China: 40-Year Experience in Energy Efficiency Development

Policies, Achievements, and Lessons Learned

WORLD BANK GROUP

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TABLE OF CONTENTS

Abbreviations

CABR	China Academy of Building Research
CBECA	China Building Energy Conservation Association
CBRC	China's Banking Regulatory Commission
CECA	China Energy Conservation Association
CEO	Chief Executive Officer
CERS	China Energy Research Society
CHUEE	China Utility-based Energy Efficiency Finance Program
CNIS	China National Institute of Standardization
EMCA	Energy Management Company Association
EnMS	Enterprise Energy Management System(s)
ESCO	Energy Service Company
FYP	Five-Year Plan
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GOA	General Office Administration
HVAC	Heating, Ventilation, and Air Conditioning
I&G	National Investment and Guaranty Co.
IFC	International Finance Corporation
LOCAL	Low-Carbon, Adaptive, and Livable
LPG	Liquefied Petroleum Gas
MIIT	Ministry of Industry and Information Technology
MOF	Ministry of Finance
MOHURD	Ministry of Housing and Urban/Rural Development
NDRC	National Development and Reform Commission
NECC	National Energy Conservation Center
NSB	National Statistics Bureau
PDCA	Plan-Do-Check-Act
PMO	Project Management Office
SAMR	State Administration of Market Regulation
SMEs	Small and Medium Enterprises
TVE	Township and Village Enterprise
UNDP	United Nations Development Programme

Preface

China has developed one of the most comprehensive and effective sets of energy efficiency policies and programs in the world. China has succeeded in delinking its fast pace of economic growth from growth in energy consumption. China's energy efficiency programs are the result of over 40 years of effort, confronting the types of energy efficiency policy and program challenges that are common across most countries. The nation's programs are not perfect, and the development process has often been one of improving, adjusting, and reinforcing. Some of the strengths of China's effort have been (a) good organization, (b) focus on overcoming implementation difficulties at local levels as well as development of national policies and programs, (c) effective blending of market-based energy efficiency investment and service mechanisms with new law-based regulations, and (d) investments in institutional development to provide the foundation for long-term gains.

With the support of the China-World Bank Partnership Facility, a team composed of Chinese experts and World Bank energy specialists, directed and coordinated by the World Bank-China Energy Unit, undertook a journey in the past to explore the rich experience that China has accumulated in energy efficiency work. The team looked for lessons from the Chinese experience that would be valuable for practitioners in other developing countries designing their own policy frameworks to scale up results in energy efficiency work in accordance with their own economic structures and institutional contexts. This report, prepared by the World Bank, presents the findings that the World Bank found the most interesting and relevant for dissemination to other countries where it also supports the development of energy efficiency.

This report certainly does not present a universal guidebook for developing energy efficiency in developing countries. It reviews only the Chinese experience in addressing that country's needs to improve efficiency. Still, both the diversity of contexts in terms of regional economic development and the multiple successive stages of development of the energy efficiency industry which China went through offer multiple opportunities for smaller developing countries to identify similarities with their own present challenges.

To facilitate the sharing of China's diverse and multidimensional experience, the first chapter of the report follows the history of energy efficiency efforts in China since 1980 by dividing China's efforts into four blocks, which China basically added on top of each other over the years. Three subsequent chapters present China's institutional setup for energy efficiency work and details on the two biggest energy-using sectors, industry and buildings. Still, this report only provides highlights; interested readers will need to review a variety of reference materials and other published sources to further grasp details, or, perhaps best, find opportunities for in-person exchange with Chinese practitioners. The final chapter of this report lists out the experiences and lessons which the authors feel would be of greatest interest to practitioners in other countries.

The hope of the World Bank and the Chinese experts who worked arduously on this report, many of whom have directly participated in the journey of several decades, is that this report can provide enough value for practitioners engaged in developing energy efficiency in other countries to generate further interest in direct South-South knowledge exchange with Chinese counterparts and fruitful cooperation.

The World Bank has been supporting the successful development of energy efficiency in China since the beginning, financing projects and producing analytical works to support its Chinese counterparts in shaping and revising the successive policies and programs. Multiple assessments of this cooperation, not only by the internal assessment department of the World Bank but more importantly by the Chinese authorities themselves, have confirmed the catalytic role of this World Bank-China partnership. This main report is

therefore accompanied by a separate paper, [1] which focuses more on this partnership over the same period. This companion paper will hopefully also inspire and provide ideas to practitioners, from the World Bank itself and from other international cooperation institutions working on energy efficiency in other countries as well as their national counterparts, to develop their own partnerships for further development of energy efficiency across the developing world.

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Energy and Extractives Global Practice

East Asia and Pacific Region

1 Energy Efficiency Development in China - The Successful Partnership of the World Bank Group and China on Energy Efficiency, 1992–2020.

Acknowledgments

This report was prepared by the World Bank with financing from the China-World Bank Partnership Facility.

It has been produced by a team of Chinese and international experts led by Christophe de Gouvello, Coordinator of the World Bank-China Energy Team, and Yanqin Song, World Bank Senior Energy Specialist, under the guidance of Jie Tang, World Bank Energy Practice Manager for East Asia and Pacific.

The main international expert and international contributor was Robert Taylor, who worked for more than 30 years with the World Bank and the China energy sector authorities on the development of the China energy sector and in particular on the development of energy efficiency in China.

The team would like to thank the whole World Bank-China Energy Team for the support provided, in particular Na Han, Team Assistant and Zijing Niu, World Bank consultant for knowledge management and coordination under CWPF.

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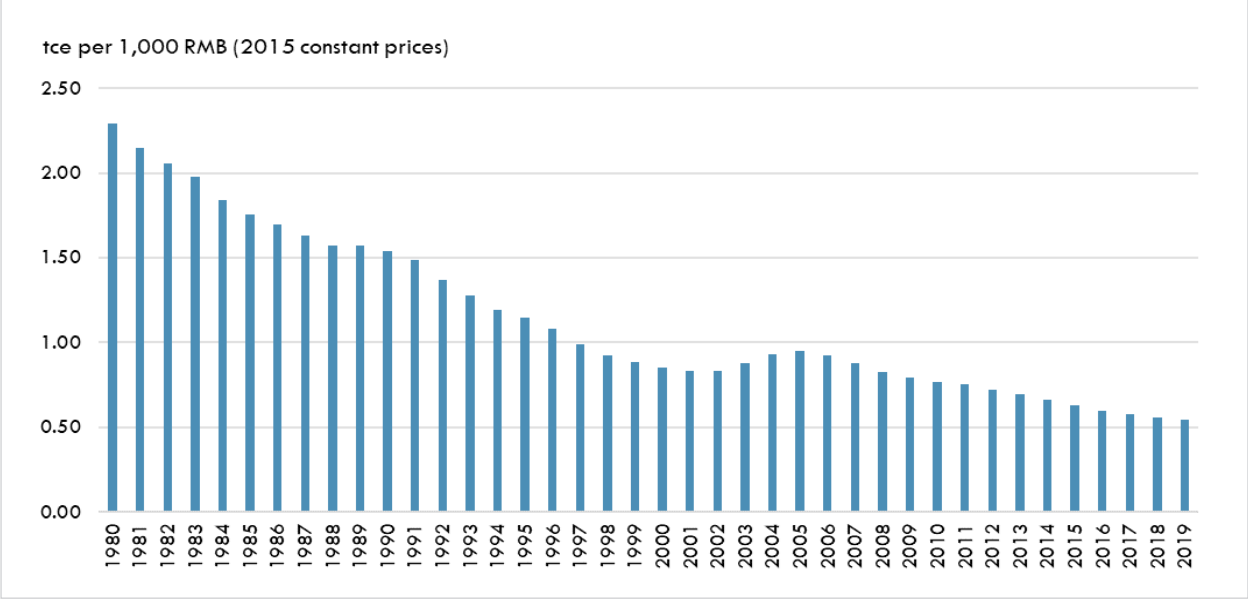
Executive Summary

China has developed one of the most comprehensive and effective sets of energy efficiency policies and programs in the world. This has been an arduous task over decades, involving the government, businesses, and civil society. Although success has abounded in many areas, China's programs are not perfect, and the development process has often been one of improving, adjusting, and reinforcing. Some of the strengths of China's effort have been (a) good organization, (b) focus on overcoming implementation difficulties at local levels as well as development of national policies and programs, (c) an effective blending of market-based energy efficiency investment and service mechanisms with new law-based regulations, and (d) investments in institutional development to provide the foundation for long-term gains. The process, experience, and results of the 40-year effort provide an amazingly rich bank of lessons for other countries with aspirations for energy efficiency gains, which this report strives to describe.

Figure ES.1: Reduction in Energy Consumption per Unit GDP, 1980–2018

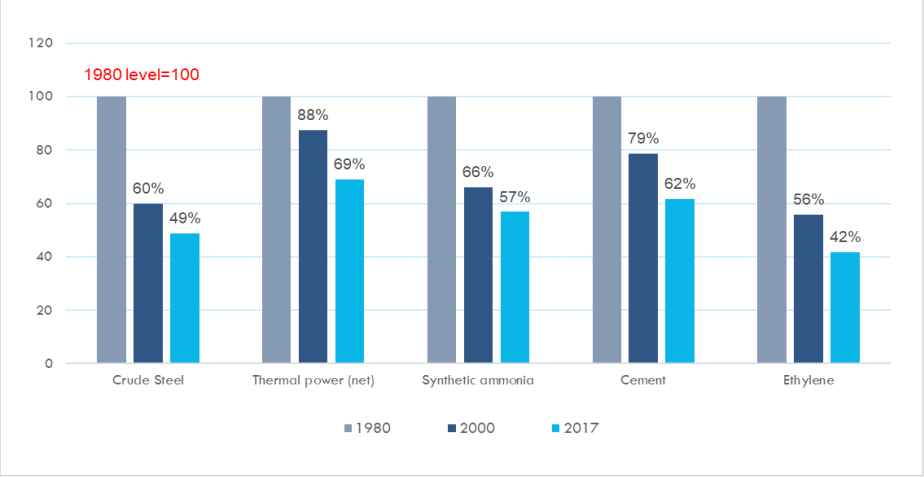


Source: China Statistical Yearbook, various years.
Note: GDP = Gross domestic product.

One of the most telling macro indicators of China's success is the reversal of a trend of increasing energy use per unit GDP beginning in 2006 and continuing thereafter, delinking growth in energy consumption from growth in GDP (see Figure ES.1). Energy use per unit GDP had fallen during the 1980s and 1990s, in part due to energy conservation efforts but mainly due to economic structural change as China's economy began to mature. This changed in the early 2000s, however, as yet more rapid industrial growth brought increases in China's energy intensity. China's leadership recognized that this continued resource-intensive development over the long haul was physically almost impossible, economically inferior, and environmentally unacceptable. With calls to build a less resource-intensive society, the country sharply increased its efforts to improve energy efficiency, building on past programs and adding new ones in a comprehensive effort. The focus was on achieving results. The trend of increasing energy intensity was bent downward, and energy intensity began to decline again, even as rapid industrial and economic growth continued.

A variety of indicators relating to physical output also show success. An example is the sharp decline in energy use in the production of key industrial commodities, such as those shown in Figure ES.2. Some of these declines are especially noteworthy for any large country—a reduction by more than 50 percent in the case of steel and 43 percent in the case of synthetic ammonia. These sharp declines are due to elimination of particularly wasteful plants, increases in scale, incorporation of new technology, and far greater attention to efficiency.

Figure ES.2: Reduction in Unit Energy Consumption per Ton of Output (1980 = 100)



Source: Authors, from a variety of Chinese sources.

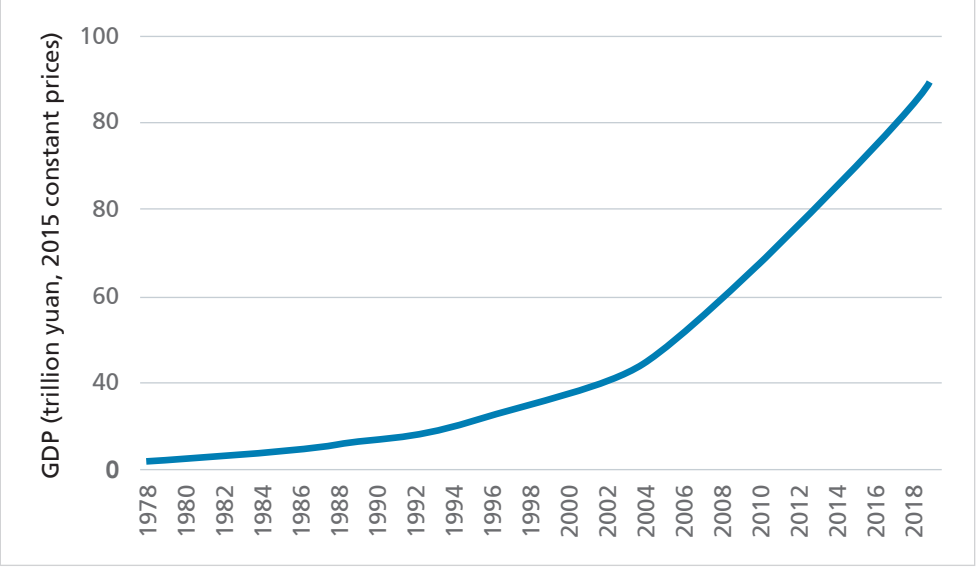
Distilling key elements of China's experience and lessons learned which may be insightful for other countries. The objective of this report is to highlight the main thrusts of China's experience and share lessons learned with outsiders also endeavoring to overcome the many challenges involved in achieving results in energy efficiency programs. Of course, China's experience is shaped by its own circumstances, as is true everywhere. Other countries must design their own policies and programs to match their own economic structures, institutional contexts, and preferences. Yet energy efficiency practitioners can easily recognize many pulls and pushes in Chinese policy development and program implementation as issues that they are also trying to deal with. While some of the lessons learned by China may not be transferable to others, many are actually highly insightful, if properly understood. The evolution of China from low-income to middle-high-income country and its wide geographical diversity brought about extensive challenges for energy efficiency work, many of which are similar to those faced today in other developing countries. Examples abound, including developing new energy statistical reporting systems, fostering improved industrial energy management, dealing with legacies of inefficient industrial plants, introducing energy efficiency standards for appliances, developing a new energy conservation law and related regulations, launching a new energy service company (ESCO) industry, introducing energy efficiency lending in banks, and more. Practitioners in more developed countries may also find lessons learned in China to be relevant for the challenges they are facing, such as implementing subnational caps on greenhouse gas (GHG) emissions, developing ESCOs that finance their own projects, or developing industrial energy efficiency reference standards for certain industries.

China has promoted many policies, regulations, approaches to market development, support efforts, and incentive programs over the last four decades, at many levels. Some have stood the test of time and others have not. Some are broad and some are sector or industry specific. This report covers only the most prominent ones considered perhaps most insightful to outsiders. The authors have added the background and context which can hopefully make China's experiences easier for outsiders to understand. The experiences and

lessons learned are only outlined in this report, however, and it is hoped that interested parties may be able to pursue more in-depth personal exchanges to gain more detailed understanding.

Four policy blocks are depicted to define successive stages of China's energy efficiency policies and programs. To help share such a rich and multidimensional experience, the report has divided the history of energy efficiency efforts in China into four blocks, which China basically added on top of each other over time. These blocks offer multiple entry points into the 40-year-long China experience which may help smaller developing countries identify similarities with their own present challenges.

Figure ES.3: The Evolution of China's Energy Efficiency Policies and Programs Since 1980



Source: Authors.

The four blocks of China's energy efficiency policies and programs since 1980 are shown in Figure ES.4. Block One focuses on energy conservation as a solution to energy shortage under the planned economy. This block covers 1980–1991 and is the only block no longer under implementation as China subsequently moved away from its planned economy to a market economy. Block Two (1992–2020) covers the transition to development of energy efficiency for economic and financial benefit and development of market-based energy efficiency efforts. Block Three (1997–2020) includes law-based energy efficiency regulatory efforts. These are also sometimes described in China as 'administrative measures'. Block Four (2006–2020) includes the addition of a new series of targeting and support efforts to build upon the efforts of Block Two and Block Three to form a truly comprehensive energy efficiency program for greener and higher quality economic and social development.

Structure of the report. Chapter 1 details the main policies and achievements that characterize each of the four blocks. Chapter 2 outlines government institutional systems for promoting energy efficiency as these systems have stood during 2006–2020. The chapter covers government institutions, planning, monitoring of work and results, and fiscal support. Chapter 3 covers energy efficiency efforts in industry, which is China's largest energy-using sector. Chapter 4 summarizes energy efficiency efforts in buildings. Finally, Chapter 5 summarizes key lessons learned and provides a list of a variety of areas of possible greatest interest to other countries. The following parts of this executive summary focus on the key features of the four blocks and introduction of the main lessons that may be relevant for other countries.

Block One: Energy Conservation as a Solution to Energy Shortage under a Largely Planned Economy (1980–1991)

China was a low-income country in 1980, with GDP per capita ranking in the middle of the lowest quartile of countries in the world. About 80 percent of the population lived in rural areas. Private ownership was minimal, with enterprises owned by the state or local collectivities. Prices were set by the state and were often not aligned with costs. As China's opening up and reforms progressed during the 1980s, shortages often became severe with the resulting more rapid economic growth. Insufficient electric power in particular was a common constraint on factory growth. Rolling power cuts were common during peak load periods.

Efforts to improve energy efficiency became urgent, with the potential to cost the state less resources and yield results quicker than just investing in supply. Industrial energy efficiency was the main focus. The amounts of national and local government funds set aside for energy efficiency projects increased in the annual and five-year plans (FYPs). Government monitoring and supervision of energy use in enterprises expanded, using standard command and control practices. Institutional responsibilities within the government were strengthened and sanctioned in the 1986 'Temporary Regulations for Energy Conservation Management' issued by the State Council, China's highest government authority.

With universities closed during the Cultural Revolution until 1977, there were new needs for technical staff in the government, technical service units, and enterprises with skills to assess energy use patterns and identify and supervise energy efficiency initiatives. By the end of the decade, about 200 technical energy conservation centers had been put in operation throughout China. With some technical support and through their own efforts, major energy-using enterprises also developed in-house capacities to diagnose energy use issues, compile energy accounts and statistics, prepare reports to the government, and develop projects.

The strengthening of the government institutional system for promoting energy efficiency during this period, reaching from the top to the bottom, subsequently proved critical for the success achieved in China's long-term energy efficiency drive. Efforts to improve energy efficiency became a more integral and serious aspect of the energy planning process in China than in most other developing countries. In addition, the success achieved in building technical capacity and institutions, including increasingly at the local and enterprise levels, also proved absolutely essential for the future. Finally, investments made in building up the energy statistical system, including statistics on energy use, also proved critical for the future.

Experience in developing local technical capacity

- **China's approach was to launch technical service and measuring stations quickly** and broadly, and then gradually improve the quality of their work over time, allowing urgent basic needs to be met initially and then building stronger capacity over time.

- **New technical staff were employed immediately in everyday field tasks,** adding practical experience to learning. This worked well as long as a few senior staff were available for quality control and on-the-job training. It was important to ensure sustainable employment. But later severe attrition of newly trained energy efficiency technical staff to other job opportunities, a common problem worldwide, became a challenge for China.

- **Focus on the financial benefits of improving energy efficiency and the practical perspectives of enterprises was largely overlooked and needed to be improved later.** Analysis and summation of priorities and investment returns from a financial point of view were typically ignored in early Chinese technical reports. Energy audit reports were sometimes viewed by enterprise managers as 'too technical' and overlooking enterprise practical realities and business concerns. This may not have mattered as much under the planned economy, but continuation of this weakness in future years became a serious drawback. Eventually, this problem was addressed when enterprises became more in charge of the process. Other countries with market economies would do well to learn from this experience and make strong efforts from the beginning to include relevant financial analysis and address practical enterprise perspectives in technical energy auditing and energy efficiency project preparation work.

Experience of developing energy statistics

- **Reliable and sufficiently detailed energy use statistics are needed** for prioritizing programs and investments, assessing impact, benchmarking enterprises and regions to compare efficiency levels, and more. China's work to develop its own comprehensive national energy balances, and eventually provincial energy balances, is a useful, recommended measure which requires that all manner of supply and use data, typically gathered from various sources, should be cross-checked and reconciled. China's work to develop industrial enterprise energy accounting and reporting also began early and has proved critical for subsequent setting of industrial standards, benchmarking of enterprises producing the same commodities for comparative purposes, and assessing enterprise energy efficiency progress over time, especially enterprise internal energy management.

- **Safeguarding energy statistical reporting from local interference.** Under the planned economy, local areas had much incentive to alter statistical reports to show compliance with targets set in economic plans. China's statistical authorities have long wrestled with this problem and devised a variety of means to best maintain the independence and integrity of the system so that it can be useful for policy makers. Especially important were reforms in 2007 to increase the energy statistical system's independence and build a full Department of Energy Statistics in the National Statistics Bureau (NSB). Statistical bureaus in other countries faced with this common problem could benefit from an exchange of views and experience with Chinese experts.

- **Developing industrial enterprise energy use reporting.** Initial enterprise energy use reports developed in the 1980s were often rough, with limited measurement capacity, many estimates, and weak capacity for cross-checking. However, the early launching of a reporting system proved wise. Energy use reporting from enterprises has improved steadily to become an essential, backbone statistical source for policy making. Current industrial enterprise energy use accounting and reporting protocols are based on a tremendous amount of practical experience.

Block Two: Transition to Promotion of Energy Efficiency for Economic Benefit and Development of Market-Based Energy Efficiency Initiatives (1992–2020)

China's transition to a market economy was gradual but steady. By the middle of the first decade of the new century, resources were being allocated by the market instead of the plan, enterprises were responding to market signals rather than planned targets, and direct command and control of the vast majority of enterprises by the state had been abolished. A wide variety of different types of enterprises are now operating in China, the vast majority focused squarely on profitability.

Energy price reform was critical to provide signals to enterprises as to the true benefits of improving energy efficiency and to increase enterprise incentives to invest and manage accordingly. In-plan energy prices at the outset of the 1990s were well below supply costs, except for some petroleum products. After a transitory 'dual-price' system, electricity prices started to reflect the long-run marginal costs of supply by the end of the century. Coal sales became market driven. Currently, average energy prices in China are at or above the costs of domestic supply or export/import value, although some cross-subsidization exists (for example, cross-subsidy of residential electricity consumers by industrial and commercial electricity consumers). This has greatly benefited the drive to encourage energy efficiency using market-based mechanisms.

China's system of government energy conservation departments and technical centers entered a difficult time of transition in the 1990s. The system's operating environment was based on direct state command and control of enterprises and now that operating environment was disappearing. Over time, new mechanisms were developed which successfully promoted energy efficiency investment in the market, including new ESCOs, and operation of new energy efficiency lending windows in banks

ESCOs are for-profit companies that pursue 'energy performance contracting' with energy users, providing project development, installation, operation, and sometimes financing service with energy savings guarantees in exchange for a share of the guaranteed energy-savings benefit. Beginning in 1997, China developed its ESCO industry from scratch to become easily the largest in the world, with annual energy performance contracting investments surpassing US$17 billion in 2018. China piloted the concept by developing three new demonstration ESCOs. Once the concept proved successful, and others aimed to copy the business, lending to the emerging new ESCOs for project financing shifted to domestic shareholders and banks with backup guarantee arrangements initially provided by the World Bank and International Finance Corporation (IFC). New government policy support was then added, resulting in a fast ramp-up of the business.

Programs were launched in the middle-to-late 2000s to develop new energy efficiency lending businesses in Chinese banks, also with the World Bank, IFC, and bilateral international assistance. By 2014, 6–10 banks with national operations led energy efficiency lending with specific, sustainable programs and dedicated staff. Some bank subsidiaries and energy efficiency project developers have also developed financial leasing instruments as part of the toolkit for commercial energy efficiency financing. National and regional guarantee companies have entered the business.

Experience in building an ESCO industry

- **A step-by-step approach.** China adopted a step-by-step approach to piloting and scaling up its ESCO industry. Three pilot ESCOs were established with local equity investment and technical staff from provincial technical centers. The ESCOs received dedicated financing from the Global Environment Facility (GEF) and World Bank for technical assistance and project finance. The pilot companies met their objective of proving that energy performance contracting could work and be profitable in China—a major challenge for a totally new business concept. Creating systems for securing commercial financing for new ESCOs was then tackled in a second-stage project, using risk guarantees to help encourage banks to enter the business.

- **Adapting models to local circumstances.** Although China's first ESCOs learned many things from international examples and experts, they also made major adaptations to business models. For example, staff from China's technical centers immediately moved to adapt the business for the industrial projects they knew well, even though this was not common abroad. The first ESCOs also greatly simplified the model contracts they reviewed from elsewhere and better matched them to Chinese business norms.

- **Providing off-balance sheet financing to ESCO clients.** China's ESCOs adopted some different approaches from many mainstream ESCOs internationally. Unlike many ESCOs in other countries, most Chinese ESCOs finance their projects, a key attraction to their customers, in both industry and commercial building sectors. If the early ESCOs did not cover investment costs, the business could not have developed. Paying for technical service was not popular among industrial enterprises in particular, which felt they could do their own technical work and looked askance at paying 'consultants'. However, ESCO provision of financing did make obtaining project financing a key constraint on growth for many new ESCOs and required a blend of financial and entrepreneurial skills, in addition to technical strength.

- **Not confronting all barriers at once.** The pilot ESCOs began operation before attempting to overcome all the many barriers in their operating environment. During the first few years, many systemic issues surrounding operation of the new ESCO business model did arise, with auditors questioning the placement of assets in other enterprises, taxation authorities puzzled as to how to classify the business, and even some local authorities declaring the business model illegal. The central government looked into the issues as they arose and helped devise practical solutions to the concrete problem cases as they were encountered.

- **Strong, consistent government support was critical.** The Chinese government undertook significant risks supporting the launch of a business model that was completely untried in the country. The government consistently supported the early growth of the industry as it encountered various problems and then enacted key new supporting policies, which helped spur a huge industry ramp-up during 2010–2015.

Experience in developing lending for energy efficiency projects in commercial banks

- **Development of specific energy efficiency bank lending programs requires special efforts,** as these loans focused on projected operating cost savings diverge from mainstream commercial bank working capital or fixed-asset production expansion loans. Moreover, individual loan sizes are often relatively small and good organization is required to ensure technical soundness while minimizing transaction costs.

- **Connecting with existing bank lending business rationale.** For large banks or other financial institutions, energy efficiency financing is at best a small niche business. In most cases, such a business needs to help meet additional, broader goals which are often bank specific. A bank may want to add an additional product focused on operating cost savings to its suite of offerings to well-established customers. Some may see the business as an opportunity to expand small and medium enterprise (SME) credit programs. Others may see needs to develop environment-friendly reputations with the government or key client groups.

- **Cost-effective and efficient loan origination.** Efficient loan origination is often a headache for institutions beginning this business. Projects are often small but still require technical assessment. The challenge is to meet requirements for both technical soundness and good client creditworthiness (good project economics is not enough). Chinese banks have developed various strategies, such as reliance on existing customers before branching out, use of 'template loans' for small projects using common technology, concentration on a few key subsectors, or development of partnerships with trusted technical groups.

- **Meeting standard loan appraisal criteria and formats with minimal adjustment.** Energy efficiency loans focused on cost reduction rather than new revenue streams may require some different emphases at appraisal. However, adjustment to internal appraisal criteria and forms is not simple. Chinese banks and especially guarantee companies have developed solutions that work.

- **Overcoming lack of familiarity of risk management departments.** Energy efficiency loans can be a hard sell, especially when business is just beginning. For example, risk management departments may look askance at 'hypothetical' calculations of 'negative costs'. To achieve success, Chinese energy efficiency loan program staff had to be trained to learn how to navigate this problem effectively.

Block Three: Law-Based Energy Efficiency Regulatory Initiatives (1997–2020)

With many new enterprises outside of the state system by the later 1990s and direct command and control of state enterprises largely gone, government units could not order enterprises to undertake measures without a firm legal foundation. New, clear, and legally grounded regulations were needed. If not, regulations and standards could be (and were) ignored or challenged. Following the study of energy conservation laws in Japan and elsewhere, China promulgated its first Energy Conservation Law in 1997. It set out the foundation for the operation of the government's energy efficiency planning and policy system, efforts to restrict especially wasteful industrial enterprises and technology, issuance and enforcement of energy use standards, and assessment of the energy use performance of proposed new investments, among other things. The law established responsibilities for key energy-using enterprises[2] to report energy use to the state and establish internal energy management positions and enabled supervision and examination by local authorities. The law was then amended in 2007, adding a legal foundation for setting and supervising macroeconomic energy efficiency targets, clarity on appliance standards and energy efficiency labels on equipment, and the underpinnings for further improving energy use statistics. The amended law also added details on building energy efficiency work, codes, and their enforcement; new sections on transportation and public institution energy efficiency; and calls for preferential tax policy.

China has developed a wide range of energy efficiency performance standards and codes detailing minimum energy efficiency requirements (or maximum unit energy consumption ceilings) for industrial equipment and processes, new building construction, and various appliances. These specify not only minimum efficiency levels for specific types of equipment but also total maximum energy consumption per unit of output (for example, energy per ton of steel produced) for a range of energy-intensive products. These standards provided an objective benchmark against which other programs operate, for example, efforts to eliminate energy-wasting industrial plants. China's system of roughly 100 specific industrial energy efficiency standards is most likely unique and may be of special interest in other countries, even if only for technical reference. For appliances, the minimum performance standard provides the floor of a ranking system, against which the performance of different models is characterized. Drafts prepared by technical committees, including representatives from those affected and leading national experts, are reviewed by supervising government agencies several times before final approval. Debate is common.

General experience in enforcing energy efficiency standards

- **Achievement of waste-reducing results from mandatory minimum efficiency standards requires concerted efforts in enforcement.** China has wrestled for many years with the issues of enforcement of energy efficiency standards and regulation. Most of these issues are common in other countries as well, including weakness in local capacity, difficulties in maintaining quality and consistency in inspections and adjudication, potential for powerful local interference, and others. While standards and codes began to be developed decades earlier, the greatest improvements in enforcement came only during 2006–2012.

2 Key energy-using enterprises are defined, to this day, as enterprises consuming annual amounts of more than 10,000 tons of coal equivalent (tce, with 7 million kcal per tce). Provincial governments can also add enterprises consuming between 5,000 and 10,000 tce per year as key enterprises, at their own discretion.

- **Top-down pressure and guidance grounded in the law need to be blended with development of local institutional capacity.** Local government institutions needed to be made responsible for inspections and enforcement, requiring steady support. In addition, however, guidance from above and legal backup have also proved important to provide consistency and countermand the possible pushback of various local interests.

Experience in enforcing energy efficiency standards for new buildings

- **China's experience has shown that issuance of energy efficiency building standards and their promotion by a central government ministry are not enough to achieve results.** Enforcement of the standards must be institutionalized at local levels, best achieved by making procedures to check building energy efficiency standard compliance a routine part of building design permitting, construction supervision, and especially final permitting for occupancy or sale. After years of mediocre results, serious improvement came only with the Issuance of specific demands and support from the highest level of the national government, backed up with additions to China's Energy Conservation Law. The State Council's 2008 regulation included specifics on instituting local-level inspections and consequences for failure to comply.

- **Measures must be taken to ensure compliance at all three stages of building construction—design, construction, and commissioning—and not just one or two.** China's central government issued a Building Energy Efficiency Acceptance Code consisting of a checklist of measures that buildings must follow to comply with the energy efficiency standard. Used to review building projects before final approval by the local government, many Chinese practitioners have pointed to the popularization of this tool as a key factor in ensuring standard compliance.

- **Annual inspections have been important,** organized by the central government to review compliance at provincial and local levels through spot checks, including site visits. Real estate developers wield substantial influence at local levels in all countries and inspections and periodic supervision from outside of localities can be critical.

Experience in developing local institutions to supervise and support industrial energy efficiency efforts

- **Developing local Energy Conservation Supervision Agencies.** By the end of 2013, there were more than 1,600 provincial, prefectural, and county government Energy Conservation Supervision Agencies operating in China, with about 16,000 staff, responsible for compliance with industrial energy efficiency policies and regulations. Staffing came from local technical centers and the energy efficiency or industrial communities at large. These provincial and local agencies have played the key role in supervising compliance with industrial standards and regulations.

- **Separation of government and service responsibilities.** Whereas the government and businesses were at times mixed in the energy conservation technical centers of the past, the new supervision agencies were charged solely with the government-directed responsibility of enforcing the Energy Conservation Law and its regulations. Business ventures, including consulting for enterprises, were spun off to energy conservation service centers or companies to avoid conflicts of interest.

- **Adopting new software tools to reduce time and cost of enforcement.** Automated measuring and reporting, as well as the use of software tools to allow inspectors to input basic date on electronic tablets

on-site and immediately and accurately assess compliance with relevant standards, have become more common. Some agencies have even employed body cameras, allowing immediate, visual evidence reporting from on-site inspections to headquarters. Managers report that such measures radically reduce the time and cost of processing noncompliance cases as well as help in quality assurance.

Experience in developing and implementing a successful appliance energy efficiency standards and labeling program

- **China's experience shows that it is possible to institute a broad and highly visible appliance energy efficiency standards and labeling program in less than a decade.**

- **Minimum energy performance requirements, definition of tiers which rank energy efficiency levels, and testing methods are combined in China's appliance energy efficiency standards.** Therefore, when a standard is updated, the minimum efficiency bar that all products must exceed, the tiers used on energy efficiency labels, and the definition of high-efficiency products used in financial support or government procurement programs are automatically changed at the same time.

- **Minimum energy performance requirements can be usefully set at levels that force a significant amount of domestically manufactured products out of the market**. China's 2019 heat pump air conditioner standard revision provides an example.

- **Other countries considering standards for products outside of the usual five to six products may find Chinese standards a useful reference.** The range of household appliances covered by energy efficiency standards in China is large.

- **The capacity and institution building process that the China National Institute of Standardization (CNIS) has experienced may be insightful** to others building national institutions with a similar function. CNIS has remained the central entity for developing and revising national appliance and industrial energy efficiency standards for decades, gaining a wealth of experience.

Block Four: Comprehensive Energy Efficiency Programs for Greener and Quality Development (2006–2020)

With the arrival of new policies to develop a less resource-intensive society, China launched a comprehensive effort of change, with interlinking objectives of energy savings, pollution control, and climate change mitigation. The continuing drive is known throughout the country under the popular rubric *'jieneng jianpai'* (save energy and reduce emissions). In essence, the use of energy has now became an undertaking to be regulated for the public good. Limits are set for different processes, and total energy use over a given area becomes restricted in ways similar to airshed ambient-level pollution control schemes. At the same time, a wide variety of programs and policies are operated to facilitate the energy savings effort, allied with market forces, as investments in energy cost savings, of course, remain financially attractive under most circumstances (unlike many air pollution control measures).

Macroeconomic energy efficiency targets began in 2006 and have continued since. A concerted effort to strengthen the market-based and regulatory initiatives of the past was made—the national supportive policies for ESCOs were launched in 2010, the effort to promote energy efficiency lending in banks took hold during

2006–2010, the Energy Conservation Law was improved in 2007, and beginning in 2006, serious efforts to improve local enforcement of standards and regulations were implemented. While top-down pressure was particularly strong during 2006–2015, there also was a strong uptick in development of all the important local institutions involved in the effort.

China made a strong national goal to reduce energy use per unit GDP during 2006–2010 by about 20 percent. During the 12th FYP (2011–2015), the central government set a goal to further reduce the energy intensity of GDP by 16 percent, followed by an additional goal during the 13th FYP (2016–2020) of another 15 percent reduction. During 2011–2015, the government also issued 'guidance' caps for total energy consumption in each province, which were not binding but were logically consistent with good management of the mandatory energy intensity targets. In the 13th FYP (2016–2020), caps on national and provincial total energy use became mandatory, in addition to the energy intensity reduction goals, defining a maximum 'space' of increased energy use by 2020.[3] Now with both energy intensity and absolute energy use targets, the new system is referred to as 'shuangkung'—'double control'.

All of China's provinces, independent municipalities, and autonomous regions have had energy savings and emission reduction targets in addition to the national targets. In the early years of the 11th FYP, when the macroeconomic targets were first rolled out, China's top leadership made it clear that governors and top provincial leadership would be held accountable for the achievement of the targets. Progress at the national and provincial levels was also widely publicized.

Table ES.1: National and Three Provincial Energy Use Targets, 2006–2020 (11–13th FYPs)

Province	11th FYP Energy Intensity Target (%)	2010 Total Energy Use (million tce)[a]	12th FYP Energy Intensity Target (%)	2015 Total Energy Use (million tce)	13th FYP Energy Intensity Target (%)	13th FYP Energy Use Cap (million tce)	13th FYP Maximum Energy Use Increase (million tce)
Jiangxi	–20	64.2	–16	84.4	–16	99.5	15.1
Shanxi	–22	150.0	–16	193.8	–15	223.9	30.1
Shandong	–22	340.7	–17	379.5	–17	420.2	40.7
National	**–20**	**3,606.0**	**–16**	**4,300.0**	**–15**	**<5,000.0**	**<700.0**

Note: a. 2010 provincial energy use data are from the series before Economic Census adjustment and may not be comparable with 2015 data series.

Experience with developing, monitoring, and enforcing binding national and provincial energy efficiency and emission targets

- **Accurate energy use statistical reporting is required.** It was not a coincidence that the capacity and independence of China's energy use reporting system were seriously upgraded when the macroeconomic target system was introduced.

- **Development of early warning systems.** Chinese government authorities at different levels charged with responsibility for ensuring target compliance have developed a range of systems and techniques for monitoring compliance to ensure that problems can be flagged to decision-makers and addressed in time for possible correction.

3 The national target was to keep total energy consumption below 5 billion tce by 2020, regardless of GDP growth, thus defining the maximum 'space' of 700 million tce increased energy use by 2020 compared to 2015.

Management of 'incremental energy use space'. One of the strengths of the Chinese experience is managing 'incremental energy use space,' especially at provincial levels. Gains in energy savings are carefully tracked, especially in existing industrial plants. The remaining space for increasing energy consumption from new development is then conservatively calculated. The balance of this available space is then an important factor in assessing approvals for new large fixed-asset investment projects. The practical experience of provincial authorities in managing development under a system of caps may be especially insightful for others aiming to roll out regional GHG emission cap systems.

China now has a comprehensive toolkit for promoting energy efficiency. The macroeconomic targets emphasize the importance of achieving verifiable results, but the application of all the tools developed over the years makes it possible for that to happen. Sector-specific programs in industry and buildings are comprehensive. Details are provided in Chapter 3 (industry) and Chapter 4 (buildings). Two key industrial programs provided especially impressive energy savings gains during 2006–2015—China's program to address serious energy inefficiency and pollution in legacy, suboptimal industrial plants and China's programs of government-enterprise energy savings agreements. Experience in these two program is briefly discussed below.

Experience in closing down especially wasteful and polluting industrial production capacity

During 1985–2005, Chinese authorities tried many efforts to reduce its huge stock of inefficient, subscale, and technically inferior industrial plants, inherited from the past, but with limited success. Success was achieved only with a strong program launched in 2005/06. Other countries also have problems of particularly inefficient and polluting plants that remain in operation, even with subsidies, because of local revenue and employment benefits. Some suggestions from China's success in dealing with these problems are as follows:

- **Efforts to close backward plants must usually be led from outside of the locality.** In China's case, the national government led and forcefully pushed the effort.

- **Leverage of new investment.** If investment in a new, modern industrial or other facility is being planned in a given locality, approval and investment mobilization may be made contingent upon closure of certain backward, wasteful, and polluting facilities in the same area. China's State Council specifically endorsed this policy.

- **Provision of outside concessional funds** for new economic development and employment generation in an area with backward capacity targeted for elimination was important for bringing local governments and communities on board. In China's case, substantial grant funds were provided, but only if backward plant closures were completed according to a dated timeline.

- **It is important to be clear and consistent in the definition of wasteful capacity that must be eliminated.** China used its national industrial energy efficiency standards for this. If a country aims to eliminate several types of especially wasteful plants—for example, old, inefficient, and wet process cement plants—a starting point may be to define precisely minimum efficiency levels required in cement production and then develop programs to assist localities to close or convert plants that cannot meet that standard.

- **Provision of clear evidence of plant destruction may be** required before declaring completion. In China's case, in early years, some localities reopened plants later or sold the equipment for operation elsewhere.

Beginning in 2006, the Chinese government has signed and supervised agreements with many industrial enterprises specifying enterprise-specific energy savings targets. The agreements and the steady dialogue during supervision also served as a platform for the relationship between the government and enterprises for the rollout of China's suite of industrial energy efficiency programs, including technical and financial support, and both carrot and stick approaches. Execution of the agreements has been mandatory for enterprises with total energy use over designated amounts. The 'Top 1,000' Program was launched at the outset of the 11th FYP (2006–2010), including energy savings agreements between the government and the leading 1,008 industrial enterprises in the country in terms of energy consumption. During 2011–2015, the energy savings agreement effort was greatly expanded with a new 'Top 10,000' Program, which is certainly the largest and broadest program ever attempted. Supervision of the program and dialogue with participating enterprises was a key task of China's Energy Conservation Supervision Agencies.

Experience in government-enterprise energy savings agreements

Many aspects of China's experience may be insightful to others developing programs for energy efficiency agreements between the government or its agents and industrial or other large enterprises, whether they are programs with mandatory or voluntary participation. Examples are as follows:

- **Link with investment support for projects in participating enterprises.** Enterprises were eligible for the country's largest program of grants for large industrial energy efficiency projects.

- **Enterprise consumption data and energy efficiency reporting tables and protocols.** Reporting became online during the Top 10,000 Program period. Useful aspects include not only the tables and calculation methods used but also how they were cross-checked and reviewed.

- **Requirements for enterprise energy management staff,** their training, their registration, their typical assigned duties, and emergence of various energy management staff issues and resolution of those issues were highlighted during program implementation.

- **Successful efforts to expand enterprise enthusiasm** for energy efficiency work during the program period, with case study examples.

Looking Ahead

China's efforts to improve energy efficiency will certainly continue into the future. China's leadership has committed to a peak of its GHG emissions by 2030 and achievement of net-zero GHG emissions by 2060. The authors estimate that energy efficiency gains accounted for 85 percent of the reduction in China's GHG emission intensity during 2006–2019. While only time will tell the precise contribution of energy efficiency in the future, it will need to be large for China to achieve its goals.

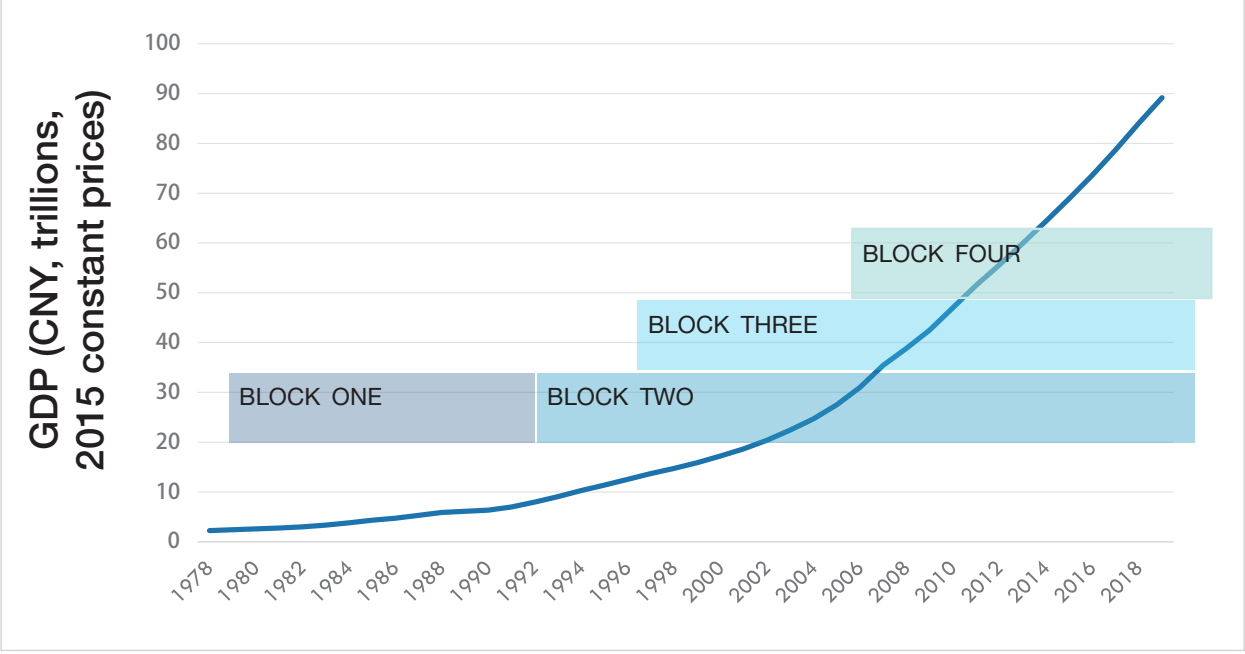
International exchange of experience will be important for China, but greater dissemination of the rich experience China has gained is important for others as well. To be readily understood, China's experience must be described with suitable context and background, and this report aims to help with that process. In addition, however, it would be useful for much more detail to be exchanged between parties. Advice on how to make this as useful to outsiders as possible is provided in Chapter 5.

Chapter 1: The Stages and Overall Achievement of China's Energy Efficiency Effort

1. This chapter reflects on the history of energy efficiency efforts in China over the last 40 years, divided into four blocks, which China basically added on top of each other over time to make a comprehensive effort. Chapter 2 outlines government institutional systems for promoting energy efficiency as these systems have stood during 2006–2020. The chapter covers government institutions, planning, monitoring of work and results, and fiscal support. Chapter 3 covers energy efficiency efforts in industry, which is China's largest energy-using sector. Chapter 4 summarizes energy efficiency efforts in buildings. Finally, Chapter 5 summarizes key lessons learned and provides a list of a variety of areas of possible greatest interest to other countries. A more detailed discussion on the list of topics is also covered in Chapters 1, 3, and 4, in sections describing lessons learned, where the specific experiences that are most relevant for other countries are marked with blue headings.

2. China promoted many policies, regulations, approaches to market development, support efforts, and incentive programs over the last four decades, at many levels. Some have stood the test of time and others have not. Some are broad and some are sector or industry specific. This report covers only the most prominent ones to shed light on how China dramatically improved energy efficiency alongside its rapid industrialization and modernization.

Figure 1.1: Evolution of China's Energy Efficiency Policies and Programs Since 1980



Source: Authors.

3. The four blocks of China's energy efficiency policies and programs since 1980 are shown in Figure 1.1. Block One focuses on energy conservation as a solution to energy shortage under the planned economy. This block covers 1980–1991 and is the only block no longer under implementation as China subsequently

moved away from its planned economy to a market economy. Block Two (1992–2020) covers the transition to development of energy efficiency for economic and financial benefit and development of market-based energy efficiency efforts. Block Three (1997–2020) includes law-based energy efficiency regulatory efforts. These are also sometimes described in China as 'administrative measures'. Block Four (2006–2020) includes the addition of a new series of targeting and support efforts to build upon the efforts of Block Two and Black Three to form a truly comprehensive energy efficiency program for greener and higher quality economic and social development.

4. The blocks are described in this chapter in the context of China's broader economic development and transition from a planned to a market economy over the period.

Block One: Energy Conservation as a Solution to Energy Shortage under a Largely Planned Economy (1980–1991)

5. China was a low-income country in 1980, with GDP per capita ranking in the middle of the lowest quartile of countries in the world. About 80 percent of the population lived in rural areas. The share of industry in GDP was high for a low-income country, at 46 percent, but industry focused more on capital goods and products needed for infrastructure than on durable goods for household consumption. Self-reliance had long been a key policy goal.

6. Under the planned economy, production targets and resource allocations were fixed in annual economic plans. Private ownership was minimal, with enterprises owned by the state or local collectives. Prices were set by the state with a view only to the transfer of currency between parties and were often not aligned with costs. Shortages of all manner of production inputs and consumption items were common. Enterprises focused on achieving production targets, undertaking investments as directed, and securing inputs as best as they could.

7. Quotas for maximum electricity demand, and state-distributed coal and petroleum product supply, were set by the state according to the plan. As China's opening up and reforms progressed during the 1980s, shortages often became severe with the resulting more rapid economic growth. Insufficient electric power in particular was a common constraint on factory growth. Rolling power cuts were common during peak loads.

8. **Launching energy conservation efforts during the 1980s.** Efforts to increase energy supplies could not keep up with rapid demand growth. Efforts to improve energy efficiency became urgent, with the potential to cost the state less resources and yield results quicker than just investing in supply. China's State Planning and State Economic Commissions had long had energy conservation departments, in addition to fuel and power bureaus. The work of these entities and their provincial and local counterparts expanded, promoting renovation projects and investment in more efficient technology in new plants. Industrial energy efficiency was the main focus. The amounts of national and local government funds set aside for energy efficiency projects increased in the annual and five-year plans. Government monitoring and supervision of energy use in enterprises expanded, using standard command and control practices. Institutional responsibilities within the government were strengthened and sanctioned in the 1986 'Temporary Regulations for Energy Conservation Management' issued by the State Council, China's highest government authority.[4]

4 See World Bank. 1993. *China: Energy Conservation Study* (February), Annex 3 for an English language summary of the content of this table-setting policy document.

9. **Building technical capacity.** With universities closed during the Cultural Revolution until 1977, new engineers were just beginning to enter the workforce in the early 1980s, joining older technical staff trained before the mid-1960s. In addition to a wide range of areas, there were new needs for technical staff in the government, technical service units, and enterprises with skills to assess energy use patterns and identify and supervise energy efficiency initiatives. Given China's size, and needs greatest at the local levels where investments must be made and practices modernized, China's needs were especially pressing.

10. By the end of the decade, about 200 technical energy conservation centers had been put in operation throughout China. These included (a) some well-established regionally based training and technical assistance centers; (b) provincial[5] level technical service units in virtually every province; and (3) provincial, prefecture, or even county-level testing and measuring stations. Five of the larger training and technical assistance centers participated in training-of-trainer programs supported by the European Economic Community. Capacities and competencies varied, but the stronger centers were running enterprise energy auditing practices, delivering a range of technical training courses for testing/measuring station and enterprise staff, providing analysis and advice for both local governments and enterprises, undertaking demonstration project design and preparation, publishing technical journals, and so on.

11. With some technical support and through their own efforts, major energy-using enterprises also developed in-house capacities to diagnose energy use issues, compile energy accounts and statistics, prepare reports to the government, and develop projects. Although formal and sophisticated energy use benchmarking activities were yet to be rolled out, managers at energy-intensive enterprises typically could recite by the end of the decade how their energy use compared with that in other factories in the province or nation.

12. **Building a strong energy statistical system.** After a trial effort in 1979, China produced its first national energy balance in 1980. In subsequent years, the collection, quality control, and summation of energy statistics steadily improved, together with improved reporting from enterprises. In 1989, China's State Statistical Bureau published its first Energy Statistical Yearbook, including comprehensive statistics on energy use as well as supply. The yearbook was one of the most comprehensive, internally consistent, energy statistical reports published in any low-income country. Also, it has since been published continuously.

13. China's development of a strong system for collecting energy statistics has been a key building block for its subsequent energy efficiency promotion efforts. In more recent years, the system has been further strengthened by measures to ensure independence of the system from possible local government interference and by periodic cross-checking and revision with data from China's separate and comprehensive Economic Census, the fourth of which was completed in 2018.

14. **LESSONS LEARNED.** The development of a government institutional system during this period, reaching from the top to the bottom, subsequently proved critical for the success achieved in China's long-term energy efficiency drive. Efforts to improve energy efficiency became a more integral and serious aspect of the energy planning process in China than in most other developing countries. The concept of comparing units of energy saved with units of energy supply was developed and popularized among energy planners in China, while these concepts were new and just emerging in other countries. In addition, the success achieved in building technical capacity and institutions, including increasingly at local and enterprise levels, also proved absolutely essential for the future. Finally, investments made in building up the energy statistical system, including statistics on energy use, also proved critical for the future.

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5 Administrative units of provincial-level rank in China, which report directly to the State Council, include provinces, four independent municipalities, and several autonomous regions. For simplicity, the word 'province' or 'provincial' is used in this report to refer to all three.

15. The system operated during the 1980s was especially strong at identifying cases of serious energy waste in industrial enterprises and applying pressure to reduce that waste. The system was also well set up for the promotion of predetermined, generic energy efficiency investments at a large scale. A serious problem, however, was that enterprise incentives for efficient use of energy still remained inadequate. If no longer an obvious, wasteful outlier, enterprises had little reason to care about efficiency. At times, the system also appeared arbitrary and its coverage incomplete.[6]

16. **Experience in developing local technical capacity.** Access to competent technical personnel to identify attractive energy efficiency improvement opportunities and design and help implement projects is a precondition for effective energy efficiency programs in all countries. Where technical capacity is weak or nonexistent, experts from outside can be brought in, but this option is rarely sustainable for long. Hence, developing local technical capacity is typically a launch point for new energy efficiency efforts which cannot be overlooked.

17. China's experience in this area may be useful to other developing countries. As a huge country, China had to face the problem of inadequate local expertise even though national-level experts may have been strong. Experts brought in from Beijing or Shanghai could not be relied on by local enterprises and other personnel to deal with local energy efficiency work in a sustainable way. Some lessons from China's experience that may prove relevant to others are as follows:

    - **China's approach was to launch technical service and measuring stations quickly and broadly and then gradually improve the quality of their work over time.** While initial work may often have not been sophisticated, this approach served the country well over the longer term, allowing urgent basic needs to be met initially and then building stronger capacity over time.

- **New technical staff were employed immediately in practical field tasks, such as measurement, and often expected to learn by doing.** This adds practical experience to learning and works well as long as a few senior staff are available for quality control and on-the-job training.

- **Ensuring sustainable employment.** Severe attrition of newly trained energy efficiency technical staff to other job opportunities is a common problem worldwide. China also was in serious danger of losing much of its new force of energy efficiency technical staff during the next decade (see paragraphs 26 and 28), until additional, attractive opportunities began to develop. It is advisable to have a strategy for ensuring maximum deployment of newly trained staff in the energy efficiency field before rolling out big training programs.

- **Including strong focus on the financial benefits of improving energy efficiency and considering the practical perspectives of enterprises.** Analysis and summation of priorities and investment returns from a financial point of view were typically ignored in early Chinese technical reports. This may not have mattered much under the planned economy, but continuation of this weakness in future years became a serious drawback. During the first decade of the new century, for example, energy audit reports were sometimes viewed with scorn by enterprise managers, judging them as 'too technical', 'too abstract', or 'template only', devoid of good financial analysis, and lacking enterprise practical realities and business concerns. This problem also is common in other countries. China's diagnostic and project preparation work has greatly improved in recent years, especially with priority emphasis placed on serving enterprises. Nevertheless, other countries with market economies would do well to learn from this experience and make strong efforts from the beginning to include relevant financial

6 For a discussion of the advantages and disadvantages of the system of the 1980s, see World Bank. 1993. *Energy Conservation Study*, 56–61.

analysis and address practical enterprise perspectives in technical energy auditing and energy efficiency project preparation work.

18. **Experience in developing energy statistics.** Development of sound energy statistical reporting and analysis systems is another foundational investment that has served China well. Reliable and sufficiently detailed energy use statistics are needed for prioritizing programs and investments, assessing impact, benchmarking enterprises and regions to compare efficiency levels, and more. China's work to develop comprehensive national energy balances and eventually provincial energy balances is a useful, recommended measure which requires that all manner of supply and use data, typically gathered from various sources, should be cross-checked and reconciled. China's work to develop industrial enterprise energy accounting and reporting also began early and has proved critical for subsequent setting of industrial standards, benchmarking of enterprises producing the same commodities for comparative purposes, and assessing enterprise energy efficiency progress over time, especially enterprise internal energy management. Two particular areas where lessons from China's experience may prove valuable to others are as follows:

    - **Safeguarding energy statistical reporting from local interference.** Under the planned economy, local areas had much incentive to alter statistical reports to show compliance with targets set in economic plans. China's statistical authorities have long wrestled with this problem and devised a variety of means to best maintain the independence and integrity of the system. Especially important were reforms in 2007 to increase the energy statistical system's independence and build a full Department of Energy Statistics in the NSB. Statistical bureaus in other countries faced with this common problem could benefit from an exchange of views and experience with Chinese experts.

    - **Developing industrial enterprise energy use reporting.** Initial enterprise energy use reports developed in the 1980s were often rough, with limited measurement capacity, many estimates, and weak capacity for cross-checking. But these systems have been steadily improving over almost 40 years. Current industrial enterprise energy use accounting and reporting protocols are based on a tremendous amount of practical experience. Cross-checking techniques and methods to identify errors are advanced. There are hardly any industrial enterprise energy accounting and reporting nuances that Chinese experts have not encountered.

Block Two: Transition to Promotion of Energy Efficiency for Economic Benefit and Development of Market-Based Energy Efficiency Initiatives (1992–2020)

19. China's transition to a market economy was gradual but steady. By the middle of the first decade of the new century, resources were being allocated by the market instead of the plan, enterprises were responding to market signals rather than planned targets, and direct command and control of the vast majority of enterprises by the state had been abolished. Two aspects of this multifaceted process that were especially relevant for energy efficiency efforts were enterprise reform and energy price reform.

20. **Changes in enterprises.** Strong industrial growth from the mid-1980s to mid-1990s was led in large part by township and village enterprises (TVEs). Initially developed by rural communes for local production to serve agriculture, these collectively owned enterprises were outside of the direct dictates of the economic plan. They began to expand rapidly, including production of consumer goods. Somewhat behind, private enterprises also eventually began to develop and prosper.

21. With a new Company Law passed in 1993, China's state-owned enterprises also began to change, with many and eventually most transforming into shareholding companies. Shareholders varied, including employees, collectives, different state investment companies, other state entities at different levels, private individuals, and others. With boards representative of shareholders, chief executive officers (CEOs) were hired and made accountable for bringing profits to the investors. In the new century, many companies went public, selling shares on domestic and international stock exchanges.

22. A wide variety of enterprises are now operating in China, the vast majority focused squarely on profitability.

23. **Energy price reform.** With the transition to a market economy, it was also imperative for prices to be reformed to provide purchasers with market signals as to the cost of supply. Energy price reform was also critical to provide signals to enterprises as to the true benefits of improving energy efficiency and to increase enterprise incentives to invest and manage accordingly. China's energy price reform effort was gradual and somewhat unique.

24. In-plan energy prices at the outset of the 1990s were well below supply costs, except for some petroleum products. But enterprises were in dire need of more supply. Especially for the rapidly expanding and new enterprises, such as TVEs, lack of sufficient energy supply was often a binding constraint holding back expansion. These enterprises were eager to obtain energy for production, even if at far higher prices. Soon the government sanctioned 'out-of-plan' supply of coal at varying 'above-plan' prices. The government also moved to allow localities, typically using surplus funds from growing enterprises, to band together to invest in new electric power plants, with provincial government assistance. Localities, and the enterprises located in them, could then obtain 'out-of-plan' additional electricity from the power plants they invested in, at the higher prices required for the power plants to pay off their bank loans.[7] The result after some years was a new (but complicated) dual track electricity pricing system. Eventually, by the late 1990s, rapid growth meant that 'out-of-plan' electricity sales surpassed 'in-plan' sales, and the dual pricing system in electricity was collapsed into one system which, on average, reflected the long-run marginal costs of supply. Coal sales also became largely market driven, with the exception of coal prices paid by large state-owned power plants, which were regulated for some years into the new century.

25. Currently, average energy prices in China are at or above the costs of domestic supply or export/import value, although some cross-subsidization exists (for example, cross-subsidy of residential electricity consumers by industrial and commercial electricity consumers). The reform in price levels has greatly benefited the drive to encourage energy efficiency using market-based mechanisms. Time-of-use pricing, including seasonal pricing, has also been used for various customer classes and regions. Penalty electricity prices as high as double regular prices have been imposed on customers that consistently fail to meet energy efficiency standards.

26. **Changes in the energy conservation promotion system.** China's system of government energy conservation departments and technical centers entered a difficult time of transition in the 1990s. The system's operating environment was based on direct state command and control of enterprises and now that operating environment was disappearing. Energy conservation staff continued to develop and implement investment plans and promote useful demonstration projects. But they had less power to direct others, and learning to promote energy efficiency based on its other advantages, such as financial

7 The State Council's regulation allowing this path-breaking policy change was issued in late 1985, titled 'Temporary Regulations on Encouraging Pooling of Investment to Provide Electricity and Implement Multiple Types of Electricity Prices'.

benefits, was a challenge for many.[8] Over time, new mechanisms were developed which successfully promoted energy efficiency investment in the market, including new ESCOs, and operation of new energy efficiency lending windows in banks. These are discussed in the following paragraphs. In addition, the government moved to institute new legal and regulatory measures which were more suitable to the market economy. These are discussed under Block Three.

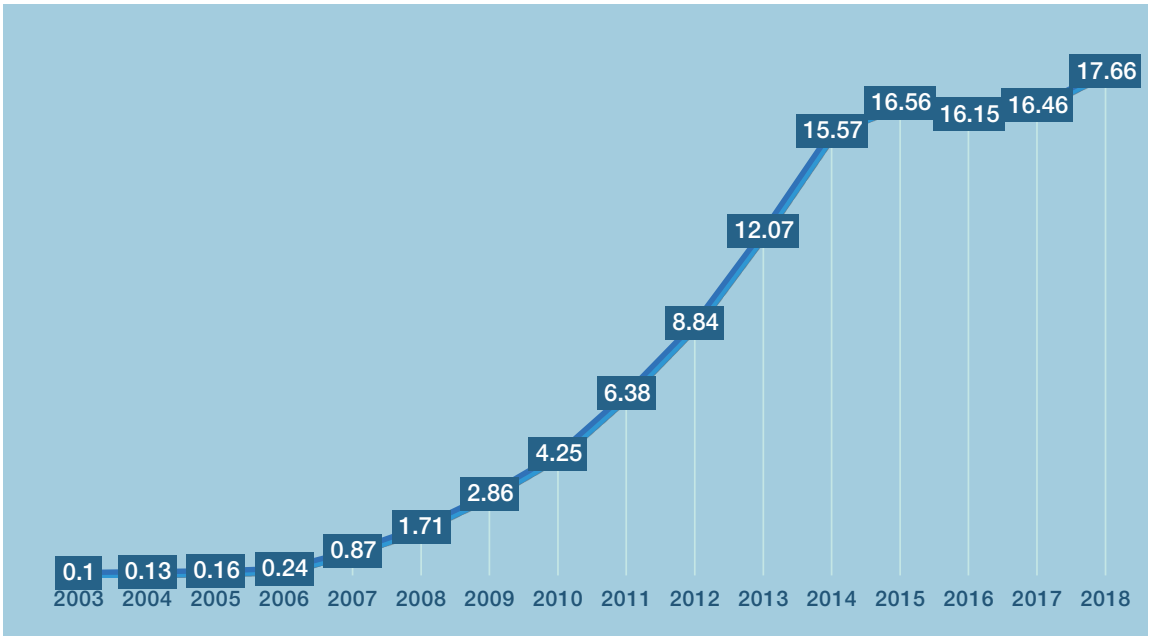
27. **Developing energy performance contracting through ESCOs.** China's ESCO industry has grown from nonexistence in 1997 to easily the largest in the world. Energy efficiency investments using energy performance contracting[9] grew from zero in 1997 to over US$17 billion in 2018.

28. Senior government officials charged with promoting energy efficiency became interested in the idea of ESCOs in 1996 as an option for the then-struggling local technical energy efficiency centers to transition to the new market environment. Officials and practitioners were greatly concerned that the big human resource investment in the centers might be lost if they could not adapt. Three pilot ESCOs were established in 1997 with local equity investment and technical staff from provincial technical centers. With international technical assistance, the pilot companies rolled out a variety of energy performance contracting projects using dedicated financing from the government, GEF, and World Bank. The pilot companies proved that energy performance contracting could work and be profitable in China. Other groups interested in the model also formed companies, some stemming from the technical centers. Lending to the ESCOs for project financing shifted to domestic banks, with backup guarantee arrangements initially provided by World Bank and IFC. More details on the story of how domestic financing for the ESCO industry took hold are provided in Annex 1. The industry grew rapidly, passing the US$1 billion mark in investments in 2008. The industry then caught the attention of China's top leadership, and a series of new supportive policies was issued by the State Council and National Development and Reform Commission (NDRC) in 2010. As shown in Figure 1.2, the industry has grown strongly to the present.

8 In a national effort to help promote better understanding of the advantage of energy efficiency projects in the market economy, China's National Energy Conservation Information Dissemination Center began in 1999 to focus especially on the impressive project financial returns in their case studies of highly replicable energy efficiency technologies. With World Bank-GEF support, the center eventually produced and disseminated over 100 such case studies before it was eventually merged with another government agency.

9 Energy performance contracting is defined here as contracting between a host and project developer (for example, an ESCO) for design and implementation of energy efficiency investments at the host's facility with at least some portion of the project developer's remuneration from the host contingent upon the investment achieving agreed energy savings.

Figure 1.2: Energy Performance Contracting Project Investment in China, 2003–2018 (US$, billions)



Source: Energy Management Company(ESCO) Association (EMCA), various reports.

29. Table 1.1 highlights some differences between most ESCOs in China and most ESCOs in North America. Unlike many ESCOs in other countries, most (but not all) Chinese ESCOs finance their projects—in essence most Chinese ESCOs are a blend of a service and equipment installation company, guaranteeing energy savings results, with a project finance company. A key attractiveness to commercial customers in China is ESCO provision of off-balance sheet financing for projects with repayment tied to successful project energy cost savings. Accordingly, projects may be simpler and quicker than in some other markets, so that ESCOs are able to secure repayment in the short or medium term. A big challenge for most Chinese ESCOs is securing sufficient financing to enable continuing project development, generally from repayment flows, shareholder funds, or commercial lending institutions. While the Chinese-style ESCOs have done well, it is not a simple business, requiring a blend of financial and entrepreneurial skills, in addition to technical strength.

Table 1.1: Comparison of Chinese and North American ESCOs

China	North America
Is there a minimum energy savings guarantee with financial consequences to ESCOs if not met?	
Yes	Yes
Do most ESCOs provide project financing to clients?	
Yes, including financing off clients' balance sheets	No
What are the main markets for most ESCOs?	
Manufacturing industry, commercial buildings	Building complexes, especially publicly owned ones
What are key concerns of most ESCO managers, besides profitability?	
Creditworthiness of clients and their repayment of project investment costs, securing ESCO's financing for growth, staying ahead of competitors in technical solutions	Maintaining long-term client relationships, avoiding arguments about savings guarantees, providing in-depth technical solutions appreciated by clients

Source: The authors.

30. Also different from ESCOs in some other countries, the industrial sector has always been a key market for Chinese ESCOs. Projects began with relatively simple industrial equipment replacement projects

but then have grown more sophisticated and technology intensive over the years. However, projects in commercial and public buildings, as well as building district heating supply renovation, have been common and grown more sophisticated over time. The three most common types of energy performance contracts include shared savings with ESCO investment financing, energy savings guarantee contracts without financing, and chauffage contracts. The shared savings contracts have consistently held the majority. However, from the beginning, shared savings contracts have included a fixed customer payment schedule, based on prior agreement on percentage shared savings levels. The payment schedule is confirmed once energy savings have been demonstrated to meet guaranteed levels at project commissioning or over an agreed, usually short, period of regular operation. Once confirmed, the fixed payment scheme is critical for ESCO financial stability and the ability of the ESCO to obtain financing for projects.

31. By 2010, some 800 ESCOs were operating in China, with project investments exceeding US$4 billion per year and commercial bank credit for at least the well-established companies now available. Building on this foundation, the strong support for new central government policies fostered the sharp growth in the industry during 2011–2015 as shown in Figure 1.2. The policy package included favorable tax treatment for ESCOs and, for some years, substantial financial awards provided upon commissioning of new, large energy performance contracts. Perhaps most important, however, was the clear reputational support for the new industry, which could be seen at the local and national levels. From 2015 on, the torrid pace of growth leveled off. This has essentially been for market reasons. During these years, China's economic growth slowed and domestic industrial production was in surplus in many sectors. Declining creditworthiness of potential industrial clients (and especially energy inefficient ones) reduced safe markets for ESCO investments. Among clients with good credit competition became more fierce. Implied interest rates in shared-savings energy performance contracts are higher than most other options financially strong clients have for financing energy efficiency projects (including, especially, use of own capital). Accordingly, it has become increasingly critical for ESCOs to provide strong technical value added, often with new technical innovations, to compete well in today's market.

32. **Energy efficiency loan operations in commercial banks.** Another market-based approach successfully developed in China with initial international cooperation is the operation of energy efficiency lending programs in commercial banks. Development of specific energy efficiency bank lending programs requires special efforts, as these loans focused on projected operating cost savings diverge from mainstream commercial bank working capital or fixed-asset production expansion loans. Moreover, individual loan sizes are often relatively small and good organization is required to ensure technical soundness while minimizing transaction costs. Programs were launched in the middle-to-late 2000s with World Bank, IFC (part of the World Bank Group), and bilateral assistance. IFC's successful program, called the China Utility-based Energy Efficiency Finance Program ('CHUEE'), provided partial risk guarantees backed with GEF and IFC resources for new energy efficiency lending programs. The World Bank's successful program, extended to three banks, provided dedicated credit for new energy efficiency lending programs. Both programs provided substantial technical assistance.[10] Most participating banks were commercial shareholding banks, although one state-owned and one private bank also were among the early developers. By 2014, 6–10 banks with national operations led energy efficiency lending with specific, sustainable programs and dedicated staff. In 2015, China's Banking Regulatory Commission (CBRC) and NDRC issued specific guidelines on how banks could ramp up their energy efficiency lending businesses. Energy efficiency lending has included growing lending to ESCOs. Some bank subsidiaries and energy efficiency project developers have also developed financial leasing instruments as part of the toolkit for commercial energy efficiency financing. National and regional guarantee companies have also entered the business.

10 For more details on both IFC and World Bank programs, see World Bank. Forthcoming. *The Successful Partnership of the World Bank Group and China on Energy Efficiency, 1992–2020.*

33. **Development of a vibrant energy efficiency technology and service industry.** An exceptionally diverse and vibrant digital technology industry for deployment in energy efficiency applications has developed in China since about 2010. Companies range from thousands of small start-ups to large ventures. Sometimes categorized under the rubric of 'smart energy technology', new and creative applications include energy optimization and control systems in large manufacturing plants or building complexes, all manner of off-site measurement, reporting, and control technologies, real-time energy use analysis programs, tablet applications for energy managers and inspectors, a wide range of cellphone applications, and others. In the authors' opinion, there is a great potential for mutual benefit from greater collaboration between Chinese companies and countries abroad in this area.

34. **LESSONS LEARNED.** China's efforts to develop market-based mechanisms to improve energy efficiency took time, but once well seeded, the ramp-up of these mechanisms to a large scale has been impressive. The government made good use of international assistance, including from the GEF, where GEF resources were well placed to address initial investment risks and systemic barriers. Specific aspects from China's experience of developing ESCOs and bank energy efficiency lending may be insightful for other countries and are discussed below.

35. **Experience in building an ESCO industry.** Developing and operating ESCOs is a difficult and often risky business, requiring a blend of technical, financial, and entrepreneurial skills. The record on developing ESCOs in other developing countries is mixed at best. China's ESCOs adopted some different approaches from many mainstream ESCOs internationally, especially provision of project financing to clients. China's step-by-step approach to piloting and scaling up its ESCO industry also had different features. However, in the authors' opinion, there is nothing inherently unique about China's ESCO development path that makes it applicable only to China and detracts from the usefulness and relevance of its experience in other market economies. Some possible specific insights for others are summarized as follows:

    - **Adapting models to local circumstances.** Although China's first ESCOs learned many things from international examples and experts, they also made major adaptations to business models. For example, staff from China's technical centers immediately moved to adapt the business for the industrial projects they knew well, even though this was not common abroad. The first ESCOs also greatly simplified the model contracts they reviewed from elsewhere and better matched them to Chinese business norms.

    - **Providing off-balance sheet financing to ESCO clients.** The proposition that ESCOs paid for up-front investment costs and asked for only a share of energy cost savings in return was attractive to clients. If the early ESCOs did not cover investment costs, the business could not have developed. Paying for technical service was not popular among enterprises, which felt they could do their own technical work and looked askance at paying 'consultants'. However, ESCO provision of financing did make obtaining project financing a key constraint on the speed of growth of individual ESCOs, unless they had deep-pocketed shareholders. Finally, provision of finance made ability to assess enterprise creditworthiness and contract repayment risks yet another core required skill for successful ESCOs.

    - **Not confronting all barriers at once.** The Chinese government, World Bank, and ESCOs made a conscious decision to proceed quickly with implementation of energy performance contracts before attempting to solve all the issues surrounding operation of the new business model. During the first few years, many systemic issues did arise, with auditors questioning the placement of assets in other enterprises, taxation authorities puzzled as to how to classify the business, and even some

local authorities declaring the business model illegal. The central government looked into the issues as they arose and helped devise practical solutions to the concrete problem cases.

Critically, issues of obtaining project financing were taken off of the table for the first pilot ESCOs. The World Bank and government provided the needed lines of credit, and the job of the ESCOs was only to see if they could operate the new business model successfully and profitably. This was difficult enough. When they succeeded, and other ESCOs began to form, the government and World Bank moved to address the financing issue head on in the second phase, with projects to assist commercial bank lending to the business with risk guarantees.

- **Strong, consistent government support was critical.** The Chinese government undertook significant risks supporting the launch of a business model that was completely untried in the country. Provincial governments organized equity investment in the first pilot companies and the central government provided a sovereign guarantee for World Bank lending for a new business that had no track record. The government consistently supported the early growth of the industry as it encountered various problems.[11] Subsequently, China's top leadership took note of the growing industry and provided key new policy support and reputational encouragement to the industry, which helped spur a huge industry ramp-up during 2010–2014.

36. **Experience in developing lending for energy efficiency projects in commercial banks.** For large banks or other financial institutions, energy efficiency financing is at best a small niche business. Typically, only some are interested and for different reasons. However, the Chinese banks and guarantee companies that have pursued energy efficiency financing have now many years of experience. Some have established unique centers that specialize in energy efficiency and some other 'green' financing. Other countries and financial institutions interested in the business could benefit from this practical experience. Perhaps the best way would be through focused exchange forums. Some key topics for such exchange and discussion might be as follows:[12]

    - **Why develop an energy efficiency lending business?** In most cases, such a business needs to help meet additional, broader goals which are often bank specific. Perhaps a bank may want to add an additional product focused on operating cost savings to their suite of offerings to well-established customers. Some may see the business as an opportunity to expand SME credit programs. Others may see needs to develop environment-friendly reputations with the government or key client groups. There are other common reasons as well.

    - **Cost-effective and efficient loan origination.** Efficient loan origination is often a headache for institutions beginning this business. Projects are often small but still require technical assessment. The challenge is to meet requirements for sound technical soundness and good client creditworthiness (good project economics is not enough). Chinese banks have developed various strategies, such as reliance on existing customers before branching out, use of 'template loans' for small projects using common technology, concentration on a few key subsectors, or development of partnerships with trusted technical groups.

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11 As is common in other countries too, relevant government agencies were restructured and key staff were often changed throughout the period. However, staff and capacity in the Project Management Office (PMO) assigned by the government to oversee ESCO development remained steady and with unchanged leadership. The PMO played a critical role in explaining the industry to new authorities and securing consistent support for more than a dozen years.

12 For more information on specific characteristics and issues in energy efficiency financing in China, how China's financial sector relates to energy efficiency financing, and an overview of relevant international initiatives in China, see Taylor, R. P. 2012. *Next Steps for Financing Energy Efficiency in China.* Energy Pathways LLC. Available on request from authors.

- **Meeting standard loan appraisal criteria and formats with minimal adjustment.** Energy efficiency loans focused on cost reduction may require some different emphases at appraisal. However, adjustment to internal appraisal criteria and forms is not simple. Chinese banks and especially guarantee companies have developed solutions that work.

- **Overcoming lack of familiarity with energy efficiency loans in risk management departments.** In virtually all cases, loans developed by loan officers must pass through internal risk management departments. Energy efficiency loans can be a hard sell, especially when business is just beginning. For example, risk management departments are used to assessment of increased revenue streams and may look askance at 'paper only' and 'hypothetical' calculations of 'negative costs'. To achieve success, Chinese energy efficiency loan program staff have had to navigate this problem effectively.

Block Three: Law-Based Energy Efficiency Regulatory Initiatives (1997–2020)

37. **Needs for a new regulatory framework.** The shift from a planned to a market economy brought new requirements for the legal and regulatory framework for energy efficiency work. With many new enterprises outside of the state system and direct command and control of state enterprises largely gone, government units could not order enterprises to undertake measures without a firm legal foundation. Regulations needed to be clear and legally grounded. If not, regulations could be (and were) ignored or challenged. For the most part, this is similar to the situation in many other market economies. However, the effort to build a legally grounded regulatory system was new for China, as part of the reform process.

38. **China's Energy Conservation Law.** China promulgated its first Energy Conservation Law in 1997 and the new law came into effect on January 1, 1998. It was subsequently substantially revised in 2007 and more modestly modified in 2016 and 2018. Similar to most other laws in China, the Energy Conservation Law is broad, with the main objective of providing sound legal underpinnings for subsequent issuance of detailed policies and regulations. In comparison with Japan's energy conservation law, for example, China's law itself is not sufficient to guide specific energy conservation activities. That specific guidance comes from the body of work it enables. This allows greater flexibility, as the details of regulations can be adjusted based on experience gained without undertaking the multiyear effort of amending the law.

39. The 1997 law set out the foundation for operation of the government's energy efficiency planning and policy system, efforts to restrict especially wasteful industrial enterprises and technology, issuance and enforcement of energy use standards, and assessment of the energy use performance of proposed new investment, among other things. The law established responsibilities for key energy-using enterprises[13] to report energy use to the state and establish internal energy management positions and enabled supervision and examination by local authorities.

40. The 2007 amended law added more clarity, additional provisions, and more details on consequences for fraud or noncompliance. As discussed under Block Four, the 2007 law came at a time when China was greatly ramping up and deepening its energy conservation effort. The 2007 law added the legal foundation for setting and supervising macroeconomic energy efficiency targets, clarity on appliance standards and energy efficiency labels on equipment, and the underpinnings for further improving energy use statistics. The new law added much more on building energy efficiency work, codes, and their enforcement; new sections on transportation and public institution energy efficiency; and calls for preferential tax policy. The law provided the underpinning for operation of six energy-saving management systems, including the

13 Key energy-using enterprises are defined, to this day, as enterprises consuming annual amounts of more than 10,000 tce (with 7 million kcal per tce). Provincial governments can also add enterprises consuming between 5,000 and 10,000 tce per year as key enterprises, at their own discretion.

energy conservation target responsibility system and its assessment and evaluation; a system for energy efficiency assessment for new fixed-assets investment projects; a system for elimination of outdated high-energy-consuming products, equipment, and production technology; energy-saving management systems in energy-intensive enterprises; the energy efficiency label management system; and an energy conservation recognition and reward system.

41. Local governments amended regional energy conservation management regulations according to the newly revised Energy Conservation Law and started to set up law enforcement agencies, such as the provincial Energy Conservation Supervision Agencies described further below.

42. **Minimum performance standards.** China has developed a wide range of standards and codes detailing minimum energy efficiency requirements (or maximum unit energy consumption ceilings) for industrial equipment and processes, new building construction, and various appliances. The standards have been expanded, revised, and strengthened steadily over the last two decades. A particularly large number of detailed standards have been issued for industrial equipment and processes. These specify not only minimum efficiency levels for specific types of equipment but also total maximum energy consumption per unit of output (for example, energy per ton of steel produced) for a range of energy-intensive products. National-level building energy efficiency codes for new buildings requiring heat were first adopted in the 1980s and upgraded in 1997. In more recent years, a wider range of new building energy efficiency standards have been added and updated (see paragraphs 175–182). China's efforts to issue and steadily upgrade household appliance minimum energy efficiency standards and labeling that ranks energy efficiency performance began in earnest in the early 2000s. Some appliance standards are now among the most stringent in the world.

43. China's minimum energy efficiency performance standards often provide an objective benchmark against which other programs operate. For example, in China's efforts to eliminate energy-wasting industrial plants (see Chapter 3), the definition of 'energy wasting' is set relative to the relevant unit energy consumption standard. Or, the methodology of the relevant standard may be a starting point when assessing the energy efficiency level of a proposed new investment. For appliances, the minimum performance standard provides the floor of the ranking system, against which the performance of different models is characterized.

44. China's energy efficiency standards are developed or upgraded through formal procedures requiring many months. One of several designated government research institutes organizes a technical committee, including representatives from those affected and leading national experts. Drafts are reviewed by supervising government agencies several times before final approval. Debate is common.

45. **Systems to enforce codes, standards, and other regulatory requirements.** Enforcement of energy efficiency regulations is an issue in all countries. Enforcement in China, a huge country, must be undertaken within greatly varying local areas. This requires strong support from above as well as capacity and willingness below. Until the late 2000s, local approaches often relied on spot-checking, with common problems of inconsistency. Beginning in the second half of the 2000s, China began to better institutionalize energy efficiency regulatory enforcement at provincial and local levels. Provincial and even prefecture and county Energy Conservation Supervision Agencies were established, specifically to look after the implementation of energy efficiency regulations in industry and supervise new energy savings responsibility contracts between the state and key energy-using enterprises. Local construction commissions improved energy efficiency building code review and enforcement with new processes. A national registrar for all appliances subject to energy efficiency standards and labeling was established, to enter required test results for different models. Results improved, although it took time to build up the needed local capacities.

46. **LESSONS LEARNED.** Chinese energy efficiency authorities and experts frequently describe their system as a blend of market-based initiatives and administrative (regulatory) mechanisms. Market-based initiatives take advantage of the natural profitability of good energy efficiency projects and help increase access to financing where it may be a constraint. Energy efficiency standards and other regulations serve to eliminate the most wasteful energy use and gradually transform performance as standards are steadily tightened. Target-setting schemes (see Block Four below) also help focus attention on energy efficiency by applying pressure. As energy managers in US factories often say, their management generally understands the potential cost savings of energy efficiency investment. However, such efforts may rank in the top 10–12 things a factory leader may want to achieve—but rarely in the top 3–4. Administrative and target-setting pressure can raise the priority level assigned to energy efficiency initiatives among key decision-makers.

47. Both the enactment of China's Energy Conservation Law and its amendment a decade later have proved essential for China's broad energy efficiency effort. The level of subsequent progress could not have been achieved without it. While legal systems and customs vary internationally, the law was needed in China's case to enable implementation of regulations when inevitable pushback came from powerful industries or real estate developers.

48. As discussed in Chapter 3 (paragraphs 121–124), China's system of roughly 100 specific industrial energy efficiency standards is most likely unique and may be of special interest in other countries, even if only for technical reference. China's experience in household appliance energy efficiency standards and labels is discussed in Chapter 4 (paragraphs 198–205). China's overall experience in enforcing standards and regulations is briefly summarized below.

49. **Experience in building systems to enforce standards and regulations.** China's enforcement of energy efficiency standards and regulations is certainly not perfect, and the steady improvements achieved have not been simple or easy. The issues that need to be confronted are common in other countries as well, including weakness in local capacity, difficulties in maintaining quality and consistency in inspections and adjudication, potential for powerful local interference, and others. What is most useful about China's experience to other countries is the long-standing and deep experience of Chinese authorities and experts in wrestling with these common problems and achieving steady improvement.

50. Perhaps a core lesson from China's experience is the need to blend local institutional capacity development with pressure and guidance grounded in law from above. Given the increasing importance of the country's energy efficiency efforts in general, and industrial standards, energy savings responsibility contracts, and building codes in particular, China made large investments of time, effort, and money in developing local supervising entities. In the end, such infrastructure is required to make enforcement a reality. In addition, however, guidance from above and legal backup are important to provide consistency and countermand possible local pushback.

51. Although perhaps unique, China's Energy Conservation Supervision Agencies, focusing on industry, have grown steadily in sophistication and capability over the decade of 2010–2019. Automated measuring and reporting is becoming more common. New software tools are used in some agencies to allow inspectors to input basic date on electronic tablets onsite and immediately and accurately assess compliance with relevant standards. Some agencies have even employed body cameras, allowing immediate, visual evidence reporting from on-site inspections to headquarters. Managers report that such measures radically reduce the time and cost of processing noncompliance cases as well as help in quality assurance.[14]

14 See Chapter 2, paras. 2.13-2.14, for more information on the institutional context of these agencies.

Block Four: Comprehensive Energy Efficiency Programs for Greener and Quality Development (2006–2020)

52. The 11th FYP (2006–2010) launched a major step-up in China's energy efficiency efforts. Mandatory macroeconomic targets were introduced at both national and provincial levels. China's various energy efficiency programs were further upgraded, and new programs were added. The broad endeavor continues to today, under the watchword *'jieneng jianpai'* or 'saving energy and reducing emissions'. China's leadership recognized that continued resource-intensive development over the long haul was physically almost impossible, economically inferior, and environmentally unacceptable. The country launched a comprehensive effort of change, with interlinking objectives of resource savings, pollution control, and climate change mitigation. Improving the efficiency of energy use was at the core of the multi-objective effort, pursued under the rubric of 'building a less resource-intensive society'. In essence, the use of energy became a regulated undertaking for the public good, in many ways similar to the way in which release of emissions is also a regulated undertaking for the public good in most countries. Limits are set for different processes, and total energy use over a given area becomes restricted in ways similar to airshed ambient-level pollution control schemes.

Table 1.2: National and Three Provincial Energy Use Targets, 11–13th FYPs

Province	11th FYP Energy Intensity Target (%)	2010 Total Energy Use (million tce)[a]	12th FYP Energy Intensity Target (%)	2015 Total Energy Use (million tce)	13th FYP Energy Intensity Target (%)	13th FYP Energy Use Cap (million tce)	13th FYP Maximum Energy Use Increase (million tce)
Jiangxi	–20	64.2	–16	84.4	–16	99.5	15.1
Shanxi	–22	150.0	–16	193.8	–15	223.9	30.1
Shandong	–22	340.7	–17	379.5	–17	420.2	40.7
National	**–20**	**3,606.0**	**–16**	**4,300.0**	**–15**	**<5,000.0**	**<700.0**

Note: a. 2010 provincial energy use data are from the series before Economic Census adjustment and may not be comparable with 2015 data series.

53. **National and provincial energy intensity targets.** China made a national goal to reduce energy use per unit GDP during 2006–2010 by about 20 percent (see Table 1.2). The upgraded energy statistical system reported a remarkable achieved reduction of 19.1 percent, whereas in the several years preceding the goal, energy use per unit GDP had been increasing. During the 12th FYP (2011–2015), a national goal was to further reduce energy use per unit GDP by 16 percent—this target was overfulfilled with a reduction of 18.4 percent. For the 13th FYP (2016–2020), the goal was to reduce energy use per unit GDP by an additional 15 percent.

54. The keys for the comprehensive results China achieved in energy savings have been strong political will at the top, with central government policies following suit, and strong organization of multi-program implementation at provincial and local levels. All of China's provinces, independent municipalities, and autonomous regions have had energy savings and emission reduction targets in addition to the national targets (Table 1.2 provides illustrations for three provinces as examples). In the early years of the 11th FYP, China's top leadership made it clear that governors and top provincial leadership would be held accountable for the achievement of the targets. As discussed in the next chapter, evaluations of provincial results were undertaken each year. As a result, provincial governments took their targets seriously and passed on targets to levels beneath them, for example, prefectures and counties.

55. As experience grew, provincial energy efficiency authorities have become adept at monitoring and managing progress on their energy intensity targets. Commonly, assumptions were made about likely provincial GDP growth, and then total energy consumption allowed was calculated and monitored so that a province can be as sure as possible that it can achieve its target. Beginning in the 12th FYP, the amount of 'increased energy use space' allowed began to be monitored and managed especially closely. From the beginning, energy use in medium and large industrial consumers has been supervised the most, as industrial sector energy efficiency programs offer the government more direct means to affect energy use levels and industry is the largest consumer in most provinces.

56. **National and provincial absolute energy consumption targets.** During the 12th FYP (2011–2015), the central government issued 'guidance' caps for total energy consumption in each province, which were not binding but were logically consistent with good management of the mandatory energy intensity targets. In the 13th FYP (2016–2020), caps on national and provincial total energy use became mandatory. The national target is to keep total energy consumption below 5 billion tce, regardless of GDP growth. To attain this, the maximum 'space' of increased energy use by 2020 is 700 million tce. Provinces also have similar new mandatory absolute energy use targets (see Table 1.2 for examples). Now with both energy intensity and absolute energy use targets, the new system is referred to as *'shuangkung'*—'double control'.[15]

57. **Parallel economic restructuring efforts.** The energy intensity and eventual absolute energy use targets apply pressure for macroeconomic change—energy-intensive economic growth runs counter to the targets. This pressure has been consistent with the government's overall efforts to adjust China's previous growth model toward 'the less resource-intensive society' with quality as opposed to quantity, concentration on high-value-added industry as opposed to basic commodities, greater service sector growth, and far stricter pollution control. During the middle 2010s, China began to face large surpluses in industrial capacity, especially in energy-intensive commodity production. There was also a broad consensus that air pollution must be seriously addressed, and dramatic reductions in pollution levels must be achieved. China was a leader in the Paris Agreement on climate change. All of these pressures meant that both closure of polluting, energy-intensive, and economically underperforming industrial plants and a leash on new energy-intensive manufacturing growth were now part of broader economic policy as well as the country's specific energy efficiency drive.

58. **The comprehensive approach.** China now has a comprehensive toolkit in place to meet its pressing energy efficiency targets. The market-based approaches discussed early, such as the use of ESCOs and commercial bank energy efficiency lending, truly began to make an impact during 2006–2020. The legal and regulatory framework put in place grounded the target system and a wide range of continuing and new regulatory tools. Upon these foundations, a series of detailed programs were upgraded or newly rolled out. Some had their seeds in previous efforts, and some were fully new. The result was that China built among the broadest and deepest packages of energy efficiency policies and programs of any country in the world.

59. In 2010, the central government issued a new electric utility demand-side management regulation, seeking to add utility-sponsored energy efficiency efforts as a supplement to the government's mainstream programs.[16] Distribution utilities were required to achieve savings equivalent to 0.3 percent of sales every year. However, Chinese utilities had not had the custom of promoting electricity savings outside of their own businesses. For the most part, the utilities responded by further promoting savings in their distribution networks and establishing ESCOs to achieve the targets and generate some new income.

15 Details on the results of the 13th FYP's energy efficiency targets and program results had not been issued as of March 2021.
16 NDRC. 2010. *Electric Power Demand Side Management Method*.. This regulation was also updated in 2017.

While the Demand-Side Management (DSM) programs continue to make some contribution, the main efforts of the country have continued to be implemented through the long-established government systems.

60. In addition to those already discussed in previous pages, key additional tools in place to help the country and provinces meet their targets include the following. Each is discussed, together with lessons learned and possible relevance for other countries, in Chapters 3 and 4, at the paragraph numbers noted.

61. For industry, some noteworthy additional programs are as follows:

- **1,000 and 10,000 Key Energy-Using Enterprise Programs.** These nationally guided and largely locally implemented programs defined energy-saving responsibilities at key enterprises and provided a platform for enterprises to achieve them with government support. Probably more direct energy savings were achieved through these programs than any others (see paragraphs 127–134).

- **Eliminating wasteful industrial capacity and plants.** Building on past efforts with improved standards as benchmarks, stronger local government capacity, new regulatory/pricing tools, increased subsidies and stronger political will, China's efforts to eliminate archaic and suboptimal scale, and wasteful industrial capacity now achieved noticeable success (see paragraphs 114–120).

- **New large investment project energy assessments.** Mandatory energy assessments of new fixed-asset investment projects were better institutionalized at subnational levels. Similar in basic concept to environmental assessments for new projects, these evaluations could now be used as a tool for provinces to consider how best to allocate 'incremental energy use space' for new industrial investment under the double control targets (see paragraphs 125 and 126).

62. China's efforts to improve energy efficiency in buildings blossomed during 2006–2020. Some particularly noteworthy programs are as follows:

- Energy efficiency standards for new buildings in different climate zones and especially institution of mechanisms for their enforcement (see paragraphs 175–182)

- Efforts to improve centralized heating systems (see paragraphs 183–186)

- Energy efficiency renovations in existing buildings (see paragraphs 187–190)

- Promotion of energy efficiency improvements in buildings of public institutions (see paragraphs 191–194)

- China's appliance energy efficiency standards and labels (see paragraphs 198–205)

- Developing new green buildings (see paragraphs 206–209)

- Developing low carbon urban forms (see paragraphs 210 and 211).

63. **LESSONS LEARNED.** China's experience in improving energy efficiency during 2006–2020, especially the relatively high GDP growth decade of 2006–2015, shows what a large country can do to consciously delink energy use growth from economic growth by operating a comprehensive collection of strong policies and programs. Much of the usefulness of China's experience to other countries lies in the specific lessons learned in its many specific programs. However, it is also instructive to remember that the impressive achievements highlighted in the next section were achieved by the comprehensiveness of the effort and sum total of the country's many programs.

64. China's comprehensive effort has required political will, good organization, and institutional capacity extending to local levels. The latter—institutional capacity—required many years of investment but was essential to help drive the necessary actions of many thousands of factories, construction companies, and individuals. Further details on China's institutional system for promoting energy efficiency are provided in Chapter 2. In other countries where institutional capacity remains weak, important energy efficiency gains can still be achieved through specific programs such as those discussed here. However, China's experience also shows that it is important to be mindful of institutional needs over the long haul and to be sure to keep such investments an important part of the program.

65. **Developing, monitoring, and enforcing binding national and provincial energy efficiency and emissions targets.** Authorities and experts in some other countries may find it difficult to imagine implementing national and subnational energy intensity targets or use energy consumption caps in their current circumstances. However, implementation of national and subnational GHG emission caps is an emerging reality or on the horizon for many. Many of the operational challenges and techniques to smooth implementation that China has wrestled with for its national and provincial energy efficiency targets are relevant for countries aiming to implement GHG emission caps, especially at subnational levels.

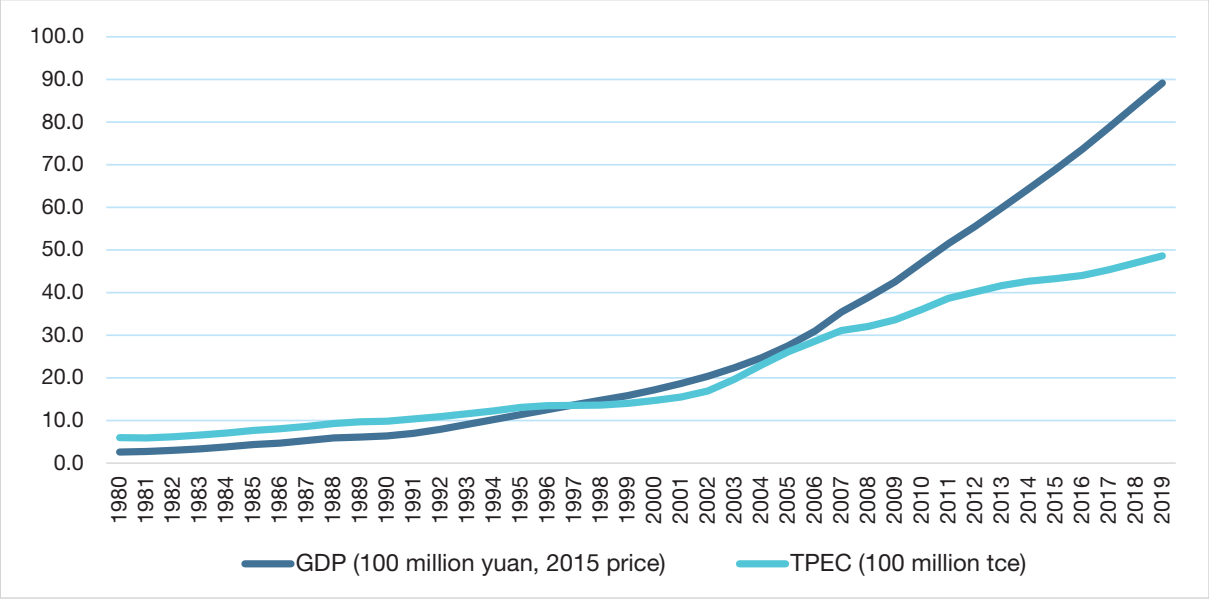
66. One of the strengths of the Chinese experience is how to manage 'incremental energy use space.' An example is use of energy efficiency assessments as part of the approval process for large new fixed-asset investment projects as a tool to allocate 'space' for new large projects. Another example is implementation and monitoring of energy savings agreements between the government and key energy-using enterprises to inject some reliability into target compliance management. Yet another example is the development of early warning systems to alert decision-makers to target compliance issues in time for possible correction.

67. China's national and provincial energy efficiency targeting system continues to evolve. The country has experimented with energy efficiency certification and trading schemes as a target compliance option. There are many debates about the evolving system. These debates and experiments are also likely to be insightful to others.

China's Macro-Level Achievements in Improving Energy Efficiency

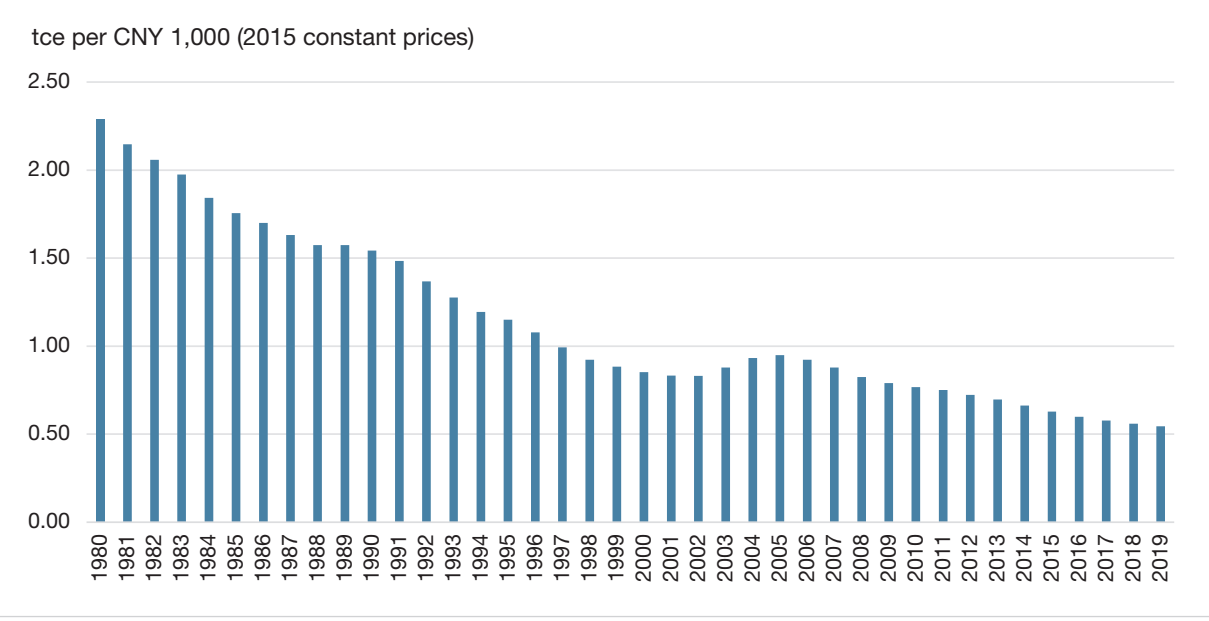
68. As shown in Figure 1.3, China's growth in energy use has increasingly become delinked from growth in GDP. Some of this delinking can be explained as a natural consequence of the maturing of China's economy in general and China's industrial sector in particular. However, the delinking has become most dramatic after 2005, when China's comprehensive efforts to improve energy efficiency really began to take hold.

Figure 1.3: Delinking of China's Energy Use and GDP Growth, 1980–2018



Source: China Statistical Yearbook, various years.
Note: TPEC = Total primary energy consumption.

Figure 1.4: Reduction in Energy Consumption per Unit GDP, 1980–2018

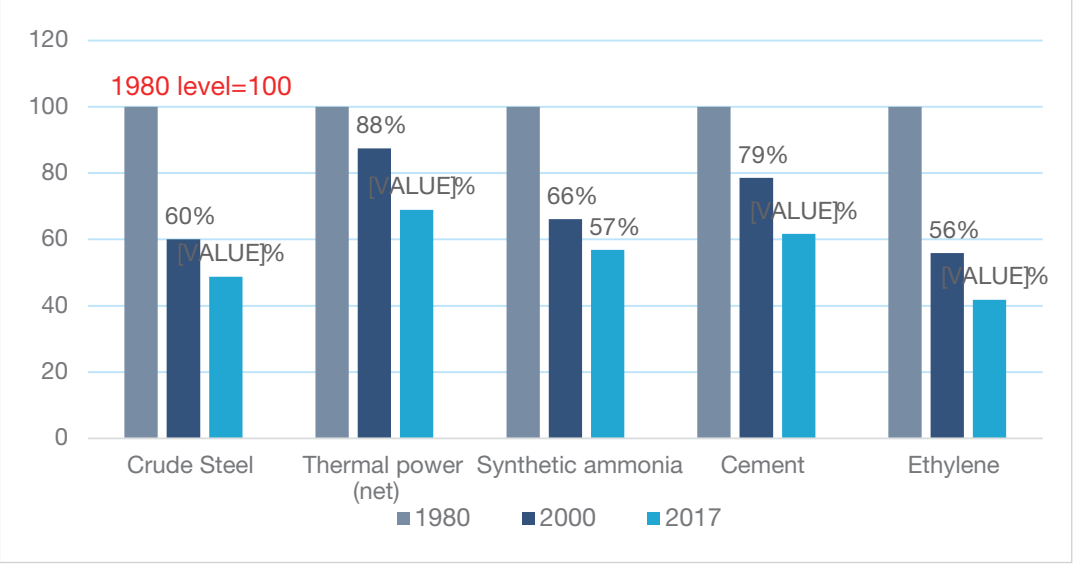


Source: China Statistical Yearbook, various years.

69. Figure 1.4 may be more insightful. The energy intensity of China's economy, measured in energy use per unit of GDP in constant prices, steadily fell through the 1980s and 1990s, as China's economy and industry diversified and economic efficiency improved. However, the fall in energy intensity flattened, and energy intensity began to increase in the early 2000s, when the economy also boomed. Perhaps the most notable result of China's new comprehensive energy efficiency drive, launched in 2006, was the turnaround in this energy intensity growth, and pushback against this trend to continue energy intensity declines again, also during a time of economic boom. Further changes in the structure of China's economy have certainly had a role, especially from about 2012, but it must be remembered that the government policy has also played a role in that, with conscious, parallel initiatives to encourage the economic restructuring. Figure 1.4 suggests that the country's effort to build a less resource-intensive society has borne fruit.

70. Finally, Figure 1.5 shows the sharp decline in energy use per unit of physical output in the production of key industrial commodities from 1980 to 2017. Some of these declines are especially noteworthy for any large country—a reduction by more than 50 percent in the case of steel and 43 percent in the case of synthetic ammonia. These sharp declines are due to elimination of particularly wasteful plants, increases in scale, incorporation of new technology, and far greater attention to efficiency.

Figure 1.5: Reduction in Unit Energy Consumption per Ton of Output (1980 = 100)



Source: Authors, from a variety of Chinese sources.

Chapter 2: Government Institutional Organization, Planning, Monitoring, and Fiscal Support

71. It is difficult to understand China's energy efficiency programs without understanding some basics about how program and plan development and implementation are organized. In addition, good organization has been a strong point of the Chinese experience, worthy of review in and of itself. Finally, for those interacting with Chinese groups and experts, it may be useful to understand how their colleagues may fit into the broader picture.

72. This chapter provides an overview of China's institutional setup for energy efficiency work, followed by a brief summary of how the government undertakes planning, targeting, and monitoring of performance. A brief introduction to fiscal and technology promotion policies and international cooperation concludes the chapter.

China's Institutional Setup for Energy Efficiency Efforts

Basic principles

73. While the government's institutional structure has been restructured many times, some basic principles have remained constant.

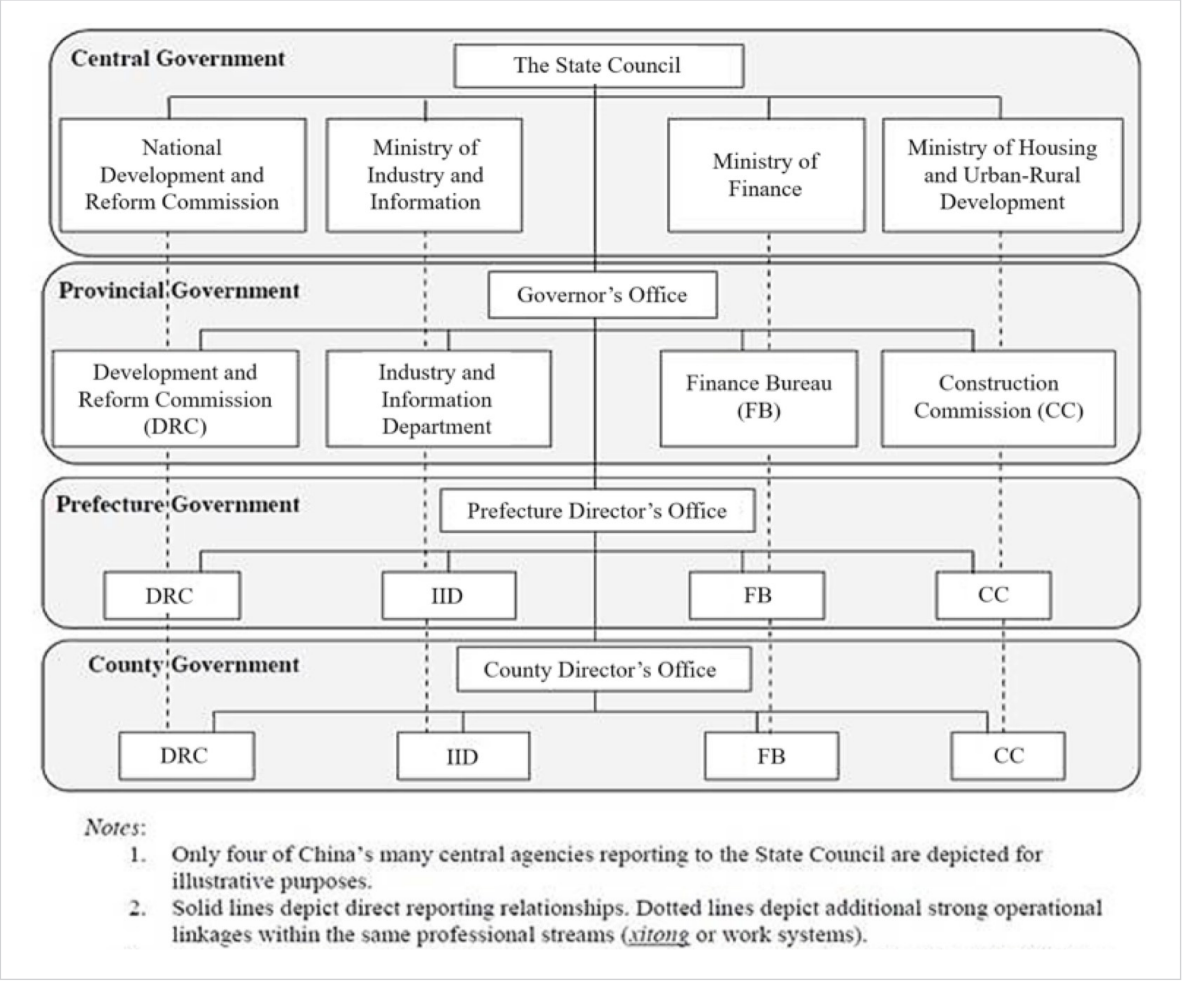
74. The State Council, led by the Premier, sits at the apex of the Chinese government. All provincial governors and 38 central government ministries, commissions, bureaus, and agencies report directly to the State Council. Directly reporting ministries and other entities include 'coordinating entities' such as the NDRC and the Ministry of Finance (MOF) and 'line ministries' which work on specific sectors (industry, urban and rural construction, and so on). All provinces[17] and all directly reporting ministries, commissions, and agencies are of equal rank. Hence, the chairman of the NDRC or any minister cannot give an order to a provincial governor. Nor can the Minister of Finance give any orders to any other ministry. Only the State Council can issue such orders.

75. The Chinese government maintains a strict hierarchy reaching down to county levels. Provincial governors report to the State Council, prefecture/municipal mayors report to provincial governors, and county/district directors report to prefecture/municipal mayors (see Figure 2.1). At each level, the setup of coordinating departments, line departments, and agencies generally mirrors the setup of the central government, although there are some variations.

76. In general, the central government is concerned mainly with macro policies and national regulations and planning. Provincial and local governments are the keys for most implementation and projects on the ground. Actual policy implementation efforts between provinces vary, depending upon local conditions and the focus of provincial leaders.

17 The term 'provinces' in this reports includes provinces, provincial-level municipalities, and provincial-level autonomous regions.

Figure 2.1: China's Multitiered Levels of Government



Source: The authors

Note: Only four of China's many central agencies reporting to the State Council are depicted for illustrative purposes. Solid lines depict direct reporting relationships. Dotted lines depict additional strong operational linkages within the same professional streams (xitong or work systems).

77. In addition to the direct hierarchy described above, the Chinese government is organized into 'systems' (xitong), incorporating similar units at the central, provincial, prefecture, and county levels. These can be thought of as systems of common practice. For example, a full government system operates on finance, including the MOF, and provincial, prefecture, and county finance departments. Virtually all central government ministries, commissions, and agencies involve 'systems" of similar units at provincial and local levels. However, some are stronger and more complete than others.

78. Government work 'systems' involve hierarchal units, but higher units in the hierarchy cannot directly order lower units, dictate personnel changes, or order policy or project changes. As noted earlier, these units report directly to provincial governors, mayors, or county directors, not to Beijing authorities. However, higher units do provide guidance and explanations of new policies and requirements to lower units in the system. They organize work meetings, training, and reporting and monitoring systems and collect new ideas. Staff within the same work system often know each other and the work being undertaken by colleagues in the same practice.

Key government institutional players

79. Figure 2.1 shows four work systems that are especially important for energy efficiency work. They operate at the national, provincial, prefectural, and county levels:

- **Development and Reform Commissions.** The NDRC is in charge of the country's overall economic policies, plans, and many key programs. It is the direct descendent of the State Planning Commission and State Economic Commission/State Economic and Trade Commission which were in place until 2003. The NDRC has four departments particularly relevant for energy efficiency: (a) The Resource Savings and Environment Department, in charge of energy efficiency planning, broad policies, and many key programs; (b) the National Energy Administration, focusing primarily on energy supply; (c) the Pricing Department, in charge of energy price policy; and (d) the Economic Operations Department, in charge of electricity demand-side management, demand response, and dealing with electric power shortages. These departments are mirrored by divisions in most provincial Development and Reform Commissions and further below.

- **Ministry of Housing and Urban/Rural Development (MOHURD) and provincial/local Construction Commissions.** This system is in charge of building energy efficiency and building heating systems.

- **Ministry of Industry and Information Technology (MIIT) and provincial/local departments.** While there were a series of industrial sector line ministries during the periods of Blocks One to Three described in Chapter 1, this system now watches over policies and programs for all industry and is in charge of the details of industrial energy efficiency work, even as the NDRC plays an important role in some key programs involving industry, such as the 1,000 or 10,000 enterprise programs.

- **MOF and provincial/local departments.** It is the country's treasury system and is responsible for allocation of state funds (including international donor funds) and subsidies for energy efficiency.

80. Three additional important national government institutions for energy efficiency are (a) Government Offices Administration of the State Council[18] which leads energy efficiency efforts in publicly owned buildings; (b) the State Administration of Market Regulation (SAMR), established in 2018 combining other entities, which is in charge of national appliance, equipment, and industrial process standards and labeling for energy efficiency; and (3) the Ministry of Science and Technology and its provincial/local departments, which oversees government efforts in research and popularization of new technology.

Central government-sponsored institutes and research centers

81. These institutions play important roles in detailed energy efficiency policy development, analysis, and project implementation, partly because government staff in China are limited in number. Some key examples are as follows:

- The Energy Research Institute (ERI) of the NDRC, in operation since 1980, which includes an Energy Efficiency Center

- The National Energy Conservation Center (NECC), sponsored by the NDRC, which implements a number of national projects, in addition to housing online enterprise energy use reporting for the NDRC and other tasks

18 国务院机关事务管理局

- CNIS, sponsored by the SAMR and the NDRC, which researches and prepares national energy efficiency standards, except for building standards

- China Academy of Building Research (CABR), which develops building codes and standards and operates an Environment and Energy Conservation Research Institute

- China Energy Conservation and Environmental Protection Group, a corporate entity that has been active in energy efficiency investment projects, especially large ones, for about 25 years.

Associations, other nongovernmental groups, and universities

82. Nongovernmental organizations also play important roles in the energy efficiency practice in China. Examples include the China Energy Conservation Association (CECA), the Energy Conservation Professional Committee of the China Energy Research Society (CERS), the China Building Energy Conservation Association (CBECA), and EMCA. These organizations play active roles in consultation for government decision-making, project evaluation, public advocacy, education and training, information services, and international exchange. Many universities, at both the national and provincial/local levels also have energy efficiency/environment centers or other groups of energy efficiency experts who provide technical service and analysis for both government and businesses.

Technical Centers and Supervision Agencies at provincial and local levels

83. Before the middle 2000s, and the launch of particularly comprehensive energy efficiency efforts in Block Four, as described in Chapter 1, the remaining provincial and local energy conservation technical centers undertook both regulation inspection tasks for the government and technical service tasks for enterprises. To avoid conflict of interest and better focus different groups on what amounts to quite different tasks, provincial and local energy efficiency technical staff were grouped into two different types of institutions. One group was the Energy Conservation Supervision Agencies, which were strictly charged with inspections and enforcement relating to China's Energy Conservation Law and associated regulations. These agencies are paid by the government and are not allowed to contract with enterprises for technical service business. The other group was the technical service centers, which now focus on providing consulting service, engineering work, and research and analysis for a broad range of clients. While government departments may contract technical service centers for analytical work, just as they contract universities or consulting businesses, they do not contract them for legal/regulatory supervision tasks. The expertise of some provincial technical centers remains strong, and they remain active, while the core staff of some other centers have moved on to join supervision agencies, ESCOs, or various consulting firms.

84. By the end of 2013, there were more than 1,600 Energy Conservation Supervision Agencies in China, with about 16,000 staff. A three-level system at the provincial, municipal and county levels has been established in most areas. By 2013, the system included 34 provincial Energy Conservation Supervision Agencies (2 each in Guizhou, Hunan, and Xinjiang), 287 prefectural agencies, and 1,396 county-level agencies. This means that every province has an agency, 90 percent of prefectures have an agency, and 45 percent of counties have an agency.

Planning, Target Setting, and Performance Evaluation

National energy efficiency planning

85. China's five-year economic and social development plans (FYPs) provide the framework for planning energy efficiency programs and policy development and implementation. Ideas for energy efficiency work in the next five-year cycle are actively discussed and collected for more than a year before the FYP starts, including collection of ideas from the bottom up as well as from the top down. The formal FYP provides just a broad summary of the goals and targets for energy efficiency work. Subsequent detailed work plans for energy efficiency and emission reduction were then issued a little later by the State Council for the 11th, 12th, and 13th FYPs (the three cycles covering 2006–2020). These cover the key sectors, policies, and programs and include detailed targets, assignment of responsibilities, and the underpinning for various types of state budget support. Progress reports are prepared every year by the involved government departments. A more comprehensive evaluation of progress is usually completed after the first three years, enabling midcourse corrections where needed. Final evaluations are completed at the end of the five-year cycle.

86. While all ministries and systems are involved, the NDRC, as the national planning agency, is the key agency charged with preparing the draft FYPs for the State Council.

National and provincial energy intensity and use target setting

87. As introduced in Chapter 1, China set national and provincial targets for the reduction of energy use per unit GDP in the 11th, 12th, and 13th FYPs under the Block Four stage of energy efficiency development. Mandatory national and provincial energy use caps were also set in the 13th FYP. From 2007, leadership officials have been held politically accountable for achieving agreed energy efficiency and emission reduction results, including targets. Provincial targets are negotiated between central government and provincial government authorities. Provincial governments also negotiate targets with lower levels, beginning with prefectures. Provincial and national targets set for each province (or autonomous region or independent municipality) are shown in Annex 2, together with the results achieved during 2006–2010. Actual annual results by province during 2013–2018 are also shown.

88. While there is considerable back-and-forth between the central and provincial governments during the process of setting macro targets, at times informed by different detailed studies commissioned by different parties, the State Council must approve the targets, as the only government entity overseeing provincial governors.

Performance evaluation

89. As specifically authorized by the State Council, the central government assesses the energy conservation performance of provinces each year. The overall assessment has been assigned to the NDRC and covers the energy efficiency targets and the implementation of energy-saving measures in the previous year. A point system is used (see Table 2.1). A full mark is 100 points, which is divided into two parts: achievement of energy efficiency targets (40 points, with extra points for overfulfillment) and implementation of energy-saving measures (60 points). The specific evaluated energy-saving measures are also shown in Table 2.1. Assessment of 95 points or more is evaluated as 'overachievement' of performance, 80–94 points as 'achieved', 60–80 as 'basically achieved', and less than 60 as 'not achieved'.

90. Beginning in 2007, provincial governments considered to have 'achieved' or 'exceeded' their targets based on the evaluations were granted awards. For those where targets were assessed as 'not achieved', the responsible officials are not granted awards or honorary titles and the central government could cease to approve large new high-energy-consuming projects in those provinces. The provincial government is also expected to submit a written report to the State Council, proposing corrective measures and a deadline for achieving them.

91. The State Council has also authorized other agencies to undertake certain narrower performance assessments relating to energy efficiency. An example is the authorization of MOHURD to review provincial and local government compliance with building energy efficiency code compliance (see paragraphs 180–182)

92. To help inform the State Council and other entities about evolving energy use and intensity patterns, energy use statistics, including statistics from key enterprises, are reported to higher levels through the independent NSB's system. The State Council made specific efforts to ensure the independent reporting integrity of the NSB's system at the outset of the move to targets under the Block Four evolution of China's energy efficiency program (see paragraph 18). Individual ministry systems also include reporting from lower to higher levels, and these ministries use this information to compile progress reports on the specific responsibilities they have. For example, more detailed key enterprise energy use and energy saving reports are submitted to the NDRC and MIIT through their systems. Progress on building energy efficiency programs and targets is reported by local Construction Commissions to MOHURD. Progress on disbursement of allocated funds for energy efficiency programs is reported through the MOF system and so on.

93. Based on its statistical data, an Energy Consumption Alerting System was developed by the NSB. The energy consumption situation in different regions is reported to the relevant government officials every quarter. The rate of consumption growth is categorized as red light, yellow light, or green light. The red light means that energy consumption is growing much faster than expected. This and other data help energy efficiency practitioners and decision-makers keep track of energy efficiency progress and make any informed decisions on time.

Table 2.1: Score Card for Provincial-Level Energy Efficiency Performance Evaluation, 11th FYP

Items	No.	Content	Score	Review Criteria
Energy Conservation Target (40 points)	1	% Energy consumption reduction per RMB 10000 of GDP	40	100% annual target achieved (40 points), 90% annual targets achieved (36 points), 80% annual targets achieved (32 points); 70% annual targets achieved (28 points); 60% annual targets achieved (24 points); 50% annual targets achieved (20 points); 50% below (0 point). If the targets are exceeded by 10%, 3 points are awarded (within a 9-point limit). If targets are not met, then performance is regarded as "unmet".
Energy Conservation Measures (60 points)	2	Organization and leadership of energy conservation activities	2	1. Established energy statistics, monitoring and evaluation systems (1 point); 2. Established clear responsibilities and coordination mechanisms, and held meetings on a regular basis to review major issues (1 point).
	3	Breakdown and implementation of energy saving targets	3	1. Assigned energy saving targets to different levels (1 point); 2. Monitored and evaluated the progress of energy saving levels (1 point); 3. Regularly published energy consumption levels (1 point).
	4	Adjustment and optimization of industrial structure	20	1. Growth of the tertiary sector (4 points); 2. Growth of high-technology industry (4 points); 3. Developed and implemented the measures for evaluation of the energy efficiency level of new (fixed asset) projects (4 points); 4. Achieved the annual targets to phase out outdated production capacity (8 points).
	5	Resources dedicated to energy conservation and implementation of key projects	10	1. Creation of public funds dedicated to energy conservation (3 points); 2. Allocation of fiscal revenue for these funds has increased annually (4 points); 3. Implement key energy conservation projects (3 points).
	6	Development and promotion of energy efficiency technologies	9	1. R&D of energy conservation of technologies has been included in annual technology development plan (2 points); 2. The percentage of R&D funds for energy conservation technologies has increased annually (3 points); 3. Implemented energy efficiency pilot projects (2 points); 4. Promoted energy-efficient products, technologies and services (2 points).
	7	Energy conservation in key enterprises and industries	8	1. Key energy-consuming enterprises (including Top 1000 enterprises) have achieved their energy conservation targets (3 points); 2. Implemented annual energy conservation monitoring plan (1 point); 3. 100% enforcement rate of annual mandatory energy efficiency standard for new buildings (4 points), 80% achievement (2 points) and 70% below (0 points).
	8	Implementation of laws and regulations	3	1. Issued and improved the supporting regulations for the Energy Conservation Law (1 point); 2. Conducted monitoring and enforcement inspections (1 point); 3. Implemented energy efficiency standards for high-energy-consuming products (1 point).
	9	Energy conservation preparation	5	1. Strengthened the capacity of energy conservation supervision centers (1 point); 2. Improved and expanded energy consumption data collection (1 point); 3. Provided metering instruments as required (1 point); 4. Conducted energy conservation trainings (1 point); 5. Implemented award recognition programs for energy conservation (1 point).
Total			**100**	

Note: R&D = Research and development.

Fiscal Support and Government Budget Investment

94. China has used state funds to support the country's energy efficiency efforts in a variety of ways. The two largest ways are (a) investment project grant support and subsidies and (b) preferential tax treatment.

Investment project grant support and subsidies

95. Policies and amounts of direct investment grant support and subsidies has varied over the last two decades. These tools were used especially during the 11th and 12th FYPs (2006–2015). Some of the grants and subsidies also helped fulfill government objectives to spur economic activity during and after the 2007-2009 global economic downturn. Since 2015 these tools have been used less, although investments in capacity building and some key programs have continued.

96. Statistics for the 11th FYP (2006-2010) provide a picture of priorities and levels of government budget support worked during the high-tide years of 2006-2015. Total budget support for improving energy efficiency over the five years totaled CNY 150 billion. Central government support totaled CNY 102 billion (68 percent) of that, amounting to 0.34 percent of total central government budget expenditures. Provincial government budget support for energy efficiency added CNY 20.4 billion (14 percent) and prefectural government support CNY 24.0 billion (16 percent).[19]

97. Most of the funds were earmarked for direct investment support. However, central government support for new high efficiency product research and development, and institutional development at provincial and local levels, still amounted to about CNY 5 billion during 2006–2011.

98. Several of the most prominent direct investment grant and subsidy programs during 2006–2015 included the following:

    - Provision of subsidies to enterprises required to close or make major upgrading investments under the government's program to eliminate particularly wasteful, backward industrial capacity. One objective was to soften the hardship posed in the less developed areas where such capacity commonly existed, including negative employment impacts. Central government funds allocated for this were CNY 22 billion during 2006–2010 (22 percent of the total). See also Chapter 3, paragraphs 118 and 119.

    - Energy efficiency renovation project awards for key energy-using enterprises. Central government grants of CNY 200–300 per tce saved were provided during 2007–2013 for qualifying large energy efficiency renovation projects in key energy-consuming enterprises. Matching provincial/local awards were required. Eschewing up-front subsidies, the 'award' grants were made upon completion of the projects and verification of the savings achieved. Central government funds for these awards amounted to 30 percent of central government allocations for energy efficiency during 2006–2010.

    - Energy performance contracting project awards, during 2009–2013. With new policies to support ESCOs, the central government allowed renovation awards to be provided to ESCOs which financed and completed qualified energy efficiency renovation projects.

19 Statistics for the 11th FYP are from Yande, Dai, Xiong Huawen, and Jiao Jian. 2012. *China Energy Efficiency Financing and Investment Report 2010.* China Science and Technology Publishing House.

- Subsidies for purchase of highly energy-efficient household appliances (2009–2012). The central government and some provincial governments provided subsidies for consumer purchase of high-efficiency household appliances, such as air conditioners. Consumers received the largest percentage discounts for Category 1 (most efficient) appliances and more modest discounts for Category 2 appliances.

- Subsidies for heat meter installations and renovation of existing buildings to improve energy efficiency. Typically with matching provincial/local funds, subsidies were provided through the MOHURD/ construction commission system for key building energy efficiency renovation investments, such as wall board insulation.

Preferential tax treatment

99. China has implemented a wide variety of preferential tax policies for energy efficiency investments, ESCOs, and energy efficiency product development or sales over the years. However, the policies have often been adjusted and changed as circumstances changed. In general, preferential tax treatment has made the most difference for new start-ups in the energy efficiency field and for some investment projects.

100. Tax relief policies have included, at times, exemption or reduction of value added tax for specific circumstances, exemption from import tariff or import value added tax for certain commodities used in projects, and corporate income tax temporary exemptions, and/or deductions and credits. Accelerated depreciation has also been allowed at times for corporate investment in specified types of projects or new high-energy-efficiency equipment.

Promotion of New Technology

101. Interest to learn about new technology, including for energy efficiency, is often a hot topic at enterprises. Enterprises, ESCOs, building owners and managers, and China's many technical institutes rely especially on their own networks, market-oriented events and expos, and consulting services to learn about recent developments. On the government side, an important effort has been the preparation and issuance of Key Energy-Saving Technology Promotion Catalogues[20] every year beginning in 2008. Publicly issued by the NDRC, these catalogues put the government's stamp of approval on key new technologies and provide descriptions useful to potential users. Technologies for consideration are proposed by manufacturers, vendors, and others and are screened, analyzed, and vetted by expert committees. Over the years, over 4,000 technologies have been proposed and reviewed, of which 260 high-efficiency technologies have been selected for listing in the Catalogues. Status as a listing in the national Catalogue expands attention among energy users, energy efficiency technical advisers, and project financiers.[21] However, it has been a challenge to keep the catalogues up-to-date with rapidly progressing market developments. The catalogues have been available only in the Chinese language.

20 In 2015, low-carbon technologies were added to the content and catalogue title.
21 Industrial Energy Accelerator. 2020. *China Energy Saving and Low-carbon Technologies Catalogue and Financial Incentives to Promote Energy Efficiency Technologies.* March 2020.

International Cooperation

102. International cooperation has been an important part of China's energy efficiency efforts virtually throughout the last 40 years. China has been eager to adopt and adapt new technology and practical ideas from abroad. China has also been an active participant in international forums, increasingly exchanging its own experience as well as listening to those of others.

103. Energy efficiency initiatives have consistently accounted for a substantial share of multilateral and bilateral donor-assisted projects. Energy efficiency projects began with demonstration and training projects in the 1980s but soon moved on a variety of programs to seed and scale up new ideas and approaches. The World Bank Group, the Asian Development Bank, the United Nations Development Programme (UNDP) and other UN organizations, and many bilateral donors have made major contributions to China's energy efficiency drive. In 1994, the World Bank, UNDP, State Planning Commission, and China's National Environmental Protection Agency jointly completed a major study with GEF support on issues and options for controlling GHG emissions. With energy efficiency assigned top priority, the GEF has provided steady and impactful support for a host of projects, especially with the World Bank and UNDP.

104. A new report, 'the Successful Partnership of the World Bank Group and China on Energy Efficiency, 1992–2020' (World Bank, forthcoming) highlights the success of World Bank-China cooperation on energy efficiency over three decades. One of the keys to success was an effective combination of joint analytical and policy work and intensive technical assistance and knowledge exchange together with project investment programs. The World Bank-China partnership took risks to introduce new market-based mechanisms for project investment, under Block Two of China's energy efficiency program (see paragraphs 19–36), and these risks have paid off over the medium and long term.

105. China's participation in international energy efficiency cooperation forums has been steadily increasing in recent years. One example is China's participation as a sponsor country in the International Partnership Energy Efficiency Cooperation (IPEEC), founded in 2009 by the Group of Eight, China, the Republic of Korea, Brazil, Mexico, and the European Community. This platform aims to promote and assist countries to improve energy efficiency by sharing experience and other information, conducting cooperative research, and other activities.

Chapter 3: Energy Efficiency in Industry

Overview and Background

106. Industrial output in China has led the world for much of the current decade. China leads world production of many industrial commodities and goods. Products are diverse, ranging from high-tech equipment to the most basic commodities, such as bricks. The industrial sector has long been the largest energy-consuming sector in the economy. Although industry's share of total energy use has fallen a little in recent years, it remains high, at over 65 percent of final commercial energy use in 2017.

107. China today has among the most advanced and technically efficient industrial plant in the world. At the same time, however, China also has inefficient plant operating at a suboptimal scale. Probably the biggest single challenge that China has had to face in its efforts to improve energy efficiency in industry is how to deal with the big internal disparities that have existed in scale, technology, and technical and management sophistication between plants. This disparity has its roots in development trends from the second half of the twentieth century. China's efforts to deal with the inefficiencies inherited from the past are quite relevant to other countries carrying legacies of especially inefficient and older industrial plants.

108. **Legacies.** Beginning in 1958 and running through most of the 1970s, national and local self-sufficiency were cornerstones of China's development approach. The watchword for local development was 'local self-reliance'. One unusual characteristic of China's resource endowment is not only the country's vast coal reserves but also the fact that coal resources can be found in almost all parts of the country, even if not always of high quality. This allowed some level of industrial development across large portions of China's countryside, with especially strong rural industrialization in the 1970s. Largely using 'intermediate' technology, rural industries included bricks, cement from vertical kilns, coal-based nitrogen fertilizer, agricultural machinery, electric power where possible, and inputs for larger industries. Other somewhat larger plants, including iron and steel or small or medium-scale thermal power and chemical fertilizer plants, were also built in virtually every province. With large, relatively modern plants being built as well, China's industrial development was characterized as 'walking on two legs', with one leg being the small and medium plants dispersed across the country and the other being large, technologically more sophisticated plants in larger industrial areas.

109. In the early 1980s, analysts commonly divided industrial plants into small, medium, and large industry. Small, inefficient, but locally important plants accounted for some 68 percent of cement production—over half of synthetic ammonia production in 1980. Small and medium plants accounted for one-fourth of crude steel production (see Annex 3). Dealing with the big disparities in energy efficiency associated with such different plants has been a key part of China's industrial energy efficiency efforts ever since.

110. **Savings per unit output and structural savings.** China's long-standing efforts to improve energy efficiency in the industry have been strongly successful, providing much of the efficiency gain behind the macro-level energy efficiency reduction statistics. Industrial energy efficiency gains include two aspects. First is a steady decline in quantities of energy use per physical unit of output (for example, energy use per ton of steel or cement produced). Annex 3 describes the energy efficiency gains per physical unit of output for a number of key commodities over the decades and some international comparisons. The second aspect is improvement in energy efficiency due to industrial structural change. When measured in terms

of energy use per unit value added (or contribution to GDP), production of basic industrial commodities such as bricks, cement, steel, nitrogen fertilizer, paper, and plate glass is energy intensive as energy use is high relative to the market value of the product. However, manufacture of more diverse, sophisticated, technology-intensive, and/or demand-customized products may not consume large amounts of energy but command far higher market value. As China's industrial sector has matured and production has shifted steadily from low-value-added, energy-intensive commodities to higher-value-added, less-energy-intensive commodities, this has also helped drive down industrial energy use per unit value added.

111. As an example of the important contribution of industrial energy efficiency gains in China's overall energy efficiency effort, industrial energy use per unit value added fell by 26 percent during the 12th FYP (see Table 3.1). Industry representing more than 65 percent of final commercial energy consumption thus provided the key contribution to the country's energy efficiency intensity gain during the same period, when energy use per unit GDP fell by 18 percent.

Table 3.1: Reduction in Energy Use per Unit Value Added in Industry, 2011–2015

	2010	2015	2015 Reduction Target	2015 Actual Reduction
kgCE of energy per CNY million, 2005 constant prices	192	142	–21%	–26%

Source: China Statistical Abstract 2016, MIIT.

112. **Relevance for other countries.** China's many years of experience and success in promoting energy efficiency improvement in industry is relevant for most other countries interested in achieving industrial energy savings. China's effort began in the early 1980s with one of the most energy inefficient industrial sectors in the world. China has had to deal with many technically backward industrial plants, both big and small, developed to enable local self-sufficiency. This is similar in many ways to the situation in many other, smaller countries where past efforts to promote import substitution and generate employment through local industrial development may have resulted in inefficient, polluting plants that continue to operate today and are difficult to curtail for many reasons. China's system of some 100 evolving industrial energy efficiency standards is unique and provides rich lessons both in application of such standards as policy tools and in development of methodologies for consistently and objectively assessing energy efficiency in many industrial processes. Rich experience exists in the development of financially attractive technical approaches to save energy in sophisticated process technology applications and common technologies that cut across industrial subsectors. China has over a decade of experience in developing and supervising energy savings responsibility contracts between the government and individual enterprises—which essentially are mandatory industrial energy savings agreements. This experience is highly relevant for others developing industrial energy savings agreements, whether they are mandatory or not. Quite a few Chinese factories have also developed enterprise energy management systems (EnMS) that provide lessons from experience to others developing systems in line with ISO 50001[22] or other similar protocols. Finally, China's industrial energy efficiency efforts remain dynamic, as much potential for further energy efficiency gains remains, and hence new or improved approaches continue to be debated and developed.

113. **Program overview.** China's industrial energy efficiency effort is remarkable in both its breadth, in terms of different policies and tools, and its depth, in terms of reach. As with China's overall energy efficiency effort, industrial energy efficiency programs reached their current comprehensive and mature state during 2006–2015, as described under Block Four in Chapter 1, although many programs were built upon past

22 ISO 50001 is the International Organization for Standardization's standard on practical ways to improve energy use in enterprises through the development of an EnMS.

efforts. The pages below present most of the key programs. In addition, more details on the use of energy performance contracting and commercial bank financing for industrial projects are provided in Chapter 1 (paragraphs 19–36). Overall government subsidy and tax credit policies are outlined in Chapter 2 (paragraphs 94–100). Institutional organization for implementation of industrial energy efficiency programs is also outlined in Chapter 2 (paragraphs 73–84).

Phasing Out Outdated, Subscale, Inefficient, and Polluting Capacity

114. China made some inroads in its effort to abandon particularly backward industrial plants and replace them with more modern plants during the 1980s and 1990s, under Block One of China's energy efficiency program. However, progress was especially difficult to achieve in an environment of chronic shortage, when there was demand for outputs regardless of how inefficiently they were being produced and pollution control efforts were just beginning. Local governments and enterprise groups also did not want to scale back production that employed local people and brought local revenue. Major progress in phasing out the outdated capacity was only achieved in 2006–2010, under Block Three, following a series of adamant and strong edicts from the highest level of government. The new effort involved a carrot and stick approach backed by central government political will. Perhaps the two most important of many policy documents were instructions and targets issued by the State Council in its 2007 'Notice on Comprehensive Program of Energy Conservation and Emission Reduction' and the State Council's follow-up 2010 'Notice on Further Strengthening of Work to Eliminate Backward Production Capacity'.

115. The State Council's 2007 instructions laid out targets for 13 specific industrial subsectors and responsibilities and policy measures to achieve them. Targets and achievements for nine of the most important subsectors are shown in Table 3.2. The targets were overfulfilled, both providing large energy savings and eliminating some of the country's worst cases of industrial pollution. The 77 GW of eliminated small thermal power plants were equivalent to about 11 percent of China's thermal power capacity in 2010. Eliminated inefficient coal mining and iron, steel, and cement production capacity was equivalent to 10–20 percent of China's total production level in 2010. However, it was not easy. In addition, the eliminated wasteful plant was estimated to account for only about half of the backward capacity in place.[23] Many of the more difficult cases still remained to be undertaken in continuing efforts during the 12th FYP (2011–2015).

116. The program to eliminate backward capacity continued into the 12th FYP as much as it had existed before. Beginning in 2012, however, circumstances began to change. First, China began to experience serious overcapacity in basic, relatively energy-intensive commodities such as steel, cement, nitrogen fertilizer, and paper due to overinvestment at provincial and local levels in previous years. The incentive of hot demand (and prices) driving some continued operation of inefficient plants began to disappear. Second, China's efforts to control air pollution were greatly expanded, especially in heavily populated areas such as the parts of the North China Plain surrounding Beijing. The program to eliminate backward capacity essentially blended into large, new 2013 directives of the State Council to deal with overcapacity generally and with air pollution in key regions. Not only were 12th FYP targets to eliminate specific categories of inefficient and polluting plants to be met one year early, but new additional targets were also set for 2015. With broader calls for provincial governments to close plants due to overcapacity issues, especially in areas of high pollution concerns, emphasis remained on closure of especially inefficient plants first.

23 Guohongmeiya Industrial Energy Efficiency and Emission Reduction Technology Promotion Center (CIEE). 2012. *China Industrial Energy Efficiency Report 2011*. Haijun Publishing House.

117. Between 2006 and 2016, phasing out backward production capacities in the coal, steel, cement, and flat glass industries alone saved 326 million tce of energy, equivalent to 11.2 percent of China's total industrial energy consumption in 2016.

Table 3.2: Selected Targets and Achievements for Closure of Outdated Production Capacity, 11th FYP (2006–2010)

Subsector	Facilities to Be Closed	Target	Actual
Thermal power	Small and obsolete thermal power generating plants (GW)	50	76.8
Coal mining	Small coal mines (million tons per year)	200	400
Iron making	Blast furnaces below 300 m^3 (million tons per year)	100	122.7
Steel making	Steel convertors and electric furnaces, annual capacity ≤ 200,000 tons (million tons per year)	55	72.2
Cement clinker	Elimination of vertical kilns through substitution of other technologies (million tons per year)	250	370
Plate glass	Old-fashioned 'pinglafa' technology production lines (million crates per year)	30	38
Coke making	Small coke ovens of less than 4.3 m height (million tons per year)	80	105.4
Ferroalloys	Furnaces of less than 6,300 kVA (million tons per year)	4.0	6.6
Calcium carbide	Furnaces of less than 6,300 kVA (million tons per year)	2.0	3.1

Source: CIEE 2012, 198.

118. **Implementation policies for the 2006–2015 initiative.** A first measure was to define specifically what was meant by 'backward' production capacity. China's systems of industrial energy efficiency standards, backed by the Energy Conservation Law, played a key role in this. In late 2005, the State Council issued a list of industrial equipment classified into three categories: equipment to be encouraged, equipment to be restricted, and equipment to be eliminated. Facilities to be eliminated could be eliminated outright or renovated to comply with standards as part of company merging processes or other upgrading efforts.

119. Policies adopted during 2007–2010 included a combined 'carrot and stick' approach, recognizing the reticence of localities to close down facilities:

- **Setting quantified and dated targets.** Targets for the different subsectors were broken down by geographic region and by year, clarifying accountability. Achievement of obsolete production capacity targets was included as an accountability in annual provincial energy efficiency improvement scorecards (see Table 2.1). The names and progress of plants to be eliminated were made public by the central government.

- **Banning market entry of new suboptimal plants.** Reiterating existing regulations, for example, involving environmental assessments and efficiency standards, restriction on licensing or investment approvals for new suboptimal plant was made even clearer.

- **Linking approval of new investment in larger, modern plants in a given region to progress on eliminating small, obsolete plants in that region.** This was a part of an overall policy of 'building large and pressuring out small' *(shangda yaxiao).*

- **Penalizing resistant obsolete plants.** Assessment of much higher electricity prices (for example, even double or more) was instituted against factories that continually ignored instructions to meet

efficiency standards and continued to operate equipment targeted for elimination, under a 'differential electricity price policy'. The State Council's instructions also allowed power supply to recalcitrant plants to be cut off or for their operating licenses to be revoked.

- **Providing central government grant funds to compensate for financial losses and for local development, provided plant elimination targets were met on time.** A total of CNY 21.9 billion in central government funding was provided during 2007–2010, channeled through the local government, and with special focus on economically disadvantaged regions. An important aim was to develop new employment and revenue-earning opportunities for communities that lost jobs and tax receipts due to the plant elimination policy. However, localities had to meet the timetable for equipment elimination to receive funds; failure to do so would jeopardize receipt of the grant funds. This grant financing program continued into the next FYP as well.

- **Strengthening requirements for firm evidence of equipment elimination.** Given problems in the past of equipment being reported as eliminated but actually still being operated or sold elsewhere, requirements for evidence of elimination were tightened. Many areas required pictures or videos of equipment destruction.

120. The thermal power generation sector provides a good example of the program. In 1990, 46 percent of the electric power boilers in operation were in plants of less than 100 MW, and very small plants of less than 25 MW accounted for 10–20 percent of thermal power capacity. Fueled by coal and sometimes fuel oil, these very small steam plants consumed as much as 600 gce per net kWh—roughly double what is consumed in modern 600 MW plants.[24] They were also big sources of local pollution. However, efforts to squeeze some of these very small plants out of operation, especially during 2000–2005, largely failed, as power shortages were severe and many localities succeeded in ignoring policy mandates. In its 2007 instructions, the State Council called out the thermal power sector specifically, requiring each province and power generating company to sign written agreements on achievement of time-based closure targets. Links with the country's huge power generation investment program were also made explicit, under the 'building large and pressuring out small' policy. With an especially strong effort in 2010, a total of almost 77 GW of small thermal power capacity was eliminated, amounting to 11 percent of China's total thermal capacity in 2010, overachieving the original target of 50 GW.

China's Industrial Energy Efficiency Standards

121. Annex 3 provides a partial list of China's many national industrial energy efficiency standards. The standards include both maximum energy use levels allowed for key types of equipment (for example, fans, transformers, and motors) and maximum energy consumption levels allowed in the production of many industrial commodities (for example, maximum unit energy consumption levels per ton of cement, steel, coke, and synthetic ammonia). In addition, important national standards also exist for how to monitor energy savings in various processes or equipment categories, how to proceed with optimal operation of key processes or equipment (for example, Industrial boilers or pump systems), or how to measure and calculate electrical or thermal balances for key equipment systems (for example, fan systems or flue gas waste heat use). These standards may be mandatory or for guidance only. Standards exist on the equipment and management of energy metering instruments. Broad standards exist for comprehensive assessments of factory energy use and savings, such as general principles for constructing energy

24 World Bank. 1991. *China: Efficiency and Environmental Impact of Coal Use.* World Bank. March 1991, p. 70.

balances for thermal equipment or full enterprises. China also has a national standard for implementing EnMS, akin to that provided in ISO 50001 (see paragraphs 135–138).

122. China's national industrial energy efficiency standards are researched, discussed with stakeholders, and drafted by CNIS. They are then approved by the State Administration for Market Regulation (or its predecessors before 2018) on behalf of the government. In addition, provincial governments may add additional industrial energy efficiency standards of their own, applicable within their boundaries, for industries, equipment types, or management methods of greater local and less national interest. However, provincial standards cannot reduce requirements of national standards; they may only add to them. Assessing compliance with industrial energy efficiency standards, and recommendation to the government on remedies for specific cases of noncompliance, is a main part of the work of provincial and local Energy Conservation Supervision Agencies (see Chapter 2, paragraphs 83 and 84). Compliance with the standards is required under China's Energy Conservation Law.

123. As policy tools, China's maximum energy use standards for equipment or key commodity production set a bar which all enterprises must operate beneath. Combined with programs such as the effort to eliminate backward capacity discussed above, or the 1,000 and 10,000 enterprise programs discussed below, enforcement of the standards helps eliminate particularly wasteful outliers in a country with diverse industrial facilities. Stringency can also be increased over time. However, this tool is insufficient by itself, as much cost-effective energy efficiency potential lies in most plants below the bar.

124. China's industrial energy efficiency standards also play a key role in promoting consistency in the definitions, calculations, and protocols used across the country concerning energy use, energy savings, energy balances, and energy monitoring. This is essential for consistent reporting, meaningful benchmarking, monitoring and management of energy savings agreements with the government, and enterprise cross-exchange.

Fixed-Asset Investment Project Energy Efficiency Assessments

125. China began a new system for mandatory energy assessments and inspections for new fixed-asset projects over a certain size in 2006, as the Block Four stage of China's energy efficiency effort commenced. The system was specifically endorsed in the 2007 amendment to the Energy Conservation Law, providing legal standing. The system is in many ways similar to that of environmental impact assessments, only the focus is on energy use. The main purpose of the system is to ensure that new projects meet all energy use regulations and standards, but assessments may also recommend use of certain new energy-efficient technology. In later years, the assessments have also become one tool among many for provinces and local governments to consider available incremental energy consumption space set by macro targets during approval processes for new energy-using projects.

126. Projects projected to consume 3,000 tce or more per year are required to submit full energy assessment reports, while projects consuming 1,000–3,000 tce can submit an assessment report table, and smaller projects are just required to complete a registration form.[25] Very large projects are reviewed by the NDRC, but most projects are reviewed by provincial and local government Development and Reform Commissions (DRCs). Expert committees review reports submitted by project sponsors and recommend revisions, approval, or disapproval.

25 There are also thresholds for electricity, oil, and natural gas demand.

Government-Enterprise Energy Savings Responsibility Agreements

127. Beginning in 2006, the government has signed and supervised agreements with many industrial enterprises specifying enterprise-specific energy savings targets. The agreements and the steady dialogue during supervision also served as a platform for the relationship between government and enterprises for the rollout of China's suite of industrial energy efficiency programs, including technical and financial support, and both carrot and stick approaches. Execution of the agreements has been mandatory for enterprises with total energy use over designated amounts.

128. **'Top 1,000' and 'Top 10,000' Programs.** The 'Top 1,000' Program was launched at the outset of the 11th FYP (2006–2010), including energy savings responsibility agreements between the government and the leading 1,008 industrial enterprises in the country in terms of energy consumption. As shown in Table 3.3, the energy savings agreements covered one-third of China's total energy consumption. The program proved successful and made a substantial contribution to China's overall achievement of its energy intensity reduction target. In the 12th FYP (2011–2015), the energy savings responsibility agreement effort was greatly expanded with a new 'Top 10,000' Program. Agreements under this program covered all enterprises that consumed over 10,000 tce per year, including some in the transport or commercial sector as well as industrial enterprises. All enterprises were publicly named at the outset of the program, and their energy use levels were listed.

Table 3.3: China's Top 1,000 and Top 10,000 Energy-Using Enterprise Programs

Program	Years	Enterprises	Share of Total Energy Use	Share of Industrial Energy Use	Energy Savings Target (million tce)	Target Achievement
Top 1,000	2006–2010	1,008	33% in 2004	46% in 2004	100	Overachieved by 50%
Top 10,000	2011–2015	16,678a	60% in 2010	85% in 2010	250	Overachieved in 4 years

Sources: Various official program documents.
Note: a. Of these, 2,750 were closed, restructured, or relocated during the program period.

129. The Top 1,000 and Top 10,000 Programs were national programs led by the central government, but the Top 10,000 Program was implemented by provincial governments. Enterprises reported energy use and other data to the central government, through provincial counterparts, and the central and provincial governments inspected results together. Direct supervision of the responsibility agreements under the Top 10,000 Program was one of the most important tasks undertaken by provincial Energy Conservation Supervision Agencies (Chapter 2, paragraphs 83 and 84).

130. Provincial and prefecture governments added responsibility agreements with additional enterprises, especially during the Top 10,000 Program, following the same model as the national program but supervised by themselves.[26] This further expanded the reach of the program.

131. **Use of agreements as platforms for government-enterprise interaction.** Five-year energy savings targets were negotiated between by the directly supervising government level with each enterprise, and progress was inspected by supervision agencies every year. It appears that a target of 20 percent reduction in energy

26 China's Energy Conservation Law defines key energy-consuming enterprises as enterprises that consume more than 10,000 tce per year. These enterprises are required to meet the energy efficiency results supervision, staffing, and reporting requirements established by the government. In addition, the law also allows provincial or local authorities to designate enterprises consuming between 5,000 and 10,000 tce as key energy-consuming enterprises, also subject to the same requirements, if they so wish. Virtually all provinces designated at least most of these enterprises as key enterprises, including them in additional Top 10,000 Program-type activities organized by the provinces.

use per physical unit of output or unit output value over five years was often used as a default target, but there were variations. In addition, however, the interactions surrounding the agreements included many topics and services. Supervising agencies inspected compliance with China's various standards and regulations, but they also helped arrange important services, including technical assistance in metering, monitoring, energy auditing and preparation of enterprise energy balances, improvement of internal energy management, internal staffing, training of staff, introduction to new technologies that might be applicable, and financing options. Especially important, the central government, with counterpart funding by provincial and prefectural governments, organized large-scale energy efficiency investment project grant programs. The awards were provided per tce of energy savings capacity created by new projects undertaken by participating enterprises (see Chapter 2, paragraph 98). Thus, participating enterprises could expect both a wide range of technical assistance and subsidies for key investments in exchange for their cooperation.

132. **Supervision and results.** Scorecards were used by supervision entities in their inspections and reporting each year, similar in many ways to the scorecards used by the central government to assess provincial energy efficiency progress (see Table 2.1). Total points achieved out of 100 ranked enterprise compliance as 'overfulfilled', 'completed', 'basically completed', or 'unfinished'. Energy savings target achievement accounted for 40 points, while other achievements accounted for the remaining 60 points, including details on internal organization of energy efficiency work, management of energy savings targets internally, internal energy management practices (totaling 25 points), implementation of standards, and technical improvements.

133. By 2014, the Top 10,000 Program had already overachieved its goal for the 12th FYP, achieving a total energy saving of 309 million tce, compared to the FYP target of 250 million tce. However, there was substantial variation between provinces and enterprises, as one might expect for such a large initiative implemented largely at provincial and local levels. For example, one key industrialized province had achieved only 82 percent of its energy savings target, while Shandong, China's largest province in terms of industrial output, had achieved 140 percent. In terms of individual enterprises, 31 percent were evaluated as having overfulfilled their responsibilities, 51 percent were evaluated as completed, 11 percent as only basically completed, and 7 percent as unfinished.

134. **The 100, 1,000, and 10,000 Program of 2016–2020.** Government-enterprise energy savings responsibility agreements continue under the 13th FYP (2016–2020). Termed the '100, 1,000, and 10,000 Program', this latest program groups key energy-using enterprises by energy use and government supervision level. The '100' enterprises include those that consumed over 3.0 million tce in 2015, and their agreements are undertaken and supervised by the central government together with provincial governments. The '1,000' enterprises include those consuming between 0.5 and 3.0 million tce in 2015 and are overseen by provincial governments. The '10,000' enterprises include those designated as key energy-using enterprises which consume less than 500,000 tce in 2015, and agreements with these enterprises are in principle developed and overseen by the local government.[27] Oversight, therefore, has become a much more local endeavor, compared with the past. No central government investment grants are specifically available for program participants during this program cycle.

27 NDRC. 2017. "Notice on Matters Relating to Development of the Energy Using Enterprise "100, 1000, 10,000" Program."

Enterprise Energy Management Systems

135. EnMS are a type of management tool with a systematic set of procedures and practices that enterprises can adopt and use themselves to improve internal management of energy use. EnMS seek to improve the energy performance of an organization both through identification and implementation of specific projects and through a wide variety of behavioral changes. Key requirements for success include (a) leadership and involvement of enterprise senior management, (b) cross-divisional participation in the energy management team and awareness and involvement of all enterprise staff, (c) documentation and careful quantification of emerging results, and (d) institution of EnMS as a permanent management system, with continual operation to achieve continuous progress. EnMS use a common plan-do-check-act (PDCA) approach. Substantial energy savings results with low costs are well documented worldwide. However, EnMS must be catered by enterprises themselves to their own specific circumstances, with strong internal commitment. They are not productively pushed from outside without full enterprise buy-in.[28]

136. Internationally, EnMS is codified in the ISO 50001 standard. In China, EnMS was piloted by Shandong Province beginning in 2008. Shandong also issued a local standard on implementing EnMS in industrial enterprises, which was soon developed into China's national standard. Since 2010, EnMS has been developed in other parts of China as well, with central government encouragement. China's EnMS standard has also been revised to align more closely with ISO 50001.

137. Shandong Province has continued to lead the nation in EnMS implementation, with about 1,000 enterprises certified as having successfully implemented the system by 2016. There are also many successful cases in other parts of China and within some of China's most famous industrial companies.

138. Performance evaluation method. In China, EnMS certification is undertaken by government-sanctioned certification companies, which focus especially on the procedures and documentation in place at an enterprise. In addition, China has supported a 'performance evaluation method'. The evaluation focuses on the energy savings results actually being achieved and the strengths and areas for further improvement in on-site EnMS implementation. The evaluation is completed by technical experts qualified to participate in an expert pool. Three-quarters of enterprises certified as having successfully implemented EnMS in Shandong used this evaluation method. It can be used in lieu of, or in addition to, regular EnMS certification.

Use of Market-Based Project Financing Systems

139. As China's energy efficiency efforts moved through Blocks Two, Three, and Four, the effort has consistently blended a mix of regulatory or administrative measures with development of market-based systems (see Chapter 1). There has always been, and continues to be, a wealth of profitable energy efficiency projects in industrial enterprises and elsewhere.[29] However, these investments rarely rank among the top priorities of enterprise managers. Investments to expand production, seize new market opportunities, and diversify products typically command top attention, compared to projects where benefits are operating cost savings calculated by staff or consultants. Particularly under Block Four, China's regulatory policies, and associated comprehensive programs such as the Top 10,000 Program, have served to help increase

28 See also World Bank. 2010. "Accelerating Energy Conservation in China's Provinces," (June), pp 66-71.

29 Industrial energy efficiency practitioners recognize that while pipelines for profitable energy efficiency projects may change as projects are implemented, the pipeline continues to develop as technologies develop and industries change, diversify their businesses, alter production lines to better meet market demands, and so on. There is almost never such a thing as 'completing all profitable projects' or being 'done'. This is one of the foundations for implementation of EnMS, which use PDCA continual processes.

the priority ranking of profitable energy efficiency projects among enterprise managers. With energy efficiency projects now commanding greater manager attention, parallel efforts to expand market-based systems have provided additional tools designed to make it easier for some enterprises to launch the investments. The main two new tools developed with international support, especially from the World Bank, are described in more detail in Chapter 1, paragraphs 26–36).

140. As in other countries, most Chinese industrial enterprises finance most energy efficiency projects with their own funds, essential with retained earnings. If possible, enterprises may prefer to utilize their limited ability to incur debt for other, larger projects or to just eschew the transaction cost and debt service burden of a new loan or contract liability even if their debt:equity ratios are low enough to allow new borrowing for energy efficiency.

141. For enterprises where an energy efficiency loan is in line with their financial situation and needs, the availability of commercial banks in China over the last decade which specialize in such products can often make a critical difference and, at a minimum, can make the transaction easier for the enterprises. About 6–10 banks in China have developed and now operate specialized energy efficiency lending businesses, once using World Bank Group and other international support to get started (see paragraph 32). These banks have a better understanding of the technologies, methods to appraise the projects, and the security of their cost saving revenue streams and hence offer a more efficient and potentially productive experience.

142. Financing through energy performance contracts with ESCOs is an attractive, additional option for using external capital for some projects in some enterprises but certainly not for all (see Chapter 1, paragraphs 27–29 for a description of this business). The availability of off-balance sheet financing through an energy performance contract can be high on the list of attractions. Additional attractions may also include full-service project implementation and the energy saving guarantee. However, energy performance contracts are among the most expensive way to finance industrial energy efficiency projects in China, in terms of implicit markups or financing interest on the equipment and installation investment. ESCOs must recover energy savings guarantee and especially financial risk premiums, as well as service costs, in their pricing. Industrial enterprises are likely to eschew an ESCO project if they are reasonably knowledgeable about the project technology and have access to less expensive financing. Accordingly, ESCOs active in the industrial market often aim to offer new, less common and high-value technical solutions (with energy performance guarantees, of course) or provide full services that are especially attractive to long-standing clients.

143. Less healthy enterprises with poor credit standing, or unestablished track records, have far few options for energy efficiency project financing. Commercial banks, leasing companies, and ESCOs providing project financing cannot incur unreasonable default risk with such enterprises, even though less healthy enterprises typically (or almost by definition) have greater potential for improving energy efficiency. These enterprises may lean more toward enterprise restructuring to expand shareholding equity and market strength, including through mergers.

Lessons Learned and Experiences Especially Relevant for Other Countries

144. China's industrial energy efficiency effort has yielded large energy savings over many years, representing the core of the country's overall energy efficiency gains. Large, nationwide programs to eliminate wasteful capacity and implement government-enterprise energy savings responsibility agreements brought the largest pieces of the energy savings achieved during 2006–2015. In contrast to earlier years, current key

energy-using industrial enterprise senior managers can easily discuss the energy efficiency achievements and plans of their factories. Despite the success achieved, more work remains to be done. Internationally, there is a popular notion among industrial energy efficiency practitioners that virtually every industrial enterprise can always cost-effectively save at least 15–20 percent more energy, even if it has achieved sustained energy savings for many years. This is in part because most healthy industrial facilities are constantly reconfiguring, adjusting, and changing, as demand for their products and production technologies change. In addition to needs to adopt new energy savings innovations, factory workshop reconfiguration almost always requires adjustments in energy supply, distribution, and control, with new energy savings opportunities. There is no such thing as being 'finished'.

145. China's industrial energy efficiency effort has required high investment over many years for the success achieved—especially institutional and human investment, undertaken at all levels of government, within enterprises and within third-party service entities and financiers. Included are the development of new organizations, such as the Energy Conservation Supervision Agencies, and the time and effort of experts and officials to develop and update standards; develop, implement, and supervise new policies; train countless officials, experts, and enterprise personnel in new approaches and requirements; help promote massive upgrading in consulting industry capabilities; foster development of new technology, including 'smart' technology; and more.

146. The entirety of China's industrial energy efficiency effort, developed as part of an aggressive national energy efficiency drive for the world's largest industrial economy, may seem overwhelming for smaller countries beginning to consider some industrial energy efficiency initiatives. But specific parts of China's experience may still be useful to consider. Some specific points therefore are discussed below.

147. **Experience in closing down especially wasteful and polluting industrial production capacity.** Other countries have problems of particularly inefficient and polluting plants that remain in operation, even with subsidies, because of local revenue and employment benefits. Some suggestions from China's success in dealing with these problems are as follows:

    - Efforts to close backward plants must usually be led from outside of the locality. In China's case, the national government led and forcefully pushed the effort.

    - If investment in a new, modern industrial or other facility is being planned in a given locality, approval and investment mobilization may be made contingent upon closure of certain backward, wasteful, and polluting facilities in the same area. China's State Council specifically endorsed this policy.

    - Provision of outside concessional funds for new economic development and employment generation in an area with backward capacity targeted for elimination was important for bringing local governments and communities on board. In China's case, substantial grant funds were provided, but only if backward plant closures were completed according to a dated timeline.

    - It is important to be clear and consistent in the definition of backward capacity that must be eliminated. China used its national industrial energy efficiency standards for this. If a country aims to eliminate several types of especially wasteful plants—for example, old, inefficient, and wet process cement plants—a starting point may be to define precisely what minimum efficiency levels are required in cement production and then develop programs to assist localities to close or convert plants that cannot meet that standard.

- Provision of clear evidence of plant destruction may be required before declaring completion. In China's case, in early years, some localities reopened plants later or sold the equipment for operation elsewhere.

148. **Using industrial energy efficiency standards as a policy tool and using China's standards as potential technical references.** Chinese industrial energy efficiency practitioners commonly point to China's system of energy efficiency standards as an essential tool for their work. While few countries may be able to develop such an elaborate system, development of some standards for particularly important subsectors or equipment in country may be useful to clarify how to calculate consumption and minimum levels of efficiency considered acceptable. Consistent plant-by-plant consumption calculations and reporting can then be used for benchmarking and development of policies for steady improvement.

149. China's roughly 100 industrial energy efficiency standards also provide a wealth of useful reference material on energy use calculations, efficiency definitions, measurement protocols, and balancing methodologies in many broad or specific settings (see Annex 3). Although not well known outside of China, many of the standards would be useful to others looking for consistent calculation methodologies, most of which have stood the test of time. In addition, China's process for developing new standards or updating them (for example, forming expert review committees and review and stakeholder commenting procedures) would also be useful for others to consider, given China's experience over many years and in many subsectors.

150. **Experience in government-enterprise energy savings agreements.** China's Top 10,000 Program of government-enterprise energy savings agreements (2011–2015) was certainly the largest and broadest program of this type ever attempted globally. Many aspects of China's experience may be insightful to others developing programs for energy efficiency agreements between the government or its agents and industrial or other large enterprises, whether they are programs with mandatory or voluntary participation. Examples of insightful aspects are as follows:

    - Enterprise consumption data and energy efficiency reporting tables and protocols. Reporting became online during the Top 10,000 Program period. Useful aspects include not only the tables and calculation methods used, but also how they were cross-checked and reviewed.

    - Requirements for enterprise energy management staff, their training, their registration, their typical assigned duties, and emergence of various energy management staff issues and resolution of those issues during program implementation.

    - Successful efforts to expand enterprise enthusiasm for energy efficiency work during the program period, with case study examples.

    - Experience in supervision of progress in fulfilling agreements between Energy Conservation Supervision Agencies and individual enterprises and program progress, as a whole, between central and provincial/local government entities.

151. **Experience in large-scale popularization of key widely applicable energy efficiency renovation technologies.** With China being the world's leader in manufacturing output, and having many years of experience in improving industrial energy efficiency, Chinese experts have both broad and specific experiences in developing and implementing all manner of industrial energy efficiency projects. Automated, digitized internal energy system control is an emerging specialty. Expert exchange on energy efficiency initiatives and project development in specific industries would certainly be fruitful for many countries.

152. In addition, China has had good success developing and broadly implementing initiatives for energy efficiency renovations that cut across industrial subsectors. Two typical and important examples are various schemes for capturing industrial waste heat for power generation and improving electric motor-driven system efficiency, through both reconfiguration of motors and better matching evolving demand and use of frequency inverters for variable speed control, in a wide variety of settings, even with large motors. Of particular note, China has succeeded in widely popularizing the use of low-temperature flue gas heat in the cement industry (below 350°C) for power generation, enabling a 30 percent improvement in the thermal energy utilization efficiency of the whole clinker production system.

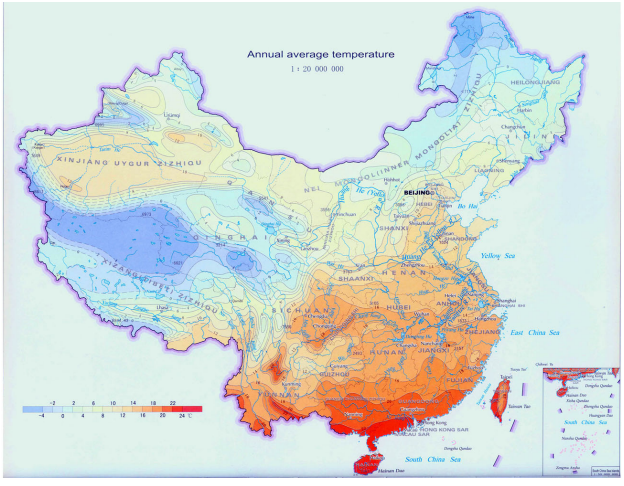
153. **Sound EnMS implementation examples.** China has many successful cases of EnMS implementation and can certainly contribute in international exchange forums on issues and solutions pertaining to implementation of ISO 50001. China's experience also shows how important it is to have in-country cases to demonstrate how energy costs can be reduced with EnMS under local conditions. In addition, other countries may wish to consider China's experience and methodology for completing EnMS energy savings performance evaluations, involving local energy efficiency advisers, in addition to standard certification based on processes. China's experience also shows how important it is to develop third-party advisory expertise to help enterprises with EnMS adoption, even if this remains an area where more needs to be done in the country.

Chapter 4: Energy Efficiency in Buildings

Overview and Background

154. In China, energy use in buildings has undergone profound change during the 40 years beginning in 1980. Although always dominated by residential buildings and household energy use, given the world's largest population, change has come from massive urbanization, changes in the types of fuel used, wholesale changes in technology and inherent energy end use efficiency, radical changes in building form, the rise of a new urban commercial sector, and new household demands, especially for cooling service and convenience. China's specific building energy efficiency efforts—focusing on the building shell, internal energy system improvements, and improved electric appliance efficiency—began in earnest later than China's industrial energy efficiency efforts. However the country's specific building energy efficiency programs have been a critical part of the nationwide energy efficiency effort since the turn of the century.

Figure 4.1: Map of Climate Zones in China



Source: http://www.chinatouristmaps.com/assets/images/chinamaps/china-temperature.jpg

155. Differing from many countries, climate and space conditioning needs vary greatly by region in China (see Figure 4.1). Winter heating is essential in northern China, especially in the 'severe cold' regions. Summers are hot and humid in much of central and southern China, and little if any heating is demanded in southern China. In terms of indoor space comfort, central and central-eastern China were traditionally yet more uncomfortable than northern China. In northern China, heat was provided for in winter. In humid Shanghai, winter indoor temperatures of 10°C were common in winter, with no heat, and summer temperatures could reach 40°C.

156. **Building energy use in the 1980s and 1990s.** In 1980, about 80 percent of the population lived in rural areas, generally in single-story buildings of local manufacture. In urban areas, buildings were rarely higher than six floors. Urban residences were owned and maintained by the work units (danwei) that household wage earners worked for. In both urban and rural areas, energy use was for the essentials of livelihood—cooking and, in the coldest areas, winter heating. Electrical appliances besides light bulbs and some radios and fans were few. There were few shops, restaurants, and hotels. Energy use for

heating and cooking in rural areas was dominated by traditional biomass fuels (for example, firewood, straw, and stalks) and some coal. Coal was the main fuel in urban buildings, used in small coal stoves, small boilers for local centralized heat, and, in some northern city centers, some district heating or city coal-based gas systems.

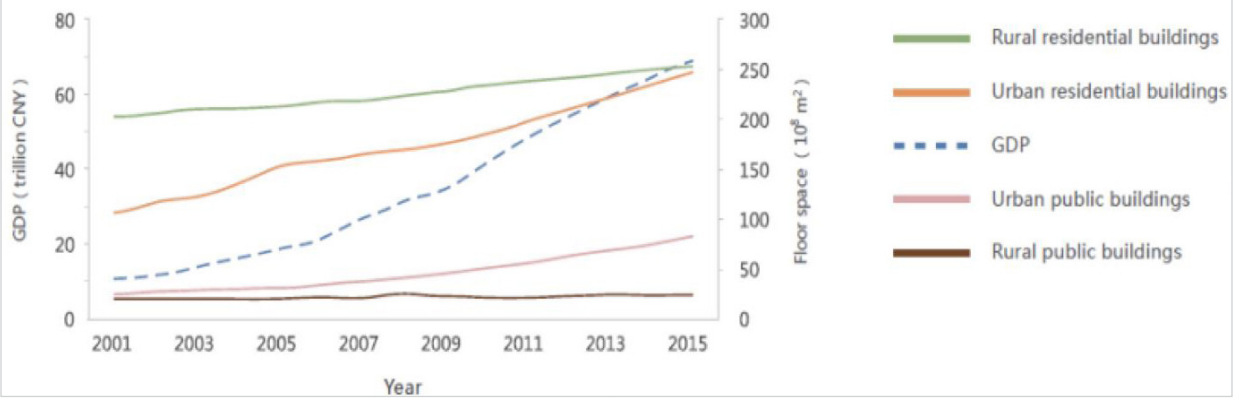
157. Street-level and indoor air pollution was a critical concern. In northern urban areas, emissions from coal stoves and small boilers typically vented at low levels, creating toxic street-level pollution in winter. Indoor air pollution from coal stoves was also a serious health concern in urban areas. Often worse, however, was chronic indoor air pollution in rural homes from biomass and coal burning for cooking and heating.

158. During the 1980s and much of the 1990s, new building stock construction grew in Chinese cities as urbanization pressures accelerated. During this time, two of the highest priority investment efforts of northern cities were expansion of district heating networks, using combined heat and power plants where possible, and expansion of city coal-gas works and distribution systems, to reduce direct coal burning for heating and cooking, respectively. In the late 1990s, apartment ownership was privatized, as households were allowed to purchase their apartments from their work units at affordable rates.

159. **Building construction since 2000.** The 2000s ushered in a boom in urban building construction. Urban residential building floor space roughly doubled between 2001 and 2015 (see Figure 4.2). Urban commercial and public institutional buildings grew sharply as well, albeit from a lower base.

160. By 2015, China's total building floor space reached 61.3 billion m^2. Residential buildings accounted for 82 percent of the total, including 24.8 billion m^2 in urban areas and 25.2 billion m^2 in rural areas. 'Public buildings', including commercial buildings, government buildings, school, hospitals, and others, accounted for the remaining 11.3 billion m^2, or 18 percent of the total.

Figure 4.2: Building Floor Area and GDP Growth in China, 2001–2015



Source: China Council for an Energy Efficient Economy. 2019. "Energy Efficiency China 2018." Web-based publication on www.cceee.org.cn., January 2019, pp. 27, based on China Statistical Yearbooks.
Note: Public buildings include both commercial buildings and buildings of public sector institutions.

161. Future new building stock construction is expected to be robust. Whereas little if any net building stock growth is expected in rural areas, growth in new urban residential, commercial, and public institution building stock is expected to be strong, perhaps doubling again before 2050.[30]

30 Zhou, N., D. Fridley, M. McNeil, N. Zheng, J. Ke, and M. Levine. 2011. *China's Energy and Carbon Emissions Outlook to 2050*. Lawrence Berkeley National Laboratory.

162. By 2019, China's urban population had soared from 20 percent in 1980 to 60 percent of the national total. While older buildings remain, especially the six-story apartment buildings built in the 1950s–1970s, many have been demolished and replaced with modern apartment buildings, including many high-rise buildings. In contrast to some other countries, the tendency in China has often been more toward replacing older buildings with new ones, as opposed to undertaking major renovations of older buildings. Large commercial shopping and office buildings are commonplace. Cooling service is demanded and provided in all areas with hot summers.

163. **Changes in energy use.** In 2015, final commercial energy consumption in China's buildings amounted to 860 million tce, or about 20 percent of the country's total. This is the same share as in 1980, when final commercial energy consumption in China's buildings was also about 20 percent. In fact, if the estimated 219 million tce of noncommercial biomass fuels used by rural households is also included, the share of residential, commercial, and public sector energy use in 1980 was actually substantially higher than in 2015, at about 43 percent.[31] Per capita residential, commercial, and public sector energy use increased only modestly over the 35 years, roughly doubling, whereas GDP per capita grew almost 19 times, in constant US dollar terms. This is a common international trend, if biomass fuels are included, as countries develop from low-income to middle-income countries.[32] However, energy service per capita greatly expanded. Heating comfort has greatly increased as heat supply has expanded well beyond the originally mandated areas and consumers have more options. Cooling supply has developed from virtually nothing to a ubiquitous home feature in warmer areas, even among modest-income families. Penetration and use of refrigerators and other household electrical appliances has also become virtually as commonplace as in fully developed countries.

164. Increase in energy service, when actual energy consumption has grown slowly, has come from efficiency gains and electrical technology, with a massive shift from the direct burning of coal and biomass fuels to expanded use of secondary energy forms such as electricity and district heat, as well as natural gas,[33] some continuation of coal-based city gas, and liquefied petroleum gas (LPG). Natural gas, followed by electricity, became 'go to' fuels for new housing complexes during the decade of 2011–2020, including for heating where district heating was not available. Once heavily relied upon, the direct burning of coal in most Chinese cities is now prohibited, as a key air pollution control measure. This would have seemed impossible in the 1990s.

165. **Urban heating.** Provision of heat in winter in the urban areas of northwest, north, and northeastern China is a basic necessity and has been covered under China's social welfare system since the 1950s. The urban building area in these northern regions accounts for about 40 percent of China's total urban building area. Since the 1950s, there has been a gradual transition from simple coal stoves to centralized heat with hot water radiators supplied by apartment complex small heat-only boilers to centralized heat with hot water radiators supplied by large-scale district heating systems. However, these transition stages have overlapped. In 2000, for example, most northern cities had ample examples of all three coal-based heating methods.

166. From 1950 to the early 2000s, centralized heating supplied from small heat-only boilers or district heating systems were based on Soviet designs, except that only heat, and no domestic hot water, is provided from the central systems. These systems are well known throughout Central Asia, the Russian Federation, and Eastern Europe. These constant flow systems are relatively simple and inexpensive to construct. However, they do not allow control of heat supply by consumers. Piping systems within

31 World Bank. 1985. "Annex 3: The Energy Sector." In *China: Long-term Development Issues and Options*. pp. 3–5.
32 For further elaboration, see World Bank. 1993. *China: Energy Conservation Study*. pp. 8–9.
33 With China's endowment of natural gas more limited per capita than that of many countries, China has given priority in its limited natural gas supply to urban residential and commercial customers and to the chemical industry for use as feedstock.

buildings are mostly vertical, single-pipe systems—hot water is pumped to the top of the building and then through vertical drop pipes through stand-alone radiators, floor by floor. Radiators in a given flat are not connected with each other but are connected to the radiators of neighbors above and below. Apartment-level metering is not undertaken. Heating bills are calculated based on heated floor area and not heat consumption.[34]

167. **The push to 'commodify' heat.** Beginning in the early 2000s, China's central government has sought to address the inefficiencies of the old-style centralized heating systems by promoting transition to consumer-controlled heating systems and the 'commodification of heat'. This reform and technical transition, however, is complex, involving new designs and/or major system reconfigurations, new metering technology, big changes in pricing and bill payment responsibilities, new risks for local heating companies, and a host of institutional issues. Although some municipalities have made major progress, not all have (see paragraphs 184 to 186).

168. In addition, new types of heating systems have entered the housing market, including natural-gas-based systems and especially electric dual-purpose heat pumps. These offer flexibility and more consumer choice, even if generally not as energy efficient as advanced district heating systems.

169. **Introduction of cooling service and the role of dual-function heat pumps.** Centralized cooling technologies based on chillers and duct systems are now common in medium and large commercial and public institutional buildings. Ductless mini-split heat pumps, however, have become by far the most popular cooling technology for residences, as well as many small office buildings, restaurants, and shops. In 2017, the stock of both wall-mounted and standing mini-split heat pumps in use in China was estimated at 400 million units. Many households have multiple units, with one in the main sitting room and one or more in bedrooms. In addition, China is a leader in development and deployment of ground-based and underground-water-based heat pumps. Ice or cold slurry cold storage systems have been developed in some buildings, as well as some district combined cooling and heating distribution systems.

170. China currently dominates world production of air conditioners and mini-split heat pumps. Annual output averaged 100 million units during 2010–2016. Of the 108 million units produced in 2016, 60 million mini-split heat pumps were sold to domestic Chinese consumers. Thus, China is also by far the largest consuming country. In 2016 and 2017, about half of the heat pumps sold in China were fixed-speed units, while the other half were more energy-efficient variable speed units. The share of variable-speed units is increasing, however, and will basically take over the market as China's new heat pump energy efficiency standard takes effect (see paragraph 200). Sizes, quality, efficiency, and prices vary substantially. Chinese companies produce high-quality and efficient units as well as low-quality and inexpensive units, including for export.

171. Flow on virtually all of the ductless mini-split heat pumps can be reversed, so that the units can provide either heating or cooling as demanded. This is particularly important in many parts of China. Space heating may account for some 40 percent of the total annual electricity use of the mini-spit heat pumps.[35] The heat pumps are three or more times energy efficient than standard electric resistance space heating. The units provide a convenient source of both on-demand heating and cooling in areas not connected to district heating. Even where apartments in northern China are connected to district heating, the heat pumps may be used to provide heating in shoulder seasons when district heating is not supplied. Since

34 ASTAE and World Bank. 2001. *China: Opportunities to Improve Energy Efficiency in Buildings*. May 2001.

35 Estimate based on the standard climate and annual use patterns presented in China's 2013 variable-speed heat pump energy efficiency standard.

2017, new designs have also been developed and sold which provide efficient operation at temperatures below 15°C or more. Such units were subsidized for deployment as part of the central government's recent effort to promote substitution of electricity for the direct burning of coal for home heating in rural and peri-urban parts of northern China.

172. **Overview of building energy efficiency programs.** Although some important initiatives were launched earlier, the early 2000s ushered in a ramp-up of programs to improve energy efficiency in new and existing buildings through improvements in design, construction methods, and materials; central heat system design changes and reforms; and rigorous energy efficiency standards and labeling of household appliances. These were important components of Blocks Three and Four of China's energy efficiency program, described in Chapter 1. Some key policy measures initiated are as follows:

- Inclusion of a full section of articles on building energy efficiency in the revised 2007 Energy Conservation Law, including on building code compliance. The previous law had only one article of general support.

- Institutionalization of stronger systems to ensure compliance with energy efficiency building codes and issuance of new codes for buildings outside of the northern heating zones.

- Launch of new regulations and implementation planning to improve energy efficiency in the buildings of public institutions.

- Issuance of regulations to require horizontal heat systems in new apartments, with apartment-level meter installation capability, followed by collective issuance of Heat Reform Guidelines by eight central government ministries (2003).

- Issuance of a host of new energy efficiency standards for household appliances over the decade and launch of China's appliance energy efficiency labeling program in 2005.

173. Subsequent energy efficiency work plans for the 12th and 13th FYPs (2011–2015 and 2016–2020, respectively) have included a series of targets for specific building energy efficiency efforts, including renovation of existing buildings, average energy efficiency levels of key equipment and appliances, energy use per square meter and occupant in the buildings of public institutions, and others.

174. The following pages include further details on (a) energy efficiency building codes for new buildings and their enforcement, (b) promotion of centralized heat system improvements, (c) renovation of existing buildings, (d) improvement of energy efficiency in the buildings of public institutions, (e) household appliance energy efficiency standards and labeling, and (f) development of green buildings. A final section highlights lessons learned and experiences especially relevant for other countries.

Energy Efficiency Codes for New Buildings and Their Enforcement

175. **National residential building energy efficiency design standards in the heating zone.** China issued its first building energy efficiency standard in 1986, covering new residential buildings that require heating in the 'severe cold' and 'cold' regions (see Figure 4.1). The code prescribed maximum allowable heat loss for different aspects of the building shell, calculated with an aim to reduce energy use for heating by 30 percent compared with a baseline depicting a typical new building designed in the early 1980s. With the new emphasis on regulation under the new market economy brought on in Block Two of China's energy

efficiency effort, the standard was made more stringent in 1995, using the same basic methodology, but with prescriptions aiming for a reduction of 50 percent in heating energy consumption.

176. Unfortunately, however, these building energy efficiency standards were not widely enforced until later, as described in paragraphs 180-182 further below. During the 1980s and 1990s, probably the most important measures to improve the efficiency of energy use in buildings were the efforts to reduce direct coal burning by expanding centralized heat and district heating and by coal gasification. Progress was also made in promoting better materials for wall construction, most notably use of hollow bricks and other improved construction materials instead of traditional solid bricks. These were promoted to reduce energy use in material production and transport (for example, embodied energy), reduce building weight, and provide improved insulation. A network of small Wall Renovation Offices (*qianggaiban*) was instituted at provincial and some local levels to promote these changes. The Wall Renovation Offices were also given responsibilities to watch over implementation of the building energy efficiency standards but had insufficient technical manpower, authority, and resources to fully undertake this work.

177. Following a major and successful drive to improve enforcement of building energy efficiency standards (see below), the standard for new buildings in the heating zones was subsequently revised in 2010 and 2018. The 2010 revision upped the targeted reduction in heating energy consumption to 65 percent of the 1980s baseline level. The 2018 revision (JGJ 26-2018) includes changes in methodology as well as stringency. While maximum heat loss prescriptions are included, performance-based requirements are also provided, detailed for different climatic subzones. The new standard also includes broader heating system regulations. Reference to savings relative to buildings in the 1980s was omitted, as a legacy of the past that no longer met current prescription and inspection needs.

178. **National residential building energy efficiency design standards in other climatic zones.** China issued a residential building energy efficiency design standard for the 'hot summer cold winter' region in 2001, which was then updated in 2010 (JGJ 134-2010). A similar standard for the 'hot summer warm winter' region was issued in 2003 and updated in 2012 (JGJ 75-2012). These standards allow choice between use of a set of prescriptions for the building shell and cooling and heating equipment and use of a performance-based modeling approach to demonstrate that heating and cooling energy consumption per square meter of floor area will be below specified maximum levels. The 'hot summer warm winter' standard includes more attention to addressing summer solar radiation issues.

179. **Other design standards for new buildings.** Some other important national building energy efficiency design standards launched during the 2000s are a national standard for commercial buildings, a standard for buildings of public institutions, and a national lighting design standards for residential and industrial buildings (with application in residential buildings voluntary). An energy efficiency design standard for rural residential buildings was issued in 2013. In addition to the national standards, localities have also usefully developed new building energy efficiency design standards catering to their own local climates, circumstances, and level of ambition. Local standards cannot be less stringent than national standards.[36]

180. **Improving enforcement of energy efficiency standards for new buildings.** With 1.6–2.0 billion m^2 of new residential and commercial buildings being added annually, poor enforcement of building energy efficiency design standards became a matter of high-level concern. In 2005, MOHURD organized a first national inspection of building energy efficiency standard enforcement, with the conclusion that only 53 percent of reviewed building designs met the mandatory standard and only 21 percent of reviewed

36 For more detailed analysis of China's building energy efficiency standards during the 2000s, see Levine, Mark, Stephane de la Rue de Can, Nina Zheng, Christopher Williams, Jennifer Amann, and Dan Staniaszek. 2012. *Building Energy-Efficiency Best Practice Policies and Policy Packages*. LBNL. October 2012.

completed buildings met the standard. With a hard push from senior leaders, as the comprehensive drive of the Block Four era was ushered in, new legal and regulatory requirements were issued, new processes were instituted during design and construction to check for compliance, and stiff penalties for noncompliance were put in place. Compliance with the standards then strongly improved over the next five years, reaching 99.5 percent at the design phase and 95.4 percent at the construction phase in 2010. Subsequent national inspections by MOHURD during 2011–2015 reported compliance of 95–100 percent in completed buildings in provincial capitals and randomly selected cities.[37]

181. The high-level insistence on improving compliance launched the successful effort that came in the form of new and specific foundational support in the amended 2007 Energy Conservation Law and the issuance of new regulations by China's State Council in 2008, which added further and clear details on the importance of compliance with the building energy efficiency standards, necessary procedures, institutional responsibilities, and the consequences of failure to comply.[38]

182. Now with strong government support, the key to improving compliance came through institution of specific checks to ensure building energy efficiency standard compliance through the regular building design, construction and acceptance phases, making these checks routine for all buildings subject to the standards. Institution of checks at all three phases was critical. While earlier enforcement efforts had focused primarily on building designs, on-site checks during construction and final building acceptance were key for results. Over time, designers and developers have become accustomed to the technical energy efficiency requirements. Some key points on the system instituted during 2006–2010 are as follows:

- Checks by a third-party design company certified and approved by the government to ensure that designs meet energy efficiency standard requirements (as well as other standards) before building construction permit sign-off by local construction commission authorities.

- Inclusion of energy efficiency standard requirements in the frequent on-site construction inspections undertaken by third-party construction inspection companies[39] and the scheduled or random on-site inspections of local building quality supervision stations, which report to local governments and are paid as government staff.

- New requirements to meet new Building Energy Efficiency Acceptance Codes, which are checklists of all the energy efficiency requirements necessary before, during, and after the construction process.[40] These checklists are perhaps the most important new measure instituted during this period. They include specific provisions for construction practices to comply with energy efficiency standards related to walls, curtain walls, doors, windows, roofing, flooring, heating, ventilation, and air conditioning (HVAC), power distribution, lighting, monitoring, and quality control. Compliance with this checklist is required for government construction commission sign-off on building completion and occupancy, similar to sign-off on compliance with safety codes.

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37 Beginning in 2005, MOHURD's annual inspection of building energy efficiency code enforcement covers at least most provinces. Three cities are included in each province, including the capital city, a randomly selected prefecture-level city, and a randomly selected county-level city. Building construction projects are randomly selected for full review of design, construction, and local inspection documentation as well as on-site inspection. Standardized inspection checklists are used. In 2010, 391 buildings under construction plus 385 newly completed buildings were included in the national inspection. To better prepare for the annual national inspection and to promote the implementation of building energy codes, local governments also conduct their own additional scheduled and random inspections. While the coverage is not as wide as some feel it should be, and towns and rural areas are not included in the national inspection, the progress made in just five years is unmistakable. See Bin, Shui. 2012. *Third Parties in the Implementation of Building Energy Efficiency Codes in China*. American Council for an Energy-Efficient Economy. Spring 2012.

38 State Council. 2008. *Energy Conservation Regulations for Civilian Buildings*. July 23, 2008.

39 These companies must be hired by developers from a list of companies certified by MOHURD, which also has regulations on their scope of work and fees.

40 MOHURD. 2007. *Code for Acceptance of Energy Efficient Building Construction*. GB 50411. First issued in 2007.

- Buildings assessed as noncompliant with building energy efficiency codes cannot be occupied or sold, and developers are subject to fines.

Promoting Centralized Heating System Improvements

183. In 2000, buildings in similar climates in Western Europe or North America consumed some 50 percent less energy per unit floor area than buildings in China's heat zone but still provided greater comfort.[41] This was due in part to excessive building shell heat loss in Chinese buildings built before real implementation of the energy efficiency building codes and to the Soviet-era coal-based centralized heat/district heating supply system design described previously (paragraph 4.13). As shown through new city-scale demonstrations in China, transition to consumer-controlled, variable-flow heating systems and institution of consumption-based heat billing can reduce energy use in these existing building by at least 30 percent.[42] However, the combination of technology, operational, and billing change is not simple, as is well known in other countries which have had such systems. International cooperation in launching the difficult shift was important, especially during 2000–2015, and included a series of joint efforts with the World Bank.

184. The following measures need to be undertaken to truly 'commodify' heat:

- **Transition to consumer control of their heat supply.** The fixed-flow, single-pipe systems are controlled by the heating company, which determines hot water temperatures for the system. Consumers have no ability to make adjustments. Variable-flow systems allow indoor temperatures to be adjusted by consumers by shutting off, slowing down, or increasing hot water flow through their radiators. Conversion from a fixed-flow to variable-flow system requires addition of radiator bypass piping, new radiator controls, and adjustments in the district heating system itself. Transition to consumer control generally brings large energy savings, as consumers demand only the heat they need (and are willing to pay for). However, it also changes the operating environment for the heat company, which now must respond to ever-changing demand similar to an electric power or gas company, rather than just supply heat based on predetermined norms.

- **Shifting responsibility for heat billing payment to consumers.** Until the turn of the century, the employers of household wage earners were responsible for payment of heat bills under the welfare system of the planned economy. Over the years, payment responsibilities have shifted to households in the large majority of cases but still not quite all.

- **Heat use metering.** Some type of heat metering needs to be installed and operated if consumers are to be billed according to the heat they actually demand. This is not complicated in apartments where all apartment radiators are horizontally connected and can be metered from one point, but it is complicated for the traditional vertical-pipe systems.[43]

- **Heat price structural reform.** In traditional operation of the Soviet-era systems, heat is priced and paid for per square meter of heated floor space. Once consumers are able to control their heat supply and heat metering is installed, pricing should be based more on heat use, so that consumers who use more pay more. In China, two-part heat pricing systems are most prevalent where the reform has been undertaken, including both a fixed charge and a variable, consumption-based charge.

41 World Bank. 2005. *China: Heat Reform and Building Energy Efficiency Project*. Project Appraisal Document. February 17, 2005. pp. 17.
42 MOHURD Vice Minister Qiu Baoxing, in the preface for MOHURD. 2013. *China Heat Reform and Building Energy Efficiency Project Outputs*.
43 ASTAE. 2002. *Heat Metering and Billing: Technical Options, Policies and Regulations—Chinese Demonstration Projects and International Experiences*. August 2002.

185. The central government has promoted the transition to consumer control and consumption-based billing in existing as well as new buildings for almost 20 years, with the 2003 Heat Reform Guidelines, the State Council's 2008 Energy Conservation Regulations for Civilian Buildings, and subsequent plans and policy documents. However, urban heat supply systems and heat pricing are under the control of municipal governments. There has been resistance to such a big change, especially from local heat supply companies, which must support renovations (especially within buildings), pass on control of heat supply levels to consumers, and weather uncertainties in revenue implications. In addition, most municipalities aim to complete energy efficiency renovations on existing buildings before instituting consumption-based billing, so that consumers are not saddled with high heat bills from poorly performing buildings constructed long ago.[44] These renovations may often require financial subsidies.

186. Over the years, the number of municipalities that have successfully undertaken consumption-based billing at a large scale has continued to increase. By 2013, the total building floor area using consumption-based billing was over 800 million m^2, up from just 1 million m^2 in 2003.[45] However, this compared to a total heated building stock in northern China of about 8 billion m^2 in that year. Subsequent progress has continued, but the reform remains incomplete.

Energy Efficiency Renovations of Existing Buildings

187. While China's mandatory building energy efficiency standards have been the key policy tool to promote energy efficiency improvements in new buildings, energy efficiency renovations in existing buildings have required another set of programs. China has promoted energy efficiency renovations steadily over the last decade and a half. Unlike some other countries, however, rapid urban renewal has meant that many of the oldest and most energy-inefficient buildings have been replaced with new buildings. In quite a few urban districts, building replacement has been more common than building renovation.

188. National promotion of energy efficiency retrofits was launched in 2007 and has continued thereafter, led by MOHURD. Key target measures include window and door replacement; addition of wall insulation, often with new external wallboard; and internal centralized heating and/or cooling system upgrades where relevant. As is true in other countries, payback periods for such investments are typically long, and some form of subsidies are often required. Benefits, however, include improved comfort as well as energy savings. In addition, now that apartments have been privatized in China, organization of program implementation for residential buildings can prove challenging. In China, municipal governments, and the district and neighborhood committees beneath them, are the key institutions. Implementation is most efficient when entire apartment buildings are renovated at the same time, organized by these local government levels, even though this involves many different apartment owners. In some programs, focus of government efforts has been only on exterior measures, avoiding the greatest complexities of multiple apartment ownership.

Table 4.1: Building Energy Efficiency Renovation Targets and Achievements, 2010–2020

Program	Achieved by 2010	2011–2015 Target	2011–2015 Achievement	2016–2020 Target
Residential building energy efficiency renovation in the heating zones (million m^2)	180	700	990	500 (all zones)

44 World Bank and Development Research Centre of the State Council. 2014. Urban *China: Toward Efficient, Inclusive and Sustainable Development*. pp. 505–6.

45 World Bank. 2014. *China: Heat Reform and Building Energy Efficiency Project*. Project Completion Report. April 24, 2014. pp. 14. Residential floor area using consumption-based billing was reported at 616 million m^2 of a total residential floor area in the heating zones of about 6 billion m^2.

Program	Achieved by 2010	2011–2015 Target	2011–2015 Achievement	2016–2020 Target
Residential building energy efficiency renovation in the hot summer, cold winter zone (million m^2)	—	50	70	Included above
Energy efficiency renovations of buildings of public institutions (million m^2)	—	60	110	100

Source: MOHURD. 2017. 13th FYP Building Energy Efficiency and Green Building Development Plan. February 2017.

189. Table 4.1 shows targets and achievements for energy efficiency building retrofits in recent FYPs. Residential buildings in the two heating zones are by far the largest target group. The most ambitious program period was 2011–2015, when targets set by the State Council, based on MOHURD's analysis and recommendations, were overachieved with almost 1 billion m^2 of residential buildings retrofitted in the heating zone. Public expenditures for the program were also high during this period, with subsidies provided by central, provincial, and local governments.

190. Efforts to promote energy efficiency gains in existing commercial buildings have also been undertaken over the last decade and a half but typically with a more market-based approach and with less reliance on large public subsidies. One of the most innovative cases has been in Shanghai, where market-based financing through commercial banks was combined with energy use monitoring and benchmarking of large commercial buildings and buildings of public institutions, as well as local government regulatory and financial support. The Shanghai effort was launched through a World Bank project beginning in 2013.[46]

Promoting Building Energy Efficiency in Public Institutions

191. Public institutions in the Chinese energy context include government and government-related office buildings and other facilities, universities and schools, and hospitals and clinics. Although some efforts had been undertaken earlier, China rolled out its first major national effort to improve energy efficiency in these institutions in 2008, when the State Council issued a new 'Regulation on Energy Conservation in Public Institutions'. Targets and work plans for public institution energy efficiency improvement have since been specifically detailed in China's overall energy efficiency plans and targets. The General Office Administration (GOA) of the State Council directs the work in government offices and facilities at the national level, guides the effort in government offices and facilities at provincial and local levels, and helps coordinate the effort in universities and schools and in hospitals and clinics, which are spearheaded by the Ministry of Education and Ministry of Health, respectively.

192. In addition to implementation of a 2005 energy efficiency technical standard for new public institution buildings, program efforts have focused on building renovations and assurances that new equipment purchased by the government meets high energy efficiency standards.

193. Retrofits supported with state budget resources were significantly increased during the 12th FYP (2011–2015). Accordingly, energy consumption per square meter floor area in public institution buildings was reduced from 23.9 kgCE in 2010 to 20.55 kgCE, overachieving the five-year target. Energy consumption per occupant was also reduced, falling from 447 kgCE per person in 2010 to 371 kgCE per person in 2015, that is, a 17 percent improvement. During the 2016–2020 plan period, more emphasis was placed on trying to use third-party financing mechanisms. An issue that remains, however, is how to improve incentives for building occupants to save energy, as energy cost savings for offices or schools fully revert to the government. Internationally, some countries have had success increasing incentives by allowing

46 "Green Energy Schemes for Low-Carbon City in Shanghai," approved in 2013 and completed in 2018.

a portion of the savings to be retained by building occupants. If a school organizes a big campaign to save energy, for example, it can retain some of the financial savings for special programs, such as buying computers or other highly desired and productive activities.

194. The government has instituted requirements that only new equipment or vehicles classified as highly energy efficient can be procurement with state budget resources. This program has had a positive impact on the market for highly energy efficient products.[47]

Financing Retrofit Projects with Market-Based Instruments

195. Building energy efficiency retrofit project economics vary substantially. Some projects have relatively quick payback periods of five years or less, such as certain HVAC or lighting efficiency improvements. Others may have longer payment periods reaching more than 10 years, such as various insulation and window upgrades.

196. The building sector has been an important market for China's ESCOs, launched under Block Two of China's energy efficiency effort. The service and guaranteed savings elements of energy performance contracting are especially attractive in this market, where building owners typically are less knowledgeable about energy efficiency technologies and options, compared to many industrial enterprises. While ESCOs also have undertaken residential heating system management and upgrading projects, generally with heating company clients, the mainstay of the buildings market for ESCOs has been commercial building projects, especially projects focusing on HVAC, hot water system, and lighting improvements. Some projects are undertaken under a chauffage model (known as 'outsourcing' in China), whereby the ESCO assumes responsibility for payment of electricity or other energy bills, agrees with the client on a general energy payment schedule that provides some savings to the client, and undertakes efficiency investments and management improvements to then lower the ESCO's bill payments. At times, Chinese ESCOs may be able to offer longer-term energy performance contracts that package together fast and longer payback investments, but this requires unusual circumstances where longer-term repayment risks are considered low, or project financing is provided by another party. Some public institutional projects have been undertaken by ESCOs, especially in hospitals or universities. However, broad use of energy performance contracting in government institutions, as in some other countries, will require enabling reforms in government budgetary and procurement systems.

197. Financing of building energy efficiency retrofits is generally a difficult business for commercial banks, unless large packages can be assembled. A notable exception, however, was a project undertaken by Shanghai together with the World Bank during 2013–2018. Although the project also supported new green building development, the project effectively combined special building energy efficiency lending from two banks, project development and implementation by ESCOs, and strong support of the municipal and district government to ramp up energy efficiency investment in commercial buildings, including retrofits.[48]

47 For more details and recommendations concerning the energy efficiency program for public institutions as it stood in 2011, see World Bank. 2012. *China: Improving Energy Efficiency in Public Institutions*..

48 World Bank. Forthcoming. *The Successful Partnership of the World Bank and China on Energy Efficiency, 1992–2020*.

Appliance Energy Efficiency Standards and Labeling

198. China is the world's largest manufacturer of household appliances and in many cases also has the highest domestic sales and number of products installed. Although more remains to be done, China's household appliance energy efficiency standards and labelling programs have been a success story. Energy efficiency standards cover a broad range of appliances. Most key standards have also been updated periodically, as technology changes and ambition for further market transmission increases. The current portfolio of appliance standards includes some of the most stringent in the world.

199. Standards. China's main energy efficiency standards for appliances each include the following:[49]

    (a) Energy efficiency tiers. Three or five energy efficiency ranges classify the efficiency levels of a given product, with '1' being the most efficient and the highest number ('3' or '5') being the lowest efficiency range. The lowest efficiency level in the lowest efficiency range represented the minimum energy performance requirement of the standard. These tiers are then depicted on China's appliance energy efficiency labels.

    (b) A minimum energy performance requirement. Appliances that do not meet this requirement cannot be sold in China. New standards typically set minimum requirements at a level that requires the most energy-inefficient appliances still on the market to withdraw.

    (c) Definition of high-efficiency products. Tiers 1 and 2 are defined as 'high efficiency'. This threshold allows an 'energy conservation' certification and typically are qualifying levels for subsidies or government procurement. For example, Tier 1 mini-split heat pumps purchased in Beijing were eligible for a 13 percent price subsidy from the Beijing municipal government in 2017, while Tier 2 heat pumps were eligible for an 8 percent subsidy.

    (d) Information on the testing methodology required to evaluate and certify energy performance.

200. National appliance energy efficiency standards are developed by CNIS and approved by the relevant central government agency supervising standards, which is currently the SAMR. Manufacturers self-test products subject to the standards and register results with CNIS and the government. Reports are randomly checked through government-sponsored tests, with consequences for incorrect reporting including fines and the possibility of being forced to remove relevant products from all retail outlets.

201. The number of different types of household appliances covered by energy efficiency standards is probably the most of any country.

202. One of the most important and ambitious energy efficiency standards issued in recent years is China's new mini-split heat pump/air conditioner standard (GB 21455-2019), issued in 2019. Whereas China previously had separate standards for fixed-speed and variable-speed heat pumps, the new standard covers both together. The new standard currently has five energy tiers, but the bottom two will be removed in 2022, effectively raising the minimum energy performance requirements such that virtually all fixed-speed models will need to withdraw from the market. Energy performance ratings in China's standard cover operation in both heating and cooling modes, based on a provided common climate profile. While comparison of minimum performance requirements in China's new standard with those of other countries for cooling is complicated, a recent analysis concludes that the minimum requirements

49 Li, Jayond, Yang Yu, and Steven Zeng. 2016. *2014 Market Analysis of China Energy Efficient Products*. CLASP. March 2016, pp. 5–7

in 2022 will be more stringent than current standards in the European Union, the United States, Korea, India, or Japan.[50]

203. **Energy efficiency labels.** China's appliance energy efficiency labeling program was launched in 2005. A sample label is provided in Figure 4.3. The label is now well-known and seen on all major appliances in retail stores. In a 2015 survey, 96 percent of randomly selected interviewees recognized the label, 75 percent recognized and understood the tiers, and 62 percent recognized and understood the technical parameters provided on the label.[51] A current challenge, however, is to improve regulations and visibility on website interfaces for online shoppers, as at least half of household appliances are now purchased online.

Figure 4.3: Sample of China's Energy Efficiency Label

204. **Linked market transformation initiatives.** China began to aggressively promote high-efficiency lighting products relatively early, launching its major Green Lighting Project in 1996. As part of this effort, the government introduced rebates on purchase of energy-saving lamps and then moved roughly a decade later to begin to phase out incandescent lamps in favor of CFLs and then LEDs, with noticeable success. Beginning in 2009, China launched major program to increase uptake of more energy-efficient air conditioners, followed by televisions, refrigerators, washing machines, water heaters, and desktop

50 Park, Won Young, Nihar Shah, Jun Young Choi, Here Jeong Kang, Dai Hoon Kim, and Amol Phadke. 2020. "Lost in Translation: Overcoming Divergent Seasonal Performance Metrics to Strengthen Air Conditioner Energy-efficiency Policies." *Energy for Sustainable Development* 55 (2020): 63. Table 6.

51 Obtain source from CLASP.

computers. At a time when the central government sought to stimulate the economy following the 2008/09 global downturn, incentives were offered trade-in old appliances for new efficient ones. Central, provincial, and local government subsidies were also offered for purchase of high-efficiency products. By 2015, however, subsidy programs were eliminated or at least sharply curtailed.

205. A continuing and influential effort aimed to help market transformation to more efficient appliances is the government's package of policies to insist on procurement of high-efficiency products when public funds are spent. The market power of the government can both foster further development of the high-efficiency products and lower their cost through competitive procurement.

Developing New Green Buildings

206. Increasing policy development and commercial interest has been dedicated to the development of new 'green' buildings over the decade of 2011–2020. While efforts focusing on just increasing energy efficiency in new buildings remain, energy efficiency work has also been increasingly folded into a broader green building development effort. The green building agenda in China includes the sustainability of building sites, air pollution impacts, water efficiency, use of more environmentally sustainable materials, indoor environmental quality, safety and durability, and other important areas. While the central government has played an important role, a number of provincial and municipal governments have been especially active, devising local standards, promoting especially ambitious plans, and developing new public-private partnerships with developers.

207. China launched green building labeling and certification programs at the outset of the decade, and coverage and recognition of these programs have increased over time. China's national green building labeling programs include three tiers, designated with stars, for buildings successfully certified as green. As building developers have increasingly sought to add 'green' in their promotion materials, national and local governments have made increasing efforts to define what is green and what is not. China's central government issued a new, quite comprehensive 'Assessment Standard for Green Buildings' in August 2019 (GB/T 50378-2019). With the support of a World Bank project financed by a GEF grant,[52] Beijing Municipality has recently drafted a local 'Code for Acceptance of Green Building Construction', along the lines of the Code for Acceptance successfully launched for enforcing the energy efficiency standard for new buildings more than a decade earlier.

208. MOHURD's '13th Five-Year Plan for Buildings Sector Development' calls for increasing the share of green buildings in new urban buildings to 50 percent by 2020. The plan also calls for large increases in use of green building materials and the share of prefabricated buildings.

209. Practitioners in both China and other countries could benefit from completion of an assessment of China's experience in promoting green buildings over the last five years, including a rigorous comparison of the strengths and weaknesses of China's multifaceted approach with the approaches used in other countries and suggestions for the future. With or without such an assessment, practitioners could certainly benefit from exchange of specific approaches and lessons learned, focusing particularly on successful measures to increase market uptake and the role of the government in those measures.

52 World Bank/GEF project, 'Urban-Scale Building Energy Efficiency and Renewable Energy Project'.

Developing Low-Carbon Urban Forms

210. As in a number of other countries, the building energy efficiency effort in China has also moved to a higher level, including the role of urban planning in the energy efficiency of the buildings. Modern China's urban design found its roots in Soviet legacies recommended by advisers: wide boulevards, cavernous buildings, and road networks devoid of multimodal horizontal integration. During the 1990s and 2000s, new urban areas exacerbated these challenges by emphasizing car-based transport, segregated residential high-rise buildings, and commercial districts linked by major roads. In contrast, data-intensive real-time monitoring of both international experience and Chinese cities has demonstrated that higher densities, compact urban forms with human-scale functionally mixed neighborhoods, and energy efficient urban fabrics, both reducing energy loads and regulating the urban microclimate, can reduce energy consumption by a factor of two or more. Living comfort, or livability, can be improved at the same time, resulting in low-carbon, adaptive, and livable (LOCAL) urban forms.

211. Overcoming the inertia of long-established practice in urban planning requires a sustained effort at different levels and among different parties. In China, direction from higher levels must be combined with demonstration of the benefits of new methods and experience on the ground. This process has begun encouragingly during the last half of the 2011–2020 decade. Local demonstration of integrating community planning and design, transportation, energy and other infrastructure systems, and green buildings has been undertaken and followed by new regulations and standards for LOCAL urban planning, both at municipal and national levels. The State Council's 'Several Opinions on Further Strengthening the Urban Planning, Development and Management Work' (2016) highlighted open blocks and narrow roads in dense networks as important concepts. The World Bank's 'Urban-scale Building Energy Efficiency and Renewable Energy Project' (2013–2019) played an important role in helping to move this agenda.

Lessons Learned and Experiences Especially Relevant for Other Countries

212. The 40 years between 1980 and 2020 have brought truly dramatic change to the efficiency and healthiness of urban building energy use. During this time, China's urban population grew by more than four times. Urban China moved from direct burning of coal in relatively small apartment blocks with few energy-using services besides cooking, basic lighting and heating where essential to use of district heating, electricity, and some gas in modern apartment blocks with great increases in household comfort and use of modern convenience appliances. With new building growth and proper enforcement of energy efficiency standards in new construction, as well as some older building energy efficiency renovations, relatively energy efficient buildings are becoming the norm.

213. China has a wealth of experience in major building energy efficiency programs to offer to others and has needs for continuing efforts. Practitioners from other countries and Chinese practitioners both could gain much from a focused two-way exchange of experiences, lessons learned, and options for the future. A partial list of potentially fruitful areas for a focused, operationally relevant exchange suggested by the authors includes

    - Development and enforcement of energy efficiency building codes and heat supply norms for different climatic subzones where heating is required, using China's JGJ 26-2018 standard as an example;

- Deployment of ground and underground water-based heat pump technology for medium-size buildings;
- Transition to the commodification of heat and consumption-based billing in buildings using Soviet-era heating systems;
- Third-party financing of energy efficiency renovations of existing residential and commercial buildings;[53]
- Improvement of building occupant incentives for increased energy efficiency in buildings of public institutions;
- Innovative third-party financing methods for public institutional investment in energy efficiency;
- Energy efficiency labeling for online retailing of household appliances; and
- The role of the government in promoting new green buildings.

214. In addition, two areas where China has specific experience that may be especially insightful for other developing countries are discussed in the following paragraphs.

215. **Improving enforcement of energy efficiency building standards**. China's experience has shown that issuance of energy efficiency building standards and their promotion by a central government ministry is not enough to achieve results. Enforcement of the standards must be institutionalized at local levels, best achieved by making procedures to check building energy efficiency standard compliance a routine part of building design permitting, construction supervision, and especially final permitting for occupancy or sale. Moreover, China's experience has shown what measures must be taken to ensure compliance at all three of these stages and not just one or two. What is remarkable about China's experience is that it was able to achieve a dramatic improvement in the enforcement of its residential building energy efficiency standard for the heating zones in just five years (paragraphs ---). While the tightness of the system was not perfect, and efforts to build local capacity have needed to continue, the improvement in large cities at least was eye-catching. The country was able to achieve this by:

- Issuance of specific demands and support from the highest level of the national government for improving the enforcement of building energy efficiency standards, backed up with additions to China's Energy Conservation law. The State Council's 2008 regulation included specifics on instituting inspections at different stages of new building development and consequences for failure to comply.
- Central government issuance of a Building Energy Efficiency Acceptance Code, consisting of a checklist of measures that buildings must follow to comply with the energy efficiency standard. Used to review building projects before final approval by local government, many Chinese practitioners have pointed to the popularization of this tool as a key factor in ensuring standard compliance.
- Institution of annual inspections organized by the central government to review compliance at provincial and local levels through spot checks, including site visits. Real estate developers wield substantial influence at local levels in all countries, and inspections and periodic supervision from outside of localities are important.

53 The experience of bankers, government agencies, and building owners in Shanghai in the World Bank project, 'China: Green Energy for Low-Carbon City in Shanghai Project', completed December 2018, may be especially relevant.

216. **Implementing a successful appliance energy efficiency standards and labeling program.** China instituted its broad and highly visible appliance energy efficiency standards and labeling program in less than a decade. New or revised standards have since been added over the years. The specific needs of other countries vary and often may need to add specifics for point of entry control where imports are important. Still, some of the aspects of China's program that others may find noteworthy and useful to consider are as follows:

- Minimum energy performance requirements, definition of tiers which rank energy efficiency levels, and testing methods are combined in China's appliance energy efficiency standards. Therefore, when a standard is updated, the minimum efficiency bar that all products must exceed, the tiers used on energy efficiency labels, and the definition of high-efficiency products used in financial support or government procurement programs are automatically changed at the same time.

- Chinese authorities have shown that they are not afraid to set minimum energy performance requirements at levels that force a significant amount of domestically manufactured products out of the market. The 2019 heat pump air conditioner standard revision provides an example.

- The range of household appliances covered by energy efficiency standards is large in China. Other countries considering standards for products outside of the usual five to six products may find Chinese standards a useful reference.

- CNIS has remained the central entity for developing and revising national appliance and industrial energy efficiency standards for decades, gaining a wealth of experience. The capacity and institution building process that CNIS has experienced may be insightful to others building national institutions with a similar function.

Chapter 5: Summary of Key Experiences and Some Areas of Possible Greatest to Other Countries

217. China's experience shows what is possible with a comprehensive energy efficiency program backed by political will. The package put together beginning in 2006 brought success in delinking growth in energy use from continuing economic growth in the world's most populous country and second-largest economy. However, the comprehensive effort was built upon investment and experience during the previous 25 years. Without that investment and experience, especially the development of expertise, institutions, and common practice, the success subsequently achieved may not have been possible. Thus, China's overall experience and development of its comprehensive package are instructive to other countries. In this chapter, the authors summarize their thoughts on some of the key components of China's success.

218. Many would argue that China had no choice but to pursue such a comprehensive national program, to continue healthy economic development and avoid even worse pollution problems than those which materialized. However, for other countries, the level of personnel, organizational, and financial investment for such a broad and deep program, and the political will required, may appear especially daunting. Still, many of the specific experiences and programs of both China's national effort and the efforts of its diverse provinces are likely to be of interest for others interested in undertaking similar specific activities. Some of China's experience, including efforts made when the country was less developed and just beginning to take energy conservation seriously, may be useful for countries that are just beginning.

219. A list of more specific experiences in China that may be insightful to other countries is provided at the end of this chapter, with references to the more detailed discussion of each in preceding chapters.

Some Key Ingredients for China's Success in Improving Energy Efficiency

220. **Energy efficiency was made a top priority.** Promoting energy efficiency is regarded as a big issue in China, and China's senior leaders have been key champions. The nation developed a new principal in its basic development policy in 2005, calling for resource-saving and environment-friendly development. This was a break with the past. As China is the most populous country in the world, it was understood that energy-intensive development was no longer a viable road for the future, both economically and environmentally. As Chinese society reached a consensus, the necessary mechanisms and policies were further upgraded or put in place to effectively implement that new development approach and eventually bend the curve of energy consumption growth. The strong political will together with national consensus underlying the new direction has been a basic driving force for promoting energy efficiency in China over the last decade and a half.

221. **Law-based target setting, programming, and implementation.** The Energy Conversation Law and five-year energy conservation and emission reduction plans provide the underpinning for development and implementation of China's energy efficiency programs. They set up the rules and targets to change the behavior of all stakeholders related to energy consumption. Developing the Energy Conservation Law was important as the written document of the national consensus for promoting energy efficiency.

Key central government departments, provincial governments, and local governments then developed specific regulations accordingly.

222. **Development of institutions.** Strong success in implementing energy efficiency programs has been grounded in China's strong institutional framework for undertaking such work. The government institutional framework of national, provincial, and local administration, with similar units in charge of similar tasks, has worked well for the energy efficiency effort. In some cases, energy efficiency work was strengthened in existing institutions, while in other cases entirely new institutions have been created, such as provincial and local Energy Conservation Supervision Agencies. See Chapter 2 for details.

223. **Prioritization of key energy-consuming industries and users.** While China has also made strong efforts to capture energy efficiency potential among the millions of residential, commercial, and transport sector users, a top priority was given to reducing energy waste among smaller numbers of key energy-consuming industries. Industrial energy use has averaged around 70 percent of the country's final commercial energy consumption over the decades of review, until falling to about 65 percent in the most recent years. The cost to dig out the high energy efficiency potential of many large and medium industrial users is relatively low and can work to help modernize factories and reduce pollution. In an industrial economy such as China's, energy conservation efforts in key industrial users can often be regards as a low-hanging fruit.

224. **A combination of pressure and incentive measures.** The simultaneous use of carrot and stick policies and programs has been important in China. Policies to provide pressure to improve energy efficiency have included a mixture of the requirements of the Energy Conservation Law and associated regulations, the pressure from enterprise energy-saving contracts with the local government, energy pricing to ensure sufficiently high energy bills, maintaining of competitive market pressure, and others. The pressure measures are regarded as the stick to drive enterprises to improve energy efficiency. Incentive policies include subsidies and financial awards from the government; tax preferential policy; and praise, publicity, and reputational benefits from the government or other influential entities. They are regarded as the carrot to further encourage private actors to improve energy efficiency. Chinese practitioners commonly advise that when a combined 'carrot and stick' approach is adopted in the same specific energy efficiency field, it is much easier for the enterprises or ordinary people to change behavior and adopt more energy-efficient activities.

225. **Sound energy efficiency standard and labeling systems.** Without a technical standard system, energy-efficient technologies cannot easily be identified from common energy utilization technologies. An energy efficiency standard acts as a rule to help decision-makers find the potential for energy efficiency improvement. Energy efficiency standards also act as mirrors for enterprise energy managers to assess their energy performance compared to all enterprises producing the same products. Energy standards also are the basis for energy-efficient labeling system for appliances. Developing a sound energy efficiency standard system has been essential for execution of China's energy efficiency effort. However, Chinese experience also shows that enforcement of mandatory minimum energy efficiency performance standards is also crucial if they are to be taken seriously.

226. **Market development for energy-saving products and services.** Energy efficiency potential is hidden in countless factories, buildings, and mobile vehicles. Potential can be captured by businesses in the market, providing technical service, introducing new products and tools, undertaking energy performance contracting, or matching potential with financing. Such business provides service to help energy users reduce energy waste and save money. With many barriers impeding the needed innovation and ability for such business to expand, China found strategic cultivation of these players and markets important. Development of new energy-efficient products, monitoring systems, service business models, and

investment mechanisms have all been new efforts in the Chinese market developed to serve the goal of energy efficiency and have required nurturing. Government and strong market players have successfully undertaken this nurturing in China, at times by clarifying market rules, legitimizing business models (such as ESCOs) to ease consumer concerns, providing targeted subsidies, bringing together parties, and fostering knowledge sharing.

227. **Capacity building and awareness raising.** Expanding expertise and understanding of energy efficiency benefits and how to achieve them not only provides policy makers with a good foundation for design of programs and long-term planning for the energy efficiency improvement but also helps cultivate a large number of professionals needed to carry out projects in energy management among countless energy users. Energy efficiency improvement in different sectors and different industries requires different professional skills and special knowledge in engineering, policy, and finance. Formal, hands-on, and work-based training is essential. The capacity building for engineers and energy managers in enterprises, capacity building for government officials from different levels and different departments, capacity building for development and promotion of new energy efficient technologies, and capacity building of third-party service providers, banks, and investors have all been essential for success in China's energy efficiency drive.

Specific Areas of Possible Greatest Interest to Other Countries

228. Many specific areas of the experience accumulated by China may be of interest to other countries, especially developing countries, which have been noted in the previous four chapters. Most of these areas considered by the authors to be of greatest potential interest to outsiders have special '**blue heading**' sections. These sections with blue headings describe aspects of the areas of possible interest that may be especially insightful for others that may be making efforts to design and implement the same type of program or policy. A list of the areas with the paragraph numbers in the previous chapters where they are discussed is provided below for easy reference. These areas of interest are presented in the same order as they appear in the four main chapters of the report.

Broad and cross-sectoral initiatives

- **Experience in developing local energy efficiency technical capacity.** Development of local technical capacity for energy efficiency work is a key requirement for countries aiming to launch or expand energy efficiency initiatives. China faced this issue early on and undertook specific measures that have been successful. The blue heading section is at paragraphs 16–17, while background on initial development of capacity is presented in paragraphs 9–11, followed by a discussion of deployment and strengthening of technical personnel for energy performance contracting (paragraphs 26–28) and government-associated supervision work and energy efficiency consulting (paragraphs 83 and 84)

- **Developing comprehensive and modern national energy statistical systems, data reporting requirements, statistical report review and quality control systems, and practical and informative macro-level statistical analysis capacities.** Development of a sound energy use statistical system proved to be an important foundational investment in China, especially needed for the comprehensive energy efficiency programs implemented over the years. The blue heading is at paragraph 18, while background is provided in paragraphs 12–13 and 92–93.

- **Building an ESCO industry from scratch.** China ESCO industry was built from scratch in 1997 to the largest in the world. China followed a different path than most countries for start-up, and the adapted business model also differs in some key respects which may be insightful for others. The blue heading section is at paragraph 35, while background is provided in paragraphs 27–31 and Annex 1.

- **Developing energy efficiency loan operations in commercial banks.** About 6–10 national-level Chinese commercial banks have successfully developed specific energy efficiency lending practices over the last decade or more. Their experience in overcoming obstacles in developing this business would be useful to other banks aiming to start energy efficiency lending programs. See paragraph 36 for the blue heading section and paragraph 32 for background.

- **Promulgating an energy efficiency law and ancillary regulatory framework.** China's Energy Conservation Law provides the legal foundation for the setup of the country's energy efficiency regulations and policy implementation. China's law could be a good reference for other countries contemplating energy conservation laws. See paragraphs 37–41.

- **Building systems to enforce standards and regulations.** Issuing standards and regulations may often be easier than making sure they are enforced, especially when local systems for enforcement are not fully in place. China has a long history of dealing with this challenge, generally succeeding with institutional change at local levels, combined with supervision from the central government. Background is provided in paragraph 45, and a general blue heading section is at paragraphs 49–51. Chapter 2 (paragraphs 82 and 83) briefly discusses institutional arrangements for supervision in the industrial sector, and enforcement of building energy efficiency standards is noted in another bullet point below.

- **Developing, monitoring, and enforcing binding national and provincial energy savings and emissions targets.** China's system of binding national and provincial energy savings targets is perhaps unique in the world. China's experience with its system may be of particular interest to countries interested in developing binding GHG emissions targets, including at subnational levels. Background can be found at paragraphs 52–57 and 87–93, and a blue heading section is at 65–67.

Industry

- **Experience in closing down especially wasteful and polluting industrial capacity.** China's industrial development included development of thousands of small and now inefficient industrial plants. However, efforts to close these wasteful and polluting plants proved difficult for many years, due to their local importance for employment and revenue. How China has largely succeeded confronting this problem is discussed in background sections paragraphs 108–109, 112, and 114–120 and a blue heading at paragraph 147.

- **Using industrial energy efficiency standards as a policy tool and using China's standards as potential technical references.** China's roughly 100 national industrial energy efficiency standards have been an essential tool for the country's industrial energy efficiency programs. The standards set minimum performance bars above which all companies must operate. They also provide consistent guidance on many definitions, reporting requirements, measurement protocols, efforts to foster behavioral change, and technical calculation methodologies. Background is provided in paragraphs 121–124 and the blue heading section is at paragraphs 148 and 149.

- **Implementing energy savings contracts between the government and enterprises.** During 2011–2015, mandatory energy savings contracts were signed between the government and more than 16,000 enterprises, covering 85 percent of national industrial energy consumption. These contracts yielded monitored and annually supervised savings and provided a platform for implementation of programs and provisions of services with enterprises. Paragraphs 127–134 provide background and paragraph 150 provides the blue heading section.

- **Popularizing key, widely applicable industrial energy efficiency renovation technologies.** A blue heading section is at 151 and 152.

- **Implementing EnMS in different factory settings.** China has implemented EnMS in a variety of industrial companies, sometimes conforming with ISO 50001 and sometimes following national or local standards. This has yielded a rich set of case studies. See paragraphs 135–138 and the blue heading section at paragraph 153.

Buildings

- **Developing and enforcing energy efficiency standards for new buildings in heating and non-heating zones.** China has developed and steadily improved its energy efficiency standards for new buildings over about three decades. Of particular interest is how enforcement of these standards was improved by institutionalizing compliance requirements in the regular construction process. See paragraphs 175–182 for background and paragraph 215 for the blue heading section of energy efficiency building code enforcement.

- **Developing and implementing appliance standards and labels and ratcheting up their stringency over time.** China implemented a successful, highly visible, and broad household appliance standards and labeling program over less than a decade. Some of its new standards are among the most stringent globally. Background is provided in paragraphs 198–205 and a blue heading section is at paragraph 217.

- **Exchanging between practitioners in other specific building energy efficiency topics.** Practitioners in other countries and Chinese practitioners both could gain much from a focused two-way exchange of experiences, lessons learned, and options for the future in the area of building energy efficiency. A list of eight specific topics for useful exchange is provided at paragraph 214.

Organizing Knowledge Exchange

229. A well-organized effort to introduce key lessons learned in China's energy efficiency journey of the last four decades to energy efficiency practitioners in other countries would be most worthwhile. However, to yield results in terms of high value to those other practitioners, this work is more difficult than it might first appear. First, many of the most insightful lessons learned are now matters of history rather than current affairs. The most valuable expertise on these lessons lies with Chinese practitioners who were directly involved at the time, and this was 20 or more years ago. Second, simply describing interesting aspects of China's experience is insufficient. The common reaction is likely to be "that is interesting, but our conditions here are different, and that won't work here."[54] Work must be built on a good understanding of the issues faced in the client countries. Specific needs can then be identified where China's experience could be most insightful. China's experience must be interpreted and presented in ways that are meaningful and resonate with the (different) local institutional setting and in terms of ongoing and different in-country initiatives. Finally, and probably most important, discussions must be undertaken on how elements of Chinese experience could actually be adapted to the local setting.

54 Note that when foreign experts simply introduced their experience to Chinese audiences in the past years, this was a common reaction of the Chinese audience.

Annex 1. Overview of the Development of Commercial Financing for Chinese ESCOs

Needs of Chinese ESCOs for Financing

As described in the main report, Chinese ESCOs began with a shared savings model, with ESCOs financing client projects and receiving a payment stream from an agreed share of client cost savings, fixed after initial guaranteed savings were proven at or soon after project commissioning. While other types of contracts have also been developed, where ESCOs provide only services, this model has nevertheless continued to dominate. The model requires ESCOs to secure substantial financing to pursue their projects. The first three ESCOs in China received dedicated financing from the GEF and World Bank. Their objective was to show that the new business model could operate profitably in China. As they began to show success, other companies aimed to enter the business. However, similar to the pilot ESCOs after the World Bank financing, the new ESCOs needed to obtain financing for their projects from commercial sources.

A chief source of financing for the early projects of new ESCOs was investment funds provided by their shareholders, either as part of equity contributions or in informal lending. New ESCOs aimed for quick project turnaround, so that reflows could be reinvested in new projects. However, reliance solely on shareholders and reflows typically was quickly insufficient, and lack of new project financing often became a stiff brake on growth.

When approached, most banks looked askance at providing credit to the new companies. Despite government support, the companies were small, had little track record, and were engaged in a totally new type of business with other parties that was difficult to understand. Risks were perceived as very high, with little upside benefit.

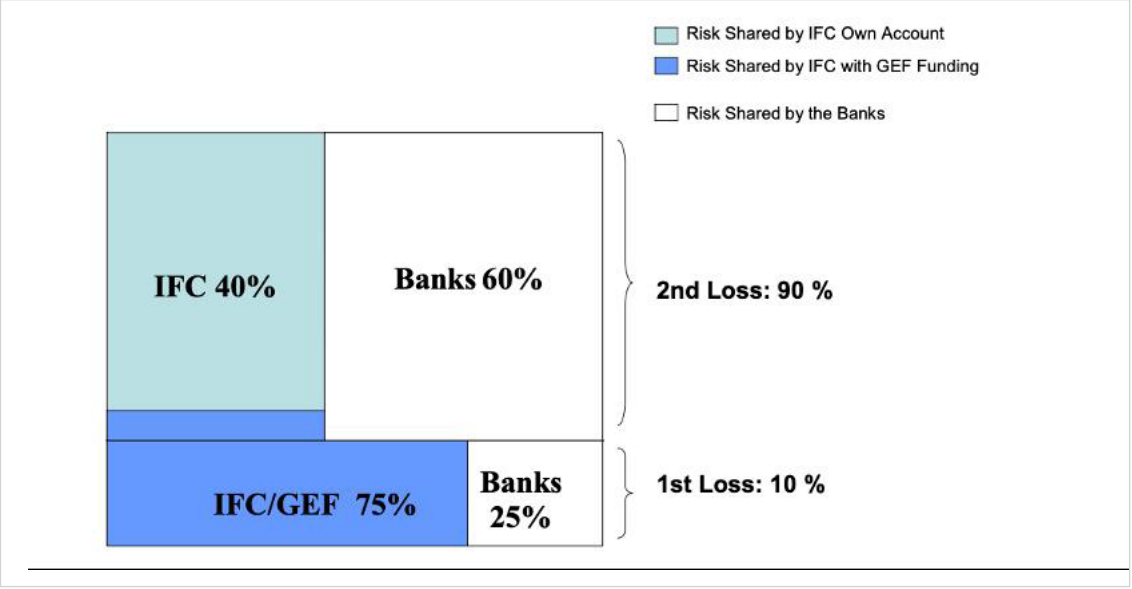
Programs to Support Development of Commercial Bank Financing of ESCOs

To help mitigate the problem of new ESCO financing, partial risk guarantee programs were supported by both the World Bank and IFC, using somewhat different approaches.

Under the World Bank's Second Energy Conservation Project (2002–2010), US$22 million of GEF funds were placed in a fund held by the MOF to backstop partial guarantees of commercial bank loans to emerging ESCOs by China's National Investment and Guaranty Co. (I&G). Given the initial reluctance of commercial banks to lend to the new companies, the program began slowly and took some time to gather momentum. Creativity was needed to explore all options for loan security, including personal guarantees. With their largely technical backgrounds, ESCO managers also needed to learn much about the world of financing, often creating proper balance sheets for the first time. Eventually, however, this project brought 12 commercial banks into ESCO lending business for the first time and loans to 42 different ESCOs, most of which received their first bank loan ever through the program. At the end of the project, slightly more than the original US$22 million of GEF funds remained in the MOF's fund, as actual default losses were small, and fund interest and guarantee fee revenue compensated for a little more than the guarantee program's operating costs. Given the time value of money, conservative estimates of carbon abatement costs were US cents per ton of carbon rather than US dollars per ton.

IFC's CHUEE 1 and 2 Projects (2006–2012) placed US$10 million of GEF funds in a risk-sharing fund held by IFC for first-loss loan guarantee protection in IFC's partial risk guarantee partnership with three major Chinese banks to develop energy efficiency loan programs. The risk-sharing arrangement for the CHUEE 1 Project is depicted below. While first-loss reserve calls turned out to be minimal, the first-loss coverage arrangement was critical both to provide partner bank management with comfort in a new business and for IFC's Board to agree to place IFC funds in a second-loss position. By project closure in 2012, the participating banks had financed 178 new energy efficiency and renewable energy investments, totaling US$783 million. Many of the energy efficiency projects were projects of ESCOs.

Figure A.1: Rish Sharing Facility of the CHUEE 1 Project



Source: IFC. 2006. *China Utility-based Energy Efficiency Finance Program GEF Project Document.* January 2006.

Following closure of the World Bank's Second Energy Conservation Project, and with agreement between relevant parties, China's MOF allocated US$20 million of the remaining GEF funds from that project's guarantee fund to new IFC projects. Included was placement of US$13 million in a first-loss position for a new IFC CHUEE 3 Project, focused on partnering with Chinese banks for energy efficiency and renewable energy loans to SMEs. The CHUEE 3 Project was launched in 2012 and closed in 2018. As a result, the US$22 million of the GEF funds originally placed for the Second Energy Conservation has now been used for a second time, generating yet more GHG emission reduction.

None of the abovementioned projects could have proceeded without the GEF's US$32 million initial financial support.

Mainstreaming Commercial Financing for ESCOs

Experience during the implementation of these projects and the years thereafter showed that there is no panacea to solve the financing difficulties faced by new ESCOs that aim to provide both financing and technical services to their clients. The ESCOs need to gain track records and sound reputations before commercial lenders may consider extending credit. But it is important for banks to be sensitized as to the nature of the business, and a variety of innovations can be explored. In due course, as the individual ESCOs mature, their prospects for obtaining financing improve.

A key breakthrough in China was the experimentation and finally a wider rollout of bank recognition of the executed project accounts receivable of relatively mature ESCOs as a type of security for lines of credit. Once the business of a solid ESCO was solidified, knowledgeable banks began to take account of the steady and predictable payment streams from well-performing completed projects in their consideration of lending amounts and loan security.

Annex 2. Provincial Energy Intensity Reduction Achievements, 2006–2018

Table A.1: Energy Intensity Reductions, 2006–2010

	Target	Actual
Nationwide	**20**	**19.3**
Beijing	20	26.6
Tianjin	20	21.0
Hebei	20	20.1
Shanxi	22 (25)	22.7
Inner Mongolia	22 (25)	22.6
Liaoning	20	20.0
Jilin	22 (30)	22.0
Heilongjiang	20	20.8
Shanghai	20	20.0
Jiangsu	20	20.4
Zhejiang	20	20.0
Anhui	20	20.4
Fujian	16	16.5
Jiangxi	20	20.0
Shandong	22	22.1
Henan	20	20.1
Hubei	20	21.7
Hunan	20	20.4
Guangdong	16	16.4
Guangxi	15	15.2
Hainan	12	12.1
Chongqing	20	21.0
Sichuan	20	20.3
Guizhou	20	20.1
Yunnan	17	17.4
Tibet	12	12.0
Shaanxi	20	20.3
Gansu	20	20.3
Qinghai	27	17.0
Ningxia	20	20.1
Xinjiang	20	8.9

Note: Percentage decline in energy consumption per unit constant GDP.

Table A.2: Energy Intensity Reductions, 2013–2018

	2013	2014	2015	2016	2017	2018
Nationwide	**3.8**	**4.7**	**5.3**	**4.8**	**3.5**	**3.0**
Beijing	4.9	3.8	6.2	4.8	4.0	3.8
Tianjin	4.4	1.5	7.2	8.4	6.2	1.5
Hebei	4.7	5.9	6.1	5.1	4.4	5.9
Shanxi	3.7	3.2	5.3	4.2	3.4	3.2
Inner Mongolia	4.6	–10.9	4.0	4.1	1.6	–10.9
Liaoning	4.5	1.2	3.5	0.4	1.6	1.2
Jilin	6.0	2.6	10.7	7.9	5.0	2.6
Heilongjiang	4.3	2.8	4.0	4.5	4.0	2.8
Shanghai	4.3	5.6	3.9	3.7	5.3	5.6
Jiangsu	4.2	6.2	6.7	4.7	5.5	6.2
Zhejiang	3.7	3.7	3.5	3.8	3.7	3.7
Anhui	3.8	5.5	5.6	5.3	5.3	5.5
Fujian	3.8	3.4	7.7	6.4	3.5	3.4
Jiangxi	3.6	4.8	3.9	4.9	5.5	4.8
Shandong	4.5	4.9	3.7	5.2	6.9	4.9
Henan	3.9	5.0	6.6	7.6	7.9	5.0
Hubei	4.1	4.3	7.7	5.0	5.5	4.3
Hunan	4.7	5.1	7.0	5.3	5.2	5.1
Guangdong	4.6	3.4	5.7	3.6	3.7	3.4
Guangxi	3.2	3.1	5.1	3.6	3.4	3.1
Hainan	4.2	1.3	1.3	3.7	2.0	1.3
Chongqing	5.1	2.5	6.3	6.9	5.1	2.5
Sichuan	4.9	4.1	7.3	5.0	5.2	4.1
Guizhou	3.9	6.5	7.5	7.0	7.0	6.5
Yunnan	3.2	4.8	8.8	5.4	4.9	4.8
Shaanxi	3.6	4.9	3.2	3.8	4.2	4.9
Gansu	4.6	2.0	7.5	9.4	0.8	2.0
Qinghai	2.2	2.9	4.3	7.9	4.7	2.9
Ningxia	3.2	–2.9	–1.2	4.3	–7.7	–2.9
Xinjiang	–8.8	4.0	3.6	3.2	0.9	4.0

Note: Percentage decline in energy consumption per unit constant GDP.

Annex 3. Partial List of National Industrial Energy Efficiency Standards

This list describes China's industrial energy efficiency standards as of around 2011, to provide an overview of the breadth and scope of the standards. Additional standards have since been promulgated, and some have also been updated. The standards are routinely available only in the Chinese language, although a few have been translated for international exchange purposes.

Subordinate System	Standard Categories	Standard Number	Standard Name
Basic standards for energy conservation	Terminological standards	GB/T 1028-2000	Terminology, Classification, Grade of Industrial Waste Heat and Calculating Method of Waste Heat Resources
		GB/T 50185-1993	Quality Inspection and Assessment Standard for Industrial Equipment and Pipeline Insulation Engineering
		GB/T 10180-2003	Test Rules for Thermal Performance of Industrial Boilers
Technical standards for energy saving	Energy-saving testing and inspection standards	GB/T 20137-2006	Method for Determining Loss and Efficiency of Three-phase Cage Asynchronous Motor
		GB/T 18342-2001	Technical Specifications for Coal Used in Chain grate Boiler
	Energy-saving design standard	GB/T 50264-1997	Code for design of insulation engineering for industrial equipment and pipelines
		GB/T 4272-2008	General Principles of Insulation Technology for Equipment and Pipeline
		GB/T 8175-2008	Technical Guidelines for Insulation of Equipment and Pipelines
		GB/T 16618-1996	General Principles of Industrial Furnace and Kiln Thermal Insulation Technology
		GB/T 50376-2006	Code for energy saving design of rubber factories

Subordinate System	Standard Categories	Standard Number	Standard Name
Energy-saving management standards	Energy efficiency standards for products and equipment	GB/T 18613-2006	Energy Efficiency Limited Value and Energy Efficiency Grade of Small and Medium-sized Three-phase Asynchronous Motor
		GB/T 19761-2009	Limited Value of Ventilator Efficiency and Evaluation Value of Energy Conservation
		GB/T 20052-2006	Energy Efficiency Limitation Value and Energy Conservation Evaluation Value of Three-phase Distribution Transformer
		GB/T 24500-2009	Energy Efficiency Limited Value and Energy Efficiency Grade of Industrial Boiler
		GB/T 24790-2009	Energy Efficiency Limited Value and Energy Efficiency Level of Power Transformer
		GB/T 24848-2010	Energy Efficiency Limited Value and Energy Efficiency Grade of Reheating Furnace for Petroleum Industry
	Rational energy use standard	GB/T 10201-2008	Guidelines for Rational Use of Heat Treatment
		GB/T 12712-1991	Technical Management Requirements for Condensate Water Recovery and Steam Trap in Steam Heating System
	Energy-saving design standard	GB/T 13234-2009	Calculating Method of Enterprise Energy Conservation
		GB/T 13338-1991	Basic Rules for Measuring and Calculating Thermal Balance of Industrial Fuel Furnace
		GB/T 13467-1992	Electric Energy Balance Testing and Calculating Method for Fan System
		GB/T 25039-2010	Measuring and Calculating Method of Thermal Balance of Glass Fiber Unit Kiln
	Energy-saving calculation standard	GB/T 17719-1999	Calculating Method and Utilization Guidelines for Flue Gas Waste Heat Resources of Industrial Boilers and Flame Heating Furnaces
		GB/T 2588-2000	General Principles for Calculating Thermal Efficiency of Equipment
		GB/T 2589-2008	General Principles for Computing Comprehensive Energy Consumption

Subordinate System	Standard Categories	Standard Number	Standard Name
Energy-saving management standards	Energy-saving monitoring standards	GB/T 15317-2009	Energy-saving Monitoring Method for Industrial Boilers
		GB/T 15318-1994	Energy-saving Monitoring Method for Industrial Heat Treatment Furnace
		GB/T 15319-1994	Monitoring Method for Energy Saving of Flame Heating Furnace
		GB/T 15910-2009	Energy-saving Monitoring Method for Thermal Conveying System
		GB/T 15911-1995	Energy-saving monitoring method for industrial electrothermal equipment
		GB/T 15913-2009	Energy-saving Monitoring Method for Fan Unit and Pipeline Network System
		GB/T 15914-1995	Monitoring Method for Energy Saving of Steam Heating Equipment
		GB/T 16664-1996	Energy-saving Monitoring Method of Enterprise Power Supply and Distribution System
		GB/T 16665-1996	Energy-saving Monitoring Method for Air Compressor Unit and Gas Supply System
		GB/T 16666-1996	Energy-saving Monitoring Method for Pumps and Liquid Conveying Systems
		GB/T 16667-1996	Monitoring Method for Energy Saving of Welding Equipment
		GB/T 16811-2005	Operation Effect and Monitoring of Industrial Boiler Water Treatment Facilities
		GB/T 24560-2009	Energy-saving Monitoring of Electrolytic and Electroplating Equipment
		GB/T 24561-2009	Energy-saving Monitoring of Drying Kiln and Baking Furnace
		GB/T 24562-2009	Energy Saving Monitoring of Fuel Heat Treatment Furnace
		GB/T 24563-2009	Energy-saving Monitoring of Gas Generator
		GB/T 24564-2009	Energy-saving Monitoring of Blast Furnace Hot Blast Furnace
		GB/T 24565-2009	Energy-saving Monitoring of Tunnel Kiln
		GB/T 24566-2009	Energy-saving Monitoring of Rectifier Equipment

Subordinate System	Standard Categories	Standard Number	Standard Name
Energy-saving management standards	Economic operation standard	GB/T 12497-2006	Economic Operation of Three-phase Asynchronous Motor
		GB/T 13462-2008	Economic Operation of Power Transformer
		GB/T 13466-2006	General Rules for Economic Operation of AC Electrically Driven Fan (Pump and Compressor) System
		GB/T 13469-2008	Economic Operation of Centrifugal Pump, Mixed Flow Pump, Axial Flow Pump and Vortex Pump System
		GB/T 13470-2008	Economic Operation of Fan System
		GB/T 17954-2007	Economic Operation of Industrial Boilers
		GB/T 19065-2003	Economic Operation of Electric Heating Boiler System
	Energy consumption quota standard	GB/T 16780-2007	Energy consumption quota per unit product of cement
		GB/T 21248-2007	Energy Consumption Limit for Copper Smelting Unit Products
		GB/T 21249-2007	Energy Consumption Limit for Zinc Smelting Unit Products
		GB/T 21250-2007	Energy Consumption Limit for Lead Smelting Unit Products
		GB/T 21251-2007	Energy Consumption Limit for Nickel Smelting Unit Products
		GB/T 21252-2007	Energy Consumption Limit per Unit Product of Building Sanitary Ceramics
		GB/T 21256-2007	Energy Consumption Limit of Main Processing Unit Products in Crude Steel Production
		GB/T 21257-2007	Energy consumption quota per unit product of caustic soda
		GB/T 21258-2007	Energy Consumption Limit per Unit Product of Conventional Coal-fired Generating Units
		GB/T 21340-2008	Energy Consumption Limit for Flat Glass Unit Products
		GB/T 21341-2008	Energy Consumption Limit for Ferroalloy Unit Products
		GB/T 21342-2008	Energy consumption quota per unit product of coke
		GB/T 21343-2008	Calcium Carbide Unit Product Energy Consumption Limit
		GB/T 21344-2008	Energy Consumption Limit for Unit Products of Ammonia Synthesis
		GB/T 21345-2008	Energy Consumption Limit for Yellow Phosphorus Unit Products

Subordinate System	Standard Categories	Standard Number	Standard Name
Energy-saving management standards	Energy consumption quota standard	GB/T 21346-2008	Energy Consumption Limit for Unit Products of Electrolytic Aluminum
		GB/T 21347-2008	Energy Consumption Limit for Magnesium Smelting Unit Products
		GB/T 21348-2008	Energy Consumption Limit for Tin Smelting Unit Products
		GB/T 21349-2008	Energy Consumption Limit for Antimony Smelting Unit Products
		GB/T 21350-2008	Energy Consumption Limit of Copper and Copper Alloy Pipe Unit Products
		GB/T 21351-2008	Energy Consumption Limit per Unit Product of Aluminum Alloy Building Profiles
		GB/T 21370-2008	Energy Consumption Limit for Carbon Unit Products
		GB 25323-2010	Energy Consumption Limit for Recycled Lead Unit Products
		GB 25326-2010	Energy Consumption Limits for Rolled and Drawn Pipes and Bars of Aluminum and Aluminum Alloys
		GB 25324-2010	Energy Consumption Limit per Unit Product of Graphite Cathode Carbon Block for Aluminum Electrolysis
		GB 25327-2010	Energy Consumption Limit per Unit Product of Alumina Enterprise
		GB 25325-2010	Energy Consumption Limit per Product of Prebaked Anode for Aluminum Electrolysis
		GB/T 12723-2008	General Principles for Establishing Energy Consumption Limits for Unit Products
		GB/T 17358-1998	Electricity Consumption Quota for Heat Treatment Production and Its Calculating and Measuring Method
		GB/T 19944-2005	Fuel Consumption Quota for Heat Treatment Production and Its Calculating and Measuring Method
	Energy measurement standards	GB 17167-2006	General Rules for Equipment and Management of Energy Metering Instruments for Energy Use Units
		GB/T 17471-1998	Principles of Energy Monitoring and Metering Instruments for Boiler Heat Network System
		GB/T 20901-2007	Requirements for equipping and managing energy measuring instruments in petroleum and petrochemical industry

Subordinate System	Standard Categories	Standard Number	Standard Name
Energy-saving management standards	Energy measurement standards	GB/T 20902-2007	Equipment and Management Requirements for Energy Metering Instruments in Non-ferrous Metal Smelting Enterprises
		GB/T 21367-2008	Requirements for Equipment and Management of Energy Metering Instruments in Chemical Enterprises
		GB/T 21368-2008	Requirements for Equipment and Management of Energy Metering Instruments in Iron and Steel Enterprises
		GB/T 21369-2008	Requirements for Equipment and Management of Energy Metering Devices in Thermal Power Generation Enterprises
		GB/T 24851-2010	Requirements for Equipment and Management of Energy Metering Instruments in Building Material Industry
		GB/T 6422-1986	Guidelines for Enterprise Energy Consumption Measurement and Testing
	Comprehensive evaluation criteria	GB/T 15587-2008	Guidelines for Energy Management in Industrial Enterprises
		GB/T 17166-1997	General Principles of Enterprise Energy Audit Technology
		GB/T 22336-2008	General Principles for Compiling Enterprise Energy Saving Standard System
		GB/T 2587-1981	General Principles for Energy Balance of Thermal Equipment
		GB/T 3484-2009	General Principles of Enterprise Energy Balance
		GB/T 2587-2009	General Principles for Energy Balance of Energy Utilization Equipment
		GB/T 23331-2009	Energy Management System Requirements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