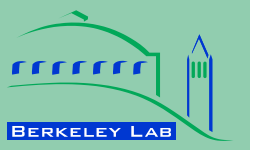

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Energy Audit Practices in China: National and Local Experiences and Issues

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Abstract

China has set an ambitious goal of reducing its energy use per unit of GDP by 20% between 2006 and 2010. Since the industrial sector consumes about two-thirds of China's primary energy, many of the country's efforts are focused on improving the energy efficiency of this sector. Industrial energy audits have become an important part of China's efforts to improve its energy intensity. In China, industrial energy audits have been employed to help enterprises indentify energy-efficiency improvement opportunities for achieving the energy-saving targets. These audits also serve as a mean to collect critical energy-consuming information necessary for governments at different levels to supervise enterprises' energy use and evaluate their energy performance.

To better understand how energy audits are carried out in China as well as their impacts on achieving China's energy-saving target, researchers at the Lawrence Berkeley National Laboratory (LBNL) conducted an in-depth study that combines a review of China's national policies and guidelines on energy auditing and a series of discussions with a variety of Chinese institutions involved in energy audits.

This report consists of four parts. First, it provides a historical overview of energy auditing in China over the past decades, describing how and why energy audits have been conducted during various periods. Next, the report reviews current energy auditing practices at both the national and regional levels. It then discusses some of the key issues related to energy audits conducted in China, which underscore the need for improvement. The report concludes with policy recommendations for China that draw upon international best practices and aim to remove barriers to maximizing the potential of energy audits.

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1. Introduction

China's 11th Five Year Plan, which covers 2006-2010, includes a goal to reduce energy use per unit of gross domestic product (GDP) by 20%. China has introduced many policies, programs, and reporting requirements in support of the achievement of this goal (Levine et al., 2010). Since the industrial sector consumes between 60% and 70% of China's primary energy (depending upon accounting methods), many of the nation's efforts are focused on improving the energy efficiency of this sector.

Over the past five years, energy audits have been conducted at many industrial facilities in China. Industrial energy audits have become an important part of China's efforts to reduce its energy intensity. Practical information about energy audit practices in China is, however, little known to the outside world. To better understand how energy audits are carried out in China as well as their impacts on achieving China's energy-saving target, researchers at Lawrence Berkeley National Laboratory (LBNL) conducted an in-depth study, which involved research on relevant national policies as well as a series of in-person meetings.

This report presents the detailed findings of this study. It consists of four parts. First, it provides a historical overview of energy auditing in China over the past few decades, describing how and why energy audits have been conducted during various periods. Next, the report reviews current energy auditing practices at both the national and regional levels, which reveals that in China industrial energy audits have been employed to help enterprises indentify energy-efficiency improvement opportunities for achieving the energy-saving targets. These audits also serve as a mean to collect critical energy-consuming information necessary for governments at different levels to supervise enterprises' energy use and evaluate their energy performance.

The report then discusses some of the key issues related to energy audits conducted in China, identifying the areas in which further improvement is needed. These issues include the lack of a long-term mechanism to promote energy auditing, lack of a national level organization for implementation of energy audits, lack of proper motivation for enterprises to conduct energy audits, limited scope of energy audits, as well as the lack of strong incentives, proper guidelines, effective assessment tools, strong capacity, and proper training for energy audits. The report concludes with policy recommendations for China that draw upon international best practices and aim to remove barriers to maximizing the potential of energy audits.

2. Methodology

This study of energy audit practices in China relied upon both a review of national policy and guidelines relative to energy auditing and a series of in-person meetings with a variety of local entities involving in energy audits in six provinces and cities − Jiangsu, Hebei, Sichuan, Shanghai, Beijing, and Suzhou. The types of organizations with which LBNL researchers had meetings included local energy conservation centers, energy conservation supervision centers, a demand-side management guidance center, an energy-saving certification agency, energy

service companies (ESCOs), non-governmental organizations (NGOs), and university energy assessment centers.

To assist in the collection of information, a comprehensive questionnaire was designed and utilized during the interviews. The scope of the questionnaire included the purposes for conducting energy audits, entities involved in energy auditing, types of energy audits, energy auditing procedure, data collection, assessment tools, energy auditing training, funding for energy audits, energy audit reporting and reviews, as well as post-audit measures and evaluation.

3. Historical Review of Energy Auditing in China

Over the last three decades, energy audits in China have gone through four different periods, each serving different purposes. The shifting purposes and practices in various periods underscore the need for developing an energy audit system that will provide consistent guidance on identifying continuous energy-efficiency improvement opportunities.

3.1 Energy Performance Assessment (1980s-early 1990s)

From the 1980s through the early 1990s, management of enterprises in China was not market-based but instead relied upon government administration of enterprises through the implementation of an annual enterprise evaluation and rating scheme that rated enterprises based on their performance. The energy performance review was a part of the total enterprise evaluation system and was required for each enterprise.

During this period, energy audits were utilized as an effective tool for governments to assess the energy performance of enterprises, including evaluating the energy flows from operations, total energy consumption, energy use per unit of key products, and energy management practices. Results of the energy audits, along with other managerial factors, were used by governments to determine the overall rating of enterprises in terms of performance.

The energy auditing concept using various formats was introduced to China by the former European Economic Community as early as 1982 (Li, 2010). In 1989, the Asian Development Bank (ADB) collaborated with the Chinese government in launching an industrial technical assistance program (TA-1021) in which industrial experts from China and abroad worked together for three years to conduct pilot energy audits in five sectors including textiles, papermaking, refineries, cement, and fertilizer manufacturing. This program was followed by another ADB technical assistance program (TA-2087) in the early 1990s in which energy audits were carried out in eight additional industrial facilities. These ADB-supported energy audits helped China move beyond the use of energy audits for the sole purpose of energy performance evaluation to focus on evaluating energy-saving potentials, identifying energy-saving measures, analyzing the economics of energy-saving options, and assessing the feasibility of acquiring international loans to support energy efficiency improvement (Nan Yang Energy Saving Network, 2006a).

Large-scale energy audits conducted by Chinese governments ended in 1993 when the country transitioned to a more market-based economy and government administration was separated from enterprise business operations. However, China's strong efforts promoting energy efficiency, including conducting energy audits, in the 1980s had helped the country to quadruple gross domestic product (GDP) while only doubling energy consumption and thus laid a solid foundation for China to achieve an average 5% annual decline in energy intensity through the 1990s (Levine et al., 2010).

3.2 Energy System Diagnostics (1990s to early 2000s)

During the 1990s to the early 2000s, China's focus related to energy audits was mostly on formulating policy, developing guidelines, and implementing pilots. In 1997, the State Economic & Trade Commission (SETC) issued *Rules on Energy-Saving Management of Key Energy Consuming Entities* and initiated research on developing the reporting system of enterprise energy utilization. To guide these efforts, SETC and the China National Bureau of Technology Supervision jointly put together and published the *General Principle of Enterprise Energy Audit* (GB/T 17166-1997)[1], a national standard that has been widely used for energy audits in China since October 1, 1998 (see Appendix A for the English translation of the standard).

Some energy audit pilots were carried out at the local level during this period. One exemplary case was the local energy audit program developed by the Nan Yang Energy Testing and Inspection Institute in Henan Province, which focused on the following three areas:

- Performing diagnostics for identifying energy-saving potentials through energy balance analysis and from inspecting how production-related materials were used
- Identifying energy-savings gaps through robust monitoring and testing of energy-consuming equipment
- Developing comprehensive training materials and organizing training workshops to guide enterprises in identifying problems and solutions through energy audits

Since energy audits carried out by the Nan Yang Institute were not specially targeted at enhancing compliance but more at helping enterprises improve their energy efficiency and thus reduce the costs of their operations, Nan Yang's program attracted significant interest with increasing participation from enterprises both within and outside of Henan Province. Between 1990 and 2003, the Nan Yang Institute conducted more than 300 comprehensive energy audits for various types of industrial enterprises in nine sectors, identifying over 4,000 energy-savings measures and training over 400 trainers nationwide. Nan Yang's energy audit experience was promoted by SETC as a national model and followed by other parts of China (Nan Yang Energy Saving Network, 2006b).

During this period, local Energy Conservation Centers or Supervision Centers began to take on the responsibility of testing and monitoring the operation performance of key energy-consuming equipment as well as the accuracy of energy measurement devices (Li, 2010).

[1] GB (Guo Biao in Chinese) stands for "mandatory national standard", and "GB/T" means "recommended national standard".

3.3 Cleaner Production Audit (2003-today)

The *Cleaner Production Promotion Law,*[2] effective on January 1, 2003, mandates a cleaner production audit at least once every five years for enterprises whose pollution level exceeds the government pollution limit or any facilities that use toxic and hazardous materials or discharge toxic and hazardous substances during production. In 2004, NDRC and the former State Environmental Protection Administration (SEPA)[3] jointly promulgated a regulation entitled *Interim Measures for Clean Production Audits*, providing detailed guidance on the content and procedures of enterprise cleaner production audits, which include preparing for the audit, carrying out the audit, developing a plan for implementing proposed improvement measures, and preparing and submitting a cleaner production audit report to relevant environmental protection agency and Development & Reform Commission. The cleaner production audits are mainly conducted under the oversight of local environmental protection bureaus. Although these audits aim at reducing environmental pollution, they have been targeting industrial processes and systems that have caused the pollution from the use of energy and the operation of energy systems. Under this regulation, participating enterprises are required, when performing cleaner production audits, to conduct input-output analyses and establish a raw material balance, an energy balance, a water balance, and a pollution factor balance in order to identify the sources of energy waste, material loss, and pollution. The cleaner production audits can be performed by enterprises themselves, local cleaner production centers, industrial associations, or qualified engineering firms (SEPA, 2004).

To widely disseminate the use of cleaner production audits in enterprises to reduce industrial energy use and environmental pollution, the *Interim Measures for Clean Production Audits* calls for all enterprises to conduct voluntary cleaner production audits. It also encourages greater participation by enterprises through offering a variety of support to enterprises that carry out cleaner production audits and achieve significant results. This support includes giving well-performing enterprises honor rewards and public recognition, giving cleaner production projects a high priority for investment, and allowing enterprises to use pollution fees collected by governments to implement recommended measures.

As an effort in achieving China's ambitious goal of reducing energy intensity by 20% by 2010, the State Council issued a directive in 2007 expanded the mandatory cleaner production audits to cover any enterprises that have failed to meet energy-saving and pollution-reduction targets (State Council, 2007a).

Large-scale industrial cleaner production audits and subsequent implementation of recommended cleaner production measures have helped China achieve remarkable results in cutting energy use and reducing pollution in the nation's industrial facilities. According to incomplete statistical data, by the end of 2008, cleaner production audits have been carried out in over 10,000 industrial enterprises, spanning over a dozen sectors including iron and steel, nonferrous metals, printing and dyeing, textile, paper, power, petroleum, chemical, building

[2] The Clean Production Promotion Law was issued on June 29, 2002 and effective on January 1, 2003.
[3] It is now called Ministry of Environmental Protection (MEP).

materials, pesticides, electroplating, and manufacturing. Between 2006 and 2008, the implementation of cleaner production program has helped China save 9 TWh of electricity and 15 million tons of coal in total while achieving significant pollution and waste reduction (Guo, 2007; Duan et al., 2009; MEP, 2009).

3.4 Energy Auditing for Meeting Targets (2006-2010)

In the four years between 2002 and 2005, implementation of energy-efficiency measures became weakened and energy audits were somewhat sidelined in China due to an energy surplus and the rapid expansion of energy-consuming heavy industry. As a result, China's energy intensity did not decrease as it had in previous years, but increased at an average rate of 3.8% per year during this period.

In 2005 the Chinese government announced an ambitious goal of reducing energy consumption per unit of GDP by 20% by 2010. One of the key initiatives for achieving this goal is the Top-1000 program, which was launched in 2006 and targets the 1,008[4] largest energy-consuming enterprises across nine sectors that each consumed a minimum of 180,000 ton of coal equivalent (tce) of energy but combined accounted for one-third of China's total energy use and almost half of industrial energy use in 2004 (NDRC, 2006a).

Achievement of the energy-saving targets is tied directly to the government evaluation system in which results of energy-saving efforts have become an integral part of the annual job performance evaluation of responsible government officials and enterprise executives. Those who fail to meet specific energy-saving targets will face serious consequences ranging from being disqualified from receiving honor awards or financial incentives to being demoted (State Council, 2007b). To achieve the specific energy-saving targets, Top-1000 enterprises are required to fulfill six sets of tasks, one of which is to perform energy audits and develop energy –saving plans (NDRC, 2006a).[5] The mandatory energy audits – which are only required once for each participating enterprise unless they fail to pass the government review – have several components including an analysis of energy consumption throughout the enterprise, an examination of the energy measurement and reporting system, an assessment of the efficiency of equipment operations, an evaluation of energy use indicators of products and production, and a detailed plan for implementing efficiency improvement measures (NDRC, 2006b).

Relevant agencies in charge of energy conservation in governments at different levels are instructed to organize a team of experts to review both the energy audit reports and the energy-saving plans submitted by enterprises based on a set of criteria established by China's

[4] The number of participating enterprises has changed to 938 due to company merges or close of business.
[5] The six tasks that Top-1000 enterprises have to fulfill include: (1) implementing an energy-saving target responsibility system, (2) developing a sound energy measurement and energy statistics system and creating a routine system for reporting enterprise energy use, (3) carrying out energy audits and developing an energy-saving plan, (4) increasing investment to accelerate the technological transformation of reducing energy consumption, (5) establishing an incentive system for encouraging energy savings, and (6) strengthening information dissemination and training related to energy savings.

National Development and Reform Commission (NDRC). To properly evaluate and verify the enterprises' submissions, provincial and local agencies are required to organize random compliance audits in at minimum of 10% of all participating enterprises located in their respective regions. Those enterprises that have not submitted these reports or failed to meet the reporting requirements face disciplinary actions including publication of the enterprise's name and/or being prevented from receiving energy-saving incentives (NDRC, 2006b).

In 2007, China amended its Energy Conservation Law, setting a legal responsibility for key energy-consuming enterprises[6] to submit, among other things, an enterprise energy utilization status report on an annual basis. The amended law specifies that the energy utilization status report discuss enterprise energy use, efficiency of its energy system, realization of energy-saving goals, energy-saving results, as well as energy-saving measures, and must be reviewed and approved by relevant government agencies. The amended law does not, however, explicitly require enterprises to conduct regular energy audits with one exception that an enterprise is obligated to undertake an energy audit in the case that it fails to pass government examination on meeting specified energy use requirements (Energy Conservation Law, 2007).

While the focus of the central government's Top-1000 Program is on the largest energy-consuming enterprises, many provincial and local governments have launched equivalent programs aimed at reducing the energy intensity of local key energy-consuming enterprises in order to meet specific targets set for each region. For example, Shandong Province initiated an integrated key enterprise program in July 2006 covering a total of about 1,000 enterprises, including the 103 Top-1000 enterprises located in the province. Since then, about another 1,000 enterprises have been added to the program and now about 70% of total provincial energy consumption is covered by energy savings responsibility contracts at various levels of government. Shanxi Province initiated the "Double 100 Program" in July 2006 which initially included 86 key enterprises from the Top-1000 program and 114 "key enterprises". In 2008, the program was expanded to a total of 996 enterprises. Jiangxi Province initiated a program in 2007 covering 100 key enterprises including 19 Top-1000 enterprises and additional 81 enterprises designated by the province (World Bank, 2010.)

As part of these expanded local efforts, a larger number of enterprises that consume less energy than a Top-1000 enterprise are required to conduct energy audits and submit energy audit reports as well as energy-saving plans to the relevant local government agencies. Table 1 shows types and number of enterprises that are required to do energy audits in the provinces/cities where LBNL conducted interviews.

The energy audits performed and energy-efficiency measures identified in China's industrial facilities have helped the country to achieve a total reduction of energy intensity by 16% from

[6] According to the amended Energy Conservation Law, any enterprise consuming 10,000 tce of energy annually is regarded as a key energy-consuming enterprise. Key energy-consuming enterprises also include enterprises that are specified by relevant national and provincial authorities with annual energy consumption of less than 10,000 tce but more than 5,000 tce.

2006 to 2009 (NBS, 2009; NBS 2010), bringing China closer to meeting the 20% reduction target by 2010. The following section provides a detailed discussion of China's current energy auditing practices at both the central and provincial levels based on the regions studied for this report.

Table 1.Types and Number of Enterprises Required to Perform Energy Audits in Selected Provinces/Cities

Location	Annual energy consumption of enterprise required to perform energy audits (tce)	Number of local enterprises that were targeted for energy audits*
Hebei	100,000 or above	100
Jiangsu	60,000 or above	120
Beijing	20,000 or above	50
Shanghai	10,000 or above	359
Sichuan	10,000 or above	239
Suzhou	5,000 or above	569

Source: Local energy conservation centers
*Excluding Top-1000 enterprises

4. Review of Current Energy Auditing Practices in China

To gain a better understanding of China's current energy auditing practices and related issues, LBNL carried out a study reviewing relevant government documents and conducting — with the assistance of staff members from the Beijing-based Demand Side Management (DSM) Technical Center of the Natural Resources Defense Council — interviews with officials at local energy conservation centers, an energy conservation supervision center, a demand-side management guidance center, an energy-saving certification agency, energy service companies (ESCOs), non-governmental organizations (NGOs), and university energy assessment centers located in Shanghai, Beijing, Suzhou, Jiangsu, Hebei, and Sichuan.

The aim of the study was to examine China's energy auditing practices including the purposes for energy audits, types of entities that perform energy audits, types of energy audits, the ways that energy audits are conducted, the data collection process, the type of assessment tools used in assisting energy audits, energy auditing training, funding for energy audits, energy audit reporting and reviews, as well as post-audit measures and evaluation. These topics are discussed separately below.

Table 2 summarizes the different types of energy audits conducted in China, providing summary information on the types of audits, their purpose, duration, and scope, who requires the audits, who conducts the audits, and post-audit activities.

Table 2. Industrial Energy Audits in China At A Glance

Type	Purpose	Duration and Scope	Required by	Conducted by	Post-audit activities
Detailed audits to meet government mandate	Satisfy government mandate under Top-1000 Meet government cleaner production requirement	45 days to several months covering every facility of an entire company Includes an energy accounting audit and an energy opportunity assessment	Governments at both central and local level	Local energy conservation centers, cleaner production centers, industrial associations, ESCOs, engineering firms, universities	Implementation of measures Evaluation of implementation
Detailed quality assurance audits	Check the quality of government-mandated energy audits	Several weeks, examining the enterprises' energy data and their systems of measuring the data	Central government	Local energy conservation centers or local energy conservation supervision centers	Approval of enterprises' energy audit reports
Detailed verification audits	Verify enterprises' actual energy savings to process government incentives for energy-efficiency projects	Several weeks focusing on evaluating the performance of the implemented project including the actual savings	Central government	Certification agency, provincial energy conservation supervision centers, and provincial financial inspection centers	Government incentives are provided based on the verified savings
Detailed audits for identifying integrated solutions	Provide comprehensive value-added services to maximize enterprises' energy-saving potentials	Several weeks on entire facilities	Subsidiaries of multinationals	Large ESCOs (e.g., Schneider Electric)	Leverage other expertise to implement identified measures through energy performance contracting
Detailed internal audits	Enterprise internal audits to prepare for government mandated audits and/or to pursue superior performance with greater energy savings	Several weeks on entire facilities	Enterprises themselves	Enterprise energy centers or ESCOs	Implementation of measures identified by the audits
Targeted audits	Retrofit an energy-intensive subsystem or equipment	Several days focusing on subsystem or a specific piece of equipment or process	Enterprises	ESCOs or equipment manufacturers	Implementation of identified measures through energy performance contracting
Walk-through audits	Meet the goals of green supply-chain initiative	1-2 days on major energy consuming systems	Multinationals	International NGOs	Implementation of measures recommended by audits to allow local manufactures to get into the preferred supplier networks of the multinationals
Investment-grade audits	Increase access to finance for energy-efficiency projects	From a couple of days up to a month focusing on specific projects	Lenders or investors	Professional auditors hired by international NGOs or energy efficiency project investment company	Project implementation

4.1 Purposes for Conducting Energy Audits

Currently, energy audits are conducted in China to fulfill government requirements, as part of international cooperation efforts related to energy-efficiency improvement, as a mean of enhancing enterprise energy management capacity, and as a basis for investment decisions.

In China, industrial energy audits have been employed to help enterprises identify energy-efficiency improvement opportunities in order to meet required energy intensity reduction targets set by governments. Energy audits are also conducted as part of the cleaner production audits to achieve resource savings and pollution reduction. In most cases, energy audits serve in parallel as a means to collect critical energy-consumption information necessary for governments at different levels to supervise enterprises' energy use and evaluate their energy performance. In addition, special energy audits are either performed to assure the quality of government-mandated energy audits or carried out to verify enterprises' actual energy savings in order to process government incentives for energy-efficiency projects.

Some international organizations have teamed up with multinational automakers, retailers, and apparel brands to use the companies' influence to "green" their supply chains in China. For example, the World Business Council for Sustainable Development (WBCSD) has partnered with General Motors China to promote energy-efficient production processes in their supplier's facilities (Wang, 2010). The Natural Resources Defense Council (NRDC) has partnered with Walmart, H&M, Gap, Levis, and Nike to identify practical opportunities to reduce energy consumption, water use and pollution in China's textile sector. As part of these efforts, participating factories in China have opened their doors to energy assessments to identify opportunities to improve their energy use, water use and resource consumption in order to get into the preferred supplier networks of these multinationals (NRDC, 2010).

In some cases, energy audits are conducted for the purpose of helping enterprises enhance their ability to manage their energy use and to identify energy-saving opportunities. For example, commissioned by BaoSteel, one of the world's largest iron and steel makers, the Nan Yang Energy Testing and Inspection Institute conducted an energy audit that lasted eight months and evaluated 70% of the steel maker's facilities. The purpose of the audit was to help BaoSteel to learn from different perspectives how to identify energy management problems as well as energy-saving opportunities (Yu, 2010). In other cases, energy audits are performed at industrial facilities as the basis for performance contract agreements or for further engineering analysis needed for making investment decisions. Statistics and detailed information on the number of such energy audits are lacking, however.

4.2 Institutions Involved In Energy Auditing

According to NDRC's *Implementation of Top-1000 Enterprise Energy Saving Action Plan*, key energy-consuming enterprises are allowed to have mandatory energy audits (including energy opportunity assessments) performed either by their in-house energy specialists or by outside

auditors (NDRC, 2006a). To assure the credibility of the audit reports, enterprises normally acquire the auditing services from a professional entity that has been certified by relevant government agencies to qualify for the design and implementation of engineering projects. These kinds of entities include local energy conservation centers, energy conservation supervision centers, cleaner production centers, industrial associations, ESCOs, engineering firms, project design companies, and universities. Box 1 below describes the key functions of these entities.

Historically, local energy conservation supervision centers and energy conservation centers[7] have been the main entities undertaking enterprise energy audits. In recent years, however, they have stopped performing government-mandated energy audits to avoid bias since they are now in charge of evaluating and approving enterprise energy audit reports on behalf of the government. Aiming to make energy audits open and fair, some local governments have required that energy audits be conducted through a public bidding process. For example, the Beijing municipal government conducted a public selection of energy audit entities in 2007. During this process, ten organizations in Beijing were selected to perform citywide energy audits (Zhao, 2008).

Institutions involved in enterprise energy audits also include domestic certification agencies and international NGOs. For example, the China General Certification (CGC), an independent certification firm affiliated with China Institute of Metrology, has been conducting energy audits on behalf of the Ministry of Finance (MOF) to verify the energy-saving results of enterprises receiving incentives from the central government (CGC, 2010). CGC is a key member of a review team assembled by MOF and NDRC to evaluate enterprise's applications for MOF energy-saving incentives and to conduct audits to verify actual energy savings in order to process the incentive.[8]

International NGOs like NRDC and Japan's International Center for Environmental Technology Transfer (ICETT) have brought international auditors to China to conduct energy assessments in the textile and ammonia industries. Since June 2010, ICETT has teamed up with China Energy Conservation Association and Jiangsu Energy Conservation Technical Service Center to conduct a series of energy assessments targeting Jiangsu's ammonia industry (Jiangsu Energy Conservation Technical Service Center, 2010).

[7] In some places (e.g. Shanghai), energy conservation supervision centers and energy conservation centers are separate entities. In most places, however, energy conservation centers and supervision centers are combined as one entity.

[8] See Section 4.10 below for a description of the incentive program

Box 1: Functions of Various Organizations Involved in Energy Auditing

- Energy Conservation Center (ECC): an entity affiliated with the local government. Despite some variation, key functions of ECCs include policy research related to energy efficiency, development of energy-efficiency standards, conducting energy-saving pilots in key areas, evaluation and promotion of energy-saving products and technologies, provision of technical assistance, trainings, and education related to energy efficiency.
- Energy Conservation Supervision Center (ECSC): part of local government responsible for monitoring and inspecting the energy-related activities of institutions and individuals to ensure compliance with energy-saving related laws, rules, regulations and standards. ECSCs also investigate violations.

  ECSC's energy-saving inspection covers energy-consuming entities, energy-related investment projects, the production and delivery of energy-consuming products and equipments, entities pursuing energy production and energy business, and institutions providing energy services.
- Demand-Side Management Guidance Center (DSM Center): an entity affiliated with the local government (e.g, Hebei DSM Center) ora state-owned enterprise (e.g., the State Grid DSM Instruction Center). Main functions include promotion and training of DSM techniques and methodologies and dissemination of related information and best practices.
- Cleaner Production Center: an entity affiliated with the local environmental protection bureau. Main functions include supervision and evaluation of enterprises' cleaner production activities, certification of cleaner production auditing entities and professionals, development of demonstration pilots, provision of trainings, and dissemination of cleaner production information and technologies.
- Energy Certification Center: an independent entity authorized by China's State Certification Oversight Commission to certify the quality of energy-related products and verify energy savings resulting from the use of energy-efficient products or implementation of energy-efficiency projects (e.g. China General Certification Center).
- University Energy Assessment Center: a university-based interdisciplinary program focusing on utilizing university resources in supporting energy assessments, adoption of energy-efficient technologies, energy efficiency trainings, and dissemination of energy-efficiency information and best practices (e.g., the Energy Assessment Center at Zhejiang University and the Energy-Saving Assessment and Technology Center of Shanghai jiaotong University) .

4.3 Types of Energy Audits

Since enterprises are required to provide a significant amount of information relative to their energy use to the governments, the majority of energy audits carried out in China in recent years are detailed audits which normally take somewhere between 45 days to a couple of months and which cover every facility of an entire company. These audits focus on a broad range of areas related to enterprise energy use and opportunities for improvement. A typical energy audit in China includes two components. One is an energy accounting audit which examines an enterprise's energy consumption level and composition, energy flows, energy measurement and statistics, energy management procedures, the performance of all major energy-consuming equipment, energy consumption relative to products and production, levels and flows of raw material consumption, as well as energy costs. Enterprises participating in government-mandated energy audits are required to conclude the energy accounting audits with the submission of an energy audit report. The other component is an energy opportunity

assessment, which identifies the areas for efficiency improvement based on the examination of an enterprise's energy system and energy use. Participating enterprises are required to prepare an energy-saving plan as the final part of a completed energy assessment (NDRC, 2006a).

Detailed energy audits are also performed – usually under the request of a government agency – by relevant entities affiliated with the government (e.g., local energy conservation supervision centers) to check the quality of energy audits conducted by enterprises or by an energy certification agency to verify actual energy savings from enterprises' implementation of energy-efficiency projects. These kinds of special audits focus more on examining the enterprises' actual performance in energy use and energy data reporting as well as implementation of energy-efficiency projects and less on assessing enterprises' opportunities for efficiency improvement (CGC, 2010).

Not all detailed energy audits are government mandated, however. Some large energy service companies (ESCOs) - especially multinationals - have conducted detailed energy audits for identifying integrated solutions to energy efficiency. For example, Schneider Electric has conducted more than 40 large-scale, comprehensive energy assessments –primarily at facilities of the subsidiaries of foreign companies – covering a dozen industrial sectors in China in 2009. These detailed assessments focused not only on the electric distribution and automation and controls but also on leveraging other expertise to provide comprehensive value-added services that help enterprises maximize their energy-saving potentials (Shi, 2010).

In addition to the types of audits described above, there are some other types of audits that are conducted in China. One is a targeted audit which focuses on a subsystem that is energy intensive or a specific piece of equipment or process that is targeted for a retrofit, e.g. lighting, a boiler, a drying process, or compressed air system. Targeted audits are typically used by ESCOs in China since many domestic ESCOs are small in size with limited technical capability and thus focus merely on selected measures. Targeted audits are also used by equipment manufacturers who are more familiar with specific technologies, systems, and/or equipment.

Another type of energy audit is a walk-through audit, which normally takes one or two days. For instance, in the energy assessments performed in Shanghai and Jiangsu as part of the greening China's supply chain initiatives, auditors walked through a facility along with facility personnel and identified simple and standard energy-efficiency measures such as lighting replacements, transformer upgrades, variable speed drives, and high-efficiency motors. A walk-through audit is also used by auditors or facility energy mangers to determine whether a detailed audit is warranted.

Audits that identify a portfolio of energy-saving measures are a new type of energy assessment in China. Under a Jiangsu-California energy collaboration program, several U.S.-based organizations including the China-US Energy Efficiency Alliance, the Natural Resources Defense Council, and the Green Energy Economics Group working with China State Grid Demand-Side

Management Guidance Center and Jiangsu Economic and Trade Commission[9] carried out pilot assessments in two Top-1000 enterprises in Jiangsu. These assessments focused on identifying a mix of energy-saving measures for an industrial facility that combines the options that have a quick payback with those have longer payback but deeper energy-saving opportunities so that a portfolio of efficiency measures could be developed with a total return on the overall investment in the portfolio being attractive to enterprises (Shen, et al., 2009). Table 3 demonstrates the concept of developing a portfolio of energy-efficiency measures for an industrial facility. The energy portfolio assessment was praised by the relevant agencies in Jiangsu but has not been widely promoted in the region due to the lack of funding for conducting energy assessments.

Table 3. Example of Portfolio Composition of Energy-Efficiency Measures in an Industrial Facility

Measure	Construction Cost (Yuan)	Demand Savings (kW)	Energy Savings (kWh)	Energy Cost Savings (Yuan)	Simple Payback (years)
High-Efficient motors	2,428,292	324.2	2,001,288	1,025,660	2.4
Variable Speed Drives	4,604,000	1,889.6	1,5003,004	7,689,040	0.6
Synchronous Belts	1,647,421	168.0	1,302,897	667,735	2.5
Downsize Motors	75,232	11.3	82,117	42,085	1.8
Replace Transformers	3,100,500	123.8	1,084,410	555,760	7.0
Repair Compressed Air Leaks	270,224	337.8	2,670,741	1,368,755	0.2
Total	12,125,669	2,855	22,144,457	11,349,034	1.1

Source: Steve Booth et al., 2008.

In addition, the investor-grade energy audit concept has recently been introduced in China by some international organizations working in the country to promote greater energy-efficiency improvement. For example, ECO-Asia, a regional clean development and climate program of the United States Agency for International Development, and the Hong Kong-based Energy Efficiency Project Investment Company are conducting a series of investor-grade energy audits to help China's Hebei Province increase access to finance for energy-efficiency projects (Dreessen, 2010).

4.4 Energy Auditing Procedures

Enterprise energy audits in China typically follow the *General Technical Principle of Enterprise Energy Audit* (GB/T 17166-1997) – a recommended national standard guiding enterprise energy audits that has been effective since October 1, 1998. The standard provides a general framework relative to energy audits including the definition, scope, methodology, and procedures as well as the preferred component of the energy audit report. This voluntary standard recommends a four-step process for performing an energy audit, which includes

[9] Jiangsu Economic and Trade Commission has changed its name to Jiangsu Economic and Information Commission

developing an energy audit plan and task assignments, signing an energy audit agreement, conducting actual audits, and writing an audit report. Appendix 1 provides the translation of this national standard. There are also other specific national standards that provide guidance on particular aspects of energy audits. A comprehensive list of national standards relating to energy audits in China is provided in Appendix 2.

In addition to the national guidelines, local standards or procedures have been developed in accordance with the national guideline to guide local energy audits. Between 2006 and 2009, with the active participation of over 80 auditors from several universities and industrial associations, the Suzhou Energy Conservation Center in Jiangsu Province conducted detailed energy audits in 569 local key energy-consuming enterprises. If fully implemented, measures recommended by these audits could bring more than 4.5 million tce of estimated annual energy savings (Bei, 2010).The experience of energy auditing in Suzhou has been promoted by NDRC nationwide and its audit report format has been recommended by NDRC as a template (NDRC, 2009a; SECC, 2009). Figure 1 displays a flow diagram showing the process for conducting energy audits in Suzhou.

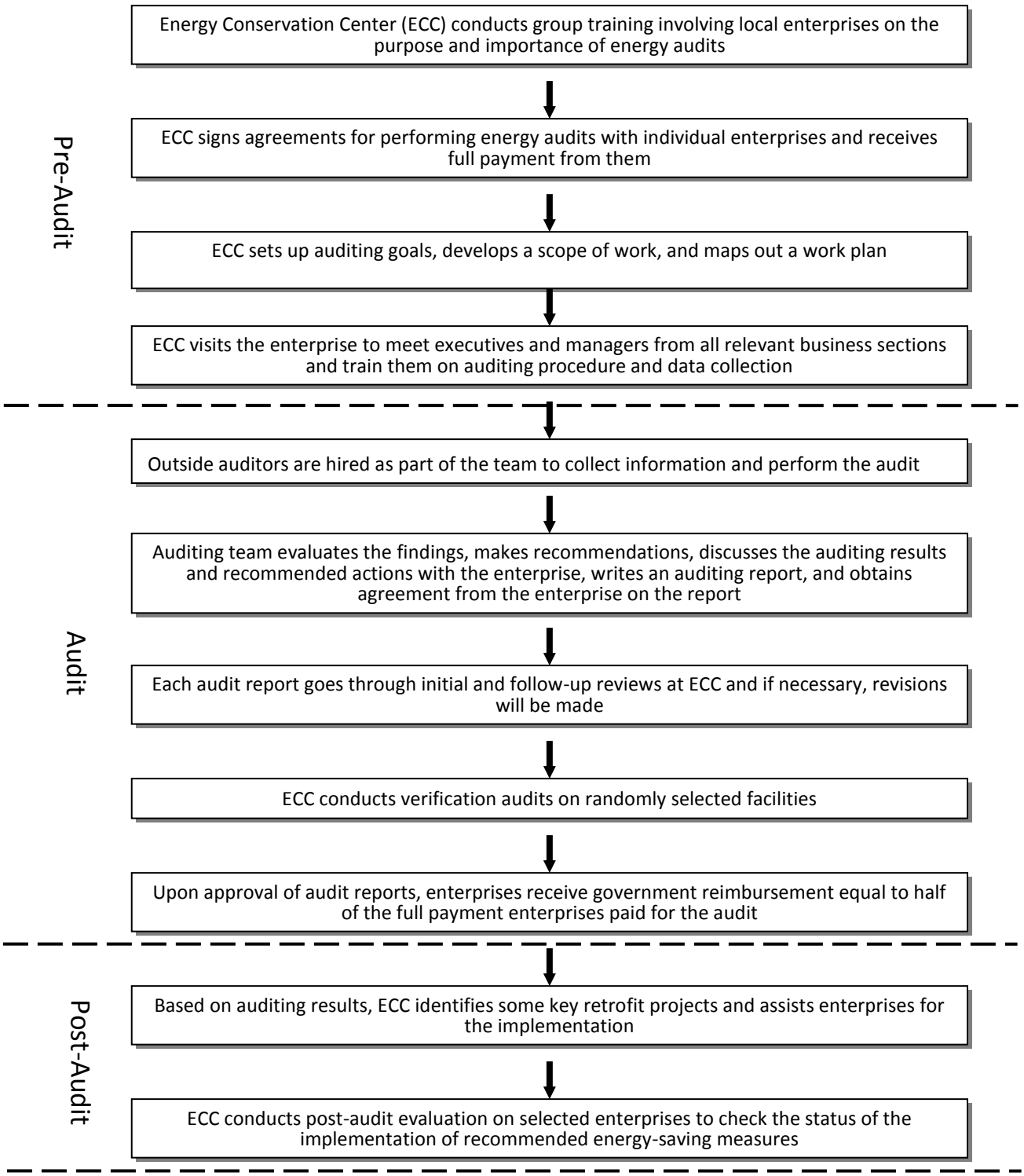

Figure 1. Energy Audit Procedure in Suzhou

Source: Suzhou Energy Conservation Center, 2009

4.5 Data Collection

This section discusses the data collection in energy audits in China. Relevant information was obtained from a series of government guidelines including *The General Principle of Enterprise Energy Audit* (GB/T 17166-1997), *Reference Case of Enterprise Energy Audit Report* issued by NDRC, and *The Template of Energy Auditing Agreement* published by the Shanghai Energy Conservation Center. Additional information on energy audit data collection was obtained through discussion with provincial energy conservation centers.

The types of data collected in a typical energy audit can be categorized into the following groups:

1. General information about the enterprise and its business (product types, total assets, production capability, number of employees, outputs, revenues, profits, tax payment, inventories of products and raw materials, etc.)
2. Specific information about energy system and energy-consuming equipment (thermal systems, electric systems, co-generation systems, water systems, air compression systems, central air conditioning systems, equipment inventory, equipment specifications and operations, etc.)
3. Enterprise energy consumption and balance (fuel types, level of energy use, where and how energy is used, energy procurement, energy costs, etc.)
4. Enterprise energy management system (institution, management procedures, energy measurement guideline, metering devices, etc.)
5. Actual measurement of operation performance of energy systems and energy-consuming equipments as well as the accuracy of energy measurement and monitoring devices

In special audits aimed at verifying energy savings in order to distribute incentives, information about baseline energy use and energy consumption after the implementation of energy-efficiency projects along with financial and technical information on retrofit projects and procured equipments are also collected (CGC, 2010).

For energy audits performed by enterprises themselves, data are normally gathered from various business sections by the manager(s) responsible for the enterprise's energy management. For audits performed by outside specialists, the auditor generally gathers information by interviewing enterprise executives and managers of different functions or areas, such as procurement, equipment operation, technology, financial, warehouse, etc. Auditors also collect information by reviewing factory-supplied documentation on order requests for materials, production processes, scrap records, and final product storage. Information is also collected through reviewing production statistics reports, energy statistics reports, production accounting records, energy metering records, utility payment records, and financial statements. In addition, auditors obtain information from their own field measurements with data-gathering devices.

4.6 Energy Audit Tools

There are several software tools available to assist enterprises in conducting energy audits in China. These tools are, however, usually developed to help enterprises complete mandatory energy audit reports and meet data reporting requirements. For example, the China Energy Conservation and Monitoring Information website provides a software tool to assist enterprises nationwide in collecting energy consumption information and analyzing enterprise energy use based on the information collected.[10] The tool was originally designed to assist enterprises in filling and electronically submitting their energy audit reports and energy utilization status reports. The Suzhou Energy Conservation Center has also developed a software package that a local enterprise can utilize to produce a wide variety of energy statistics forms and complete 90% of the required contents of the energy audit report (Bei, 2010).

There are some simple tools that have been developed locally to help enterprises calculate energy and cost savings from more efficient operations of energy systems and equipment. For example, the Shanghai Energy Conservation Supervision Center has set up an online-based energy conservation diagnostics hotline, which is equipped with a collection of simple energy-saving calculators for steam system, boiler, furnace, air compressor, motor, pump, fan, HVAC, and lighting. Figure 2 shows the interface of one of the calculators developed by the Shanghai Energy Conservation Supervision Center that estimates the efficiency gain as well as the energy- and cost-saving potential from replacing an electric motor.

Some U.S. organizations working in China including Lawrence Berkeley National Laboratory (LBNL), Natural Resource Defense Council (NRDC), Regulatory Assistance Project (RAP), Eco-Asia, Green Energy Economics Group (GEEG), and Institute of Industrial Productivity (IIP) either have developed or are in the process of developing various assessment tools aimed at assisting local governments and industrial facilities in China to identify energy-savings opportunities, assess technical, economic, and financial performance of selected efficiency options, and evaluate the cost-effectiveness of energy-efficiency programs. Some of the tools (for example, LBNL's BEST-Cement[11] and GEEG's portfolio tool) have been applied in industrial energy assessments performed in a number of Chinese provinces.

[10] See http://www.chinaeci.com/wenzhang.php?lanmu_id=41&jt_id=11 for a general description of the software.
[11] See http://china.lbl.gov/research/industry/best-cement-china for description of and how to download the tool.

Motor Efficiency Calculation and Energy Savings Estimation from Motor Retrofitting

主题：电动机效率计算和高效电动机替换节能量计算

JO2和Y系列电动机通过下拉菜单输入额定功率和极数（或者同步转数），再输入测试的输入功率，计算电动机效率；如果输入年运行时间，可进一步算出如更换为YX高效电动机以后的年节电量；如输入年平均电价，可算出年节约费用

发表时间：2006年4月30日

1. 请输入 Data Input		
电动机系列： Motor Type	JO2	
额定功率： Rated Power	0.6	KW
电动机极数 # of poles (RPM)	2极(3000r/	
输入功率： Input Power		KW
开始计算 Calculate		
输出结果 Data Output		
输出轴功率Output Shaft Power		KW
效率： Efficiency		%
选择在这个工况点用高效电动机替代现有电动机，计算节电量和减少的电费 Calculation of energy savings and electricity bill reduction from replacing existing motor with motor of high efficiency		
2. 请输入 Data Input		
年运行时间 Operation Hour(yr)		小时 Hour
电价： Electricity Rate		元 Yuan
开始计算 Calculate		
输出结果 Data Output		
年节电量 Electricity Saving (yr)		KWH
年减少电费 Bill Reduction (yr)		元 Yuan

Figure 2 Interface of Motor Efficiency and Energy Saving Calculator

4.7 Energy Auditing Training

There is limited energy auditing training at both the national and local levels in China. To help the Top-1000 enterprises carry out required energy audits, NDRC organized a series of workshops across China in 2006 that included sessions introducing auditing procedures, on writing audit reports, and on utilizing energy management software. Training materials, including relevant textbooks, published energy auditing reports templates for major industries, and documents such as *Basic Knowledge of Energy Auditing and Analysis of Energy Conservation Potential* and *Manual of Energy Management Software for Enterprises* were distributed (Price, et al., 2010).

At the local level, significant training efforts have focused on informing enterprises prior to and during national and local energy auditing activities about related government guidelines, data requirements, reporting formats, activities schedules, and administrative procedures with relatively less time spent in strengthening the capacities of enterprises in identifying energy-saving opportunities in their facilities. Sometimes the trainings go beyond administrative procedures to provide enterprises with more regular and comprehensive training. In Shanghai, for example, the Shanghai Energy Conservation Supervision Center offers enterprise managers a series of one-day training sessions twice a month for six months. These sessions cover a wide range of topics including relevant laws and regulations, energy-efficiency standards, energy audit guidelines, enterprise energy management, energy-efficiency technologies, and applications. Those who successfully complete the training and pass the exams receive an official training certificate from the Shanghai Municipal Development and Reform Commission (Shanghai Energy Conservation Supervision Center, 2010).

4.8 Funding for Energy Audits

The majority of enterprise energy audits performed in China – which cost anywhere between ¥40,000 to ¥400,000 (US$6,000 to $60,000), depending on the size of the facility and type of the sector – are self-funded by enterprises (Liu, 2010). However, to encourage more enterprises, especially smaller enterprises, to perform energy audits for greater energy-efficiency improvement, local governments have been increasingly interested in offering public funding to support enterprise energy audits. In Beijing, for example, some districts have provided enterprises with incentives that cover 100 percent of their energy audit costs and funding for a single audit can be as high as ¥200,000 (Liu, 2010). In Jiangsu, for example, the provincial government provides a subsidy of ¥20,000 (US$2,950) to ¥30,000 (US$4,425), depending on the scale of the audit, to each of the enterprises conducting energy audits. In Suzhou, various districts have allocated funds from government budgets to support energy audits by reimbursing a participating enterprise 20% to 50% of the auditing costs upon successful submission of an audit report.[12]

[12] Personal communication with energy conservation centers in Nanjing, Suzhou, Beijing, and Shanghai.

Central or local governments provide full funding for special energy audits that are either performed by local energy conservation/supervision centers under the request of relevant government agencies to check the quality of enterprise energy audits or performed by institutions like CGC to verify energy-saving results for issuance of incentives.[13]

4.9 Energy Audit Reporting and Reviews

There is a comprehensive system in place in China to collect, report and monitor enterprises' energy and environmental data at different levels — both national and local — and for different types of enterprises including the key energy-consuming enterprises (annual energy consumption over 5,000 tce) and the Top-1000 enterprises (annual energy consumption over 180,000 tce). Appendix 3 discusses the energy data reporting system for industrial enterprises in China in detail.

Submission of an energy audit report by key energy-consuming enterprises is part of the energy data reporting requirement under the Top-1000 program. In the official document *Implementation of Top-1000 Enterprises Energy-Saving Action Plan* released jointly by five central governmental agencies led by NDRC, Top-1000 enterprises are required to submit a detailed energy audit report along with an energy-saving plan upon the completion of the audit and regularly report to NDRC their energy utilization status. These reports have helped governments at different levels collect critical energy-consuming information necessary to supervise enterprises' energy use and evaluate their energy performance.

NDRC published two directives in 2006 specifying requirements for energy audit reports and energy-saving plans for the Top-1000 enterprises. The first document included two sample reports, one on energy audits and another on energy-saving plans (NDRC, 2006c). NDRC recommended that all Top-1000 enterprises use these templates for reporting energy audit results and proposing efficiency measures to be taken. The second document, *Guide on Reviewing Enterprise Energy Audit Report and Energy Saving Plan*, provides recommendations on the format and contents of the energy audit report and energy-saving plan and explicitly states that submissions that do not follow these guidelines will not be accepted (NDRC, 2006b). Energy audits in the local programs typically follow the same reporting guideline as the national program. Table 4 lists the information that enterprises must include in their submissions based on the national guideline.

[13] Interview with staff at China General Certification and energy conservation centers in Nanjing, Suzhou, Beijing, and Shanghai.

Table 4. Required Information in Top-1000 Energy Audit Report and Energy-Saving Plan

Energy Audit Report	Energy-Saving Plan
▪ Enterprise overview (including energy use overview, energy management overview, and energy flow) ▪ Status of enterprise's energy measurement/metering and energy statistics systems ▪ Monitoring and analysis of efficiency of key energy-consuming equipment ▪ Analysis of enterprise's relevant energy consumption indicators ▪ Assessment of specific energy indicators for key technologies and products ▪ Analysis of energy consumption indicators in relation to output value and energy costs ▪ Impacts of enterprise energy assessment scheme on energy saving results ▪ Evaluation of the factors affecting energy consumption changes ▪ Cost-effectiveness of retrofit projects ▪ Enterprise's thinking and suggestions on rational use of energy	▪ Enterprise general information ▪ Overview of enterprise's energy use and energy conservation efforts ▪ Problems that have been identified and the gaps with both domestic and international best practices ▪ Guiding principles of the energy-saving plan ▪ Goals of the plan (cannot be lower than the targeted goals agreed with the government) ▪ Major tasks of the plan ▪ Key planned projects and measures (measures need to be aimed at achieving the goals) ▪ Steps needed to ensure the implementation of the plan ▪ Implementation plan

The government guideline instructs provincial government agencies in charge of energy conservation to review all submissions related to energy audits in their respective territories in a time frame of no longer than six months. The provincial review results are then summarized and sent to NDRC. Those enterprises whose submissions failed to pass the evaluation are required to make further improvements on the report and resubmit within three months (NDRC, 2006a & NDRC, 2006b). The evaluation together with quality assurance audits in randomly-selected facilities – which are free of charge to enterprises – were conducted primarily by local energy conservation centers or energy conservation supervision centers on behalf of relevant government agencies. The evaluation focused on four areas: (1) checked whether reports met government requirements in terms of formatting and contents, (2) verified the accuracy and completeness of submitted information, (3) ensured the implemented measures will help enterprises meet the targets, and (4) determined the feasibility and rationality of an enterprise's energy-saving measures and energy conservation plans.

To make the review process consistent, some local energy conservation or supervision centers have developed a checklist or a scoring system. For example, the Jiangsu Energy Conservation Technical Service Center created a scoring scheme in which information submitted on each of the ten required areas is assigned a score point ranging from 0 to 10. The final score helps the reviewers determine the quality of the report (Jiangsu Energy Conservation Technical Service

Center, 2010). Some local governments have taken a further step by linking the results of the evaluation of energy audit reports with government incentives. In Changzhou, Jiangsu, for example, energy audit reports are grouped into three categories: excellent, pass, and fail. For reports that are labeled as failed, no government incentives will be offered while reports passing the examination or being labeled as excellence will receive ¥20,000 and ¥30,000 in incentives, respectively. In Beijing, enterprise energy audit reports are also rated and companies would be prohibited from receiving any government incentives if their audit reports do not pass the government examination (Liu, 2010).

4.10 Post-Audit Measure Implementation

At the national level, energy audits conducted at the Top-1000 enterprises have helped the enterprises and the government to gain a much better understanding about the current situation regarding enterprise energy use. In 2007 and 2008, Top-1000 enterprises invested over 50 billion RMB ($US 7.5B) and 90 billion RMB ($US 13.5B), respectively, in technology innovation and implemented energy-saving technical renovation projects that could result in energy savings of 20 million and 30 million tce, separately (NDRC, 2008; NDRC, 2009b).

Following the commencement of the Top-1000 program, the Chinese government established a series of subsequent energy-efficiency programs such as the Ten Key Projects and a program for elimination of inefficient industrial facilities. Additional supporting policies, including significant financial incentives from the central government, were also established.

One of the key financial supporting policies is the *Financial Rewards on Energy-Saving Technical Retrofits in China*, a program of the Ministry of Finance (MOF) and NDRC to reward enterprises for energy savings achieved through technical renovation projects. The funding of the rewards is from the central government budget and the reward is set at 200 RMB per tce saved in the East region, and 250 RMB in the Middle and West regions of China. Eligible projects must be one of the five Ten Key Projects under the 11th FYP (i.e., coal-fired industrial boilers/furnaces, use of waste heat and waste pressure, oil conservation and substitution, improvement of motor system, and energy system optimization) (NDRC, 2006d). To qualify for the incentives, projects must be approved, examined, or recorded at local Development and Reform Commissions, or Economic and Trade Commissions. Energy savings from the qualified projects need to be over 10,000 tce. The incentive program also requires enterprises to have comprehensive energy measurement, accounting and management systems. Qualifying enterprises can include Top-1000 enterprise, but it is not a requirement (MOF and NDRC, 2007; MOF, 2007).

The government has created a system for validating these savings. Under the incentive program, for the initial settlement, enterprises submit their applications for funding to the provinces for review and approval, which is then sent to NDRC and MOF after receiving provincial approval (or to the NDRC and MOF directly in the case of enterprises under direct administration of central authorities). CGC and 27 institutions, which are mainly provincial energy conservation supervision centers and provincial financial inspection centers, participate in this effort. To ensure fairness in the process, efficiency projects are crossed-examined,

meaning that team members in one province are required to review projects in another province and reviewing projects in their own territory is not allowed. For each project, two rounds of review are conducted by the team, one is an initial review examining the feasibility of the project and reasonableness of the estimated savings and another is a final review evaluating the performance of the project including the actual savings. For a project that passes the initial review, MOF, through provincial financing bureaus, provides 60% of the total incentive upfront based on the estimated savings. After the final review, MOF dispenses the remaining portion of the incentive based on the amount of energy that is actually saved. If there is a discrepancy between the estimated and actual savings (e.g., estimated savings are more than actual savings), the enterprises are required to refund the difference (MOF, 2007). Between 2007 and 2009, the teams reviewed and audited a total of 3,500 energy efficiency projects carried out by more than 1,500 enterprises with the majority being Top-1000 facilities (CGC, 2010).

While national incentives have primarily targeted the large enterprises, provincial and local incentives are focused on smaller enterprises. The Shanghai Municipal Government, for example, awards ¥300 (US$44) per tce of saved energy to enterprises that have achieved measured savings of 5,000 to 10,000 tce (Shanghai Energy Conservation Center, 2010).

In 2008, NDRC and MOF jointly published guidance on energy-saving verification for energy conservation projects. The guidance specifies that an energy use baseline needs to be established, information on actual energy use after project implementation should be obtained, and an energy measurement system needs to be developed. The energy conservation measures are validated through documentation and on-the-spot baseline validation (NDRC and MOF, 2008). NDRC plans to list authorized validation entities, and has provided local governments with a list of criteria for selecting one to two energy-saving validation institutions in each jurisdiction. To meet the requirements, validation entities need to be independent legal entities, have the required instruments and equipment for energy-saving measurement and verification, understand the process and method for verifying energy-savings, have technical know-how and practical experience of conducting energy-saving validation, possess knowledge of the main processes of energy-consuming industries, and have a proper system to ensure data quality and reliability. Institutions that are selected for conducting the validation work will be evaluated by the experts hired by NDRC and MOF (Beijing Municipal Government, 2008).

To accelerate the implementation of energy efficiency measures in China, in April 2010 the Central government released a policy notice *Accelerating Energy Performance Contracting to Promote the Development of Energy Service Industry in China* (State Council, 2010), which was followed by the announcement of a new incentive program established by MOF and NDRC in June 2010. The new incentive, which is targeted at projects with energy savings between 100 and 10,000 tce (between 500 and 10,000 tce for industrial projects), is complementary to the energy-saving incentive program described above and directed to ESCOs. To qualify for the incentives, prospective ESCOs must be registered with and admitted by NDRC and MOF, are required to cover at least 70% of the project capital costs, agree to share energy savings with

the clients, and establish a complete energy management system with which energy savings are measurable and verifiable.

Funding for these incentives from the Central government will be matched by local funds. For every tce of energy saved, the Central government will provide 240 RMB and the provincial governments will match at least 60 RMB (MOF, 2010). The level of local matching fund varies depending on the local situation. Shanghai, for example, has announced that the city will match 360 RMB per tce, which will provide ESCOs a combined incentive of 600 RMB for every tce of energy saved (Wei, 2010). In its new *Interim Measures on Financial Incentives for Energy Management Contracting*, the Beijing Municipal Government announced that the city will give 260 RMB for per tce of energy saved to qualified ESCOs who receive the award from the Central Government, making the combined award to be 500 RMB for per tce of energy saved. For local energy service companies who are not qualified for the Central Government award, the municipal government will either offer an award of 450 RMB for per tce of energy saved or provide an incentive that is equivalent to 15-20% of the project cost (Beijing Evening News, 2010). The Central government allocated 2 billion RMB for this program in 2010 (Xu, 2010). In addition to the direct subsidies, substantial tax benefits are also provided to ESCOs, including temporary business tax exemption, exemption of value-added tax on project assets transferred to the clients, exemption of corporate income taxes for the first three years, and reduction of corporate income taxes by 50% for another three years (State Council, 2010).

A national standard regarding the contract used in energy performance contracting (EPC) was issued in August 2010 and will take effect on January 1, 2011 (EMCA, 2010). This standard provides definitions and terms related to EPC in China, specifies types and technical requirements of energy service contracts, and provides reference templates of the contracts.

Authorization and supervision of ESCOs is critical to ensure the quality of their projects. In August 2010, NDRC announced the first group of ESCOs comprising of 461 companies in China that are authorized to perform EPC projects in buildings, industry, transportation and public sectors. Information about these companies including their names, types of service, addresses, and contact information is provided on NDRC website (NDRC, 2010a). In the same month, the Ministry of Industry and Information Technology (MIIT) also announced the first group comprising of 53 ESCOs that are eligible to carry out industrial energy-saving projects (MIIT, 2010). These companies are qualified to apply for government incentives, and they are also subjected to government monitoring and supervision rule set forth in the government regulation (MOF, 2010).

The Supplemental Notice on Financial Incentives for Energy Performance Contracting issued by NDRC in October, 2010 has further defined the scope of incentives for energy-saving projects. The notice states that government rewards will be provided to boiler/furnace retrofitting, utilization of waste heat and waste pressure, motor system efficiency improvement, energy system optimization, green lighting, and building efficiency. Projects such as newly contracted projects, projects with the purpose of increasing production capacity, projects associated with to-be-phased out facilities, and projects on solar, wind, biomass and combined heat and power

are, however, not qualified for the EPC incentives (NDRC, 2010b). To facilitate information exchange relative to energy auditing, NDRC has provided a large amount of information on its website.[14] It includes relevant provincial guidelines, local activities and major achievements, as well as regional experiences and best practices.

At the provincial/city level, our study revealed that provincial and local governments have made considerable efforts in addressing the problems identified by the audits with the assistance of local energy conservation centers. In spite of some variation among the different regions, measures that were commonly adopted include accelerating the elimination of inefficient industrial facilities/production, establishing special energy conservation funds or incentive programs, targeting key enterprises or projects with special technical and financial assistance, offering consultative services free of charge to enterprises in the area of project implementation, and setting energy consumption limits for both key energy-consuming equipment and production of major products. In Shanghai, results of industrial energy audits are used in benchmarking the energy performance of local industrial enterprises against their domestic and international peers. The benchmarking helps enterprises identify gaps while at the same time enabling local government to pay attention to enterprises that are performing relatively poorly in terms of energy efficiency compared with the benchmark (Yu, 2010).

In addition to facilitate implementation of energy-saving projects, provincial and local governments have also developed regional lists of products and technologies that are recommended for elimination, created local catalogs of recommended energy-efficient equipment and technologies, and published regional directories of preferred energy service companies (ESCOs).

4.11 Post-Audit Evaluation

To evaluate the energy-saving efforts of the Top-1000 enterprises and assess the results including the progress toward meeting the target, a national performance-rating scheme was developed and has been widely utilized. Table 5 lists the major components of this rating system. Companies that score 95 points or above surpass the target; companies with a score between 80 and 94 points meet the target; companies who receive a score between 60-79 partially meet the target; and those who score below 60 points are deemed to fail. A company that meets or surpasses the target will receive praise, awards, and promotion while those that fail to meet the target will face a series of punitive actions including the company name being revealed publicly, suspension of the right to receive any awards or titles of honor, removal of the special treatment of receiving an exemption for inspecting product quality, and disapproval of new capital investment projects or expansion of industrial land use (NDRC, 2007). Most provinces and cities have adopted the same rating scheme in the evaluation of energy conservation performance of local enterprises.

[14] http://www.ndrc.gov.cn/search/searchresultnew.jsp

In Suzhou, the city government has taken one step further to create the nation's first comprehensive energy efficiency rating and labeling scheme for manufacturing industries. The system, which is called Energy Efficiency Star, was approved by the Suzhou government in late 2009 and to be adopted citywide in 2010. This system assesses the results of implementing energy-efficiency measures recommended by energy audits in industrial enterprises and evaluates the efficiency of their energy use, effectiveness of adopted technologies, and performance of their energy management. Based on enterprises' overall performance on energy efficiency, they will receive a rating indicated by a label of one star through five stars. The enterprises with superior energy performance will be awarded a 5-star plaque, which will give enterprises the publicity and the access to government incentive and customized technical assistance (SECC, 2010).

Table 5. National Rating Scheme for Evaluating Enterprise Energy-Saving Measures and Results

Indicator	Evaluation Areas	Score	Evaluation Criteria
Meeting Energy-Saving Target (40 points)	Amount of Energy Saved	40 points	▪ Met 100% of the annual target – 40 points ▪ Met 90% of the target – 35 points ▪ Met 80% – 30 points ▪ Met 75% – 25 points ▪ Met 60% – 20 points ▪ Met 50% – 15 points ▪ Below 50% of the target – 0 points ▪ Each 10% over 100% of the target will earn an additional 2 points (up to 6 points)
Taking Energy-Saving Measures (60 points)	Organization and Leadership	5 points	▪ Establish leadership group headed by enterprise top executives – 3 points ▪ Create special unit within enterprise for administration and coordination – 2 points
	Energy-Saving Target Allocation and Realization	10 points	▪ Allocate the target to each business section, workshop, and individual – 3 points ▪ Evaluate the implementation of allocation – 3 points ▪ Develop reward and punishment scheme for the realization of the target – 4 points
	Progress on Technical Improvement and Project Implementation	25 points	▪ Energy consumption per unit of product and total energy consumption are ranked among the top 20% of all T-1000 enterprises – 10 points ▪ Ranked at top 50% or better – 5 points ▪ Ranked below 50% – 0 points ▪ Allocate funds to support energy saving and increase funding each year – 4 points ▪ Develop and Implement annual energy saving plan – 4 points ▪ Phase out inefficient production capacity – 7 points

	Comply with Relevant Laws and Regulations	10 points	▪ Comply with Energy Conservation Law and other national and local regulations on energy conservation – 2 points ▪ Comply with energy consumption limit set for high energy-consuming products – 4 points ▪ Enforce energy consumption limit for key energy-consuming equipments – 2 points ▪ Integrate energy-saving principles in new, retrofit, or expansion projects – 2 points
	Progress on the Implementation of Energy Management System	10 points	▪ Conduct energy audits or monitor energy performance and implement recommended measures – 2 points ▪ Create an energy statistician position, develop enterprise energy statistics system, submit energy statistics report in a timely manner – 3 points ▪ Install energy measurement devices and make routine test and calibration – 3 points ▪ Disseminate energy-saving information and provide energy-saving training – 2 points
Total		100 points	

Source: NDRC, 2007.

5. Findings Related to Energy Auditing in China

Energy auditing can be an important first step in identifying energy-efficiency opportunities in industrial facilities. Audits can also provide a clear picture of the energy supply and consumption in the facility, and can act as a roadmap for significantly improving enterprise energy use and helping enterprises reduce energy-related costs. During last two decades, especially in the 11th Five-Year Plan period, large-scale energy audits have been performed in industrial facilities throughout China. These audits have not only helped enterprises identify energy-efficiency improvement opportunities, but also serve in parallel as a means to collect critical energy-consuming information necessary for governments at different levels to supervise enterprises' energy use and evaluate their energy performance. Energy audits have had a positive impact on the improvement of energy efficiency in China while at the same time assisting Chinese enterprises to improve their energy management practices including the evaluation of the efficiency of energy system, collection and analysis of energy usage data, identification of opportunities for efficiency improvement, and implementation of energy-efficiency projects. In spite of the significant progress, however, a number of issues remain in China that prevents energy audits from achieving their full potential. The section below discusses some of the key findings from LBNL's study of Chinese energy auditing practices that point toward potential areas for further improvement.

5.1 Lack of Long-Term and Concerted Policy Mechanisms to Promote Energy Auditing

The motivation for conducting large-scale energy audits in China has changed over time, as have the programs and methods for implementation. Often, due to a lack of long-term policy mechanisms, the use of energy audits ceased when programs ended. The necessity to create a long-term policy mechanism and supporting measures to spur more energy audits in enterprises have not been truly reflected in China's legislative and regulatory efforts.

In addition, to meet various requirements of different government programs, a variety of audits are conducted that serve different purposes but have some common tasks. For example, both energy audits conducted under the Top-1000 program and cleaner production audits under the cleaner production program require enterprises to collect information on enterprises' energy use and identify opportunities of reducing energy waste. The overlapping requirements oblige enterprises to invest additional resources that could be avoided if a more concerted mechanism was in place.

Strong policy guidance is essential for promotion of continuous, effective energy assessments. Without such guidance, it will be difficult to develop a long-term institutional strategy and implementation plan that could direct national and local efforts in establishing goals, designing programs, providing incentives, taking supporting measures, and building capacity related to energy assessments. Furthermore, the lack of continuous policy mechanisms promoting energy auditing makes it difficult to instill a cultural change in the attitude of enterprises towards energy assessments.

5.2 Lack of a National-Level Organization for Implementation of Energy Audits

At the national level, NDRC's Department of Energy Conservation and Comprehensive Resources Utilization is the leading agency in formulating policies and issuing regulations governing energy audits in the Top-1000 program. There is, however, no entity at the national level in charge of organizing and coordinating the implementation of NDRC's energy auditing policy or overseeing the myriad energy auditing efforts throughout China. The National Energy Conservation Center (NECC) was established in October 2008 to lead national energy-efficiency implementation efforts and to coordinate activities of the provincial energy conservation centers. However, NECC's main duties do not include energy audits.[15]

Internationally, entities exist at the national level in other countries to organize and coordinate energy audit programs. In Japan, for example, the Energy Conservation Center of Japan (ECCJ), which is supported by relevant agencies in the Japanese national government, carries out industrial energy audits at the request of manufacturing facilities. Between 1998 and 2007, ECCJ conducted energy audits in 2,513 industrial facilities. Under Japanese law, ECCJ is also in charge of providing professional trainings and administering national examinations for qualifying Facility Energy Managers (Lu, et al., forthcoming). In the U.S., the Department of Energy (DOE) operates the Save Energy Now program in which manufacturers can apply to DOE for a comprehensive energy assessment that, if the application is accepted, will be funded by DOE and performed by qualified energy specialists who have received DOE training and are equipped with DOE assessment tools. Under the DOE's Save Energy Now Program, large, energy-intensive plants in the U.S. can apply to receive a 3-day system assessment from a qualified energy specialist who will use DOE's assessment tools to analyze energy use and help find ways to improve efficiency. Small- and medium-sized plants can apply to receive a 1-day assessment from one of DOE's university-based Industrial Assessment Centers (IACs). Since January 2006, the Save Energy Now Program has completed a total of 2,629 energy assessments, which have resulted in annual energy savings of 39 trillion Btu (equal to 1.4 million tce).[16] The U.S. IAC program has been in operation for 33 years, has trained over 2,800 students in the methods of conducting energy assessments, and has conducted over 14,800 assessments for U.S. manufacturers.[17]

International experience shows that having a national-level entity to organize and coordinate energy assessment activities can be effective in helping enterprises identify greater energy-saving opportunities. Having well-organized energy audit activities managed by a national-level entity can help minimize the potential risks of an individual auditing firm – an engineering firm, a design institute, or an ESCO – recommending energy-saving measures solely aligned with its business interests rather than the best opportunities of the host company in mind as the firm might be the one who will do the design or implementation for the host company. A national-level entity can also design energy audit programs that motivate enterprises to conduct energy

[15] For NECC's duties, please visit NECC's website at http://gjjnzx.ndrc.gov.cn/zxjj/default.html

[16] For detailed information, please visit DOE Save Energy Now website at http://www1.eere.energy.gov/industry/saveenergynow/assessments.html

[17] For detailed information, please visit IAC website at http://www.iac.rutgers.edu

audits through offering incentives, providing technical guidance related to the scope of energy audits and how to conduct economic feasibility analysis as a key component of energy audits, developing effective energy assessment tools, and providing training on energy assessments. Finally, a national-level entity can help disseminate information on energy-saving opportunities through case studies, databases, energy audit reports, workshops, and other means of publicity so that information is shared among both enterprises and organizations that conduct energy audits.

5.3 Lack of Proper Motivation for Enterprises to Conduct Energy Audits

Most energy audits currently undertaken in China are mandatory for the purpose of meeting the government's energy intensity reduction target. While mandated energy audits help mobilize resources and assist enterprises in meeting their energy-saving target, they often do not provide enough information to assist enterprises in going beyond the target to realize greater efficiency gains.

Our study revealed that mandated energy audits were sometimes seen by enterprises as a government function rather than as business activity. As such, enterprises somewhat felt that energy audits were an administrative burden as well as a means for exposing problems rather than a process for helping them to become more competitive. As a consequence, enterprises are reluctant to undertake extensive efforts to go beyond their targets and energy auditors often only recommend quick fixes to help the enterprises to meet their targets. China perhaps needs to be careful to avoid a situation like what happened in Thailand, where Thailand's Energy Conservation Law of 2000 mandated that all key energy-consuming enterprises in the country carry out energy audits. Once the audits were completed and approved by government entities, enterprises met their legal obligation and became eligible to apply for government funding. As a result, the audits were superficial and without proper customization to the realities in various enterprises. The audits were less useful, especially for enterprises that were seriously considering making significant investments (Taylor, 2010).

5.4 Limited Technical Scope of Energy Audits

Since most enterprise energy audits in China are conducted – with the support of significant human and financial resources – to meet government obligations, their scopes are somewhat limited to gathering the needed information for reporting. Since energy-saving plans commonly prescribe measures aimed at meeting the regulatory targets, opportunities for achieving more substantial energy savings and improving energy efficiency beyond the current target are generally not further investigated.

In addition, some of the energy audits focus only on retrofitting particular technologies or a specific set of equipment. These technology-based audits may not help enterprises identify the best opportunities presented through a portfolio approach from a whole facility point of view. They may not help enterprise achieve optimal saving results when technology or equipment is assessed separately from the operations of all linked systems.

5.5 Lack of Proper Economic Feasibility Analysis in Energy Audits

There is also a weak link between the technical assessment and the economic and financial feasibility analysis of energy-efficiency measures in China's current energy audit practice. There are a series of national standards and guidelines in place to provide guidance on how to assess total energy consumption, energy use relative to products and production processes, efficiency of operating equipment, measurement of energy and energy use, and energy-saving potentials. There is, however, a lack of general guidelines on how to make an effective evaluation of the cost-effectiveness of energy-efficiency measures. Despite the fact that NDRC has offered some advice on the evaluation of the economic feasibility of energy-efficiency measures, the methodology is somewhat simplified and focuses primarily on simple payback period (NDRC, 2006c). While simple payback is fast to calculate and easy to understand, it does not reflect the total economic benefits, especially the benefits that occur after measures pay for themselves. To include all benefits over the full lifetime of any measure, life-cycle cost analysis should be used as a core component of the enterprises' decision-making metrics.

5.6 Lack of Suitable Incentives for Energy Audits

In spite of some local efforts to provide financial incentives to support energy audits, the majority of energy audits in China are self-funded by enterprises, raising the issue of whether it is fair to have enterprises pay for the audits that are mandated by the governments (Ma, 2009). With the goal of conducting an audit to primarily meet government mandates, enterprises typically spend no more than they need to satisfy the regulatory requirements.

International experience shows that financial as well as other types of incentives are often offered to encourage greater participation of enterprises in energy audit programs. Internationally, government subsidies for energy audits come in many formats ranging from free services, cost sharing, to direct subsidies. Incentives are sometimes only made available to enterprises that have invested in energy-efficiency measures as recommended in the audit reports to ensure a successful implementation. Other government financial support includes offering special loans with preferential conditions to energy-efficiency work including energy audits and providing special efficiency investment funds with the prerequisite that energy audits were performed ahead of time. Besides the financial support, governments in other countries have also provided enterprises with other types of support including priority access to technical and financial resources, customized assistance, and personalized trainings that will guide them through the crucial steps to be more energy efficient (Lu et al., forthcoming).

5.7 Lack of Systematic Standardization on Energy Assessment

There are national standards (primarily the GB/T17166-1997) and guidelines related to energy audits in China. These standards and guidelines are, however, more relevant to providing guidance on energy accounting audits. There is to some extent a lack of standards and

guidelines at both national and local level that could provide with enterprises clear guidance on how to conduct energy assessments for identifying energy-saving opportunities.

Internationally, guidelines are developed and applied to provide energy auditors standardized procedures and methodologies in conducting energy assessments. In the U.S., for example, program guidelines on energy assessments are designed to assist Industrial Assessment Centers (IACs) in the performance, creation, and delivery of the industrial energy assessment and the assessment report. IAC guidelines specify the scope, procedures, and approaches of energy assessments as well as post-audit report requirements. In addition to the guidelines on how to conduct energy assessments, the IAC program further standardizes its energy assessment practices through instituting a series of guidelines that covering every aspect of the assessment work. The series include client guidelines for determining eligible clients to serve, faculty and staff guidelines specifying respective roles, responsibilities, and activities for energy auditors, website guidelines for creating and maintaining IAC websites, report guidelines specifying the format and contents of energy assessment reports, a database manual to guide IACs on collecting, inputting, and using energy assessment data collection, an assessment recommendation code system manual to organize data in a useful way, and a recommendation rejection code system manual for documenting the reasons of rejecting certain recommendations.

Over the decades, these guidelines have helped standardize IACs' work, allowing energy assessments to be conducted consistently across the U.S. and producing results that are comparable. The IAC searchable database comprising of a total of 15,000 assessments is used by IAC program administrators to evaluate recommendations of energy-efficiency measures and their implementation, conduct statistical analyses on industrial energy use, benchmark industrial energy performance, and make regional comparison on industrial energy efficiency.[18]

5.8 Lack of Effective Energy Assessment Tools

LBNL's study of Chinese energy auditing practices found that neither standardized energy assessment tools nor professional analytical software for assessing technical, economic, and financial potentials of energy savings are routinely used in industrial energy audits in China. There are calculators available to estimate energy-saving potentials for certain technologies; but these tools are rather basic and perhaps only serve as an educational gadget rather than an effective tool for identifying deeper energy-saving opportunities.

There are several advantages to employing energy assessment software for energy audits. First, an assessment tool can provide a systematic approach to assessing energy system performance, analyzing collected data, calculating emissions, and reporting results in a timely manner, saving time for enterprises to focus on improving the performance of their energy-consuming systems. Software tools are also easier to use and able to help minimize

[18] For detailed information on IAC guidelines and database, please visit IAC website at http://iac.rutgers.edu/technicaldocs/

inconsistencies and possible errors caused by human calculations. In addition, if designed properly, a software tool can be modular, adapting relatively easily to the changing conditions of different facilities.

The Industrial Technologies Program of the U.S. Department of Energy (DOE), for example, offers a collection of free software tools to help industrial facilities analyze their energy systems and identify energy-savings opportunities. The tools, which are accessible through DOE's web site,[19] can assess the energy situation plant-wide and help industrial facilities improve the efficiency of motor-driven, process heating, and steam systems, as well as data centers. These software tools have been utilized widely by energy professionals in conducting industrial energy audits in the U.S.

5.9 Lack of Capacity and Proper Training for Energy Audits

For a relatively long period, China's focus has been on developing its economy. Enterprise's focus has thus been on pursuing greater economic output rather than on more efficient use of resources. As a consequence, knowledge about industrial energy efficiency is relatively limited in many enterprises, staff skills related to energy-efficiency technologies are weak, and experience of identifying energy-saving opportunities are somewhat minimal. While some of the largest enterprises are capable of conducting quality energy audits and identifying energy-efficiency opportunities, a large number of enterprises found this task difficult due to a lack of skills and qualified personnel. There are a significant number of outside experts from a variety of institutions that can assist enterprises in conducting energy audits; however, the technical expertise and abilities of these organizations varies widely, with some highly skilled in energy auditing and others in great need of training (Price, et al., 2010).

The lack of systematic programs designed to train energy professionals has further hindered the effort in building a strong capacity for energy audits in China. At the national level, trainings on energy audits are less regular and focus largely on providing enterprise managers and outside auditors with instructions on making preparation for the mandatory audits and understanding the government requirements for reporting energy audit results. At the provincial and local level, local energy conservation/supervision centers have been providing training to enterprises on energy audits. But these trainings have focused largely on laws and regulations, energy-reporting procedures, as well as data collection for reporting rather than on deepening enterprises' understanding of technical and economic potentials of energy-efficiency measures. The shortage of trained trainers and the lack of comprehensive and consistent training materials make it more difficult for China to develop a systematic training system. The lack of linkage between energy audit trainings and job requirements and evaluation for enterprise energy managers further weakens the effectiveness of capacity building efforts.

Internationally, systematic training programs have been developed to ensure the success of energy audit programs. In the U.S., for example, DOE's Industrial Technologies Program has a

[19] The URL is http://www1.eere.energy.gov/industry/bestpractices/software.html

training program throughout the year and around the country that provides system-wide and component-specific trainings to enterprises and qualifies energy professionals for energy assessment. To become a qualified energy specialist for conducting energy assessment, individuals need to attend one of the qualification trainings which each lasts two to three-and-half days, pass practical and/or written tests, and become proficient in using the relevant DOE tools (Lu, et al., forthcoming). DOE has published a searchable database with a full list of qualified energy assessment specialists on its website.[20]

To foster professional development through encouragement of pursuing long-term career goals in energy auditing, many countries have gone one step further to not just train but also certify auditors. The Association of Energy Engineers (AEE) in the U.S. developed dual certification programs – the Certified Energy Auditor (CEA) and Certified Energy Auditor in Training (CEAIT) programs – which are both recognized by the U.S. federal government, as well as by Fortune 1000 corporations, utilities and energy service companies. All applicants are required to meet specific educational and/or experience criteria, complete an extensive energy auditing training program, and pass a four-hour written examination with questions covering a great diversity of areas of knowledge such as energy auditing methodology, auditing instrumentation, auditing tools, economic analysis, building systems technology, lighting, HVAC, building envelope, controls, boilers and steam systems, water auditing, and reviewing auditing reports. To remain certified, energy professionals need to accumulate eight professional credits every three years by carrying out energy auditing activities, participating in energy auditing-related seminars and college courses, and obtaining professional awards or having papers presented and published relative to energy auditing.[21]

In spite of the existence of such a system where professional entities can be certified by relevant government agencies to qualify for the design and implementation of engineering projects, there is currently no official certification program in China in which individuals can be certified as energy auditors. Without a sound certification or qualification system, the quality of an energy audit cannot be assured. Without the ability to be certified, energy auditors – especially those not affiliated with a certified professional entity – face difficulty in convincing enterprises to take certain energy-saving measures as their creditability is often questioned.

6. Policy Recommendations for Facilitating Effective Energy Audits/Assessments

To promote energy audits, Chinese governments – at both the central and local levels – have taken effective measures including offering incentives, disseminating information, sharing best practices, and recognizing superior performance. While these measures should be continued, stronger policies and institutional strategies are also needed in order for China to take advantage of the opportunities that energy assessments can offer. Several policy

[20] The list can be found at http://www1.eere.energy.gov/industry/bestpractices/qualified_specialists/

[21] For detailed information on AEE's energy auditing certification programs, please visit AEE's official website: http://www.aeecenter.org/i4a/pages/index.cfm?pageid=3330

recommendations aimed at facilitating the development of best energy audit practices and continuous energy-efficiency improvement are provided below.

6.1 Maintain continuing and concerted policy support from the central government for energy audits

China's national energy intensity reduction target and associated programs like the Top-1000 Enterprises program have been important drivers for promoting energy audits in China. However, given China's growing demand for energy as well as global climate change challenges, stronger policies and continuous top-level commitment is needed to fully support energy auditing in China. Central policy support and top-level commitment are important to guarantee that energy auditing receives adequate resources, both in terms of funding and administration, and can guide national and local efforts in establishing goals, developing long-term institutional strategies, making implementation plans, providing incentives, taking supporting measures, and building strong capacity all related to energy audits. In addition, more concerted efforts are needed at the central level. Separate energy audit tasks under different programs should be integrated.

6.2 Designate a national-level entity to lead the effort in organizing and coordinating energy audit activities

A national-level entity, such as the US DOE or the Energy Conservation Center of Japan, with responsibility for oversight and coordination of energy auditing activities could provide China with the institutional capacity to greatly improve the quality and results of energy auditing activities. An example of a possible national-level entity for this role is the National Energy Conservation Center (NECC). While it will be difficult for an organization such as the NECC to perform large-scale energy audits due to its limited staff, it can, however, leverage greater resources by building strategic alliances with provincial energy conservation centers, industrial associations, research and higher education institutions, and enterprises for carrying out large-scale energy audit activities. The national-level entity could also play a leading role in implementing a national-level energy audit program through creating a searchable directory of qualified energy auditing professionals, building a website that provides comprehensive technical information and domestic and international best practices in energy auditing, developing energy assessment tools, and providing systematic training for energy audit professionals.

6.3 Focus energy audits on assessing cost-effective energy-saving opportunities rather than on energy statistics and accounting audits

Energy assessments should be separated from energy accounting audits so that attention will be given to identifying energy-saving potentials in industrial enterprises to help them uncover real opportunities to improve industrial productivity and save energy and costs.

Economic and financial analysis in energy audits should go beyond the simple payback calculation and properly assess the economic and financial feasibility of energy-efficiency measures so that investors' concerns regarding uncertainty on investment returns can be addressed. In addition, energy audits should also consider taking a portfolio approach through which deeper but more costly energy-saving opportunities are bundled with options that have shorter payback periods so that the overall financial return of the portfolio is attractive.

6.4 Create specific funding to support energy audits

Government financial support for energy audits is more cost effective than providing direct project funding. Support for energy audits could help enterprises identify cost-effective energy-saving options that can be self-financed. Governments should particularly target enterprises that have made serious commitments to and/or have greater potential for energy-efficiency improvement. By providing funding to support energy audits in these enterprises, China will greatly improve the cost/benefit of the public funding while at the same time significantly increasing the implementation of identified energy-savings opportunities. Other strategies China should consider include offering loan support to enterprises that take the recommended measures and providing qualified enterprises with priority access to technical/financial resources and customized assistance.

6.5 Develop standards and assessment tools to effectively support energy audits

Suitable standards and guidelines are needed in China to provide guidance on conducting energy assessments in a consistent way. Guidelines on how to conduct economic and financial feasibility analysis are also needed in order to guide enterprises to identify measures that are financeable.

The national level entity overseeing China's energy auditing program could partner with a wide variety of groups such as industrial associations, research and higher education institutions, engineering firms, and other relevant parties to develop a suite of software tools to assist enterprises in identifying cost-effective efficiency improvement opportunities. The tools should be easy to use but powerful enough to evaluate both sector-specific opportunities and cross-cutting technologies as well as assess both facility-wide energy profile and performance of specific energy systems. To assist enterprises and prospective investors in making sound investment decisions, the tools should be equipped with proper functions of evaluating economic and financial feasibility and performing investment analysis. To increase the wide adoption of the tools, governments could consider of requesting the use of the tools as the prerequisite of receiving public funding for energy audits.

6.6 Build strong capacity in energy auditing

Increased capacity in energy auditing could start with the development of effective training programs at both national and provincial levels. At the national level, the entity overseeing China's energy auditing efforts could take the lead in designing comprehensive training

curricula and developing an effective train-the-trainer program that holds trainings on a regular basis and provides system-wide and component-specific trainings to enterprise energy managers, staff of provincial energy conservation centers, and energy audit professionals. At the provincial level, local energy conservation centers could develop respective training programs to train local enterprises in identifying energy-saving opportunities. In all training programs, trainees should be taught about technical options, economic/financial feasibility, and the use of assessment tools. To improve their effectiveness, energy audit training should be linked directly to the job requirements and work evaluation of enterprise energy managers,

Furthermore, to assure the quality of energy auditing, China could consider of creating a certification or qualification system for energy audit professionals. It is commendable that NDRC is developing two pilot enterprise energy management professional certification programs, one in Shandong and another in Tianjin.[22] This effort will certainly contribute to building a strong capacity in energy efficiency, including energy auditing. There is, however, a need to create an effective mechanism at the national level to certify or qualify energy professionals specializing in energy auditing and develop a set of criteria that would determine whether an entity is capable of performing energy audits.

6.7 Strengthen international cooperation in energy auditing

International cooperation could focus on enhancing information exchange on international experiences and lessons learned related to the design and administration of energy audit programs. It could also focus on localizing energy auditing guidebooks based on international best practice, sharing information on energy audit methodologies and assessment tools, and collaborating on building strong capacity in energy auditing. Developing local pilot and demonstration projects through international collaboration could be an effective way to bring bottom-up experience to the national attention and thus inform and enhance national policy. China could also benefit from actively participating in relevant international programs such as the International Partnership for Energy Efficiency Cooperation (IPEEC), which has specified industrial energy audits as one of the concrete areas for international cooperation.

7. Conclusions

Energy-efficiency audits are a key means for identification and implementation of cost-effective energy-efficiency opportunities in industrial facilities. Such energy-efficiency assessments will become even more important as they are useful tools that enterprises – large and small – can employ to achieve greater efficiency improvement and carbon reductions that go beyond current options. Such assessments can be valuable for assisting enterprises in taking actions to meet China's energy intensity reduction targets in the 12th Five Year Plan as well as China's international commitment to reduce the country's carbon intensity by 40 to 45 percent from 2005 levels by 2020.

[22] For more information about the pilots, please visit http://gjjnzx.ndrc.gov.cn/gzdt/t20100107_323625.htm

Energy audits have made a positive impact on the improvement of energy efficiency in China. Efficiency measures identified through energy audits and taken by enterprises have made significant contribution to the realization of China's ambitious goal of reducing its energy intensity by 20% by 2010. Energy auditing has not only helped enterprises identify energy-efficiency improvement opportunities but has also helped enterprises to improve their energy management structure including the evaluation of the efficiency of energy systems, collection and analysis of energy usage data, identification of opportunities for efficiency improvement, and implementation of energy-efficiency projects.

Despite the progress, issues still remain in China preventing energy auditing from achieving its full potential. To remove the barriers, effective policy support is needed. By adopting the recommendations listed above and implementing other enabling policies, China will be able to reap the benefits of improved energy efficiency, move toward a more secure energy future, and make significant contribution to the effort in combating climate change.

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10. Acronyms

ADB	Asian Development Bank
AEE	Association of Energy Engineers
Btu	British thermal units
CEA	Certified Energy Auditor
CEAIT	Certified Energy Auditor in Training
CGC	China General Certification
DOE	Department of Energy
DSM	Demand Side Management
ECC	Energy Conservation Center
ECCJ	Energy Conservation Center of Japan
EMCA	ESCO Committee of China Energy Conservation Association
EPC	energy performance contracting
ESCOs	energy service companies
GB	National Standards (Guo Biao)
GDP	gross domestic product
GEEG	Green Energy Economics Group
IAC	Industrial Assessment Centers
ICETT	International Center for Environmental Technology Transfer
IIP	Institute for Industrial Productivity
IPEEC	International Partnership for Energy Efficiency Cooperation
kW	kilo-watt
LBNL	Lawrence Berkeley National Laboratory
MEP	Ministry of Environmental Protection
MIIT	Ministry of Industry and Information Technology
MOF	Ministry of Finance
NBS	National Bureau of Statistics of China
NDRC	National Development and Reform Commission
NECC	National Energy Conservation Center
NETC	National Economic and Trade Commission
NGOs	non-governmental organizations
NRDC	National Resources Defense Council
RAP	Regulatory Assistance Project
SECC	Suzhou Energy Conservation Center
SEPA	State Environmental Protection Administration
SETC	State Economic & Trade Commission
TA	technical assistance
tce	ton of coal equivalent
TWh	terawatt hour
WBCSD	World Business Council for Sustainable Development

Appendix 1: General Principle of Enterprise Energy Audits *(GB/T17166-1997)*

Released date: Dec 22, 1997
Effective date: Oct 1, 1998

Published by National Bureau of Technology Supervision

Introduction

Energy auditing is a method of scientific energy management and service, including objective investigation of energy efficiency, energy consumption and cost-effectiveness of energy usage in different types of end-use facilities (or equipment), depending on different types of energy audits. Through statistical analysis, testing and examination, diagnosis and evaluation of physical and financial energy flow, energy auditing also provides energy-saving retrofitting measures.

This standard formulates principles of the definition, content, method and procedure for energy auditing as well as principles for writing energy audit reports. This standard is the general technical principle for enterprises' energy audits, and it places an emphasis on explanation and unification of common issues and principle issues. Specific standards for energy audits will be established depending on future needs.

Appendix A is the appendix of this standard.

This standard is promulgated by Department of Resources Conservation and Comprehensive Utilization of National Economic and Trade Commission, and Department of Standardization of State Bureau of Technical Supervision.

This standard is recognized and managed by Energy Management Sub-Committee of National Technical Committee of Energy and Management Standardization.

This standard is drafted by: Energy Research Institute of State Development and Planning Commission, China National Standardization Institute, and Tsinghua University.

Draftsmen of this standard: Xin Dingguo, Meng Zhaoli, Li Aixian, Zeng Guang'an, Wang Hanqing, and Huang Zhijie.

1. Scope

This standard specifies the definition, content, method and procedure of energy auditing as well as the principles for writing energy audit reports.

This standard applies to enterprises and other units that have independent accounting.

2. Referenced Standards

The articles in the following standards become the articles of this standard by referencing them in this standard. At the time this standard was published, versions used here were effective. All standards would be modified. Each party that is using this standard should explore and discuss the possibility to adopt the latest versions of the following standards.

GB/T2588-81	The general principles for calculation of thermal efficiency of equipment
GB/T 2589-90	General principles for calculation of the comprehensive energy consumption
GB/T 6422-86	Directives for measuring and testing energy consumption in industrial enterprises
GB/T 13234-91	Method of calculating energy saved in industrial enterprises
GB/T 15587-1995	Guideline for energy management in industry enterprises
GB/T 16614-1996	Statistical method of energy balance in enterprises
GB/T 16615-1996	Methods of drawing up energy balance table in enterprises
GB/T 16616-1996	Methods of drawing energy network diagram in enterprises
GB/T 17167-1997	General principle for equipping and managing of the measuring instrument of energy in organization of energy using

3. Definitions

This standard adopts the following definitions.

3.1 Energy audit

Energy audit institutions (units) test, examine, analyze and evaluate the physical and financial flow of energy consumption in enterprises and other energy-using units, by using related national energy-conservation regulations and standards.

3.2 Audit period

The time period that is audited. Common observation period is one year, or other time period that is specified.

4. Content of Energy Audit

Based on objectives and requirements of enterprises' energy audits, some or all of the following can be included in the contents of an energy audit:

a) Energy management situation in the enterprise
b) Energy consumption and energy flow of the enterprise
c) Energy measurement and statistical data of the enterprise
d) Calculating analysis of energy consumption indicators of the enterprise
e) Calculating analysis of operational efficiency of energy-using equipment

f) Calculating analysis of comprehensive energy consumption of products and output values
g) Calculating analysis of energy costs
h) Calculation of energy savings
i) Financial and economic analyses of evaluating energy-saving technical renovation projects

5. Method of Energy Audits

5.1 Basic method of conducting energy audits in enterprises

The basic method of an energy audit is investigation, research, analysis and comparison through onsite examination, data review, case studies and inventory. When necessary, onsite testing can be supplemented.

5.2 Basis for energy audits

5.2.1 The audit of an enterprise's energy management should follow the requirements of GB/T 15587.
5.2.2 The audit of an enterprise's energy consumption and energy flow should follow the requirements of GB/T 16616.
5.2.3 The audit of an enterprise's energy measurement and statistical data should follow the requirements of GB/T 6422, GB/T 16614 and GB/T 17167.
5.2.4 Calculating analysis of operational efficiency of energy-using equipment should follow the requirements of GB/T 2588.
5.2.5 Calculating analysis of energy consumption indicators should follow the requirements of GB/T 16615.
5.2.6 Calculating analysis of comprehensive energy consumption of products and output values should follow the requirements of GB/T 2589.
5.2.7 Calculating analysis of energy costs should follow the requirements of Appendix A.
5.2.8 Calculation of energy savings should follow the requirements of GB/T 13234.

6. Procedures for Energy Audits

6.1 Drafting proposals for tasks of energy audits

Based on the purpose and requirements of energy audits, objectives and specific content of energy audits should be decided; energy audit plans and task proposals should be developed.

6.2 Signing energy audit agreements

Energy auditing institutions sign agreements with clients of energy audits. The agreements then become the basis for conducting energy audits.

6.3 Implementing energy audits

Data collection, sorting and verification should be conducted. Calculating analysis and evaluation should be conducted according to the requirements of the task-proposal. On-site investigation and testing can be conducted when necessary.

6.4 Providing energy audit reports

After the audit, the energy auditing report should be provided to the clients by energy auditing institutions within 15 days.

7. Drafting Energy Audit Reports

7.1 Reports of energy audit have two parts: abstract and main body.

7.2 Abstract of energy audit reports should be at the beginning of the reports, with no more than 2000 words. Abstract should include a brief explanation of the following:

a) Main tasks and content of the energy audit
b) Energy consumption structure (during the energy audit period) of the enterprise
c) Energy consumption indicators
d) Impact evaluation of energy costs and energy utilization
e) Financial analysis and economic evaluation of energy-saving technical renovation projects
f) Existing issues and analysis of energy-saving potentials
g) Conclusion of the energy audit and suggestions

7.3 Main body of the energy auditing report should be written up in detail. The report should include detailed explanations of all of the content listed in Article 7.2, and should also include the following:

a) Overview of the enterprise (including characteristics of the main processes, position of this enterprise domestically and within its sector)
b) Energy management systems in the enterprise
c) Analysis of energy consumption in the enterprise (energy flow, physical energy balance, energy statistical data collection and measurement, energy prices, etc.)

Appendix A of General Principle of Enterprise Energy Audits (GB/T17166-1997)
Calculation Method of Energy Cost Indicators

A1 Comprehensive Energy Consumption and Total Energy Costs

A1.1 Costs of purchased energy

The calculation of purchased energy costs should consider input and output of all types of purchased energy sources during the energy audit period, as well as the relationship between inventory and consumption. Energy that is consumed by the enterprise itself should be calculated.

A1.2 Calculation of comprehensive energy consumption and total energy costs

Comprehensive energy consumption should be calculated using Equation (1):

$$E = \sum_{i=1}^{n} E_i \times r_i$$

Total energy costs of the enterprise should be calculated using Equation (2):

$$R = \sum_{i=1}^{n} R_i$$

Where:

E—Comprehensive energy consumption of the enterprise, tce/year;

E_i—Physical quantity of consumed energy source i, t (or other physical untis)/year;

r_i—Conversion factor to standard coal of energy source i;

n—Number of consumed energy sources in the enterprise;

R—Total energy costs of the enterprise, 10,000 RMB/year;

R_i—Total energy costs of consumed energy source i, 10,000 RMB/year.

Note: Commonly annual values are calculated. If the energy audit period used is not one year, energy auditing institutions or persons can calculate the units based on specific conditions.

A2 Energy Costs per Unit of Product in Direct Production

A2.1 Energy costs per unit of product during direct production can be calculated by using energy consumed (physical amounts) per unit of product and the unit price of the product.

A2.2 Physical energy consumption per unit of product can be calculated by using physical energy consumption of the production system during the energy audit period and the product production.

A3 Indirect Energy Consumption and Energy Losses

A3.1 An energy audit should examine the level of indirect energy consumption at the enterprise, and analyze the share of indirect energy consumption in total energy consumption of the enterprise.

A3.2 An energy audit should analyze the amount of and reasons to energy losses.

A3.3 When calculating comprehensive energy consumption per unit of product and energy costs per unit of product, indirect energy consumption and energy losses should be distributed to products' energy consumption indicators according to products' shares of energy consumption in direct production.

Appendix 2: National Standards (Guo Biao) Relating to Energy Audits[23]

GB/T 17166-1997 General Principle of Energy Audit on Industrial and Commercial Enterprises
This standard formulates principles of the definition, content, methodology and procedure of energy audit as well as principles for writing energy audit reports. This standard is the general technical principle for energy audits conducted in industrial and commercial enterprises. It emphasizes on explanation and unification of common issues and principle issues. It is the foundation of establishing more detailed and specific energy audit standards.

Issued Date: December 22, 1997
Effective Date: October 1, 1998

GB/T 2588-2000 General Principles for Calculation of Thermal Efficiency of Equipment
This standard provides methodologies for calculating thermal efficiency of energy-consuming equipment, setting up calculating boundaries and identifies key items that should be included in thermal balances. This standard is applicable to thermal equipment that uses fuel and heat.

Issued Date: March 16, 2000
Effective Date: September 1, 2000

GB/T 2589-2008 General Principles for Calculation of Comprehensive Energy Consumption
This standard specifies the definition and calculation methods of comprehensive energy consumption, and it can be used in energy-using enterprises to calculate and verify key energy-consuming indicators. As an update of previous version, this standard covers more energy sources and includes four methods of calculating comprehensive energy consumption. It also provides a list of coefficients to convert various energy sources to coal equivalent.

Issued Date: February 3, 2008
Effective Date: June 1, 2008

GB 6422-1986 Directives for Measuring and Testing Energy Consumption in Industrial Enterprises
This standard provides basic requirements, test conditions, and test methodologies for industrial enterprises to adopt when measuring energy consumption, effective energy use, energy loss of energy-using equipment and testing energy efficiency of energy-using equipment, devices and systems.

Issued Date: May 27, 1986
Effective Date: April 1, 1987

[23]This appendix is excerpted from Zhang, Anne, 2010. *Summary of Chinese National Standards Related to Energy Audit.* Natural Resources Defense Council.

GB/T 13234-2009 Method of Calculating Energy Saved in Industrial Enterprises

This standard specifies that enterprise's energy saving is the difference in energy consumption between actual energy consumption within enterprise's statistical report period, and the energy consumption calculated in accordance with comparative baseline. It separately defines categories of enterprise energy savings[24] and calculation method for energy saving rate. It is applicable to calculation of enterprise energy savings and energy saving rate, also can be referred to in calculation of macro energy savings.

Issued Date: March 11, 2009
Effective Date: November 1, 2009

GB/T 15587-2008 Guideline for Energy Management in Industry Enterprises

This standard specifies general requirements of establishing energy management systems as well as implementing energy management in industrial enterprises. It includes the content and requirements for industrial enterprise energy management, energy planning and methodology for analyzing on energy conservation potential, as well as management of advancement in energy conservation technology.

Issued Date: September 18, 2009
Effective Date: May 1, 2009

GB/T 15316-2009 General Principles for Monitoring and Testing of Energy Savings

This general principle establishes general technical principles for monitoring enterprise energy consumption, standardizes definitions for energy utilization status and energy conservation monitoring, and specifies content and requirements for energy monitoring. It is a specific technical standard for energy conservation monitoring, and energy conservation monitoring work by other enterprises.

Issued Date: March 11, 2009
Effective Date: November 1, 2009

GB/T 16614-1996 Statistical Method of Energy Balance in Enterprises

This standard specifies the basic principles of statistical method of energy balance in enterprises, and provides a key template for energy statistical system in mechanical industry. It can be applied to determine energy statistical systems, energy statistical indicators and methodology.

Issued Date: November 28, 1996
Effective Date: July 1, 1997

[24] The enterprise energy savings have different types including: energy saved of product/products, energy saved of output and energy saved of technique/techniques, energy saved of production mix variety, as well as energy saved by energy types.

GB/T 16615-1996 Methods of Drawing up Energy Balance Table in Enterprises

This standard specifies the principles and methodology of preparing energy balance tables for enterprises. It lists the main components of an energy balance, provides general requirements of energy balance input data as well as a methodology for calculating energy utilization rates.

Issued Date: November 28, 1996
Effective Date: July 1, 1997

GB/T 16616-1996 Methods of Drawing Energy Network Diagram in Enterprises

Energy network diagrams can be used to display energy flows of enterprises, and to show the results of enterprises' energy balance visually. This standard specifies the drawing principles and methodologies of energy network diagrams, which can assist the enterprises to identify key areas for technical retrofitting, and to find energy-saving opportunities.

Issued Date: November 28, 1996
Effective Date: July 1, 1997

GB 17167-2006 General Principle for Equipping and Managing of the Measuring Instrument of Energy in Organization of Energy Using

This standard with mandatory requirements on equipping and managing energy measurement instrument is an updated version of its 1997 standard (GB/T 17167-1997), which was a fully recommended version. It establishes basic requirements for installation and management of energy measurement devices. It is applicable to independently budgeted energy consuming entities such as enterprises, public utilities, administrative agencies and social organizations.

Issued Date: June 2, 2006
Effective Date: January 1, 2007

Appendix 3: Monitoring and Reporting of Industrial Energy Data in China

This appendix provides an overview of the current statistical system used in China to report, collect and monitor energy and environmental data at different levels, i.e., the national level (all the industrial enterprises), the Key Energy-Using Enterprises (重点用能单位, annual energy consumption >5,000 tce), and the Top-1000 Enterprises (千家企业, annual energy consumption >180,000 tce). Based on published governmental guidelines and regulations, this appendix outlines what data are required to be reported, by whom, to whom, and in what frequency.

Industrial Enterprises

The National Bureau of Statistics (国家统计局, NBS) in China established the *Energy Statistical Reporting System* (能源统计报表制度) to collect data of energy production, imports, exports, consumption, purchase, inventory as well as energy efficiency nationally and regionally (NBS, 2009). The common framework of the *Energy Statistical Reporting System* with required reporting items is set up by NBS for provinces to adopt, in order to ensure consistency in statistical methodologies, calculation methods, and statistical scopes.

Four main components are in the *Energy Statistical Reporting System*, including comprehensive annual reports (综合年报表), comprehensive periodic reports (综合定期报表), local-level annual reports (基层年报表), and local-level periodic reports (基层定期报表). Annual reports usually include more indicators than the periodic reports, with a wider statistical scope and more detailed categories. Periodic reports demand quick turn-around time of data collection, i.e., quarterly or monthly data reporting, but only target a few indicators. Both annual reports and periodic reports have comprehensive and local-level reports. Local statistical bureaus of provinces/cities/municipalities provide the comprehensive reports to NBS directly. The local-level reports are formulated by the NBS, but can be supplemented with local conditions. Local statistical bureaus then distribute the local-level reports to industrial enterprises for data collection. As a result, the system covers almost all energy-related activities in one province or region annually, and emphasizes on industrial energy consumption at the local level periodically.

Table A1 shows the required data items under the *Energy Statistical Reporting System* used in Jiangsu Province. Although there are provincial differences depending on their local energy structure, the main data requirements of annual comprehensive reporting include:

- energy balance by fuel (in physical quantity and in standard coal equivalent)
- sectoral energy consumption by fuel (primary energy use and final energy use)
- resources (coal, oil and natural gas) production, sales and distribution
- transportation energy consumption by mode
- energy imports and exports by fuel
- electricity consumption by sector
- economic energy intensity (reporting both energy consumption and GDP in fixed-prices)

Local-level data reporting include:

- energy purchase, consumption and inventory at industrial enterprises (by fuel)
- water consumption at industrial enterprises
- energy purchase, consumption and inventory at key energy-using enterprises (by fuel)
- energy consumption of main industrial products

It should be noted that both the Key Energy-Using Enterprises and the Top-1000 Enterprises are covered in the NBS system, as by definition, their annual energy consumption are larger than 5,000 tonnes of coal equivalent per year.

Table A1. Template of the Energy Statistical Reporting System

# of Tables	Reporting Items	Reporting Frequency	Statistical Scopes	Submitted to	Submission methods
Comprehensive Annual Reports					
P303-1	Energy balance table (physical)	Annually	All (excludes military system)	City/Provincial statistical bureaus	Email by the end of March
P303-2	Primary Energy consumption by sector (physical)				
P303-3	End-use energy consumption by sector (physical)				
P303-4	Energy balance table (standard coal)				
P303-5	End-use energy consumption by sector (standard coal)				
SP320	Coal production and sales		Local mineral bureaus, coal production companies/groups	Local statistical bureaus	Email or fax by the end of February
SP321	Crude oil, natural gas production and sales		Oil/natural gas extraction groups/companies		
SP322	Crude oil and petroleum products resources and distribution		Petrochemical companies/groups		
SP323	Energy consumption and inventory of transportation and postal services		Railway, air, road and water-transportation companies	Provincial transportation office, provincial communications office, provincial postal office	
SP324	Energy imports and exports		Customs	Local customs	
SP325	Purchase, sales and inventory of petroleum products		Petrochemical companies/groups	Petrochemical companies/groups	
SP326	Energy purchase, consumption and inventory		Provincial construction bureau, fuel companies	Provincial construction bureau, fuel companies	
SP327	Electricity consumption		Power companies	Power companies and power industry associations	
P406	Energy intensity per unit of GDP		Consistent with indicators	City/Provincial statistical bureaus	
Comprehensive periodic reports					
SP420	Energy consumption and inventory of transportation and postal services	Quarterly	Railway, air, road and water-transportation companies	Provincial transportation office, provincial communications office, provincial postal office	Email, submit in 15 days after the end of quarter
SP421	Energy imports and exports		Customs	Local customs	
SP422	Purchase, sales and inventory of petroleum products		Petrochemical companies/groups	Petrochemical companies/groups	
SP423	Energy purchase, consumption and inventory		Provincial construction bureau, fuel companies	Provincial construction bureau, fuel companies	
P407	Electricity consumption	Monthly	Power companies	Power companies and power industry associations	Email, submit in five days after the end of month; for October, submit in nine days after the end of month

# of Tables	Reporting Items	Reporting Frequency	Statistical Scopes	Submitted to	Submission methods
Local-level annual reports					
P201	Energy purchase, consumption and inventory of industrial enterprises	Annually	Industrial enterprises	City/Provincial statistical bureaus, power industry associations, petrochemical groups	Email by the end of February
P201-1	Appendix of Energy purchase, consumption and inventory of industrial enterprises		Industrial enterprises that transformed and recycled energy		
P206	Water consumption at industrial enterprises		Industrial enterprises		
Local-level periodic reports					
P201	Energy purchase, consumption and inventory of industrial enterprises	Quarterly	Industrial enterprises	City/Provincial statistical bureaus, power industry associations, petrochemical groups	Email, submit in 12 days after the end of quarter; for the last quarter, submit by Jan 15th
P201-1	Appendix of Energy purchase, consumption and inventory of industrial enterprises		Industrial enterprises that transformed and recycled energy		
P201-2	Energy purchase, consumption and inventory of industrial enterprises in key energy-using enterprises	Monthly	Annual energy consumption > 5,000 tce		Email, submit in 12 days after the end of month; for December, submit by Jan 15th; no submission for January
P201-3	Appendix of Energy purchase, consumption and inventory of industrial enterprises in key energy-using enterprises		Annual energy consumption > 5,000 tce; Industrial enterprises that transformed and recycled energy		
P206	Water consumption at industrial enterprises	Quarterly	Industrial enterprises		Email, submit in 15 days after the end of 1st, 2nd, and 4th quarter; for the third quarter, submit by Oct 20th
P207	Energy consumption per unit of main industrial products	Monthly	Annual energy consumption > 5,000 tce	City/Provincial statistical bureaus	Email, submit in 11 days after the end of month; no submission for January

Source: Jiangsu Government website, valid through June 2010.

Physical energy intensities of main industrial products are collected through the table of energy consumption per unit of main industrial products (P207, 主要耗能工业企业单位产品能源消耗情况), which requires enterprises to provide data on both production and energy consumption. The covered products include: coal mining and washing, oil and natural gas extraction, ferrous metals mining, chemical fibers, textile products, paper-making and paper-products, coking, oil refining, inorganic alkali, inorganic salt, ethylene, synthesis ammonia, cement, flat glass, ferrous metal smelting and manufacturing, copper, aluminum, lead and zinc smelting, non-ferrous metal smelting and manufacturing and coal-fired power.

In regard to the data collecting and reporting process, variations have also been seen among different cities and provinces, in data reporting institutes/ organizations, reporting methods, and reporting deadlines. However, the basic data reporting procedure is similar across the country.

Figure A1 illustrates the process and structure of *the Energy Statistical Reporting System*, where different energy users/producers report to their corresponding agencies. Industrial enterprises report data on energy consumption, purchases, and inventory to city-level statistical bureaus and industrial associations. Power companies report electricity usage to electricity associations. Mining bureaus and coal-using power companies report their coal production and consumption to city-level statistical bureaus. Oil and natural gas (extraction and refining) companies report production, sales and distribution to city-level statistical bureaus. Transportation sector's energy consumption is reported by rail-way, road and water-transport companies to provincial transportation bureaus. Energy imports and exports are reported by custom entities to provincial customs.

The scope and depth of this system has been expanded with the issuance of three guidelines on the data reporting, monitoring and evaluation systems of economic energy intensity have been issued by NBS and National Development and Reform Commission (NDRC) in 2007 (《单位 GDP 能耗统计、监测、考核指标体系实施方案》). The guidelines direct the energy data collection to include energy data of small enterprises (规模以下), which have less than 5 million RMB in annual sales, and to cover more types of energy sources, such as renewable energy, low heat-value fuels and industrial wastes. Waste heat and waste energy utilization shall also be included. Moreover, this expanding of statistical scope is not only for industrial sector, which has always been the one of the priorities, but also for construction sector, public buildings, residential energy consumption, and tertiary sector (catering and delivering services energy consumption).

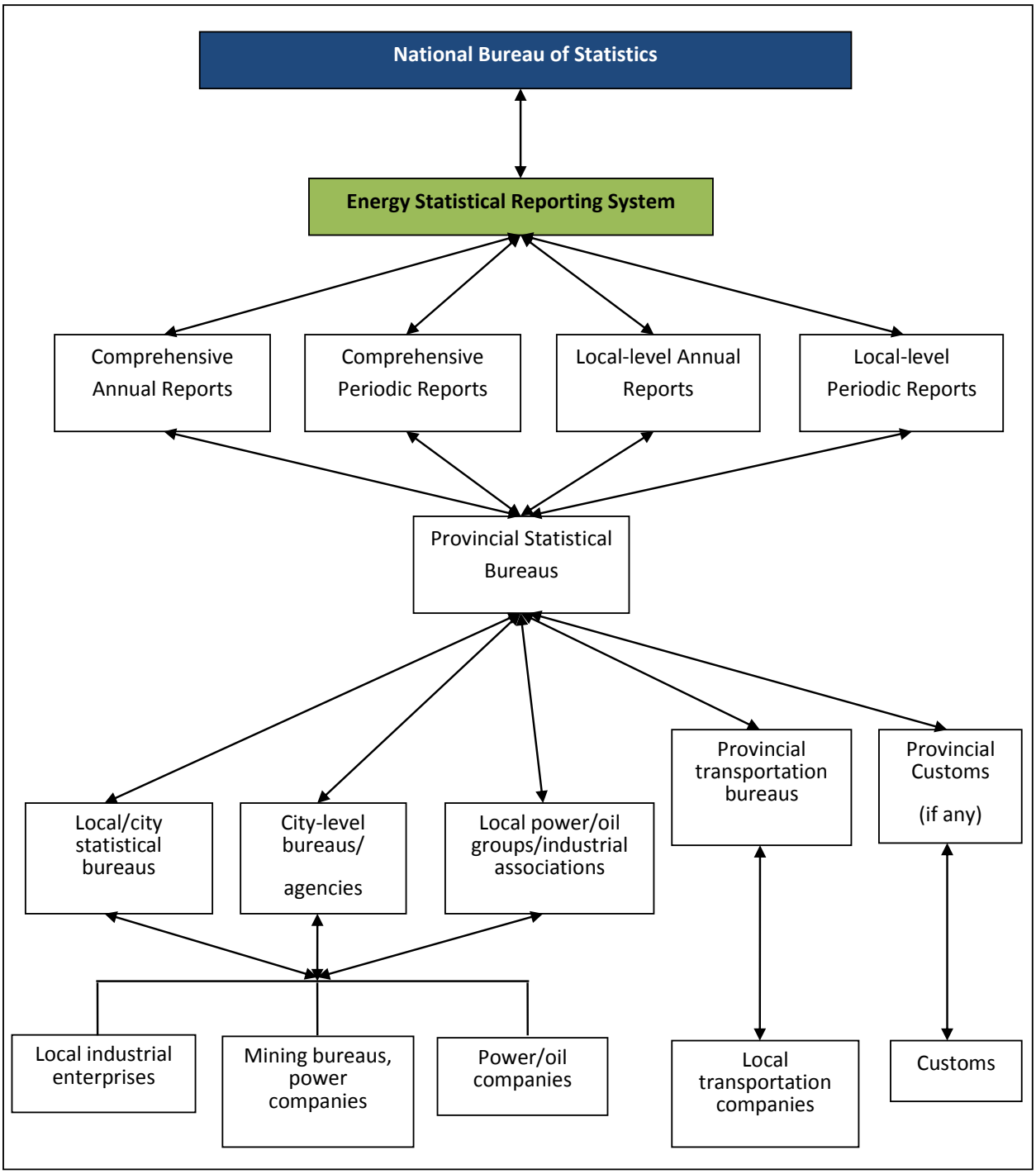

Figure A1. Structure of the Energy Statistical System

Source: NBS, 2009; Jiangsu Government website, 2010; Shandong Government website, 2010.

The *Energy Statistical Reporting System* plays a critical role in China's industrial energy data reporting system. It covers a wide scope of enterprises, including both the Key Energy-Using

Enterprises and the Top-1000 Enterprises, which will be described in the section below. It tracks important economic and energy indicators, including economic energy intensity, physical energy intensity, as well as specific energy consumption of main industrial products. The yearly outcome of this NBS system is the energy chapters in national and provincial statistical yearbooks. Eventually, the *Energy Statistical Reporting System* serves the purpose of understanding the country's situation in energy consumption and production, and evaluating China's progress toward its energy/climate targets at the national level.

However, this system is difficult for NBS to conduct independent evaluation and verification or indentify misreported and low-quality data (Sinton, 2001). Because its structure is built as layers upon layers, i.e., NBS depends on the provincial bureaus' provincial data to prepare for the national one, and the provincial bureaus then depend on lower-level entities for data collecting. The quality of the data gathered also largely depends on the coordination and capacities of enterprises, statistical bureaus, industrial associations, and local governmental agencies. Sufficient funding, staff and capacity building for energy statistics is necessary for high-quality of work.

Key Energy-Using Enterprises

Definition

In the *Energy Conservation Law of the People's Republic of China* (1997), the Key Energy-Using Enterprises (重点用能单位) were identified as a key area in which to strengthen energy management in Chapter II Article 20. These enterprises either consumed no less than 10,000 tce annually, or were designated by related governmental authorities[25] with comprehensive energy consumption between 5,000 to 10,000 tce per year (Energy Conservation Law, 1997).

The *Energy Conservation Law* (1997) generally required that energy conservation management agencies at local and national levels to supervise and examine the situation of energy utilization in Key Energy-Using Enterprises ("对重点用能单位的能源利用状况进行监督检查"). Institutions/ companies with certain testing/technical conditions can be commissioned to conduct the examination (Energy Conservation Law, 1997).

The *Energy Conservation Management Regulation of Key Energy-Using Enterprises* (《重点用能单位节能管理办法》) was issued in 1999 by then National Economic and Trade Commission

[25] Include relevant agencies in the State Council and local energy conservation management agencies in city, municipalities, autonomous regions, and provinces.

(NETC, 前国家经济贸易委员会). To supervise the energy management of the Key Energy-Using Enterprises, the regulation set the duties and responsibilities for each level of local economic and trade commissions, and required the NETC and NBS to publish the list of Key Energy-Using Enterprises (annual energy consumption ≥ 10,000tce), as well as annual reports of these enterprises' energy utilization status (MIIT, 2009).

In the amended *Energy Conservation Law* (2008), although the definition of the Key Energy-Using Enterprises remained the same as before, they stand out as a separate section (under Chapter 3 Section 6 "重点用能单位节能"). The *Law* explicitly requires the Key Energy-Using Enterprises to complete their annual "energy utilization status reports" (能源利用状况报告), which cover energy consumption, energy efficiency of production systems and equipment, completion situation of energy-saving targets, cost-effective analysis of energy savings as well as implemented energy conservation measures (Energy Conservation Law, 2008). The Law also formulates specific incentives and penalties for both enterprises and institutions that provide energy consultation, evaluation and assessments

Data reporting system

A data reporting system has been set up for the Key Energy-Using Enterprises to report on their energy utilization regularly with a purpose of tracking, monitoring, managing and evaluating their energy consumption.

Starting in 2008, NDRC established a unified reporting structure for every Key Energy-Using Enterprise to fill in. Information needed from the enterprises is summarized in the following Table A2.

These detailed data and information are collected through two channels. One is through a twelve-spreadsheet Excel workbook, which is distributed from NDRC to local governments and then from local authorities to local enterprises. The other is through an online data reporting software, called "The Reporting System for Key Energy-Using Enterprises Energy Utilization Reports" (重点用能单位能源利用状况报告填报系统). This system is developed by a Chinese IT company, commissioned by the NDRC. Enterprises are instructed to either submit their data in electronic copies of the Excel spreadsheets, or fill the tables through this online reporting tool.

Table A2. Required Data Reporting Information for the Key Energy-Using Enterprises

# of tables	Data input spreadsheets	Detailed information to report
1	Basic Information	Information on the enterprise, energy managers/staff, economic and energy consumption indicators, and energy consumption per unit of main products
2	Energy Consumption (1)	Purchased energy by fuel, consumed energy by fuel, and inventory
3	Energy Consumption (2)	Energy input and output for transformation, and Recycled/reutilized energy
4	Physical Energy Balance	Energy consumption/losses by process
5	Comprehensive Energy Consumption per Unit of Products	Comprehensive energy consumption of products and year-on-year changes
6	Explanations on factors changing energy/production	Explanations and analyses on key factors
7	Completion of Energy Saving Targets	Tracking the completion of the 11th FYP energy saving goals
8	Evaluation	Self-evaluation on the completion of the targets
9	Main energy-consuming equipment	Overview on energy-consuming equipment (universal and specialized equipment), operation and updates
10	Implementing national standards	Self-assessment of heat, electricity usage
11	List of energy-saving technical renovation retrofits projects	Including project type, name, retrofitted measures, invested capital, time and expected savings
12	Change of energy-saving projects over the last year	Explain the reasons to the changes in energy-saving projects

Source: NDRC, 2008.

To facilitate the process of filling and reporting, positions of energy managers are required to be established within the Key Energy-Using Enterprises and with a notification to related local governmental authorities. The energy managers (能源管理负责人) shall be responsible for analyzing, evaluating and organizing the composition of the energy utilization status reports. Necessary training on energy conservation is required to become energy managers (Energy Conservation Law, 2008).

Monitoring and Evaluation

When the reports are completed, enterprises are required to submit the reports to local energy conservation management authorities for review and examination by the end of March (NDRC, 2008). As this reporting system was established in 2008, companies were asked to file their 2008 annual reports by March 2009, and at the same time, submit their annual reports for both 2006 and 2007.

Provincial-level governmental authorities are responsible for organizing reviewing reports from larger enterprises (annual energy consumption > 10,000 tce). City-level governmental agencies take the lead in reviewing reports from smaller enterprises (5,000-10,000 tce/year) in their regions, then submit the reports to provincial-level governments.

If certain Key Energy Using Enterprises are found to be energy inefficient, or have an insufficient energy management system, governmental authorities are given the power to conduct onsite investigations, testing the efficiency of their equipment/production systems, require enterprises to conduct energy audits, and provide requirements for modifications in written. Enterprises are required to meet the requirements in a specified timeframe.

According to the amended *Energy Conservation Law*, the Key Energy-Using Enterprises bear a series of legal responsibilities for submitting the energy utilization reports as well as implementing the instructed modification requirements. The *Law* states that if enterprises fail to submit or fail to report the real situation, and do not re-submit their annual reports by their deadlines, companies will be fined in a range of 10,000 RMB –50,000 RMB. If enterprises refuse to implement instructed modifications from the energy management authorities, or their implementation fails to meet the requirements, they will be fined between 100,000 RMB to 300,000 RMB. In addition, if the Key Energy-Using Enterprises did not establish positions for energy managers at their facilities, and further refused to make necessary changes, they will be fined more than 10,000 RMB, and below 30,000 RMB (Energy Conservation Law, 2008).

With annual status reports from the Key Energy-Using Enterprises of their regions, provincial-governments are directed to prepare an integrated report with reviews and analyses on their regional enterprises' energy consumption and efficiency. By the end of April, integrated reports from provincial governments are required to be submitted to NDRC. The Department of Resources Conservation and Environmental Protection of NDRC aggregates the reports at the national level, and publishes the national report to the public (NDRC, 2008). The procedures of data reporting for the Key Energy-Using Enterprises are illustrated in the following Figure A2.

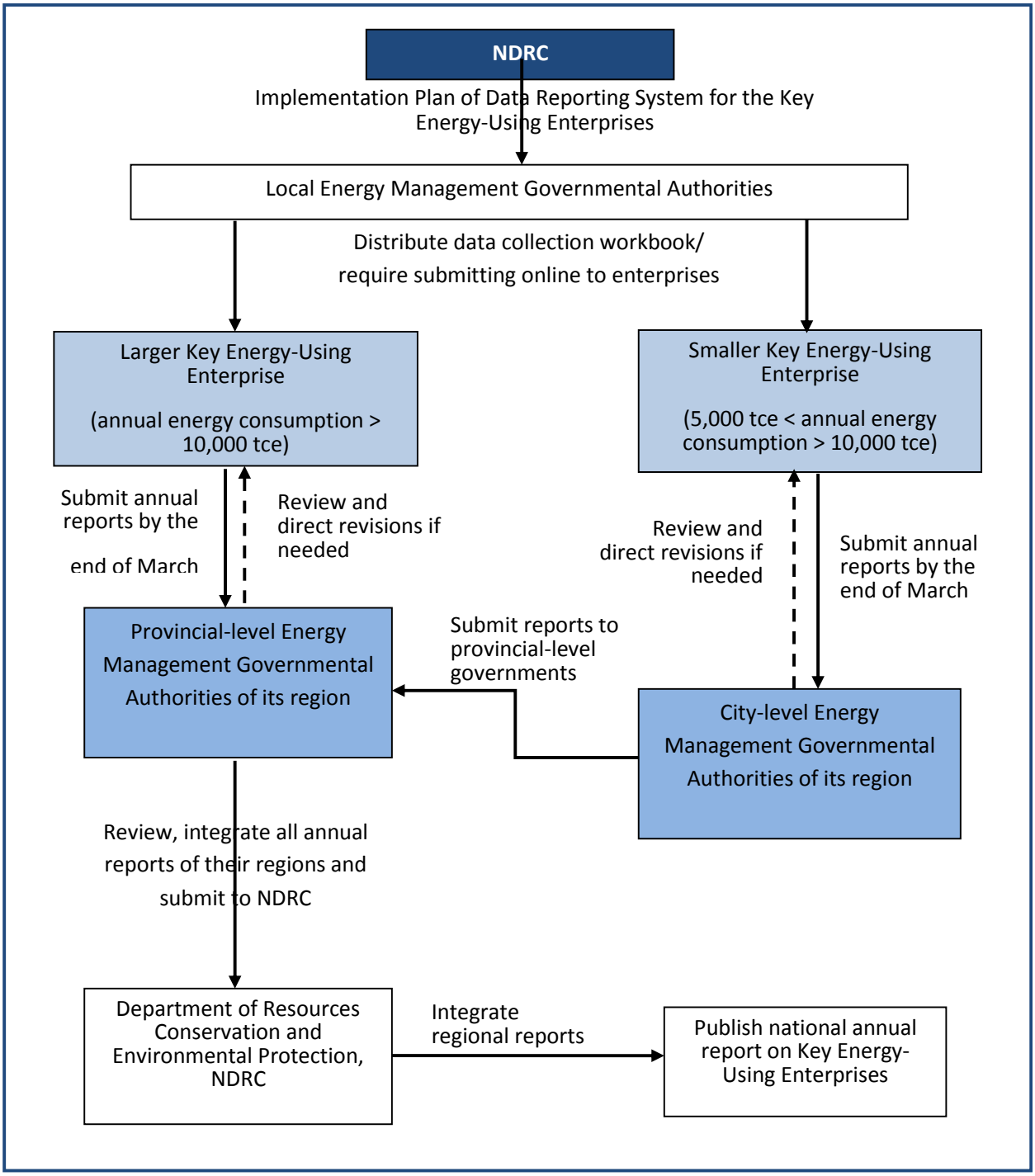

Figure A2. Data Reporting Procedures for the Key Energy-Using Enterprises

Source: NDRC, 2008.

Top-1000 Enterprises

The Top-1000 Energy-Consuming Enterprises Program (千家企业节能行动) was launched in April 2006, to support the China's 20% economic energy intensity reduction goal during the 11th FYP. Enterprises in industries of iron & steel, non-ferrous metals, coal, power, petrochemical, chemicals, building materials, textile and pulp & paper, with annual comprehensive energy consumption more than 180,000 tce are targeted under this program

Six tasks for the enterprises were established under the *Implementation Plan of the Top-1000 Energy-Consuming Enterprises Program* (*Implementation Plan*,《千家企业节能行动方案》), which was announced by NDRC, the Office of National Energy Leading Group, NBS, the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and the State-owned Assets Supervision and Administration Commission (SASAC). Two of these requirements relate to data collection and reporting:

- Establish sound energy measuring and statistical system; submit energy utilization status reports of enterprises regularly;
- Conduct energy audits and develop energy conservation plans.

Information on enterprises' energy consumption, energy efficiency, cost-effectiveness of energy savings, and energy-efficient measures are required for the energy utilization status reports. The *Implementation Plan* directed that NBS is responsible for organizing and deploying this work.

The Top-1000 Enterprises are also required to undertake energy audits by following the Chinese energy audit standard (GB/T 17166-1997). The *Implementation Plan* specifies that the energy audits are to be used to analyze the situation on the ground, identify key issues and potentials, and provide feasible and practical energy-saving measures ("通过能源审计，分析现状，查找问题，挖掘潜力，提出切实可行的节能措施"). Based on the energy audits, enterprises can formulate their annual energy conservation plans.

In order to track, monitor and evaluate the progress of the Top-1000 Enterprises, government entities, including energy conservation authorities at the provincial or local-level, NBS, AQSIQ and SASAC, were designed to take the lead on different tasks, as shown in Table A3 and Figure A3.

For data collection and reporting of the Top-1000 Enterprises, local governments (local energy conservation authorities) supervise and urge the enterprises within their territories to submit related data and information and conduct regular or random checking on enterprises' energy utilization. NBS of China is responsible for establishing the information system for the Top-1000 Program and tracking, collecting and reviewing data from the Top-1000 Enterprises. NBS is also in charge of analyzing and integrating the progress of the Top-1000 Program. AQSIQ takes the lead in ensuring the enterprises have the correct and complete measuring equipment. SASAC is focusing on the "central enterprises" (中央企业), whose investment capital is from SASAC, under the commission of the State Council of China. NDRC publishes reports on the progress of Top-1000 Programs, covering the realized energy savings in total and of individual companies. NDRC also organizes verification teams from central governments, research institutions and industrial associations to local provinces to investigate the progress every year in spring.

In addition, industrial associations will assist the target allocation and evaluation system for the Top-1000 Enterprises, research domestic and international best practices of industrial sectors, and provide consultations and training to enterprises in energy-efficient measures and technologies.

Table A3. Duties and responsibilities of governmental entities

Government entities	Responsible for…
Energy conservation authorities at provincial/county/city-level	• supervise and urge enterprises to strengthen energy management • supervise and urge enterprises to submit information • organize experts to review energy audit reports and energy conservation plans • supervise and urge the implementation of the plans • conduct regular or random checks on enterprises • convert reducing energy intensities of products targets to absolute energy savings • allocate energy-saving targets to enterprises • promote voluntary agreements and other new mechanisms • reward enterprises that meet their targets or reach international best practices
NBS	• establish information system for Top-1000 enterprises • track, collect and review data • organize training on data collection and reporting • analyze the progress of the program
AQSIQ	• examine energy measuring instrument/equipment of the enterprises • guide the enterprises to establish measuring systems at enterprises • urge enterprises to calibrate and adjust measuring instrument • instruct enterprise in utilizing the measured data
SASAC	• review the performance of the "central enterprises" • integrate energy conservation targets into enterprises' performance reviews
NDRC	• PublishTop-1000 Enterprises' energy utilization status reports • Organize verification teams to local provinces

Source: NDRC, 2006.

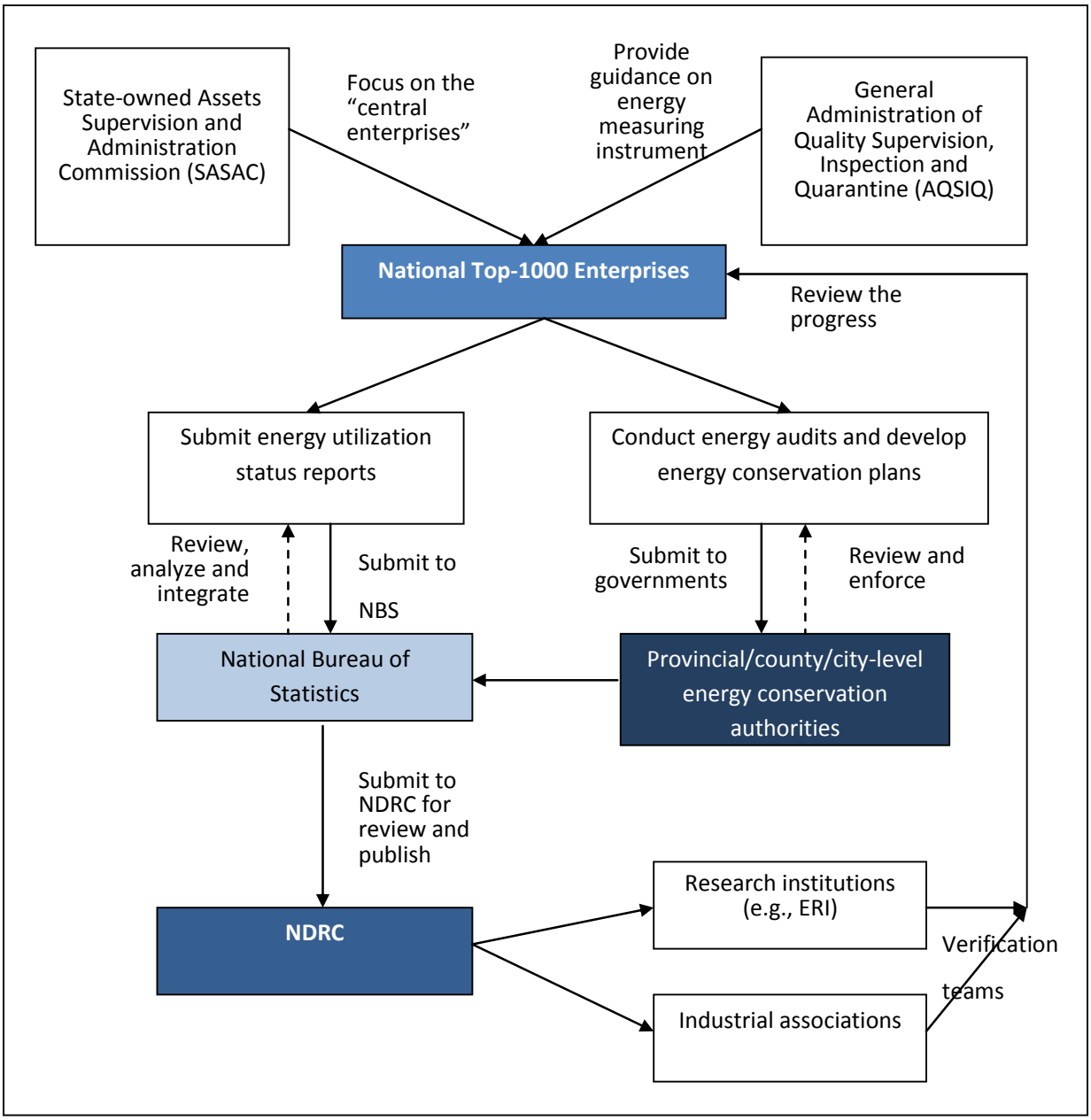

Figure A3. Structure of the Top-1000 Program

Source: NDRC, 2006.

Energy savings of the Top-1000 Program for the first four years are publicly available on NDRC's website. However, more detailed information on the program's progress, including progress of energy audits, identified barriers and opportunities are not provided publicly

Monitoring and Evaluation

The evaluation of Top-1000 Program has two parts. First, enterprises submit reports of their self-evaluation on the completion of energy-saving targets to provincial energy conservation/ supervision centers and provincial Development and Reform Committees, or Economic and Information Committees. Second, provincial governments then convene an evaluation team, with energy experts from industry, associations and organizations, to conduct evaluation and verification of self-evaluated reports. Verification results are submitted to local governments as well as NDRC. A rating scheme is developed and used by inspectors to evaluate the performance of Top-1000 enterprises.

Energy conservation target (40 points maximum)	100% of target achieved: 40 points; 90% achieved: 35; 80% achieved: 30; 70% achieved 25; 60% achieved: 20; 50% achieved: 0
Energy conservation measures (60 points maximum)	Energy conservation leading group: 3 points Energy conservation management department: 2
	Decomposition of target to unit and person 3 Assessment of energy conservation target 3 Reward and punishment system 4
	Energy efficiency performance in 1000 enterprises: 10 for top 10% and 5 for top 50%. Energy conservation R&D fund 4 Annual energy conservation plan 4 Closure of backward equipment 7 Retirement of outdated equipment
	Implementation of local regulation 2 Implementation of energy consumption norm 4 Norm management for energy consuming equipments 2 Implementation of energy conservation design 2
	Energy audit and monitoring system 2 Energy statistics manger and account 3 Energy monitoring appliance 3 Energy conservation training 2

Source: Seligsohn, D., 2010. Testimony Before the Congressional-Executive Commission on China China's System for Measuring, Monitoring, and Reporting Energy and Climate Data. World Resources Institute, 2010. http://www.wri.org/publication/cecc-testimony-china-measuring-monitoring-reporting

Central Stated-Owned Enterprises

Beginning in March 2010, a new regulation, "The Interim Regulation on Energy-Conservation, Emission-Reduction Supervision and Management" (《中央企业节能减排监督管理暂行办法》) has been issued to the Central State-Owned Enterprises (中央企业, or central enterprises). The State-owned Assets Supervision and Administration Commission (SASAC) of the State Council, which has been responsible for supervising the economic performance of the central enterprises, is now being given the authority to supervise their implementation of national energy-saving and emission-reduction policies, organize and participate in the energy-conservation evaluation of the central enterprises, and to supervise the establishment of energy-saving management, monitoring and evaluation systems within these enterprises.

The central enterprises have been grouped into three categories, based on their energy consumption as well as emitted pollution, as showed in Table A4.

Table A4. Number of and Characterization of Central State-Owned Enterprises

Category	# of Enterprises	Energy consumption	SO2 emissions	COD Emissions
Key Enterprises (重点类企业)	32	>2 million tce per year	>50,000 tonnes per year	>5,000 tonnes per year
Concerned Enterprises (关注类企业)	51	>100,000 tce per year	>1,000 tonnes per year	>200 tonnes per year
General Enterprises (一般类企业)	45	Other central enterprises that are not included in the first two categories		

Source: SASAC, 2010. The Interim Regulation on Energy-Conservation, Emission-Reduction Supervision and Management of Central State-owned Enterprises.

The central enterprises are required to set up internal management systems for energy conservation and emission reduction, establish specific energy-conservation and emission reduction plans, and integrate them into corporate development strategies as well as enterprises' annual work plans.

The main difference between the "key" and "concerned" enterprises is in the establishment of energy-saving coordination, supervision and management departments. While the "concerned" enterprises are required to have internal agencies established in energy-related departments, the "key" enterprises should have specific functional departments responsible for energy conservation. The attention of "general" enterprises is more focused on the energy-

conservation managers or supervisors, who are in charge of energy-related measurements, reporting and analysis.

Monitoring and Evaluation

After the internal management and reporting systems have been put into place, central enterprises are required to evaluate the energy-saving and emission-reduction performance of their sub-companies first, and then submit a summary report to SASAC every three, six and twelve months. Information on companies' energy consumption, emissions of key pollutants, annual changes of energy consumption and pollutants emissions, implemented energy-saving & emission reduction measures, and savings is included in the reports. "Key" and "concerned" enterprises are also required to provide benchmarking results and analysis. Verification of the submitted reports is conducted mainly by SASAC, through its Audit Office, experts' reviews, onsite examinations, or commissioning third-party institutions.

A carrot and stick approach has been used to incentivize central enterprises. Managers of the companies will be down-graded if SASAC finds faults in reported energy data. Managers can only get a low score on performance review if their companies did not achieve their energy-saving targets. Companies will get SASAC's reward of "Best Enterprise in Energy Conservation and Emission Reduction" (节能减排优秀企业奖)" if they outperformed in energy-conservation and emission-reduction, such as completing energy-saving targets, signing agreements with local governments on energy conservation, having established energy data monitoring and management system, or key energy performance indicators are close to the best practices in China.

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