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# Assessment of China's energy-saving and emission-reduction accomplishments and opportunities during the 11th Five Year Plan

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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.

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## 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, 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

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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,

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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 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]

**Table 1**
Energy use, energy intensity, and GDP data (2005–2008).

| Indicator | Unit | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| Energy | Mtce | 2247 | 2463 | 2656 | 2850 |
| | EJ | 65.85 | 72.18 | 77.84 | 83.53 |
| GDP | Billion 2005 RMB | 18,322 | 20,449 | 22,982 | 25,848 |
| | Billion 2005 USD[a] | 2239 | 2499 | 2809 | 3159 |
| Energy intensity | kgce/RMB | 0.1226 | 0.1204 | 0.1156 | 0.1103 |
| | MJ/USD[a] | 29.40 | 28.87 | 27.72 | 26.45 |
| Energy intensity reduction | % per year | | −1.79% | −4.04% | −4.59% |

[a] 2005 average exchange rate: 1 RMB=0.12222 USD.

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, 2008). Energy intensity reduction values are from the National Development and Reform Commission (NDRC) (NDRC, 2009a, 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.

Fig. 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

(*footnote continued*)
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).

[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.

[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.