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1 Introduction

In November 2014, leaders from China and the United States issued the “China-U.S. Joint Statement on Climate Change” and proposed the Climate-Smart/Low-Carbon Cities Initiative. The joint statement expressed China’s commitment to peak carbon emissions around 2030, and indicated that China would attempt to peak earlier if possible. In late 2015 at the United Nations Climate Change Conference in Paris, more than 100 countries committed to emission reduction targets, signifying a sweeping international movement to address climate change. China’s goal to peak carbon emissions is a key part of this important voluntary international agreement.

As the world’s largest emitter of carbon dioxide, China’s progress to decouple its economic growth from carbon-based fuels is a significant step in the global effort to fight climate change, and an important opportunity to pioneer low-carbon development. When China peaks its emissions, it will signal a successful transition away from the traditional model of energy-intensive development and provide a roadmap for other transitioning economies.

The Alliance of Peaking Pioneer Cities (APPC) is supporting China’s efforts to peak carbon emissions through leadership, innovative programs, and cross-city collaboration. In September 2015 at the U.S.-China Climate-Smart/Low-Carbon Cities Summit, Chinese officials announced 16 pilot cities and provinces. This alliance agreed to peak carbon dioxide emissions ahead of the national goal (pre-2030) through accelerating low-carbon development and leveraging international cooperation. In December 2015 at the United Nations Climate Change Conference in Paris, China’s special envoy on climate change, Xie Zhenhua, said that China supports the development of local low-carbon action carried out on all levels of government, and that early peaking cities and provinces had already achieved remarkable results. As part of China’s low-carbon pilot plans, 23 cities have officially proposed peak carbon emissions targets. The work that cities are undertaking is crucial; 70% of China’s carbon emissions come from cities, and China is expected to continue the largest urbanization process in history for the next 10–15 years. Whether governments achieve their sustainable development objectives depends on the ability to manage the relationship between economic transformation and urbanization. Peaking carbon dioxide emissions is a key indicator of low-carbon development success. Over time, China will go further than just peaking emissions. By expanding the scope and depth of pilots, China will ensure that its sustainable development objective is achieved.

This report examines the early progress of the APPC, looking at low-carbon practices across some of the most important levers to reduce emissions. The report profiles the pilot cities and provinces participating in the APPC program, and surveys their current emissions-reducing activities. The report identifies potential opportunities for program improvement, drawing on both domestic and international experience, with a special focus on relevant practices in U.S. cities. The report offers some preliminary perspectives on prioritization of activities at both the city and portfolio level, and suggests ways for ongoing improvement to ensure the processes, systems, and tools used by the APPC grow to support the full ambition of the program. The report also identifies specific ways for the U.S. and China to continue to lead the world in addressing climate change through subnational city collaboration. By sharing lessons learned and promoting best practices, the U.S. and China can support increased bilateral cooperation and solidify their leadership position in global low-carbon development.

China and the U.S. are the world's two largest carbon emitters and economies, and the world's biggest developing and developed economies, respectively. Their joint statement on climate change has compelled others around the world to act, and provided a model to follow. Nurturing a vibrant bilateral cooperation on city-level low-carbon solutions will continue to push global progress forward. By developing models for low-carbon development worldwide, China and the U.S. can be pivotal in leading the low-carbon revolution.

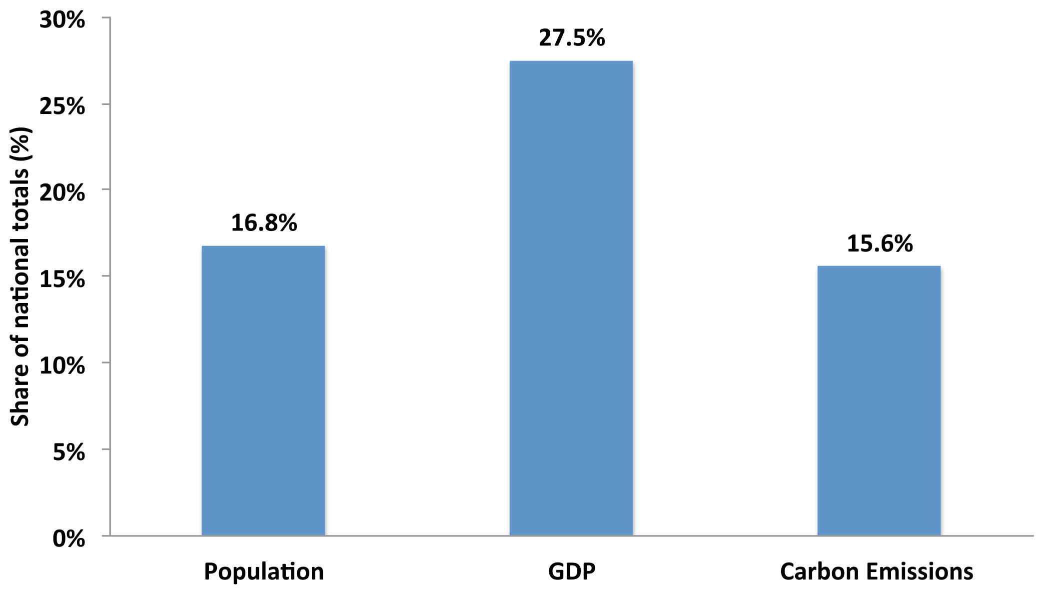
2 Low-Carbon Targets Comparison

Urbanization is a hallmark of modern economies and is a major driver of national energy consumption and greenhouse gas (GHG) emissions growth. At present, 56%[1] of China's population is urbanized, compared to 81%[2] in the United States. Accordingly, reducing cities' emissions is an important component of both nations' GHG reduction strategies, especially in China, where urbanization is rapidly increasing.

2.1 CHINA APPC'S PEAKING GOALS

The national government has indicated that China's GHG emissions will peak around 2030. In support of this goal, to date 21 cities and two provinces (collectively the APPC) have announced early peaking targets. These cities and provinces represent 17% of China's population, 28% of its GDP, and 16% of its GHG emissions (Figure 2.1).[3]

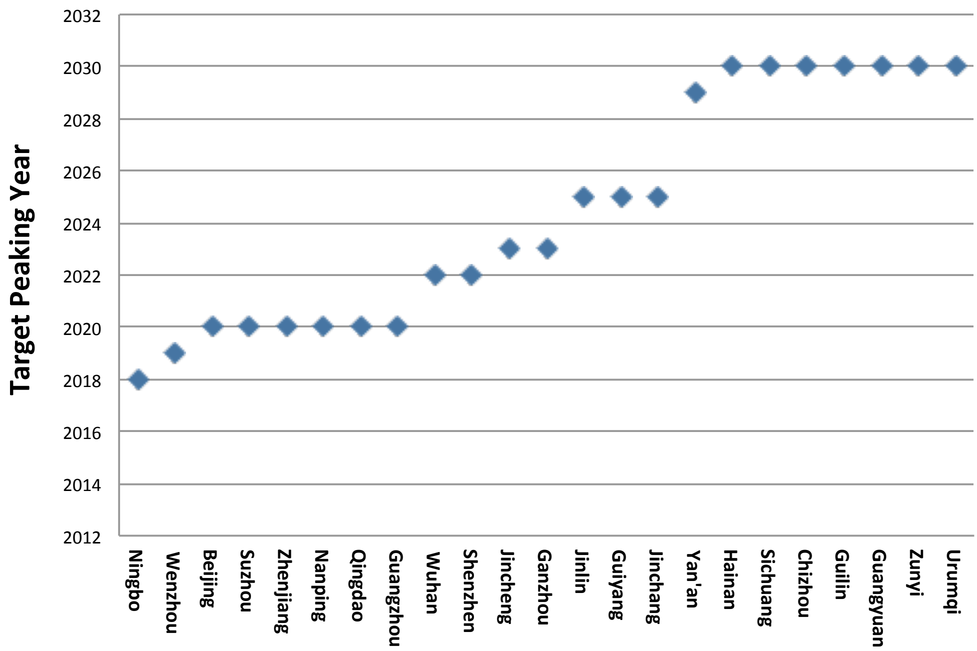
FIGURE 2.1: APPC URBAN POPULATION, GDP, AND GHG EMISSIONS PERCENTAGE OF CHINA TOTAL (2015)



Of these cities, eight (including Ningbo and Wenzhou) have committed to peak in 2020 or before, seven (including Shenzhen and Wuhan) have committed to peak between

2021 and 2025, and eight cities and provinces have committed to peak between 2026 and 2030 (Figure 2.2). To achieve these aggressive targets, APPC cities must explore innovative peaking strategies, learn from international best practices, and accelerate economic and social development toward higher value-added industries.

FIGURE 2.2: APPC GHG PEAKING TARGET DATES



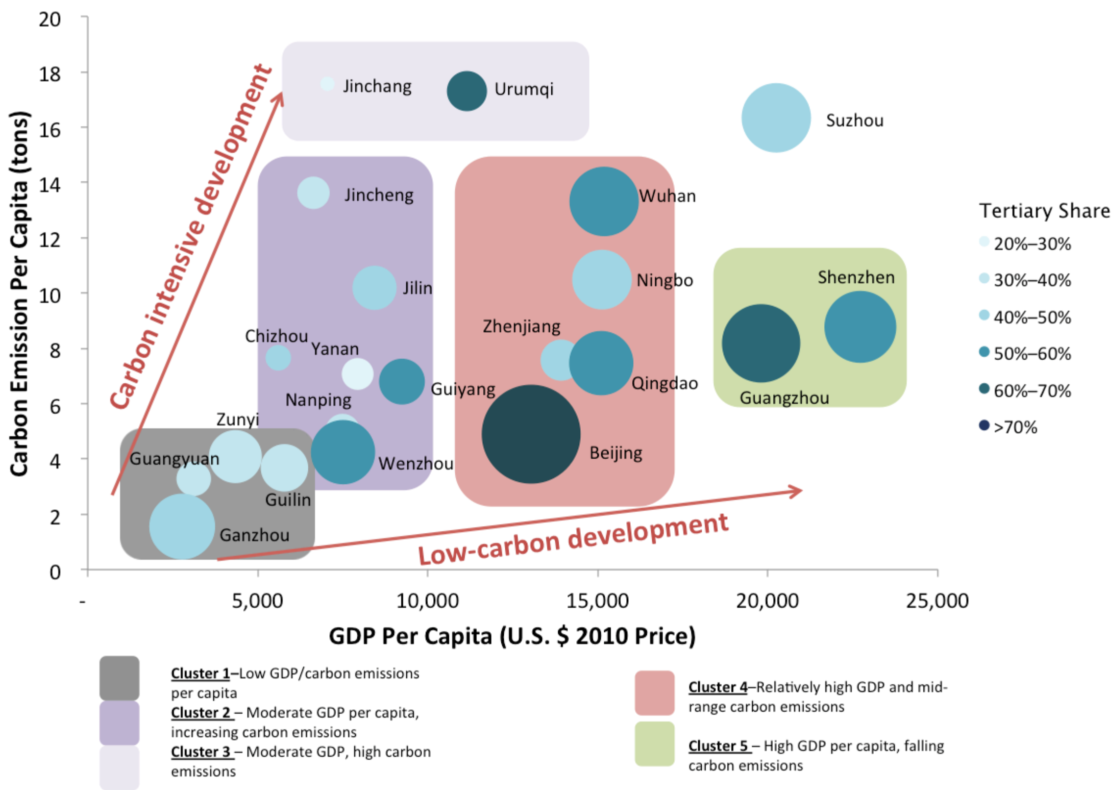
2.2 APPC'S EMISSIONS AND ECONOMIC DEVELOPMENT

A number of factors determine a city's GHG emissions, including its climate and fuel mix. However, one of the most important factors is its level of economic development. Since industrial processes often utilize significant quantities of fossil fuels, GHG emissions naturally tend to increase as nations and cities shift from agrarian to industrial economies. Emissions from both Europe and the U.S. grew when the countries industrialized in the 19th and 20th centuries, and China is currently experiencing a similar phenomenon as its industrial sector, wealth, and urban areas grow.

The U.S. has generally completed its industrialization and urbanization processes. Indeed, over the past several decades the U.S. has gradually become post-industrial, as heavy industry's share of the economy shrinks and is replaced by tertiary industry (service sector). Tertiary industry is generally not energy intensive, and accordingly U.S. cities' GHG emissions have largely peaked.

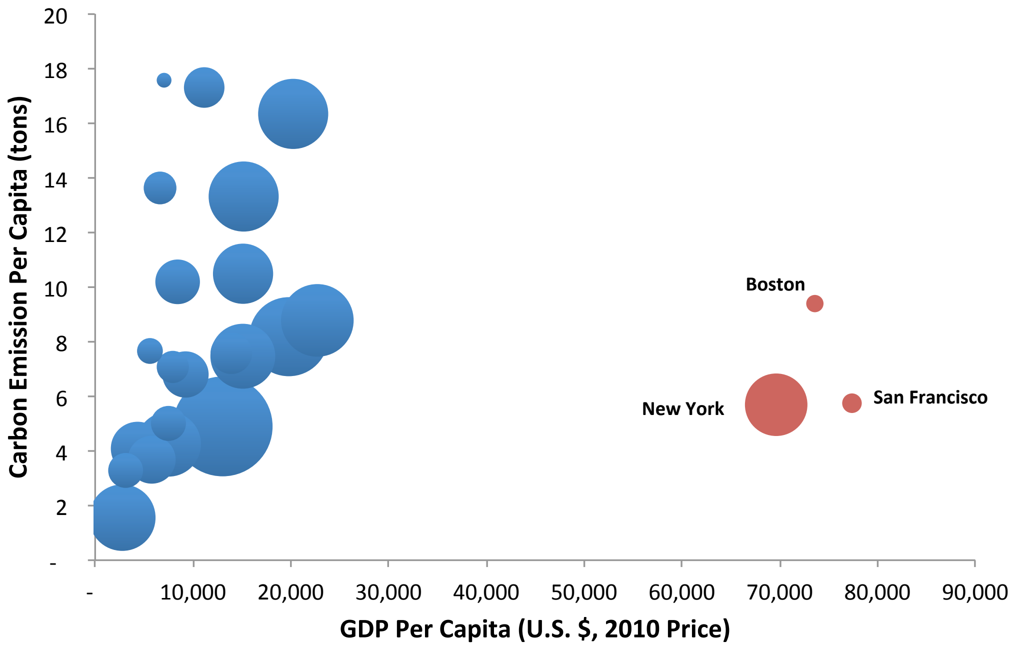
APPC cities span a wide range of economic development (per capita GDP) and GHG emissions (Figure 2.3). The cities can be divided into five different clusters based on their emissions and economic development. Cluster 1 includes low-GDP/low-emission cities that have relatively little tertiary industry. These cities have low emissions because they have yet to fully industrialize. In contrast, cities in cluster 5 are relatively wealthy, and have low emissions and more tertiary industry. Cities like Shenzhen and Guangzhou are building higher value-added, knowledge-based industries and are thus able to grow their economies while limiting GHG growth. These clusters and the implications for economic development and early peaking strategies will be discussed in greater detail in Chapter 4.

FIGURE 2.3: APPC CITIES' PER CAPITA GHG EMISSIONS VS. PER CAPITA GDP (CIRCLE SIZES ARE PROPORTIONAL TO CITY POPULATION. CIRCLE COLORS REPRESENT SHARE OF CITIES' TERTIARY INDUSTRY IN ECONOMIES.)



U.S. cities have achieved high per capita GDP while maintaining relatively low per capita GHG emissions (Figure 2.4). For China to peak its GHG emissions while continuing to grow its economy, the majority of its cities must follow the low-carbon development path of Guangzhou, Shenzhen, and most U.S. cities. There is much that Chinese cities can learn from U.S. cities' experience as they strive to meet their early peaking targets.

FIGURE 2.4: COMPARISON BETWEEN CHINESE AND SELECT U.S. CITIES PER CAPITA GHG EMISSIONS AND GDP



3 Measures and Programs to Reduce Carbon Emissions

3.1 INTRODUCTION

To mitigate carbon emissions, APPC cities can choose from a spectrum of policy and market-based programs across four main levers:

1. **Industrial shift**—shifting away from carbon- and energy-intensive industries and processes improves the efficiency of the economy and cuts the carbon emissions per unit of GDP.
2. **Demand reduction**—controlling demand reduces the consumption of resources and energy.
3. **Energy efficiency**—improving energy efficiency reduces the consumption of resources and energy.
4. **Decarbonization**—increasing the share of non-fossil fuel energy in the energy mix reduces carbon emissions per energy consumption.

Acting in concert, these four levers build the foundation for sustainable development and carbon emission reductions.

Within each lever, a comprehensive set of strategies is required for cities to make progress on their goals. The sheer number of available approaches can be daunting, but considering them in a structure is helpful (Figure 3.1). This report splits the approaches into four levers (detailed above) spanning multiple sectors, where strategies are executed through one or more city programs.

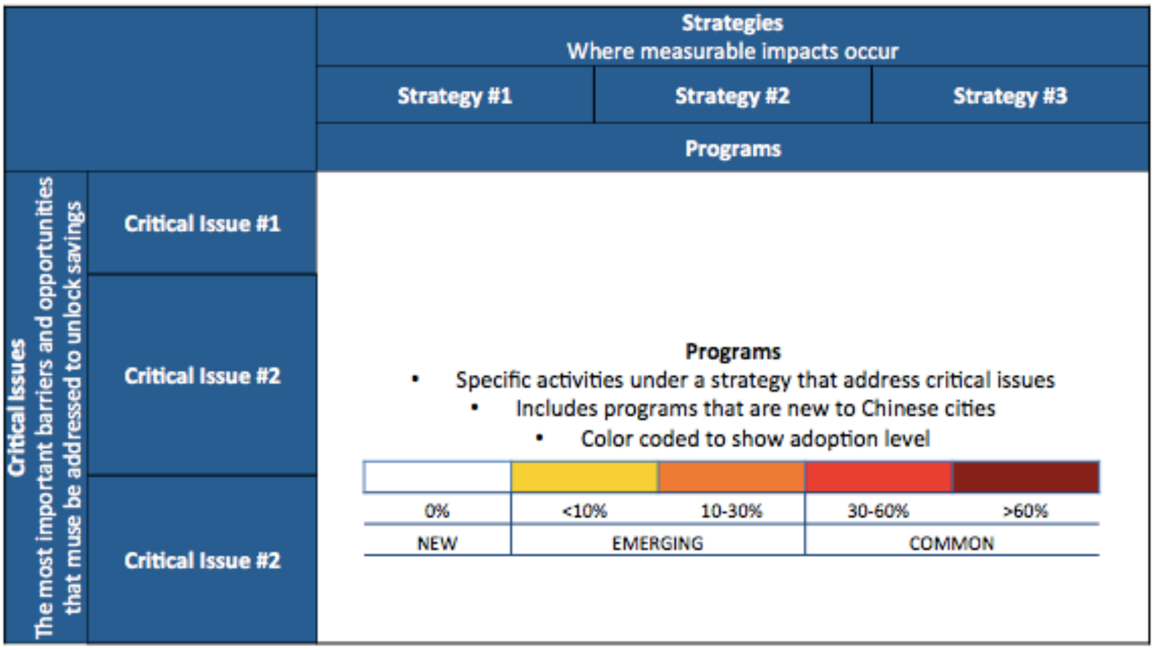
FIGURE 3.1: CITY LOW-CARBON LEVERS, STRATEGIES, AND PROGRAMS

Lever	Sector Focus	Representative Strategies	Representative Programs
1. Industrial Shift	Industry	• Shifting to higher value-add industry • Shifting to service sector	• Low-carbon industrial zones • Skills training
2. Demand Reduction	Industry Passenger Transport Freight Transport	• Materials recycling and reuse • Producing higher quality materials	• Recycling economy • Public transit infrastructure
3. Energy Efficiency	Industry Buildings Passenger Transport Freight Transport	• Obsolete capacity retirement • Increasing the efficiency of new buildings • Fleet adoption	• Energy audits • Building codes • Charge stations
4. Decarbonization	Power District Energy Industry	• Increase grid-scale renewable energy • Development of new district energy systems	• Renewable portfolio standards • Replacing coal with natural gas

A scorecard assessment can help effectively manage and accelerate impact across the peaking cities. Creating a scorecard enables cities to benchmark their progress in relation to other cities, both domestic and international. As a first step toward creating a comprehensive assessment, the APPC Secretariat surveyed current city activity across strategies and programs. The resulting activity assessment displays the current program focus of different cities and, for a city manager reading this report, how common or unique the city's activities are. Future assessments will include metrics for program effectiveness, economics, and impact.

Building off the activity analysis and after a comparison to international city programs, this report uses heat maps to measure program activity and demonstrates the efforts taken by most of the low-carbon pilots in China (Figure 3.2). The horizontal dimension of the map lists strategies—these create GHG emissions reductions. The vertical dimension plots the critical issues historically impeding these strategies, and which must be addressed to be most effective. At the intersection of the strategies and issues are the programs; these are the specific activities APPC cities are taking. Each program is color coded to show the percentage of APPC cities taking action. In addition to domestic programs, relevant programs from outside of China (mainly from U.S. experience) are included.

FIGURE 3.2: HEAT MAP TEMPLATE



3.2 LEVER 1: INDUSTRIAL SHIFT

China urgently needs to transform from the world's low-cost factory—producing energy-intensive, commoditized, manufactured goods for both domestic and export markets—to a balanced industrial economy oriented towards value-added manufactured goods and a growing tertiary sector. Such a shift will require moving up the manufacturing chain (e.g., from commodity steel and chemicals to sectors like advanced materials, new energy vehicles, and aerospace) as well as shifting to service industries. Since advanced manufacturing and service activities typically consume less energy per unit of value-added than heavy industrial sector activities, such structural change can reduce energy consumption while sustaining economic growth. For example, in California structural change was as important as improvements in energy efficiency in reducing overall energy consumption between 1997 and 2008.[4]

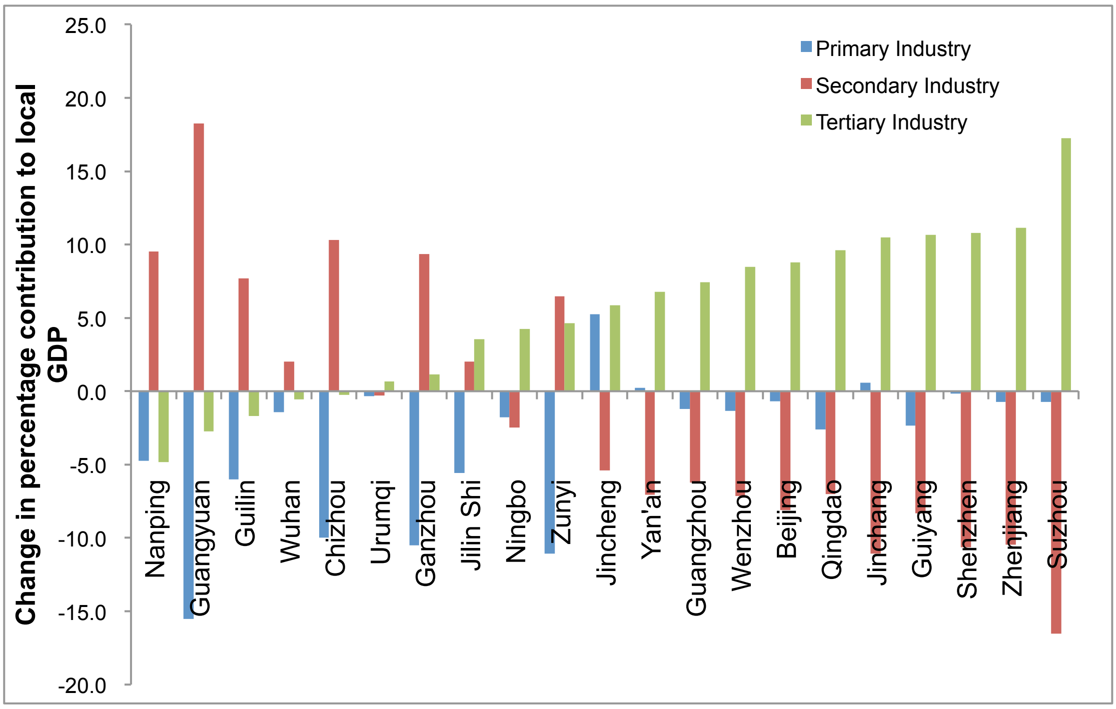
Industrial shift is the dominant lever that China has used consistently for emissions control in recent years at national, regional and city levels. Industrial shift not only helps reduce emissions from production, but also improves local economies and their national and international competitiveness.

In China, industrial shift has two components: 1) the shift within the industrial sector to higher value-added activities, and 2) the shift from the industrial sector to the service sector. By all measures, APPC cities vary widely in their starting points, profiles, and goals;

therefore, the programs and implementation of the structural shift lever likewise vary significantly, as do the outcomes of their application.

During the last decade, numerous cities in China launched industrial shift programs resulting in significant changes in the contributions of different sectors to the local economy, (Figure 3.3). Due to different starting places, two typical trends emerge. Some of the cities – especially those located in Central and Western China, as well as in the mountainous areas where there was previously a lack of secondary industry development – increased the proportion of secondary industry at the expense of primary and sometimes tertiary industry. In the Eastern China cities, as well as cities with high industrialization, there is a significant increase of tertiary industry and decrease of secondary industry to compensate.

FIGURE 3.3: CHANGE OF PROPORTION OF INDUSTRIES (2005-2014)



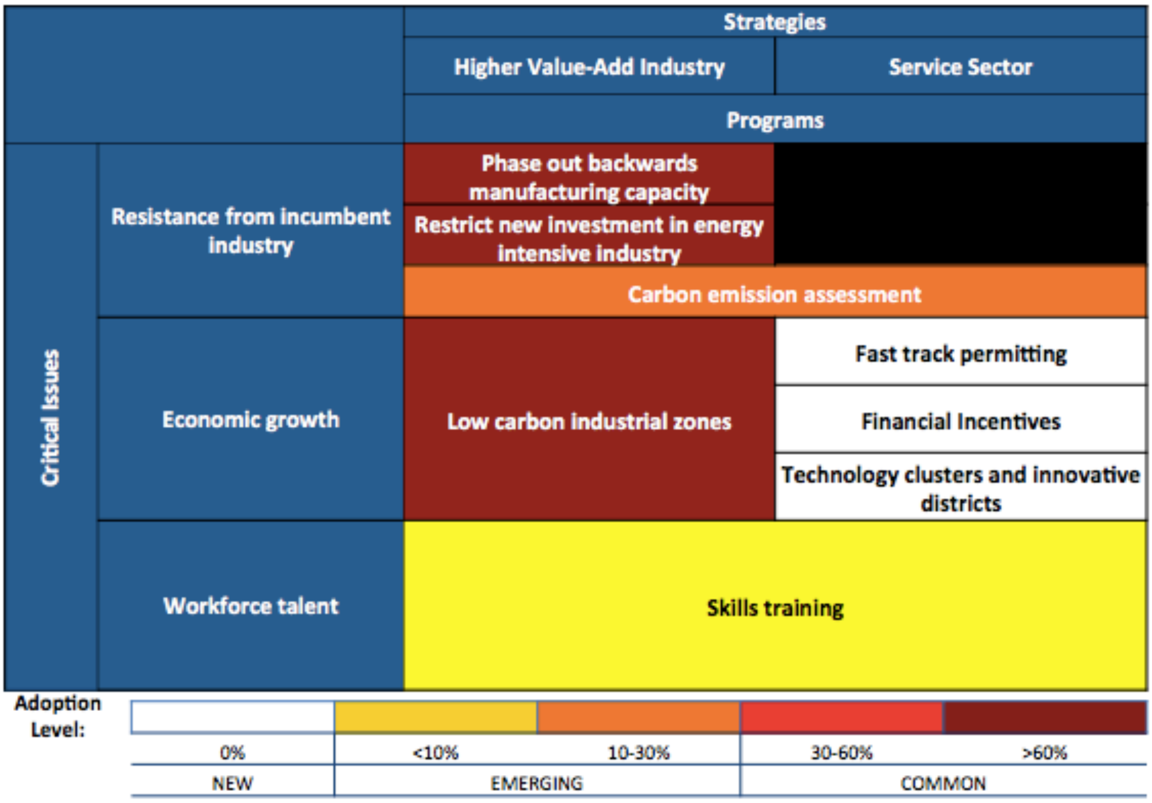
Three critical barriers need to be addressed to capture the opportunity from industrial shift:

- **Resistance from Incumbent Industry:** To free up capital, energy, workforce capacity, and resources for new industrial and service activities, other resources must be moved out of old and inefficient industries.
- **Economic Growth:** A persistent perception is that city GDP targets can best be achieved through large and understood investments in capital-intensive industries.

Investing in new industries can be perceived as a risk to GDP growth until proven development approaches are recognized.

- **Workforce Talent:** Cities must ensure that new industries can maintain the same levels of employment as old, heavy industries are phased out. Heavy industry employees must be retrained to staff new industries and service sector companies.

FIGURE 3.4: INDUSTRIAL SHIFT HEAT MAP



3.2.1 Common Practice Programs

Low Carbon Industrial Zones

Low carbon industrial zones provide incentives and other benefits for low-carbon, value-added industries. These zones typically target strategic industries, including new energy products, advanced equipment manufacturing, information technologies, and pharmaceuticals. The Ministry of Industry and Information Technology (MIIT) and National Development and Reform Commission (NDRC) are piloting low carbon industrial zones to accelerate the decarbonization of heavy industries such as iron and steel and petrochemicals. Low carbon industrial zones, such as Jilin Chemical Industry Circular Economy Demonstration Zone, Suzhou Industrial Park, and Guiyang High-Tech Industrial

Development Area have already contributed to industrial shift and low carbon development in low carbon pilot cities.[5]

Phase Out Backward Production Capacity

Closing uneconomic older plants has become an effective national policy to reduce energy and carbon intensity in China. This policy has already been implemented in many APPC cities. This program is critical in redirecting resources towards new enterprises and reducing overall energy intensity. It is also linked to energy efficiency, where outdated capacity is retired to increase the utilization of newer facilities. During the 12th Five-Year-Plan (2011-2015), Urumqi, for example, phased out 81 plants across 16 industries, including 450 MW of power capacity, 1.78 million tons (Mt) of steel capacity, 1.86 Mt of iron capacity, and 1.74 Mt of cement capacity.[6]

Restrict new investment in energy intensive industry

Restricting new investment in energy-intensive industry is crucial to guiding resources and investment to low carbon new industries and service sector. With the guidance of the central and provincial governments, Suzhou published the “Guiding directory for restricted and prohibited industry” in 2004, which restricted the investment in energy-intensive industries.[7] In 2007, Suzhou published the more comprehensive “Guiding directory for industry development,” which categorized industries into four tiers: encouraged, restricted, prohibited and phasing out.[8] Meanwhile, Suzhou also published a policy on land use control in 2005, in which it strictly limited the land use supply to restricted and prohibited industries.[9]

3.2.2 Emerging Programs

Skills Training

The new economy requires new types of workers. Training requirements for moving from secondary to tertiary sector employment are typically much greater than training workers for alternative roles in the secondary sector. City governments can ease the pain of shifting from traditional heavy industry to service or value-added industries by providing workforce-training programs, and encouraging industries and universities to do the same. These training programs should be tailored to the needs of targeted growth industries. As one of the first developed cities in China, Guangzhou launched a re-employment training program in 1999 to help laid-off workers find new jobs in other industries or the service sector.[10] However, previous skill training programs were not focused on low carbon areas. To pursue carbon emission peaking, APPC cities can enhance the relationship between skills training and the new industries they are trying to create under their peaking strategy.

Carbon Emission Assessment for Fixed Assets Investment

The ability to invest in new production capacity is not guaranteed; cities frequently restrict the growth of energy-intensive industries through permitting and approval constraints, including expanding energy efficiency appraisals and integrating them with environmental appraisals for new large industrial facilities. This is already happening in some cities in the APPC. A carbon emission assessment is based on carbon emission projections, carbon intensity assessment, and emission reduction assessment. If the overall assessment is deemed high-carbon, a red light stops the project. A moderate carbon emission level results in a yellow light and requires further emission control measures or the purchase of carbon offsets. Low carbon projects with a green light receive expedited approval.[11]

3.2.3 Innovative Programs

Create Technology Clusters and Innovative Districts

Cities can attract businesses and investment, develop real estate, and guide new business interests through the development of business districts. The success of these business districts is often dependent upon establishing a vibrant and attractive cluster of employment and social opportunities. One popular model that has proven successful in the U.S. is based on combining educational research and medical technology clusters (i.e.,"eds and meds"). Employment and GDP growth are serious concerns for Chinese cities when they consider new business district development. In the U.S., cities often create specific nonprofit entities called economic development corporations (EDC). EDCs work in close alignment with the city government to create public/private partnerships in new business district development. In Zhejiang Province, Hangzhou, Ningbo and Wenzhou launched a "distinctive town" program.[12] The local government in these APPC cities works closely with enterprises to create a policy framework that attracts and accelerates innovation and new industries.

Fast Track Permitting and Financial Incentives for Low-Carbon Tertiary Industry

Cities can stimulate structural change by providing incentives such as simpler permitting for high value-added and low-energy-consuming industries. Many new value-added industry and service businesses face difficulty in meeting permitting requirements — reducing this burden allows increased growth. Cities can similarly stimulate structural change by providing financial incentives. Many new value-added, low-carbon industries and service businesses (or anchor institutions) find accessing capital difficult. This may be especially true in China where new, non-state owned companies do not have access to private capital. This trend can be reversed at the city level. When investment in these anchor institutions is aligned with other economic development efforts, it helps spur innovation, invite alternative investment, and attract talent (who then join the skilled workforce and become patrons of these new businesses). For example, Louisiana– a state with a high percentage of petroleum industry employment – provides tax rebates of 35% of payroll and 25% on workforce technology equipment for software and digital companies to help stimulate complementary high-tech growth. To induce IBM to build a facility and hire 800 employees, Louisiana also provided funds to cover relocation some operating expenses, and recruit workers. It also provides funds for technology related workforce recruitment and training.[13]

KEY TAKEAWAYS

- Structural shift is already a core component of many APPC cities' peaking programs. While there are variations in approach, current practices primarily focus on closing outdated and inefficient manufacturing capacity and promoting low carbon industrial development zones.
- Initial attempts to transition workforces from energy-intensive to low-carbon industry are emerging, based largely upon prior industrial retraining programs. Global experience suggests retraining must focus on recognizing emerging industries' needs and training workers specifically towards those tasks. Transitions to service sector jobs, where desired, require very different skills and commensurately aggressive retraining protocols.
- Successful strategies to promote innovative industries and service sector jobs focus on establishing a vibrant and attractive cluster of employment and social opportunities. One popular model that has proven successful is based on combining educational research and digital technology clusters. These approaches provide a stable core around which social structures can thrive.
- Other incentives such as expedited permitting and financial incentives, while not sustainable in the long-term, can help kick-start an initial transition and incentivize clusters of service and value-added industrial development.

3.3 LEVER 2: DEMAND REDUCTION

In 2014, the energy consumption of energy-intensive industries such as iron and steel, building materials, chemicals, and nonferrous metals accounted for more than 70% of the total energy consumption of China's industrial sector.14 Generally, this distribution holds true at the city level as well. Reducing the consumption of energy-intensive products is one of the key levers to achieve energy saving and emission reduction. It not only directly reduces the energy consumption and emissions from manufacturing processes, but also reduces upstream GHG emissions from raw material extraction and shipping.

Demand for energy-intensive industrial products can be reduced by 1) minimizing unnecessary construction and demolition practices, 2) prioritizing the use of recycled and remanufactured materials, and 3) increasing material strength (e.g., in the steel and concrete used to construct buildings) to extend the lifetime of products and buildings. Increasing the quality of these heavy industrial materials is aligned with China's goals to shift to a higher value-added industrial economy and reduce energy demand per RMB of output.

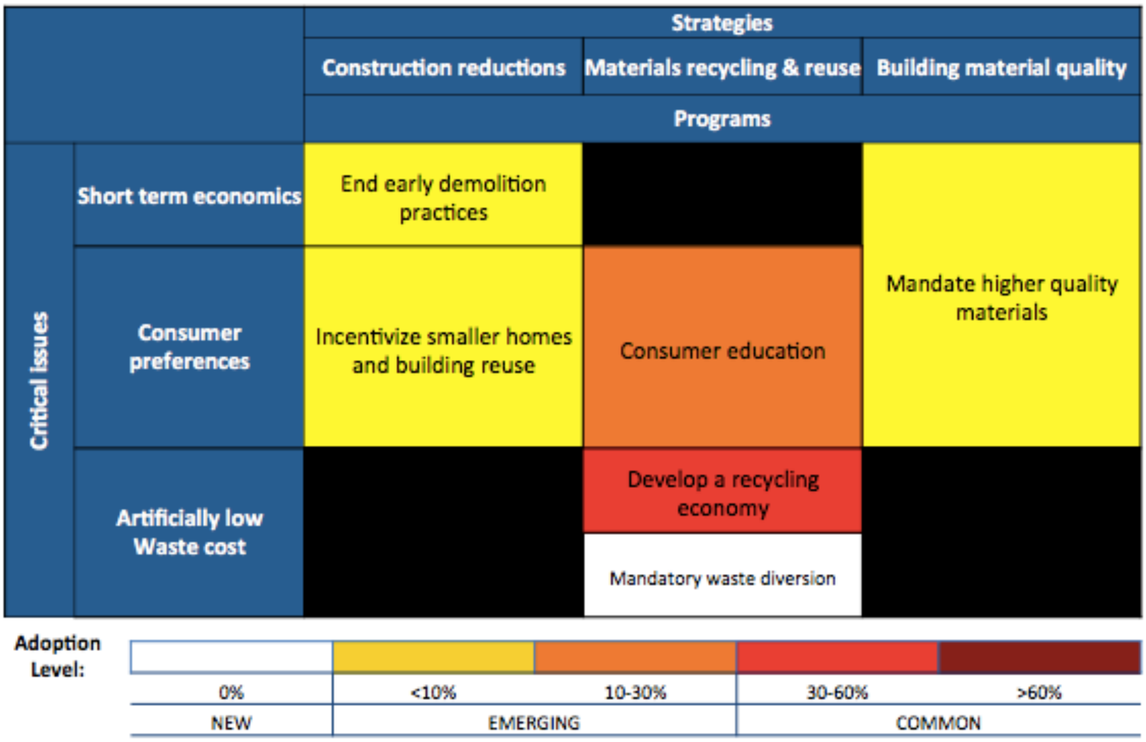
There are three critical issues programs must address to help cities capture this opportunity:

Short-Term Economic Thinking: Short-term economic benefits are often prioritized and the long-term costs associated with low-quality goods, materials, and construction are not adequately considered when evaluating the economics of quality-related decisions. This results in increased energy consumption for manufacture, construction, demolition, and redevelopment to replace materials prematurely. This waste is avoidable by considering lifecycle economics.

Consumer Preferences: As China develops, industrial, commercial and consumer demand for larger, more energy-intensive products, buildings and infrastructure is increasing, driving additional embedded energy demand in the materials required to fulfill this expanding preference.

Artificially Low Waste Cost: Waste disposal is kept artificially low by many cities to effectively subsidize production, construction, consumption, and manufacture. This makes recycling economically uncompetitive, supporting a "linear" rather than "circular" economy.

FIGURE 3.5: INDUSTRIAL DEMAND REDUCTION HEAT MAP



3.3.1.1 Common Practice Programs

Develop a Recycling Economy

Recycling and remanufacturing materials, rather than using raw materials to create new supply, reduces industrial energy consumption. The benefits of not processing or mining raw materials can be incorporated into financial support for recycling. Markets can often be created for recycled waste products; this is easiest in industrial clusters where one facility's waste can be an input for another facility. Though many cities have pursued some measure of recycling economy development, a gap exists to reach levels common in many developed economies. Bohai By-Product-Synergy (BPS) project in Qinhuangdao City is based on the concept of matching wastes and undervalued resources at one industrial facility with potential users at other industrial facilities. Implementation of BPS can result in new revenues for industrial facilities, operational savings, as well as improved energy efficiency, environmental performance, and GHG emissions reductions. The concept has been successfully embraced by the chemical and cement industries in China, and Bohai BPS is negotiating with cement plants in Qinhuangdao to implement these practices. In addition, the Bohai BPS Project has developed an online resource exchange platform called the "marketplace" to facilitate data collection, data sharing, synergy identification, and synergy transaction.

3.3.1.2 Emerging Programs

End "Major Demolition and Construction" Practices and Reduce Irrational Demand for Materials

Demolition and construction practices are dependent on permitting and approval at the city level. Cities can slow the rate of demolition by defining stricter conditions under which building owners are allowed to raze buildings. Though cities frequently reference the protection of older buildings in urban master plans, such as Beijing's "Urban Master Plan 2004-2020," specific measures to prevent demolition are rarely provided. Additionally, these are not specific to lowering carbon emissions or material use.

Require Higher Quality Materials and Construction Practices for Longer Building Lifetimes

Improved building codes (also discussed in 3.4.2) will reduce the demand for construction materials and stimulate demand for higher value-added industrial products, leading to long-term regional economic gain. Improvements in material quality can support such changes in code. For example, One World Trade Center in New York City improved the compressive strength of its concrete from 8,000 to 14,000 pounds per square inch. This stronger concrete had better thermal performance and reduced the heating, ventilating, and air conditioning needs of the building, leading to long-term and short-term energy savings and a longer building lifetime. Overall, the building required 40% less cement for construction compared to conventional designs, saving 33,000 tGHG from materials alone. Using city construction and material standards to help drive adoption and use of such solutions is an important lever to reduce the demand for energy-intensive materials over time.

Incentivizing Smaller Buildings and Building Reuse

Real estate owners' preferences can sometimes drift towards larger, more energy-intensive buildings with financial success. This holds true for personal residences where more space equates with luxury, as well as commercial and industrial buildings where additional space provides optionality to growing businesses. Countering this march for additional space can reduce not only the amount of material that goes into new buildings, but also slow the routine teardowns of older buildings and apartment complexes. Programs to address this demand must inherently focus on shifting social norms. Possible approaches for incentivizing compact homes, smaller buildings, and building reuse include: older building retrofit subsidies, minimum building lifetime standards, or economic incentives for smaller sized commercial and residential units.

Consumer Education on Sustainability and Low Carbon Lifestyle

Mass information campaigns on the economic and environmental benefits of switching to environmentally-compatible choices and practices can shift Chinese preferences over time and lead to growth in demand for alternative products and lifestyles. While potentially a slow process, there have been marked signs of progress. Zhenjiang has pioneered a personal carbon accounting system to help engage consumers on a daily basis understand the carbon consequences of their choices. Innovative social engagement platforms leveraging technology have been similarly developed and deployed in numerous cities in the U.S. For example, Pecan Street in Austin, Texas works with communities to install software to better understand how residents are using energy and provide directed education and advice on how to can save money and mitigate environmental impacts.[15]

3.3.1.3 New Programs

Mandatory Waste Diversion and Recycling

Mandatory recycling programs are effective, but depending on the composition of waste may not have favorable economics. Energy and emissions considerations suggest the highest value targets for recycling are construction and industrial waste streams. Construction waste is particularly problematic as it is often bulky and of lower-value, requiring mandates, subsidies, or incentives to induce collection, transport, and reprocessing. Some cities in the U.S. (e.g., Austin, Texas and Seattle, Washington) require that high percentages of construction waste be recycled in order to reduce burdens on landfills and natural resources.

KEY TAKEAWAYS

- Reducing demand for construction materials is a primary method to lower production of energy-intensive heavy industry products, but has received limited attention at the city level to-date. Initial programs have focused on material recycling, particularly within isolated industrial clusters.
- Chinese cities have begun reducing demolition and new construction, but this practice is still prevalent and must end.
- To successfully transition away from the "demolition and construction" cycle, buildings and other infrastructure should be constructed from higher quality materials in order to improve energy efficiency and increase lifetime value. Mandating quality standards and incentivizing more compact building space decisions by occupants will support progress.
- Recycling programs and the circular economy must be expanded and incentivized through increasing the cost of waste disposal coupled with mandatory recycling in some sectors

3.3.2 Transport Demand Reduction

Transportation demand reductions can be achieved in passenger as well as freight travel. The three main ways to reduce urban passenger transportation are to 1) reduce the number of trips, 2) shorten necessary trips, and 3) shift trips to other modes of travel (e.g., walking, biking, and public transit.). For freight transportation, demand is a product of industrial activity and is therefore reduced through industrial shift (see Industry section 3.2). In addition, the freight industry can shift to more efficient modes (e.g., rail) and can optimize logistics. Reducing demand can also produce additional gains in energy efficiency by reduced idling and stop-and-go traffic.

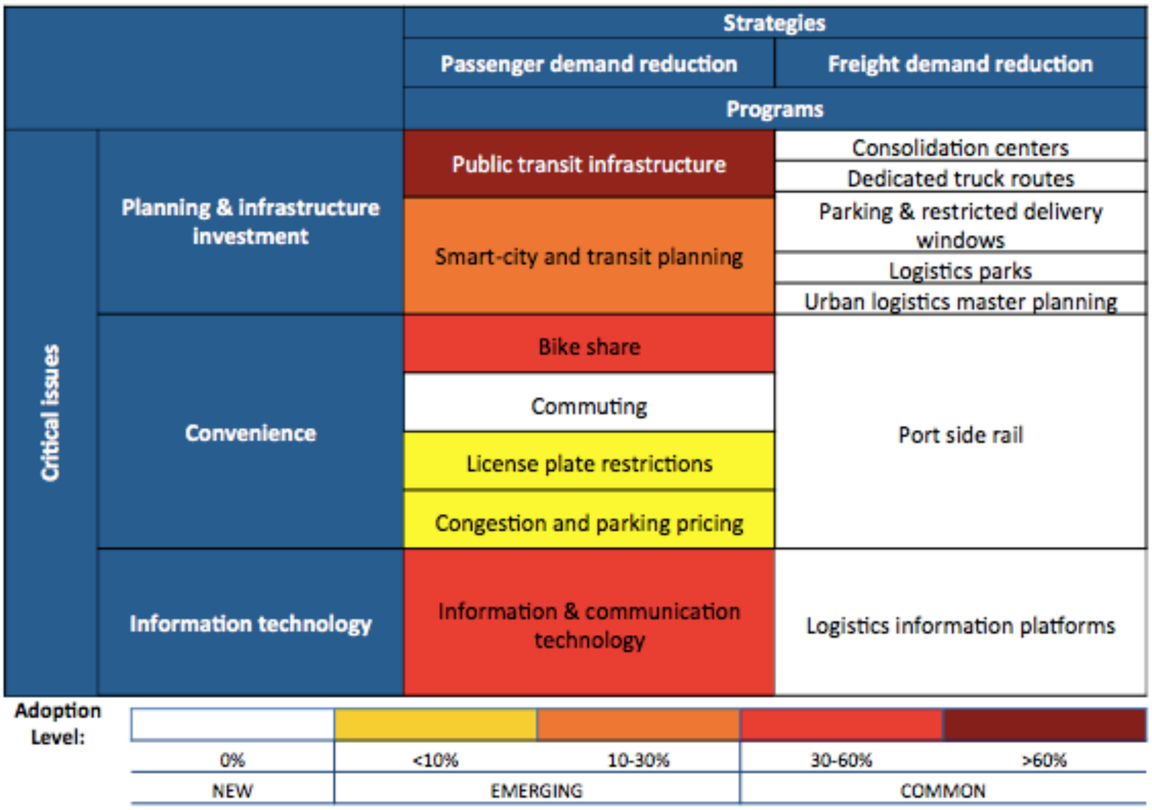
In addition to the cost of saved fuel, compact cities with reduced travel distance and lower private auto use also save on vehicle depreciation and infrastructure. Despite a higher share of trips, overall public transit travel distance may actually be reduced because of shorter trip distance in more compact cities. And the cost of transportation is lower for public transit compared with that of autos, and negligible or free for nonmotorized modes.

Improvements in freight efficiency often come with very attractive paybacks. For example, investments in IT systems to improve logistics efficiency can pay back in less than a year.

Infrastructure investments have a longer payback, but also a long useful life with large societal benefits (avoided congestion and industry competitiveness).

The critical issues are infrastructure investment and uncoordinated city planning (approving new development without considering transportation constraints or traffic-related congestion or emissions). Cities must also improve the convenience of and incentives for using more efficient modes, like rail or water instead of freight trucks or public transit, as well as nonmotorized modes instead of private autos. And information and communication technology (ICT) should be deployed to improve and streamline overall system performance.

FIGURE 3.6: TRANSPORTATION DEMAND REDUCTION PROGRAM HEAT MAP



3.3.2.1 Common Passenger Programs

Public Transit Infrastructure

Chinese cities are investing heavily in public transit infrastructure, but it has been difficult to maintain pace with rapid urbanization and growth. Many Chinese cities are building or expanding metro systems as well as implementing bus rapid transit (BRT). To overcome its limitations to securing capital for metro systems, the city of Shenzhen has implemented a "Rail Plus Property Development" model where the financing for the rail is backstopped by the increase in surrounding land value.[16]

Bike Sharing

Bike sharing programs are being implemented successfully in many cities around the world. China has been a leader, and Wuhan and Hangzhou have the two largest programs in the world, with 90,000 and 60,000 bikes respectively. Bike sharing encourages nonmotorized travel and can complement public transit if stations are located near commuter hubs.

Information and Communication Technology

Information and communication technology can be used to better manage the transportation system. It can provide real time information to improve user experience, solve real-time congestion issues, and improve predictive transit algorithms. It also allows transport planners to collect more granular data to improve transportation master planning for cities.

3.3.2.2 Emerging Passenger Programs

Smart City and Transit Planning

City design affects the average trip distance as well as the convenience of public transit and nonmotorized modes. Smart-city and transit planning principles include creating a dense network of streets and paths, investing in public transit and cycling and walking infrastructure, creating pedestrian- and transit-only zones, zoning for mixed-use to co-locate amenities and commercial buildings near residential communities, matching density with transit capacity, and preventing sprawl. Leading Chinese examples include Cheng Gong Central City Planning Kunming, Yuelai Eco-City, and Chongqing.[17]

Implementation requires long-term, integrated transportation planning. Seattle, Washington offers the leading example from the U.S. In the spring of 2015, the city introduced Move Seattle, a ten-year, $835-million initiative that integrates multiple plans for mass transit, walking, biking, and freight. Move Seattle aims to provide over 70% of residents with all-day transit service within a ten-minute walk from their homes.[18]

License Plate Restrictions

With rapid growth of car ownership and congestion in megacities like Beijing, Tianjin, and Shanghai, cities use license plate lotteries or auction regulations to limit the number of vehicles allowed on the road. Automobile energy consumption per passenger trip is three times higher than for buses, and automobiles have a 40-times larger vehicle footprint per passenger—worsening already heavy congestion in cities.[19]

Congestion and Parking Pricing

Bus tracking system are common in China and parking sensors have been implemented in parts of Shenzhen and Guangzhou, Guangdong Province.[20] To go further, Chinese cities could change parking prices based on demand, enforce parking use automatically, and allow drivers to check parking availability and price before they drive. San Francisco recently installed parking sensors in parts of downtown to implement the above three parking strategies, reducing targeted traffic by an estimated 10%.[21] Cities can also manage private auto use through congestion pricing (as done in London, Stockholm, and Singapore).[22]

3.3.2.3 Innovative Passenger Programs

Commuting Solutions

Commuting transit apps can improve user convenience (applying techniques from Didi or Uber to public transit). Cities can design their own or take a market-based approach. In a 2009 partnership with Google, Portland's TriMet became the first public transit agency to open its mass transit schedules to the public through a web-based route planner and an open application programming interface (API).[23] App developers compete to provide the most convenient user interface. Trip planning features include easy comparison of cost and speed across various modes (bike, bus, rail, taxi, etc.), real-time updates, and ticket purchasing. Use of Portland's mass transit systems increased significantly since implementation.[24]

3.3.2.4 Freight Programs

Due to a limited availability of data, a comprehensive analysis of APPC city activity on freight was not possible. Instead, a set of programs is offered below for consideration.

Parking and Restricted Delivery Windows

Many cities in the U.S. and EU have restricted delivery windows during the daytime. These programs reduce truck activity primarily by reducing idling and stop-and-go driving. The reduction of daytime truck traffic can also reduce overall urban congestion, improving the fuel efficiency of urban traffic in general.

Dedicated Truck Routes

Dedicated truck routes have a similar effect as off-peak delivery. Keeping trucks on wide roads with good traffic fluidity (without sharp corners that are difficult for trucks to navigate) can help improve traffic fluidity and reduce idling and stop-and-go driving.

Logistics Parks

Logistics parks are common in China. One of the key purposes of a logistics park is to position logistics activity near key transport infrastructure—reducing the length of truck travel in city areas. The problem is that logistics parks are often poorly planned and are built far away from transport infrastructure and industrial plants. As a result they are often underused and ineffective.

Urban Logistics Master Planning

Urban logistics master planning is a thorough analysis of freight transport activity to plan and inform infrastructure deployment such as the planning and provision of parking and loading docks. It relies on data collection and modeling to identify key areas of freight demand and estimate infrastructure needs. Master planning also determines the location of urban industrial and commercial facilities, which are key generators of urban freight activity. Ensuring that freight origination and destination sites are concentrated near high-capacity transport lines can reduce urban truck driving.

Port-Side Rail

Port-side rail can provide high-capacity connections between ports and national rail networks. This can eliminate the need for trucks to drive through urban areas from ports to rail terminals. Port-side rail also makes intermodal transportation more efficient and less expensive. By eliminating the need for short-distance truck trips between port and intermodal facilities, known as drayage, costs and container transportation times are greatly reduced.

Urban Logistics Information Platforms

Urban logistics information platforms help reduce truck activity by improving the efficiency of truck use. By matching urban trucks with urban freight, these platforms can reduce empty running by trucks and also fill partially loaded trucks. Consolidation centers are warehouses where small freight shipments coming into the city can be combined. Trucks leaving the consolidation centers for urban delivery runs are fully loaded and drive optimized routes that minimize overall truck driving.

KEY TAKEAWAYS

- Infrastructure investment and integrated transportation planning are the foundation for managing transportation demand. The rapid growth of Chinese cities and continuing trend toward private autos leaves little room for error. For passenger travel, smart growth principles can reduce trip distance and make public or nonmotorized travel more attractive. For freight, master planning can match logistics hubs to key corridors and consolidation centers to keep goods flowing smoothly within and between cities.
- Information and communication technology can help get the most out of the transportation system as a whole. Planners can monitor conditions and redirect flows, while users can plan trips and compare price and convenience for different options. Online freight markets can match empty trucks with loads.
- Cities are using license plate restrictions to reduce congestion and encourage more efficient mode choice (e.g., public transit, walking, biking). Global experience suggests congestion pricing and parking management can add flexibility to the toolkit.

3.4 LEVER 3: ENERGY EFFICIENCY

Energy efficiency emission savings are captured by programs in the industrial, buildings, and transportation sectors.

3.4.1 Industrial Energy Efficiency

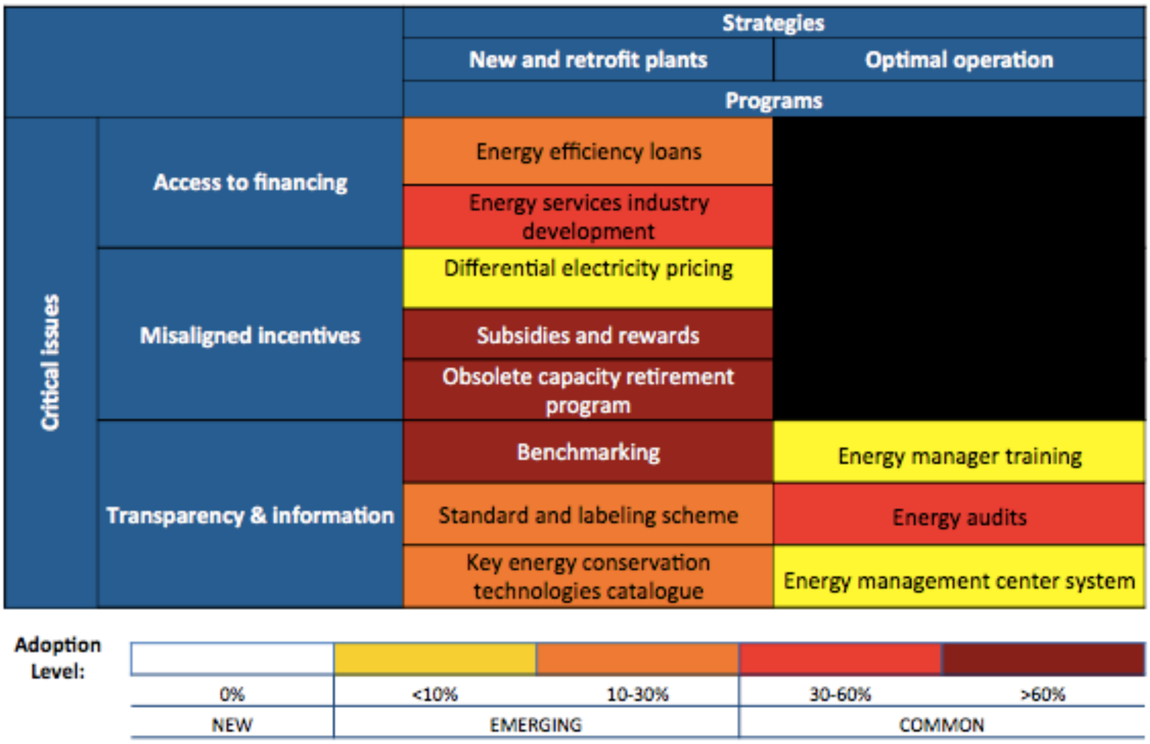
Most industrial facilities in low carbon cities must adopt all currently available commercialized energy efficient technologies—including management and control systems—to meet national and city-level goals for emissions and energy intensity. Cities can exceed these goals by employing integrative design, which connects multiple industrial processes (i.e., waste, input, and energy streams) to optimize across multiple co-located industries.

Both conventional and integrative energy efficiency improvements come from 1) increases in efficiency in new plants and facilities, and 2) retrofits of older plants with more efficient technologies and practices. All strategies must be undertaken at the facility or network level, and thus cities must work closely with industrial partners to ensure opportunities are captured through practical plant and industry operations improvements.

There are three critical issues in capturing the opportunity:

- **Access to Financing:** Many industrial energy efficiency upgrades have a high upfront cost, but will pay back over time. Securing the required capital from banks or government institutions can be challenging for small and medium-sized enterprises (SMEs), which lack the access to state funding of larger SOEs. Larger facilities must compete capital investments in efficiency with options for expansion or growth. Additionally, many facilities operating at lower capacity levels have uncertain payback periods, impairing the business case for investment.
- **Misaligned incentives:** Traditionally the success of Chinese manufacturing facilities has been measured by production – both internally and at the government level. Efficiency has not been a top priority, as facilities focused on maintaining and increasing production. To pursue efficiency, manufacturing facilities often must be incentivized to do so.
- **Energy transparency:** Top management frequently lacks information on the scale of opportunities presented by efficiency, and does not consider it a priority. A lack of data and performance transparency similarly impair decision-making at other levels of plant management, making optimization difficult.

FIGURE 3.7: INDUSTRIAL ENERGY EFFICIENCY PROGRAMS



3.4.1.1 Common Practice Programs

China's Top-10,000 enterprise program benchmarks plant performance and enables the government to recommend improvement programs for poor performers while rewarding leaders. Continuation and expansion of this program is critical to achieving national climate goals, and ongoing support by municipal governments is essential.

Subsidies and Rewards for Energy Efficiency

Programs that single out best performers and reward them for energy efficiency have helped shift manufacturing incentives from production to energy productivity as a measure of success. During the 12th Five Year Plan, the Ministry of Finance and the National Development and Reform Commission promulgated "Energy-saving Technical Transformation Financial Incentive Fund Management Measures," which provide rewards to enterprises that implemented energy-saving transformation. Complementing the Top-1,000 and 10,000 enterprises program, the Ministry of Finance established the Energy-Saving Technological Improvement Fund in 2006 to support industrial energy efficiency improvement. In 2011, funding mechanisms were modified in three ways to make it easier for enterprises to apply for subsidies. Despite this relaxation of criteria, it is still difficult for smaller businesses to obtain funding. Because the competition for limited funding is based on the amount of energy saving, this measure clearly favors larger enterprises with greater energy-saving potential. To address this issue, some cities have adjusted criteria to enable smaller enterprises to compete for the subsidies and increased overall subsidy funds.

Energy Audits

Industrial energy audits are a proven approach to reduce industrial energy consumption, with government-supported programs in both China and the U.S. underpinning a broad network of commercial and consulting activity geared to unlock the savings for industrial partners. While centralized and commercially driven approaches have proven effective in energy-intensive industries, distributed loads in small- and medium-sized businesses are more difficult to address economically. This has led to the development of increasingly nimble and often IT-enabled approaches that penetrate all segments of industry. For example, the Comprehensive Industrial Energy Efficiency Program (CIEEP) of San Diego Gas and Electric offers its industrial customers of all sizes a no-cost facility audit to identify their comprehensive energy efficiency solutions, implementation support, and the ability to track savings over time.

Development of the Energy Services Industry

The energy services industry (including energy service companies, or ESCOs) has been steadily growing in China; it offers a means for companies to gain access to funding for efficiency. ESCOs provide capital funding to industrial partners in order to pursue efficiency projects, with the payback on capital coming from the energy savings. Once the ESCO is repaid, the industrial facility can reap the benefits of savings without risking any of their own capital. The majority of financial risk is borne by the ESCO, reducing the worry about payback periods or limited capital. Currently ESCOs have limited funding in China and must pull from their own resources instead of gaining capital from banks or other financiers. Because of this, they often pursue smaller projects with shortened payback times in order to maintain their supply of capital; this also means they must frequently pursue projects with a lower return and lower energy impact. If these companies were granted additional loans or loan guarantees, it would expand their ability to help capture the existing industrial efficiency opportunity.

3.4.1.2 Emerging Programs

Energy Management Center System

Centralized energy management centers provide companies real-time information on energy use and how it compares to their peers, supporting the dynamic optimization of business performance. These programs require that companies be connected and coordinated at the city, state, or national level. The U.S. Department of Energy estimates that through the adoption of proven energy management system best practices, about 7% of total U.S. industrial energy consumption can be saved. The Superior Energy Performance Program (SEP)—developed and implemented by the U.S. Department of Energy and the U.S. Council for Energy-Efficient Manufacturing—aims to improve industrial energy efficiency at industrial facilities by implementing ISO 50001 energy management system standard. SEP is a voluntary program. It requires participating facilities to implement an energy management system based on the ISO 50001 standard and pursue third-party verification after achieving the established energy performance improvement targets.[25]

Energy Efficiency Standards and Labeling Scheme

Though appliance efficiency labeling has been a core focus of awareness building for consumers, there has been limited progress developing and labeling efficiency performance for industrial equipment. Such a program would likely have to be coordinated at the national level, but as key stakeholders, cities could help initiate and be involved in determining how these standards would be set.

Loans for Energy Efficiency

Direct loans available for efficiency projects circumvent the need for energy service companies and can frequently be an excellent investment for city governments, given their rapid payback. The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's Technology-to-Market program regularly provides loans to companies in the U.S. for efficiency applications. In this way, the government supports energy savings and industrial competitiveness.

Key Energy Conservation Technologies Catalogue

Popular at the national level but still limited at the city level, conservation technology catalogues can be coordinated with other similar cities to create repositories of information on key technologies industries should evaluate at their plants. These catalogues can also be incorporated with work in benchmarking to determine whether industries are missing economic opportunities to deploy key technologies.

Differential Energy Pricing

Increasing the price for energy at inefficient enterprises (if they use more than the benchmarked standard) creates an additional economic incentive for these groups to reduce energy use. This punitive pricing makes the financial case for efficiency evident and further rewards businesses that invest heavily in efficiency as their rates continue to decrease.

Energy Manager Training

Energy managers are educated within a facility or company to understand that energy efficiency opportunities are not just an environmental requirement, but an economic opportunity. Energy managers are trained to embed long-acting, rigorous, and systematic mechanisms around energy efficiency into their industrial processes and reap the benefits they provide. This may also provide new information on ways to pursue government programs and gain access to funding, resources, and recognition. In this way, energy managers can take charge of their own companies' financial success through access to better information on opportunities in the efficiency market. Since 2008, Energy Foundation China's China Industrial Program (CIP) has supported an energy manager pilot program in Shandong province together with Shandong Energy Efficiency Association. This has involved developing training programs and introducing global best practices to the emerging corps of energy managers in plants. The success of the pilot led to a national pilot program initiated by NDRC and NECC. The training program and training materials in Shangdong have been replicated and further improved for the national pilot program.

KEY TAKEAWAYS

- Energy efficiency has been pursued by many companies and programs in China, the most significant being the Top-10,000 program. Due to this and other programs, as well as their nature as international organizations, many industrial companies are already aware of some cost saving efficiency technologies and practices. However, due to lack of capital access and incentives traditionally favoring production over efficiency, many companies do not consider efficiency a first priority.
- Easier access to financial capital, either from firms specializing in it or in loans directly from the government, will make efficiency an economically feasible option for more companies. This is particularly true with small and mid-size companies that lack the connections some larger enterprises have to capital. If cities choose to give loans to select companies for efficiency upgrades with a strong payback, while developing a private sector of energy service companies specializing in these loans, companies can feel financially comfortable pursuing efficiency.
- Recognition at the city, state, and national level can influence companies to make efficiency a priority — singling out both best and worst performers can push companies forward. This can be achieved through audits, subsidies, rewards, and benchmarking. Any or all of these are effective tactics in convincing companies that success and prestige will be gained through efficiency, while avoiding it will lead to shame. This gives efficiency not only an economic imperative, but an imperative of esteem as well.
- Education around the technologies and practices most useful to efficiency is becoming increasingly prevalent among engineering specialists in China, but high-level executives and managers are often not aware of these opportunities. Since these individuals frequently are the ones making investment and capital decisions, engineers are more likely to go along with their word than question it. By educating these decision-makers, they are more likely to realize the advantages efficiency can bring and instruct their employees to be more diligent in pursuing it.
- Chinese cities mainly rely on regulations to control businesses. Economic or market based instruments such as differentiated pricing to phase out old, outdated facilities are top-down methods that both push out inefficient manufacturers and push the remaining manufactures towards efficiency.

3.4.2 Buildings Energy Efficiency

China's building sector must become significantly more efficient in order to meet national and city-level goals for emissions. Research suggests that building sector emissions could be reduced by over 50% by capturing cost-effective building efficiency opportunities in new construction as well as in retrofits.[26] Highly efficient new construction presents the largest opportunity due to China's rapid growth, but improving efficiency of the existing building stock also presents a significant opportunity. Cost effectiveness of building efficiency ranges from low to no cost and to long-term investments. Economies of scale can help bring down the costs of more advanced methods and technology over time.

Programs must address four critical issues to allow cities to capture this opportunity:

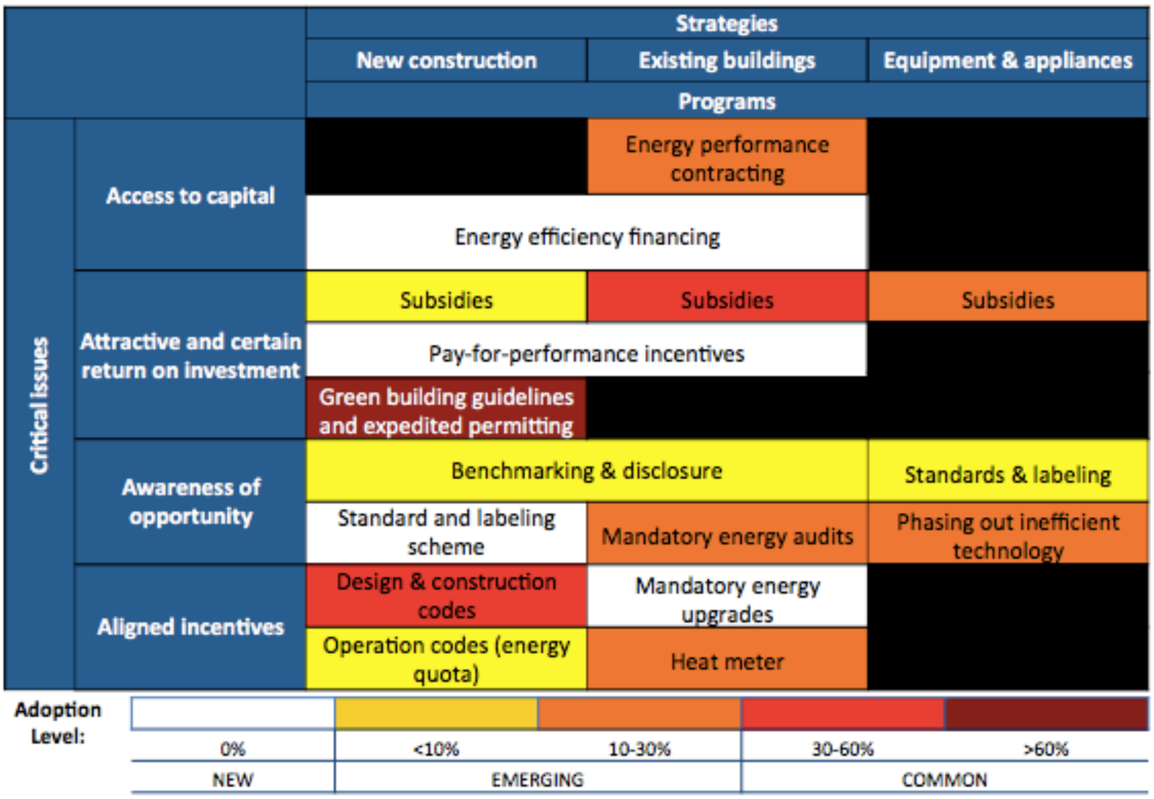
Access to capital: Many building owners do not have the capital to pay for energy upgrades. Mechanisms to enable building owners to finance energy efficiency upgrades, and also high-performance new construction, can play a critical role in encouraging building owners to capture building efficiency opportunities.

Attractive and certain return on investment: Often building owners only implement upgrades that provide a high return on investment, partly due to competing economic opportunities, but also due to a lack of confidence in energy savings projections. Increasing the return on investment and reducing associated (or perceived) risk can help spur additional investment in building energy efficiency.

Awareness of the opportunities: Building owners, occupants, and service providers need to be aware of the opportunities presented by building efficiency. In many cases, little attention is paid to building energy use in both existing buildings and during the design of new buildings, resulting in many missed opportunities.

Alignment of incentives: Split incentives occur where a party benefiting from an investment is separate from the investor. Many building tenant-landlord relationships result in a split incentive, as the landlord owns the building and equipment but the tenant is responsible for paying the energy bill. Alternatively, if a customer is charged a flat rate for heating, they are not incentivized to reduce their consumption. Aligning incentives is critical to enable building efficiency to scale.

FIGURE 3.8: BUILDING ENERGY EFFICIENCY PROGRAMS



3.4.2.1 Common Practice Programs

Common practice programs in China include city-mandated energy codes, green building guidelines, and expedited permitting.

City-Mandated Energy Codes: Stringency and Compliance Paths

A number of Chinese pilot cities have issued their own building energy codes mandating higher levels of efficiency than required nationally. For example, in 2013, Beijing mandated that residential buildings reach an energy savings target of 75% below 1980 efficiency levels, and in 2015, the city issued a revised energy code—higher than the national level—to improve the energy efficiency standards for public buildings. Baoding and Qingdao also have city-level energy codes.

In addition to stringency, compliance paths are also an important consideration when implementing advanced energy codes. A prescriptive path requires meeting specific design measures and component-level performance values, which can help bring costs down by standardizing technologies required in the market. Alternatively, the performance-based approach requires whole-building energy simulation to show a building complies with the targets. This option allows more flexibility to designers to choose the most cost-effective way to achieve city-level targets for building performance, but typically requires a deeper level of expertise in the building industry. Although China's national building energy code has both a performance-based compliance path and a prescriptive path, the performance path is rarely used.

In the U.S., building codes have proven to be an effective driver of energy efficiency in new construction, and many U.S. cities are adopting their own more stringent energy codes as a key component of their climate action plans. Several leading cities with ambitious climate action goals are moving away from the prescriptive compliance path and requiring design teams to use the performance path to demonstrate their building's performance relative to national standards. Examples in the U.S. include Boulder, Colorado, which requires buildings to exceed typical national standards by 30% and requires buildings to go through the performance compliance path for all buildings larger than 2000 square meters. Other U.S. cities, such as Seattle, have created a prescriptive option that meets their targets, but allow both compliance paths.

City-Mandated Energy Codes: Compliance and Enforcement

Compliance is critical to achieving impact through energy codes. Although compliance rates at the design stage are very high in larger cities in China, they are reportedly low in smaller cities and urban areas.[27] In addition, compliance rates at the construction phase are considerably lower, and like most building energy codes throughout the world, actual operational energy consumption is not regulated or evaluated.

Compliance and enforcement requires significant investment, and also adequate training for inspectors and industry. For example, New York City's code compliance office has an annual budget of $96 million, which normalizes to $54 per $1,000 of residential construction activity, and equates to approximately 0.1% of the city's overall budget. The city of Boston's building code department has an annual budget of $16 million, which normalizes to approximately $15 per $1,000 of residential construction activity, and equates to less than 0.1% of the city's overall budget.[28]

Streamlining compliance checking through software can help increase compliance rates and lower the cost of enforcement. The U.S. Department of Energy created two compliance software programs, COMCheck and RESCheck. These tools help streamline the compliance evaluation process for individual buildings, help ensure consistency, and help increase actual compliance rates by making it easier for both design teams and code enforcers to understand code requirements.

Cities with lower compliance rates can increase their impact through increasing investment in compliance and enforcement. Leveraging software solutions can help increase compliance rates while reducing costs.

Good compliance at the design and construction stages is a critical step, but does not ensure that actual building energy will align with the intentions of the code or specific climate action goals. International best practices (at the city and national levels) are shifting towards outcome-based energy codes, where building energy use is regulated based on actual measured data.

A number of Chinese cities are piloting the Chinese Energy Quota standard, which sets clear targets for energy consumption for buildings, but current compliance and enforcement is not well established. There may be opportunities for Chinese cities implementing the Energy Quota to learn from other international experiences such as that of Sweden and the City of Seattle, Washington.[29]

INNOVATIVE PROGRAM HIGHLIGHT

Sweden's Outcome-Based Code

Sweden is one of the first countries to use an outcome-based energy code. Sweden's code sets mandatory targets for building energy use excluding plug loads. These targets vary across three climate zones and include residential and commercial buildings. Electrically heated buildings must have a separate more stringent target. The targets are shown below, and do not include occupant loads such as appliances.

FIGURE 3.9: SWEDEN'S ENERGY CODE REQUIREMENTS IN 2011 (KWH/M2/Y)

Climate Zone (North to South)	I	II	III
Residential – nonelectric heat	140	120	100
Commercial – nonelectric heat	150	130	110
Residential and Commercial – electric heat	95	75	55

Compliance is checked at the design stage based on design calculations, and then again based on measured energy data after 24 months of operation.

Green Building Guidelines and Expedited Permitting

Many peaking cities in China are working to promote green buildings through several mechanisms: 1) requiring that all municipal buildings meet green building rating systems, such as the Ministry of Housing and Urban-Rural Development's (MOHURD) Green Building Evaluation and Labeling Program and Building Efficiency Evaluation and Labeling Program; and 2) establishing demonstration districts. Examples include Shenzhen's regulations for government buildings and Beidaihe's National Green Energy Demonstration districts.

Similar efforts are prevalent in leading U.S. cities. Common best practice programs include requiring government buildings to meet green building standards or guidelines such as LEED, and providing incentives to any buildings that meet these standards. This has helped create demand for LEED and has helped to increase best practices. One key strength of the LEED rating system is that it requires third-party verification. This approach builds trust in the market in the rating, an essential prerequisite for green building rating systems to translate into market value. Cities can increase their impacts in this area by pushing for green rating systems to adopt third-party verification.

3.4.2.2 Emerging Programs

Energy retrofit programs, energy data disclosure programs, and heat metering are less common but have a high potential for impact in China.

Energy Retrofit Programs

Energy retrofit programs in Chinese cities have mainly focused on providing incentives. Examples include Huai'an's public building retrofit program focused on building envelope upgrades and heating systems, and Urumqi's residential energy efficiency retrofit projects. Making energy retrofit programs mandatory could increase their effectiveness. In the U.S., Austin, Texas requires energy upgrades for poorly performing multifamily residential buildings, and several cities in California require basic prescriptive energy upgrades at the point of sale.

Energy Data Disclosure

Energy data disclosure programs in China involve monitoring building energy consumption in all government buildings and large public buildings. Notable examples include Qingdao and Guiyang. Making this data publically available can make these programs more effective as this allow services providers to identify potential upgrade opportunities and new markets for product development. It also enables energy information to be taken into account in real estate business decisions.

Heat Metering

Heat metering is used to measure consumption of district heating resources. Many buildings in China that are connected to older district heating systems pay a fixed fee for heat and are not metered. Retrofitting heat meters enables district heat providers to charge customers for the amount of energy used. This incentivizes building owners or occupants to reduce their consumption.

Energy Performance Contracting and Energy Service Companies

Energy performance contracting (EPC) overcomes the issue of access to capital by paying for energy upgrades through energy savings. A building owner pays for the upgrades over time with money that otherwise would have been spent on energy. Suzhou has implemented over 100 EPC projects. This business mechanism is currently not well established in China and presents a considerable market opportunity for driving energy and carbon savings. at least in government and institutional sectors, where it has been successful in the U.S.

3.4.2.3 Innovative Programs

Two critical areas where there are opportunities to evolve China's programs are building efficiency finance and incentives delivered based on verified energy performance.

Pay-for-Performance Programs

Pay-for-performance programs incentivize building owners to save energy based on actual measured performance relative to a specific target (typically 15% energy reduction). Buildings meeting the savings target are paid for each verified kWh reduction, creating a win-win profit dynamic for developers and contractors alike while helping meet utility efficiency targets that can help drive market transformation.

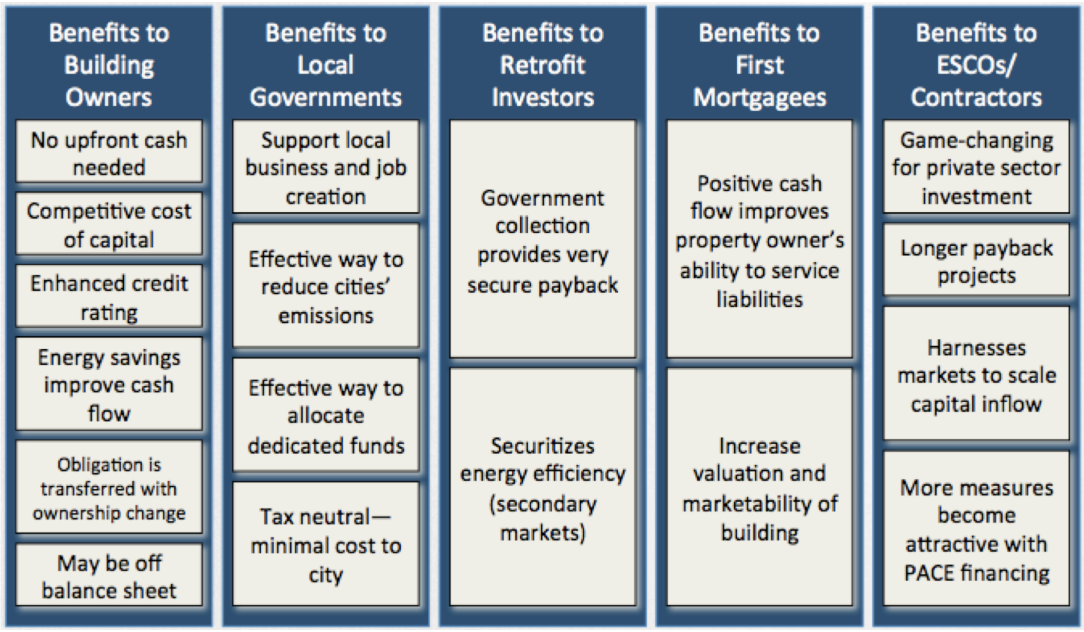
INNOVATIVE PROGRAM HIGHLIGHT

Property Assessed Clean Energy Financing

Property assessed clean energy (PACE) financing programs allow for financing of up to 100% of an energy project cost and a repayment term of up to 20 years via an assessment added to the property's tax bill. PACE financing can stay with the building upon sale. PACE can also be used to fund additional incremental efficiency and renewable costs in new building developments. PACE is well proven in the U.S., with Connecticut and California leading the way.

Because Chinese cities already collect commercial property taxes and will soon collect residential property taxes based on upcoming reforms, PACE has a strong potential for success in China. If implemented in a coordinated way among cities, PACE in China could become more standard than in the U.S. However, being able to secure financing at scale in China is dependent on the ability of cities to collect property taxes.

FIGURE 3.10: PACE FINANCING BENEFITS



Adapted from Johnson Controls, Property Assessed Energy Financing Benefits and Barrier Busting

INNOVATIVE PROGRAM HIGHLIGHT

Seattle Pay-for-Performance Program, Seattle City Light, Seattle, Washington

Seattle City Light, a local utility serving Seattle, Washington, and owned by the city, has been piloting an innovative approach to incentivizing energy savings; incentives are provided based on verified savings rather than estimated savings associated with individual measures. Building owners are given the flexibility to choose the best way to save energy rather than being held to a prescriptive approach. Once a building's energy savings exceed a minimum threshold, often 15%, the building owner is paid for the savings. Seattle's initial pilot issued a payment of $0.03/kWh for the lowest threshold of savings, and escalated this value for larger savings. This program allows the utility to tap into the cheapest source of energy—energy savings. Seattle will be rolling out this program at scale in 2016.*

KEY TAKEAWAYS

- Implementing building energy "stretch codes" and programs promoting green buildings are already part of many APPC cities' peaking efforts.
- Chinese cities may be able to enhance current efforts in these two areas by incorporating international best practice code enforcement, implementing and enforcing an outcome-based code, and requiring third-party verification for energy labeling.
- Ensuring compliance is critical to achieving building sector goals, and therefore warrants significant investment. Smaller cities show room for improvement on design compliance, and all cities should consider expanding compliance efforts beyond design into construction and operation (including outcome-based codes).
- Several emerging programs show a high potential for impact based on international experience: energy data disclosure, energy retrofit, heat metering, and energy retrofit programs. These programs can help kick-start market demand for energy efficiency by aligning financial incentives, highlighting new opportunities, and helping build industry capacity to meet new demands for building efficiency.
- PACE financing and pay-for-performance incentive programs are currently addressing the critical issues facing the U.S. buildings sector, such as access to capital and misaligned incentives. PACE has been highly successful in the U.S. at enabling access to capital. Pay-for-performance, although still emerging in the U.S., shows significant promise for driving verified energy savings.

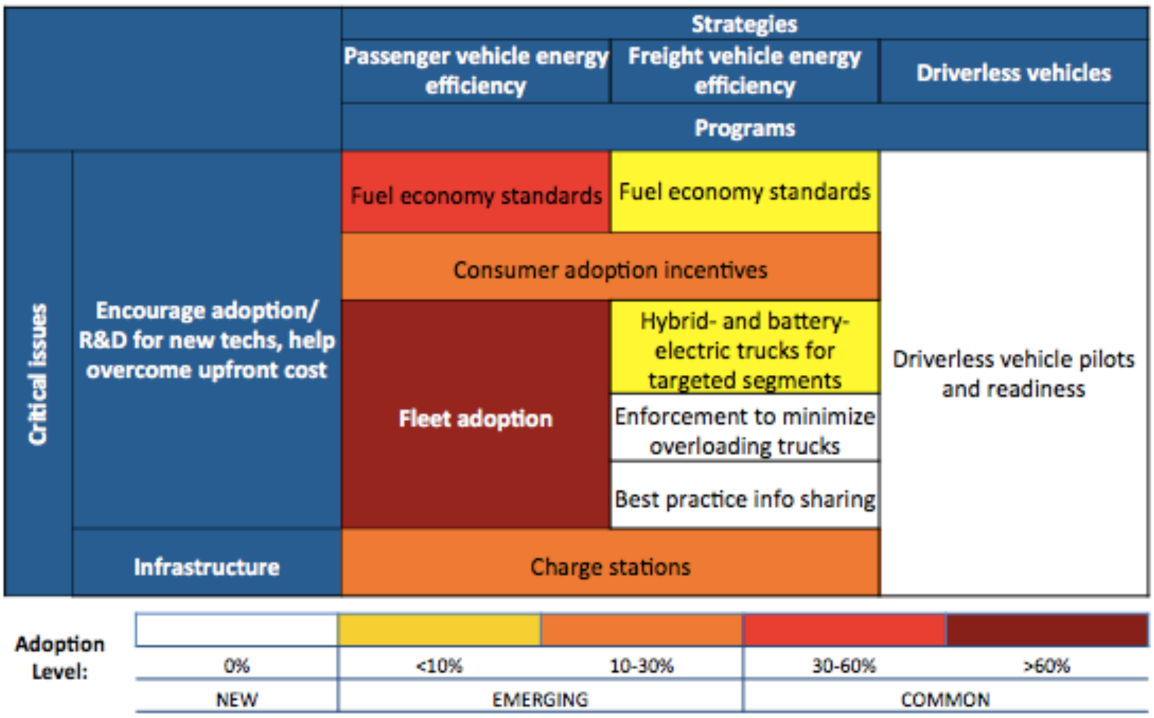
3.4.3 Transportation Energy Efficiency

Energy efficiency improvements in transport span both passenger and freight travel. Urban passenger energy use and emissions can be reduced through improved tires and aerodynamics, reduced weight, advanced engine and transmission upgrades, automatic start-stop at idle, hybrid electric vehicles and plug-in or pure electric vehicles (EVs). Trucks are a major contributor of transport emissions in China, predominantly in long-haul trucking. Freight movements are a smaller source of urban emissions than passenger transportation, but produce large negative externalities, particularly air pollution.

Upfront cost pay back with fuel savings during operation. At current energy prices, simple paybacks range from about one year to over ten years for today's EVs. However, EV cost has been falling rapidly, and this trend is expected to continue, with a projected three-year payback by 2025, even with today's low oil prices.

The biggest challenge for capturing this opportunity is stimulating demand for new technologies and overcoming upfront cost. Unfamiliar technologies come with reliability questions, uncertain performance, or simply a lack of awareness. Furthermore, some key technologies have not yet reached cost maturity due to their small scale. Electric vehicles also require investment in charging infrastructure.

FIGURE 3.11: TRANSPORTATION ENERGY EFFICIENCY PROGRAMS



3.4.3.1 Common Practice Passenger Transportation Programs

Fleet Adoption

China has also used fleet adoption to stimulate demand by purchasing new energy vehicles (NEVs) for municipal, taxi, and other large fleets. Shenzhen has more than 850 electric taxis and electric buses. Indianapolis, Indiana, is a leading example in the U.S., with more than 200 EVs in use through an innovative public-private leasing partnership. The city will pay a total of $32 million over the seven-year lease, saving $8.7 million relative to its current fleet spending. Indianapolis' EV car-sharing program will be the largest in the country, with 1,000 EVs available for rent.[30] Pilots for car renting also exist in Hangzhou and Kunming.

3.4.3.2 Emerging Passenger Transportation Programs

Electric or NEVs offer the biggest savings potential with energy per distance traveled reduced by around two-thirds and no tailpipe emissions. Chinese NEV programs have gained traction, with more than 100,000 vehicles sold in 2015, more than double compared with 2014. Key policies include financial incentives (to be phased out by 2020) and exemption from license plate lottery/auctions. China has set a target of 5 million NEVs on the road in 2020.

Consumer Adoption Incentives

California is leading the way in the U.S. by combining consumer incentives (including nonfinancial) with a market-based mandate. It is one of 31 states offering financial incentives in addition to those at the national level. It also offers popular nonfinancial benefits for low- and zero-emission vehicles, including access to carpool lanes and preferred parking. Consumer incentives are combined with an automaker mandate. Starting in 2017, in order to sell automobiles in California, manufactures are required to sell an increasing share of zero-emission vehicles, rising to 15% by 2025. The program is flexible and market oriented: hybrid or plug-in hybrid electric vehicles can make a partial contribution toward compliance, and manufacturers who exceed or fall short can buy and sell credits.[31]

Charging Infrastructure

Lack of charging infrastructure can also limit EV adoption. China aims to have 4.8 million charging stations by 2020, but missed its 2015 target of 400,000. In the U.S., early adopters have mostly relied on overnight charging at home, but this is less applicable in China where private garages are rare. California recently approved a proposal for the electric utility to begin installing charge stations, although for only 1,500 stations initially. These will add to those available from subscription network operators and automakers like Tesla and Nissan.

3.4.3.3 Innovative Passenger Transportation Programs

Driverless Vehicles

Although uncertainty remains about the future of driverless vehicles, technological progress and investment have accelerated greatly over the past five years. Some features, like automated parking and adaptive cruise control are already available, and many experts predict fully autonomous vehicles will be on the market in the next five to ten years.

In China, Baidu recently announced a partnership to deploy driverless cars in Anhui Province, Wuhu. These cars can connect with other vehicles and infrastructure to optimize driving for efficiency and safety, and to reduce traffic congestion. In the longer term, experts predict that driverless taxis will beat privately owned autos for both cost and convenience, winning over the majority of the market. This could accelerate electrification and allow vehicles to be better tailored for their exact use (e.g., size, top speed, and range). Energy and emissions could be reduced by over 90%.[32] Implemented across the U.S., it is estimated that this could save $1 trillion and 2 billion barrels of oil annually.

The U.S. Department of Transportation recently announced a program called Smart City Challenge, which will provide up to $40 million to one city for becoming "the country's first city to fully integrate innovative technologies—self-driving cars, connected vehicles, and smart sensors—into its transportation network." Austin, Texas, is one of seven finalists for the Smart City Challenge. Key components of the city's proposal include: piloting connected and autonomous vehicles while integrating with public transit and car sharing, fleet electrification, infrastructure sensors, and packaged mobility service.[33]

3.4.3.4 Emerging Freight Transportation Programs

Hybrid and Electric Trucks for Targeted Market Segments

Hybrid and electric trucks for targeted market segments are an emerging opportunity area for energy efficiency in urban freight. The business case for hybrid trucks is highly dependent on their duty cycle. Trucks that begin and end the day at a fixed location, drive primarily in stop-and go-traffic, spend a significant amount of time idling, and have large auxiliary power demands tend to have short payback periods for investments in hybrid or electric drivetrains. In the U.S., fleets like couriers and express delivery trucks, garbage trucks, utility bucket trucks, and drayage trucks are areas where hybridization and electrification are emerging. Plug-in electric hybrids and pure electric trucks require charge stations to charge batteries when the trucks are not operating. This problem is easier for trucks than passenger vehicles because the trucks typically return to a yard or depot at the end of the day, and charging stations at those depots are generally enough to serve hybrid and electric trucks.

Best Practice Information Sharing

Since freight transportation is a commercial activity and truck purchases are an investment, a particularly high focus is put on the cost-effectiveness of fuel efficiency gains. Best practice information sharing is a key way to inform truck buyers of payback potential of efficiency technologies. In the U.S., NACFE provides analysis of the business case for truck fuel economy. Other organizations like Calstart's Hybrid Truck User Forum (HTUF) provide similar analysis for the business case for hybrid and electric trucks. The business case for hybrid and electric trucks can be enhanced by consumer adoption incentives, which lower the cost of ownership of those vehicles. For example, the California Heavy Duty Voucher Incentive Program (HVIP) provides subsidies for the purchase of electric and hybrid trucks in market segments where the business case is near maturity.

3.4.3.5 Innovative Freight Transportation Programs

Driverless Vehicles

Similar to passenger vehicles, driverless vehicles are a new frontier in freight transportation. Driverless trucks could be programmed to be flawless "eco-drivers" operating the truck in the most efficient way possible. Furthermore, driverless trucks can be grouped close together in convoys, which greatly reduces the aerodynamic drag and fuel consumption. Finally, driverless trucks have the potential to reduce trucking costs by eliminating the need for drivers. Trucks without drivers would not be subject to hours or service limitations, increasing annual use and, therefore, enhancing the business case for efficiency improvements. A successful pilot of automated trucks has already been carried out in Europe, where a convoy of self-driving trucks from the Netherlands and Sweden successfully drove to Rotterdam.

KEY TAKEAWAYS

- Cities can combine incentives (including nonfinancial), mandates, and other programs to stimulate demand and overcome upfront cost for new and energy-efficient vehicle technologies.
- Electrification is a key technology for improving transportation efficiency and reducing emissions, and developing charging infrastructure is a critical enabler for Chinese cities.
- Driverless vehicles could create major disruption. They offer huge potential for energy savings, improved safety, and reduced traffic congestion, but they also bring important challenges and infrastructure uncertainty. Chinese cities should work to understand and guide implementation.

3.5 LEVER 4: DECARBONIZATION

Decarbonization emission savings are driven primarily in the power sector (which includes industrial power systems) and opportunities in district heating.

3.5.1 Power Decarbonization

The power sector must replace coal and natural gas generators with distributed and grid-scale renewable energy. Because high penetration of renewable energy introduces more variability in power generation, a third element of power sector decarbonization is demand flexibility to better integrate renewables. Research supports scenarios where two-thirds of a city's electricity could come from renewable energy sources by 2050.[34]

Unsubsidized utility-scale renewables are not yet cost competitive with thermal assets in most of China. However, distributed renewables are or will soon be cost-competitive in many key Chinese cities (due to higher retail rates). Demand flexibility is currently not compensated in most of China, and therefore not cost effective by market signals, but depending on local infrastructure may be valuable.

There are three critical issues in capturing the opportunity:

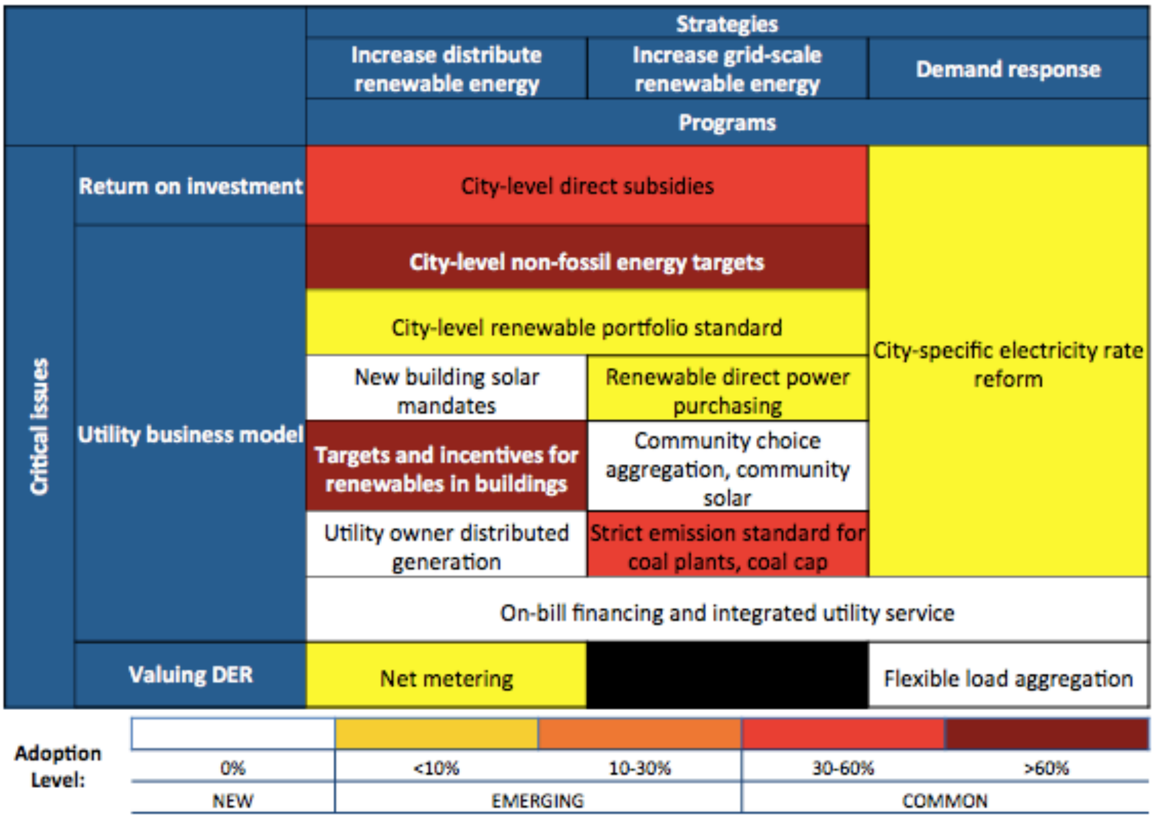
Return on Investment: Utility-scale renewables are not yet competitive with coal-fired generation. Building owners are often not willing to pay high upfront costs for distributed renewables. Demand flexibility is not currently compensated, resulting in under investment.

Utility Business Model: Under the current system, the growth of distributed renewables or energy efficiency results in decreased utility sales. Without adequate compensation reform or price differentiation, utilities are disincentivized to promote distributed renewables. Additionally, current wholesale and retail pricing does not reflect the real-time cost of generation and transmission. Therefore, utilities are not motivated to deploy demand flexibility to increase system utilization efficiency and reduce cost.

Value of Distributed Energy Resources: The current power pricing mechanism does not appropriately capture the external costs and benefits of renewables and demand flexibility for the grid. For example, flexible and inflexible generators are compensated with the same electricity price. Additionally, environmental costs are not considered. Accordingly, renewables and demand flexibility are not properly compensated.

China's March 2015 power sector reform created two major opportunities for increased renewables and demand flexibility adoption. First, retail sales will be decoupled from traditional transmission and distribution utilities. New retail companies allow diverse stakeholders to enter the retail market. Second, two interprovincial and a dozen of intraprovincial power transaction centers were established in the past few months, enabling direct power purchasing between generators and large customers.

FIGURE 3.12: POWER SECTOR DECARBONIZATION PROGRAMS



3.5.1.1 Common Practice Programs

Common practice programs in China are non-fossil targets, renewable portfolio standards, coal emissions standards and coal cap, and direct subsidies for renewables.

Non-Fossil Targets and Renewable Portfolio Standards

China has established national non-fossil targets, which have been allocated further to each province. Local development and reform commissions (DRCs) are responsible for meeting these targets, which consider all primary energy use. Renewable Portfolio Standards (RPS), also established at the national level, are linked to the non-fossil targets, but focus specifically on driving renewable energy uptake in the power sector. The current RPS (in its public comment period) specifies a non-nuclear or hydro share of renewables generation for each province. All provincial targets currently exceed 7% renewables by 2020. Several low-carbon cities also have set their own targets.

An RPS focuses on implementation by assigning targets to each generator company. It is not certain yet whether the RPS will be legally binding, but given the national government's close involvement with investment and operation decisions for the grid, legal repercussions are not as critical as they might be in the U.S.

To help support an RPS, renewable energy certificates (RECs) are given to renewable generators for every verified unit of electricity produced. These generators can sell the RECs (along with their electricity) to end users or electric retailers. Generator companies then pass the certificates to some form of regulatory body to demonstrate their compliance with their regulatory obligations.

RECs help standardize the accounting for renewable energy generation and provide an economically driven alternative to the top-down mandates allocated to each province. RECs allow provinces where renewable energy might be less economic to meet their RPS by buying RECs from other provinces that exceed their RPS's. A REC program is currently being explored in China, and APPC cities should look to be involved in early pilots.

International REC programs have been moderately successful, but the price for RECs has often been too low to produce the intended scale of change. More aggressive RPS's have helped stimulate the demand (and price for RECs), further boosting the economics of new renewable energy projects.

Cities can further this trend by instituting an RPS on large power consumers. Coupled with new renewable procurement mechanisms (interprovincial transaction centers and direct purchasing), corporate RPS and corporate sustainability targets can create new demand for renewables. In the U.S., corporate off take accounted for approximately 40% of new renewable capacity in 2015. Energy efficiency goals could also be tied to any RPS (and certified as discussed in 3.1.1) to ensure efficiency is emphasized as a more economic alternative to procuring new RE.

Emissions Standards for Fossil-Fuel Generators and Coal Cap

Emissions standards for fossil-fuel generators exist at the national level in China, focusing primarily on criteria pollutants (i.e., SO_2, NO_X, and PM). It requires strict compliance in eastern provinces but serves as recommendation for developing provinces in western China.

Many major Chinese cities have implemented stricter emissions standards for coal plants than the national standards, and in the case of Beijing, have forbidden most coal-fired power plants within city limits.

However, there is often no effective reporting and monitoring system in place to ensure enforcement. Noncompliant actors should be fined or closed. In the U.S., the Environmental Protection Agency is responsible for regulating and overseeing enforcement of the Clean Air Act's Mercury and Air Toxics Standards. This has resulted in the installation of emissions scrubbers and the expected retirement of anywhere between 25 GW to 60 GW of coal-fired capacity.

Several low-carbon cities have set caps for coal consumption or strict emission standards for coal plants. Hangzhou has been enforcing upgrades and shutting down obsolete plants. Wuhan set the coal consumption in 2017 to the same level as the one in 2012 in its "Wuhan's Action plan on improving air quality (2013-2017)."

Direct Subsidies for Renewables

Low-carbon cities have adopted various forms of incentives and subsidies for distributed renewables. Hangzhou initiated a demonstration district for distributed PV and PV installation pilot programs in rural areas. Baoding has built over 200 MW of rooftop solar, some of which is integrated with energy storage. Feed-in tariffs are a common subsidy for both distributed and grid-scale renewables. They are designed to accelerate investment in renewables by offering a price premium for that resource until it becomes cost competitive. This is accomplished by entering into long-term contracts with renewable energy producers where the contracted price enjoys a premium relative to wholesale prices. The programs often include some form of a "tariff degression" (where the tariffs for new projects decline over time) to spur continued innovation and cost reduction. This policy tool was implemented in the U.S. in 1978 through the Public Utility Regulatory Policies Act and has resulted in significant wind capacity development.

Feed-in-tariffs have been implemented at the national level in China as the financial incentive to increase both distributed and grid-scale renewable adoption. Some low-carbon pilot cities, such as Hangzhou, have a city-level feed-in-tariff as well, but generally city-level implementation is still limited.

3.5.1.2 Emerging Programs

Emerging programs in China include direct power purchasing, time-based pricing, and net metering.

Renewable Direct Power Purchasing

Direct purchasing represents a way for cities to get involved with corporate renewables procurement. The new transaction centers in China, coupled with virtual purchase power agreements (PPA) contracts, can serve as a mechanism for corporations to purchase renewable power and reduce renewables curtailment, which is a major problem in some parts of China. For example, Jinchang helped renewable generators sign contracts with ferroalloy and petrochemical plants, as well as new materials, new construction, and retrofit programs, which mitigated renewable curtailment while reducing the production cost of the industrial companies. Going one step further, cities can encourage such corporate purchasing by instituting a corporate renewable portfolio standard where corporations are required to purchase a portion of their power from renewable generators.

Time-Based Pricing (Including Time-of-Use, Critical Peak and Locational Marginal Pricing, and Demand Charges) with Enabling Technology

There are many variations of energy rate structures to incentivize/disincentivize power consumption during specific times of day. While much of China has static time-of-use pricing, it does not have dynamic time-of-use pricing. As electric vehicles become more common on the grid, the potential to "flex" distributed resources will become more dynamic. Establishing utility programs that distribute the necessary technologies, including advanced metering infrastructure and controllable equipment such as electric vehicles, air conditioners, hot water heaters, etc., must be paired with establishing rate structures and contracts that enable the utility to access sinks or curtailment resources when necessary. Puget Sound Electric in the Pacific Northwest has launched an electric vehicle charging program using time-of-use rates to incentivize electric vehicle charging at specific times of day.

Net Energy Metering

Net energy metering (NEM) is a policy tool that allows consumers who generate their own renewable energy to sell excess power back to the grid while drawing power from the grid when necessary. NEM involves compensation rates that vary among different regions, ranging from the same price level as the wholesale rate to the retail rate for consumers. NEM has played a major role in the U.S. in catalyzing the adoption of renewables as it creates a revenue stream for the panel owner, reducing the net cost of the asset.

3.5.1.3 Innovative Programs

Innovative programs that may apply in China are new-building solar mandates, utility-owned distributed generation, on-bill financing, community choice aggregation, and community solar to address the utility business model critical issue; and flexible load aggregation to address the value of distributed energy resources.

New-Building Solar Mandates

Solar mandates can be included in new building codes. This could be applied to all new residential and commercial developments. Installing distributed solar on new builds is the cheapest form of solar development with the exception of utility-scale solar, because new construction can be cost-effectively predesigned for solar installations.

Solar mandates would work well for cities where renewable energy subsidies are already in place and the market is relatively mature. For example, two cities in California have implemented this mandate as a way to require distributed renewable energy when it costs the least to implement: during building construction.

Utility-Owned Distributed Generation

Distributed generation (DG) owned by large-scale utilities is an emerging trend in deregulated markets in the U.S., and it could potentially eliminate the conflict interests between utilities and DG owners (traditionally customers), as the revenue generated by DG can now be shared between utilities and customers. In this program the renewable resources can be in front of the meter or behind the meter.

In front of the meter, the utility purchases a portfolio of distributed systems to be located on commercial or residential rooftops. Participants in the program simply receive some form of compensation for the use of their rooftops (monthly credit or a net metering) and still purchase electricity in the traditional fashion from their utility. In a behind-the-meter model, the utility-owned distributed resources could include solar PV, smart inverters, storage, and flexible loads (appliances and HVAC). This allows the utility to have complete control over the resource. Such a program is structured similar to a demand response program and requires more complex metering and rate structures. Behind-the-meter systems enable increased load flexibility and dispatchability, whereas front-of-the-meter systems are simply distributed generation that do not impact the load profile of the buildings on which they are situated.

Either of the programs described above could be offered in an integrated utility service menu as an alternative to residents owning their own PV systems. Under both wholesale and retail market reform in China, distributed renewable developers with generation assets can combine generation with retail business, and harness the full value from all sorts of demand-side distributed resources by coordinating both generation and demand.

Community Choice Aggregation

Community choice aggregation (CCA) is a system for local governments in the U.S. to aggregate demand to procure power directly. Under this system, the local utility remains responsible for the transmission and distribution of power, but is no longer responsible for energy purchasing. Instead, the local community purchases power in bulk, and often times the local community will favor a portfolio with a higher percentage of renewables. Several cities and counties in California, including Marin, Sonoma, and San Diego, are running CCA programs. Overall CCAs in California have seen 5–10% lower costs of electricity generation than the incumbent utilities, with much higher renewables percentages. This CCA mechanism can be a reference for the emerging retail company business model in China.

Community Solar

In several U.S. states, residents can buy electricity from shared solar systems located a few miles away from their homes. Under a regulatory framework called virtual net metering (VNM), every kWh produced by the shared solar system is credited directly to the bills of individual customers. Although the total installed shared solar capacity was only 66 MW by end of 2014, analysts expect more than half a GW of community solar will be installed annually by 2020. Under current regulations, community solar is not viable in China, but with growing penetration of renewables and the reform moving forward, it could be possible in the near future. Meanwhile, retail companies can act as the intermediaries to aggregate demand to match solar supply.

Flexible Load Aggregation

Demand flexibility uses communication and control technology to shift electricity use across hours of the day, while delivering end-use services (e.g., air conditioning, domestic hot water, electric vehicle charging) at the same or better quality. This is achieved by applying automatic control to reshape customers' demand profile continuously in ways that are invisible or minimally affect the customer, and by leveraging more granular rate structures that monetize demand flexibility's ability to reduce costs for customers and the grid.

Aggregating demand flexibility can create additional value. EnerNOC, the United States' largest demand response provider, has aggregated controllable electricity demand from U.S. industrial sites, bidding this into electricity markets as a resource. OhmConnect, an energy use behavioral management platform, bundles electricity use from home owners who give the platform control of their thermostat or electric vehicle charger, and sells the flexibility into California energy markets, passing on most of the value to end customers.

The current power market in China does not provide opportunities for flexible load to directly participate in the energy market, but moving forward with the power sector reform, it might be possible to establish capacity markets and/or provide direct compensation for flexibility resources.

INNOVATIVE PROGRAM HIGHLIGHT

On-bill Financing and Integrated Utility Services Model

On-bill financing allows a utility to finance energy efficiency upgrades or renewable energy systems for a property, which customers then repay through their monthly utility bill. The upfront capital can be provided by a third party or the utility. It is recommended that any program be structured as a transferable tariff that a subsequent building owner can assume. If the customer does not pay his or her bill, then power is cut off. This cut-off ability results in lower default rates and improves contract enforceability, which is critical in China since credit ratings and civil courts are uncommon.

The integrated utility service model (IUS) is a new utility business model where packages of bundled energy efficiency and solar are extended to all customers in order to overcome upfront capital cost barriers to renewable energy adoption, while stabilizing the utility's business model. Measures are paid back through regular monthly payments on the customer's utility bill. Deeper efficiency and renewable energy upgrades can be made when a program is set up to enable longer financing terms and transferability of the on-bill tariff. This offering can be made to both residential and commercial customers.

The IUS model is currently being piloted by Fort Collins Municipal Utility in Colorado for single family homes, through a program called Efficiency Works – Neighborhood. The pilot will integrate solar PV offerings with efficiency measures for single family households through on-bill financing. This program is one of the key actions the City is taking to meet its aggressive goals of 80% emissions reductions by 2030 (from a 2005 baseline), one of the most aggressive city climate action goals in the nation.

KEY TAKEAWAYS

- Power sector reforms and programs are best driven at national or regional levels, but city-level policies can support top-down initiatives by leveraging consumer demand for clean energy and political pressure to restrict coal-fired generation. An example of restricting coal-fired generation is Wuhan's coal-cap and emissions standards.
- Absent incentives, on average the economics of distributed and utility-scale renewables is close to, but not quite at, grid parity. Cities can stimulate production via subsidies (e.g., FIT) or mandates (e.g., RPS) and also look to demonstrate advantageous situations that have favorable integration economics.
- Similarly, flexibility (demand and generation) is critical to integrating variable renewables, but is not currently compensated. Cities can promote flexibility via adjusting the utility business model (time-based pricing, integrated utilities service) or promoting new retail company business models.

3.5.2 District Energy System Decarbonization

District energy systems have proven to be a very cost-effective way to reduce carbon emissions in the building sector. New technologies enable much greater carbon reductions, and innovative implementation approaches are helping increase uptake. Emissions from district energy are reduced through improving the efficiency of existing plants and switching fuel sources.

In dense urban areas and industrial parks, district heat solutions can supply heat economically. Combining these systems with district cooling, cogeneration, or waste-heat recovery solutions typically improves the economics even further. Although district energy projects are capital intensive, they offer long-term stable financial returns. As such they are typically operated by state-owned enterprises that have access to capital. Transitioning these plants from coal to other renewable or lower-carbon sources is dependent on the local resources, and waste-to-energy options present favorable economics in most locations in China.

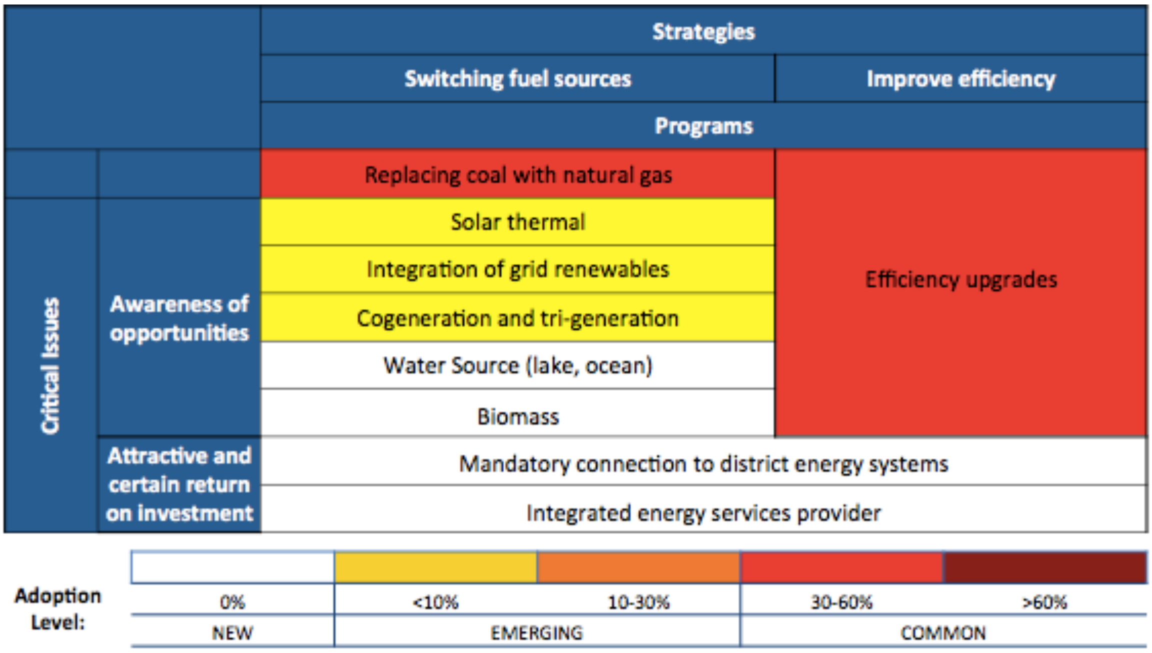
The critical issues to address are:

Lack of awareness: The technology and market is rapidly changing in the district energy space, with new alternative energy sources and new deployment models. In addition, best-case solutions are very localized in nature, so a key barrier to development (or retrofit) of advanced low carbon district energy systems is a full awareness of the opportunities. Cities need to explore a full range of technical and implementation solutions to maximize economical GHG mitigation opportunities.

Attractive and certain return on investment: In some cases the high capital costs of developing advanced district energy systems can make projects unviable. Economic viability depends largely on the ability of a city to integrate and coordinate multiple end users. The more valuable the system is for stakeholders, the better the returns of the project.

The number of district energy systems is expected to continue to grow, likely reaching 1,000 during the 13th five-year plan period. Most district energy projects are carried out voluntarily by local enterprises or local governments. By setting national-level targets for district heating, and supporting these with city-specific targets, cities will be more focused on driving district level solutions. Along with any established targets, China could issue national guidelines for heat planning. These should focus mostly on new developments. But guidelines for deploying new district heating systems in existing developments should also be developed as national heating requirements expand to new climate zones in China. Given the distinct need for local adaptation of district heating, national guidelines should be high-level and should recommend how these standards should be adapted in different climate zones and with different building use mixes.

FIGURE 3.13: DISTRICT ENERGY SYSTEM DECARBONIZATION PROGRAMS AND TECHNOLOGIES



3.5.2.1 Common Programs

China historically has had high shares of district heating, building several hundred district energy projects in recent decades. Most of the activity in the district heating space in China is around continued development of new district heating systems, and also carrying out efficiency upgrades and switching from coal to natural gas in existing systems.

Energy Efficiency Upgrades for District Heating Systems

A number of cities in China are upgrading their district heating systems. These efforts typically include upgrades to heating distribution systems (piping systems, insulation, heat exchangers), and also replacing central boilers with more efficient units.

One example program is Jilin's warm houses project where the district retired eight boiler rooms and retrofitted 134 small boiler rooms, accounting for 90.5% of small decentralized boilers. The district built a 500 km new heating trunk network and 833 km of secondary network, and retrofitted 1,279.5 kilometers of old pipe network.

Fuel Switching from Coal to Gas in Existing Systems

Many Chinese cities are replacing coal boilers in their district energy systems with natural gas. One leading example is the city of Yan'an. As of 2015, with the first municipal financial investment of about 100 million RMB, the city completed the transformation of 68% of the coal-fired boilers, reducing coal consumption by about 4.3 million tons.

3.5.2.2 Emerging Programs and Technology

Utilizing renewable energy sources for district heating sources has significant potential for impact in China. District systems using renewable sources as solar thermal and ground source heating have already been implemented.

Cogeneration and Tri-generation (CHP and CCHP)

Cogeneration and tri-generation (combined cooling, heating, and power) technologies are being promoted in cities such as Shanghai.[35] These systems can be connected to district energy systems or applied at the building level in larger buildings that have high loads.

Interfacing with Renewables on the Electricity Grid

There are new opportunities emerging to tie in intermittent renewable electricity sources to district heating. The city of Urumqi has tapped into the 30% excess generation from wind farms to supplement its district heating needs.[36] This excess generation occurs during periods when there is high wind speed but the grid is unable to take the additional electricity due to lower demand or the inability to turn down base load power plants. This type of system can help stabilize the electricity grid when higher penetrations of intermittent renewable sources are added.

3.5.2.3 Innovative Programs and Technology

There are a number of high potential impact opportunities presented by leveraging international best practice and innovative technologies:

Mandatory Connection

Some cities in North America, such as Vancouver, Canada, have set development permit requirements that require all buildings in an area served by district heating to connect to the system. Cities with a large industrial base should require using industrial surplus heat for district heating. This is mandatory in some areas of the EU if the payback time is less than 4 years. This applies if a new heat production unit is built or if an existing system is renovated and it has a thermal capacity above 20 MW.

Water-sourced Heating and Cooling

Water sources such as lakes, reservoirs, and oceans can be used for heating and cooling with heat pumps. This has been done in a number of district systems in the U.S. and throughout the world. In some cases, cold water can be used directly for cooling as done in Toronto's district cooling system.

Biomass Combined Heat and Power

Utilizing biomass for heating systems has become a popular solution for low-carbon heating in North America and Europe. These systems typically use waste wood sources, and modern technical solutions such as gasification enable particulate emissions to be minimized.

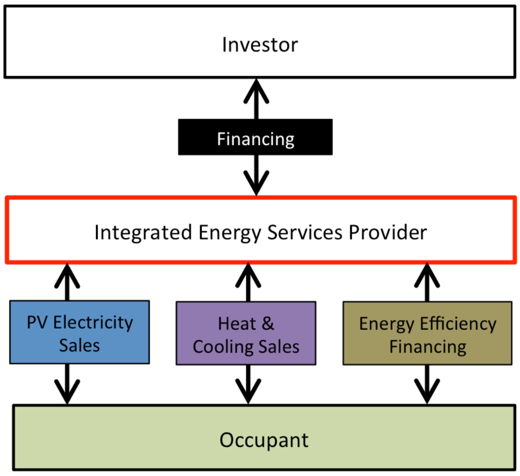
INNOVATIVE PROGRAM HIGHLIGHT

Integrated Energy Services Provider, Pittsburg, Pennsylvania

A new mixed-used development in Pittsburg created an innovative business model to achieve net zero energy (NZE). This development is located on a 175-acre former industrial site, and will reach 6 million square feet at final build out. The resulting NZE development will be lifecycle cost-neutral or better compared to business as usual and has lower first costs to parcel developers, all while creating a community that is more livable, healthy, comfortable, resilient, and environmentally sustainable.

The key element of this project is the concept of an integrated energy services provider (IESP) who manages multiple energy-related operations. In the net zero energy district, the IESP would manage multiple energy-related operations and act as a multipurpose developer, financier, operator, and administrator of energy systems, to make sure that the whole district meets its energy efficiency goal most economically. After construction is completed, the IESP will be responsible for the energy supply, equipment maintenance, and management.

FIGURE 3.14: ROLES OF THE INTEGRATED ENERGY SERVICES PROVIDER



INNOVATIVE PROGRAM HIGHLIGHT (CONTINUED)

The IESP is responsible for all renewable energy development and management; installing ground-mounted, rooftop, or carport-mounted PV systems for occupants; and supplying sufficient electric power. Although the cost to be spent on solar PV system is higher, having one single solar developer means on-site renewables can be phased and developed at a large scale, negotiating lower costs and capturing economies of scale in mass installations. The IESP also develops and operates a central district heating and cooling system. This development utilizes a large-scale geothermal heat pump system for heating and cooling, which is one of the most efficient options for district energy. Compared to individual building plants, district heating and cooling is much more efficient, has lower maintenance costs, is more reliable, and has longer equipment lifetimes.

Lastly, the integrated energy services provider conducts green financing of the incremental cost of constructing energy efficient buildings. Compared to typical buildings, superefficient buildings may cost 8%–15% more upfront, as a result of expert integrative design, high-performance envelopes, smart controls, rigorous construction quality, and testing and commissioning. This incremental first cost could be covered by the IESP via direct investment or by other investors via green financing.

KEY TAKEAWAYS

- District energy presents a large opportunity for decarbonization in China due to the dominance of the carbon-intensive energy sources currently used, and the viability of alternative options such as renewables and waste heat. Although capital intensive, district systems are cost-effective over the long term and provide numerous economic benefits such as stable energy prices.
- Current activity in Chinese cities is largely focused on retrofitting existing coal boilers and heating systems with higher efficiency units or fuel switching to natural gas, in addition to continued development of new district energy systems.
- Although these upgrades are impactful, a much larger opportunity is presented by utilizing best-practice alternative energy sources such as geothermal, waste heat (industrial, power plants, incineration), and solar thermal. These sources can be phased in over time for existing systems, or replaced outright, and should be considered for all new systems.
- Many of these technologies have been piloted or deployed at scale in China and can be scaled up. Cities should look to these examples, as well as international best practices, to inform future district energy planning.
- Chinese cities may be able to enhance current development and expansion of district energy systems by incorporating global best practices, such as connection requirements and incentives for buildings and industry.

3.6 CONCLUSIONS

FIGURE 3.15: SUMMARY PROGRAMS – CURRENT AND POTENTIAL

Strategy	Sector	**Common Practice** Where cities are currently most active	**Emerging** Proven in China or internationally but as of yet limited uptake	**Innovative** Less proven but potential for high impact or momentum building
1. Industrial Shift	Industry	• Phase out inefficient manufacturing capacity • Promote low carbon industrial zones • Restrict new investment in energy intensive industry	• Creating technology clusters and innovation districts • Skills training • Carbon emission assessment	• Fast track permitting • Financial incentives
2. Demand Reduction	Industry	• Develop a recycling economy	• Require higher quality materials • Mandatory waste diversion • End early demolition practices • Consumer education	• Incentivize smaller buildings
	Transportation	• Public transit infrastructure • Bike share • Information & communication technology	• Smart-city and transit planning • License plate restrictions • Congestion and parking pricing	• Commuting apps
3. Energy Efficiency	Industry	• Subsidies and rewards • Obsolete capacity retirement • Benchmarking • Energy services industry • Energy audits	• Energy efficiency loans • Standard and labeling scheme • Key technologies catalogue • Energy management center	• Differential electricity pricing • Energy manager training
	Buildings	• Green building guidelines and expedited permitting • Design and construction codes • Subsidies	• Benchmarking and data disclosure • Heat meter • Mandatory energy upgrades • Mandatory energy audits	• Operation energy codes • Energy efficiency financing • Pay-for-performance
	Transportation	• Fleet adoption	• Consumer adoption incentives • Charging stations • Best practice information sharing	• Hybrid and battery trucks • Minimize overloading • Driverless vehicle pilots
4. Decar-bonization	Power	• Renewable portfolio standards • Coal caps • Emissions standards • Direct subsidies for renewables	• Time-of-use pricing • Net metering • Flexible load aggregation	• Corporate renewable direct purchasing • Integrated utility services
	District Energy	• Development of new district energy systems • Energy efficiency upgrades • Replacing coal with natural gas	• Incentives to connect to district energy • Technologies: ground source, industrial heat recovery, CHP / CCHP, integration with grid renewables, solar thermal	• Mandatory connection to district energy • Technologies: biomass, water sourced heating and cooling

The programs presented in this chapter fall into three broad categories (see columns in Figure 3.15):

- Common practice—programs that are commonly deployed by most APPC cities.
- Emerging—less commonly deployed, but effective programs.
- Innovative—new, less proven but high potential programs that should be considered.

For common practice programs, APPC cities can share and compare information to see if their respective programs are delivering to their full potential in an efficient manner. Collaboration between cities and with the APPC can help institutionalize best practices in these common programs and identify areas for improvement. For emerging programs, cities can learn from the experience of others and evaluate the appropriateness of these programs. Again, information sharing is key; lessons learned and standards of best practices should be freely available to allow for quick implementation of emerging programs. Finally, for innovative programs, the APPC can help coordinate activity to pilot programs in suitable cities and help monitor and evaluate the progress and outcomes. As pilots are proven out, other cities can follow in their footsteps. The APPC can help quickly scale successful innovative programs across all APPC cities.

Many of the common practice programs are policy oriented or direct interventions, such as the closing of inefficient plants, direct subsidies, or investment in public transportation. While direct interventions can be very effective, APPC cities lag on market-based and other enabling interventions (emerging programs), which can also be very impactful. For example, skills training is not widely deployed by APPC cities, but is critical to enable market players to shift to low-carbon industries. In the buildings sector, benchmarking and data disclosure do not directly lower buildings emissions, but do allow buyers and tenants to make informed, carbon-conscious decisions. To effectively meet their peaking targets, APPC cities need to utilize a full suite of direct and market-based programs.

Additionally, the program areas fall into four levers or strategies (presented throughout this chapter):

- Industrial shift—This lever tends to be well developed in all cities, thanks in part to guidance from national policies, with innovative programs such as fast track permitting and financial incentives showing great potential.
- Demand reduction—This lever is underdeveloped and challenging. Progress has been driven mostly by local policies such as promoting the recycling economy and public transportation infrastructure investment. There has been a notable lack of initiatives to cultivate customer preferences. Key opportunity areas include widening

the scope of projects, such as stopping demolitions, encouraging the use of high quality materials, promoting small size building, and integrated planning with public transit. Also, cities should consider policies that reduce freight demand.

- Energy efficiency—Most efficiency measures have long-term economic benefits. However, the main barrier most Chinese cities face are the lack of understanding, motivation and upfront capital to pursue. Low carbon peaking pioneer cities already have many efficiency improvement programs underway, however they are mainly driven by policy. There is significant potential to additionally promote energy efficiency using market driven forces.
- Decarbonization of the energy mix—This lever is driven mostly by top-down regulatory policies, but local programs and new technologies are ripe for city-level implementation strategies.

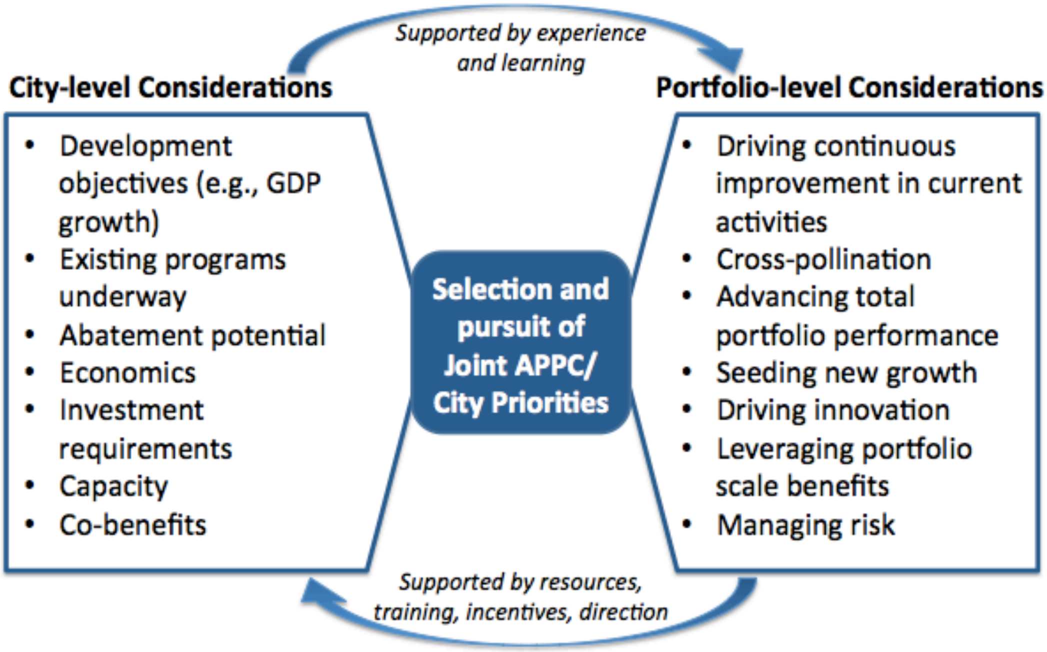
Going further with the four levers, and implementing emerging and innovative programs, can help APPC cities capture a higher percentage of their carbon emissions savings opportunities. Working in collaboration with the APPC will provide cities with the opportunity to learn from each other (as well as U.S. cities) to improve and expand their portfolio of programs and facilitate early peaking.

4 Prioritizing Programs

APPC cities seeking to peak their carbon emissions and follow a clean growth strategy can choose from numerous programs outlined in Chapter 3. However, given resource constraints and other overarching goals, it is not possible to implement all carbon mitigation measures. On both the individual city level and for the APPC as a whole, prioritizing programs and sequencing them appropriately is important to capture the full carbon savings potential.

Individual cities and the APPC will consider different factors and will have distinct but complementary objectives for prioritization (Figure 4.1). Cities must incorporate broader city goals, most notably economic growth, into their peaking strategies. Other considerations include experience with certain programs, the economics of implementation, and co-benefits (e.g., air quality). Cities can prioritize their programs to expedite and support other goals, instead of having programs work against them. For the APPC, the goal is to support Chinese cities to peak as rapidly as possible, and then maintain a sustainable green growth pathway. This can include driving continuous improvement in city activities through facilitated problem solving, leveraging the scale of the portfolio of cities to create financing opportunities, and driving innovation by tapping into international experience.

FIGURE 4.1: PRIORITIZATION OF PROGRAMS HAPPENS AT THE CITY AND PORTFOLIO LEVELS



4.1 CITY LEVEL PRIORITIZATION

Cities can start by considering their own heat map (Figure 4.2). Given traction in a selected area, cities are faced with one of two choices:

1. **Build upon existing successes and use available capacity to innovate and expand current programs**

   Pros: System of actors primed for ongoing change leadership

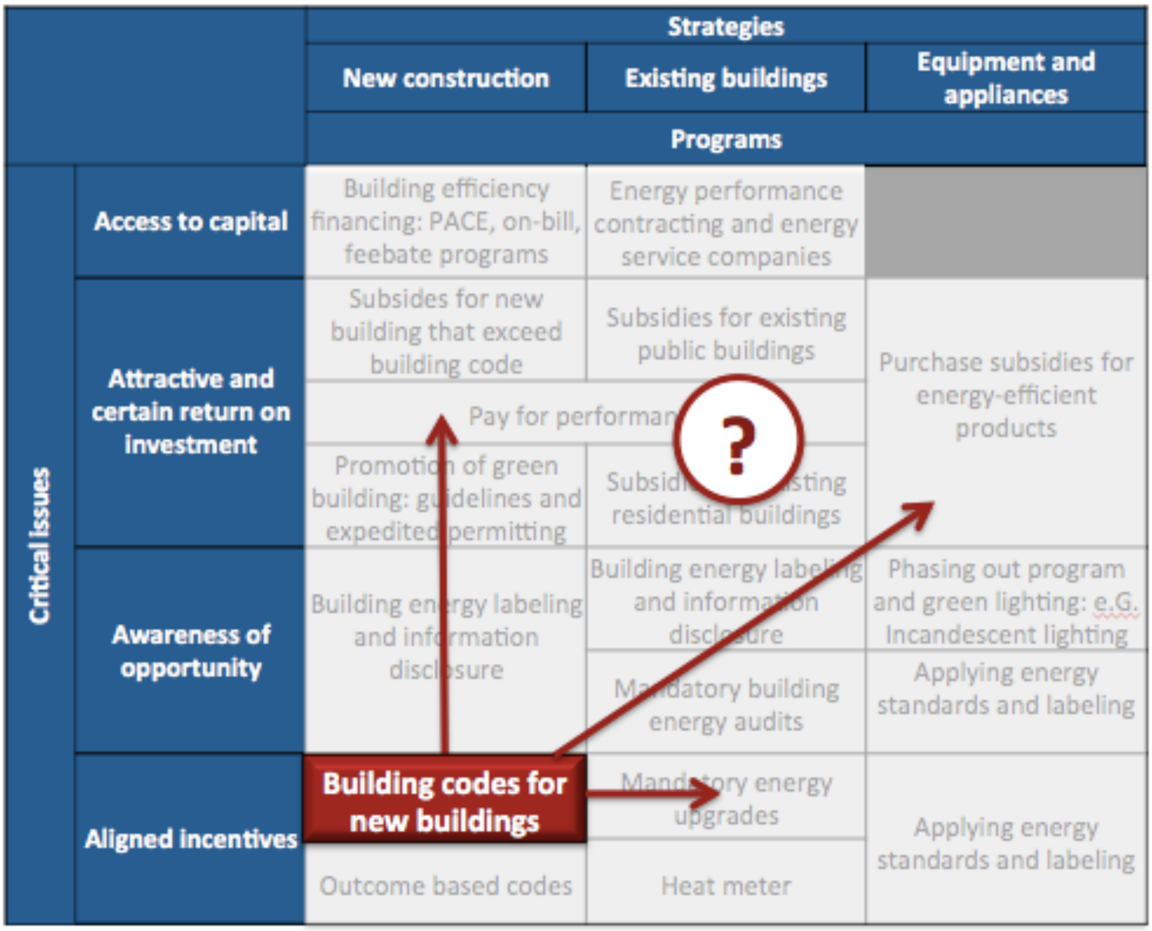
   Cons: May be larger gains elsewhere

2. **Initiate new programs targeting other sources of emissions reductions**

   Pros: Opportunity to expand network of change; access to new emissions savings areas

   Cons: Disproportionately large resource investments required to initiate new programs

FIGURE 4.2: INDIVIDUAL CITY HEAT MAP DECISION-MAKING FRAMEWORK



Layering in the information of a city's cohort cluster (introduced in Chapter 2) can further inform the decision, indicating whether a city is leading, lagging, or in the middle regarding specific programs. Programs where the city is lagging offer an opportunity for quick implementation through learning from peers. Programs where the city is leading offer an opportunity to teach others and reach out internationally for ongoing leadership (discussed in Chapter 5). Middle-ground programs indicate an opportunity for the city to distinguish its activities from others and drive innovation to move to the front of its peer group.

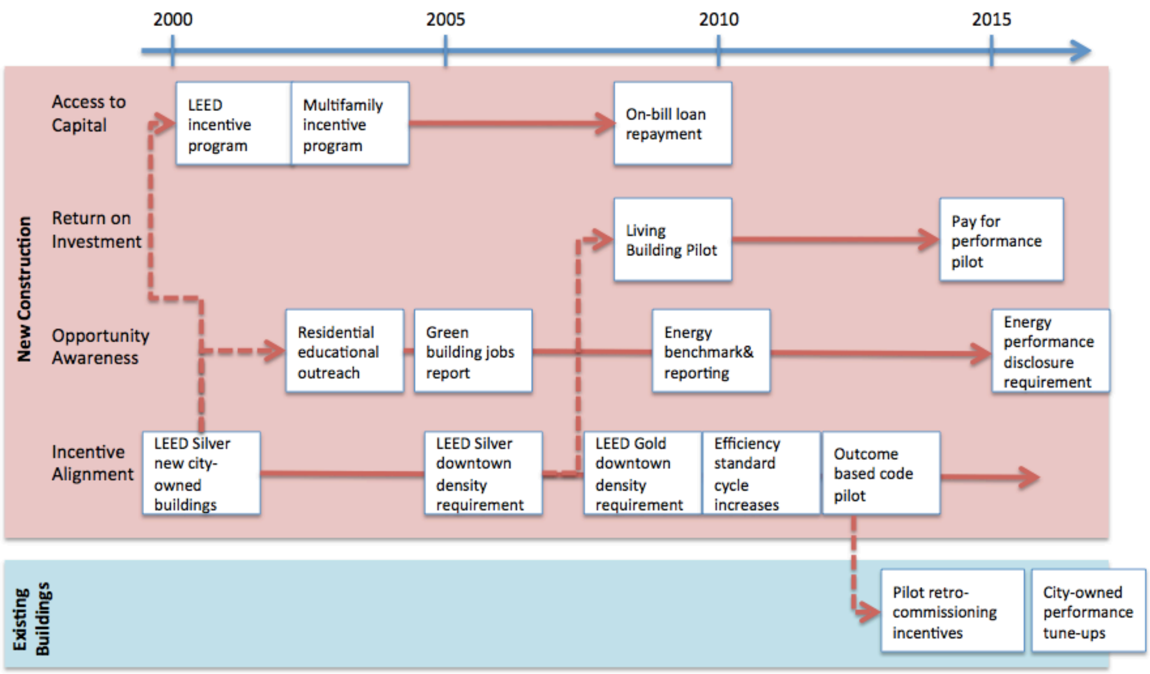
Regardless of whether cities go deep or broad on a particular sector, successful plans will simultaneously target both the bottom and the top end of the market. At the top end, cities will incentivize early movers to go beyond what the market currently requires, pushing the boundaries on what is possible and economically feasible. This is the market-based approach. At the same time, cities will establish the floor of the market—dictating what is the lowest socially acceptable metric the targeted sector must meet. This is achieved by regulation. Combining markets and regulation, and iterating on this combination in successive waves, helps cities continually push their carbon abatement programs forward for both leaders and laggards.

Effective sequencing can help create great impact. Many programs that implement the same measure are interrelated and can build off each other. Some programs require advanced knowledge and strong workforce capacity (e.g., highly stringent building codes, industrial energy upgrade loans). If a city does not yet possess this capacity and knowledge, it will need to deploy programs that build it (e.g., workforce education, pilot projects). Other programs are relatively small in scope but create necessary momentum (e.g., outreach campaigns) for much more ambitious activities that require political and public support (e.g., required energy use disclosure of all privately owned buildings).

SEATTLE CASE STUDY—GOING DEEP

Seattle, Washington, provides an example of digging deep into one sector (Figure 4.3). Over two decades ago, Seattle began an energy efficient buildings program.[37] By continually refining existing programs and piloting innovative ones in one key subsector—LEED certification and green buildings—Seattle became a national leader in the space. Today, the city has ambitious targets to cut building-related emissions by 82% by 2050—a goal that likely seemed farfetched just a decade ago.

FIGURE 4.3: SEATTLE KEY ACTIVITIES IN ESTABLISHING U.S. LEADERSHIP ON GREEN BUILDINGS



Until recently, Seattle had limited expertise on green buildings. After passing its first comprehensive building energy code in 1980, the city lost momentum. It wasn't until eighteen years later that the city created its first Sustainable Building Action Plan and hired full-time green building staff. At this key juncture the city implemented multiple building programs.

With green awareness growing in the early 2000s, Seattle put in place programs that would build capacity for going beyond standard code. The city legislated that newly constructed city-owned buildings must achieve a LEED Silver certification (raising the floor). In 2002, the city had its first LEED-rated building, the Justice Center. Building off of this demonstration project, Seattle published a report on the worker productivity benefits of sustainable buildings. The report helped influence key decision makers in the local real estate development industry (raising the ceiling). These actions helped further explore and demonstrate what was possible in Seattle's market and inspire others to follow suit.

Next, the city launched multiple incentives and information programs to build basic market capacity for LEED buildings. This successfully positioned Seattle as a leader in LEED projects, a title the city has held since 2006. By 2014 over 45% of Seattle's commercial office buildings were either EnergyStar or LEED certified.[38] This mature market provided the opportunity to carry out programs that previously would have been too difficult to implement. These included increasing energy performance required by code (raising the floor) and establishing innovative programs (e.g., energy performance benchmarking, Living Building Pilot) that raised even higher the top end of the market.

As an established leader in green buildings, Seattle continues to innovate and dive deeper on this subsector. Seattle recently passed legislation requiring energy performance disclosure for all buildings over 10,000 square feet and requires building tune-ups that will be phased in over four years starting in 2018. By 2030, Seattle plans to have minimum energy performance requirements and incentives for improved performance, all based on measured energy use, and with financing widely available that remains with the building upon ownership transfer.

4.2 PORTFOLIO LEVEL PRIORITIZATION

In support of China's national goals, the APPC wants to ensure that cities peak carbon emissions low and early. The APPC will broadly serve as resource support for member cities and will focus on key areas that will be of concern to all members.

Just as cities need to raise both the floor and ceiling for individual sectors, the APPC needs to do the same for cities—helping innovators advance the space, while making sure cities just starting out achieve rapid progress.

The heat maps throughout this report are tools for the APPC leaders to help member cities make collective progress and better prepare APPC to **support peer networks**. The heat maps can be used to help identify city clusters (e.g., cities with a similar economic or industrial makeup, size, and common peaking programs underway). Peer networks can be domestic or international and should aim to share best practices and key learnings from implementation. This will expedite program implementation and create greater impact.

Many cities will find that they do not have the expertise to implement certain programs; part of this will be a matter of sequencing programs to gain experience, but the APPC can assist in **building capacity**. From its database of programs, the APPC can identify what capacity is needed for which programs and target training accordingly. These activities lend themselves to more peer interaction, helping to facilitate even greater resource sharing.

All programs require financing, some significantly more than others. The APPC can take a leading role in helping to **establish grants, loans, and capital** to make these projects a reality. By cataloguing what's available, and pushing for innovative financing mechanisms, the APPC will play a vital role in project implementation.

Similarly, through its central position and access to key learnings, the APPC can develop **tools and resources** for member cities to use when developing and implementing programs. A few tools are available to help cities prioritize their carbon peaking actions, but each requires further tailoring to the specific needs of the APPC. The World Bank's TRACE tool is a feasibility and impact assessment tool.[39] It has been used worldwide and has been modified by Lawrence Berkley National Laboratory specifically for China (BEST).[40] This tool helps identify whether a city has the capability to implement the program, program implementation costs, and its relative level of impact, but does not address other issues of societal economics, upfront capital requirements, and specific program linkages to carbon dioxide emission reductions. Similarly, the CLIMACT Pro tool is used to prioritize climate actions, but has a specific focus on climate adaptation as opposed to emission peaking.[41] The APPC could assist cities by building upon these tools.

For emerging programs, the APPC can help identify potential cities and expedite implementation. And for programs that have not yet been piloted in China, the APPC can help leader cities find cutting-edge **pilot programs** and localize them for the Chinese context. In this way, the APPC can continue to raise the ceiling on what is done in China.

4.3 NEXT STEPS

Prioritizing programs will be a key component for APPC cities to meet their carbon abatement targets. But the tools currently available fall short of what is necessary to build truly robust carbon emissions programs. Recommended next steps are discussed below (see Figure 4.4).

FIGURE 4.4: NEXT STEPS IN DEVELOPMENT OF THE APPC CITY ASSESSMENT METHODOLOGY

Next Steps	Why it Matters
Technical Potential Assessments	Cities should understand the technical carbon dioxide savings potential before committing resources to a program. It is critical that specific actions link to expected impact, and that cities are able to design programs that achieve their emissions targets predictably
Economic Impact	The portfolio of programs selected should be balanced to support green growth objectives. This means ensuring that the economic cost or benefit of the portfolio is understood and optimized to have positive impact on GDP, employment, structure, and other key economic drivers
Investment Requirements	Financing for carbon abatement programs is immature in China; understanding how to finance the program is key. Understanding total capital requirements will help cities identify the necessary government, multilateral, public, and private sources required, as well as the best approaches to operationalize access (e.g., on-bill financing, ESCO financing)
Sequencing Approaches	Programs should be executed in reinforcing waves of activity. The first wave should provide quick wins to build momentum and confidence as well as lay the ground work for future waves. For each lever, wave sequencing will differ. Understanding and sharing the most effective "recipes" will be a critical focus
Impact Measurement	Choosing the right programs means understanding the actual carbon emissions reductions achieved in practice. Measuring program progress and relating to specific characteristics of the program implementation will be core to use of the heat maps going forward

The heat map and cluster chart provide a first step, helping cities visualize *activity* levels (not impact). But these tools are just snapshots in time and they fail to address wider questions of economic viability or emissions reduction potential. Techno-economic considerations are vital and should be part of the next iteration of this tool. These tools give cities a first glance into what projects could be prioritized, but more guidance is needed on which to prioritize and how to sequence them. This requires a better understanding of the potential carbon emissions savings. Likewise, although cities can use cost curves to understand the economics behind a project, APPC cities need tools that evaluate the entire economic impact of potential measures and programs, as well as estimate the upfront capital required to implement those programs.

Investment and financing will remain a barrier for many cities, but the APPC can continue to work on tools that simplify this process. International learnings will be especially useful.

5 Collaboration Opportunities on Urban Low-Carbon Development

Climate change is a common challenge facing the U.S. and China, and it can be a key area to strengthen the communication and collaboration between the countries as they seek to lead the world in its resolution. The U.S.-China Joint Announcement on Climate Change in 2014 was a first step in this collaborative, solution-focused relationship. Emerging from the early work in the APPC, there are five major areas for ongoing focus and development that will accelerate mutual progress and strengthen pan-Pacific ties.

1. **Promote deeper exchanges on low-carbon practices and programs**
   Chinese peaking pioneer cities have implemented a range of policies and measures intended to promote early peaking. While these efforts have achieved initial progress, there is significant room to refine their selection and execution, with the joint goals of achieving global best practice and scaling effectively. The heat maps in Chapter 3 illustrate the magnitude of the potential improvement opportunity for China. The process of surveying city practices also highlighted that global innovations exist – some of which have been highlighted in this report – that should be embraced and adapted for scaling in China. These range from specific practices around technology deployment (e.g., industrial structural shift methods, building energy savings capture, electric vehicles promotion, renewable electricity deployment) to process improvements that can be incorporated into the APPC administration (e.g., cohort learning, training approaches, and other capacity-building techniques). Through creation of a multi-level collaboration platform and encouraging local governments, companies, and think-tanks to participate, Chinese cities could more rapidly learn international best practices and assemble the tools required to achieve their desired green growth goals. Both China and the U.S. have multiple research institutes with significant experience and capabilities in low-carbon development. Together, the countries should set up a low-carbon cities

research network with regular communications to ensure cities on both sides of the Pacific benefit from insights generated. Going forward, the collaboration should focus on supporting pioneer cities in pursuit of early peaking and low-carbon pathways, using the APPC platform to help drive the practical realization of the concept of the ecological civilization.

2. **Identify common low-carbon pathways applicable to different city types**
   Beyond understanding specific programs and practices available to cities, there is a need to integrate these individual solutions into tailored packages that can be prescribed for cities based on some combination of factors like population, geography, industrial structure, regional dynamics, and natural resource availability. Overlaying city-level experience, portfolio intelligence, and pattern recognition, these "recipes" could be used to identify strategic pathways that allow cities to travel different routes to different low-carbon end-states. Grounded in practical experience, these pathways would provide a highly replicable system to guide cities in both countries on their strategic choices toward green growth.

3. **Promote collaboration on low-carbon technologies and green finance**
   City peaking and low-carbon urban development requires a wide range of solutions, many of which practically do not yet exist, are in the early stages of emerging, or benefit from unified international approaches. Collaboration in the design, development, and deployment of new market technologies (e.g., zero-energy buildings, electric vehicles, factory automation), new market models (e.g., carbon markets), and shared ways to scale capital (e.g., green finance mechanisms) are fruitful areas for the U.S. and China to continue driving deep collaboration to craft and scale new solutions. Collaboration in the development of a financing platform such as a U.S.-China low-carbon cities development fund would provide capital support for cities in both countries to build and implement low carbon plans.

4. **Assist Chinese cities in learning to innovate**
   Economic constraints, governmental responsibilities, and historical precedents frequently limit the vision and ability of Chinese cities to innovate. Providing external support and challenge to help leaders understand where and how to innovate on traditional approaches will help China's pioneer cities make more rapid progress than they would otherwise, and

simultaneously promote cultural exchange and understanding. Chinese low-carbon peaking pioneer cities are encouraged to start such innovation at small-scale in a town, a new district, or a small region, where they can apply the most advanced concepts and technologies with greater freedom to experiment and learn.

5. **Enable global city progress on the low-carbon transition**

   The joint position of China and the U.S. as leaders of the low-carbon transition can translate directly into sub-national leadership as well. Through formal and informal networks, the two countries have the obligation to jointly share the experience and solutions generated through bilateral cooperation to accelerate peaking and low-carbon development of cities globally. Together, Chinese and U.S. cities could play a catalytic role in pushing locally based world-wide action to address climate change, promoting solutions that ensure sustainable economic, social, and environmental development in the process.

6 Key Conclusions and Recommendations

This report provides an initial assessment of progress within the APPC network, and builds a durable framework that can be used to help guide focus and progress as the initiative gains momentum. Rather than being a definitive assessment, it is an incremental step in building a cities-focused program to drive China's peaking solutions, and help deliver against its international commitments. The report highlights many opportunities to draw upon international expertise and support, noting that the APPC commitment itself was a product of joint international leadership by China and the U.S.

KEY CONCLUSIONS

1. Peaking city emissions and driving continuous progress on urban low-carbon solutions is a necessary area for joint leadership by China and the U.S. in the global response to climate change.

Chinese cities are drivers of national economic development and carbon emissions, and play a key role in the nation's low-carbon transition. APPC cities account for 16.8% of China's total population and 27.5% of the national GDP, and generate 15.6% of the country's carbon emissions. For Chinese cities, meeting peak targets is important to ensure achievement of the national 2030 peak goal. Chinese cities can also provide a model for an expedited transformation to low-carbon development. While major U.S. cities have peaked carbon emissions, continually reducing city-level emissions is critical for the U.S. to achieve absolute emission reduction targets by 2025. In both cases, Chinese and U.S. leadership provide solutions from which the rest of the world can learn.

2. Early peaking can promote low-carbon development and economic growth—a win-win for cities.

Talent, technology, and capital are at the heart of a city's ability to innovate. American pioneering cities show that investing in education, medical care, the knowledge economy, low-carbon environmental protection, and smart urban development reduces carbon emissions and creates economic and employment opportunities. China's pioneering cities show that the pursuit of early peaking can expedite the development of emerging industries and the service sector, reduce their dependence on high-carbon industries, and support both low-carbon development and economic growth. In all cases, solutions that align social, economic, and environmental benefits demonstrate that low-carbon development can be a win-win for cities and society. Peaking activites offer development and market opportunities for both the U.S. and China.

3. Peaking plans must be tailored to individual cities, but shared learnings from peer experience can accelerate progress.

China and the U.S. are the world's two largest emitters of carbon dioxide and thus hold the greatest reduction potential. But cities differ in population, access to natural resources, industrial structure, and technological expertise, meaning there's not one single path for low-carbon development. When forming peaking and low-carbon plans, cities should consider how to optimize traditional industries, the development of low-carbon emerging industries, how technological development can contribute, and how to optimize the energy structure. Learning from the experiences of others through national or international peers can help accelerate progress on specific dimensions of tailored, city-level solutions.

4. Sustainable policies and innovative market mechanisms are critical for China's goal to peak carbon emissions.

Peaking impacts all aspects of a city. It requires regulation and enforcement as well as the participation of the market, government, and society. American pioneering cities have set regulations and standards, created economic policies, monitored implementation, and motivated participation from the private sector; this helped cities peak and then reduce emissions. As part of the country's overall reforms, China is encouraging pioneer cities to pilot innovation in governance and market mechanisms, which is important for long-term low-carbon development.

KEY RECOMMENDATIONS

1. Promote and enhance U.S.-China cooperation for peaking carbon emissions.

The U.S. has already achieved high levels of urbanization, whereas China is still in the throes of rapidly urbanizing. As both countries address climate change, U.S.

and Chinese cities have the potential to strengthen cooperation and expedite progress. Cities should strategically cooperate for enhanced learning. Joint cooperation among governments, businesses, think tanks, and others on low-carbon development in metropolitan cities will help drive the low-carbon transformation. For traditional industrial cities, fostering low-carbon industries and actively exploring different methods to peak urban emissions can provide a reference for accelerating the global low-carbon transition. Through vigorously promoting green low-carbon development transition, city carbon emission peaking and sustainable development can be a hallmark and highlight of the U.S.-China relationship. Providing global leadership in international cooperation at the city level will provide an example, patirularly for developing countries, with vital experiences and references.

2. Promote innovative policies, exchange best practices, and cooperate on technological research, development, and deployment.

To realize faster and lower peaks, both China and the U.S. should promote and enhance city-level bilateral and multilateral cooperation and exchanges on low-carbon technologies, best practices, innovative policies, and business models. The U.S. and China should play to their strengths and focus on key areas such as green buildings, high-efficiency cars, clean energy, and smart cities. The two countries should enhance mutual investment and joint research and development, while continually seeking out areas of common interest for potential collaboration. The two countries should develop open communication platforms and networks to promote the integration of low-carbon technology products alongside market demand.

3. Improve policies supporting pioneering cities.

Pioneering cities should have the freedom to implement innovative approaches to peak rapidly and at low levels; cities must start by assessing their current progress and start with projects that match their current capabitilities. Cities should focus on innovation, freely share lessons learned and help scale projects so they can be deployed nationally. Cities are also encouraged to implement innovation in government performance management, industrial policy, economic tools, and regulations and standards. For cities that have made significant progress, the government should provide additional support in terms of financial resources, land use, and project implementation. Pioneering cities should take realistic stock of their starting point, focus on innovation, and share lessons learned to help replicate success nationally. Pioneering cities should be encouraged to expedite low-carbon standards that surpass national requirements and carry out mandatory energy audits for high energy-intensive and high carbon-intensive enterprises. Low-carbon cities should be encouraged to use legislation where applicable. Cities' capacity to enforce laws, clarify both penalties and rewards, and ensure regulations and standards are implemented properly should be strengthened to ensure rapid progress.

4. Improve information quality needed for decision-making including inventory, monitoring, and data analysis systems

Peaking plans require data. Building capacity for cities to collect energy statistics and greenhouse gas emissions inventories is critical. Cities are encouraged to establish and improve their comprehensive carbon emission management platform; this includes inventory management, inventory creation, and inventory analysis based on the creation of a city level greenhouse gas inventory database. Data should be public, transparent, scientific, and standardized. This must be done while strengthening the collection and monitoring of energy consumption and carbon emissions data from industry, building, transportation, and other sectors at the city level by harnessing the Internet, big data, and other technologies.

End Notes

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