Sustainable Low-Carbon City Development in China

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Sustainable Low-Carbon Cities in China: Why it Matters and What Can be Done

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Cities contribute an estimated 70 percent of the world’s energy-related greenhouse gases (GHG). Their locations—often in low-elevation coastal zones—and large populations make them particularly vulnerable to the impacts of climate change. But cities often take steps, even ahead of national governments, to reduce GHG emissions. So it is with China’s cities, which are well placed to chart a low-carbon growth path to help reach China’s national targets for reducing the energy and carbon intensity of its economy.

At the onset of the 12th Five-Year Plan (FYP) for 2011–15, many Chinese cities are already on a high carbon-emission growth path. With China set to add an estimated 350 million residents to its cities over the next 20 years, the case for urgent action is strong. However, the imperative to reduce carbon intensity is only one of many competing priorities for government officials in the midst of unprecedented urbanization, modernization, and economic development. The good news is that the actions to achieve both globally relevant carbon emission reductions and local sustainable development are closely aligned: cities that embark on a low-carbon transformation will also become more livable, efficient, competitive, and ultimately sustainable. Low-carbon growth only adds
another imperative to solve the immediate development concerns of Chinese cities.

China’s cities will need to act on multiple fronts, in some cases scaling up elements of existing good practice, in others changing established ways of doing business. Actions affecting land-use and spatial development are among the most critical to achieving low-carbon growth as carbon emissions are closely connected to urban form. Spatial development also has very strong “lock-in” effects: once cities grow and define their urban form, it is almost impossible to retrofit them because the built environment is largely irreversible and very costly to modify. Furthermore, cities need energy-efficient buildings and industries. They need a transport system that offers alternatives to automobiles. They need to shift to efficient management of water, wastewater, and solid waste. And they need to incorporate responses to climate change in their planning, investment decisions, and emergency-preparedness plans.

Cities Are Key to Meeting China’s Carbon Reduction Targets

China’s cities continue to absorb about 13 million rural residents each year. Accompanied by high economic growth, this rapid urbanization puts tremendous pressure on all forms of public services: energy, water, transport, and waste. This pressure will continue during the 12th Five-Year Plan period (2011–15) with explicit targets for a 4 percentage point increase in urbanization to 51.5 percent and the creation of 45 million jobs in urban areas. That cities are responsible for about 70 percent of global energy-related GHG emissions adds an additional challenge for Chinese cities, given that China is already the single largest contributor of carbon emissions.

China’s leaders have made ambitious commitments to reduce the carbon and energy intensity of the economy and transition to a low-carbon growth path. Consider President Hu Jintao’s commitment to a 40–45 percent reduction in the carbon intensity of GDP by 2020, relative to 2005. The 12th Five-Year Plan includes, for the first time ever, an explicit target to reduce carbon intensity by 17 percent by the end of 2015.

Chinese cities can contribute to such change because the structure of government gives them a high level of autonomy. They are politically, financially, and administratively organized to act quickly and to realize national policy goals. Indeed, they have been the primary agents driving the economic transformation in the last three decades. Today, in response to the emerging focus on environmentally sustainable growth, many cities
are already developing eco-city and low-carbon city initiatives. Such initiatives are expected to intensify as the implementation of the 12th Five-Year Plan unfolds. The National Development and Reform Commission recently announced that areas in five provinces and eight cities are to pilot low-carbon growth while specific plans are also being developed to pilot carbon-emissions trading schemes.

But despite this promising attention and activity, more work is needed to produce an integrated vision and action plan to shift China’s cities onto a low-carbon path.

**Low-Carbon Growth in Chinese Cities: Definitions and Visions**

The first step in offering guidance on a low-carbon transition is to have a common understanding of the current carbon footprint of Chinese cities and to articulate a shared vision of what would constitute low-carbon growth.

**What Is the Carbon Footprint of Chinese Cities Today?**

Most assessments of carbon emissions are based on the location of economic activity, not on consumption of goods and services produced. On the basis of these assessments, many Chinese cities are already high emitters of carbon due to characteristics that distinguish them from other cities around the world. Chinese cities are important centers of industrial production of goods for national and global export markets. As a result, industry and power generation are major contributors to the carbon footprint of Chinese cities, especially so because the energy mix is dominated by coal. Data from Beijing, Shanghai, and Tianjin suggest that about 40 percent of their city emissions is from power generation and another 40 percent is from industrial activities (see figure 1). The remaining emissions, about 20 percent, come from transport, buildings, and waste. Overall, carbon emissions are likely to continue to grow quickly across all key sources—power, industry, buildings, transport, and waste—unless decisive measures are implemented to lower carbon intensity.

**What Is a Low-Carbon City?**

There is no universally applicable definition of a low-carbon city. There are two reasons for this. First, cities differ in their initial carbon endowments. Cities engaged in energy-intensive heavy industry, or those in colder, northern provinces requiring a lot of heating, will start with higher absolute carbon intensities than cities focusing on service and non-
energy-intensive industries or those in moderate climates with less need for heating or cooling. Second, the essential *raison d’etre* of cities is to provide economic opportunities and quality of life for its citizens—and not simply focus on carbon reductions. Actions that compromise on this fundamental fact risk undermining a city’s long-term sustainability. Therefore, definitions of a low-carbon city should above all focus on how cities change their carbon emission *trajectories* independent of their initial carbon *endowments*, but in ways that do not compromise economic development and livability (see also box 1).

### Box 1

**Measuring Low-Carbon Cities**

Standards for measuring a city’s carbon performance are still a work in progress. Above all, a number of key accounting issues need to be resolved, especially on how to account for carbon emitted when activities and services are consumed in locations different from where the carbon is emitted. Furthermore, the relation-
A central message emerging from the review of low-carbon city development is that there is, in fact, a strong alignment between low-carbon and locally appropriate sustainable development strategies for cities. A low-carbon city is therefore, above all, a sustainable, efficient, livable, and competitive city. The low-carbon development angle adds an important additional lens for evaluating a city’s sustainable development objective. Examples of the close alignment between local development and the benefits of mitigating global climate change include (see figure 2):

Smart urban form and spatial development. Low-carbon cities need compact urban form and smart spatial development. But related concerns linked to the rapid expansion of cities such as congestion, local pollution,
and safety also increase when public transport becomes less competitive as a result of poor spatial growth. Rural agricultural land is over-consumed. Cities expand into areas with higher risks of disasters or higher ecological values. Contingent liabilities increase from off-budget borrowing linked to land expansion. And equity concerns arise over the compensation of rural land users on the urban periphery. Reforms in land-use planning, municipal financial frameworks, and changes in spatial development can address these concerns and promote low-carbon growth.

**Urban energy use.** Addressing local concerns relating to air pollution, energy security, and energy efficiency is also aligned with low-carbon growth. For example, reducing carbon emissions from heating by replacing small, decentralized, coal-fired boilers with more efficient, modern, larger, and cleaner central systems—accompanied by innovations in distribution and system management leading to consumption-based billing and better demand management—will lower the cost of service provision, improve the quality of heating services, and reduce local pollution. Similarly, enhanced energy efficiency results in not just a greener, lower-carbon industry, but a more competitive industry.

**Urban transport.** Local policy makers have to contend with congestion, accidents, safety, and equity implications of rapid motorization, which is also causing fast growth in carbon emissions. The broader sustainable urban transport agenda is aligned with the low-carbon agenda through concentrating development near public transport nodes; promoting walking, cycling, and public transport as alternatives to private automobiles; and managing demand to restrict automobile use.

**Municipal services.** Waste minimization, recycling, and modern disposal methods can lower carbon emissions of solid waste systems. For urban water and wastewater systems, holistic solutions to manage demand and to develop integrated waste, stormwater protection, and flood management systems also address water scarcity, service quality, and carbon emissions.

The close alignment between local and global benefits becomes less straightforward with respect to issues related to the overall economic structure of a city and the aggregate demand for energy from industry. Replacing energy-intensive manufacturing with relatively low-energy-intensive economic activities, such as services, sometimes offers a seemingly easy transition to a low-carbon economy. However, such strategies need to be considered carefully. Future GDP growth will be driven more by services and lower-carbon industries—both decisive for reducing the carbon intensity in many Chinese cities. For today’s industrial centers, however, simply relocating higher-emission industries outside a city
boundary to reduce the carbon footprint of that city—while reducing carbon emissions locally—would make little (if any) difference on larger spatial scales. But rapidly growing small and medium-sized cities may have the opportunity to leapfrog and bypass the polluting, high-carbon growth paths taken by an earlier generation.

**What Needs to Be Done: A Framework for Action**

To achieve low-carbon outcomes, city leaders will need to engage in a comprehensive set of actions. All key sectors under city management will have important roles, including land and spatial development, urban energy use for industry and buildings, transport, and municipal services. In some cases, elements of good practice need to be scaled up. In others, there is a need to significantly change existing ways of doing business and forge new partnerships. Moreover, policy themes that cut across sectors need to be addressed to provide a supportive environment to realize sectoral priorities. The combination of cross-cutting policy themes and sectoral priorities forms a framework for action to achieve low-carbon growth in China’s cities (see figure 3).

**Figure 3  A Framework for Action: Cross-cutting Policy Themes and Sectoral Priorities**

Source: Authors.
Policy Imperatives and Key Cross-cutting Actions

What is needed for cities to become low-carbon cities? Many important cross-cutting actions relate to overarching policy directions and guidance provided to cities, incentives for low-carbon development, and efforts to overcome institutional constraints. Cities are the key units of action and accountability, but they are also part of a national effort, and the achievement of low-carbon city objectives will depend critically on national policies and reforms. Therefore, the central government will have a key role in providing an enabling environment for cities to implement low-carbon development strategies. Five key cross-cutting actions are described here, in line with the framework shown in figure 3.

Set the Right Indicators to Encourage Low-Carbon Growth

In China’s institutional setting, local government leadership responds directly to quantifiable indicators for which they are held accountable by higher authorities. The target in the 12th Five-Year Plan—to reduce carbon intensity per unit of GDP by 17 percent—will therefore provide a strong administrative impetus for the formulation of local low-carbon development strategies. This aggregate target has to be translated into more detailed indicators to more closely track the carbon intensity of the economy and the performance of specific sectors.

While some of these indicators are straightforward, such as those related to electricity consumption, identifying appropriate indicators is more difficult in other sectors, such as urban transport and spatial development. An important first step for the national and local governments will be to determine appropriate indicators that can be easily tracked and that will provide the right incentives to lower the carbon emissions of specific sectors.

Early lessons suggest that output indicators, while important in their ability to measure easily tangible results, are sometimes not optimal. Indicators such as kilometers of urban rail laid or number of wind turbines installed may not in themselves be indicators of the desired outcomes—even if they are intermediate steps to measure the increase in public transport’s share of trips or the increase in renewables’ share of electricity used. Instead, identifiable and measurable outcome indicators will be required (see box 2).

Complement Administrative Measures with Market-Based Approaches and Tools

Administrative tools, critical to China’s growth in the past three decades, will remain important in the short term. But gains can be achieved from
integrating policies and approaches based on market mechanisms whenever possible. Chinese governance places strong emphasis on government leadership and administrative guidance, and examples abound of how this tradition has helped to deliver energy efficiency outcomes. During the 11th Five-Year Plan period these included mandatory efficiency targets disaggregated at the local level, a focus on a smaller number of large entities to achieve gains, and holding local governments and enterprises accountable for achieving agreed targets. These types of measures will continue to play a vital role in the transition to a low-carbon economy. It is thus an ideal starting point that the 12th Five-Year Plan includes

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**Box 2**

**Indicators Can Set the Right Administrative Incentives for Local Governments**

Based on international and Chinese experience, the following low-carbon indicators may serve as an initial guide for further review and discussion:

- **Carbon emissions**: emissions per capita and emission intensity.
- **Energy**: energy consumption per capita, energy intensity, and share of renewable energy.
- **Green buildings**: energy consumption per square meter in commercial and residential buildings.
- **Sustainable transport**: share of green transport mode trips (percentage of citizens walking, cycling, or using public transport).
- **Smart urban form**: population density and mixed land use.

Quantitative indicators need to be complemented with qualitative indicators of policies, regulations, and standards. “Yes/No” indicators can help determine progress toward a comprehensive package of policies, ranging from land zoning and building codes, to energy efficiency and clean energy standards, and to green transport policies (congestion pricing, parking fees) and municipal finance frameworks that promote low-carbon urban growth. More research is needed in this area and future editions of this book will continue to compile and collect emerging knowledge.

*Source: Chapter 3.*
explicit targets—not only for energy efficiency but also for carbon intensity.

However, relying only on administrative tools will not be sufficient to realize the carbon emission targets or lead to the most cost-effective solutions. It can also have distortionary effects. Similarly, relying on market forces can sometimes bring major economic efficiencies, but this too is not sufficient in the Chinese development context. What is needed is a blend of the two sets of tools—administrative and market-based—with the emphasis on the market-based approaches increasing over time. Three key market principles and mechanisms are most relevant to low-carbon cities: setting appropriate prices, using market discipline, and introducing transparent competitive methods (see box 3).

**Box 3**

**Three Market Principles for Low-Carbon Cities**

*Set appropriate prices.* Prices send users a signal of value. Using price signals for public services to increase efficiency and reduce waste also supports low-carbon urban growth. Appropriate tariffs for water, wastewater, and solid waste can not only ensure cost recovery but also create a culture of conservation and promote recycling. Similarly, setting appropriate prices for fuel, parking, car ownership, and car use will help reflect the costs that drivers impose on others in congestion, accidents, and local pollution. Suitable energy pricing mechanisms are also essential to encourage residential and commercial consumers to adopt energy-efficient construction and operations. Perhaps the price signals that most urgently need correcting are those for land. Current land policy undervalues “rural” land on the urban periphery, creating incentives for overconsumption and inefficient use.

*Use market discipline and market-based frameworks in providing urban services.* In many ways, the spectacular development of China’s cities in the last three decades reflects the success of market principles. In the transport sector, fiscal discipline and cost-recovery frameworks underlying the development of roads and bus networks have allowed those services to grow with the expansion of demand. In the energy sector, energy service companies were created with explicit financial incentives to deliver energy conservation. But there remain further opportunities for more consistent and accelerated use of market-based incentives in the delivery of urban services to achieve low-carbon goals.

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Break the Link between Land Use, Finance, and Urban Sprawl

A particularly important issue for Chinese leadership to consider is the spatial growth of Chinese cities and the links with municipal finance. Spatial growth patterns determine long-term carbon use in a city. Once cities grow and define their urban shape, it is almost impossible to change and retrofit them because their built form is highly durable, largely irreversible, and very costly to modify. There is almost no asset in the local economy as long lived as the urban form—with an asset life of more than 100 years. Cities that have spread over large areas and with fragmented land use are locked into high-carbon development paths.

Urban sprawl—with rapid growth of low-density areas at the urban periphery—can increase carbon emissions through three mechanisms. First, low-density development increases carbon emissions from urban transport through longer commutes and more private motorized trips. Second, low-density areas increase living space per person, and consequently lead to higher per capita emissions from home heating, cooling, and general power consumption. Third, low-density development produces infrastructure used less intensively than that in dense urban cores, such as suburban highway access roads, raising emissions per capita. Figure 4 shows that Chinese cities are starting from a good base of densities—but the financial incentives now in place undermine this advantage by promoting urban sprawl.

Many Chinese cities have more than doubled their built area in a 10-year period. The dynamics of urban spatial growth are closely linked to shortcomings in the municipal finance framework, with an imbalance...
between the sources of finances available to Chinese cities and the demands for services and infrastructure. This mismatch, combined with possibilities for cities to derive potentially large revenue from sales of collectively owned rural land, in large part drives excessive land use and conversion in the urban periphery. In addition to “locking in” high-carbon land-use patterns, the practice creates contingent liabilities linked to the off-budget borrowings of land-backed, state-owned, urban investment companies.

The central government should therefore reexamine the financial incentives of municipal governments and curtail their ability to engage in excessive land conversion (see box 4). Specifically, the central government could offer cities an alternative sustainable financing framework, including through the ability to directly raise debt.
Encourage More Intersectoral and Interjurisdictional Cooperation

Many of China’s public service and infrastructure achievements come from the ability to hold specific elements of government accountable for specific outcomes. Agencies are empowered with an unusual level of decision-making authority and then held accountable for promised targets. While this has facilitated project execution, it has also lowered interest in and focus on cooperation across sectoral and jurisdictional boundaries. Authorities building an urban road may find it easier and quicker to avoid connecting with an inter-urban highway than to engage in potentially protracted discussions with a different municipal or provincial authority on how to facilitate such an interchange. For the same reasons, intermodal facilities between bus and urban rail, or between inter-urban and urban modes of transport, are often not adequately

Box 4

Financing Structures for Cities Need to Be Fundamentally Rethought

Municipalities have significant responsibilities for local economic development and for providing a range of urban public services. But they have limited options to mobilize finance. Their share of the total tax base is not commensurate with their responsibilities, and they are not allowed to mobilize debt directly.

Assistance is needed to establish transparent, credible, and stable local revenue streams to help local governments to access capital markets. Currently, the bulk of urban financing is structured through off-balance-sheet government platforms that depend heavily on land sales and redevelopment for their revenue base. This creates incentives for land development inconsistent with low-carbon spatial forms.

National policy makers should create a sustainable and alternative financing paradigm for Chinese cities. Work on this complex issue is still in its developmental stages, but it will likely need to include tax reform, better access to debt and capital markets, and refined mechanisms to allow fiscal transfers from higher levels of government. The national government and cities will also have an opportunity to introduce innovative financing mechanisms that focus explicitly on supporting low-carbon development, such as carbon finance, environmental or green bonds, and various concessional finance programs.

Source: Authors.
addressed and consequently never get programmed, allocated land, or implemented.

The result can be an infrastructure system with key pieces constructed in record time, but with suboptimal integration across elements managed by different agencies. While this is an issue for all leaders aiming to create livable and efficient modern cities, it is particularly important for low-carbon growth. Attracting car users to public transport requires road agencies, public transport agencies, and traffic and sidewalk management agencies to cooperate and provide seamless high-quality experiences. Managing scarce regional water resources and building energy- and cost-efficient waste systems will similarly require more cooperation among county, district, and sometimes municipal governments.

The challenge for Chinese cities will be to facilitate such cooperation across sectors and jurisdictional boundaries without significantly compromising the strong culture of implementation that has been at the core of economic development in the last three decades. Often in China, the best solutions will likely be local and context-sensitive pragmatic answers to particular issues rather than wholesale changes in approach. It will be important to identify such solutions as they emerge and find ways of mainstreaming them across cities.

**Balance Mitigation and Adaptation Measures**

China ranks among the most vulnerable countries exposed to climate change impacts and meteorological hazards. Projections show that it will be vulnerable to more frequent and intense rainfall and floods in the southwest, and while typhoons are predicted to fall in number, their intensity and impacts are projected to increase. China’s water scarcity is also expected to become more severe, with arid areas at risk of increased desertification. And the 130 million residents of China’s coastal cities are particularly vulnerable to rising sea levels.

Although the costs of adapting to climate change can initially be high, the costs of delaying action to integrate climate risk management into these investments and to ensure climate-smart growth could be much higher. Costs will result not only from direct damages but also from indirect impacts, including supply-line disruptions, productivity losses, and relocation costs. Prevention is cost-effective, and governments can take measures to build safer cities. The challenge for city governments is not merely to have a short-term view of policies but to adopt a long-term cost-benefit outlook, favoring measures for climate change adaptation and disaster prevention.
Adapting to climate risks builds on elements of sound urban planning, which are linked to successful adaptation and effective low-carbon city development (see box 5). The concept of “integrated climate risk management” captures this link and builds in adaptation measures that are flexible, spread the risk, and are integrated with city planning. Flexibility and resilience are particularly important for cities because impacts at the local level are expected but cannot yet be predicted with precision at the scale of a city.

**Sectoral Priorities and Key Actions**

The cross-cutting actions identified in the previous section help to create a favorable policy environment for low-carbon cities. To realize the desired low-carbon outcomes, however, actions will need to focus on addressing specific sectoral challenges, particularly those related to energy, transport, and other municipal services including water and waste management services (see figure 5 for a breakdown of carbon emissions

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**Box 5**

**Adaptation—Elements of an Integrated Climate Risk Management Approach**

Investments in climate change adaptation link to successful urban planning and low-carbon city development. The following five elements characterize an integrated climate risk management approach:

- **Mapping risks**: understanding the vulnerable terrains and critical water flows.
- **Identifying vulnerable communities**: the poorest are often the greatest at risk.
- **Emergency preparedness**: using early warning systems to mitigate impacts and community-based approaches to respond speedily and effectively to climatic events.
- **Working with nature**: nonstructural strategies that “work with nature” need to complement traditional engineering solutions that “manage and control nature,” especially in the context of flood plains and shore management.
- **Planning for response**: implementing a standard system of “safe” routes and facilities, establishing community-based response plans, and introducing official coordination and response plans.

*Source: Authors.*
This section reviews key lessons and experiences for each of those sectors, based on the experience of Chinese cities and World Bank–supported programs.

**Energy—the Key Driver of Carbon Emission across All Sectors**

*Encouraging a cleaner and greener supply of electricity.* National and to some degree regional characteristics, together with associated national policies and trends, are the main determining factors influencing the eventual carbon footprint of a city’s electricity consumption. At the national level, gains in reducing the carbon intensity of power generation have been overtaken by increases in aggregate demand (see figure 6). While no municipality in China has direct control over national policies and trends relating to electricity generation, municipalities still have some options to reduce their carbon footprint. For example, they can import power from sources that have lower emissions, generate green power locally, increase local renewable and other distributed sources of generation in the city mix, and provide end users with a choice of green electricity supply (see box 6).

*Industrial energy efficiency—a story of success and continuing potential.* Industrial plants in or near urban centers produce a large share of emis-
Figure 6  Carbon Emissions in the Power Sector in China

Source: Chapter 5.

Box 6

Key Energy Sector Recommendations

The 11th Five-Year Plan period yielded an impressive 19.1 percent reduction in the energy intensity of the GDP, which was achieved primarily by focusing on the industrial energy sector. Contributing factors included setting administrative targets for subnational governments, focusing on the energy efficiency potential of the largest enterprises, systematically incorporating energy assessments in new project appraisal, creating a system of incentives and requirements to eliminate inefficient capacity and plants, creating the Energy Services Company industry, and developing grant programs to encourage energy efficiency. To build on this recent success in the energy sector, leaders should consider the following actions:

Energy generation

- Maximize the use of renewable energy as well as technical options such as co-generation and tri-generation.
- Evaluate all choices to make and buy electricity. When possible, consider buying low-carbon electricity from outside the municipality.
- Develop programs that allow end users to voluntarily pay for the incremental costs of green electricity.

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sions in Chinese cities and were a major focus of the efforts to reduce the energy intensity of the economy during the 11th Five-Year Plan. Some critics have cited anecdotes of local officials being placed under pressure to meet energy efficiency targets by shutting down industries, schools, and even hospitals in the name of energy efficiency. Such unproductive and isolated events notwithstanding, the overall experience in terms of promoting industrial energy efficiency has been positive and sets the policy and program foundations for achieving more long-term energy savings.

The core elements of industrial energy efficiency reforms—administrative targets and incentives, a focus on the biggest emitters, and incentive programs to accelerate new-technology adoption—work well in the Chinese context. Strengthening market-based tools within this administrative structure would increase the effectiveness of this approach. This could include support for the nascent financial sector to provide credit for energy efficiency and for energy efficiency service companies that have a profit incentive linked to energy efficiency. Market thinking also remains relevant to enhancing policy effectiveness such as using transparent competitive approaches to allocate public funds and incorporating social and environmental costs into energy pricing policy.

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<td><strong>Industrial sector</strong></td>
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<td>• Consider an enhanced role for market-based methods, including pricing energy to reflect externality costs and creating transparent competition for public grant funds.</td>
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<td>• Support a financial market that provides credit for energy efficiency.</td>
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<td>• Further support the energy service industry through benchmarking and peer learning.</td>
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| **Building efficiency and district heating** |
| • Consistently implement building energy efficiency codes for new construction. |
| • Retrofit public buildings to achieve energy efficiency. |
| • Accelerate material labeling to encourage appropriate technologies. |
| • Switch to consumption-based billing to provide end users with an incentive to preserve energy and make their buildings more energy efficient. |

*Source: Authors.*
Building energy efficiency and district heating—cost-effective options to mitigate carbon emissions. Buildings are a low-cost option to obtain significant reductions in carbon emissions. They account for one-third of global energy consumption, and a business-as-usual scenario could see close to a 50 percent increase in consumption by 2035 relative to 2007. With about 40 percent of China’s 2030 building stock yet to be built, implementing building codes for energy efficiency can yield substantial results. China is among the first non-OECD countries to introduce such mandatory codes, but opportunities remain for municipalities to implement codes that are stricter and more comprehensive than the national standard—and for more effective monitoring and support to ensure compliance. An ongoing national initiative on labeling building materials can also improve new building standards by certifying the quality and sustainability of materials. Despite a concerted national effort to retrofit existing buildings, only limited progress has been achieved. The key challenge remains creating an institutional framework that encourages end users to actively participate. Public buildings may offer a good entry point for retrofitting efforts.

District heating reform should complement energy efficiency measures for buildings. A key element is consumption-based billing. Paying for heat according to the meter will provide a strong incentive to conserve energy for heating. District heating also gives cities the ability to switch to greener fuels with more flexibility than distributed solutions. And while most energy reduction programs are aimed at heating, there is good potential to conserve energy during the cooling seasons.

Urban Transport Policy—the Fastest Growing Source of Carbon Emissions
Transport produces about 26 percent of China’s carbon emissions from fuel combustion. It is also the fastest growing consumer of fossil fuels and source of carbon emissions. Transport emissions result from a complex interplay of the economic activity in a city, the transport activity, and the way trips are split across modes. In general, there are three key strategic options for a city to reduce the carbon footprint of its urban transport, all highly relevant to Chinese cities (see box 7).

Changing the distribution of activities in space. A city can influence the distribution of activities in space—by changing land-use patterns, densities, and urban design and reducing the total level of transport activity. Better land-use planning and compact city development can lead to fewer or shorter motorized trips and to a larger share of motorized trips on public transport.
Box 7

Key Urban Transport Sector Recommendations

While Chinese cities have focused primarily on building out road networks to facilitate automobility and spatial expansion, some recent steps are consistent with low-carbon growth. These include a 2005 State Council directive to prioritize public transport, as well as the development, currently under way, of more than 5,000 kilometers of urban rail in 23 cities. Future efforts to develop a low-carbon transport growth path could include:

Walking and cycling

• Preserve and increase the contribution of walking and cycling.
• Improve the experience of walking/cycling by building smaller block sizes and developing secondary road networks; improving the quality of feeder roads, improving basic facilities such as toilets, lights, trees, and benches; and improving safety along key arterial corridors.

Public transport

• Enhance the quality of basic bus services with attention to planning, regulation, infrastructure improvements, and on-street priority.
• Develop a customer-oriented approach to attract users of choice, paying attention to the door-to-door customer experience and to intermodal facilities and services, including premium services.
• Focus on integration across modes and services, particularly schedules, fares, and physical facilities for buses and bicycles at rail stations.
• Integrate land-use and transport planning—improving urban planning to bring it in line with international best practice for transit development.

Addressing motor vehicles

• Consider policies to manage auto ownership and use, including taxation and fees for ownership, parking, fuel, and use.
• Enhance parking management, which is a simple and important way to manage auto demand.
• Use electric vehicles and other technologies, especially as the market matures and if the electricity grid becomes significantly greener.

Source: Authors.
Supporting low-carbon transport modes. A city can also improve the quality of relatively “low emission” modes, such as walking, cycling, and various forms of public transport. Even today, between 50 percent and 60 percent of trips in most Chinese cities are by walking or cycling. But in most Chinese cities the trend is negative, with bicycle use falling precipitously. To transition to a low-carbon growth path, Chinese cities should preserve, as far as possible, the trips using non-motorized means, and then, ultimately, again attract the pool of trip-makers who could consider these modes for some of their trips.

For public transport, even with the significant investments in urban rail, more attention is needed to improve bus services, which will remain the mainstay for most cities. Significant mass transit investments currently under way in urban rail provide opportunities for quantum improvements in service if the investments are properly integrated with the bus network. China also has some good bus rapid transit systems, which offer many of the benefits of urban rail at a lower cost. But they require careful attention to system performance, including operating plans, traffic management, and system integration.

Reducing emissions from private vehicle use. A city can directly influence what vehicles and how much private transport is used. Most of the transport-related carbon emissions in China’s urban areas are generated by motorized passenger transport (see figure 7), and private cars have the

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**Figure 7** Autos Represent a Small Share of Trips but a Large Share of Transport Sector Emissions

- Share of total trips made using autos (2006)
- Autos’ share of annual transport sector CO₂ emissions (2006)

Source: Chapter 12.
largest transport-related carbon emissions per capita. Two approaches can reduce emissions from motorized vehicles. The first is to adopt technological measures—such as electric vehicles, energy-efficient technologies, or technologies to strengthen road freight logistics—that reduce the carbon emissions of motorized vehicles per unit of travel. The second is to adopt demand management measures that reduce the amount of automotive travel. Such measures include both nonpricing controls on vehicle ownership and use (such as restrictions on parking or days the car can be used) and pricing controls (such as fuel taxes, higher parking fees, and congestion pricing).

Other Municipal Services—Also Part of the Solution

*Waste is another rapidly growing source of carbon emissions.* Global estimates suggest that solid waste accounts for 5–10 percent of carbon emissions generated within a city boundary. If current rates of growth in waste generation are not tempered, residents of Chinese cities may become among the highest generators of urban waste globally. Regardless of the growth trajectory of waste, significant efforts will be needed by Chinese cities to address their waste management needs in coming years. Cities could effectively reduce carbon emissions related to the waste sector by developing an integrated sustainable waste management approach based on a hierarchical “reduce-reuse-recycle-compost-dispose” philosophy that minimizes the amount of waste disposed (see box 8).

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**Box 8**

**Key Water, Wastewater, and Solid Waste Recommendations**

Chinese cities have increased both the access to and the sustainability of all their key municipal services. Almost all households are now connected to a 24-hour water supply, and in recent years China has implemented the world’s largest-ever wastewater treatment investment program. Cities have also gradually moved in the direction of cost recovery tariffs. Many actions necessary to lower the municipal services’ carbon footprint are now well understood and also generally required for optimal functioning of the respective sectors, independent of their carbon impact. Recommended actions include:

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The water and wastewater sector also offers some opportunities for emission reductions. The sector does not, at first glance, offer obvious opportunities to reduce a city's carbon footprint. Estimates suggest that even in 2020 it will be responsible for less than 1 percent of China’s carbon emissions. But there still are good reasons to focus on the sector, including

**Box 8 (continued)**

**Water supply**

- Consider compact urban development patterns to minimize infrastructure needs and pumping costs.
- Reevaluate raw water intake strategies to minimize energy use requirements.
- Reevaluate advanced water treatment methods (for example, desalination) to minimize energy use.
- Enhance demand management, including through appropriate pricing strategies.

**Wastewater/drainage**

- Introduce holistic and integrated approaches to flood protection and natural wastewater purification, and expand wastewater provision using natural systems such as constructed wetlands.
- Consider decentralized methods of treatment as coverage is expanded to peri-urban areas.
- Consider low-energy, anaerobic treatments, particularly in smaller cities and towns.
- Minimize carbon emissions from sludge disposal.

**Solid waste**

- Promote waste minimization, waste segregation, composting, and recycling through a combination of pricing, increased awareness, and administrative control measures.
- Reduce the need for incineration and, if incineration is needed, ensure that emissions meet most advanced global standards.
- Ensure that landfills are designed and managed professionally and that methane gas is captured for energy generation where possible.

*Source: Authors.*
the considerable overlap between low-carbon solutions and established good practice. In addition, some technical proposals to address water scarcity are potentially very energy intensive and need to be balanced with stronger demand management.

Finally, in addition to the reforms in the key urban sectors, city officials can introduce innovative reforms in other less obviously related sectors. Preserving and reusing historic built assets, for example, reduces the energy needed to build new buildings, while downtown regeneration goes hand-in-hand with livable, walkable downtown areas that support bicycle and pedestrian transport. Urban agriculture and forestry are both gaining momentum as innovative ways to reduce emissions and—in urban agriculture—also improve food security. Finally, developments in information and communication technology, such as smart grids and electric vehicles, will be an essential backbone for any low-carbon city development (see box 9).

**Box 9**

**A Growing Role for Technology**

Technology will be critical in the effort of Chinese cities to develop low-carbon economies. This includes renewable energy technologies currently under development or in an early stage of commercialization, technologies that reduce emissions from fossil-fuel generation, and other energy-saving transportation technologies. Equally important will be “smart” systems based on information and communication technologies to optimize system performance. These include “smart grid” technologies, systems applications to increase the efficiency of wastewater treatment processes, and software applications to benchmark industrial energy efficiency efforts.

Perhaps less obvious are some “lower tech” traditional technologies that can support the transition to a low-carbon growth path. In transport the core tested technologies that will create livable cities with low-carbon transport systems are bicycles and buses. Renovating and reusing old buildings, particularly those built before the 1920s, can be an energy-efficient alternative to rebuilding. For wastewater, anaerobic methods offer opportunities for less carbon-intensive treatment. For solid waste, well-constructed landfills complemented with recycling are an alternative to energy-intensive incineration.

*Source: Authors.*
Developing a Plan of Action

To realize low-carbon urban development and implement a comprehensive multisectoral policy agenda will require coordinated action from a range of stakeholders. Different levels of government in China will need to be actively involved, and complementary initiatives will be required from civil society. By focusing on “how,” this section proposes recommendations to turn the outlined policy framework into an actionable set of priorities for key stakeholders.

National Government Leadership

The central government has to create an enabling environment. While cities are key units of action and accountability, the achievement of low-carbon city objectives needs clear national leadership. Most of the cross-cutting policy themes identified above lend themselves primarily to national government policy interventions, including setting low-carbon development indicators, complementing administrative with market-based approaches, breaking the link between municipal finance and urban sprawl, encouraging more intersectoral and interjurisdictional cooperation, and balancing mitigation with adaptation.

Some of these actions will require analytical policy guidance but may be relatively easy to implement, such as finding the right indicators to encourage low-carbon development or providing clear guidance to cities on the climate change adaptation agenda. Others, such as increasing the role of market-based approaches in the economy, essentially call for accelerating broader reform efforts long under way. But two reform areas will require a marked departure from business as usual. The first is the need to comprehensively reform existing municipal finance mechanisms and create stable and adequate revenue sources for cities that take away the incentive for excessive rural land conversion and urban sprawl. Without such a reform, complex as it might be, cities will continue to find it challenging to reduce their overreliance on land sales as a key source of city financing. The second is to promote an administrative culture that facilitates cooperation across intersectoral and interjurisdictional boundaries—essential for addressing the complex management challenges in introducing effective low-carbon development solutions.

Some sectoral priorities will also require action from the central government. In particular, the central government will need to continue to take the lead in greening the country’s energy supply and in overall technological and industrial policy. Regulatory refinements will be needed to
facilitate innovations in energy consumption (such as possibly giving cities flexibility in their sources of energy) and deployment of new transport technologies (such as electric vehicles). Finally, the central government will have to set priorities and provide targeted concessional finance for low-carbon initiatives—ranging from promoting public transport to developing decentralized renewable energy and wastewater treatment systems.

**Local Government Leadership**

Even with strong national leadership, cities will carry the bulk of responsibility for implementing the low-carbon city agenda. Chinese cities have significant autonomy to implement policy directives and a track record of implementing ambitious policy agendas effectively and with agility. City leaders are expected to be charged with quickly establishing a roadmap for action during the 12th Five-Year Plan to achieve low-carbon outcomes. From a *substantive* standpoint, this will require implementation of the sectoral agendas highlighted in the previous section and summarized in boxes 6, 7, and 8. From a *process* standpoint, city leaders will need to:

- **Determine the city’s carbon footprint.** This requires establishing an accounting framework with baselines and benchmarks—based on a globally or nationally recognized inventory methodology—to measure progress. Conducting a citywide carbon emissions inventory requires a consistent methodology, robust data collection, and transparency. Knowledge of a city’s footprint is critical to informing citizens and policy makers about the level and source of baseline emissions.
- **Develop a vision and set a low-carbon target.** This will require bottom-up analyses of options and a top-down articulation of a long-term vision from the city’s officials. Establishing carbon emission targets at the city level would include four steps: determining the carbon reduction potential, including developing a city’s carbon emission abatement cost curve (see box 10); developing the carbon emission abatement scenarios; defining the carbon emission vision and target for the city; and disaggregating the carbon emission target for the city, using quantifiable and monitorable indicators.
- **Implement a low-carbon city action plan.** A low-carbon city strategy and implementation plan will need to be developed and organized into a balanced and ranked set of cross-sectoral and sectoral actions—with each activity fully costed and with financing identified. The low-carbon-city action plans should clearly address institutional integration.
Box 10

When to Adopt Which Abatement Technology at What Cost

Cities must choose from a variety of possible actions to promote low-carbon development. Scientific approaches to balance actions—and identify priorities—across sectors can help. Analytical tools can provide quantitative fact-based analyses to help policy makers and business leaders identify and prioritize potential solutions across sectors. One such methodology is the GHG Abatement Cost Curve developed by the McKinsey Institute and applied by countries around the world, including China (McKinsey 2009).

The cost of an abatement technology reflects its resource (or techno-engineering) costs—its capital, operating, and maintenance costs—offset by any energy or other savings associated with abating one tonne of CO₂ equivalent (one tCO₂e) per year using this technology. For each sector, the abatement technologies can be arrayed from the lowest to the highest cost, and from this range the sector abatement cost curve can be constructed. The curves plot the estimated maximum technical abatement potential of each option and the realistic costs of implementing them. For Chinese cities, abatement options could be considered in at least four key emission-intensive sectors: industry, power, buildings, and transport. The analysis could be extended to cover other potentially important sectors, such as municipal services (solid waste, water, and wastewater), as well as actions with important co-benefits, such as those related to air pollution. Figure B10.1 shows the general schematic of a typical GHG abatement cost curve.

**Figure B10.1 Marginal Abatement Cost Curve**

Source: Based on data from McKinsey & Company 2009 (see chapter 3).

Note: CCS = carbon capture and sequestration; IGCC = integrated gasification combined cycle.

(continued next page)
This is especially crucial given the strong interdependencies of many activities, particularly those for urban land use and transport. The action plans should also clearly identify the local economic development benefits.

- *Carefully monitor progress.* Monitoring, verifying, and reporting carbon emissions will ensure that the city is moving toward a low-carbon growth path and is on track to deliver sustainable development. A measuring and reporting system should again use a nationally or globally recognized inventory methodology, be based on a robust data collection system, and start with a solid baseline inventory that provides a benchmark for comparing subsequent inventories. Inventories should be conducted regularly, with results reported and verified.

**What Citizens Can Do**

Cities will also have to seek the support of their citizens and build a consensus around a resource-efficient and low-carbon lifestyle. With rising incomes and higher individual purchasing power and consumption demands, a low-carbon lifestyle will be a key determinant of future energy demand in Chinese cities. Some tools have been developed internationally to engage citizens in understanding their individual and household carbon footprints and in taking actions to reduce them. Similar partnerships at the city level can generate interest in Chinese households to improve the quality of their lives in less carbon-intensive ways.
Citizens should be made aware of the link between lifestyles, carbon footprints, and the global and local impact of these lifestyles. Citizens can then choose public transport and walk and cycle where possible. They can also choose to live close to work and along public transport corridors to reduce commuting distances and related emissions. They can reduce home energy consumption through the use of energy-efficient appliances. And they can support a low-carbon waste management system by recycling, composting, and generally reducing household waste. Informed, motivated, and proactive citizens will no doubt be essential for the success of any low-carbon city.

* * *

China is acutely aware of the need to reduce its carbon emissions and has made ambitious commitments to reduce carbon intensity. The development of low-carbon cities is the key to succeeding in this undertaking, making the timely adoption of a framework and action plan, such as the one outlined in this overview, crucial. In the upcoming 12th Five-Year Plan period and beyond, China has an opportunity to implement low-carbon strategies and approaches, ranging from innovations in new technology, to increased efficiency in existing industries, and to better management of the growth of cities. This will also make its future cities more sustainable, more efficient, more competitive, and more livable.

References


Tasked with supporting strong economic development that provides jobs and a good quality of life for its growing number of residents, China’s cities also must ensure sustainable development in line with national efforts to transition to a less carbon-intensive economy, as outlined in China’s 12th Five-Year Plan.

*Sustainable Low-Carbon City Development in China* summarizes, through the specific lens of low-carbon development, the lessons of the World Bank’s activities related to sustainable urban development in China. The book presents overall policy recommendations in low-carbon city development and highlights specific experiences across key sectors, including energy, transport, solid waste, and water. The book also explores cities’ role in climate adaptation and opportunities presented by carbon finance and other global mechanisms to finance low-carbon city development.

The intended audience of this edited book is government officials of municipalities, cities, and townships in China. The lessons presented will also be of interest to other countries and development partners supporting low-carbon urban programs.