LBNL-54879

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Designing Energy Conservation Voluntary Agreements for the Industrial Sector in China: Experience from a Pilot Project with Two Steel Mills in Shandong Province

Lynn Price, Ernst Worrell, Jonathan Sinton

Environmental Energy Technologies Division

May 2004

This work was supported under the U.S. Department of Energy Contract No. DE-AC02-05CH11231.

Disclaimer

Designing Energy Conservation Voluntary Agreements for the Industrial Sector in China: Experience from a Pilot Project with Two Steel Mills in Shandong Province

Lynn Price, Ernst Worrell, Jonathan Sinton

Energy Analysis Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, Berkeley, California, United States

Abstract. China faces a significant challenge in the years ahead to continue to provide essential materials and products for a rapidly growing economy while addressing pressing environmental concerns. China's industrial sector consumes about 70% of the nation's total energy each year and is heavily dependent on the country's abundant, yet polluting, coal resources. Industrial production locally pollutes the air with emissions of criteria pollutants, uses scarce water and oil resources, emits greenhouse gases contributing to climate change, and produces wastes. Fostering innovative approaches that are tailored to China's emerging market-based political economy to reduce the use of polluting energy resources and to diminish pollution from industrial production is one of the most important challenges facing the nation today. The use of Voluntary Agreements as a policy for increasing energy-efficiency in industry, which has been a popular approach in many industrialized countries since the early 1990s, is being tested for use in China through a pilot project with two steel mills in Shandong Province. The pilot project was developed through international collaboration with experts in China, the Netherlands, and the U.S. Designing the pilot project involved development of approaches for energy-efficiency potential assessments for the steel mills, target-setting to establish the Voluntary Agreement energy-efficiency goals, preparing energy-efficiency plans for implementation of energy-saving technologies and measures, and monitoring and evaluating the project's energy savings.

* This work was supported the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

1. INTRODUCTION

The use of Voluntary Agreements as a policy for increasing energy-efficiency in industry, which has been a popular approach in many industrialized countries since the early 1990s, is being tested for use in China through a pilot project with the steel industry in Shandong Province. China faces a significant challenge in the years ahead to continue to provide essential materials and products for a rapidly growing economy while addressing pressing environmental concerns. China's industrial sector consumes about 70% of the nation's total energy each year and is heavily dependent on the country's abundant, yet polluting, coal resources. Industrial production locally pollutes the air with emissions of criteria pollutants, uses scarce water and oil resources, emits greenhouse gases contributing to climate change, and produces solid wastes. Fostering innovative approaches that are tailored to China's emerging market-based political economy to reduce the use of polluting energy resources and to diminish pollution from industrial production is one of the most important challenges facing the nation today.[i]

2. INDUSTRIAL ENERGY USE IN CHINA

Globally, the industrial sector accounts for about 40% of primary energy use. In 1998, developing countries used an estimated 48 EJ for industrial production, over one-third of world total industrial primary energy use (Price et al., 1998). Industrial output and energy use in developing countries is dominated by China, India, and Brazil. China alone accounts for almost 30 EJ, or about 23% of world industrial energy use (National Bureau of Statistics, 1999).

China's industrial sector is extremely energy-intensive and accounts for about 70% of the country's total primary energy use. Industrial energy use in China has grown about 5% per year since 1980 (Sinton et al., 1996; National Bureau of Statistics, 1999). This growth is five times faster than the average growth that took place in the industrial sector worldwide during the same time period.

The industrial sector can be divided into light and heavy industry, reflecting the relative energy-intensity of the manufacturing processes. In China, about 80% of the energy used in the industrial sector is consumed by heavy industry. Of this, the largest energy-consuming industries are building materials, ferrous metals, and chemicals (Sinton et al., 1996).

3. INDUSTRIAL ENERGY EFFICIENCY POLICY IN CHINA: 1980-2000

Energy-efficiency policy in China has evolved greatly since the People's Republic was established in 1949. At that time and for the next few decades, rapid growth in energy supply was the main energy policy in China. Energy prices were subsidized, a central allocation system provided energy primarily to the industrial sector, and little attention was paid to the environment or energy efficiency. As a result, China's rapidly growing energy system was extremely inefficient (Levine, 2000).

In 1980, following a meeting of more than 100 non-governmental energy experts who declared that China's energy policy was in a crisis situation and required radical restructuring, the Chinese government implemented an extensive series of reforms beginning with the Sixth Five-Year Plan which took effect in 1981 (Levine, 2000). The government announced that it would place equal emphasis on development of energy supply and energy conservation in order to ensure an adequate supply of energy, emphasizing energy conservation in the near term (Lu, 1993). Many energy-efficiency policies and programs were developed and implemented by the central government. Most of these programs were directed toward the industrial sector.

Energy management offices, departments, and agencies were established at all levels of government to implement, manage, monitor, and enforce the numerous rules, standards, and programs related to energy conservation. The Office of Energy Conservation Work in the State Council oversaw all of the efforts. Ministries for specific industrial sectors, such as the Metallurgy Ministry, focused on sector-specific issues. The China Energy Conservation Association, the National Supervising Center of Energy Conservation, and the Energy Conservation Testing Technology Service Centers, along with provincial energy conservation agencies, were also established

Energy efficiency and energy conservation management for the industrial sector during this period involved controlling energy intensity and energy supply through the use of quotas. Energy conservation goals were set in the form of physical energy intensity standards for various manufacturing processes. Other standards addressed industrial equipment such as boilers and motors. Success in attainment of the standards was considered when allocating energy supply quotas for industrial enterprises (Sinton et al., 1998; Liu et al., 1994). Other energy management efforts included dissemination of energy-efficient technologies and products, retiring energy-intensive mechanical and electrical devices, restricting energy-wasting production practices, and monitoring enterprise energy conservation.

Low interest loans for energy conservation projects, tax breaks for energy-efficient products, and monetary energy conservation awards for enterprises were all used to encourage investment in energy efficiency. Funding for energy-efficiency investments was provided by the newly established China Energy Conservation Investment Corporation (CECIC). During this period, energy-efficiency funding for capital construction, retrofits, and transformation projects was equivalent to $16.5 billion (1995 US$) (Sinton et al., 1998).

Information on energy use and intensities was gathered through the national resources conservation and comprehensive utilization network and statistics were compiled by the energy statistical reporting system. National, local, and sectoral energy conservation technology service centers were also established. Education and training programs included the establishment of energy conservation training centers. Over 200 energy conservation centers were established during this period to provide energy monitoring and efficiency services, develop and promote energy-saving technologies, and perform feasibility studies (Liu et al., 1994).

An analysis of the energy savings that resulted from these energy-efficiency efforts found that if energy intensity had remained frozen at 1977 levels, then China would have used 80 EJ in 1995, more than twice as high as the actual consumption of 36 EJ that year (Sinton et al., 1998). Decomposition analyses have shown that most of the energy savings during this period were due to reductions in energy intensity, not structural shifts toward less energy-intensive industry (Huang, 1993; Lin, 1992; Palmer, 1992; Sinton, 1996; Sinton and Levine, 1994; Worrell et al., 1997).

In 1993, the Chinese government enacted a number of significant financial reforms, initiating China’s transition to a market-based economy. Energy price reforms included deregulation of coal prices, increases in oil prices, and partial deregulation of electricity prices. A simplified tax code introduced in 1994 eliminated tax rate reductions and tax breaks on energy-efficiency technology development and investment projects. Some banks also began to reduce low-interest lending for efficiency projects.

In 1997, the Chinese government passed the Energy Conservation Law (ECL) which provides broad guidance for the establishment of energy-efficiency policies in China. Article 20 of the ECL requires substantial improvement in industrial energy efficiency in 7200 key energy-consuming industrial facilities in China. This portion of the Law states that "the State will enhance energy conservation management in key energy-consuming entities."

A number of provincial administrations have formulated implementing regulations in accordance with the ECL: Shandong, Shanghai, Beijing, Zhejiang, Jiangsu, Shanxi, Gansu, Sichuan, Yunnan, and Hubei. Although a review of the Shandong, Zhejiang, and Shanghai implementing regulations characterized them as vague (Wang, 1999), they are still an important step toward providing provincial governments with the tools required to implement energy conservation programs within their jurisdictions.

During this period, energy quotas were eliminated and monitoring of energy intensity levels declined. In 1998, most industrial ministries were demoted to the bureau level and placed under the authority of the State Economic and Trade Commission (SETC). Industrial bureaus were merged into a single Industrial Management Department within SETC in 2000. Quality of statistical collection diminished as state control over enterprises weakened.

In 1999, SETC issued a catalogue of "Outdated Technology Processes and Products" initiating an effort to phase out non-competitive processes or products that consume too much energy or are polluting. The two volumes of this catalogue address 11 industrial sectors (China Environmental Review, 2000). SETC also mandated closure of some inefficient petrochemical plants as well as hundreds of small cement and glass plants, mainly in northern China, small refineries, coal mines, sugar mills, and paper mills for financial, energy efficiency and environmental reasons. This campaign was extended in 2000 to include over 200 small iron and steel plants (China Daily, 2000a and 2000b; Nengyuan, 2000), and similar initiatives continue today.

The 10th Five-Year Plan, which became effective in March 2001, includes a renewed focus on energy end-use efficiency and productivity improvement, development of supporting regulations for the ECL at the local and sectoral levels, formulation of annual energy conservation plans to improve energy utilization efficiency and productivity, formulation of preferential economic policies to support energy conservation demonstration and dissemination projects, enhanced energy management of key energy-using enterprises, and harnessing of grass-roots social forces to save energy.

In 1999, the U.S.-based Energy Foundation, through its China Sustainable Energy Project, funded the China Energy Conservation Association (CECA), under the State Economic and Trade Commission (SETC), and Lawrence Berkeley National Laboratory (LBNL) to began a project with the goals of: 1) developing implementing regulations and relevant standards for the ECL to promote industrial energy conservation and improvement of energy efficiency and 2) promoting the new planning in energy-intensive sectors for energy efficiency to reduce energy consumption of key enterprises (CECA, 2000). CECA, along with a Policy Review Team made up of Chinese energy analysts, experts from Tsinghua University, as well as former staff of China's Ministry of Metallurgy, worked with LBNL and international experts to determine the best approach for reaching these goals. These efforts include analyzing international industrial energy efficiency policies and programs and their adaptability to China, analyzing the status and opportunities for energy conservation in key energy-intensive industrial sectors, reviewing existing energy conservation regulations and policies, and making recommendations for new regulations and policies that work well under a "market-based" economy. The result of these efforts was to recommend further evaluation of the use of Voluntary Agreements for increasing energy efficiency in the industrial sector.

4. INTERNATIONAL EXPERIENCE WITH VOLUNTARY AGREEMENTS

Voluntary Agreements to meet specific energy-use or energy-efficiency targets are used in the industrial sector in many countries around the world (Bertoldi, 1999; Chidiak, 1999; Hansen and Larsen, 1999; Mazurek and Lehman, 1999; Newman, 1998; Paton, 2002). Such agreements can be viewed as a tool for developing a long-term strategic plan for increasing industrial energy efficiency that fully engages not only the engineers and management at industrial facilities, but also includes government, industry associations, financial institutions, and others. An agreement or target can be formulated in various ways. Two common methods are those based on specified energy-efficiency (or energy intensity) improvement targets and those based on absolute energy use or greenhouse gas emissions reduction commitments. Either an individual company or an industrial subsector, as represented by a party such as an industry association, can enter into such agreements.

Voluntary Agreements typically have a long-term outlook, covering a period of five to ten years. The agreements focus the attention of all actors on energy efficiency or greenhouse gas emissions reduction goals. The key elements of Voluntary Agreement programs are the assessment of energy-efficiency potential of the participants as well as target-setting through a negotiated process with all parties. Supporting programs and policies, such as audits, assessments, benchmarking, monitoring, information dissemination, and financial incentives, all play roles in assisting the participants in meeting the target goals.

In its review of 350 voluntary actions and programs, the International Energy Agency found that "past and present experiences with voluntary actions show that, properly designed and implemented, they can achieve stated objectives, sometimes even exceeding those of minimum regulatory standards, and help integrate economic and environmental goals" (IEA, 1997). Another analysis of seven Voluntary Agreement programs found that the programs could be credited with about 50% of the observed energy-efficiency improvement or emissions reductions. In addition to these so-called direct effects of the programs, there are also important medium- and long-term impacts including: changing attitudes and awareness of managerial and technical staff regarding energy efficiency; addressing market, institutional, and regulatory barriers to technology adoption and innovation; fostering market transformation to establish greater potential for sustainable energy-efficiency investments; promoting positive dynamic interactions between different actors involved in technology research and development, deployment, and market development; and facilitating cooperative arrangements that provide learning mechanisms within a sector or industry to combine knowledge and develop new competencies in industry (Dowd et al., 2001; Delmas and Terlaak, 2000).

Based on experience to date, the "Seven Golden Rules" for these type of agreements are: 1) make sure they are negotiated agreements based on assessments of energy efficiency potentials that are more than "business-as-usual", 2) set clear, well-defined targets and specific timetables for achieving those targets, 3) ensure long-lasting government support in the form of policies and programs that assist industries in implementing energy-efficiency improvements, 4) focus on large, energy-intensive industries to start with because this is where the greatest savings are found, 5) establish clear monitoring guidelines, 6) evaluate progress using physical energy intensity measurements, and 7) provide for independent verification of progress (Blok, 2000).

5. ENERGY CONSERVATION VOLUNTARY AGREEMENT PILOT PROJECT IN SHANDONG PROVINCE

The Energy Conservation Voluntary Agreement Pilot Project with two iron and steel enterprises in Shandong Province was modeled after successful international industrial Voluntary Agreement programs, taking China-specific conditions into consideration (Price et al., 2003a). The main participants in the pilot project are 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, now NDRC), and the China Energy Conservation Association (CECA).[ii]

The two steel mills participating in this project have both invested in energy-efficient technologies in the past, but are different in terms of scale and management approach. The Jigang steel mill was built in 1958 and currently produces about 3.0 million tonnes of steel. This plant has four coking furnaces with coke dry quenching, six blast furnaces, two basic oxygen furnaces, one electric arc furnace, and slab and billet continuous casting machines. Jigang is located outside of Jinan, the capital city of Shandong Province, and benefits from a close relationship with the provincial government. The Laigang steel mill was built in 1970 and produces about 2.5 million tonnes of steel per year. The blast furnace, electric arc furnace and basic oxygen converter are all small scale. The product finishing lines are very modern and use state-of-the-art technology. Laigang uses a modern management style and they have been able to attract non-governmental capital from the Asian Development Bank and the Shandong's World Bank-sponsored Energy Management Center to make investments in energy-conservation equipment.

For the Voluntary Agreements, the two iron and steel enterprises are responsible for assessing the current energy-efficiency potential of their enterprises, developing energy-efficiency targets and energy conservation plans, and implementing these plans in order to achieve the agreed-upon targets. The energy-efficiency sector targets of the Energy Conservation Voluntary pilot policy program are based on physical energy intensity metrics.

Using international Voluntary Agreement schemes as a model, the targets were set through a process in which the government and enterprises negotiate the target level based on detailed evaluations of the potential for energy-efficiency improvement in a given industrial sector. Article 4 of China's ECL provides general guidance for establishment of such a program, stating that "the State Council and the governments of provinces, autonomous regions and municipalities directly under the central government should: strengthen their efforts in energy conservation; restructure industry, enterprises, products, and energy consumption patterns; promote technological progress for energy conservation; reduce energy consumption per unit of economic output and energy consumption per physical unit of product;…and encourage the national economy to develop in an energy-efficient manner" (PRC, 1997).

SETC and the Shandong ETC fulfilled the government role in the pilot project and determined which supporting programs to include in the pilot to assist the enterprises in reaching their energy-efficiency targets. An expert Technical Team assisted in evaluating the enterprises' targets and will evaluate the project progress annually.

6. METHODOLOGY FOR ASSESSMENT OF ENERGY-EFFICIENCY IMPROVEMENT POTENTIAL

Assessment of the energy-efficiency improvement potential for each participating enterprise is an essential element in the design of an Energy Conservation Voluntary Agreement Pilot Program because it provides all parties to the Voluntary Agreement with the same information regarding the current energy consumption at the enterprise as well as the options available to reduce energy consumption. This information was needed for negotiating an ambitious, yet realistic energy conservation target. The energy-efficiency assessment was an essential first step for development of energy-efficiency targets and detailed Energy Conservation Plans to document the actions to be taken to reach the Voluntary Agreement targets.

LBNL developed a *Methodology for Assessment of Enterprise Energy-Efficiency Potential* for the steel industry Energy Conservation Voluntary Agreement Pilot Project that incorporates key elements of the various methods used in other countries and in China to determine the energy-efficiency potential of an enterprise. LBNL also developed a user-friendly computer spreadsheet tool to assist the pilot enterprises in implementing this methodology. The energy-efficiency assessment methodology involves determination of the enterprise's physical energy consumption based on total energy consumption for production of iron and steel at that enterprise (subtracting the offsite energy and energy used for non-production purposes).[iii] This "total production energy intensity" is calculated for each major process step at the enterprise.

Once the total production energy intensity was calculated, the technical and achievable energy-efficiency potentials for each enterprise were determined. The technical energy-efficiency potential was calculated by comparing the total production energy intensity for each pilot enterprise with benchmark energy intensities that represent internationally available state-of-the-art iron and steel production processes. The achievable energy-efficiency potential was determined by identification of inefficient processes within each enterprise and identification of technologies and measures that could be implemented to improve the energy efficiency of the enterprise, based on the feasibility and cost-effectiveness of implementing technologies. The potential energy intensity reductions associated with implementation of these technologies and measures were estimated to determine the achievable energy-efficiency potential, which was in turn used to set the Energy Conservation Voluntary Agreement Pilot Project targets.

The energy-consuming processes of iron and steel enterprises can be analyzed based on the energy used by fuel type for each process step in the production of iron and steel. The information required includes all energy inputs, recovered energy and energy used for self-generation, as well as the data needed to calculate the process-step energy intensity of the enterprise.

In order to determine the technical energy-efficiency potential for the pilot iron and steel enterprises, the enterprise process-step total production energy intensity must be compared to the process-step energy intensity of a benchmark "state-of-the-art" iron and steel enterprise. Such benchmarks can be constructed using either a hypothetical energy-efficient steel plant[iv] or benchmarking to an actual energy-efficient steel plant.[v] For the Energy Conservation Voluntary Agreement Pilot Project an energy-efficiency assessment spreadsheet tool was developed that provides benchmark energy-efficiency values for each major steelmaking process step.[vi]

Once the actual energy intensity and benchmark energy intensity have been calculated for each enterprise, they can be used to construct an Energy Efficiency Index (EEI). The EEI is a measurement of the total production energy intensity of an enterprise compared to a benchmark energy intensity. For the Energy Conservation Voluntary Agreements, the EEI is used to calculate enterprise energy-efficiency potential and it is used for evaluating enterprise progress toward the chosen energy-intensity target.

The EEI can be used to calculate enterprise energy-efficiency potential by comparing actual enterprise energy intensity to the energy intensity that would result if the enterprise used "state-of-the-art" technology for each process step. The difference between the actual energy intensity, which is the energy use per ton of product produced, and that of the reference or benchmark technology, is calculated for each of the key process steps of the enterprise and then aggregated for the entire enterprise. The aggregated EEI is calculated as follows:

$$EEI = 100 * \frac{\sum_{i=1}^{n} P_i \cdot EI_i}{\sum_{i=1}^{n} P_i \cdot EI_{i,B}} = 100 * \frac{E_{tot}}{\sum_{i=1}^{n} P_i \cdot EI_{i,B}} \quad (1)$$

Where:

EEI	= energy efficiency index
n	= number of process steps to be aggregated
EI_i	= actual energy intensity (EI) of process step i
$EI_{i,B}$	= benchmark energy intensity (EI) of process step i
P_i	= production quantity for process step i
E_{tot}	= total actual energy consumption for all process steps

The EEI provides an indication of how the actual total production energy intensity of the enterprise compares to the benchmark energy intensity. By definition, a plant that uses the benchmark technology will have an EEI of 100. In practice, all plants will have an EEI greater than 100. The gap between actual enterprise energy intensity at each process step and the reference level energy consumption can be viewed as the technical energy-efficiency potential of the plant. The EEI is an initial screening tool that helps to identify which processes are most efficient and which are most inefficient compared to state-of-the-art conditions and which are most likely to have a substantial potential for energy-efficiency improvement.

The information developed using the *Methodology for Assessment of Enterprise Energy-Efficiency Potential*, including the enterprise total production energy intensity by process step, EEI, technical energy-efficiency potential by process step, and achievable energy-efficiency potential by process step are all fundamental for determining the enterprise Voluntary Agreement target.

7. DEVELOPMENT OF SUPPORTING POLICIES

While the enterprises were evaluating their energy-efficiency potential, the government entities developed policies to offer in support of the Voluntary Agreement. Supporting policies are the key motivational element to encourage enterprises to participate fully in the Voluntary Agreement program. Supporting programs and policies, such as government facilitation of the Voluntary Agreement negotiation and implementation process (including provision of technical assistance and information dissemination programs), enterprise audits and assessments, financial assistance and incentives, and government and public recognition all play an important role in assisting the participants in meeting the target goals. Supporting policies also include elimination or reduction of taxes or environmental regulations for participants.

Existing Voluntary Agreement programs use a variety of supporting policies to motivate and assist industry in reaching its energy efficiency or greenhouse gas emission reduction goals. Table 1 provides an overview of the supporting policies and measures in several Voluntary Agreement programs.

***Table 1**. Overview of Supporting Policies and Measures in Selected Voluntary Agreement Programs*

		Supporting Policies and Measures				
Country	*VA Scheme*	*Government Facilitation of VA Process*	*Audits and Assessments*	*Financial Assistance and Incentives*	*Government and Public Recognition*	*Exemption from Regulation and Taxes*
Australia	Greenhouse Challenge	X			X	
Canada	Canadian Industry Program for Energy Conservation	X			X	
Denmark	Agreements on Industrial Energy Efficiency	X	X	X		X
Netherlands	Long Term Agreements	X	X	X	X	X
Sweden	EKO-Energi	X	X		X	
UK	Make a Corporate Commitment, Climate Change Agreements	X			X	X

8. TARGET-SETTING

After the assessment of enterprise energy-efficiency potential was completed and supporting policies were established, all parties to the Voluntary Agreement turned to target-setting. Target-setting is an essential element of Voluntary Agreements. Targets provide all parties to the agreement with a quantitative goal to be reached within the period of the Voluntary Agreement. An important precondition for realistic yet ambitious target-setting is that all parties have the same information regarding the enterprise energy-efficiency potential as well as the governmental supporting policies to assist the enterprise in implementing energy-efficiency technologies and measures.

Using information developed through the assessment of enterprise energy-efficiency improvement potential, as well as information on historical and planned energy intensity reductions at each plant, CECA and the Technical Team worked with representatives at the enterprises and the local government to set achievable yet challenging targets for energy-efficiency improvement within the Pilot Project. During the assessment of enterprise energy-efficiency improvement potential, the calculations of current total production energy consumption and energy intensity by process were made for each of the pilot enterprises. The potential energy intensity in 2005 and was also calculated for both a “business-as-usual” and a “with Voluntary Agreement” scenario. These values, combined with information on historical and planned energy-intensity reductions at each enterprise, were used by all parties to the Voluntary Agreement to determine the targets for the Energy Conservation Voluntary Agreement Pilot Project.

9. SHANDONG PROVINCE VOLUNTARY AGREEMENT WITH LAIGANG AND JIGANG STEEL MILLS

The Voluntary Agreement between Shandong ETC and Laigang and Jigang steel enterprises was signed in April, 2003. At the signing ceremony, both national and provincial decision makers highly praised the sector target Voluntary Agreement approach and stated that they would like to widen implementation within Shandong Province and throughout China in the future.

The signed Voluntary Agreement outlines the targets for both steel enterprises. The parties to the Voluntary Agreement decided to use an energy-intensity target based on two standard Chinese metrics instead of the EEI for this pilot.[vii] In addition, the Energy Conservation Rate (ECR), based on comparable energy intensity, will be used to measure the change in intensity over time. In keeping with the national Five-Year Plan schedule, the base year for the targets will be 2000. The parties to the Voluntary Agreement chose a target for 2005 and expect to choose a further target for 2010 in 2005.

Supporting policies for the Energy Conservation Voluntary Agreement Pilot Project include incentive policies provided by the Shandong provincial government as well as the NDRC. The policies to be provided by Shandong ETC are:

- Give priority consideration to the two pilot enterprises under existing preferential policies.
- Coordinate the provision of guarantees for loans and other financial activities required for energy-efficiency projects at the pilot enterprises.
- Use various media to publicize the energy-conservation achievements and contributions of the pilot enterprises.
- Organize intermediary organizations to provide the pilot enterprises with policy, technical, management, and other advice and services.
- Upon evaluation, exempt the pilot enterprises from monitoring of the status of energy utilization.

In addition, NDRC will be requested to provide the following supporting policies:

- For energy-conservation benefits realized through energy-conservation projects, and in accordance with resources comprehensive-utilization policy, investigate and propose recommendations for preferential policies to encourage energy conservation.
- Give priority support to projects undertaken by the pilot enterprises that fulfill the criteria set by national preferential policies.
- Grant a portion of research and development costs for projects undertaken by the pilot enterprises that have significant results in energy and resource conservation and comprehensive utilization, short payback times, and outstanding economic and social benefits, to support enterprises to carry out energy-conservation research and development.
- Give priority to the pilot enterprises when bringing in foreign investment capital.
- Award pilot enterprises the honorable title of “China Energy-Efficiency Voluntary Agreement Pilot Enterprise”.

10. LESSONS LEARNED

Preliminary lessons learned from the development of the Shandong Province Enterprise Energy-Efficiency Voluntary Agreement Pilot are that while the general concepts of negotiated agreements and of the value of energy-efficiency improvement in industry were easily comprehended and accepted by the Chinese involved in this project, more specific components of the successful Voluntary Agreements from around the world were not immediately understood or ultimately adopted.

Historically, Chinese industry has operated under annual quotas for energy consumption that were accompanied by fines and penalties if exceeded. Voluntary Agreements, on the other hand, move away from this concept to a focus on long-range planning where annual energy-efficiency progress may fluctuate but ultimately the targets are met in the long run. In the Shandong Province pilot, however, this concept is missing; the pilot plan outlines annual targets for 2003 and 2005, accompanied with the threat of fines for exceeding the quotas. The pilot plan does not include targets for 2010 but rather allows for the development of further long-term pilots of 5 and 10 years duration after completion of this pilot. International advisors also advocated the use of a single, comprehensive energy-efficiency measurement system (the EEI). The Shandong Province pilot, however, uses two standard Chinese energy intensity metrics, neither of which adequately measure actual energy intensity trends at the enterprises.[viii] In addition, the pilot plan requests each enterprise to provide twelve additional measurements of energy-efficiency annually. Finally, while some of the supporting policies were established prior to the development of the targets, other supporting policies were not set but rather were advocated as possible policies that the central government could provide. This gives the enterprises no certainty regarding these polices and leads to a situation where relatively weak targets were set for 2005.

On the positive side, in addition to understanding the general concept of Voluntary Agreements and including all of the essential elements in the pilot project design, the Shandong pilot project has extended the energy conservation Voluntary Agreement into the area of environmental pollutants, requesting the enterprises to provide data on their sulfur dioxide and carbon dioxide emissions annually. This is an important link to be made in China, where the drivers for adoption of energy-efficient technologies include the reduction of local, regional, and global pollutants as well as reduction of energy consumption. Also, introducing a new policy mechanism can be a long process when dealing with multiple levels of government as well as members of industry that are unclear on the benefits they will accrue from the policy. The educational and motivational aspects of such an effort cannot be understated. The Shandong Voluntary Agreement pilot has provided the basis for the development of 15 Voluntary Agreements between a diverse array of enterprises and the municipality of Tsingdao (Qingdao) (Qingdao News Net, 2003) and the use of Voluntary Agreements with 8 pilot enterprises in the *Energy Conservation and GHG Emissions Reduction in Chinese Township and Village Enterprise* project of the United Nations Development Programme, the Global Environment Facility, United Nations Industrial Development Organization, and the Chinese Ministry of Agriculture (UNIDO, 2004). Finally, the mechanism of Voluntary Agreements is included as an industrial policy initiative in the upcoming, multi-year China End-Use Energy Efficiency Program of the NDRC, United Nations Development Programme, and the Global Environment Facility (SETC/UNDP/GEF, 2002).

11. ACKNOWLEDGMENTS

This project has been conducted by the State Economic and Trade Commission (SETC), now National Development and Reform Commission (NDRC). This project was sponsored by the China Sustainable Energy Program of the Energy Foundation. Significant technical support for this project was provided by Lawrence Berkeley National Laboratory. Support for Lawrence Berkeley National Laboratory was provided by the China Sustainable Energy Program of the

Energy Foundation under contract number DE-AC03-76SF00098. The authors also acknowledge the invaluable assistance of Zhang Ruiying of the Energy Foundation, Jiang Yun of the China Energy Conservation Association, Wil Nuijen of Novem in the Netherlands, as well as Kornelis Blok and Dian Phylipsen of Ecofys in the Netherlands throughout this project. Finally, the authors would like to thank the members of the Chinese Policy Review Team for its guidance during this project.

12. REFERENCES

Bertoldi, P., 1999. "The Use of Long-Term Agreements to Improve Energy Efficiency in the Industrial Sector: Overview of the European Experiences and Proposal for a Common Framework," *Proceedings of the 1999 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry*. Washington, DC: ACEEE.

Blok, K., 2000. "Experiences with Long Term Agreements on Energy-efficiency Improvements in the European Union," Presentation at the *Workshop on Learning from International Best Practice Energy Policies in the Industrial Sector*, May 22-23, 2000, Beijing.

Chidiak, M., 1999. "Voluntary Agreements for Energy Efficiency in Five EU Countries," in *Energy Efficiency and* CO_2 Reduction*: The Dimensions of Social Change: 1999 European Council for an Energy-Efficient Economy Summer Study*, May 31-June 4, Mandelieu, France.

China Daily. 2000a. "China to Close Down 50 Small Steelworks." 29 June. http://www.chinadaily.com.cn.

China Daily. 2000b. "Polluting Firms to be Closed Down." 9 May. http://www.chinadaily.com.cn.

China Energy Conservation Association. 2000. "China Sustainable Energy Program: Progresses on the 'Developing Chinese Regulatory Infrastructure' Project," document prepared for the Meeting of the Management Team and Policy Research Team, November 13-15, 2000.

China Environmental Review, 2000. *Legislation on Redundant Technology in China*, Summer 2000.

Delmas, M. and Terlaak, A., 2000. "Voluntary Agreements for the Environment: Innovation and Transaction Costs," CAVA Working Paper 00/02/13, February.

Dowd, J., Friedman, K, and Boyd, G., 2001. "How Well Do Voluntary Agreements and Programs Perform At Improving Industrial Energy Efficiency," *Proceedings of the 2001 ACEEE Summer Study on Energy Efficiency in Industry*. Washington, DC: American Council for an Energy-Efficient Economy.

Hansen, K, and Larsen, A., 1999. "Voluntary Agreements in Industry: A Comparative Description of the Process and a Normative Analysis," *Proceedings of the 1999 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry*. Washington, DC: ACEEE.

Huang, J-P., 1993. "Industry Energy Use and Structural Change: A Case Study of the People's Republic of China," *Energy Economics* 15(2): 131-136.

International Energy Agency, 1997. *Voluntary Actions for Energy-Related CO_2 Abatement*. Paris: OECD/IEA.

International Iron and Steel Institute, 1998. *Energy Use in the Steel Industry,* Brussels: IISI.

Levine, M.D., 2000. "Energy Efficiency Laws and Policies in China," Presentation to the *Earth Technologies Forum*, Washington DC, October 31, 2000.

Lin, X., 1992. "Declining Energy Intensity in China's Industrial Sector," *The Journal of Energy and Development*, 16(2): 195-218.

Liu, Z.P., Sinton, J.E., Yang, F.Q., Levine, M.D., and Ting, M.K., 1994. *Industrial Sector Energy Conservation Programs in the People's Republic of China during the Seventh Five-Year Plan (1986-1990).* Berkeley, CA: Lawrence Berkeley National Laboratory (LBL-36395).

Lu, Y., 1993. *Fueling One Billion: An Insider's Story of Chinese Energy Policy Development*. Washington, DC: Washington Institute Press.

Mazurek, J. and Lehman, B., 1999. "Monitoring and Verification of Long-Term Voluntary Approaches in the Industrial Sector: An Initial Survey," *Proceedings of the 1999 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry*. Washington, DC: ACEEE.

Michels, K., 2000. *ICARUS-4: Sector Study for the Iron and Steel Industry. Revision 2*. Utrecht, The Netherlands: Utrecht University, Department of Science, Technology and Society, NWS-E-2000-10

National Bureau of Statistics. 1999. *China Statistical Yearbook 1999*. Beijing: China Statistics Press.

Nengyuan. 2000. Goals for the Reduction in Production and Mine Closures for the Coal Industry in 2000. Nengyuan 2000(3):14. March.

Newman, J., 1998. "Evaluation of Energy-Related Voluntary Agreements," in Martin et al., (eds.) *Industrial Energy Efficiency Policies: Understanding Success and Failure: Proceedings of a Workshop Organized by the International Network for Energy Demand Analysis in the Industrial Sector*. Utrecht, The Netherlands, June 11-12, 1998 (LBNL-42368).

Palmer, W., 1992. E*lectric Power Shortages and the Chinese Economy*. PhD dissertation. Madison: University of Wisconsin, Department of Economics.

Paton, B., 2002. "Voluntary Environmental Initiatives and Sustainable Industry," in ten Brink, P., ed., 2002. *Voluntary Environmental Agreements: Process, Practice and Future Use*. Sheffield, UK: Greenleaf Publishing Ltd.

People's Republic of China, 1997. *The Law on Energy Conservation of the People's Republic of China.* Approved at the 28th Session of the Standing Committee of the Eighth National People's Congress.

Price, L., Michaelis, L., Worrell, E., and Khrushch, M., 1998. "Sectoral Trends and Driving Forces of Global Energy Use and Greenhouse Gas Emissions," *Mitigation and Adaptation Strategies for Global Change* **3**: 263-319.

Price, L., Worrell, E., Sinton, J., and Jiang, Y., 2001. "Industrial Energy Efficiency Policy in China," *Proceedings of the 2001 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry*, Washington, DC: ACEEE (LBNL-50452).

Price, L., Sinton, J., Worrell, E., Phylipsen, D., Hu, X., and Li, J., 2002. "Energy Use and Carbon Dioxide Emissions from Steel Production in China," *Energy* 27: 429-446.

Price, L. Jiang, Y., Worrell, E., Du, W., Sinton, J.E, 2003a. *Development of an Energy Conservation Voluntary Agreement Pilot Project in the Steel Sector in Shandong Province: Report to the State Economic and Trade Commission, People's Republic of China*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-51608).

Price, L., Worrell, E., Sinton, J., and Jiang, Y., 2003b. "Voluntary Agreements for Increasing Energy Efficiency in Industry: Case Study of a Pilot Project with the Steel Industry in Shandong Province," *Proceedings of the 2003 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Industry*, Washington, DC: ACEEE (LBNL-52715).

Qingdao News Net, 2003. "15 Enterprises Sign Voluntary Energy Agreements," *Qingdao Evening News*, November 6th, 2003.

Sinton, J.E. and Levine, M.D., 1994. "Changing Energy Intensity in Chinese Industry: The Relative Importance of Structural Shift and Intensity Change," *Energy Policy* 22(3): 239-258.

Sinton, J.E., 1996. *Energy Efficiency in Chinese Industry: Positive and Negative Influences of Economic System Reforms*. PhD dissertation. Berkeley, CA: University of California, Energy and Resources Group.

Sinton, J.E., Fridley, D.G., Levine, M.D., Yang, F., Zhenping, J., Xing, Z., Kejun, J., Xiaofeng, L., 1996. *China Energy Databook*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBL-32822 Rev. 4).

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

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

State Economic and Trade Commission/United Nations Development Programme/Global Environmental Facility, 2002. *China's End-use Energy Efficiency Program (EUEEP): Project Brief*. Beijing.

United Nations Industrial Development Organization, 2004. *Energy Conservation and GHG Emissions Reduction in Chinese TVEs - Phase II.* http://www.unido.org/en/doc/4536

Wang, A.L., 1999. *A Comparative Analysis of the 1997 Energy Conservation Law of China and the Implementing Regulations of Shandong, Zhejiang, and Shanghai*. NY: Natural Resources Defense Council.

Worrell, E., Price, L., Martin, N., Farla, J., and Schaeffer, R., 1997. "Energy Intensity in the Iron and Steel Industry: A Comparison of Physical and Economic Indicators," *Energy Policy* 25(7-9): 727-744.

Worrell E., Martin, N., and Price, L., 1999. *Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-41724).

---

[i] This paper contains excerpts from Price et al., 2003a; Price et al., 2003b; Price et al., 2001.

[ii] The SETC was recently 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).

[iii] Offsite energy use includes energy used to heat homes and buildings that are not directly part of the iron and steel plant, as well as energy used for transport outside the plant. Internal transport energy use is included (Price et al., 2002).

[iv] Data for a construction of a hypothetical energy-efficient steel plant are available from the International Iron and Steel Institute in IISI, 1998. This document provides data for both a hypothetical "All-Tech" plant that includes technologies that may not be currently economical but lead to significant energy savings and a hypothetical "Eco-Tech" plant that is based on the use of technologies and measures that are considered economical. These values can be used to construct a benchmark "All-Tech" or "Eco-Tech" comparable energy intensity. The difference between this benchmark value and the total production energy intensity values for each pilot enterprise could be considered to represent the technical energy-efficiency potential.

[v] Another source of data for a "state-of-the-art" benchmark are values for an actual energy-efficient steel enterprise, such as the Shanghai Baosteel plant. Data from this plant or other world-class energy-efficient steel enterprises could be used to calculate a "state-of-the-art" benchmark comparable energy intensity.

[vi] The simple computer spreadsheet tool that has been developed for use in the Energy Conservation Voluntary Agreement Pilot Project is based on the IISI "Eco-Tech" plant (IISI, 1998).

[vii] The two Chinese intensity metrics are comparable (*kebi*) and comprehensive (*zonghe*) energy intensity. The comparable energy intensity normalizes production relative to the ratio of iron to steel produced in order to provide a metric to compare steel plants within China and to plants in other countries. The comprehensive energy intensity metric includes all plant energy use, including uses not directly linked to the production of steel such as for employee homes and schools, as well as other on-site facilities.

[viii] The enterprises and Shandong ETC are currently re-visiting the possibility of using the EEI for monitoring progress.