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Assessment of China's Energy-Saving and Emission-Reduction Accomplishments and Opportunities During the 11th Five Year Plan

Lynn Price, Mark D. Levine, Nan Zhou, David Fridley, Nathaniel Aden, Hongyou Lu, Michael McNeil, Nina Zheng, Yining Qin[a] and Ping Yowargana[b]

[a] China Energy Group, Energy Analysis Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, MS 90R4000, Berkeley, CA 94720, United States
[b] Azure International, Suite H, Floor 6, Oriental Kenzo, 48 Dongzhimenwai Dajie, Dong Cheng District, Beijing, 100027, China

Abstract

From 1980 to 2002, China experienced a 5% average annual reduction in energy consumption per unit of gross domestic product (GDP). With a dramatic reversal of this historic relationship, energy intensity increased 5% per year during 2002-2005. China's 11th Five Year Plan (FYP) set a target of reducing energy intensity by 20% by 2010. This paper assesses selected policies and programs that China has instituted to fulfill the national goal, finding that China made substantial progress and many of the energy-efficiency programs appear to be on track to meet – or in some cases exceed – their energy-saving targets. Most of the Ten Key Projects, the Top-1000 Program, and the Small Plant Closure Program will meet or surpass the 11th FYP savings goals. China's appliance standards and labeling program has become very robust. China has greatly enhanced its enforcement of new building energy standards but energy-efficiency programs for buildings retrofits, as well as the goal of adjusting China's economic structure, are failing. It is important to maintain and strengthen the existing energy-saving policies and programs that are successful while revising programs or adding new policy mechanisms to improve the programs that are not on track to achieve the stated goals.

Keywords: China, energy intensity, energy efficiency programs

1. Introduction

From 1980 to 2002, China experienced a 5% average annual reduction in energy consumption per unit of gross domestic product (GDP). Government policies and programs implemented during this period focused on strict oversight of industrial energy use, financial incentives for energy-efficiency investments, provision of information and other energy-efficiency services through over 200 energy conservation service centers spread throughout China, energy-efficiency education and training, and research, development, and demonstration programs (Sinton et al., 1998; Sinton et al., 1999; Sinton and Fridley, 2000; Wang et al., 1995). Since energy demand grew less than half as fast as GDP, the need for investment in energy supply was reduced and capital could be used for other investments that supported important social goals.

With a dramatic reversal of the historic relationship between energy use and GDP growth, energy use per unit of GDP increased an average of 5% per year during the period 2002-2005 (NBS, various years).[1] Senior members of the government called on China to reduce energy intensity by 20% in five years in order to regain the relationship between energy and GDP growth experienced during the 1980s and 1990s. China's 11th Five Year Plan (FYP), which covers the period 2006-2010, required all government divisions at different levels to ensure the achievement of this binding energy conservation target and established specific energy-efficiency targets for electricity generation, selected industrial processes, appliances, and transport.

This paper[2] provides an assessment of selected policies and programs that China has instituted in its quest to fulfill the national goal of a 20% reduction in energy intensity by 2010.[3] It begins with an overall assessment of the energy use and energy savings achieved through 2008. Next, the relative contributions of activity increases and energy intensity improvements are assessed. Specific policies are then evaluated in terms of energy savings and accomplishment of stated policy goals. Where applicable, Chinese policies and programs

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[1]Based on NBS official GDP and energy values prior to the 2009 revision.

[2] This paper is based upon a larger report (Levine et al., 2010) available here: http://china.lbl.gov/sites/china.lbl.gov/files/LBNL_3385E.Ace_Study_Report_FINAL.pdf. This work was supported by the China Sustainable Energy Program of the Energy Foundation through the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. We also greatly appreciate the guidance that has been provided by Hu Min of CSEP, Qi Ye (formerly of CSEP), as well as He Jiankun and Zhang Xiliang and their colleagues at Tsinghua University. We also thank Martin Joerss, August Wu, Jian Sun, Haimeng Zhang, and Sabine Wu of McKinsey & Company for their thoughtful discussions during preparation of this report. The report could not have been written without the information provided to us through numerous interviews which are referenced throughout the report. We greatly appreciate the time the interviewees spent with us to provide background information on China's various energy-efficiency policies and programs. We greatly appreciate the reviewer comments that were provided on the larger report by Qi Ye, Distinguished Professor of Environmental Policy and Management, School of Public Policy and Management, Tsinghua University; Li Minghui, Post Ph.D. Assistant Researcher, Institute of Energy, Environment and Economy, Tsinghua University; Jennifer Morgan, Director, Climate and Energy Program, World Resources Institute; Deborah Seligsohn, Principal Advisor, China Climate and Energy Program, World Resources Institute; Robert Taylor formerly of the World Bank and now an independent consultant; and Bo Shen formerly of Natural Resources Defense Council and now a member of LBNL's China Energy Group. Finally, we would like to thank our colleagues and visiting researchers in the China Energy Group at LBNL for their thoughtful review and comments, especially Tian Zhiyu of China's Energy Research Institute, Ke Jing of Shandong University, and Stephanie Ohshita, Associate Professor in the Department of Environmental Science at the University of San Francisco who is currently on sabbatical working with the China Energy Group at LBNL.

[3] It is noted that the goal was originally announced as "20% more or less" (20%左右).

are compared to similar programs found in other countries. Finally, recommendations regarding possible improvements to the current policies and programs are provided and additional recommendations are made for possible energy-saving activities in the 12th FYP.

2. Methodology

This evaluation began with an assessment of the overall energy savings attributed to the 11th FYP during 2006-2008. A baseline was developed as well as estimates of savings from individual policies and programs. Next, annual energy savings were decomposed to understand the relative contributions of structural change and energy efficiency. Finally, individual programs or policies were evaluated to assess their overall energy savings and to determine whether they are meeting their stated goals.

To assess the impact of energy-saving policies and programs that were implemented during the 11th FYP period, it is necessary to estimate the level of energy consumption that would have occurred in China without these efforts. This so-called "counterfactual baseline" can only be estimated since it describes a situation that did not happen – in this case, energy use if China had not adopted its 20% intensity reduction target. The analysis estimated the difference in actual energy use and the energy use of a case in which the 2005 energy intensity (energy use/unit of GDP) is assumed to remain constant in 2006, 2007, and 2008. This 2005 intensity baseline was then compared to both energy savings as reported by official announcements and evaluations and to program- or policy-specific evaluations undertaken as part of this study to determine the savings attributable to the 11th FYP programs versus the savings that would have occurred in the absence of these programs. Energy savings[4] and CO_2 emissions reductions[5] from programs and policies are reported both as year-to-year annual savings and as annual cumulative incremental savings. Annual cumulative incremental savings are defined as the savings from the previous year added to the savings of the current year.[6]

[4] Energy use and energy savings are reported in Chinese units of standard coal equivalent (sce); values are typically expressed as metric tons of coal equivalent (tce) and million metric tons of coal equivalent (Mtce). One tce equals 29.27 gigajoules (GJs) and 27.78 million British thermal units (MBtus). Energy use and energy savings are reported in both final (site) and primary (source) values that reflect electricity conversion efficiencies as well as transmission and distribution losses. To convert electricity to a final (site) coal equivalent value, the conversion factor of 0.1229 kilogram coal equivalent (kgce)/kilowatt hour (kWh) is used. To convert electricity to a primary (source) coal equivalent value, the conversion factor of 0.404 kgce/kWh is used. Transmission and distribution (T&D) losses for China's power grid are 7.55% (Kahrl and Roland-Holst, 2006), while average net generation efficiency of fossil fuel-fired power plants in 2009 is 35.20% (NBS, 2008). The national average efficiency of thermal power generation including the T&D loss is 32.55%. Therefore, the actual conversion coefficient from final to primary electricity is 3.07, which would result in lower primary electricity values than those calculated using 0.404 kgce/kWh.

[5] CO2 emissions are expressed in kilotonnes of CO2. The conversion factors used for calculating CO2 emissions from energy consumption are taken from the 2006 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The emission factor for grid electricity is assumed to be 0.85305 kg CO2/kWh (NBS, 2007).

[6] For example, the savings of 20 Mtce in 2006 from a hypothetical program are added to the savings of 40 Mtce realized in 2007, for an annual cumulative incremental savings of 60 Mtce in 2007 since the 20 Mtce saved in 2006 are still not being consumed (or emitted) in 2007. In 2008, the annual cumulative incremental savings are 40 Mtce saved in 2008 added to the 40 Mtce saved in 2007 and the 20 Mtce saved in 2006 for a total annual cumulative incremental savings of 100 Mtce. It can be argued that the cumulative program savings in 2008 are 20 Mtce for 2006 added to 60 Mtce for 2007 and 100 Mtce for 2008, but this method of adding the savings is not adopted for this analysis.

The policy evaluation in this paper is conducted in three steps. First, the policy or program is described, the stated goals are explained, and reported results to date are identified. Second, a quantitative evaluation is made in which a baseline for the specific policy or program is developed and energy savings are calculated from the baseline. Third, a qualitative evaluation is undertaken in which the current level of progress is compared to the stated policy or program goals, including an evaluation of whether the program components were carried out successfully and whether the program savings are in line with stated goals. If applicable, the policy or program implementation is then compared to international "best practice" to determine whether specific elements were undertaken in a manner consistent with programs found in other countries.

3. Assessment of Energy Use and Energy Savings During the 2006-2008 Period

Table 1 provides energy, GDP, and energy intensity data for 2005 through 2008. Energy use values are reported by the National Bureau of Statistics (NBS) (NBS, 2007; NBS 2008). Energy intensity reduction values are from the National Development and Reform Commission (NDRC) (NDRC, 2009a; NDRC, 2009b).[7] GDP values were then derived using these two values. This method was chosen because the energy values and energy intensity reduction values were the most clearly reported values; GDP values have undergone a series of revisions and may continue to be revised.

Table 1. Energy Use, Energy Intensity, and GDP Data (2005-2008)

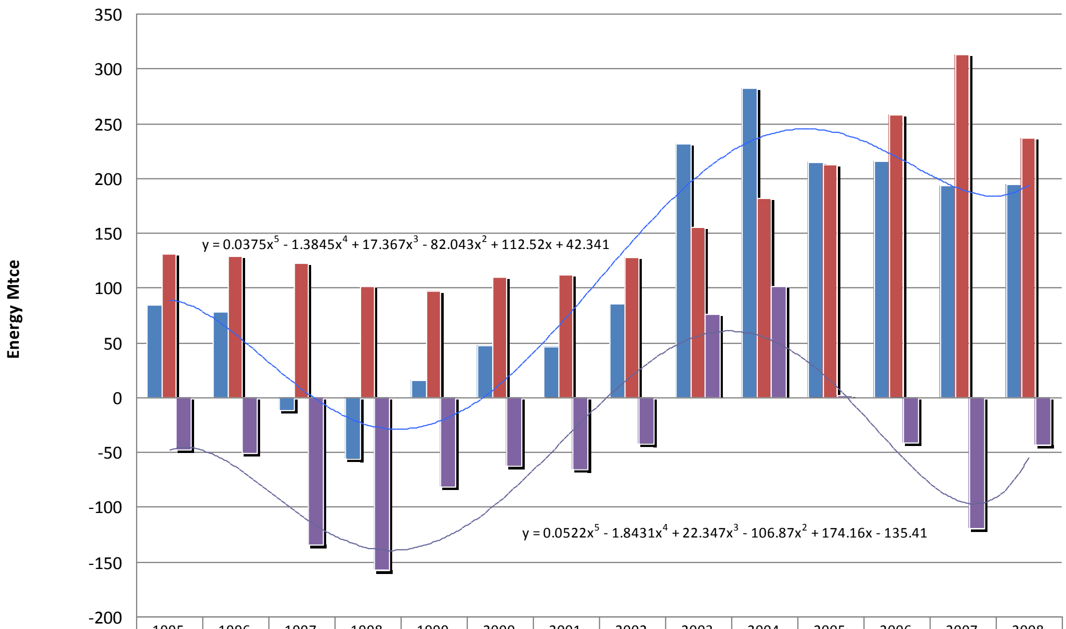
Indicator	Unit	2005	2006	2007	2008
Energy	Mtce	2,247	2,463	2,656	2,850
	EJ	65.85	72.18	77.84	83.53
GDP	Billion 2005 RMB	18,322	20,449	22,982	25,848
	Billion 2005 USD*	2,239	2,499	2,809	3159
Energy Intensity	kgce/RMB	0.1226	0.1204	0.1156	0.1103
	MJ/USD*	29.40	28.87	27.72	26.45
Energy Intensity Reduction	% per year		-1.79%	-4.04%	-4.59%

* 2005 average exchange rate: 1 RMB=0.12222 USD.

Figure 1 provides a decomposition of the energy use of China's economy and provides a historic context for understanding the trends during the 11th FYP. While the change in energy use (blue bars) has been both positive and negative during 1995-2008, increases of 216 Mtce (6.33 EJ), 193 Mtce (5.66 EJ), and 194 Mtce (5.69 EJ) were experienced during 2006, 2007, and 2008, respectively. The red bar illustrates how much of the annual change was due to "activity", such as the production of raw materials or manufactured goods. The purple bar illustrates how much of the annual change was due to "intensity", or the amount of energy used per unit of activity. Adding these two provides total energy use. This decomposition shows that during the 11th FYP to date, growth in energy use was due primarily to the large growth in activity that began to increase in 2002 and peaked in 2007. The decomposition further shows that the growth in energy use was dampened by reductions in energy efficiency, especially in 2007, which offset the growth in activity.

[7] In December 2009, NBS announced that the energy intensity reduction for 2008 had been revised to -5.2% (Ma Jiantang, 2009). This analysis has not been updated to reflect that revision; doing so would indicate even greater savings than are identified in this report.

Reductions in energy intensity in the secondary sector[8] appear to have made the largest contribution. A disaggregation of the affects of changes in activity, structure, and energy efficiency for heavy industry[9] indicates that improvements in energy efficiency offset increases in activity and structural changes, helping to reverse the growth in overall energy use experienced between 2002 and 2004.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Δ Energy Use	84.39	77.72	-11.50	-55.84	16.17	47.22	46.46	85.98	231.93	282.37	214.55	215.88	193.13	194.17
Activity	131.585	128.80	123.01	101.80	97.68	110.23	112.32	128.18	155.85	181.36	212.14	257.70	312.64	237.15
Efficiency	-47.195	-51.08	-134.51	-157.64	-81.51	-63.01	-65.86	-42.20	76.08	101.01	2.41	-41.82	-119.51	-42.98

Figure 1. Trends in Energy Use, Activity, and Energy Efficiency for the Chinese Economy, 1995-2008.

A frozen 2005 energy intensity baseline was calculated by multiplying the 2005 energy intensity value of 0.1226 kgce/RMB (29.40 MJ/USD) by the GDP values for each year in order to derive the energy consumption that would have occurred if the 2005 energy intensity had not declined during 2006-2008.[10] Using this baseline, China's total energy use in 2008 was 10% lower than it would have been without policy intervention. From 2006 through 2008, total energy consumption was 45 Mtce (1.32 EJ), 162 Mtce (4.75 EJ), and 320 Mtce

[8] The primary sector of the economy involves changing natural resources into primary products and includes agriculture, agribusiness, fishing, forestry and all mining and quarrying industries. Most products from this sector are considered raw materials for other industries. The Secondary sector includes those economic sectors that create a finished, usable product: manufacturing and construction. The tertiary sector involves the provision of services to businesses as well as final consumers. Services may involve the transport, distribution and sale of goods from producer to a consumer as may happen in wholesaling and retailing, or may involve the provision of a service, such as in pest control or entertainment. Goods may be transformed in the process of providing a service, as happens in the restaurant industry or in equipment repair. However, the focus is on people interacting with people and serving the customer rather than transforming physical goods.

[9] Defined as ferrous metals, non-metallic minerals, chemicals, non-ferrous metals, fuel, paper, and textiles. See Appendix A for further decomposition analyses of specific industrial subsectors.

[10] Costs are reported in Chinese Renminbi (RMB) and U.S. dollars. To convert the costs from US$ to RMB, the conversion factor of 6.84 RMB/US$ is used (BOC, 2009).

(9.38 EJ) less than it would have been if energy intensity of GDP had remained constant. The cumulative effect of these efficiency improvements has been 527 Mtce (15.45 EJ) less energy use than would have been required at the 2005 energy intensity level.

This paper provides a detailed assessment of selected Central government-level energy-saving policies or programs that have been carried out during the 11th FYP. The programs reviewed are: Ten Key Projects, Buildings Energy Efficiency, Top-1000 Energy-Consuming Enterprises Program, Structural Adjustment/Small Plant Closures, and Appliance Standards and Energy-Efficiency Labels.[11] Table 2 provides information on the 11th FYP targets for the Central government-level energy-saving policies or programs assessed, along with estimates of the energy savings realized during the 2006-2008 period from these programs. The selected policies or programs represent the main Central government-level efforts to save energy in the buildings and industrial sectors; not all energy-saving policies or programs are covered due to lack of publicly-available information or data, because they began late within the 11th FYP period and there are no results to report, or because they focus on sectors of the economy not covered by this report, such as transportation.

This analysis found that the Ten Key Projects have saved a total of 102 Mtce (2.99 EJ) in primary energy during 2006-2008. Within the Ten Key Projects, buildings energy efficiency efforts are estimated to have saved 41 Mtce (1.20 EJ). The Top-1000 Program is estimated to have saved 124 Mtce (3.63 EJ) during this period. Since the Ten Key Projects includes three project types that have been adopted by Top-1000 enterprises, the potential overlap between the Ten Key Projects and Top-1000 Program was estimated to be 12 Mtce (0.35 EJ). This analysis further found that the small plant closures have resulted in savings of 129 Mtce (3.78 EJ) and that the appliance standards have saved 37 Mtce (1.08 EJ) during 2006-2008. It is assumed that the remainder of the savings is the result of a variety of other efforts, including provincial-level energy-savings programs that are not evaluated in this paper due to lack of reported data and information (see Figure 2).

[11] In addition to these programs at the Central government level, there are numerous activities at the provincial level that are not assessed in this report.

Table 2. 11th FYP Energy-Saving Targets and Savings to Date, 2006-2008, Based on Frozen 2005 Efficiency Baseline[3]

Policy/Program	11th FYP Target		Savings to Date 2006-2008	
	Final Energy			
	Mtce	EJ	Mtce	EJ
Ten Key Projects	245	7.2	94	2.8
Buildings Energy Efficiency	101	3.0	35	1.0
(Overlap Ten Key Projects and Buildings Energy Efficiency)	-101	-3.0	-35	-1.0
Top-1000 Program	100	2.9	96	2.8
(Overlap Ten Key Projects and Top-1000 Program)	-26	0.8	-10	-0.3
Small Plant Closures	91	2.7	75	2.2
Appliance Standards	24	0.7	11	0.3
Other savings including provincial programs	885	25.9	144	4.2
Total Final Energy Savings	**1320**	**38.7**	**409**	**12.0**
	Primary Energy			
	Mtce	EJ	Mtce	EJ
Ten Key Projects	268	7.9	102	3.0
Buildings Energy Efficiency	112	3.3	41	1.2
(Overlap Ten Key Projects and Buildings Energy Efficiency)	-112	-3.3	-41	-1.2
Top-1000 Program	130	3.8	124	3.6
(Overlap Ten Key Projects and Top-1000 Program)	-32	-0.9	-12	-0.4
Small Plant Closures	118	3.5	91	2.7
Appliance Standards	79	2.3	37	1.1
Other savings including provincial programs	1146	33.6	185	5.4
Total Primary Energy Savings	**1709**	**50.1**	**527**	**15.4**
	Emissions Reduction (MtCO2)			
Ten Key Projects	743		287	
Buildings Energy Efficiency	348		100	
(Overlap Ten Key Projects and Buildings Energy Efficiency)	-348		-100	
Top-1000 Program	235		197	
(Overlap Ten Key Projects and Top-1000 Program)	-67		-27	
Small Plant Closures	222		171	
Appliance Standards	167		78	
Other savings including provincial programs	2973		612	
Total Emissions Reductions	**4273**		**1318**	

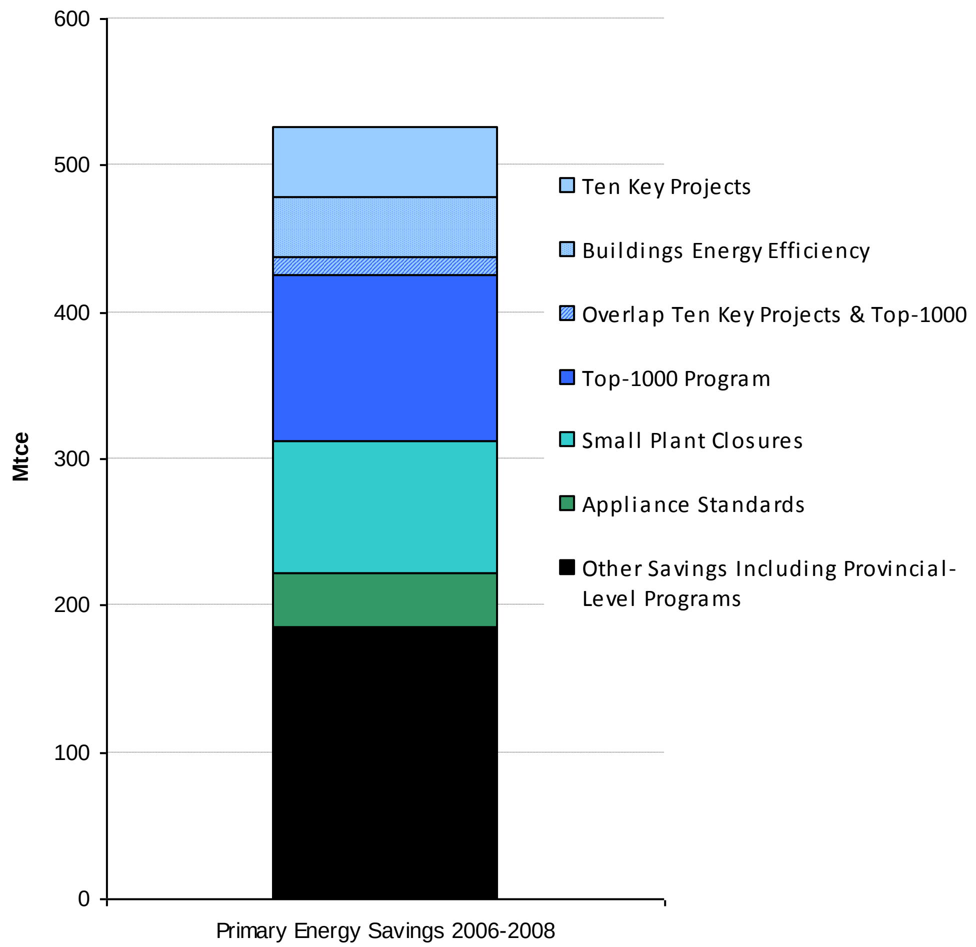


Figure 2. 2006-2008 Estimated Energy Savings from 11th FYP Programs and Policies

4. Policy Evaluation 2006-2008

Shortly after the November 2005 Politburo announcement of a national goal of reducing energy use per unit of GDP by 20% in five years, China's 11th FYP provided an initial view of the means to achieve this target. In late 2006, the State Council approved and distributed a scheme disaggregating the 11th FYP's national energy-saving target into energy-saving targets for each province. In response to a Central government request, most Provinces proposed a 20% target in line with the national target, although there some targets were higher and some lower than 20%. After a negotiation process, the State Council approved the provincial targets. The State Council required local governments to disaggregate provincial targets to cities and counties (Zhou, 2006).[12]

This paper presents a review of selected key national-level policies and programs that were in place during the 11th FYP in order to evaluate their contribution to the total energy savings achieved between 2006 and 2008 as well as to evaluate their effectiveness. This paper does not attempt to evaluate the numerous provincial-level policies and programs that have been established in each province to compliment the national-level efforts due to a lack of reported data and information.

[12] For a recent overview of China's energy efficiency policies and programs, see Zhou et al., 2010.

4.1. Ten Key Projects

The Ten Key Energy Conservation Projects ("Ten Key Projects") aim to increase energy efficiency through adjusting and optimizing the economic structure, promoting energy-efficient technologies, establishing a strict management system, and implementing effective incentive mechanisms. The Ten Key Projects focus on coal-fired industrial boiler (kiln) retrofits, district cogeneration projects, waste heat and pressure utilization projects, petroleum conservation and substitution projects, motors energy efficiency projects, energy system optimization projects, building energy conservation projects, green lighting projects, government agency energy conservation projects, and energy saving monitoring and testing and technology service system building projects. The overall target is to save about 250 Mtce (7.33 EJ) (excluding oil substitution) by the end of the 11th FYP. In addition, the energy intensities of major products in key industries are expected to reach or approach the advanced international level achieved at the beginning of 21st century (NDRC, 2006).
In 2007, total government investment for the Ten Key Projects was about 5.58 billion RMB (735 million USD)[13]. Of this, 800 million RMB (10.5 million USD) was allocated to support 136 sub-projects in waste heat and waste pressure utilization, energy system optimization, and building energy conservation with an estimated energy saving of 5.2 Mtce (0.15 EJ). Another 4.78 billion RMB (632 million RMB) was allocated to reward, instead of subsidize, enterprises that achieved their energy-saving goals (NDRC, 2008). In the first three years of the 11th FYP, total investment from the central budget and central fiscal funding to support Ten Key Projects was around 15 billion RMB (1.98 million RMB) (Xu Kexin, 2009). The savings of Ten Key Projects from 2006-2008 is estimated at around 150 Mtce (4.40 EJ) (Lv Wenbin, 2009; Cai Zhihua, 2009).

This analysis estimated that if the Ten Key Projects are on track to achieve the 2010 goals, they would have achieved a total primary energy savings of 102 Mtce (2.99 EJ) during the 2006-2008 period.[14] Since it has been reported that the total program has saved 150 Mtce (4.40 EJ) to date (Lv Wenbin, 2009; Cai Zhihua, 2009), it appears that the program is on track to meet or surpass the 11th FYP goal.[15]

Evaluation of the Ten Key Projects is difficult due to lack of information regarding the activities and savings undertaken for each of the projects. Some of the savings from industrial sector projects, such as renovation of coal-fired industrial boilers, waste heat and waste pressure utilization, and motor system energy efficiency, are most likely also counted in the savings attributed to the Top-1000 enterprises.[16] In addition, targets were not defined or tracked for the energy system optimization, government procurement, or energy conservation monitoring and evaluation system projects, making evaluation of these programs impossible. There are many specific goals outlined within the Ten Key Projects (e.g. to increase the efficiency of coal-fired industrial boilers by 5%; to install 40 GW of new CHP units, to increase motor system energy efficiency by 2%, etc.), but it is not obvious how such goals are tracked or evaluated.

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[13] 2007 average exchange rate 1 RMB = 0.13167 USD.
[14] See full LBNL report for details of how the calculations were made.
[15] It has been stated that the goal for the Ten Key Projects is an energy savings of 250 Mtce. However, adding the individual targets results in overall program primary energy savings of 268 Mtce. It is not possible to explain the discrepancy given the information at hand.
[16] Note that the buildings sector energy efficiency measures included in the Ten Key Projects as well as the Top-1000 Program are discussed in more detail in subsequent sections of this report.

International “best practice” regarding the development and implementation of energy-efficiency programs involves a multi-step process. Once the program policy objective is determined, then how those objectives will be met by different programs must be established. Once the list of programs is identified, then the individual programs must be designed and implemented. Program monitoring and evaluation, which should be included as a key program design element, will provide feedback regarding the progress in accomplishment of the policy objective, the relative success of the various programs implemented to achieve the policy objective, and the effectiveness of the specific program being evaluated. It appears that the Ten Key Projects did not follow international best practice in terms of program design, given the weaknesses in the program described above.

4.2. Buildings Energy Efficiency

Building energy consumption accounts for 25% of total primary energy use in China (Zhou et al., 2007).[17] Total floor area was approximately 58 billion square meters (m^2) in 2007.[18] Two billion m^2 of building space have been added each year during the past several years (TUBERC, 2009). This represents a significant fraction of the construction in the world; some estimates are as high a 50% of global construction (Xinhua, 2007).

Under the 20% energy intensity reduction target of the 11th FYP, the energy-saving target for the building sector is 100 Mtce (2.93 EJ) in primary energy (Wu Y., 2009). The targets disaggregated by policy are: 63% from strengthening enforcement of building energy standards, 16% from retrofit of existing buildings and reform of heat supply systems, 11 through energy management systems in large commercial buildings, and 11% from renewable energy. In addition, the Green Lights program (covered under the Ten Key Projects) program has a goal of saving 29 TWh. All of these policies are under the jurisdiction of a centralized Ministry of Housing and Urban-Rural Development (MOHURD) under the State Council.

The *Civil Building Energy Conservation Ordinance* was released in 2008 (MOC/MOHURD, 2008*)*. The bill includes regulations in six areas: building energy management systems, energy efficiency rating systems, energy consumption statistics, energy-saving retrofits, construction practices, and licensing of new buildings (Wu, 2009). For new buildings, the law requires full implementation of the standard and tightens it in some regions to 65% reduction in design heating energy compared to buildings without insulation. For existing buildings, it requires government buildings (and large public buildings) to take the lead in energy retrofits. It also promotes the use of renewable energy by encouraging local jurisdictions to support such applications.

Building standards cover all new construction in urban areas in China. In 2006, just 60% of new buildings in large urban areas met the energy-saving standard during the design stage and only 38% at the construction stage. In southern China, the percentages were just 10% and 8%, respectively (Wu, 2009). Since 2007, MOHURD has put into place a systematic enforcement program. Inspection and random checking have been widely instituted. Based

[17] The building energy consumption data has been adjusted based on the data on energy use that are not available from official Chinese sources. For details, refer to Zhou and Lin (2008).

[18] Official Chinese data for the area of buildings excludes all rural buildings. As a result, almost all analysts (including Chinese analysts) greatly underestimate this area. We include an estimate of rural building area in our numbers.

on these efforts, more recent survey results show very much higher implementation rates: in 2008, 98% at the design phase and 81% at construction phase (Qiu, 2009).[19] Analyzing available data modeling building turnover and energy use with and without tighter standards and/or stronger enforcement, it is estimated that cumulative savings between 2006 and 2008 were 36 Mtce (1.1 EJ) and will reach 90 Mtce (2.6 EJ) by 2010.

For retrofit of existing buildings and reform of heat supply systems, the target for the 11th FYP is to achieve 20% reduction in heating energy use through metering of heat supply and pricing reform (14 Mtce, or 0.4 EJ) and through retrofitting 150 million m^2 floor area to realize 50% heating intensity reduction (2 Mtce, or 0.06 EJ) by the end of 2010 (Wu, 2009). Only 21 million m^2 of building area have completed the heat metering reform, accounting for less than 1% of the targeted floor area. The poor performance in heating supply reform can be explained by difficulties at the provincial level of developing and implementing policies on heat metering and associated charges for heat. The retrofit program is meeting the targets for floor area, but the energy-savings target is not being realized by a considerable margin. The total estimated primary energy saving in 2008 is only 0.27 Mtce (0.008 EJ), accounting for merely 14% of the overall target. The greatest barrier to achieving these targets is economic. Incentives of 50 RMB/m^2 (7.2 USD/m^2)[20] are provided for retrofits in China's severe cold zone and 45 RMB/ m^2 (6.5 USD/m^2) in the cold zone (MOF, 2008). However, a large percentage of the retrofitted households only installed a heat meter rather than implementing retrofit measures, because the incentive provided is insufficient to induce the purchase of energy-efficiency measures (at a typical cost of 300 RMB/m^2 or 43 USD/m^2).

There are no official data or publications that report savings from the energy management programs to date. Our estimates of savings from unofficial data on the floor space and energy intensities of these building types indicate that the target is a reasonable one. Given the administrative systems in place, the government plans to establish a quota on energy use in these buildings, substantial incentives from the government, and cost-effectiveness of energy management systems (in most cases without the subsidy), it is very likely that these targets will be met or exceeded.

The government has provided a fund to support solar energy demonstration projects. This fund is for solar technologies that provide heat and electricity. In March 2009, the Ministry of Finance and MOHURD made available a subsidy specifically targeting the use of photovoltaics on buildings. The subsidy is 20 RMB/watt peak (Wp) (2.9 USD/Wp)[21], which will cover nearly half of the investment. Because of the high costs of solar electricity, it is not likely that the demonstration projects will lead to large-scale commercialization of these technologies by 2010. Only a small fraction of the 11 Mtce (0.3 EJ) target for renewables is likely to be met.

In 2008, MOHURD established its building energy-efficiency labeling system with the purpose of increasing public awareness of building energy consumption and inducing the building industry to building more efficient buildings. The labeling system will also provide a quantitative basis for energy-saving assessments that are used in the implementing incentive policies. Currently, the system is in a pilot stage, with small numbers of demonstration buildings scattered through China. China has an interesting – and by most criteria – advanced

[19] These numbers are derived from surveys carried out under the auspices of MOHURD. However, there is no explanation of what "compliance" means (e.g., checking of boxes, casual inspection, careful inspection).
[20] 2008 average rate 1 RMB = 0.14415 USD.
[21] 2009 average rate 1 RMB = 0.14661 USD.

system for rating energy-efficient new buildings. This system has been demonstrated for a small number of buildings to date, but its use is expected to grow rapidly as new, "green" buildings are constructed.

The overall energy-saving target set for buildings is ambitious. China has implemented serious policies and measures to support the target, and some appear to have achieved significant results, such as the building codes enforcement. Overall, China's efforts to reduce the growth of energy in buildings are much stronger and more significant than that of any other developing country.

There are, however, major deficiencies. China has no system for systematically gathering data about energy use in buildings. As a result, it is impossible to know how effective the policies are in their implementation. Only estimates can be made. There is a need for China to establish a systematic methodology for gathering baseline data, assessing energy-saving potentials, measuring energy use, and using this information for establishing targets and measuring the progress in meeting them. The standards themselves are uncertain in their impact because behavioral factors often result in buildings using much less energy than is stipulated in the standards.

Benchmarking is a common way to evaluate a building's energy performance. Benchmarking of energy use provides means to compare a building to other buildings or to national average or best practice. Such information is of value to many parties: policy makers, building owners, renters (who pay for energy use), prospective purchasers of buildings, and builders.
Overall, implementation of energy-efficiency standards for new buildings in large urban areas is on track to meet or exceed the target. Because standards amount to more than 60% of the overall target for buildings (of 100 Mtce, or 2.93 EJ), they will likely make possible the overall attainment of the 2010 goal. However, it is not possible to know if this is the case because of the absence of a system in China to gather and evaluate statistical data on building characteristics and energy use. Surveys indicate that enforcement of the standards has improved greatly in the past three years; however, it is not possible to know how much, if any, heating and cooling energy is saved by the standards. The codes do not apply to rural areas.

4.3. Top-1000 Energy-Consuming Enterprises Program[22]

One of the key initiatives for realizing China's 20% energy intensity reduction goal is the Top-1000 Energy-Consuming Enterprises program (Top-1000 program) which set energy-saving targets for China's 1000 highest energy-consuming enterprises (defined as those enterprises from nine industrial sectors that consume 180,000 tce (0.005 EJ) or higher annually). The Top-1000 program was launched by NDRC, NBS, and other government agencies in April 2006 (NDRC, 2006c).

The Top-1000 program includes large-scale enterprises in nine major energy-consuming industries. The goals of the Top-1000 program are to significantly improve the Top-1000 enterprises' energy efficiency; reduce unit energy consumption to national advanced level for all major products; have some enterprises attain either international advanced level or national leading level; and achieve energy savings of 100 Mtce (2.93 EJ) in the 11th FYP period.

[22] Some of the material in this section is excerpted from Price et al., 2008a and Price et al., 2009.

The Top-1000 enterprises are expected to establish an energy conservation organization, formulate energy efficiency goals, establish an energy utilization reporting system, conduct energy audits, conduct training, formulate an energy conservation plan, adopt energy conservation incentives, and invest in energy efficiency improvement options. The enterprises are required to report their energy consumption by fuel quarterly to NBS (NDRC, 2006c).

The national government established the goals of the program and published a list of the Top-1000 enterprises. The local energy-saving authorities were directed to implement the Top-1000 program, including the tracking, supervision, and management of the energy-saving activities of the enterprises. The local authorities were directed to oversee the enterprises in their energy management, energy auditing, and energy reporting requirements, to improve their monitoring of the enterprises through audits and sampling, to promote the use of new mechanisms such as target-setting agreements, encourage enterprises to meet energy saving targets, and to attain international advanced levels ahead of schedule (NDRC, 2006c).

In September 2007, NDRC and NBS reported that the Top-1000 enterprises had realized energy savings of 20 Mtce (0.59 EJ) in 2006. In 2008, NDRC reported that the Top-1000 Program enterprises saved 38.17 Mtce (1.1 EJ) in 2007 (Liu Jingru et al., 2009), that the enterprises invested over 50 billion RMB (6.6 billion USD) in technology innovation, and implemented over 8,000 energy-saving projects in 2007 (Zhao, 2008). In November 2009, NDRC announced that the Top-1000 program had reached its target energy savings of 100 Mtce (2.93 EJ) (NDRC, 2009c). [23]

Energy use of the Top-1000 Program enterprises only grew at a rate of 6.7% per year between 2004 and 2006.[24] Assuming this rate continues, final energy consumption of the Top-1000 Program enterprises would grow from 733 Mtce (21.5 EJ) in 2005 to 1016 Mtce (29.8 EJ) in 2010 under a baseline, business-as-usual scenario.[25] Given the baseline scenario, meeting the program goal means that the Top-1000 enterprises would consume 916 Mtce (26.8 EJ) (final energy) in 2010. Top-1000 program 2006 energy-related CO_2 emissions are estimated to be 2,432[26] $MtCO_2$ based on the fuel share data provided in the 2007 evaluation report (NDRC and NBS, 2007). Based on the energy consumption projection, the baseline CO_2 emissions for the Top-1000 Program enterprises are projected to grow from 1723 $MtCO_2$ in 2005 to 2388 $MtCO_2$ in 2010. If the program goal is met, energy-related emissions for the Top-1000 enterprises would be 2153 $MtCO_2$, a cumulative savings of 235 $MtCO_2$. Due to limited data availability, it is difficult to assess how much of these reported savings are due to the activities and policies associated with the Top-1000 program and how much would have occurred in the absence of the program.

The Top-1000 program was based on experience gained over three years through a pilot program with two steel mills in Shandong Province that relied heavily on European experiences with voluntary agreement programs (Price, et al., 2005a). The Top-1000 program

[23] This announcement was not accompanied by any type of detailed report and thus cannot be evaluated at this time.

[24] Calculated based on 2004 and 2005 actual energy use and 2006 actual energy use plus reported savings. Note that there were 1008 enterprises in the program in 2004. By 2006, 19 enterprises were added and 29 enterprises dropped out of the program, resulting in a total of 998 enterprises.

[25] Unlike the other programs reviewed in this report, energy use for the Top-1000 program is reported using a site (final) electricity conversion factor, not a source (primary) value.

[26] Using the site (final) electricity conversion factor, this value is 2,432 MtCO2. However, for this report electricity was converted using the source (primary) value.

was designed quickly in 2006 in support of China's 20% energy/GDP reduction goals. As such, some elements of the program have been designed or implemented differently than in similar programs in other countries.[27]

Target-setting typically begins with an assessment of the energy efficiency or GHG mitigation potential of each industrial facility. In the Top-1000 program, targets were set by NDRC for each enterprise in order to support the provincial-level targets and to reach the overall program savings target of 100 Mtce (2.93 EJ). The targets were not based on detailed assessments of energy-savings potential of each enterprise or each industrial sector. This approach was taken due to time constraints. The resulting target of 100 Mtce (2.93 EJ) may not be very ambitious given the energy-intensity of these industries. More detailed assessments may have identified higher potential energy savings and possibly a more ambitious goal could have been set for the Top-1000 program.

Energy auditing involves collecting data on all of the major energy-consuming processes and equipment in a plant as well as documenting specific technologies used in the production process and identifying opportunities for energy-efficiency improvement. In 2007, the Top-1000 enterprises undertook energy audits and developed energy action plans outlining how they expect to meet their energy-saving targets. A number of the Top-1000 enterprises found this task difficult due to the lack of qualified auditing personnel and needed to hire outside experts for assistance (Lu, 2006). The audits were often not very detailed, incomplete, did not analyze the data, or contained useless information (Ma, 2008).

Internationally, programs similar to the Top-1000 program also typically establish a harmonized set of **supporting programs** for participating enterprises. Policies typically include financial incentives, technical assistance, rewards and publicity for enterprises that reach targets, and sometimes penalties for failure to reach targets (Price et al., 2005). Supporting policies and programs for the Top-1000 program were not established prior to the announcement of the program (NDRC, 2006c) although a number of supporting policies have been established over the three years since the Top-1000 program commenced.

Information dissemination of energy-efficiency guidebooks, databases, software tools, and industry- or technology-specific energy-efficiency reports is an important component of energy efficiency programs in many countries (Galitsky et al., 2004). The Top-1000 program currently has not developed a systematic means for gathering or disseminating energy-efficiency information sources to the participating enterprises. [28]

It is extremely important to establish effective **monitoring** guidelines that provide an overview of reporting requirements, how the project's savings will be documented, and what level of accuracy is desired at the beginning of an energy-efficiency or target-setting program. Ideally, monitoring also includes verification by an independent third party that will validate the information (Schiller, 2007). In China, NBS is in charge of collecting data from the enterprises for the Top-1000 program; reporting is directly to NBS online via a website. Capacity building is needed related to the on-line reporting system, for development of an

[27] Some of this discussion is based on material presented in McKane et al., 2007 and Price et al., 2008b.
[28] The Top-1000 program did develop materials for a 2-day workshop that was held for the Top-1000 enterprises in five cities throughout China in October 2006. The presentations from that workshop are posted on the NDRC website: http://hzs.ndrc.gov.cn/jnxd/t20061108_92567.htm The Top-1000 web page on NDRC's website, however, simply provides short news articles reporting on related notices, meetings, and Provincial activities.

indicator system, for development of standards for boundary setting, and for data analysis. There is currently little transparency in the data reporting for the Top-1000 Program. To date, there has only been one officially-released summary report on the progress of the program (NDRC and NBS, 2007). There is no third party review or verification of the reported results at the enterprise, sector, provincial, or national level.

Overall, the Top-1000 Enterprises Program appears to be successful. The government has recently reported that the program has already met its cumulative final energy-saving target of 100 Mtce (2.93 EJ). The use of energy-saving agreements signed by high-level representatives from government and the enterprises has been very effective for stimulating action in the Top-1000 program. With the list of Top-1000 enterprises made public and promotion of government officials contingent on meeting targets, substantial attention and resources were directed to the program. Some provinces extended the program to a wider scope of enterprises.

Due to rapid implementation, program targets were established without detailed assessments. The program goal represents only 15% of total required energy savings in the 11th FYP, yet the Top-1000 enterprises represent the highest energy consumption in the economy. A more ambitious goal likely could have been set based on assessment of potential savings in industrial sub-sectors.

4.4. Structural Optimization/Small Plant Closures

The 11th FYP calls for "a more rational structure of industries, products, and industrial organization" and an increase in the ratio of service sector value-added to total GDP of 3%. Despite this goal, the share of industrial sector energy use grew from 69% of total energy use in 2000 to 72% in 2007 (NBS, various years). In addition, the share of GDP attributed to the secondary sector of the economy[29] increased from 45.9% in 2000 to 48.6% in 2007 (NBS, 2007).

Overall, industrial concentration in China is relatively low. Due to market demand and high prices of energy-intensive products, existing manufacturers continue producing from smaller facilities. Major Chinese energy-consuming industries are also less active in mergers and acquisitions For example, in 2006, steel production from the top ten largest iron and steel enterprises in China represented 34.35% of the total production, which was a decrease from that of 2005 (35.38%). In 2007, the top 10 steel enterprises accounted for 36.8% of total crude steel production (Shan and Wang, 2007). At the end of 2007, there were 5,028 cement enterprises with a total clinker production of 956.3 Mt. The four largest cement enterprises produced 11.9% of China's total clinker production, while the top ten companies produced 19.43%, and the top 60 companies produced 32% (CCA, 2008).

In 2007, China's State Council announced a *Comprehensive Working Plan of Energy Conservation and Emission Reduction* to accelerate the closing of small plants and outdated

[29] The primary sector of the economy involves changing natural resources into primary products and includes agriculture, agribusiness, fishing, forestry and all mining and quarrying industries. Most products from this sector are considered raw materials for other industries. The Secondary sector includes those economic sectors that create a finished, usable product: manufacturing and construction. The tertiary sector involves the provision of services to businesses as well as final consumers. Services may involve the transport, distribution and sale of goods from producer to a consumer as may happen in wholesaling and retailing, or may involve the provision of a service, such as in pest control or entertainment.

capacity in 14 high energy-consumption industries: electric power, iron-making, steel-making, electrolytic aluminium, ferroalloy, calcium carbide, coking, cement, coal, plate glass, pulp and paper, alcohol, monosodium glutamate, and citric acid (State Council, 2007). The policy estimates that the closures will save 118 Mtce (3.46 EJ) and reduce 2.4 Mt of sulfur dioxide (SO_2) by 2010. [30]

The amount of capacity that has been closed by the end of 2008 has only been reported for 10 of the 14 sub-sectors (NDRC, 2009a; NDRC, 2009b). In order to determine whether the small plant closures that occurred during the 2006-2008 period were driven by policy guidance or would have happened anyway under normal market conditions where smaller, inefficient facilities are phased out due to higher operating costs or other reasons, data on historical plant closures of the electric power sector were evaluated to see if the rate of closure increased during the 11th FYP.

China started to close small coal-fired power plants during 9th FYP. Closed capacity peaked in 1999 with 3,360 MW and capacity closures continued through 2002. However, closure of small and inefficient power plants stopped completely in 2003-2004, due to power supply shortages experience in China at that time. Phasing-out small coal-fired plants resumed by the last year of 10th FYP in 2005 and began to ramp up quickly in the 11th FYP, with an annual average growth rate of closure capacity of 115% from 2005 to 2008. Contrary to the progress in 9th FYP and early years of 10th FYP, with an average closed capacity rate of -4%, China reversed course and the aggregate closed capacity from 2006-2008 was 34,210 MW.

Capacity closures to date have been reported for ten sectors (see Table 3). To be on track, closures should be at 60% of the target by the end of 2008. Seven of the ten sectors have reached or surpassed that target, with four sectors significantly ahead of the target. Two other sectors (cement and alcohol) are nearly at the 60% target, while one sector (electrolytic aluminium) is significantly below the target, realizing only 16% of the scheduled capacity closures by the end of 2008. Overall, for the reported sectors, it appears that this program is on or ahead of schedule to meet the 2010 capacity closure targets.

[30] In 2010, the government expanded this program by increasing the targets for sectors that were found to have more potential (e.g. the 2010 target for the cement industry closures was increased from 50 Mt to 89.83 Mt in production capacity) and expanding from 13 sectors to 18 sectors by adding copper smelting, zinc smelting, lead smelting, leather manufacturing, textile printing and dyeing, and the chemical fiber industry (MIIT, 2010).

Table 3. Small Plants Closure and Phase-Out of Outdated Capacity Results To Date, 2006-2008

Industry	Unit	11th FYP Targets	Realized Capacity Closures 2006-2008*	Share of Target
Cement	Mt	250	140	56%
Iron-making	Mt	100	60.59	61%
Steel-making	Mt	55	43.47	79%
Electricity	GW	50	38.26	77%
Pulp & paper	Mt	6.5	5.47	84%
Alcohol	Mt	1.6	0.945	59%
Monosodium glutamate	Mt	0.2	0.165	83%
Electrolytic aluminum	Mt	0.65	0.105	16%
Citric acid	Mt	0.08	0.072	90%
Coking	Mt	80	n/a	
Ferroalloy	Mt	4	n/a	
Calcium carbide	Mt	2	n/a	
Glass	M weight cases	30	n/a	

Source: State Council, 2007; Feng Fei et al., n.d.; *NDRC, 2009a and 2009b.
Note: n/a = not available

This analysis estimates that total net energy savings (the difference in energy consumed by the small, inefficient plants and the energy consumed by more modern facilities that presumably replaced the closed plants) from the replacement of inefficient capacity with more efficient facilities resulted in savings of 63 Mtce (1.8 EJ) final energy and 150 Mtce (4.4 EJ) primary energy. Assuming these savings represent about 85% of the total savings from all 14 subsectors, net savings are about 106 Mtce (3.1 EJ) final energy and 129 Mtce (3.8 EJ) primary energy.[31] When compared to the overall program goal of 118 Mtce (3.5 EJ) net energy savings in final energy, it appears that the program has saved an estimated 76% of the total goal in the first three years, which is ahead of schedule.

4.5. Appliance Standards and Energy-Efficiency Labels

China is one of the world's largest producers and consumers of household appliances as urban and rural ownership rates grew at an extraordinary pace. By 2008, China's 190 million urban households had on average 1.3 color televisions, a clothes washer, refrigerator and air conditioner (NBS, 2009). Sustained rises in appliance ownership have corresponded to growing residential electricity use at an annual average rate of 13.9% between 1980 and 2007 (NBS, various years).

China now has minimum energy performance standards (MEPS) that mandate maximum allowable energy consumption for 30 types of appliances and equipment with each MEPS revision typically increasing stringency by about 10% over the previous level. In 2005, a

[31] The State Council stated that China's goal was to save 31.5 Mtce and reduce 400,000 tons of SO2 in 2007 (State Council, 2007a).

mandatory categorical energy information label known as the China Energy Label (CEL) was established to promote consumer awareness and market transformation and currently cover 13 appliances. The CEL includes either three or five categories of efficiency, ranked from 1 (highest) to 3 or 5 (MEPS), and a product's rating is based on self-reported energy consumption data from manufacturers. In December 2007, China launched a "Home Appliance Going to the Countryside" pilot program that has since been expanded nationwide to cover ten product categories. This program provides a 13% rebate to rural residents who purchase selected brands of efficient appliances (Class 1 and/or Class 2 in the CEL) from qualifying retailers and is primarily funded by the central government (Xinhua, 2009a). While news sources have reported rural purchases of more than 16 million units of home appliances since December 2007, the lack of detailed market and sales data precludes in-depth analysis of the rebate's impact on rural market transformation (Xinhua, 2009).

The basis for estimating energy savings to date (2006 to 2008) was established in a recent study that evaluated the impact of China's appliance standards and voluntary labeling program on major appliance types by focusing on policies implemented as of 2007 and applicable reach standards to be implemented in the near future (Fridley, et al., 2007). Table 4 shows that in primary energy terms, the estimated cumulative energy savings to date (2006 to 2008) are 36.9 Mtce (1.1 EJ) or projected total of 79 Mtce (2.3 EJ) during the entire 11th FYP period.

Table 4. Annual Appliance Savings in Primary Energy, 2006-2010

Appliance	Unit	2006	2007	2008	2009 (Projected)	2010 (Projected)	2006-2008
Clothes Washer	Mtce	0.06	0.07	0.07	0.08	0.09	0.20
	PJ	1.76	2.05	2.05	2.34	2.64	5.86
TV	Mtce	0.73	1.24	1.92	3.13	4.45	3.89
	PJ	21.39	36.34	56.27	91.73	130.42	114.01
Refrigerator	Mtce	5.55	6.90	8.19	9.41	10.48	20.64
	PJ	162.66	202.22	240.03	275.78	307.14	604.91
Air Conditioner	Mtce	2.33	3.14	3.97	5.22	6.49	9.45
	PJ	68.29	92.03	116.35	152.99	190.21	226.96
Video Cassette Player	Mtce	0.13	0.22	0.32	0.43	0.56	0.66
	PJ	3.81	6.45	9.38	12.60	16.41	19.34
Computer	Mtce	0.03	0.05	0.08	0.11	0.14	0.16
	PJ	0.88	1.47	2.34	3.22	4.10	4.69
Printer	Mtce	0.01	0.01	0.01	0.02	0.03	0.03
	PJ	0.29	0.29	0.29	0.59	0.88	0.88
Lighting	Mtce	0.50	0.61	0.73	0.79	0.85	1.84
	PJ	14.65	17.88	21.39	23.15	24.91	53.93
Total	Mtce	9.34	12.22	15.29	19.19	23.09	36.86
	PJ	273.73	358.14	448.11	562.41	676.71	1,082.28

Note: based on conversion of 0.404 kgce (11.84 MJ) primary energy input per kWh
Source: Fridley, et al., 2007

In recognizing the savings potential of household appliances, NDRC announced 2010 energy-efficiency goals for four household appliances and products. These 2010 efficiency goals have therefore been met in part, but in the absence of sales data by efficiency level, it is not possible at this point to quantify the market share of these higher efficiency appliances. For room air conditioners, refrigerators and household gas water heaters, new standards for the most efficient classes have met the 2010 efficiency goals. Household gas cookers, however, remain less efficient than the 2010 target of 60-65%, with the 2008 standard specifying a minimum thermal efficiency of only 55%.

Recently, the central government has increased efforts to improve enforcement and monitoring mechanisms for appliance energy-efficiency standards. Begun in 2006, check-testing targeting refrigerators, room air conditioners and washers from retailers in the major cities of Guangzhou, Beijing and Hefei found mixed levels of compliance among cities and model types. A second round undertaken in 2007 found improved compliance with no great regional variation. These past two years of check-testing have revealed that consistent testing and monitoring are critical to identifying enforcement weaknesses and improving compliance with appliance efficiency standards. To date, check testing has involved less than 1% of product models on the market, and the goal is to achieve regular check testing for 20% of product models. The goal is ambitious, as China's appliance sector remains largely unconsolidated, with over 250 companies producing over 3000 models of clothes washers alone. Enforcement thus remains a key issue in the success of China's standards and labeling program as financial, administrative and infrastructure support for the program can be strengthened. The absence of up-to-date impact evaluations of standards and labeling efforts and shortage of sales data by efficiency classes in China's rapidly evolving appliance market are other crucial areas of weakness.

Best practice in implementation of standards and labeling includes clear program mandate, defined methodological approach and sufficient funding and trained personnel for implementation, monitoring and compliance (Waide, n.d.). A leading example of this is the U.S. Energy Star voluntary labeling program, which has maintained stringent labeling criteria by consistently revising its residential and office product specifications to typically only qualify the top 20-25% most efficient products on the market (Karney, 2007). Moreover, Energy Star has undertaken a novel approach to accelerate market transformation by creating linkages to stakeholders across sectors where subsequent rebates and outreach campaigns have helped influence consumer decision-making. Although China cooperated with Energy Star in the implementation of its own voluntary energy-efficiency label, an increasing number of products subject to voluntary labeling specifications have been subsumed within the mandatory standards program. This in turn decides the timeline of specification development and revision and reduces the flexibility of voluntary label revisions to reflect product efficiency changes in China's evolving market.

Best practice program evaluations to identify weaknesses in program design and implementation and to help measure the program's overall impact can include both process and impact evaluations (Vine, et al., 2001). International best practice examples include EU's comprehensive evaluation of its energy labeling program two years after the program implementation in 1992 and the U.S. Energy Star's evaluation studies. While China has made clear progress in launching compliance check-testing and recent round-robin testing, monitoring and verification of product performance relative to MEPS and energy labels are inadequate as even the check-testing sample sizes were too small and shortage of resources and funding in monitoring and evaluation efforts remain. Besides small staff size of only six full-time staff members, the recently established China Energy Label Center also does not have a regular budget to support auditing or verification testing programs (Zhou et al., 2008).

5. Findings and Recommendations

5.1. Overall Findings

China made substantial progress toward its goal of achieving 20% energy intensity reduction from 2006 to 2010. It seems likely that the target will be met or nearly met. It is noted that the goal was originally announced as "20% more or less" ("20%左右"). Considering that energy use per unit of GDP had increased between 2002 and 2006, the achievements of the 20% intensity reduction program are substantial. The success in meeting the 20% intensity target through to date is due to increases in energy efficiency or conservation; these increases have been sufficient to overcome the lack of success in achieving structural change.

Evaluating individual energy-savings programs and policies to determine the magnitude of their contributions has been difficult due to lack of data. In most cases, the results are based on calculated savings from known details of the programs (appliance standards), surveys (enforcement of building codes), or statements by government officials indicating the magnitude of savings without documentary sources. In spite of the limitations of these approaches, the results documented in this report should be viewed as meaningful albeit imprecise; the overall achievements in pursuing the energy intensity goal argue that these programs have been successful.

This assessment found that many of the energy-efficiency programs implemented during the 11th FYP in support of China's 20% energy/GDP reduction goal appear to be on track to meet – or in some cases even exceed – their energy-saving targets. Based on information gathered through interviews, reports, and websites, it appears that most of the Ten Key Projects, the Top-1000 Program, and the Small Plant Closure Program are on track to meet or surpass the 11th FYP savings goals. China's appliance standards and labeling program, which was established prior to the 11th FYP, has become very robust during the 11th FYP period, as illustrated by the development of new or revised standards that have met three out of four of the *Medium to Long-term Energy Conservation Plan's* 2010 energy-efficiency targets. China has greatly enhanced enforcement of new building energy standards with calculated impacts that are on track to meet the goals. However, energy-efficiency programs for buildings retrofits, as well as the goal of adjusting China's economic structure to reduce the share of energy consumed by industry, do not appear to be on track to meet the stated goals.

It was difficult to adequately assess the progress of the energy-efficiency programs implemented in support of the 11th FYP in detail due to lack of publicly-available systematic reporting and monitoring of these programs. In addition, the information that is available is often reported in units that are not clearly defined (e.g. whether electricity is accounted for at the site, 0.1229 kgce/kWh (3.6 MJ/kWh), or source, 0.404 kgce/kWh (11.8 MJ/kWh), value), programmatic targets are not clearly delineated as to whether they represent annual or cumulative savings goals through 2010, and conflicting and difficult to interpret information is provided through interviews, reports, and websites. Further, the overall 20% energy/GDP target is a relative target (ratio of energy to economic output), while most of the targets for the individual programs are absolute targets (e.g. savings of 100 Mtce (2.93 EJ) by 2010 for the Top-1000 program), making it difficult to relate the individual programs to the overall energy intensity goal.

5.2. Recommendations

Maintain existing policies and programs that are successful
It is important to maintain and strengthen the successful existing energy-saving policies and programs established under the 11th FYP, including setting an overall energy-savings goal. Significant effort was invested in gathering and analyzing data, training personnel to track and manage energy use, developing implementation guidelines, and creating financial incentives for energy saving. These efforts can yield further benefits and should be continued, rather than moving to new policies and programs in the 12th FYP.

Add explicit mechanisms to promote structural change
In the 11th FYP, the main mechanism for promoting structural change was phasing out obsolete production capacity which proved to be insufficient to achieve the desired increase in the economic share of the service sector, or a decrease in the economic share of industry. Additional mechanisms are needed to address structural change in a stronger and more explicit manner. Mechanisms could include further energy pricing reform, control of market access, and further change in tax policies on energy-intensive products and industries. For example, tiered energy pricing—whereby rates are higher for more consumption—would encourage consumers to use less. Decoupling utility revenues from electricity sales can encourage utilities to promote efficiency rather than consumption. Restricting permits, or increasing taxes, for energy-intensive industries can promote a shift in economic structure toward less intensive enterprises.

Continue to build the National Energy Conservation Center to facilitate information dissemination and training
Implementation of multiple policies and programs will benefit from the full establishment of the National Energy Conservation Center which can serve as a central contact point for sharing information on energy-saving technologies, operations and management practices, case studies of successful programs, and international best practices. The Center can also provide training, guidance documents, and software tools with standardized methodologies to provincial energy conservation and energy supervision centers.

Strengthen the capacity of provincial energy conservation centers
The capacity of China's provincial energy conservation centers should be strengthened through training and addition of staff with technical capabilities. Enhanced coordination through a national center, including the use of standardized auditing and benchmarking protocols, would create consistency across the provincial centers. Even as market-based technical services companies develop (e.g., ESCOs), governmental energy conservation centers should strengthen technical expertise to monitor and verify energy improvements at the enterprises in their jurisdiction.

Build capacity to systematically collect and analyze data focused on end-use energy consumption
A key feature of successful energy-saving programs is the implementation of a systematic data collection and reporting system for end-use energy consumption. Such a system enables government and businesses to analyze energy use patterns and identify savings opportunities. Examples from the U.S. include the *Commercial Building Energy Consumption Survey* (CBECS), the *Residential Energy Consumption Survey* (RECS), and the *Manufacturing Energy Consumption Survey* (MECS). Such capacity could be built at organizations such as

the Energy Research Institute, the National Energy Conservation Center, or the National Bureau of Statistics.

Continue with 20% Energy Intensity Target

The 20% energy intensity target provided strong motivation for action and it is recommended that China set another target for energy intensity reduction for the 12th FYP. There are compelling reasons to believe that the level of 20% is reasonable. For the 12th FYP, the apparatus of government in promoting energy-savings policies and programs is already in place, and further gains could be expected. It may be necessary to separate the structural change goal from the energy intensity goal and address the structural change issue using different mechanisms.

Allocate target more scientifically, including a bottom-up analysis of energy saving potential

For the 12th FYP, there is opportunity for scientific analysis to better inform the allocation of the energy intensity target across provinces and sectors. In particular, a bottom-up analysis considering the energy and economic situation in each province or sector would help to determine realistic energy-saving potentials and provide a better basis for target allocation. Methodologies and experience with allocation of absolute energy and carbon targets from the Netherlands, UK, and elsewhere can be utilized, with modification for China's energy intensity target.

Add a target for Carbon Intensity

Given the government's recent international announcements regarding climate change, it is reasonable to also have a target for reduction of carbon intensity (CO_2 emissions per unit of GDP). In general, it should be easier to achieve a given carbon intensity reduction than to achieve the comparable energy intensity reduction. Everything that contributes to energy efficiency counts toward the carbon intensity target, while low carbon energy sources are only credited to the carbon intensity target.

Create a consistent and transparent system for gathering and analyzing data on energy intensity

Improvements are needed to make data reporting consistent across enterprises and provinces, and to clearly establish the methodologies for analyzing the data and assessing the performance of programs that reduce energy intensity.

Increase the level of public reporting regarding energy-saving policies and programs

At present, it is difficult to obtain necessary data to monitor and verify the progress of energy-saving programs and policies. Public sharing of data would increase attention to energy-saving programs, encourage consistency in data reporting, and encourage enterprises and government offices to achieve their goals.

Standardize the metrics for targets and reporting

The 12th FYP should have more standardization in establishing targets, reporting energy data, and quantifying progress toward targets. It is recommended that energy savings be reported in primary energy units, accounting for the generation, transmission, and distribution losses from electricity production. The relationships between the overall energy intensity target and individual program target metrics should be made explicit. To avoid confusion, targets for each energy-saving program should indicate both annual savings and cumulative savings goals during the FYP period.

Establish systematic annual data reporting on greenhouse gas emissions
In support of the carbon intensity target (CO_2/GDP) announced by President Hu Jintao in September 2009, a systematic means of gathering annual data on greenhouse gas emissions is needed. Initially, reporting could focus on CO_2, and later be expanded to other greenhouse gases. Reporting by provinces and individual enterprises would augment China's national greenhouse gas inventory and energy data reporting.

Improve the design phase for energy-saving projects
The need for improvement in the design phase was observed across the projects. Improved program design involves clearly setting program objectives, schedules, and targets; identifying target energy consumers; specify energy-efficiency measures and other mechanisms to be utilized; development of an implementation strategy, including key milestones; development of funding mechanisms or incentives; dissemination of information to program participants; establishment of a monitoring plan, including project indicators and monitoring procedures; and establishment of an evaluation plan.

Revise the approach to existing building energy retrofits in cold climates, treating building envelope, control systems, and heat supply together
More attention should be paid to building retrofit projects and heat supply reform. The existing program consisting primarily of incentives for retrofits fails to address institutional reform (specifically the problems due to the division of responsibility between the heat supply companies and buildings bureaus); the pace of energy pricing reform is too slow; and there is inadequate scientific consideration of the best and most cost-effective measures to achieve more efficient heating supply, building energy retrofits, and building energy control systems simultaneously. Such an integrated program needs to be established to serve as the basis for implementation during the 12^{th} FYP.

Expand the enforcement of building energy standards that have been effective in large urban areas to the rest of the nation, improve building energy labels and provide incentives for "green building"
Continued attention to enforcement of new building energy-efficiency standards and the measurement of actual energy use are needed to ensure that efficient designs lead to real energy savings in operation. Energy-efficiency policies need to be implemented in smaller cities and rural areas. Further incentives are needed to encourage "green buildings" with advanced energy-efficiency features. In addition, there is a need to develop better characterization of building energy through life-cycle analysis, to identify and limit the use of energy-intensive building materials.

Continue to emphasize energy management of large-scale public and governmental buildings
Large-scale public buildings use 10-20 times more than residential buildings. A robust system should be established to include performing in-depth energy audits of existing buildings, gathering data on energy performance (preferably before and after retrofit for existing buildings), monitoring the effects of occupant choice in the operation of buildings, public reporting on the energy use of buildings, expansion of the use of building energy labels, and extension of the program to medium-sized buildings in large and medium-sized cities.

Enhance policy design and effectiveness through expanded surveys, monitoring and establishing meaningful baselines of building energy consumption/efficiency

Building energy consumption data and data reporting methodologies should be standardized and made more transparent for better evaluation of policy progress. Surveys on building characteristics and energy consumption patterns that are representative of national building stock should be conducted on a regular basis. A scientific baseline needs to be developed to reflect the energy-efficiency improvement in buildings and the increasing demand for more comfort and delivered energy services. Benchmarking protocols could be developed to monitor building energy consumption and allow better comparison among buildings.

Continue and expand the Top-1000 Program
It is recommended that the Top-1000 Program be continued during the 12th FYP, extended to include additional large, energy-intensive enterprises, and strengthened to be more effective.

Targets should be determined based on energy-saving potential of enterprise or sector
Target-setting in China should be based on an assessment of the actual potential of either the Top-1000 enterprises individually, or the key sectors included in the Top-1000 program. Best practice internationally is to set energy-saving targets based on an understanding of what the enterprise or the sector can actually achieve. In the Netherlands, UK, and Japan, studies of the energy-saving potential of industrial sub-sectors informed both the government and the enterprises.

Energy auditing capabilities need to be improved
Standardized methodologies, auditing tools, training for energy auditors, and reports that provide detailed recommendations are key elements of a high-quality auditing program. Energy auditing standards, guidebooks, tools, and training should be developed and disseminated to enterprises, sector associations, universities, energy conservation centers, and other entities involved in energy auditing in China. There is a need for the government to establish a single clearinghouse to maintain and update the standards, guidebooks, tools, and training material.

Benchmarking could be simplified so that it can be used by more industries
During the 11th FYP, a number of pilot projects involving industrial energy benchmarking tools were carried out. Some benchmarking tools require users to input detailed information on industry-specific process; simplified tools that require less data would lead to greater use. Wider availability of benchmarking tools would help more enterprises track their energy use, understand their competitiveness in terms of energy efficiency, and find energy-saving opportunities.

Reporting and evaluation needs to be strengthened
A notable weakness in the Top-1000 program and other industrial programs is the lack of public reporting and third party verification of energy use and savings. Because an online reporting system has been established, it would be relatively easy to make more of the data accessible in an aggregated or anonymous manner to protect confidential plant-level. Verification by organizations other than the enterprises or supervising government offices is needed to ensure that savings are real and that 12th FYP goals can be achieved.

Dissemination of information on energy-saving opportunities and experiences is needed
Information dissemination is an important component of industrial energy-efficiency programs across countries. The further development of the National Energy Conservation Center could help to compile technical information sources such as energy-efficiency guidebooks, databases, software tools, and industry- or technology-specific energy-efficiency

reports. Such guidebooks and databases can provide information on existing and new technologies and measures as well as energy management practices.

Promote opportunities for structural change within industries
Energy-intensive industries in China still have a large potential for efficiency gains through mergers and consolidation. While balancing local needs and desired structural change, economies of scale should be further promoted in heavy industry. Adoption of international best practices in energy management and technologies would also encourage efficiency gains in industrial enterprises and discourage low-quality inefficient plants.

Address local concerns about small plant closures through further development of transition plans
To enhance implementation of programs directed at small plant closures and structural optimization, further support for transition plans could be offered. How to establish a phasing-out mechanism for different sectors is a major question to consider for the next phase of structural change programs. Key factors such as central and provincial negotiations, employment issues, social safety, and economic and social conditions in different regions should be considered as well.

Combine market mechanisms with administrative measures
Market mechanisms, such as energy pricing reform and tax incentives, can be combined with administrative measures to encourage a structural shift away from energy-intensive, low value-added production. Administrative measures can provide a push by the government to the local enterprises with binding targets, market access and other requirements, or guidelines. Market mechanisms can provide a pull by favoring efficient enterprises and eliminating backward enterprises.

Create additional mechanisms explicitly focused on structural change
Additional mechanisms are needed to promote structural change. In the 11th FYP China developed a series of policies to close small, inefficient plants, but these policies alone are not enough to realize desired structural change. Additional measures are needed, such as energy price reform, resource and consumption taxes, further adjustments to import and export taxes, and consideration of energy or carbon taxes.

Revise and strengthen energy performance standards for appliances
Continuous and timely revisions to MEPS are very important in a rapidly-changing appliance market. All of the Chinese MEPS should be revised during the 12th FYP period to reflect recent changes in the appliance market. China may also need to consider introducing new standards as non-MEPS products begin to increase market penetration.

Undertake regular national surveys of energy end-use to assess program effectiveness
Evaluations are very important for assessing the impact of the standards and labeling program, and to provide input to future standards development or revisions. Such evaluations, however, are hampered by the broad lack of end-use data by appliance in both residential and commercial sectors. Regularly undertaken national surveys modeled after the US *Residential Energy Consumption Survey* (RECS) or the *Commercial Building Energy Consumption Survey* (CBECS) would provide a wealth of data to improve prioritization of standards development, the setting of appropriate efficiency levels, and assessment of program impact.

Provide further support for enforcement of existing programs

Despite substantial improvements in implementation, remaining obstacles exist in enforcement of the standards and labeling programs. China has recently embarked on check-testing and round-robin testing of its appliance standards and labeling for select appliances. The program, however, lacks sufficient financial and human resources for administration and implementation.

Clarify the relationship between mandatory and voluntary efficiency labels
Because of the functional overlap between the China Energy Label and the voluntary endorsement label, as the China Energy Label becomes increasingly applied to more products, there should be an effort to define the link between the two labeling programs, particularly with respect to such programs as government energy efficiency procurement. At the same time, periodic reviews of the China Energy Label should be conducted to understand its market transformation impact, through efficiency distribution surveys and consumer surveys.

Increase participation in international networks for enforcement of appliance standards
China should consider participating in international or regional networks that help facilitate information exchange and coordination between national governments on enforcement of appliance standards. China can benefit from the exchange of best practices in compliance and enforcement with other network members.

6. References

Bank of China (BOC), 2009. http://www.boc.cn/sourcedb/lswhpj/index2 .htm

Cai Zhihua, 2009. Interview with Cai Zhihua, Energy Saving Department, Department of Resource Conservation and Environmental Protection, NDRC, May 6, 2009.

China Cement Association (CCA), 2008. *China Cement Almanac 2007*. Beijing: CCA.

Feng Fei, Wang Jinzhao, Li Minzhi, Wang Qingyi, Wang Xuejun, He Kebin, n.d. *Midterm Evaluation of Implementation of the Work of Energy Conservation and Emission Reduction during the Eleventh Five-Year Plan and Policy Directions under New Situation*.

Fridley D., Aden N., Zhou N., and Lin J. 2007. *Impacts of China's Current Appliance Standards and Labeling Program to 2020*. LBNL-62802. Berkeley, CA: Lawrence Berkeley National Laboratory. http://china.lbl.gov/sites/china.lbl.gov/files/LBNL-62802.pdf

Galitsky, C., Price, L., and Worrell, E., 2004. *Energy Efficiency Programs and Policies in the Industrial Sector in Industrialized Countries*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-54068).

Intergovernmental Panel on Climate Change (IPCC), 2006. *IPCC Guidelines for National Greenhouse Gas Inventories; Reference Manua*l (Volume 2. Energy). http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html

Kahrl, F. and Roland-Holst, D., 2006. *China's Carbon Challenge: Insights from the Electric Power Sector.* http://are.berkeley.edu/~dwrh/CERES_Web/Docs/CCC_110106.pdf

Karney, R., 2007. Remarks at *EnergyStar Criteria for Refrigerator Revision Meeting*. June 4, 2007, U.S. Department of Energy.

Levine, M.D., Price, L., Zhou, N., Fridley, D., Aden, N., Lu, H., McNeil, M., Zheng, N., Qin, Y., Yowargana, P., 2010. *Assessment of China's Energy-Saving and Emission-Reduction Accomplishments and Opportunities During the 11th Five-Year Plan*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-3385E). http://china.lbl.gov/sites/china.lbl.gov/files/LBNL_3385E.Ace_Study_Report_FINAL.pdf

Liu Jingru, Yu Cong, and Liu Zhiping, 2009. "Energy Conservation Moves Forward Steadily with Significant Achievements – A Review of 30 Years of Open Door Reform," *Energy of China*, Vol. 31, No. 2, February 2009, pp. 17-22.

Lv Wenbin, 2009. Personal communication with Lv Wenbin, NDRC, May 24, 2009.

Ma Hailin, 2008. Presentation by Ma Hailin, Dalian University of Technology, at the Energy Foundation's Industrial Energy Efficiency Planning Meeting, 10 July 2008, Yantai, China.

Ma Jiantang, Director of NBS, 2009. *Energy consumption per unit of GDP in 2008 dropped 5.2% from last year.* Dec 25, 2009. http://www1.www.gov.cn/wszb/zhibo359/content_1496381.htm

McKane, A., Price, L., and de la Rue du Can, S., 2007. *Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies.* Geneva: United Nations Industrial Development Organization. http://ies.lbl.gov/iespubs/63134.pdf

Ministry of Construction (MOC)/Ministry of Housing and Urban-Rural Development (MOHURD), 2008. *The Notice on Implementation of the Civil Building Energy Conservation Ordinance*. http://www.cin.gov.cn/ZCFG/jswj/jskj/200812/t20081211_183179.htm

Ministry of Finance (MOF), 2008. The Notice on the Management Methods of the Award Fund for Heat Supply Reform and Energy Efficiency Retrofit in Existing Building in Northern Heating Zone, http://jjs.mof.gov.cn/zhengwuxinxi/zhengcefagui/200805/t20080523_34063.html

Ministry of Industry and Information Technology (MIIT), 2010. Phasing Out Backward Capacities for 11th FYP. May. http://www.miit.gov.cn/n11293472/n11293832/n13095885/13232432.html

National Bureau of Statistics (NBS), various years. *China Statistical Yearbooks*. Beijing: NBS.

National Bureau of Statistics, 2007. *China Statistical Yearbook*. Beijing: NBS.

National Bureau of Statistics, 2008. *China Statistical Yearbook*. Beijing: NBS.

National Bureau of Statistics, 2009. *China Statistical Yearbook*. Beijing: NBS.

National Development and Reform Commission (NRDC), 2006. *Implementation Suggestions of Ten Key Energy-Conservation Projects during the Eleventh Five-Year Plan*, NDRC Department of Resource Conservation and Environmental Protection Document #: [2006]1457.

National Development and Reform Commission (NDRC), 2008. *The Progress of Ten Key Energy-Conservation Projects.* March 28, 2008.
http://zhs.ndrc.gov.cn/2007gmjj2008gmjj/2007gmjj/t20080328_201192.htm

National Development and Reform Commission (NDRC), 2009a. "Overcome Difficulties with Full Efforts and Contribute to Climate Change Mitigation -- An interview with Xie Zhenhua, Vice-Chairman of National Development and Reform Committee", June 26, 2009. http://www.ndrc.gov.cn/xwfb/t20090626_288055.htm

National Development and Reform Commission (NDRC), 2009b. "National and Provincial Development and Reform Commissions Held a Meeting on Resources Conservation and Environmental Protection in Xi'an, March 31, 2009."
http://hzs.ndrc.gov.cn/newgzdt/t20090331_270198.htm

National Development and Reform Commission (NDRC), 2009c. *Announcement of Assessment and Evaluation Results of Top-1000 Enterprises Energy Conservation Program, 2009* (千家企业节能目标评价考核结果的公告，2009 年第 18 号) Nov 16, 2009. http://www.sdpc.gov.cn/zcfb/zcfbgg/2009gg/t20091124_315017.htm, http://zfxxgk.ndrc.gov.cn/PublicItemView.aspx?ItemID={6dccc4b4-dbd6-4449-a6bc-d23a7cc519c9}

National Development and Reform Commission and National Bureau of Statistics, 2007. *Report on the State of the Energy Use of the Top-1000 Enterprises (Year 2007).*

Price, L., Galitsky, C., Sinton, J., Worrell, E., Graus, W., 2005. *Tax and Fiscal Policies for Promotion of Industrial Energy Efficiency: A Survey of International Experience*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-58128).

Price, L., Wang, X., Jiang, Y., 2008a. *China's Top-1000 Energy-Consuming Enterprise Program: Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-519E).

Price, L., Galitsky, C., Kramer, K.J., and McKane, A., 2008b. *International Experience with Key Program Elements of Industrial Energy Efficiency or Greenhouse Gas Emissions Reduction Target-Setting Programs*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-63807), http://ies.lbl.gov/iespubs/LBNL-63807.pdf. See also associated website that provides links to most of the reports reference in this document: http://industrial-energy.lbl.gov/resources

Price, L., Xuejun Wang, Jiang Yun, 2010. "The Challenge of Reducing Energy Consumption of the Top-1000 Largest Industrial Enterprises in China", Energy Policy, Vol. 38 Issue 11.

Qiu Baoxing, 2009. "From Special Inspection to Fiscal Subsidy-- Annual Perspective of Architectural Energy-Saving in China." http://www.chinagb.net/news/fugle/20090330/46797.shtml

Schiller, S. 2007. *National Action Plan for Energy Efficiency: Model Energy-Efficiency Program Impact Evaluation Guide*. http://www.epa.gov/solar/documents/evaluation_guide.pdf

Shan Shanghua and Wang Xiaoming, 2007. "Why it is so Difficult to Adjust the Industrial Structure of Steel Industry in China?" *China Steel*, Vol. 5, pp. 9-11.

Sinton J., Levine M.D., and Wang Q., 1998, "Energy Efficiency in China: Accomplishments and Challenges," *Energy Policy* 26 (11):813-829

Sinton J., Levine M.D., Fridley D., Yang F., and Lin J., 1999. *Status Report on Energy Efficiency Policy and Programs in China.* LBNL-44605. Berkeley, CA: Lawrence Berkeley National Laboratory.

Sinton, J. and Fridley, D., 2000. *Status Report on Energy Efficiency Policy and Programs in China: Recent and Related Developments*. Berkeley, CA: Lawrence Berkeley National Laboratory.

State Council, 2007. State Council Document [2007] 15. *Comprehensive Working Plan of Energy Conservation and Emission Reduction.* May 23, 2007.

Tsinghua University Building Energy Efficiency Research Centre (TUBERC), 2009. *2009 Annual report on China Building Energy Efficiency*, Beijing: China Building Industry Publishing Company.

Vine, E., du Pont, P. and P. Waide, 2001. "Evaluating the impact of appliance efficiency labeling programs and standards: process, impact and market transformation evaluations." *Energy* 26: 1041-1059.

Waide, P., n.d. *International Best Practice for Equipment Minimum Energy Performance Standards (MEPS) and Labelling Programmes*.
http://www.resourcesaver.com/file/toolmanager/O105UF987.pdf

Wang Q., Sinton J., and Levine, M.D., 1995. *China's Energy Conservation Policies and Their Implementation, 1980 to the Present, and Beyond.* Berkeley, CA: Lawrence Berkeley National Laboratory.

Wu Yong, 2009. Personal communication with Wu Yong, MOHURD, May 8, 2009.

Xinhua, 2007. ''Half of the New Global Construction Built in China,''
http://news.xinhuanet.com/newscenter/2007-08/23/content_6593780.htmS.

Xinhua, 2009. "Subsidized rural home appliance sales top US$4.1 bln." July 31, 2009. http://www.china.org.cn/business/2009-07/31/content_18242361.htm

Xu Kexin, 2009. "Deputy Department Head of Resource Conservation and Environmental Protection of National Development and Reform Commission He Bingguang said Ten Key Energy-Conservation Projects Need an Investment of 400 Billion RMB in the Next Two Years," Reported by First Financial Daily, April 17, 2009. http://energy.people.com.cn/GB/9146125.html

Zhao, T., 2008. "High-energy-consuming firms save 38.17m tons of coal," *China Daily*. 2008-09-04.

Zhou, D., 2006. "Allocation of the National Energy Intensity Target to the Provinces and Sectors: Policy Recommendations" presentation at the Energy Foundation *Forum on Implementing China's 2010 20-Percent Energy Efficiency Target*, 9 November 2006.

Zhou N., McNeil M., Fridley D., Lin J., Price L., Rue du Can, S., Sathaye J., and Levine M., 2007. *Energy Use in China: Sectoral Trends and Future Outlook*, Lawrence Berkeley National Laboratory, LBNL- 61904.

Zhou N., Zheng N., and Fridley D., 2008. *Check-Testing of Manufacturer Self Reported Labeling Data & Compliance with MEPS.* LBNL-247E. Berkeley, CA: Lawrence Berkeley National Laboratory.

Zhou N. and Lin J., 2008. "The Reality and Future Scenarios of Commercial Building Energy Consumption in China," *Energy& Buildings*.

Zhou, N., Levine, M.D., and Price, L., 2010. "Overview of Current Energy-Efficiency Policies in China," *Energy Policy*, Vol. 38, Issue 11.