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Energy auditing guidelines for iron and steel enterprises and building materials enterprises in China

GUIDELINES SUMMARY

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ABOUT THIS DOCUMENT

This document provides a summary of two sets of guidelines on energy auditing in iron and steel enterprises and building enterprises in China. The original guidelines were published by China's Ministry of Industry and Information Technology (MIIT) in January 2013. [1]

A summary of the guidelines follows below. It is based on the original Chinese documents, which were translated by the Institute for Industrial Productivity (IIP). It does not represent an official document by the MIIT and it does not reflect the views of IIP.

ABOUT THE GUIDELINES

Energy auditing is a key requirement for industrial enterprises under China's Top 10,000 Enterprises Program. To this end, MIIT developed the guidelines to assist building and iron and steel enterprises conduct energy audits and help them identify and realize energy efficiency improvements in a systematic way. However, the detailed information contained within them will also be helpful to researchers and energy service consultants who wish to understand and learn from the energy efficiency experiences in China's iron and steel industry.

Definition of an energy audit

The guidelines define an "energy audit" as the inspection, examination, analysis and evaluation of an enterprise's physical and financial processes relating to energy use. It is conducted by an audit institution in accordance with relevant national energy-saving regulations and standard specifications. The aim of an energy audit is to systematically identify the potential for saving energy and make recommendations for improvement.

China's energy auditing standard

The guidelines reference the 'General Principle for Energy Audits on Industrial and Commercial Enterprises' (GB/T 17166), which is China's national standard for energy auditing. The standard came into effect in 1998 and was based on recommendations rather than mandatory requirements. The standard outlines the "principles of the definition, content, method and procedure of energy audit, as well as the principles for writing energy audit reports. This standard is the general technical principle for enterprises' energy audits (GB/T 17166)."

Energy auditing requirements

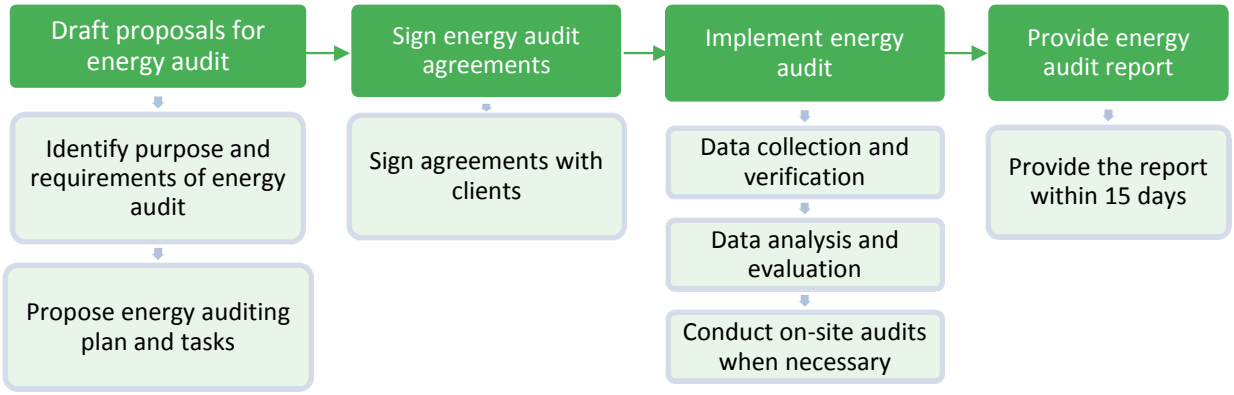
The Chinese energy auditing standard provides a list of components that should be included in an energy audit of an enterprise, including:

- energy management processes
- energy consumption and energy flows
- energy measurement and statistical data
- an analysis of energy consumption indicators
- an analysis of the operational efficiency of energy-using equipment
- an analysis of comprehensive energy consumption of products and output values
- an analysis of energy costs
- calculation of energy savings
- financial and economic analyses of energy-saving technical renovation projects.

[1] *Guidelines on Energy Audits for Iron and Steel Enterprises* and *Guidelines on Energy Audits for Building Enterprises* in Chinese: www.miit.gov.cn/n11293472/n11293832/n11294042/n12876231/15279072.html

The standard also specifies the procedures for energy audits, including drafting proposals, signing energy audit agreements, implementing energy audits, and providing energy audit reports, as illustrated in the figure below.

Figure 1: Procedures for energy auditing (GB/T 17166)



Relevant laws and regulations

China's energy auditing practices have been through three phases. The first phase, from the 1980s to early 1990s, focused on energy performance assessments. From the 1990s to early 2000s, the second phase of China's energy audits development emphasized energy system diagnostics. The third phase, from 2003 to the present, paid more attention to cleaner production audits (Shen et al., 2010).

In the 11th Five Year Plan (2006-2010), energy auditing was one of the key tools for improving the energy efficiency of industrial enterprises and achieving energy-saving targets, such as for the Top-1,000 Program. The Top-1,000 Program achieved its energy-saving target of 100 million tonnes of coal equivalent (Mtce) and achieved 150 Mtce by 2010. The success of the Top-1,000 Program has expanded the program to the Top-10,000 Program, which covers approximately 85 percent of national industrial energy use. As in the Top-1,000 Program, energy auditing has again become a requirement for the industrial enterprises in the Top-10,000 Program.

Aside from the energy auditing standard, other regulations and standards that are related to energy auditing and industrial energy efficiency have been issued gradually during the 10th and 11th Five Year Plan periods (2000-2005 and 2006-2010, respectively). Table 1 below shows the names and dates of relevant standards and regulations.

Table 1: Regulations and standards relevant to energy audits

Year		Regulation Name
1997 (Amended in 2007)		The energy conservation law of the People's Republic of China
2006		The thousand enterprises energy saving implementation plan
2011		The 10,000 enterprises energy saving and low carbon implementation plan
Year	Standard #	Standard Name
1981	GB/T2588	The general principles for the calculation of thermal efficiency of equipment
1986	GB/T 6422	Directive for measuring and testing energy consumption in industrial enterprises
1990	GB/T 2589	General principles for the calculation of comprehensive energy consumption
1991	GB/T 13234	Methods for calculating energy saved in industrial enterprises
1993	GB/T 3486	Technical guides for the evaluation of the rationality of heat usage in industrial enterprises
1995	GB/T 15587	Guidelines for energy management in industrial enterprises
1996	GB/T 16614	Statistical methods for energy balancing in enterprises
1996	GB/T 16615	Methods for developing energy balance tables in enterprises
1996	GB/T 16616	Methods for developing energy network diagrams in enterprises
1997	GB/T 17167	General principle for equipping and managing of the energy measuring instruments in energy-using organizations
1998	GB/T 3485	Technical guides for evaluating the rationality of electricity usage in industrial enterprises
2000	GB/T 2588	General principles for the calculation of the thermal efficiency of equipment
2006	GB/T 17167	General principle for equipping and managing of the energy measuring instruments in energy-using organizations
2006	GB/T 7119	Evaluation guide for water saving enterprises
2008	GB/T 2589	General principles for calculation of comprehensive energy consumption
2008	GB/T15587	Guideline for energy management in industrial enterprises
2009	GB/T 15316	General principles for monitoring and testing of energy savings
2009	GB/T 6422	Testing guide for energy consumption of equipment
2009	GB/T 13234	Energy saving calculation methods for enterprises

Types of industrial energy audits

Based on interviews and surveys conducted by the Lawrence Berkeley National Laboratory (LBNL), China's industrial energy audits can be grouped into the following types:

- detailed energy audits;
- targeted audits on energy systems;
- walk-through audits; and
- investment grade audits.

Detailed energy audits can be further broken down into:

- audits to meet government mandates;
- detailed quality assurance audits;
- verification audits;
- internal audits; and
- audits for identifying integrated solutions (Shen et al., 2010).

Table 2 below summarizes the purpose, duration, scope and post-audit activities for each type of the industrial energy audits, as well as who requires and who conducts the audits.

Table 2: Industrial energy audits in China

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

Source: Shen et al., 2010.

THE ENERGY AUDITING GUIDELINES

While the GB/T 17166 standard provides an overview of how to conduct energy audits, the energy auditing guidelines provide more detailed guidance on the actual procedures of conducting energy audits for specific industrial sectors, including data measurements and collection, energy-efficiency analysis and energy-saving potential analysis.

More importantly, the energy auditing guidelines also provide information on the main industrial processes. For the iron and steel sector, the guidelines include explanations on coking, sintering, iron-making, steel-making (basic oxygen furnace and electric arc furnace), and continuous casting and rolling. Similarly, for the building materials sector, the guidelines introduce basic production processes, process charts, and heat balance tables of different sectors, including cement, flat-glass, and ceramics. In addition, regulations on conducting energy audits in industrial enterprises are also provided along with report templates and documentation requirements for energy auditing reports.

SUMMARY OF THE KEY GUIDELINES FOR IRON AND STEEL ENTERPRISES

Energy audits of iron and steel enterprises should include the following key steps:

1. **Preparation for an energy audit**

    - Identify energy auditing tasks
        - identify type and scope of energy audit
        - Identify the timeframe
    - Organize an energy auditing team
    - Identify the relevant laws and standards

2. **Launch energy audit**

    - Identify energy audit boundary and units
    - Allocate energy auditing tasks
    - Collect data
        - information about the enterprise: enterprise type, ownership, main products, production capacity, output, energy consumption, energy mix and key energy-using systems
        - energy management: energy management structure and staff, energy management positions and responsibility, energy management documentation
        - production process and equipment: main production processes, equipment type, size, and capacity, inventory of equipment and previous reports on energy efficiency testing
        - instruments for energy data collection: main instrument used for data measurement
        - energy consumption and energy balance, including monthly and annual energy use reports, energy balance tables, energy cost tables, energy conversions used and heating values of fuels
        - raw materials usage, including consumption reports by month and year of the raw materials and auxiliary materials used
        - main energy consumption indicators, including specific energy consumption, capacity and production of waste heat recovery units, fuel and electricity consumption indicators for each of the production lines
        - application of energy-saving technologies and measures, including adopted energy technologies and equipment and their impact, and the results of adopting waste heat recovery and energy management centers

3. Conducting energy audits

- Energy audits on energy management
- Energy audits on the instruments used for energy data collection
- Energy audits on energy use

4. Analysis

- Analysis of energy efficiency
- Analysis of energy-saving potential

5. Making energy-saving recommendations

Normally, auditing energy use is the most important component of an industrial energy audit because it directly relates to how much energy-saving potential there is, and how cost-effective the energy-saving measures could be. Below is a summary of the key recommendations for conducting audits on energy use in iron and steel enterprises:

- Examining if the equipment of each of the assessed unit/sections meet the requirements of "Guiding Catalogues of Industrial Structural Adjustments", "Requirements for New Iron and Steel Projects", "Requirements for New Coking Plants", as well as the standard of "Design Criterion for Energy Saving of Iron and Steel Industry (GB 50632-2010)".
- Conducting necessary on-site testing of coking ovens, sintering machines, pellet-firing machines, blast furnaces, hot blast heaters, basic oxygen furnaces, electric arc furnaces, refining furnaces, reheating furnaces, and annealing ovens based on the needs of energy assessments, following the requirements of "Testing Guide for Energy Consumption of Equipment (GB/T 6422)" and "Basic Rules for the Measurement and Calculation of Thermal Equilibrium of Industrial Fuel-Fired Furnaces (GB/T 13338)". Based on testing data and operational records and following the technical guidelines of "General Principles of Energy Balance of Equipment Using Energy (GB/T 2587)" and "General Principles for Calculation of Thermal Efficiency of Equipment (GB/T 2588)," conduct a heat balance analysis and calculate the thermal energy efficiency of the assessed equipment.
- Examining boilers' energy efficiency based on the regulation of "Supervision Administration Regulation on Energy Conservation Technology for Boilers (TSG G0002)". If the requirements are not met, qualified institutions should conduct on-site energy efficiency assessments by following the regulation "Energy Efficiency Tests and Evaluation Regulations for Industrial Boilers (TSG G0003)". Energy efficiency levels should be calculated based on the assessment results.
- Examining electricity balance conditions for fans, pumps and compressed air, following the requirements of "Technical Guides for Evaluating the Rationality of Electricity Usage in Industrial Enterprises (GB/T 3485)" and, if the requirements are not met, on-site assessments should be conducted.
- Calculating load factors, distribution losses and power factors of each of the assessed units/sections based on the standards of "Technical Guides for Evaluating the Rationality of Electricity Usage in Industrial Enterprises (GB/T 3485)" and "Monitoring and Testing Methods for Energy Saving of Power Supply Distribution Systems of Industrial Enterprises (GB/T 16664)".
- Measuring and calculating waste heat resources of each of the assessed units/sections, by using the standard "Terms, Classification, Grades of Waste Heat in Industry and Calculating Methods for Quantifying Waste Heat Resources (GB/T 1028)".

- Examining the amount and types of energy consumption in each of the assessed units/sections, as well as verifying the indicators of waste heat recovery in order to identify any potential issues in energy use.
- Evaluating the conditions of energy management centers in industrial enterprises.

KEY GUIDELINES FOR BUILDING MATERIALS ENTERPRISES

Energy audits in building materials enterprises should include the following key steps:

1. Allocating energy auditing tasks

2. Collection data

- Information about the enterprise: enterprise type, ownership, main products, production capacity, output, energy consumption, energy mix and key energy-using systems
- Energy management: energy management structure and staff, energy management positions and responsibility, and energy management documentation
- Production processes and equipment: main production processes, equipment type, size, and capacity, inventory of equipment and previous reports on energy efficiency tests
- Instruments for energy data collection: main instrument used for data measurement
- Energy consumption and energy balance, including monthly and annual energy use reports, energy balance tables, energy cost tables, energy conversions used and heating values of fuels
- Raw materials usage, including consumption reports by month and year of raw materials and auxiliary materials used
- Main energy consumption indicators, including specific energy consumption, capacity and production of waste heat recovery units, and fuel and electricity consumption indicators for each of the production lines
- Application of energy-saving technologies and measures, including adopted energy technologies and equipment and their impact, and the results of adopting waste heat recovery and energy management centers

3. Conducting energy audits

- Energy audits on energy management
- Energy audits on the instrumentation for energy data collection
- Energy audits on energy use

4. Analysis

- Analysis of energy efficiency
- Analysis of energy-saving potentials

6. Making energy-saving recommendations

Normally, auditing energy use is the most important component of an industrial energy audit, because it directly relates to how much energy-saving potential there is, and how cost-effective the energy-saving measures could be. Below is a summary of the key guidelines for conducting audits on energy use in cement enterprises:

- Examining if the equipment – including preheaters, precalciners, rotary kilns, coolers in clinker-making and cement-grinding processes – meets the requirements of “Guiding Catalogues of Industrial Structural Adjustments”, “Requirements for New Cement Projects”, as well as the standard of “Code for Design of Cement Plants (GB 50295-2008)”.

- Conducting on-site heat balance testing for rotary kilns that have not had a heat balance assessment in the past two years. Qualified institutes should conduct assessments based on the national standards, "Methods for the Calculation of Heat Balance, Heat Efficiency and Comprehensive Energy Consumption of Cement Rotary Kilns (JC/T 730)" and "Measuring Methods of Heat Balance of Cement Rotary Kilns (JC/T 733)". The results of the assessments should be used to calculate the energy efficiency levels of the cement rotary kilns.
- Verifying waste heat resources of each production line by using the national standard of "Terms, Classification, Grade of Waste Heat in Industry and Calculating Methods for Quantifying Waste Heat Resources (GB/T 1028)", and examining how waste heat resources are used, with particular focus on electricity generation systems using waste heat. The calculation of the efficiency levels of waste heat recovery systems should follow the requirements of "Code for the Design of Waste Heat Power Generation in Cement Plants (GB 50588)".
- Examining waste heat boiler conditions based on the regulation "Supervision Administration Regulation on Energy Conservation Technology for Boilers (TSG G0002)". If the enterprise does not meet the requirements, qualified institutes should conduct on-site energy efficiency assessments by following the regulation "Energy Efficiency Tests and Evaluation Regulations for Industrial Boilers (TSG G0003)". Energy efficiency levels should be calculated based on the assessment results.
- Verifying the amount and types of energy consumption in each of the production lines and conducting an energy balance analysis.

The guidelines provide guidance on the key components of energy efficiency analyses, which include energy balance analysis, estimating indicators of energy use (such as verifying production, estimating specific energy consumption and verifying the recovered energy through waste heat recovery), estimating energy costs, providing benchmarking analysis as well as analysis of key factors that impact energy intensity.

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