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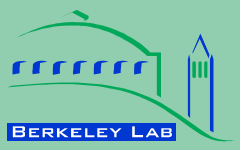

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China's Top-1000 Energy-Consuming Enterprises Program: Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China

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Disclaimer

ABSTRACT

In 2005, the Chinese government announced an ambitious goal of reducing energy consumption per unit of GDP by 20% between 2005 and 2010. One of the key initiatives for realizing this goal is the Top-1000 Energy-Consuming Enterprises program. The energy consumption of these 1000 enterprises accounted for 33% of national and 47% of industrial energy usage in 2004. Under the Top-1000 program, 2010 energy consumption targets were determined for each enterprise. The objective of this paper is to evaluate the program design and initial results, given limited information and data, in order to understand the possible implications of its success in terms of energy and carbon dioxide emissions reductions and to recommend future program modifications based on international experience with similar target-setting agreement programs. Even though the Top-1000 Program was designed and implemented rapidly, it appears that – depending upon the GDP growth rate -- it could contribute to somewhere between approximately 10% and 25% of the savings required to support China's efforts to meet a 20% reduction in energy use per unit of GDP by 2010.

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ACRONYMS

ACEEE	American Council for an Energy Efficient Economy
AERES	Association des Entreprises pour la Réduction de l'Effet de Serre
AGR	average growth rate
B	billion
CADDET	Centre for Analysis and Dissemination of Demonstrated Technologies
CECA	China Energy Conservation Association
CO_2	carbon dioxide
ECC	energy conservation center
ECP	energy conservation plan
EJ	exajoule
ETC	Economic and Trade Commission
EU	European Union
EUEEP	End Use Energy Efficiency Program
GDP	gross domestic product
GEF	Global Environmental Facility
GHG	greenhouse gas
GJ	gigajoule
IFC	International Finance Corporation
kgce	kilogram coal equivalent
kWh	kilowatt hour
LPG	liquefied petroleum gas
LTA	Long Term Agreement
M	million
MOF	Ministry of Finance
Mtce	million tons of coal equivalent
$MtCO_2$	million tons carbon dioxide
M&V	monitoring and verification
NBS	National Bureau of Statistics
NDRC	National Development and Reform Commission
PJ	petajoule
RMB	renminbi
SETC	State Economic and Trade Commission
t	ton (metric)
tce	ton coal equivalent
U.K.	United Kingdom
U.S.	United States
USDOE	United States Department of Energy

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Introduction

China's 11th Five Year Plan, announced in 2005, established an ambitious goal of reducing energy intensity, defined as energy consumption per unit of gross domestic product (GDP), by 20% between 2005 and 2010. Even though China's GDP increased at an average annual growth rate (AGR) of 9.8% from 2000 to 2005, the current goal assumes an average GDP growth rate of 7.5% from 2005 to 2010, which implies that energy use will only increase at an average rate of 2.8%. However, both GDP and energy use have been growing much faster recently. In 2006, total energy consumption reached 2,457 million tons of coal equivalent (Mtce), equivalent to 72 exajoules (EJ), a 9.3% increase from 2005, while the GDP growth rate was 10.7% (NBS, 2007).

If we assume that China's energy/GDP elasticity is 1 and GDP grows 7.5% per year, total energy consumption in 2010 will reach 3,226 Mtce (95 EJ). Achievement of the 2010 20% energy intensity target will require a reduction in energy use to 2,580 Mtce (76 EJ), or a savings of 646 Mtce (19 EJ). If GDP increases at a rate of 8.5% or 9.5%, reaching the target will require savings of 670 or 700 Mtce (20 or 21 EJ), respectively (Feng, 2007). Figure 1 illustrates energy consumption in 2010 given a GDP AGR of 10% and 7.5% (assuming an energy/GDP elasticity of 1), as well as the energy consumption required to meet the 20% savings target if GDP grows an average of 7.5%.

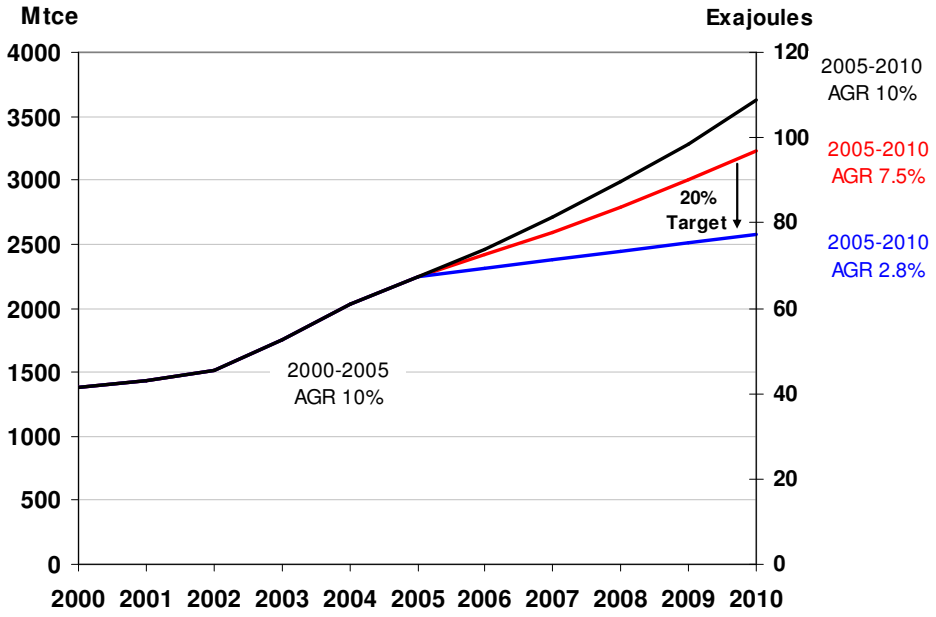


Figure 1. Recent and Projected Trends in Energy Consumption in China, 2000-2010

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 has set energy-saving targets for China's 1000 highest energy-consuming enterprises. The Top-1000 program was launched by the Department of Resource Conservation and Environmental Protection of the National Development and Reform Commission (NDRC), the National Bureau of Statistics (NBS), the State-owned Assets Supervision and Administration Commission, the Office of National Energy Leading Group, and the General Administration of Quality Supervision, Inspection and Quarantine in April 2006 through the issuance of a notice and implementation plan (NDRC, 2006a). The implementation plan provided guidance to the enterprises, calling on them to significantly improve their energy efficiency with the goal that energy intensity (energy used per unit of production) reach the level of advanced domestic production and that some enterprises attain either international or industry advanced levels of energy intensity. The implementation plan further stipulated that the enterprises within the Top-1000 program should realize savings of 100 Mtce (2.9 EJ) between 2006 and 2010 from the expected 2010 energy consumption of these 1000 enterprises (NDRC, 2006a).

Figure 2 shows China's total primary energy consumption in 2005, along with the energy consumption of the industrial sector broken into large sub-sectors. In 2005, the industrial sector energy consumption was 1,416 Mtce (42 EJ), or 64% of China's total primary energy consumption (Lin et al., 2007). The final energy consumption of China's 1000 most energy-intensive enterprises amounted to 673 Mtce (19.7 EJ) in 2004, accounting for 33% of national energy consumption and 47% of industrial energy usage (Wang, 2006a). If electricity generation, transmission, and distribution losses are accounted for, the primary energy consumption of the Top-1000 enterprises represents an even greater share of total primary energy use in China.

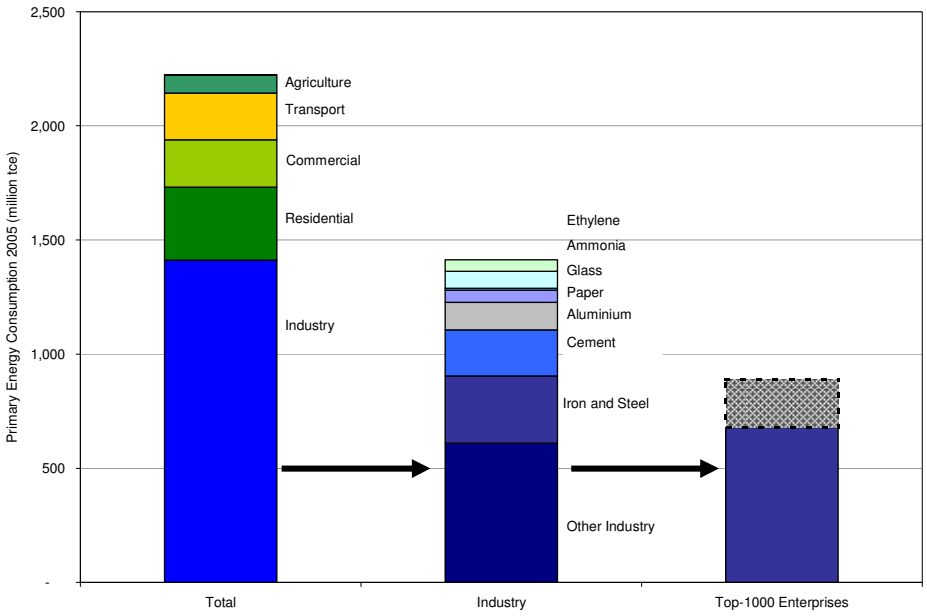


Figure 2. Energy Consumption of China, China's Industrial Sector, and the Top-1000 Energy-Consuming Enterprises, 2005

Note: Top-1000 program energy consumption is typically reported in final energy units (dark blue box). The shaded area provides the Mtce equivalent of electricity generation, transmission, and distribution losses so that the Top-1000 program can be compared in primary energy terms with the other two bars. Industry sub-sector breakdown based on LBNL LEAP model, not Chinese statistics.

While there are many evaluations of industrial energy efficiency programs in other countries (Bernstein et al., 2007; Price, 2005; WEC, 2003; WEC 2004), no external evaluation has been made of China's Top-1000 program. Such an evaluation is difficult because the program was just established in 2006. However, a government-issued report on initial results as well as other descriptive material about the program provides enough information for a preliminary assessment. The objective of this report is to provide an overall description as well as a preliminary evaluation of the Top-1000 program target and design. The 2010 program target will be evaluated based on information provided in the first published monitoring documents. The program design will be evaluated through a comparison with some important industrial energy efficiency programs outside of China.

In this report, the Top-1000 program is described, including a characterization of the industries included in the program, the target-setting process, the expectations of the enterprises in the program, the role of government, and energy efficiency funding and financial incentives. Activities undertaken to date in the Top-1000 program are then described. Results of the program's first year of activities are provided in the next section, followed by an analysis of the achievements. Policy implications are discussed next, providing information on how the key elements of the program have been designed and implemented in other programs around the world. Finally, conclusions and recommendations are provided in the last section.

Description of the Top-1000 Energy-Consuming Enterprise Program

Background

China's Top-1000 Energy-Consuming Enterprise Program is modeled on international target-setting programs (also called voluntary or negotiated agreement programs). These types of target-setting programs that focus on energy efficiency improvement and reduction of energy-related greenhouse gas (GHG) emissions by industry have been implemented in industrialized countries since the 1990s. A number of these national-level programs are now being modified and strengthened, while additional countries, including some recently industrialized and developing countries, are adopting these type of agreements in an effort to increase the energy efficiency of their industrial sectors (Price, 2005).

These programs are "essentially a contract between the government and industry, or negotiated targets with commitments and time schedules on the part of all participating parties" (IEA, 1997). Such agreement programs typically have a long-term outlook, covering a period of five to ten years, so that strategic energy-efficiency investments can be planned and implemented. A key element is that they focus the attention of all actors on energy efficiency or emission reduction goals.

The essential elements of such programs include the assessment of the energy-efficiency potential of the industrial facility as well as target-setting through a negotiated process. Participation by industries is motivated through the use of both incentives and disincentives. Supporting programs and policies, such as facility audits, assessments, benchmarking, monitoring, information dissemination, and financial incentives all play an important role in assisting the participants in understanding and managing their energy use and GHG emissions in order to meet the target goals. Some of the more successful voluntary agreement programs are based on the use of a mechanism to reduce environmental regulations or taxes for participants (Price, 2005).

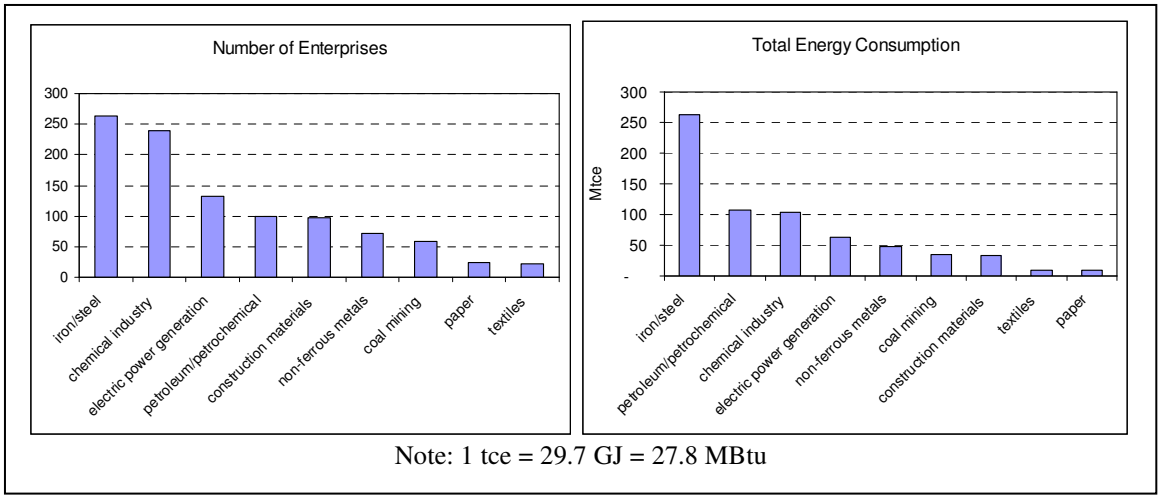
The Economic and Trade Commission of Shandong Province undertook a target-setting energy efficiency agreement pilot project with two iron and steel enterprises in 2003 which was modeled after successful international industrial voluntary agreement programs, taking China-specific conditions into consideration (Price et al., 2003). The main participants in the pilot project were two iron and steel enterprises in Shandong Province – Jinan Iron and Steel (Jigang) and Laiwu Iron and Steel (Laigang), the Shandong Economic and Trade Commission (ETC), the State Economic and Trade Commission (SETC), and the China Energy Conservation Association (CECA).[1] The agreements had a base year of 2002 and set performance targets for 2005 (Price et al., 2003). Over this period, Jinan Iron and Steel saved 292,000 tce (8.6 PJ) and reduced energy consumption per ton of steel by 9.5% while Laiwu saved 130,000 tce (3.8 PJ) and

[1] The SETC was disbanded and many of its functions, including oversight of the Shandong Province Voluntary Agreement pilot, were transferred to the new National Development and Reform Commission (NDRC).

reduced its energy intensity by 9% (Wang, 2007). The pilot was considered a success due to the achievement of the targets along with the knowledge gained related to establishing targets, energy management within the companies, making energy-efficiency investments, and establishing energy efficiency policies at the provincial level (Hu, 2007). The pilot was used as a model for the Top-1000 program.

Characterization of the Top-1000 Industries

The industries included in the Top-1000 Energy-Consuming Enterprise program are large-scale enterprises in nine major energy-consuming industries that each consumed a minimum of 180,000 tce (5.3 PJ) in 2004: iron and steel, petroleum and petrochemicals, chemicals, electric power generation, non-ferrous metals, coal mining, construction materials, textiles, and pulp and paper. Figure 3 provides information on the number of enterprises and the energy consumption by sector. The iron and steel and chemical industries dominate in terms of number of enterprises; the iron and steel enterprises also dominate in terms of energy consumption.



Note: 1 tce = 29.7 GJ = 27.8 MBtu

Figure 3. Number of Enterprises and Total Energy Consumption by Sector of the Top-1000 Energy-Consuming Enterprises, 2004

In 2004, these enterprises consumed an average of 0.67 Mtce of comprehensive energy each (19.6 PJ). Average energy consumption per enterprise ranged from a low of 0.35 Mtce (10.3 PJ) for the enterprises in the building materials sector to a high of 1.07 Mtce (31.4 PJ) for the enterprises in the petroleum and petrochemicals sector. The energy consumption of the enterprises in the iron and steel sector was also high, averaging 1.0 Mtce (29.3 PJ); all of the remaining enterprises averaged 0.67 Mtce (19.6 PJ) or lower.

Figure 4 shows that the Top-1000 program enterprises are spread throughout China, with the largest number of enterprises in the coastal area of the East Region (268 enterprises) where Shanghai as well as a number of more developed provinces are located and the North Region (268 enterprises), followed by the South Central Region (192 enterprises) where Guangdong and the Pearl River Delta industrial area are located. The Northeast, Southwest, and Northwest Regions have 102, 97, and 81 enterprises, respectively.

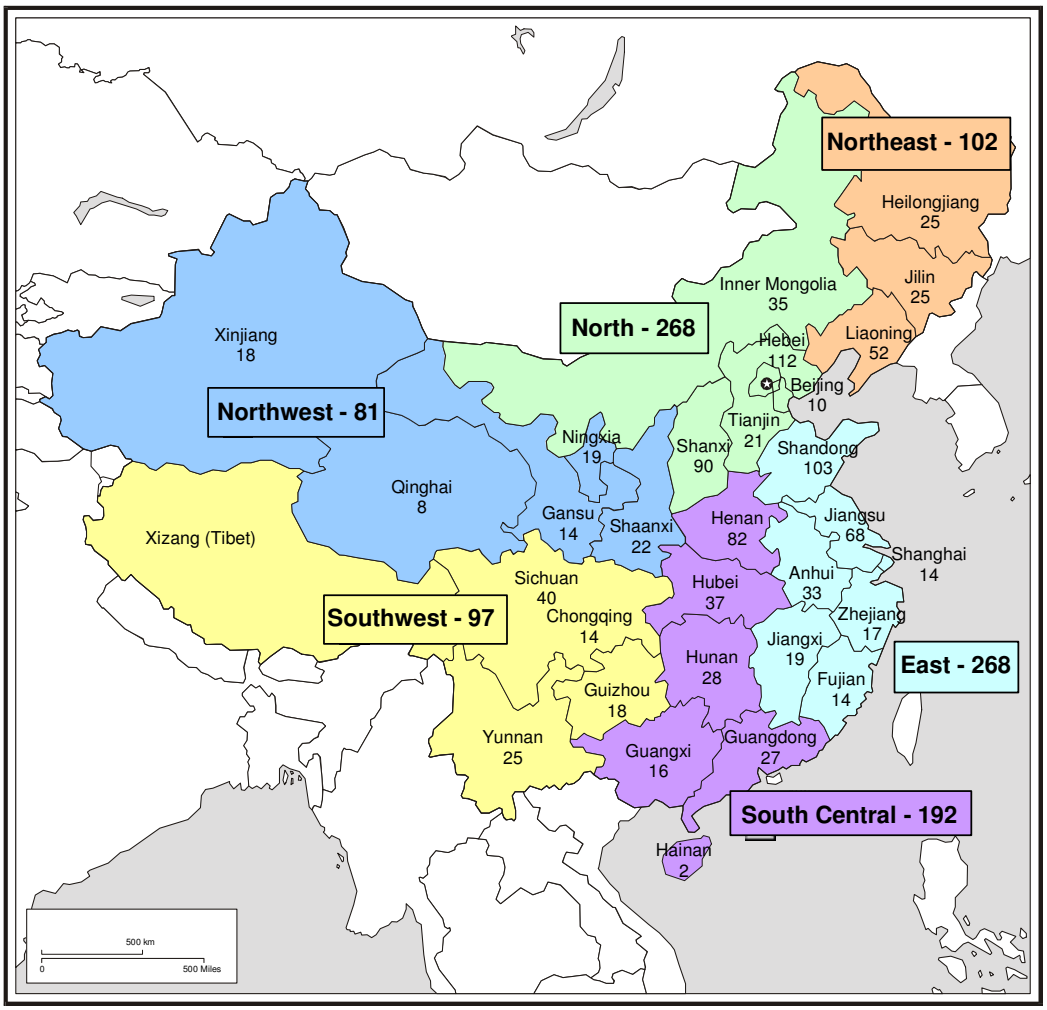


Figure 4. Geographic Location of Top-1000 Energy-Consuming Enterprises, 2004

Target-Setting for the Top-1000 Energy-Consuming Enterprises

The major targets of the Top-1000 Energy-Consuming Enterprise program are to significantly improve the Top-1000 enterprises' energy efficiency; reduce unit energy consumption to domestic best practice level for all major products; have some enterprises attain either international best practice levels or sector best practice levels; improve the energy efficiency of each sector; and achieve energy savings of approximately 100 million tons of coal equivalent in the 11th Five-Year period. This program target has been broken down to the provincial level. All participating enterprises have signed energy conservation agreements with local governments and have promised to reach the energy savings target in the next five years. For example, NDRC signed an agreement with the Beijing Municipal Government covering ten enterprises within Beijing's jurisdiction. The Beijing Municipal Government, in turn, signed energy-efficiency target contracts that include energy saving amounts with each of the ten enterprises (Wang, 2006b).

Achievement of the energy-saving targets is part of the provincial government evaluation system in which the responsible government officials are evaluated annually each year on whether or not the targets under their jurisdiction have been achieved. Regions and enterprises that do not meet the targets will not be given annual rewards or honorary titles, leaders in state-owned enterprises will not receive annual evaluation awards, and officials will not be promoted without meeting the energy conservation targets (NDRC, 2007a). Use of the evaluation system in this manner provides strong incentives to government officials to assist the enterprises in achieving the energy-saving targets.

Expectations of the Top-1000 Energy-Consuming Enterprises

According to the implementation plan of the program, 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, 2006a).

Role of the National, Provincial, and Local Governments

A number of national government departments and entities are involved in the Top-1000 program, including the Department of Resource Conservation and Environmental Protection of NDRC (China's macroeconomic management agency under the State Council which promotes energy saving), the National Bureau of Statistics (which collects and manages statistical information of enterprises), the State-owned Assets Supervision and Administration Commission (which manages major state-owned enterprises), the Office of National Energy Leading Group, and the General Administration of Quality Supervision, Inspection and Quarantine.

The national government has established and publicized the guiding principles and goals of the program and published a list of the Top-1000 enterprises by name. The energy saving authorities of the province, district, or city are directed to collaborate with related organizations to lead and implement the Top-1000 program, including the tracking, supervision, and management of the energy-saving activities of the enterprises. The local authorities are directed to oversee and "urge" the enterprises in their energy management, energy auditing, and energy reporting requirements. They are directed to improve their monitoring of the enterprises through audits and sampling and to promote the use of new mechanisms such as target-setting agreements and encourage enterprises to meet energy saving targets and attain international advanced levels ahead of schedule (NDRC, 2006a).

Energy Efficiency Funding and Financial Incentives[2]

During the late 1990s and early 2000s, the low level of government spending on energy efficiency in China combined with significant growth in production of energy-intensive commodities such as steel, cement, and chemicals contributed to an increase in energy use per unit of GDP after 2002 following the long period of decline in energy intensity

[2] Some of the information in this section is based on Zhou et al., forthcoming.

since the 1980s. Government investment in energy conservation as a percentage of government investment in energy supply declined from a high of about 13% in 1983 to levels closer to 4% and 5% in the early 2000s. It has been estimated that investments of 150 to 200 billion RMB¥ ($21B to $29B)[3] per year are required to reduce the growth rate of energy to half of the projected growth rate of the economy over the next 15 to 20 years (Lin, 2005; Levine, 2005).

In 2007, the Chinese central government allocated a total of 23.5B RMB¥ ($3.4B) to improve energy efficiency and abate pollution (MOF, 2008). The funding supported the Ten Key Projects, elimination of inefficient facilities, and environmental protection measures. The Ministry of Finance and NDRC will use a portion of this funding to award enterprises at a rate of 200 RMB¥ ($29) for every tce saved per year for enterprises in East China to 250 RMB¥ ($36) for every tce saved per year for enterprises in Mid or West China (Lu, 2007; Jiang, 2007, MOF and NDRC, 2007) related to the implementation of five of the Ten Key Projects. The rewards and rebates are paid to enterprises that have energy metering and measuring systems that can document proven savings of at least 10,000 tce (0.29 PJ) from "energy saving technical transformation" projects. Assuming an average emissions factor for China of 2.42 tons carbon dioxide (CO_2) per ton coal equivalent, this funding is equivalent to $12 to $15 per ton of CO_2 emissions reduced. In 2008, the central government allocated even greater funding of 41.8B RMB¥ ($6B) to promote saving energy and reducing emissions. This funding consists of 27B RMB¥ ($3.9B) to promote saving energy and reducing pollutant emissions from the Ministry of Finance and 14.8B RMB¥ ($2.1B) from the Central Construction Investment (Sha Luo and Jie Han, 2008).

Provincial governments have also encouraged enterprises to use the national-level funds as well as established provincial-level funds in support of energy efficiency investments. In 2006, enterprises implemented 18 projects in Shandong Province and overall investment was 3.14B RMB¥ ($450M) including national bond funds of about 139M RMB¥ ($120M) (Wang, 2007). In 2007, Shandong Province began to use the existing National Bond for energy conservation award funds. Shandong Province also initiated a special provincial fund of 2.13B RMB¥ ($304M) to encourage local enterprises to implement energy efficiency projects (Jiang, 2008). In 2007, the enterprises planned 12 projects of 1.49B RMB¥ ($213M), including 80.6M RMB¥ ($11.5M) from the national bond (Wang, 2007).

Some provincial energy conservation centers have received financial support from the central government in support of the 20% energy/GDP reduction target. A total of 20 energy conservation centers have received such funding, including nine (Xinjiang, Ningxia, Qinghai, Gansu, Yunnan, Guizhou, Sichuan, Shanxi, Guangxi) that received 4M RMB¥ ($571,000), two (Jiangxi and Neimeng) that received 3M RMB¥ ($429,000) and nine (Liaoning, Helongjiang, Jilin, Hubei, Henan, Shannxi, Hunan, Anhui, Chongqing) that received 2.4 million RMB¥ ($343,000). At the same time, local governments will

[3] Based on a currency conversion factor of $1 = 7.0 RMB¥

allocate at least the same amount of money as received from the central government as support funds to local energy conservation centers (Jiang, 2006).

Tax rebates for exports of energy-intensive products runs counter to stated government policies to reduce energy use from these industries and to promote structural shift to less energy-intensive products. As a result, on September 15, 2006, China's Ministry of Finance (MOF) reduced export tax rebates for many low-value-added but high energy-consuming products. The rebate was reduced from 11% to 8% for steel, from 13% to 8% for cement, from 13% to 11% for glass, and from 13% to 5%, 8% or 11% for some nonferrous metal products (MOF, 2006). On April 11, 2007, the government announced a further reduction of the tax rebate for steel products, canceling or reducing tax rebates on exports of most steel products (MOF, 2007). During 2007, export rebates were eliminated on 553 energy-intensive and highly-polluting products (MOF, 2008).

A differentiated electricity pricing policy was initiated in 2004 in which electricity prices can be set based on the enterprise energy intensity level for eight high energy-consuming industries (electrolytic aluminum, ferroalloy, calcium carbide, caustic soda, cement, and steel). Enterprises fall into one of four categories based on their level of energy efficiency - encouraged, permitted, restricted, and eliminated – and are charged increasingly higher electricity rates in order to phase out inefficient enterprises (Moskovitz, 2007). Encouraged and permitted enterprises pay the normal price for electricity while enterprises in the restricted and eliminated categories pay surcharges of 5 fen and 20 fen per kWh ($0.007/kWh and $0.029/kWh), respectively, which is about 10% and 30% of the average price of electricity per kWh. In 2004, 30 provinces implemented this policy, covering approximately 8,000 enterprises. Between 2004 and 2006, approximately 900 firms in the eliminated category and 380 firms in the restricted category had closed, invested in energy efficiency, or changed production processes. In 2007, the policy was adjusted to allow local provincial authorities to retain revenue collected through the differential electricity pricing system, providing stronger incentives for provincial authorities to enforce its implementation (Moskovitz, 2008).

In addition to these domestic funding resources, international energy efficiency funding has also increased recently. The United Nations Development Program/Global Environment Facility (GEF)-funded End-Use Energy Efficiency Program (EUEEP), which is currently in its first phase of four phases of a 12-year strategic plan "developed by the Chinese government to dramatically improve the efficiency if its major end-use sectors," will provide between 770,000 RMB¥ ($110,000) and 840,000 RMB¥ ($120,000) to eight energy conservation centers in Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Fujian, Shandong, and Guangdong. Funding for EUEEP consists of 119M RMB¥ ($17M) from the GEF, private sector inputs of 224M RMB¥ ($32M), and government inputs of 219M RMB¥ ($31.35M) (UNDP, 2005). The World Bank's investment branch, the International Finance Corporation (IFC) has established a 130M RMB¥ ($18.6M) risk-sharing facility to the Bank of Beijing for energy efficiency projects, augmenting the Bank of Beijing's 300M RMB¥ ($43M) loan portfolio for energy projects. The lending will focus on energy service companies that provide

services related to industrial boilers, waste-heat recovery and other applications (Davies, 2007).

Overall, it is estimated that during the 11th Five-Year Plan, total energy conservation investment will be about 1 trillion RMB¥ ($143B) and the proportion of energy conservation investment in total energy industry investment is projected to reach 15% at the end of this period (Feng, 2007).

Activities to Date

The Top-1000 program was announced in April, 2006 with the issuance of the *1,000 Enterprise Energy Conservation Action Implementation Plan* that outlined the program. During the summer of 2006, targets were set for each enterprise by NDRC in order to reach the overall savings target of 100 Mtce (2.9 EJ). NDRC allocated the overall reduction target and then allocated targets to each province. NDRC then signed "responsibility documents" for the Top-1000 enterprise targets with 30 provincial level governments who in turn signed with the Top-1000 enterprises in their region (Dai, 2007).

In October, 2006 NDRC conducted a series of training sessions for the Top-1000 enterprises in five locations across China (Shenyang, Jinan, Kunming, Changsha, and Shijiazhuang), attended by about 2,200 Top-1000 enterprise staff members and others (Dai, 2007). The sessions covered the topics of energy and energy conservation measurement, energy statistics, enterprise energy auditing, an example of energy audits in a power plant, the ten major energy conservation projects in the 11th Five Year Plan, major energy saving technologies in nine energy-consuming industries, guidelines for energy conservation plans for enterprises, application of benchmarking in large scale power plants, an introduction to the Kyoto Protocol Clean Development Mechanism, and energy performance contracting and the Energy Conservation Service Industry Committee of China Energy Conservation Association (NDRC, 2006b).[4]

Guidance given to the enterprises regarding energy audits for the Top-1000 program consisted of the information provided in the NDRC training as well as energy auditing guidelines that were issued by NDRC to every province. The *Guide to the Enterprise Energy Auditing Report and the Enterprise Energy Conservation Plan Auditing Report* provides guidelines and training materials related to undertaking an energy audit (e.g. how to do an energy balance, which energy indicators to use, how to use energy measuring equipment, etc.). The China National Institute of Standardization, CNIS is in the process of developing an energy auditing standard. In addition, the National Bureau of Statistics held a series of energy statistics training sessions for the Top-1000 enterprises (Dai, 2007).

[4] The training materials are available at: http://hzs.ndrc.gov.cn/jnxd/t20061108_92567.htm

During the winter and spring of 2007, the Top-1000 enterprises undertook energy audits that documented the current energy consumption situation at the enterprise and identified energy efficiency opportunities. The enterprises then developed energy action plans outlining how they expect to meet their energy-saving targets. While some Top-1000 enterprises have the expertise to conduct energy audits and identify energy efficiency opportunities, a number of enterprises found this task difficult due to the lack of qualified auditing personnel and needed to hire outside experts for assistance (Lu, 2006). There are a variety of outside experts that can provide energy auditing services including private consulting firms, energy service companies, provincial energy conservation centers, and the China Energy Conservation Association (CECA). The technical expertise and abilities of these organizations varies widely, with some highly skilled in energy auditing and others in need of significant training. The most qualified provincial energy conservation centers in the area of energy auditing are in Sichuan, Jiangsu, and Henan provinces, and in addition Shanghai and Shandong energy conservation centers are well qualified in energy conservation work (Jiang, 2006). The Shanghai Energy Conservation Service Center and the Jiangsu Energy Conservation Training Center have both completed training on motor system optimization through the China Motor System Energy Conservation Program (McKane et al., 2003).

Energy audits typically cost about 200,000 RMB¥ ($28,600) and NDRC did not provide funding for this effort (Jiang, 2007). By August 31, 2007 a total of 967 energy audit reports and 836 energy conservation plans had been completed and submitted to NDRC by the 30 provincial level governments (Dai, 2007). In October and November, 2007, two energy auditing workshops were held in Beijing for the Top-1000 enterprises to undergo training in energy auditing, writing energy audit reports, and using energy management software. Documents, including a report on *Basic Knowledge of Energy Auditing and Analysis of Energy Conservation Potential* and *Manual of Energy Management Software for Enterprises* along with a series of textbooks and published energy auditing reports templates for nine major industries, were distributed. The China Energy Conservation and Monitoring Information website provides an energy auditing software to assist enterprises in undertaking energy auditing (CECS, 2008).

Results

In September 2007, NDRC and NBS held a workshop in Shenyang, China to release the *Top-1000 Enterprises Energy Use Report 2007* (NDRC and NBS, 2007). The report documents the energy consumption, energy intensity, energy management activities, and the energy-efficient technology and equipment used based on statistics submitted to NBS by 954 enterprises and information from the energy audit reports of 942 enterprises. The data indicated that the final energy consumption (not accounting for losses from electricity generation, transmission, and distribution) of the Top-1000 enterprises had increased from 733 Mtce (21.5 EJ) in 2005 to 797 Mtce (23.4 EJ) in 2006. Shandong, Hebei, Liaoning, Shanxi, Jiangsu, and Henan Provinces accounted for 50% of the total energy consumption of the Top-1000 enterprises.

Figure 5 shows that the number of enterprises within each sector remained relatively stable between 2004 and 2006 (values for 2005 were not reported), with slight decreases in the steel, petroleum/petrochemical, construction materials, and non-ferrous metals sectors and a slight increase in the electric power sector. Overall, the initial list of 1008 enterprises issued in 2004 was revised to reflect the fact that 19 enterprises were added to the program and 29 enterprises dropped out for various reasons including closure and consolidation, bringing the total number of Top-1000 enterprises in 2006 to 998.

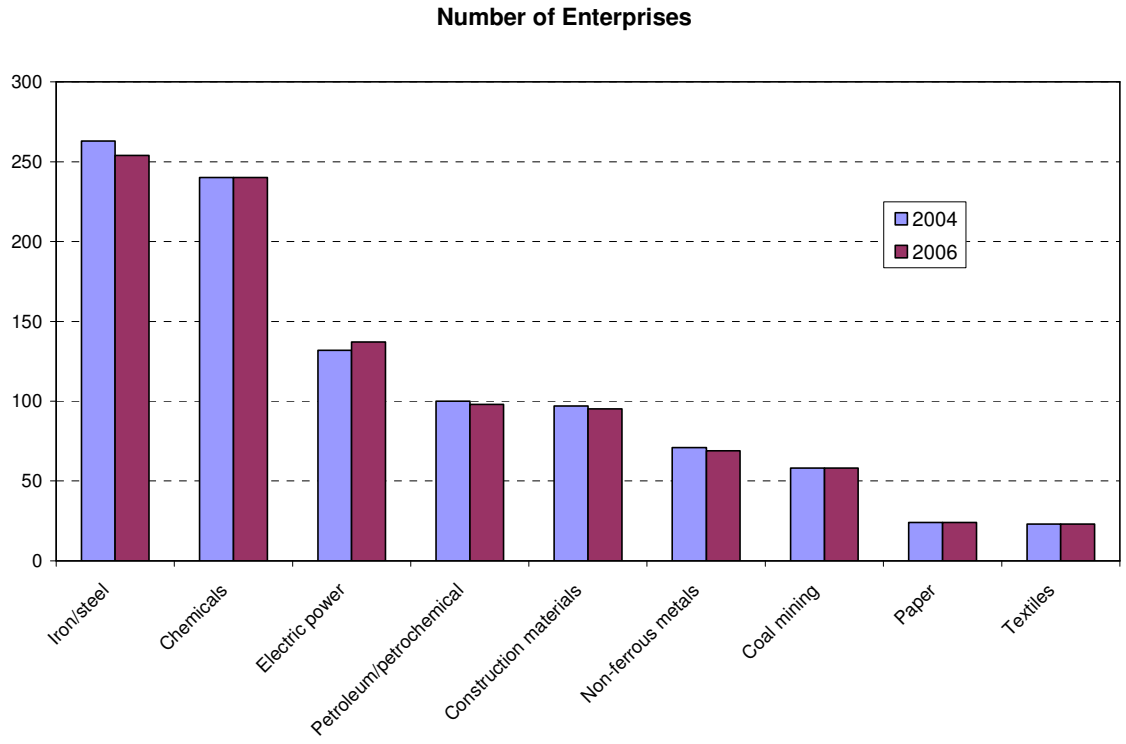


Figure 5. Number of Enterprises by Sector, 2004 and 2006. Source: NRDC and NBS, 2007.

Between 2005 and 2006, energy consumption (shown in Figure 6) grew in enterprises in the petroleum/petrochemical, chemicals, electric power, coal mining, and paper sectors and decreased in the non-ferrous metals and construction materials sectors. In 2006, enterprise energy consumption fuel shares were 36.1% coal, 21.3% crude oil, 12.97% electricity, 8.91% coke, 1.91% heat, 1.48% natural gas, and 17.33% other energy sources such as petroleum diesel, fuel oil, LPG, washed coal, coal gas from blast furnace, and coke oven gas.

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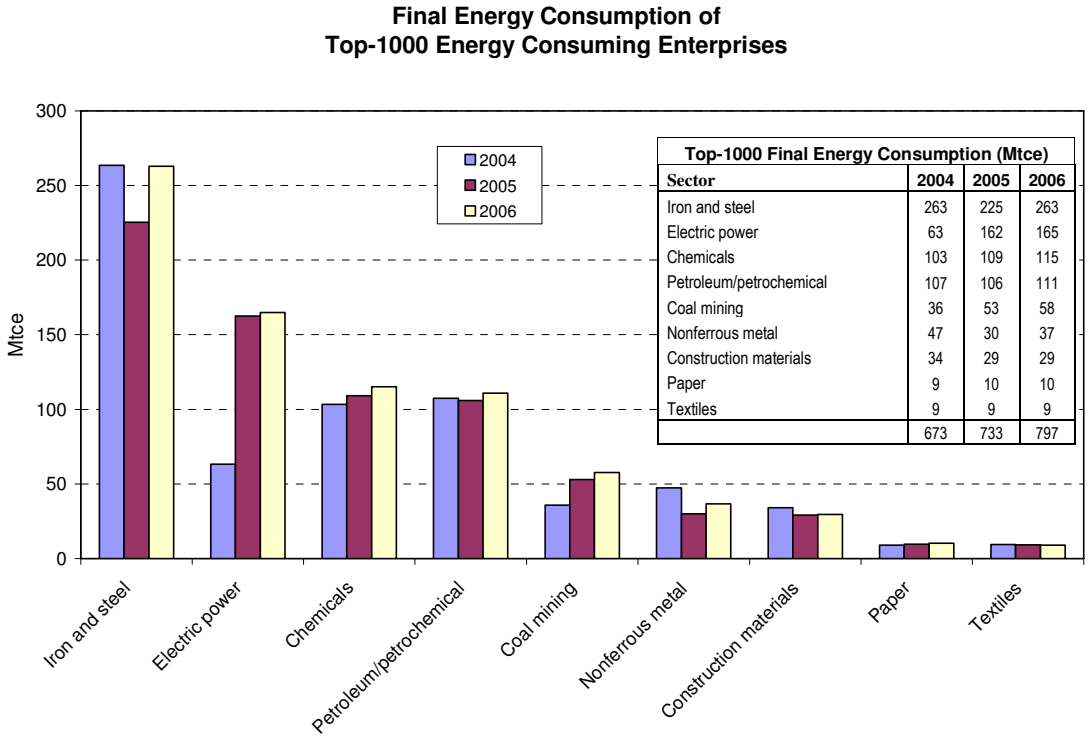


Top-1000 Final Energy Consumption (Mtce)			
Sector	2004	2005	2006
Iron and steel	263	225	263
Electric power	63	162	165
Chemicals	103	109	115
Petroleum/petrochemical	107	106	111
Coal mining	36	53	58
Nonferrous metal	47	30	37
Construction materials	34	29	29
Paper	9	10	10
Textiles	9	9	9
	673	733	797

Figure 6. Enterprise Energy Consumption by Sector, 2004-2006. Source: NRDC and NBS, 2007

Energy savings results were calculated by NDRC and NBS by multiplying the 2006 production (e.g. tons or kWh) of 36 industrial products, ranging from crude steel to synthetic ammonia to polyester fiber, by the 2005 unit energy consumption for each product to determine what the 2006 energy use would have been if energy efficiency had not improved between 2005 and 2006. This value was then subtracted from the actual 2006 energy consumption value for these products to determine the energy savings. The calculation resulted in savings of 14.92 Mtce (437 PJ) for the products for which this calculation could be made. The report then estimates that including the remaining industrial products that are not explicitly accounted for in the calculation would result in total energy savings of 20 Mtce in 2006. Figure 7 shows the 14.92 Mtce (437 PJ) energy savings by sector as well as the non-allocated savings of 5.08 Mtce (149 PJ).

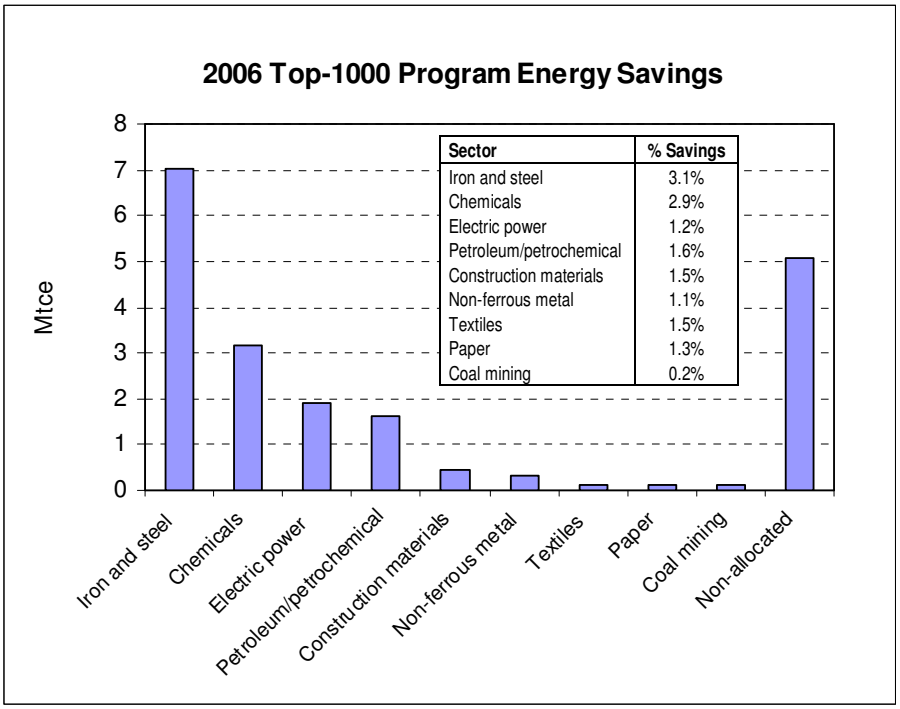


Figure 7. 2006 Top-1000 Program Energy Savings. Source: NDRC and NBS, 2007.

Analysis

It is difficult to perform a detailed analysis of the reported progress of the Top-1000 Program due to data confidentiality issues that result in release of only relatively aggregate data. Currently, only specific staff members of NDRC (and its think-tank, the Energy Research Institute) and NBS have access to the data and the only officially released data are those provided in the September 2007 report issued by NDRC and NBS as well as data provided in documents and presentations made shortly after the program was announced in 2006 (NDRC, 2006a; Wang, 2006a; Wang 2006b; Wang 2006c). Even so, the reported data can be used to evaluate the progress of the Top-1000 program toward the target as well as to assess the energy savings in terms of carbon dioxide (CO_2) emissions reductions.

As an example of the difficulty in evaluating the data that has been released, the September 2007 report provides graphs showing energy use per unit of product for 10 products, but it is not possible to adequately assess whether these produces were produced efficiently because no information is given about the production process used to produce the products.

For example, for cement production the unit energy intensity (kgce/t) of each Top-1000 program cement plant is plotted for both 2005 and 2006 (see Figure 8) and it is reported that the 2006 average intensity value for cement production was 113 kgce/t (3.3 GJ/t). It

is further reported that the international advanced level for all cement plants in China is 102 kgce/t (3.0 GJ/t) and the national average level is 156 kgce/t (4.6 GJ/t) (NDRC and NBS, 2007). These statistics, however, hide significant differences in intensity values that are dependent upon the technologies used to produce cement as well as whether the cement has been blended with admixtures, reducing the need to produce the most energy-intensive component, clinker. For Portland cement, which is 95% clinker and 5% other additives, the international best practice value is 100 kgce/t (2.9 GJ/t) but for cement in which the clinker is mixed with blast furnace slag or fly ash (a waste from electricity production), the international best practice energy intensity values are 70 kgce/t (2.1 GJ/t) or 57 kgce/t (1.7 GJ/t), respectively (Worrell et al., 2007).

Cement can be made using many different kiln types – in fact, China employs the most kiln types of any country in the world to produce cement. Each kiln type, as well as the auxiliary blending and grinding equipment, has different efficiency levels. It is reported that "the cement enterprises mainly adopted the advanced new dry process…the technology and the production line represented the national advanced level...however, some energy-intensive/high-emission kilns, e.g. vertical shaft kilns, wet process kilns, and dry-process hollow kilns, were still used" (NDRC and NBS, 2007).

Without knowing which plants produce what types of cements and which technologies are used, it is impossible to evaluate the relative efficiency of the Top-1000 Program cement sector as a whole. Even so, Figure 8 indicates that while about 25 plants appear to be at the international advanced level, the remaining 65 plants have intensities above this level with 22 plants above 150 kgce/t (4.4 GJ/t) and six plants above 225 kgce/t (6.6 GJ/t).

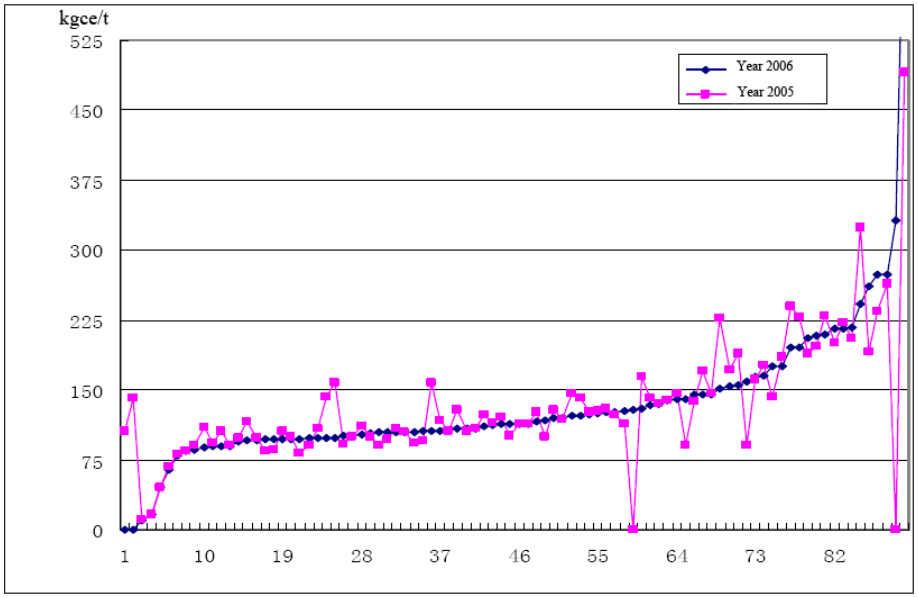


Figure 8. Comprehensive Energy Consumption per Ton of Cement.
Source: NDRC and NBS, 2007. (Note that plants with a value of 0 were not participating in the Top-1000 program at that time or they did not report their data).

Overall, the Top-1000 program is reported to have saved 20 Mtce (0.6 EJ) in its first year (2006) (NDRC and NBS, 2007) and 8 Mtce in the first quarter of 2007 (Yan, 2007), for a total of 28 Mtce (0.8 EJ) savings. Since the Top-1000 program was only announced in April 2006, the savings equal to 20% of the target during the first year is seemingly impressive.

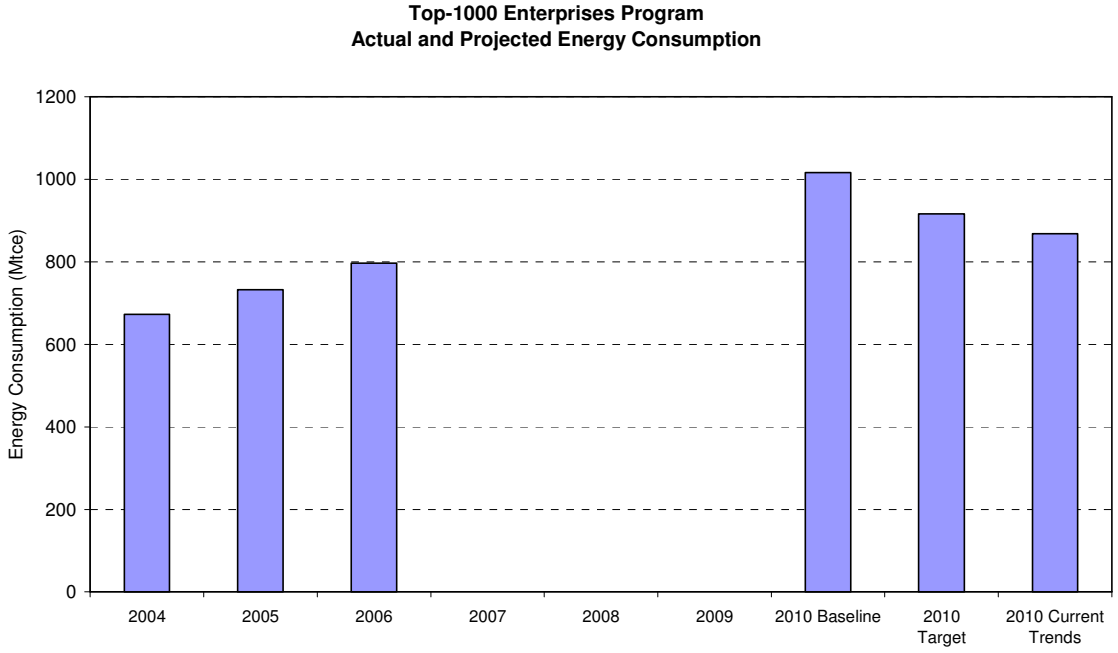
Some of this initial savings most likely resulted from increased attention to energy management, including the introduction of full-time or part-time energy managers, which were established in more than 95% of the Top-1000 enterprises. Energy management includes an energy purchase management system, energy use management system, an assessment of each production process, etc. Energy management guidelines that are being followed by the Top-1000 enterprises have been recently published in a report titled *Evaluation Guide for the Enterprise Energy Auditing Report and the Enterprise Energy Conservation Plan Report.* Other savings during the first year came from closure of small, inefficient production processes within enterprises. For example, in the iron and steel sector small sinter machines and casting converters were almost completely phased out and small-scale production lines in the paper industry are being rapidly phased out. Finally, small retrofit projects, such as renovation of fans and pumps in the coal mining industry, were reported (NDRC and NBS, 2007). Larger retrofit projects that require significant planning and financing will most likely be used to improve energy efficiency in Top-1000 enterprises during the coming years, in combination with continued energy management, smaller retrofits, and elimination of inefficient facilities.

In order to assess the Top-1000 program goal of 100 Mtce (2.9 EJ) savings by the end of 2010, as well as to make projections of other possible outcomes, a baseline energy use scenario for the Top-1000 Program must first be developed since there is no official 2010 "business-as-usual" energy consumption value from which the energy savings of the Top-1000 enterprises will be measured. The national-level 20% target for 2010 assumes an average GDP growth rate of 7.5% from 2005 to 2010, which implies that energy use will only increase at an average rate of 2.8%. However, both GDP and energy use have been growing much faster recently. In 2006, total energy consumption reached 2,463 Mtce (72.2 EJ), a 9.6% increase from 2005, while the GDP growth rate was 10.7% (NBS, 2007). However, energy use of the Top-1000 Program enterprises only grew at a rate of 6.7% per year between 2004 and 2006.[5] Assuming this rate continues, energy consumption of the Top-1000 Program enterprises would grow from 733 Mtce (21.5 EJ) in 2005 to 1016 Mtce (30 EJ) in 2010 under a baseline, business-as-usual scenario.

If energy savings continue to be realized at the rate experienced in 2006 – 20 Mtce/year (0.6 EJ/year) -- it appears that the Top-1000 program will be able to meet the overall program goal of 100 Mtce (2.9 EJ) savings by the end of 2010. Given the baseline scenario projected above, meeting the program goal in this "Target" scenario means that the Top-1000 enterprises would consume 916 Mtce (27 EJ) in 2010. Another possible

[5] 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.

"Current Trends" scenario is based upon the reported 2007 first quarter savings of 8 Mtce (0.23 EJ). If that rate of savings continued through 2007, then the annual savings of 32 Mtce (0.94 EJ), added to the 2006 savings of 20 Mtce (0.6 EJ), would mean that the enterprises were already more than half-way to the 2010 goal at the end of 2007.[6] Continuation of annual savings of 32 Mtce (0.94 EJ) for 2008, 2009, and 2010 would lead to cumulative savings for the Top-1000 Program of 148 Mtce (4.3 EJ), reducing total energy use in 2010 to 868 Mtce (25.4 EJ). Figure 9 illustrates these scenarios and Table 1 provides an overview of the projected energy savings.



Baseline Scenario = annual energy growth based on 2004-2006 actual (6.7% per year)
Target Scenario = 20 Mtce savings per year 2006-2010 to achieve 100 Mtce target
Current Trends Scenario = 32 Mtce savings per year 2007-2010
Note: Emissions based on 2006 fuel mix; electricity reported as source, accounting for generation, transmission, and distribution losses

Figure 9. Actual (2004 to 2006) and Projected 2010 Energy Consumption for the Top-1000 Energy-Consuming Enterprises Program Under Baseline, Target, and Current Trends Scenarios

[6] In March 2008 it was reported that the 1,000 Enterprise Program had savings of "more than 20 million standard tons of coal" in 2007 (Ding, 2008).

Table 1. Actual (2004 to 2006) and Projected (2007 to 2010) Energy Consumption Values of Top-1000 Energy-Consuming Enterprises Program Under Baseline, Target, and Current Trends Scenarios.

Top-1000 Energy Consumption (Mtce)							
Scenario	2004	2005	2006	2007	2008	2009	2010
Baseline Scenario (6.7% annual growth between 2005 and 2010)	673	733	817	863	911	962	1016
Actual to 2006, then Target Scenario	673	733	797	823	851	882	916
Actual to 2006, then Current Trends Scenario	673	733	797	811	827	846	868
T1000 savings annual - Target Scenario			20	20	20	20	20
T1000 savings cumulative - Target Scenario			20	40	60	80	100
T1000 savings annual - Current Trends Scenario			20	32	32	32	32
T1000 savings cumulative - Current Trends Scenario			20	52	84	116	148

Top-1000 program 2006 energy-related CO_2 emissions are estimated to be 2,423 $MtCO_2$ based on the data provided in the 2007 evaluation report that explains that the 2006 energy consumption of 797 Mtce (23.4 EJ) is made up of the following fuel shares: "36.10% coal, 21.30% crude oil, 12.97% electricity, 8.91% coke, 1.91% heat, 1.48% natural gas, and 17.33% other energy sources" (NDRC and NBS, 2007). Table 2 provides the details of the calculation of energy-related CO_2 emissions.

Table 2. Estimated Top-1000 Program 2006 Energy-Related CO_2 Emissions.

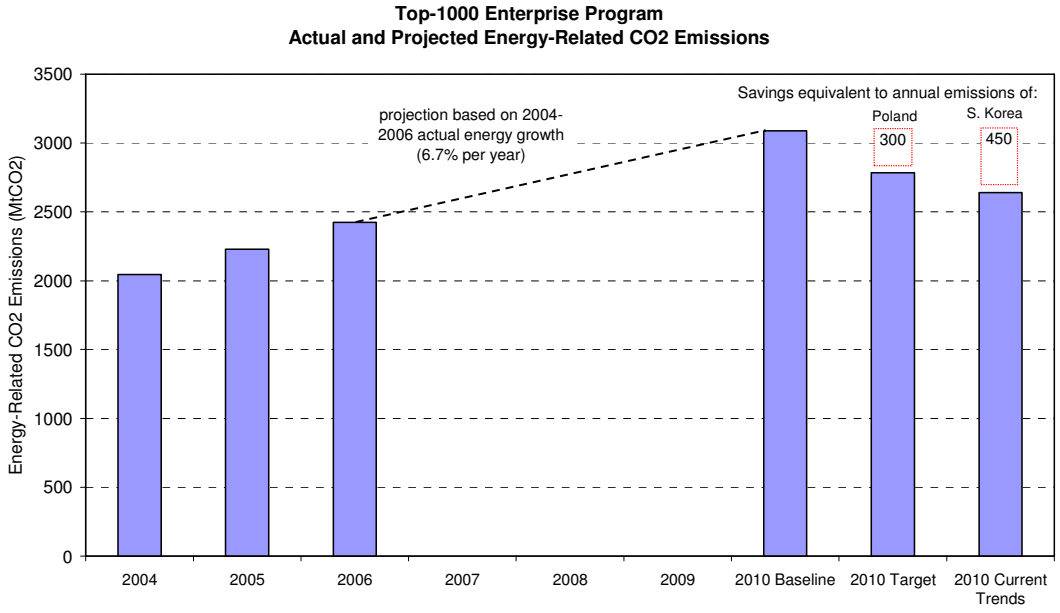
	Coal	Coke	Crude Oil	Natural Gas	Heat	Electricity	Other	Total
Fuel Share (%)	36.1	8.91	21.3	1.48	1.91	12.97	17.33	
Energy (Mtce)	288	71	170	12	15	103	138	797
Emissions (MtCO2)	812	193	361	19	34	710	294	2423

Notes: Fuel emission factors from IPCC, 1996. Electricity emission factor = 0.843 kgCO2/kWh. Emission factor for "other" assumed to be the same as for crude oil (2.15 tCO2/tce), since it falls between coal (2.88 tCO2/tce) and natural gas 1.64 tCO2/tce).

Assuming 2006 total energy-related CO_2 emissions for China are 5,650 $MtCO_2$ (Netherlands Environmental Assessment Agency, 2007), the estimated emissions from Top-1000 Program enterprises represent 43% of China's total emissions. The share of Top-1000 Program CO_2 emissions is higher than the share of Top-1000 program energy use in China's total energy use (32%) because these industrial facilities rely heavily on carbon-intensive fuels such as coal, coke, and electricity (which is predominately coal-based) and use relatively small amounts of lower carbon fuels such as natural gas and renewables.

Based on this calculation, the Top-1000 program energy consumption scenarios presented earlier can be converted to energy-related CO_2 emissions scenarios. Figure 10 shows the projected emissions for the baseline and emissions reduction scenarios. Table 3 provides the details of the calculations. Based on the energy consumption projection, the baseline CO_2 emissions for the Top-1000 program enterprises are projected to grow from

2,228 $MtCO_2$ in 2005 to 3,089 $MtCO_2$ in 2010. If the program goal is met, as shown in the "Target" scenario, energy-related emissions for the Top-1000 enterprises would be 2,785 $MtCO_2$, a cumulative savings of 304 $MtCO_2$. Under the "Current Trends" scenario that assumes that the reported 2007 first quarter savings of 24 $MtCO_2$ resulted in annual savings of 97 $MtCO_2$ and these savings are repeated in 2008, 2009, and 2010, the 2010 energy-related CO_2 emissions would be 2,639 $MtCO_2$ and cumulative 2010 emissions reductions would be 450 $MtCO_2$.



Baseline Scenario = annual energy growth based on 2004-2006 actual (6.7% per year)
Target Scenario = 61 MtCO2 (20 Mtce savings) per year 2006-2010 to achieve 300 MtCO2 (100 Mtce) target
Current Trends Scenario = 97 MtCO2 (32 Mtce) savings per year 2007-2010
Note: Emissions based on 2006 fuel mix; electricity reported as source, accounting for generation, transmission, and distribution losses

Figure 10. Actual (2004 to 2006) and Projected 2010 Baseline, Target, Current Trends, and Increased Energy-Related CO_2 Emissions Reduction Scenarios for the Top-1000 Energy-Consuming Enterprises Program

Table 3. Actual (2004 to 2006) and Projected (2007 to 2010) Energy-Related CO_2 Emissions of Top-1000 Energy-Consuming Enterprises Program Under Baseline, Target, and Current Trends Scenarios.

Top-1000 Energy-Related CO2 Emissions (MtCO2)							
Scenario	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Baseline Scenario (E/GDP elasticity=1, 10% growth)	2046	2228	2456	2701	2971	3268	3595
Actual to 2006, then Target Scenario	2046	2228	2423	2580	2789	3025	3291
Actual to 2006, then Current Trends Scenario	2046	2228	2423	2543	2716	2916	3145
T1000 savings annual - Target Scenario			61	61	61	61	61
T1000 savings cumulative - Target Scenario			61	122	182	243	304
T1000 savings annual - Current Trends Scenario			61	97	97	97	97
T1000 savings cumulative - Current Trends Scenario			61	158	255	353	450

Policy Implications

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 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. In this section, international experience in the areas of target-setting, supporting policies, information dissemination, and monitoring, is first discussed and then the experience with these key program components in the Top-1000 program is described. Suggestions are made for improvements that may be implemented during the remaining years of the program or that can be seen as lessons learned for any possible follow-on programs.[7]

Target-Setting

The process for establishing energy efficiency or greenhouse gas (GHG) emission reduction targets begins with an assessment – by the company or an independent third party – of the energy efficiency or GHG mitigation potential of each industrial facility. Assessment results are then provided to the government as the basis for target-setting negotiations.

In the UK's Climate Change Agreement program, the government obtained information regarding energy efficiency potential in energy-intensive industries through guides and case studies produced within the Energy Efficiency Best Practices Program (Shock, 2000) as well as through scenarios of industrial sector carbon dioxide emissions (ETSU, 1999). In addition, individual companies estimated their energy efficiency potential and provided this information to their trade associations who then negotiated with the government to set a target for the entire sector. The negotiations were informed by the information on energy efficiency potential and general standards of energy management in the sector.

In the Netherlands, Long-Term Agreements (LTAs) in The Netherlands between the Dutch Ministries and industrial sectors were established in support of the overall national energy-efficiency improvement target of a 20% reduction in energy efficiency between 1989 and 2000. Sector-specific energy-efficiency potential studies were the basis for distributing the targets among the various industrial sectors. Following the studies, NOVEM,[8] the Dutch Agency for Energy and Environment, established an inventory of economically-viable measures that could be implemented by the companies in each industrial sector and based on this inventory set a target for energy efficiency improvement for each sector (Nuijen and Booij, 2002). While most industries adopted a target of 20% reduction, some negotiated different levels due to the particular circumstances of their industrial sector. For example, the petroleum refining industry's

[7] Some of this discussion is based on material presented in McKane et al., 2007 and Price et al., 2008.
[8] Now SenterNovem.

overall target was a 10% reduction, while the target for Philips Lighting was a 25% reduction. In addition to the target, the agreements outline specific commitments for individual companies, including preparation of an energy conservation plan and annual monitoring of developments in energy efficiency.

The Dutch Benchmarking Covenants, which began in 2001, use a benchmarking approach for target-setting in which an expert third party undertakes a study of the international best practice in terms of energy efficiency for each participating company's processing plants. The results of the international best practice benchmarking study are then sent to the Benchmarking Commission to verify the accuracy and completeness of the expert third party's methods and results of the study (Commissie Benchmarking, 1999).

In Japan's Keidanren Voluntary Action Plan on the Environment, which commits to stabilizing greenhouse gas emissions of Keidanren members at 1990 levels by 2010, numerical savings targets were set voluntarily by 38 sectors in 1997. The number of sectors has since grown to 58, including 35 from industrial and energy-converting sectors. Individual firms commit to targets within their industrial associations but these are not legally binding. Individual targets are set following technical and economic analyses of energy-saving technologies and potential. Firms have chosen absolute targets, intensity targets, and targets for improving the energy efficiency of products. Of the 35 industrial sectors, 12 committed to absolute CO_2 emissions reduction targets, 9 to CO_2 intensity reduction targets, 5 to absolute energy use reduction targets, and 15 to energy intensity targets (Wakabayashi and Sugiyama, 2007).

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 savings target of 100 Mtce (2.9 EJ) for the Top-1000 Program. Initially, NDRC set preliminary targets for each enterprise taking into consideration their general situation such as which industrial sector they belonged to since the potential energy savings vary by sector, as well as the general technology level of the enterprise, if known. 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. Since the Top-1000 Program was designed in support of the 11th Five Year Plan which began in 2006, it would have been necessary to start the target-setting process three or four years prior to follow international practice, which was impossible given both the time pressure and the large number of participating enterprises. The resulting target of 100 Mtce (2.9 EJ) only represents 15% or less of the required savings of 646 to 700 Mtce (19 to 20.5 EJ) (depending upon the assumed growth rates) to meet the 2010 goal of reducing energy use per unit of GDP. Given the energy-intensity of these industries, more detailed assessments may have identified higher potential energy savings for these industries and a more ambitious goal could have been set for the Top-1000 program based on the potential savings identified.

Supporting Policies

Target-setting programs also typically establish a harmonized set of supporting programs for participating enterprises. Ideally, such policies and programs should be in place at the commencement of the program so that enterprises have a full understanding of the type and range of support they will receive as they set out to achieve their targets. Such policies typically include financial incentives, technical assistance, rewards and publicity for enterprises that reach targets, and sometimes penalties for failure to reach targets. Financial incentives for investing in energy-efficiency technologies and measures include targeted grants or subsidies, tax relief, and loans for investments in energy efficiency. Tax relief for purchase of energy-efficient technologies can be granted through tax exemptions, tax reductions, and accelerated depreciation. A common approach is to provide a list of technologies for special tax treatment (Price et al., 2005b). In countries such as Denmark, the Netherlands, Sweden, and the U.S., funding covering 40% to 100% of the cost of energy-savings assessments is provided, often as a benefit of participating in target-setting programs (WEC, 2004).[9] In the Climate Change Agreements in the UK (DEFRA, 2004) and the Danish energy efficiency agreements (Togeby et al., 1999), incentives for meeting agreed-upon targets are provided in the form of a reduction of the required energy tax. Payment of the full tax if the target is not met can be viewed as a form of penalty. If targets are not met within the French AERES agreements, a penalty fee is imposed at the end of two evaluation periods (AERES, n.d.).

Supporting policies and programs for the Top-1000 program were not established prior to the announcement of the program. Instead, the *1,000 Enterprise Energy Conservation Action Implementation Plan* (NDRC, 2006a), which was issued in April 2006, outlined that that government would begin efforts in the following areas:

- **Strengthen Energy Saving Supervision Management According to the Law**…investigate enforcement of national energy saving law, regulations, policies, and standards; investigate energy management status, and energy saving technology improvement, and the retirement of outdated technologies; increase the level of supervision of illegal and non-authorized activities, strictly investigate and handle energy waste in this investigation… establish stricter management systems, strengthen the responsibility system, complete incentive policy implementation, establish supervision mechanisms and system; increase the level of punishment.
- **Implement Strengthened Energy Savings Tax and Fiscal Policy.** …accelerate the formulation and implementation of beneficial tax and fiscal policies, especially with regard to resource savings. According to the progress of tax and fiscal reform, develop an income tax and incentive policy for enterprises that produce products covered by the *Energy and Water Savings Products Directory* and the *Resource Comprehensive Utilization Directory*; research the potential implications of value

[9] The exception to this approach is the European Union's Emissions Trading Scheme where the EU countries allocated emissions targets on the basis of past emissions while only small efforts are being made to account for a company's ability to abate its emissions, but with a complex trading market in place to enable enterprises to sell excess emissions credits or purchase emissions credits to cover gaps between their actual performance and their target.

added tax introduction with respect to resource saving technologies, equipment, and products within a given time frame.

- **Increase Support Level of Energy Saving Improvement Projects.** Establish a budget channel to support enterprise energy savings improvements; lead social investment in energy savings; provide financial support to strengthen enterprise energy saving abilities; research and establish multiple channels for project finance; coordinate national-level state banks, international financial institutions to provide low interest loans for Thousand Enterprise technology improvements.
- **Establish Energy Saving Technology Dissemination New Mechanism** …accelerate the retirement of outdated high energy consuming equipment, and promote the dissemination of highly efficient energy saving technologies and products…cultivate specialized energy-saving technology service system, particularly promote integrated energy management, provide so-called "One Dragon" service including from diagnostic, financing, design, retrofit, to operation and management for the energy saving transformation in the Thousand Enterprises.
- **Summarize, Honor and Award Advanced Models**. By comparing the annual result of domestic and international advanced level, regularly select some "National Energy Saving Advanced Enterprise" and "National energy saving advanced individuals;" advanced energy saving enterprises will be honored, advanced energy saving individuals will be awarded. At the same time, enterprises that successfully implement energy savings will serve as examples through national media reports.

Although given the time constraints for developing and implementing the Top-1000 Program, it is understandable that the full program was not established at the time it was announced, this did weaken the initial impact of the program due to lack of clarity regarding what the central government would offer to the enterprises and how the program should be implemented at the provincial level. For example, in November, 2006, a number of provincial government officials, who were given provincial level energy/GDP reduction targets in addition to responsibility for overseeing successful implementation of the Top-1000 Program for those enterprises located in their province, expressed concern and confusion over the establishment of both provincial and national level policies and programs in support of the Top-1000 Program at the Energy Foundation's *Forum on Implementing China's 2010 20-Percent Energy Efficiency Target*. As described earlier, a number of these supporting policies and programs have subsequently been developed and put in place during 2006 and 2007, while others are still in discussion or have not yet been established.

Information Dissemination

Internationally, information dissemination is an important component of target-setting and other industrial energy efficiency programs. Technical information sources such as energy efficiency guidebooks, databases, software tools, and industry- or technology-specific energy efficiency reports are produced in many countries (Galitsky et al., 2004). The U.S. Department of Energy's (US DOE's) Industrial Technologies Program provides many software tools for assessing energy efficiency of motors, pumps, compressed air systems, process heating and steam systems, as well as Sourcebooks that provide

information on these industrial systems and a Quick Plant Energy Profiler online software tool that helps industrial plant personnel understand how energy is being used at their plant and how they may save energy and money.[10] The USDOE also provides case studies that describe energy-efficiency demonstration projects in operating industrial facilities in the aluminium, chemicals, forest products, glass, metal casting, mining, petroleum, steel, cement, textiles, and other sectors and sourcebooks, tip sheets, technical fact sheets and handbooks, and market assessments for steam, process heating, compressed air, and motors, pumps, and fans. Case studies providing information on commercial energy-saving technologies for a number of industrial sectors are also provided by the Centre for Analysis and Dissemination of Demonstrated Energy Technologies (CADDET).

Energy efficiency reports or guidebooks provide information on existing and new technologies and measures as well as energy management practices. Examples include Australia's Energy Efficiency Best Practice Guides, the Netherlands' descriptions of energy efficiency projects undertaken by LTA members, Norway's Industrial Energy Efficiency Network sector reports, and the UK Carbon Trust technology guides. The Canadian Industry Program for Energy Conservation's sector-wide energy efficiency guides provide information on energy efficiency measures for aluminium, automotive, brewery, cement, dairy, foundry, lime, pulp/paper, rubber, and solid wood industries. The U.S. ENERGY STAR for Industry Energy Guides include both process-specific and utility energy efficiency measures for breweries, cement, corn refining, fruit and vegetable processing, glass, motor vehicle assembly, petroleum refining, and pharmaceuticals. As part of the Dutch Long-term Agreements 2 (LTA2), SenterNovem and representatives of the sector develop and maintain a "measurement list" of possible efficiency improvements that consists of a detailed description of the measure, investment costs, energy savings, returns on investment and if financial support is available for the measure.[11]

The Top-1000 program currently has not developed a systematic means for gathering or disseminating energy efficiency information sources to the participating enterprises.[12] As previously mentioned, 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.[13] The Top-1000 web page on NDRC's website, however, simply provides short news articles reporting on related notices, meetings, and Provincial activities.

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[10] See http://www1.eere.energy.gov/industry/bestpractices/software.html

[11] SenterNovem presents lists with energy efficiency improvements for more than 20 sectors on their website: http://www.senternovem.nl/mja/tools/maatregellijsten/index.asp. To determine the return on investment (ROI), SenterNovem developed a tool to determine ROIs of measures. This Excel tool can be downloaded from: http://www.senternovem.nl/mmfiles/tvt_ncw_tcm24-111964.xls (in Dutch).

[12] The Energy Foundation has funded Lawrence Berkeley National Laboratory to develop energy efficiency guides, which are being translated by ERI, that identify international energy-efficiency technologies for a number of energy-intensive industries.

[13] The presentations from that workshop are posted on the NDRC website: http://hzs.ndrc.gov.cn/jnxd/t20061108_92567.htm

Monitoring

International experience indicates that is extremely important to establish effective monitoring guidelines at the beginning of an energy-efficiency or target-setting program. Clear and transparent monitoring guidelines should be outlined that give enterprises an overview of what needs to be reported, when it should be reported, how it should be reported and to whom. Enough detail should be provided at the beginning of the project about how the project's savings will be documented and what level of accuracy is desired. Ideally, monitoring also includes verification by an independent third party that will validate the submitted information and oversee the monitoring procedures. It is important to clearly define the monitoring process, outline the format and requirements of monitoring reports, and provide clear definitions regarding energy use and energy saving measures. According to the U.S. National Action Plan for Energy Efficiency, a monitoring and verification (M&V) plan should include the project description, inventories (where appropriate), description of the proposed measure(s), estimates of energy savings, a budget for M&V, and proposed construction and M&V schedules (Schiller, 2007). Any metering and analysis should be designated to be performed consistently, logically and with accuracy acceptable to all parties. Details for key elements and an example M&V plan are given in the report.

The monitoring requirements of the Dutch LTAs, which were outlined in a handbook (Novem, 1999), involved annual reporting on the energy-efficiency improvement achieved, including data on total energy use, the Energy Efficiency Index level achieved, and progress on the projects carried out to reach the Energy Efficiency Index for that year. For example, the data required for the steel industry included total primary energy consumption for twelve types of steel end products, including four intermediate steel products (e.g. coke, sinter, pellets and pig iron). For each product step the energy consumption was converted into primary energy consumption and the energy intensity of each step was calculated. Corrections were allowed for changes in the mix of products, extra energy use as a result of stricter environmental regulations, and the degree of capacity utilization of existing product installations (Hoogovens Technical Services, 1992; NIJSI and MEA, 1992). The annual reports were submitted to an independent third party to check the reported values for accuracy (Nuijen, 2002).

Companies that take part in the Dutch LTA2 are required to submit annual monitoring reports to SenterNovem on the progress they have made implementing their energy conservation plan (ECP). These corporate monitoring reports give companies a general view of how well they are succeeding in realizing their energy efficiency targets so that management can confirm the company policy or make an interim revision. SenterNovem uses the corporate monitoring report to assess whether a company is making enough effort to realize its ECP by evaluating the company's energy efficiency goals, the measures intended to be employed, and the schedule for reaching the goals. A corporate monitoring report provides yearly insight into the company's progress with implementing the Long-Term Agreements and the ECP. The report must provide data on the improvement in energy efficiency in the relevant facility/facilities compared to 1998 (the reference year), and the realized emissions reduction of CO_2. SenterNovem presents

the LTA branch reports in a yearly brochure, thus providing an overview of the energy-saving measures taken by Dutch companies and the results they have achieved (SenterNovem, 2005; Novem, 1999). In the Dutch Benchmarking Covenants, an independent Benchmarking Verification Bureau monitors the covenant, verifying that each company has completed the different stages in the benchmark process, ensuring that the definition of the world lead is adequate, determining that the energy efficiency plan has been properly developed, and providing feedback on this to the company and to the competent authority (Commissie Benchmarking, n.d.).

Each entity participating in the UK Climate Change Agreements is required to report primary energy used for each type of fuel, carbon emissions, throughput, product mix adjustments, and emission trading adjustments for the target period. The UK Department for Environment, Food, and Rural Affairs provides detailed guidance, including spreadsheets, related to a number of issues such as changes in corporate ownership, accounting for combined heat and power, and use of emissions trading (DEFRA, 2008).

Companies participating in the Japanese Keidanren Voluntary Action Plan perform annual surveys of their achievements, which are made public. In addition, the Advisory Committee on Natural Resources and Energy and the Industrial Structure Council also annually review the surveys submitted by the industries. Within Keidanren, there is also an Evaluation Committee that evaluates and provides feedback on the industry reports (Wakabayashi and Sugiyama, 2007).

The National Bureau of Statistics (NBS) is in charge of collecting data from the enterprises for the Top-1000 program. There is a generic spreadsheet that can be used for all Top-1000 plants to report their energy consumption by fuel quarterly on-line. The Top-1000 reporting is directly to NBS online via a website, not through regional statistical bureaus. The data collection is done in this manner to improve accuracy and reliability, to make it easier for the enterprises, and to reduce work for regional statistical bureau staff members. NBS will release information on average or total energy use or energy use by industry, but not by specific enterprise. Enterprise-specific data is, however, provided to NDRC. Capacity building is needed for training for enterprises to operate the on-line reporting system, for development of an indicator system, for development of standards for boundary setting, and for data analysis. As currently structured, there is 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). In addition, there is no 3rd party review or verification of the reported results at the enterprise, sector, provincial, or national level.

Conclusions and Recommendations

The Top-1000 program is an ambitious effort to reduce energy consumption of China's largest energy-consuming enterprises between 2005 and 2010. The reported energy savings for the first year of the program (2006) indicate that it is on target to reach the program goal of saving 100 Mtce in 2010. Based on preliminary reports of progress in

2007, the program may even surpass this goal if current savings trends are maintained. A "Current Trends" scenario found that energy savings in 2010 would be 148 Mtce (4.3 EJ). When calculated in terms of saved CO_2 emissions, the potential impact of the Top-1000 program on reducing future growth of emissions from the Chinese industrial sector is enormous. Meeting the 2010 energy-savings target will result in energy-related CO_2 emissions reductions of 300 $MtCO_2$, an amount equivalent to the 2005 annual emissions of Poland. Emissions reductions of 450 $MtCO_2$ will be realized under a "Current Trends" scenario, saving the equivalent of South Korea's 2005 annual energy-related CO_2 emissions.

Recommendations for improvement to the Top-1000 program, or to any similar subsequent programs in the 12th Five Year Plan that address industrial energy efficiency, are to carefully evaluate the potential for energy-savings at the enterprise level in order to establish ambitious, yet realistic energy-saving targets, improve energy auditing capacity, increase information dissemination through establishment of a central information depository that can collect and distribute reports, tools, case studies, and other materials to Provincial-level energy conservation centers as well as to the enterprises themselves, and strengthen the monitoring and reporting so that annual reports can clearly explain what has worked and what needs improvement in terms of the implementation of the program.

A number of specific recommendations that were previously provided in Price and Wang (2007) have since been partially or fully implemented in conjunction with the Top-1000 program, such as development of a system of rewards for enterprises. The recommendations are repeated here for further consideration:

- Establish a package of *effective supporting policies* designed explicitly for the Top-1000 program as soon as possible in order to provide enterprises with appropriate incentives and support for achieving their targets
- Develop *supporting policies at the provincial level* that can supplement national-level supporting policies by offering increased or supplemental incentives, further technical support, and additional publicity
- Direct *energy efficiency investment incentives* – such as subsidies, grants, loans, and tax relief – towards expensive yet high energy-saving investments that may be otherwise disregarded by enterprises due to the high initial investment costs
- Produce a *Shandong Province case study* describing the policies and energy management systems implemented in the Energy Efficiency Agreement Pilot Project in order to understand and disseminate lessons learned
- Assess the possible application of *energy taxes or other fiscal mechanisms* within the Top-1000 program
- Evaluate establishment of a *system of awards* for enterprises that meet their targets – and possibly a system of penalties for those that fail to meet their targets – in terms of how the award funding would be generated and whether such awards could be offered at a level that would provide motivation to enterprises

- Have sector associations or other sector-specific experts develop *energy efficiency information sources* for identifying energy-savings technologies and measures for the Top-1000 enterprise sectors
- Develop *benchmarking tools* in conjunction with sector associations or other sector-specific experts to assist with evaluation of each enterprise's energy efficiency potential, to provide a simplified energy auditing tool, and to assist in development of each enterprise's energy action plan
- Develop detailed *energy management guidance documentation* based on international best practice, including a framework to standardize, measure and recognize industrial system optimization efforts
- Review a sample of the *enterprise audit reports* to determine whether they are comprehensive and high-quality and to identify areas where further training related to specific elements of energy auditing could improve audit quality
- Establish a *database or directory of energy auditing entities*, identifying their areas of expertise
- Review a sample of the *enterprise energy action plans* to determine whether they are comprehensive and high-quality and to identify areas where further training related to specific elements of development and use of energy action plans could improve their quality
- Develop *enterprise-level monitoring and reporting guidelines* that include not only reporting on annual energy use, but also information on annual production levels, enterprise organizational changes, and on progress on the specific energy-saving activities outlined in the enterprise action plan be developed.
- Explore the potential for development of an *energy and greenhouse gas management tool* based on the World Resources Institute/World Business Council for Sustainable Development's Greenhouse Gas Protocol and testing of the use of this protocol in specific Top-1000 industrial sectors
- Ensure that an *evaluation system* is in place that is capable of providing feedback on program and policy design so that the Top-1000 program can be adjusted during the 2005 to 2010 period if such adjustments are indicated by the evaluation and so that the evaluation results from the Top-1000 program can be effectively used to design any similar post-2010 programs
- Engage key sector-focused industrial associations and research institutions to *develop and deliver sector-specific information* for energy audits, energy benchmarking, and identification of energy-efficient technologies and measures, working with provincial-level energy conservation centers and technical universities to build their sector-specific capabilities
- Establish the *National Energy Conservation Center* and/or another national-level energy information dissemination and training center as soon as possible to play a coordination role for many elements of the Top-1000 program
- Conduct a limited number of *study tours* to countries in Europe and other countries with strong target-setting programs for enterprise representatives from enterprises that are playing a leading role within the Top-1000 program

- Evaluate the possibility of holding an *industrial energy efficiency conference* similar to ACEEE's Summer Study on Energy Efficiency in Industry in China in order to expose more Chinese to the latest developments in industrial sector research on energy-efficient technologies, measures, policies, and programs
- Establish a *Chinese/English language website* that provides information on international experience with supporting policies, program elements, program development and design, and program delivery for target-setting programs to compliment and link to NDRC's Top-1000 Program website
- Coordinate with *international programs that can contribute to key Top-1000 program elements* such as the United Nations Development Program/Global Environmental Facility End-Use Energy Efficiency Program, the EU-China Energy and Environment Programme for Promotion of Benchmarking Tools for Energy Conservation in Energy Intensive Industries, U.S. Department of Energy Industrial Technologies Program, the Jiangsu Demand-Side Management, and the U.S. Environmental Protection Agency/Ministry of Environmental Protection/Asian Development Bank Private Sector Financing Project in order to ensure that advantage is taken of overlapping activities and that collaborative efforts are undertaken whenever possible
- Coordinate with *international programs that have a Chinese industrial energy efficiency component* such as the Asia Pacific Partnership for Clean Development and Climate, the Clean Development Mechanism of the Kyoto Protocol, and the International Energy Agency – World Bank Energy Efficiency Indicators Project in order to ensure that advantage is taken of overlapping activities with the Top-1000 program and that collaborative efforts are undertaken whenever possible

Even though the Top-1000 program was designed and implemented rapidly and did not fully implement best practices regarding establishment of targets, development of supporting policies and programs, information dissemination, and monitoring and evaluation, it appears that – depending upon the GDP growth rate -- it could contribute to somewhere between approximately 10% and 25% of the savings required to support China's efforts to meet a 20% reduction in energy use per unit of GDP by 2010. China has not yet succeeded in realizing the annual savings needed to meet the 20% reduction goal. In 2006, energy consumption per unit of GDP declined 1.33% compared with 2005 and in 2007 energy consumption per unit of GDP declined 3.27% compared with 2006 (NDRC, 2008). Although the annual target of 4% reduction in energy intensity was not reached, these two years represent the first drop in this metric since it began to increase in 2002.

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