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

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Abstract

China set an ambitious goal of reducing its energy use per unit of GDP by 20% between 2006 and 2010. Much of the country's effort is focused on improving the energy efficiency of the industrial sector, which consumes about two-thirds of China's primary energy. Industrial energy audits are an important part of China's efforts to improve its energy intensity. Such audits are employed to help enterprises identify energy-efficiency improvement opportunities and serve as a means to collect critical energy-consuming information. Information about energy audit practices in China is, however, little known to the outside world. This study combines a review of China's national policies and programs on energy auditing with information collected from surveying a variety of Chinese institutions involved in energy audits. A key goal of the study is to conduct a gap analysis to identify how current practices in China related to energy auditing differ from energy auditing practices found around the world. This article presents our findings on the study of China's energy auditing practices at the national and provincial levels. It discusses key issues related to the energy audits conducted in China and offers policy recommendations that draw upon international best practices.

Keywords: *China, Industrial Energy Efficiency, Energy Audit*

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 industrial facilities throughout 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, an in-depth study, which involved a review of relevant national policies as well as a series of in-person meetings, was conducted.

This paper discusses the findings of the study (Shen et al., 2010).¹ First, it describes current energy auditing practices at both the national and provincial levels, which reveals that industrial energy audits have been employed to help Chinese enterprises identify energy-efficiency improvement opportunities for achieving the energy-saving targets while also serving as a mean to collect critical energy-consuming information that allows governments at different levels to oversee enterprises' energy use and evaluate their energy performance.

The paper then discusses some of the key issues related to energy audits conducted in China. These issues include the lack of a long-term mechanism to promote energy auditing, lack of a national level organization for organizing and coordinating energy auditing activities, 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. A gap analysis is undertaken, making comparisons between how energy auditing is conducted in China and other countries with the aim of identifying the areas in which further improvement could be made in China. The paper then offers policy recommendations for China to remove barriers to maximizing the potential of energy audits.

2. Methodology

The purpose of this study was to conduct a gap analysis between the current energy auditing situation in China and energy auditing programs and practices found around the world. The study relied upon both a review of Chinese 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

¹ This paper is an extraction from our larger report, which is available online at <http://china.lbl.gov/publications/energy-audit-practices-china-national-and-local-experiences-and-issues>. Our work was supported by the China Sustainable Energy Program (CSEP) of the Energy Foundation, the Regulatory Assistance Project (RAP), Dow Chemical Company (through a charitable contribution) and the Partnership for Climate Action Program of the U.S. Agency for International Development through the Institute for Sustainable Communities through the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. We greatly appreciate the guidance that has been provided by He Ping of CSEP and David Moskovitz of RAP. We thank staff at the DSM Technical Center of the Natural Resources Defense Council (NRDC) Beijing Office for their valuable assistance in developing the questionnaire, arranging interviews, and collecting information. The report could not have been written without the information provided to us through numerous interviews which are referenced throughout the report. We greatly appreciate the time the interviewees spent with us to provide information on their work in conducting energy audits. We greatly appreciate the comments received on the larger report by David Crossley of RAP, Li Tianan and Liu Yulong of the Center for Industrial Energy Efficiency (Beijing), Li Yuqi of NRDC, and Shi Xiaoyu of the World Resources Institute Beijing Office and review comments on this paper by Michaela Martin of ICF International and an anonymous Energy Policy reviewer.

and cities (Jiangsu, Hebei, Sichuan, Shanghai, Beijing, and Suzhou) in order to assess Chinese experience relative to the international experience with energy auditing.

The types of organizations interviewed in China included local energy conservation centers, energy conservation supervision centers, demand-side management guidance centers, energy-saving certification agencies, energy service companies (ESCOs), non-governmental organizations (NGOs), and university-based energy assessment centers. The interviews were conducted using a guided approach through which the same general questions were asked from each interviewee; this approach allows a degree of freedom and adaptability for obtaining information from the interviewees while at the same time making the results easier to analyze and compare (Kvale, 1996).

To assist in the collection of information, a comprehensive questionnaire was designed and used prior to the in-person meetings. The questionnaire was comprised of both close-ended questions to which respondents' answers would be limited to a fixed set of options and open-ended questions to which respondents' answers would not be constrained by a fixed set of possible responses. This approach facilitated faster interviews. On the other hand, this format gave respondents enough flexibility and freedom to better express their opinions and also provides the opportunity to follow up with the respondents' answers through face-to-face meetings. The scope of the questionnaire included the purpose for conducting energy audits, entities involved in energy auditing, types of energy audits, energy auditing procedures, data collection, use of assessment tools, energy auditing training, funding for energy audits, energy audit reporting and reviews, as well as post-audit measures and evaluation.

3. Energy Auditing Practices in China²

Over the last three decades, industrial energy audits in China have gone through different periods.³ The largest and most recent energy auditing program was undertaken during the 11th Five-Year Plan (FYP) (2006-2010). In 2005, the Chinese government announced an ambitious goal of reducing the country's energy intensity, defined as energy use per unit of gross domestic product (GDP), by 20% by 2010. One of the key initiatives for achieving this goal was the Top-1000 program, which was launched in 2006 and targeted the 1,008⁴ largest energy-consuming enterprises across nine sectors that each consumed a minimum of 180,000 tons of coal equivalent (tce) (or 5,268 TJ⁵) 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).

² Given space limitations, this paper only discusses some key aspects of China's practices. For detailed information, please see the original report on which this paper is based (Shen et al., 2010)

³ Industrial energy audits in China have gone through four different periods since the 1980s. The first focused on energy performance assessments from the 1980s to the early 1990s. This was followed by the energy system diagnostics program from the 1990s to the early 2000s and cleaner production auditing since 2003. The most recent activity was the largest under the Top-1000 program from 2006 to 2010. For a historic review of China's energy audit program in the last three decades, please see the original report.

⁴ The number of participating enterprises later changed to 938 due to company merges or business closures.

⁵ 1 tonne of coal equivalent (tce) = 29.27 GJ, based on the National Bureau of Statistics of China's conversion factor (NBS, 2011).

To achieve the specific energy-saving targets, Top-1000 enterprises were required to fulfill six sets of tasks, one of which is to perform energy audits and develop energy-saving plans (NDRC, 2006a).⁶ The mandatory energy audits – which are only required once for each participating enterprise unless they failed to pass the government review – had 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 measures (NDRC, 2006b).

While the focus of the central government's Top-1000 Program was on the largest energy-consuming enterprises, many provincial and local governments 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.⁷ Table 1 provides a brief description of different kinds of energy audits in China, including information on the types of audits, their purpose, duration, scope, who requires the audits, who conducts the audits, and post-audit activities.

⁶ 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.

⁷ For example, Shandong Province initiated a 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 "local 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).

Table 1. Industrial Energy Audits in China at a Glance

Type	Purpose	Duration and Scope	Required by	Funded by	Conducted by	Post-audit activities
Detailed mandatory audits	Satisfy government mandate under Top-1000 and/or meet government cleaner production requirement	45 days to several months covering every facility of an entire company; consisting of an energy accounting audit and an assessment for energy-saving opportunity	Governments at both central and local level	Mainly enterprise; some local audits are partially reimbursed by the local government	Local energy conservation centers, cleaner production centers, industrial associations, ESCOs, engineering firms, universities	Implementation of measures Evaluation of implementation results
Quality assurance audits	Check the quality of government-mandated energy audits	Several weeks, reviewing enterprises energy data and their systems for measuring the data	Central government	Government	Local energy conservation centers or local energy conservation supervision centers	Approval of enterprises' energy audit reports
Validation 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	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 integrated solutions to maximize enterprise energy-saving potentials	Several weeks, focusing on entire facilities	Subsidiaries of multinationals	Enterprise, but expenses could be recovered from the energy service contract	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 achieve superior performance with greater energy savings	Several weeks focusing on entire facilities	Enterprises	Enterprise	Enterprise energy centers or external auditors	Implementation of the identified measures
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	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	Multinational companies	Multinational companies	International NGOs	Implementation of the identified measures 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	A couple of days to a month focusing on specific projects	Lenders or investors	Investor	Professional auditors hired by international NGOs or investors	Implementation of the project

3.1. Institutions Involved in Energy Auditing

Entities that often conduct industrial energy audits in China include local energy conservation centers, energy conservation supervision centers, cleaner production centers, industrial associations, ESCOs, engineering firms, project design companies, and universities.⁸ These are professional entities that have been certified by relevant government agencies to qualify for performing the design and implementation of engineering projects. Box 1 describes the key functions of these entities. 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 energy auditing also include domestic entities in charge of validating enterprises' energy-savings and international NGOs promoting energy efficiency in China. For example, the Ministry of Finance (MOF) and National Development and Reform Commission (NDRC) assembled an evaluation team involving two dozen institutions, which are mainly provincial energy conservation supervision centers and provincial financial inspection centers, to review enterprise applications for MOF energy-saving incentives and to conduct audits to verify actual energy savings in order to process the incentive.⁹ International NGOs like Japan's International Center for Environmental Technology Transfer and the U.S.-based Natural Resources Defense Council have brought international auditors to China to conduct energy assessments in the textile and ammonia industries.

⁸ In many places, energy conservation supervision centers and energy conservation centers are separate entities. In some places, however, energy conservation centers and supervision centers are combined as one entity. Historically, local energy conservation supervision centers and energy conservation centers were the main entities undertaking industrial 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.

⁹ See Section 3.4 below for a description of the incentive program

Box 1 Functions of Various Organizations Involved in Energy Auditing in China

- **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 entities and professionals conducting cleaner production audits, development of demonstration pilots, provision of trainings, and dissemination of cleaner production information and technologies.
- **Demand-Side Management Guidance Center (DSM Center):** an entity affiliated with the local government (e.g, Hebei DSM Center) or a 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.
- **Energy Certification Center:** an independent entity authorized by China's State Certification Oversight Commission to certify the quality of energy-consuming 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).
- **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 related to energy use.

ECSC's inspections cover energy-consuming entities, energy-related investment projects, the production and delivery of energy-consuming products and equipment, and entities pursuing energy production, operating energy-related business, or providing energy services.
- **Energy Service Company (ESCO):** a business that utilizes performance-based contracting to develop and implement energy efficiency projects for its customers. Its service is paid through the savings generated by the project.
- **University Energy Assessment Center:** a university-based interdisciplinary program focusing on utilizing university resources in supporting energy assessments, promoting energy-efficient technologies, providing energy efficiency trainings, and disseminating energy-efficiency information and best practices.

3.2. Types of Energy Audits

Industrial energy audits in China focus on a broad range of areas related to enterprise energy use and the potentials for improvement. A typical audit includes two components. One is an energy accounting audit which examines an enterprise's energy consumption level and composition on an annual basis, energy flows, energy measurement and statistics, energy management procedures, the performance of all major energy-consuming equipment, energy intensity relative to products and production, levels and flows of raw material consumption, as well as energy costs. Enterprises are required to conclude the accounting audits with the submission of an energy audit report. Another component is an energy-saving 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 assessment (NDRC, 2006a).

Detailed energy audits are also performed – usually under the request of a government agency – to ensure the quality of energy audits performed by enterprises or for verifying actual energy savings from enterprises' implementation of energy-efficiency projects. These types of special audits focus more on examining the enterprises' annual energy use and energy data reporting 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 individual solutions for which Schneider specializes but also on leveraging the technical expertise of other companies to identify integrated solutions that help enterprises maximize their overall energy-saving potentials (Shi, 2010).

In addition to the facility-wide audit, there is a targeted audit which focuses on a subsystem or a specific piece of equipment or process, e.g. lighting, a boiler, a drying process, or compressed air system. Targeted audits are commonly used by ESCOs in China since many local 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, sub-systems, and/or equipment.

Walk-through audits, which normally last one or two days, are common to identify standard energy-efficiency measures or determine whether a detailed audit is warranted. 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 measures such as lighting replacements, transformer upgrades, variable speed drives, and high-efficiency motors.

Audits aimed at identifying a portfolio of measures are a new type of energy assessment in China. These assessments focus on identifying a mix of energy-saving measures and combining the measures of quick payback with those having longer payback but deeper energy-saving potentials to create a favorable and sizeable project, in which the return on the total investment is attractive to enterprises or investors (Shen, et al., 2009).

In addition, the investor-grade energy audit concept has recently been introduced to China. For example, ECO-Asia, a regional clean development and climate program of the United States Agency for International Development, and a Hong Kong-based efficiency project investment company have conducted a series of investor-grade audits to help China's Hebei Province increase access to finance for energy-efficiency projects (Dreessen, 2010).

3.3. Energy Audit Reporting and Reviews

Submission of an energy audit report by key energy-consuming enterprises is part of the energy data reporting requirement under the Top-1000 program.¹⁰ These reports have helped the government collect critical energy-consuming information necessary to oversee enterprises' energy use and assess their energy performance.

Enterprise energy audit reports need to follow certain guideline and requirements (NDRC, 2006c) and submissions that do not follow these guidelines will not be accepted (NDRC, 2006b). Energy audits in the local programs typically follow the same reporting guidelines as the national program. Table 2 lists the information that enterprises must include in their submissions based on the national guideline.

¹⁰ For a detailed discussion of energy data reporting system for industrial enterprises in China, please see the Appendix 3 of the original report (Shen et al., 2010).

Table 2. Required Information in Energy Audit Report and Energy-Saving Plan

Energy Audit Report	Energy-Saving Plan
<ul style="list-style-type: none"> ▪ Enterprise overview (including overview on energy use, energy management, and energy flow) ▪ Status of enterprise's energy measurement/metering and data collection systems ▪ Monitoring and analysis of efficiency of key energy-consuming equipment ▪ Analysis of enterprise's key 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 on energy-saving results ▪ Evaluation of the factors affecting energy consumption ▪ Cost-effectiveness of retrofit projects ▪ Enterprise suggestions on rational use of energy 	<ul style="list-style-type: none"> ▪ 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 are aimed at achieving the goals) ▪ Steps needed to ensure the implementation of the plan ▪ Implementation plan

The national guideline requires relevant provincial and city government agencies to review submissions in their respective territories within six months. Enterprises failing to pass the evaluation are required to make improvements on the report and resubmit within three months (NDRC, 2006a; NDRC, 2006b). The evaluation, which is free of charge to enterprises and conducted primarily by local energy conservation centers or energy conservation supervision centers, focuses on four areas: (1) checks whether reports met government requirements in terms of formatting and contents, (2) verifies the accuracy and completeness of submitted information, (3) ensures the implemented measures will help enterprises meet their targets, and (4) determines 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 were put into ten categories and each category was 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 quality of energy audit reports with monetary incentives. In Changzhou, Jiangsu, for example, energy audit reports are grouped into three levels: excellent, pass, and fail. For reports that are labeled as fail, no incentives will be offered while reports passing the examination or being labeled as excellent will receive ¥20,000 RMB (US\$2,946) and ¥30,000 RMB (US\$4,419) in incentives¹¹, respectively. In Beijing, enterprise energy audit reports are also rated and companies are prohibited from receiving any government monetary incentives if their audit reports do not pass the government examination (Liu, 2010).

¹¹ ¥ is Chinese currency (also called RMB). ¥1 = US\$0.1473 in June 2010 on average.

3.4. Post-Audit Measure Implementation

Energy audits conducted at the Top-1000 enterprises have helped facilities to target their investment in energy efficiency improvement. These enterprises invested –using their own capital or borrowed funds – over ¥50 billion RMB (6.6 billion USD) and ¥90 billion RMB (12 billion USD)¹² in 2007 and 2008, respectively, in innovation and retrofit projects that resulted in energy savings of 20 million and 30 million tce (585-878 PJ), separately (NDRC, 2008; NDRC, 2009).

Incentives provided for industrial energy audits in China are usually in the form of indirect incentives. First, due to the lack of a nationally administrated energy auditing program, incentives for energy audits are generally a job for the local government. Second, incentives are usually provided for the promotion of energy-saving projects, rather than for the performance of energy audits. For example, MOF and NDRC have provided monetary rewards of ¥200 RMB per tce (US\$1 per GJ) of savings for qualified industrial facilities¹³ in the East region of China and ¥250 RMB (US\$1.3 per GJ) in the Middle and West regions and created a system for validating the savings.¹⁴

While national incentives have primarily targeted the large enterprises who have achieved measured savings of over 10,000 tce (293 TJ), provincial and local incentives are focused on smaller enterprises. The Shanghai Municipal Government, for example, awards ¥300 RMB per tce (US\$1.5 per GJ) of saved energy to enterprises that have achieved measured savings of 5,000 to 10,000 tce (146-293 TJ) (Shanghai Energy Conservation Center, 2010).

¹² ¥1 = US\$0.1316 in 2007 on average.

¹³ 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 (or 293 TJ). 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).

¹⁴ 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). Members of a government appointed review team, which are mainly provincial energy conservation supervision centers and provincial financial inspection centers, participate in this effort. To ensure fairness in the process, 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, 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).

To accelerate the implementation of energy efficiency measures, the Chinese government announced a new incentive program in June 2010 to incentivize energy service companies (ESCOs)¹⁵ and target smaller projects with energy savings anywhere between 100 and 10,000 tce (2.9-293 TJ) (between 500 and 10,000 tce (15-293 TJ) for industrial projects) (MOF, 2010).

Funding for these incentives from the Central government will be matched by local funds. For every tce of energy saved, MOF provides ¥240 RMB (US\$35) and the provincial governments will match ¥60 RMB (US\$8.8) or more¹⁶ (MOF, 2010). In addition to the direct subsidies, substantial tax benefits are also provided to ESCOs, including a 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).

To guide energy performance contracting (EPC) for ESCOs, China issued a national standard in August 2010, which was effective on January 1, 2011 (EMCA, 2010). This standard provides definitions and terms related to EPCs in China, specifies types and technical requirements of energy service contracts, and provides reference templates of the contracts. To be eligible for receiving government incentives, ESCOs must be registered with relevant government agencies – who make the company names public – and are subject to government monitoring and supervision rule (MOF, 2010).

At the provincial/city level, local governments have undertaken considerable effort to address the problems identified by the audits. 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 energy audits are used in benchmarking the energy performance of local industrial facilities against their domestic and international peers. The benchmarking helps enterprises identify gaps while at the same time enabling the local government to pay attention to enterprises that are performing relatively poorly in terms of energy efficiency compared with the benchmark (Yu, 2010).

¹⁵ 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 based on relevant national standards (e.g., GB/T 13234-2009 for calculating energy savings in industrial facilities).

¹⁶ 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 (US\$1.8 per GJ), which will provide ESCOs a combined incentive of ¥600 RMB for every tce (US\$3 per GJ) of energy saved (Wei, 2010). Beijing announced that the city will give qualified ESCOs ¥260 RMB for each tce (US\$1.3 per GJ) of energy saved, making the combined award ¥500 RMB per tce (US\$2.5 per GJ) of energy saved. For local energy service companies who are not qualified for the national incentive, the Beijing municipal government will either offer an award of ¥450 RMB for per tce (US\$2.3 per GJ) of energy saved or provide an incentive that is equivalent to 15-20% of the project cost (Beijing Evening News, 2010).

In addition to facilitating the implementation of energy-saving projects, provincial and local governments have also issued regional lists of products and technologies that need to be eliminated, created local catalogs of recommended energy-efficient equipment and technologies, and published regional directories of preferred energy service companies (ESCOs).

4. Gap Analysis of Energy Auditing in China Compared to International Experience

During last three decades, especially during 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 oversee enterprise energy use and evaluate their energy performance. Energy audits have had a positive impact on the improvement of energy efficiency in China. The energy audits performed and energy-efficiency measures implemented in China's industrial facilities during the last five years have helped the country to achieve its goal of reducing energy intensity by about 20% from 2006 to 2010.

In order to assess China's energy auditing experience, key components of the activities in China were compared to energy auditing programs in countries from around the world. Table 3 provides a comparison of various energy audit programs in selected countries that forms a basis for this assessment and comparison. .

Table 3. Comparison of Energy Auditing/Assessment Programs in Selected Countries

Country	Program (Mandatory or Voluntary)	Responsible Agencies	Audits carried out by	Type and scope of audit/assessment	Funding for audits	Other supporting measures	Tools and guidelines	Training and certification	Monitoring and evaluation
China	<ul style="list-style-type: none"> Top-1000 (Mandatory) 	<ul style="list-style-type: none"> NDRC in charge of issuing policies and guidelines and overseeing the implementation, which was mainly carried out by local governments 	<ul style="list-style-type: none"> Local energy conservation centers, cleaner production centers, industrial associations, ESCOs, engineering firms, universities 	<ul style="list-style-type: none"> Detailed audits at key energy-consuming enterprises to meet government mandate 45 days or longer covering every facility of an entire company and consisting of an energy accounting audit and an energy opportunity assessment 	<ul style="list-style-type: none"> Self-funded by enterprises 	<ul style="list-style-type: none"> Government incentives provided based on the verified savings 	<ul style="list-style-type: none"> No uniform assessment tools A national standard on auditing procedures Reference guides on conducting the energy audit 	<ul style="list-style-type: none"> Lack of systematic professional training programs No professional certification program for energy auditors 	<ul style="list-style-type: none"> Energy audit reports reviewed and approved by government Governments evaluate and rate an enterprise's energy saving results, which are linked directly with the job performance of the enterprise's leaders
Japan	<ul style="list-style-type: none"> Energy Conservation Audits (Voluntary) 	<ul style="list-style-type: none"> Supported by the Ministry of Economy, Trade and Industry and the Japanese private sector 	<ul style="list-style-type: none"> Energy Conservation Center Japan 	<ul style="list-style-type: none"> 1 day free quick assessment on energy management and efficiency of equipment and processes. 	<ul style="list-style-type: none"> No cost for SMEs (<\$1 million of capital or <300 employees) 	<ul style="list-style-type: none"> Offer assessment training Energy managers' examination and certification 	<ul style="list-style-type: none"> No uniform assessment tools Reference guide on conducting the energy audit 	<ul style="list-style-type: none"> Separate program on Energy Managers Examination and Certification 	<ul style="list-style-type: none"> Online publication of annual reports with results on energy assessments performed, including results of energy savings
Finland	<ul style="list-style-type: none"> Energy Audit Program in Industry (Voluntary) 	<ul style="list-style-type: none"> Ministry of Trade and Industry 	<ul style="list-style-type: none"> Motiva Oy 	<ul style="list-style-type: none"> Preliminary one day energy audits for small industrial end-users Detailed energy audits for energy-intensive industrial users at three levels (low, medium or high energy-intensive plants) 	<ul style="list-style-type: none"> Plants that spend less than 42,000 euros per year are eligible for one-day assessment. Detailed energy audits are open to energy-intensive plants 	<ul style="list-style-type: none"> Energy auditor training 	<ul style="list-style-type: none"> Software tool (MOTIVATTI 2.0) to simulate individual energy-saving measures Energy Auditor's Handbook Excel-based data sheets for data collection during the assessments 	<ul style="list-style-type: none"> Four types of energy auditor training and three levels of certification 	<ul style="list-style-type: none"> Developed an online monitoring system Conduct a program-level evaluation each year Quality control through a standard checklist
France	<ul style="list-style-type: none"> Decision Making 	<ul style="list-style-type: none"> Agence de l'Environnement 	<ul style="list-style-type: none"> Agence de l'Environnement 	<ul style="list-style-type: none"> 2-day surveys to identify opportunities 	<ul style="list-style-type: none"> ADEME funding 	<ul style="list-style-type: none"> Subsidizes up to 70% of the 	<ul style="list-style-type: none"> Provide "specifications" 	<ul style="list-style-type: none"> Provide 2.5-3 day training for energy 	<ul style="list-style-type: none"> Perform random checking of the

	Support Scheme (Voluntary)	ent et de la Maîtrise de l'Energie (ADEME)	ment et de la Maîtrise de l'Energie (ADEME)	and priorities <ul style="list-style-type: none"> ▪ "Conseils d'orientation" for complex sites ▪ Diagnostics and feasibility studies for detailed assessments 		assessment costs <ul style="list-style-type: none"> ▪ Guaranteed loans to support energy-efficiency through another program 	to define each type of energy audit models	auditors <ul style="list-style-type: none"> ▪ ADEME authorized qualified independent energy professionals to be energy auditors ▪ ADEME also published lists of certified consultants 	auditing reports <ul style="list-style-type: none"> ▪ Conduct an independent re-audit based on clients' complaints
U.S.	<ul style="list-style-type: none"> ▪ Industrial Assessment Centers (IACs) for small and medium enterprises (SMEs) (Voluntary) 	<ul style="list-style-type: none"> ▪ DOE in charge of developing policy, issuing guidelines, and organizing implementation at the national level 	<ul style="list-style-type: none"> ▪ University-based Industrial Assessment Centers (IACs) for SMEs 	<ul style="list-style-type: none"> ▪ 1-day assessment at facility level for medium plants (annual primary energy consumption between 26 and 500 Billion Btu/year) 	<ul style="list-style-type: none"> ▪ Funded by DOE for SMEs 	<ul style="list-style-type: none"> ▪ Assessment database with assessment recommendations and implementation results based on more than 15,000 assessments 	<ul style="list-style-type: none"> ▪ A suite of free assessment tools downloadable from DOE web-site ▪ A series of manuals adopted by IACs to guide energy assessment 	<ul style="list-style-type: none"> ▪ DOE training programs throughout the year and around the country providing system-wide and component-specific trainings to enterprises and qualifies energy professionals ▪ Qualified student auditors receive certificates from DOE 	<ul style="list-style-type: none"> ▪ Plants surveyed by IACs 1 year after the assessment to determine the implementation results of taking the recommended measures ▪ IAC Database provides information on payback times and implementation rates for the recommended energy-saving measures.
	<ul style="list-style-type: none"> ▪ Save Energy Now (SEN) and SEN Leaders¹⁷ (Voluntary) 		<ul style="list-style-type: none"> ▪ DOE-trained qualified specialists for large plants 	<ul style="list-style-type: none"> ▪ 3-day assessment at equipment/system level for large plants (primary energy consumption ≥500 Billion Btu/year) 	<ul style="list-style-type: none"> ▪ Funded by DOE under voluntary commitments on reducing energy intensity 25% or more in ten years 	<ul style="list-style-type: none"> ▪ Customized technical assistance ▪ Online and downloadable software tools for cross-cutting and system-specific energy assessments ▪ Technical publications with information 	<ul style="list-style-type: none"> ▪ Qualified Specialist Training (ranging from 1-3 days) and webcasts (2 hours) on end-use systems ▪ Participants who successfully completed the training became Qualified Specialists whose names are published at DOE web-site 	<ul style="list-style-type: none"> ▪ Follow-ups of the audited plants, six, twelve and 24-months after the energy assessments are completed 	

¹⁷ This program has recently been replaced by DOE's new Better Buildings, Better Plants program (<http://www4.eere.energy.gov/challenge/home>)

						and best practices on energy efficiency improvement <ul style="list-style-type: none">▪ Training and webinars on software tools, technologies, information and resources			
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4.1. Lack of Long-Term and Concerted Policy Mechanisms to Promote Energy Auditing

Over the last few decades, 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 the absence of long-term policy mechanisms and symptomatic of the "campaign-style" approach to regulation and policy-making in China, 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 has 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 the energy audits conducted under the Top-1000 program and the cleaner production audits under the cleaner production program require enterprises to collect information on their energy use and identify opportunities for reducing energy waste. The overlapping requirements oblige enterprises to invest additional resources that could be avoided if a more concerted effort that integrates separate auditing programs was made.

Strong policy guidance is essential for the 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.

4.2. Lack of a National-Level Organization for Implementation of Energy Audits

At the national level, NDRC 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 program 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.¹⁸

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 small and medium industrial facilities (ECCJ, 2010). Under Japanese law, ECCJ is also in charge of providing professional training and administering national examinations for qualifying Facility Energy

¹⁸ For NECC's duties, please visit NECC's website at <http://gjznzx.ndrc.gov.cn/zxjj/default.html>

Managers (Lu and Price, 2011). In the U.S., the Department of Energy (DOE) operated the Save Energy Now (SEN) program in which manufacturers applied to DOE for a comprehensive energy assessment that, if the application was accepted, would be funded by DOE and performed by DOE-trained qualified energy specialists. Under this program, large, energy-intensive plants in the U.S. applied to receive a 3-day system assessment from a qualified energy specialist. Small and medium plants can get a 1-day assessment from one of DOE's university-based Industrial Assessment Centers (IACs). Since January 2006, the SEN and Save Energy Now Leader Programs under SEN have carried out energy assessments at 1,016 large plants and identified 167.3 trillion Btu (equal to 6 million tce or 177 PJ) of primary energy savings (as of Oct. 2011) (SENA, 2011). The IAC program has conducted over 15,000 assessments for U.S. manufacturers since 1974.¹⁹ During 2006-2011 (as of Oct. 2011), the IAC program completed 2,286 energy assessments which identified 50.18 trillion Btu (1.8 million tce or 53 PJ) of primary energy savings and through implementation of energy-saving measures resulted in primary energy savings of 15 trillion Btu (0.5 million tce or 16 PJ) (SENA, 2011).

In Finland, Motiva Oy was first established as the national energy information center for governmental agencies in 1993, and has gradually expanded its services to business, local authorities and organizations. One of the cornerstones of Motiva's services is the energy audit scheme. Through various measures, including energy conservation agreements, subsidies, energy auditors' training, tool developing, consulting, networking, information dissemination, and monitoring, Motiva has been operating the national voluntary energy auditing program, which provides up to 40% of energy auditing subsidies to industry. It is estimated that the subsidies granted during 1993-2007 totaled 23.1 million euro.²⁰ Under the Energy Conservation Agreements Program, Motiva has also facilitated 512 energy audits in the industry sector and 134 energy audits in the energy sector during 1998-2006.²¹

International experience shows that having a national-level entity to organize and coordinate energy assessment activities can be effective in carrying out large-scale energy assessments. A national-level entity can take the lead in developing a national energy audit program with a wide range of activities including offering incentives, providing technical guidance, developing assessment tools, providing trainings, and disseminating information. Having well-organized energy audits could also 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 recommending the best opportunities for the host company as the firm might be the one who will do the design or implementation for the host company.

¹⁹For detailed information, please visit IAC website at <http://www.iac.rutgers.edu>

²⁰ For detailed information, please visit Motiva Oy's Energy Auditing website:
http://www.motiva.fi/en/areas_of_operation/energy_auditing

²¹ For detailed information on subsidies, please visit the Energy Conservation Agreements Program website:
http://www.motiva.fi/en/areas_of_operation/energy_efficiency_agreements/energy_conservation_agreements_1997-2007/energy_audits_and_subsidies

4.3. 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.

This 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 obligations. With such a process, China could find itself in a situation similar to what happened in Thailand under the country's Energy Conservation Law of 2000 which mandated that all key energy-consuming enterprises 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 not useful, especially for enterprises that were seriously considering making significant investments (Taylor, 2010).

4.4. Limited Technical Scope of Energy Audits

Since most enterprise energy audits in China are conducted – with the input 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 from these audits 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 narrowly-focused 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 within integrated systems.

4.5. 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 conducting a technical assessment. There is, however, a lack of general guidelines on how to assess the cost-effectiveness of the energy-efficiency measures. Despite the existence of government 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 a fast method to calculate and easy to understand, it does not reflect the total economic benefits, especially the full benefits that occur after measures pay for themselves, such as reduced operation and maintenance costs. To include all benefits over the full lifetime of any measure, life-cycle analysis in the use phase should be adopted as a core component of the enterprises' decision-making metrics.

4.6. 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 meeting 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, to 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.

In France's Decision Making Support Scheme, subsidies were given to industrial facilities in the form of co-payments of energy auditing costs. These subsidies varied from 50% to 70% of the costs, depending on different types of energy audits and their associated costs. For example, a "pre-audit", or a rapid assessment, which identifies easy and quick measures for energy-efficiency improvement, can receive 70% of costs as subsidies (or up to 2,300 euro). A more detailed energy assessment, which recommends a list of potential energy-saving measures based on on-site data and energy use conditions as well as proposes an action plan for the plant managers, can receive up to 50% of the assessment costs (or up to 30,000 euro) (Desprez, 2002). Under the French program, subsidies could only be paid to the industrial facilities after the energy auditors completed the assessments and the energy auditing reports were evaluated by the French regional delegations.

Other government financial support includes offering special loans with preferential conditions to energy-efficiency work that includes energy audits and providing special efficiency investment funds with the prerequisite that energy audits were performed ahead of time. Besides 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 and Price, 2011).

4.7. Lack of Systematic Standardization on Energy Assessment

There are national standards (primarily the GB/T17166-1997) and government 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. IAC guidelines specify the scope, procedures, and approaches of energy assessments as well as post-audit report requirements. The IAC program further standardizes its assessment practices through instituting a series of guidelines that cover 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 member websites, report guidelines specifying the format and contents of energy assessment reports, as well as a database manual to guide the collection, input, and analysis of gathered data, a recommendation code manual to organize data in a useful way, and a rejection code manual for documenting the reasons of rejecting certain recommendations.

Over the decades, these guidelines have helped standardize the work of the IACs, 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 over 15,000 assessments is used by IAC program administrators and DOE to evaluate recommendations of energy-efficiency measures and their implementation, conduct statistical analyses on industrial energy use, benchmark industrial energy performance, and make regional comparisons on industrial energy efficiency.²²

The American Society of Mechanical Engineers (ASME) has also developed assessment standards for steam, process heating, compressed air, and pumping and provided guiding documents for each of the systems. These system-specific standards provide plants with appropriate guidance in conducting energy-system assessments and help them identify paths to realizing energy savings.²³

The International Organization for Standardization (ISO) launched the ISO 50001 energy management standard on June 17, 2011. The new standard provides both public and private institutions with management strategies to integrate energy use into their management practices.²⁴ Standards like ISO 50001 enable long-term results and ensure energy assessments have long-term value.

²² For detailed information on IAC guidelines and database, please visit IAC website at <http://iac.rutgers.edu/technicaldocs/>

²³ The standards are available on ASME website: <http://www.asme.org/kb/standards#searchBy=EA->

²⁴ http://www.iso.org/iso/specific-applications_energy

4.8. Lack of Effective Energy Assessment Tools

This study 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 simple 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.

The Advance Manufacturing Office (AMO) of the U.S. DOE²⁵ offers a collection of free professional 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,²⁶ can both help industrial facilities assess the plant-wide energy situation and assist them identify opportunities of improving the efficiency of particular motor-driven, process heating, and steam systems. These software tools have been utilized widely by energy professionals in conducting industrial energy assessments in the U.S.

Motiva in Finland has developed several tools to assist energy auditors and to standardize the energy auditing process. These tools include: the motiwatti calculation program, summary tables, reporting tools, inspection checklist, and measurement records. In addition, detailed guidelines on how to conduct energy assessments have been developed, and energy assessments need to comply with the guidelines in order to receive eligible subsidies.

4.9. Lack of Capacity and Proper Training for Energy Audits

Since China's focus has been on developing its economy over the past decades, enterprises in turn have focused 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 high 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 instructions on making preparation for the mandatory audits and improving the understanding about 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

²⁵ Formerly the Industrial Technologies Program (ITP).

²⁶ The URL is <http://www1.eere.energy.gov/industry/bestpractices/software.html>

regulations, energy-reporting procedures, as well as data collection for reporting rather than on improving the 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 training and job requirements 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, the IAC program has trained about 3,000 engineers and DOE has a training program throughout the year and around the country that provides system-specific trainings to enterprises and qualifies energy professionals for energy assessments. To become a qualified energy specialist for conducting energy assessments, 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 and Price, 2011). DOE has published a searchable database with a full list of qualified energy assessment specialists on its website.²⁷

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. For example, as part of the evolving Superior Energy Performance Program, the U.S. is creating various types of certified practitioners accredited by the American National Standards Institute (ANSI) to support plants in assessing and verifying energy efficiency opportunities.²⁸

Under the French Decision Making Supporting Scheme, ADEME (the French Environment and Energy Management Agency, or Agence de l'Environnement et de la Maîtrise de l'Energie) authorized qualified independent energy professionals to be energy auditors, and ADEME also published lists of certified consultants through an agreement for technical and non-technical requirements with energy consultants (Despretz, 2002).

In Finland, the government offers four types of energy auditor training on basic energy assessments (which is mandatory), special courses for process industries, and courses on energy auditor trainings. Three levels of certificates – qualified mechanical auditors, electrical auditors, and personnel of clients from the process industry – are provided to energy auditors as well.

In spite of the existence of certification program that qualify professional entities for the design and implementation of engineering projects, there is currently no official 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 professional entity – face difficulty in convincing enterprises to take certain energy-saving measures as their creditability is often questioned.

²⁷ The list can be found at http://www1.eere.energy.gov/industry/bestpractices/qualified_specialists/

²⁸ http://www.superiorenergyperformance.net/certified_practitioners.html

5. Policy Recommendations for Facilitating Effective Energy Audits/Assessments

To promote energy audits, Chinese governments – at 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 recommendations aimed at facilitating the development of best energy audit practices and continuous energy-efficiency improvement, based on the findings of the gap analysis, are provided below.

5.1. 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. However, given China's growing demand for energy as well as local pollution and global climate change challenges, stronger policies and continuous top-level commitment is needed to fully support energy auditing in China. National 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.

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

A national-level entity with responsibility for administration and coordination of energy auditing activities could provide China with the institutional capacity to greatly improve the effectiveness of energy auditing activities. An entity like the National Energy Conservation Center (NECC) could play a more active role in China. 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, university-based energy efficiency centers, industrial associations, 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 web-site that provides comprehensive technical information and domestic and international best practices related to energy auditing, developing energy assessment tools, and providing systematic training for energy audit professionals.

5.3. Focus energy audits on assessing cost-effective energy-saving opportunities rather than on energy accounting audits

Energy assessments should be separated from energy accounting audits so that attention could be given to identification of energy-saving potentials in industrial facilities. 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 could get combined with measures of shorter payback to create a bundled project with attractive return on total investment.

In the wake of increased efforts in China to promote energy performance contracting and ESCO business expansion, energy audits should shift from being mandated by the government to being demanded in the market. ESCOs should play a larger role than before in assessing energy-saving potentials, especially those hidden opportunities, through carrying out energy audits that target maximizing returns generated from energy savings.

5.4. 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 would help enterprises identify cost-effective energy-saving opportunities that could 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 assessments 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 measures. Other strategies China could 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.

5.5. 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 with attractive return on investment.

Standards like ISO 50001 should be particularly promoted to ensure energy assessments are included as an integral part of enterprise energy management practice and have long-term value. Standardization is also essential in guiding ESCO development as services provided by ESCOs increasingly become a strong mechanism for identifying and achieving energy efficiency opportunities. Currently China is creating a process of registering ESCOs and qualifying them for receiving government incentives. The number of

ESCOs has grown 10 times in two years in China as a result of significant financial and tax incentives. Clearly, developing standardized guidelines for ESCOs are critical to ensure the performance of energy services companies and thus the healthy development of ESCO industry.

The national level entity administering 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 the 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 return analysis. To increase the wide adoption of the tools, governments could consider of requesting the use of the tools as the prerequisite of plants’ receiving incentives for energy audits.

5.6. 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 coordinating China’s energy auditing efforts could take the lead in designing comprehensive training curricula and developing an effective train-the-trainer program. Trainings need to be organized on a regular basis and should provide 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 specific energy-saving opportunities. In all training programs, trainees should be taught about technical options, economic/financial feasibility, and the use of assessment tools. In addition, improving staff skills on energy management and on the use of proper auditing devices should also be part of the training scheme. To improve its effectiveness, energy audit training should be linked directly to the job requirements and performance evaluation of enterprise energy managers,

Furthermore, to assure the quality of energy auditing, China could consider of developing a certification or qualification scheme for energy audit professionals. It is commendable that NDRC has developed two pilot enterprise energy management professional certification programs, one in Shandong and another in Tianjin.²⁹ This effort will certainly contribute to building a strong capacity in energy efficiency, including energy auditing. There is, however, more 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 could help determine whether an entity is capable of performing energy audits.

²⁹ For more information about the pilots, please visit http://gjjnzx.ndrc.gov.cn/gzdt/t20100107_323625.htm

5.7. 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.

6. Conclusions

Energy-efficiency audits are a key means for identification and implementation of cost-effective energy-efficiency opportunities in industrial facilities. Such 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.

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. The gap analysis undertaken in this study identified a number of areas where improvements could be made in China’s energy auditing efforts, especially when compared to more mature and robust programs found around the world. 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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