050
Building Sector Outcomes	End-use energy consumption (100 million tce)	5.5	7.2	8.5	8.5	7.3
	End-use CO2 emission (100 million tons)	10.5	10.3	8.6	5.7	2.8
	Percentage of electricity consumption	22%	36%	47%	56%	66%
	Percentage of coal consumption	58%	39%	24%	12%	2%
Floor Area Control and Building Industrialization	Floor area per capita – urban（m^2/cap.）	27	32	36	41	46
	Floor area per employee – public building, service sector（m^2/cap.）	38	42	50	50	50
	Building industrialization rate – urban	0%	25%	50%	75%	100%
Integrated Design and Passive House	% of passive house – new urban residential buildings	0%	10%	27%	38%	60%
	% of nearly zero-energy building – rural residential buildings	0%	1%	12%	28%	60%
	% of ultra-low-energy building – new public buildings	0%	10%	25%	33%	60%
	Retrofit rate of urban residential/public buildings – Northern areas	2%/0%	35%	55%	67%	75%
	Retrofit rate of urban residential/public buildings – Southern and transitional areas	2%/0%	10%	25%	45%	75%
	Deep retrofit rate of urban residential/public buildings	0%	29%	45%	67%	100%
Efficiency Improvement	Penetration of super-efficient equipment and energy systems	0%	25%	50%	75%	100%
Clean Energy	Penetration of solar water heater in urban residential buildings	17%	25%	34%	42%	50%
	Penetration of solar water heater in public buildings	0%	9%	18%	27%	36%
	Penetration of electrified cookers – urban residential	4%	18%	32%	46%	60%
	Penetration of electrified cookers – rural residential	6%	18%	31%	43%	55%

Source: RF China Team Analysis.

Figure 3. Roadmap of Goals for Reducing China's Building Energy Use by 50% by 2050

The short-term phase focuses on laying the foundation of each strategy and forming a policy framework aiming at controlling actual energy use in buildings. The mid-term phase focuses on deploying ultra-low-energy buildings. The long-term phase encompasses full implementation and realization of the key strategies and a shift to cleaner, smarter energy systems. Policy strategies that can help achieve the goals shown on the roadmap and that are linked to the five building strategies discussed above can be grouped into four categories:

1. **Codes and Enforcement:** Establish and effectively enforce performance standards, mandatory energy-use targets, and codes to increase the deployment of super-efficient equipment and provide standard definitions for ultra-low-energy and passive buildings.
2. **Disclosure and Transparency:** Transparently disclose information and data to support informed decision making, help build market demand for building efficiency, and drive demand for performance that exceeds code requirements (e.g., passive and ultra-low-energy buildings, super-efficient equipment) and directly incentivizes building efficiency retrofits.
3. **Market Forces:** Support power-sector and energy-tariff reform to help correct distorted price signals and promote innovation that increases efficiency, significantly reduces costs, and increases utilization of clean energy in the building sector.
4. **Financing and Investment:** Increase access to private capital by increasing financing and investment opportunities to stimulate behavior changes and stakeholder demand for efficiency; this will help realize all five building strategies.

Figure 4 lists the specific policies and measures for each of the four categories defined above.

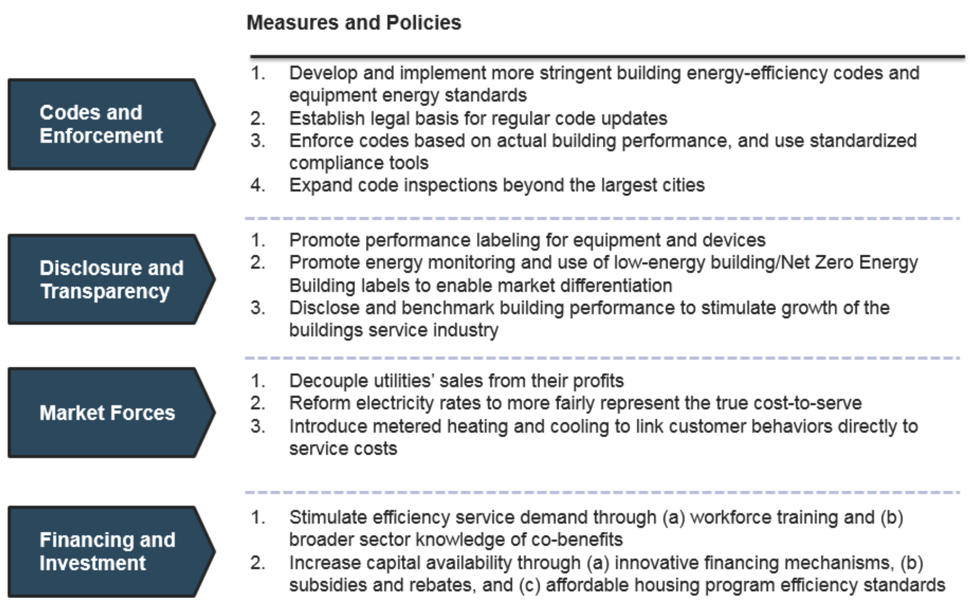
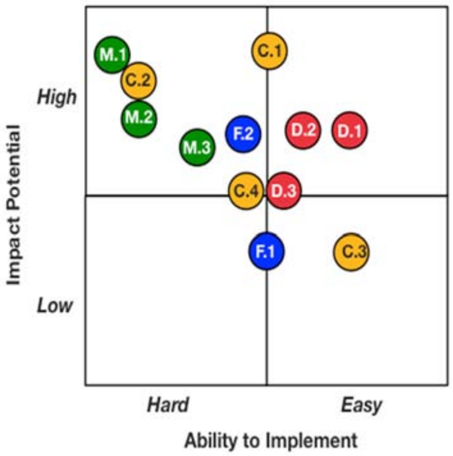


Figure 4. Building Sector Policy Solutions and Measures

Figure 5 lists the above policies and measures according to ease of implementation and magnitude of impact. The policy solutions generally fall into three categories as seen in Figure 5: low-hanging fruit (easy to accomplish and high impact, should be pursued immediately), long term (high impact but difficult to accomplish, should be pursued over time), and consider for momentum-building (easy to accomplish, but low impact—should be pursued as part of related policy measures). Based on the policy rankings, we developed policy roadmaps for Chinese buildings for the short / mid term (2010-2030) and the long term (2030-2050).



C	**Codes and Enforcement**
C.1	More stringent building codes
C.2	Legal basis for code updates
C.3	Standardized compliance tools
C.4	Expand inspections to smaller cities
D	**Disclosure and Transparency**
D.1	Equipment/device labeling
D.2	Building metering and labeling
D.3	Building energy performance disclosure
M	**Market Forces**
M.1	Decoupling
M.2	Energy pricing reform
M.3	Heat reform
F	**Financing and Investment**
F.1	Stimulate service demand
F.2	Capital availability

Figure 5. Categorization of Building Sector Policy Solutions

Short-term and Mid-term Phases (2010–2030): Establish building energy-saving policy framework aimed at controlling energy consumption growth

The focus of this phase includes: improving building energy codes and standards with the goal of controlling actual energy use; strengthening metering, measurement, benchmarking, and statistics related to building energy use; increasing support of research and development related to building energy-saving technologies with the goal of gradually reducing associated costs; accelerating energy-saving technology pilot and demonstration projects; laying the foundation for fully utilizing market mechanisms; and strengthening supervision and management of the building energy-efficiency industry, including improving personnel training and education. Strategic tasks, goals, and timelines for the four key strategies are as follows:

1. Reinforce urban and rural planning management, establishing a rational per-capita floor area goal, encouraging development of small-floor-plan residences, gradually reducing the number of unoccupied residences, and restricting building demolition to restrain large-scale construction.
2. Achieve 50% prefabricated buildings by establishing comprehensive standard and codes for such buildings, reforming the construction management system, and increasing investment in research and development as well as industry support. Include the concept of integrated design in education materials and strengthen education for design and construction personnel. Eventually incorporate integrated design into building codes. Improve enforcement of and compliance with current building codes and regulations, Accelerate formation of design and construction standard and codes for ultra-low energy buildings such as passive houses, near-zero-energy-consumption buildings, and deep retrofits. Set up long-term targets and a roadmap for regular code revisions to achieve the passive house and net-zero-energy-building levels. Implement energy consumption quotas before 2020.
3. Include national survey on building energy consumption in the national statistical system, and establish benchmarking and disclosure program to stimulate the market for building energy efficiency.

4. Promote innovative financing system for energy-saving retrofits. Deepen reform of heat metering. Fortify technology development and policy incentives and expand demonstrations, especially in key regions.
5. Enhance energy-efficiency standards for home appliances and office and general equipment, and expand the range of equipment covered by those standards. Update standards periodically, and gradually improve standards through effective enforcement.
6. Reduce technology cost by increasing support for technology research and development and for breakthroughs in key high-efficiency technologies. Promote cost-effective efficient equipment with help of market mechanisms and financial and tax incentives if necessary, including appropriate phase-out of those incentives.
7. Accelerate development of renewable-energy technologies such as solar PV, solar thermal, and biomass, and improve quality standards for solar water heaters and solar PV units. Further integrate these technologies into buildings by introducing a grid integration mechanism, conducting demonstrations of efficient utilization of biomass energy in rural areas, and promoting usage of biomass energy for heating and cooking.
8. Improve electricity infrastructure, making it accessible to all rural areas while improving electricity stability. Enhance competitiveness of electricity as an energy source by means of price reform that will encourage residents to adopt electric cookers and water heaters. Promote heat pumps in commercial buildings and electrical end uses in buildings. Offer necessary financial support for building heating supply infrastructure (pipes and network), and promote low-grade industrial waste heat as a heat supply source.

Long-term Phase (2030–2050): Full implementation of all building policy solutions and strategies

From 2030 to 2050, with a comprehensive policy framework for saving energy in buildings, strategies and policy solutions can be broadly implemented. Strategic tasks, goals, and timeline for the four key strategies are as follows:

1. Continue to improve ultra-low-energy building design and construction codes and accelerate promotion of ultra-low-energy buildings in suitable regions. The ratio of ultra-low-energy buildings in new residential and commercial construction increases every year and from 2040 on, and gradual retrofitting of buildings built from 2010 to 2030 increases the accumulated ratio of ultra-low-energy urban residential and commercial buildings. Complete heat-metering reform, and establish market mechanism that promotes building energy efficiency and retrofits of existing buildings, especially in transitional and southern regions.
2. Continue to improve and upgrade energy-efficiency standards for home appliances and office and general equipment and strengthen enforcement regimes. Promotion of high-efficiency appliances and building equipment will rely on market mechanisms and consumer behavior changes after phase-out of financial incentives.
3. Achieve significant building integration of renewable-energy technologies by means of comprehensive codes and mechanisms for renewable-energy utilization. Further promote biomass energy technology, solar water heaters, building PV generation, and distributed energy systems. Further encourage residents to adopt electric cookers and water heaters. Promote heat pumps in commercial buildings and continue to increase electrification of building energy end uses.

Conclusion

Driven by urbanization, rising incomes, and demand for commercial services, China's residential and commercial building sectors will undergo significant expansion in the coming 35 years. Chinese buildings are relatively inefficient compared to international levels, and the total energy consumed by China's buildings is expected to rise as a result of this expansion. Our bottom-up, end-use model shows that, under a BAU scenario, China's total residential and commercial building energy use could increase threefold from 2010 to 2050. Much of this increased energy demand would come from growing heating and cooling loads, a result of growing demand for thermal comfort as economic development progresses. However, our study also reveals significant energy-savings potential if China follows a transformative development pathway for buildings. This pathway includes several strategies: better-constructed, longer-life buildings (in part through prefabrication); passive and integrative design in existing building retrofits as well as new building construction; super-efficient equipment; smart controls; and a clean-energy infrastructure. These cost-effective opportunities can reduce the total expected building energy consumption in 2050 by more than 50%. The transformative scenario can also reduce total annual building-energy-related CO_2 emissions by 80% by 2050 compared to the BAU scenario, i.e., to a level that is 60% lower than the 2010 base level.

This paper assesses the barriers to each of these strategies and proposes specific policy solutions to fully realize the potential cost-effective energy savings. The measures and policies outlined in this report are critical to capture opportunities over the next five, 15, and 35 years. To achieve 50% reduction in building energy use by 2050, these policy solutions need to be aligned with key metrics and goals identified in the China buildings roadmap.

The policy solutions can be summarized as follows, grouped into four categories:

1. Increase information and data disclosure and transparency to better inform decision making through promoting labeling of green buildings and energy-consuming products and sharing building performance data through disclosure programs.

2. Establish and effectively enforce performance standards, mandatory energy reduction requirements, and codes by:

- establishing a legal basis for regular updates and improvements of energy codes
- developing and implementing more stringent energy codes
- making codes more effective through standardized compliance tools and a focus on actual building performance
- expanding code inspections beyond just the largest cities
- providing adequate resources for effective enforcement

3. Support reform of the power sector and of energy prices to help correct pricing signals that do not create the right consumer incentives and promote innovation to increase efficiency and save significant costs. This can be accomplished by decoupling utilities' sales from their profits, reforming prices to ensure that electricity rates represent the true cost-to-serve, and introducing metered heating and cooling to link customer behavior directly to costs.

4. Increase access to private capital through greater financing and investment opportunities to help stimulate behavior change and stakeholder demand for efficiency by:

- developing workforce competence
- supporting broader knowledge of the co-benefits of building energy efficiency, such as comfort, health, and productivity
- supporting private-sector investment through innovative financing mechanisms
- establishing subsidies and rebate programs
- setting minimum targets for ensuring that a percentage of newly constructed affordable housing meets energy-efficiency standards

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