



# Energy conservation in China's energy-intensive enterprises: An empirical study of the Ten-Thousand Enterprises Program



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## ABSTRACT

The Ten-Thousand Enterprises Program is China's keystone energy conservation and climate change program. The program has effectively created a class of energy-intensive enterprises that are regulated by the government for energy conservation purposes. Through an empirical study conducted in Changchun, this paper shows that the adoption of energy efficiency technologies and practices has been highly uneven in this class of enterprises because of two reasons. First, a de facto two-tier regulatory system has emerged within the framework of the Ten-Thousand Enterprises Program. Central state-owned enterprises are closely regulated by the State-Owned Assets Supervision and Administration Commission (SASAC) which is a central government apparatus, whereas local state-owned enterprises and privately owned enterprises are regulated by the local government, which has fewer resources and incentives to implement the program rigorously. Second, the Ten-Thousand Enterprises Program bundles together different types of enterprises. This approach places smaller enterprises at a disadvantage and limits their ability to conserve energy.

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## Introduction

As the world's largest energy consumer and CO<sub>2</sub> emitter, China is under increasing international pressure to control, if not reduce, its rapidly growing carbon emissions. Thus far, China has pledged to cut its carbon intensity by 40–45% by 2020 relative to its 2005 levels (Lo, 2014; Zhang, 2011). One of the most important policies for realizing the target is the Ten-Thousand Enterprises Energy Conservation Low-Carbon Program (hereafter Ten-Thousand Enterprises Program) in the 12th Five-Year Plan (2011–2015). In essence, the program has created a class of energy-intensive enterprises that are regulated by the government for energy conservation purposes. Given the large amount of energy consumed by these enterprises, their energy conservation behavior becomes crucial to the understanding of the governance of energy and climate change in China.

Despite increasing interest in the subject, there is little empirical research into China's energy-intensive enterprises and the Ten-Thousand Enterprises Program. The relevant literature is either technical in nature—examining the technologies and potential of energy efficiency at the firm level (Kong et al., 2013) and sector level (Ke et al., 2012b; Zhang and Wang, 2008), calculating the regional total energy efficiency factor of the industrial sector (Wang et al., 2012), and using input–output analysis to compute the embodied energy

use in China's industrial sectors (Liu et al., 2012b)—or consists of policy-focused, macro-descriptive discussion with insufficient in-depth and context-rich insights into energy conservation in Chinese enterprises (Chen et al., 2013; Zhao and Ortolano, 2010), the number and type of enterprises examined is limited, and the methodology does not allow for comparison between different types of enterprises.

The objective of this paper is to explore and explain energy conservation behavior among the “ten-thousand” energy-intensive enterprises. A special focus is on the diversity, in terms of size, operation, and ownership structure of the energy-intensive enterprises and how this diversity influences firms' behavior of energy conservation. The objective is pursued by: (1) characterizing the energy-intensive enterprises, (2) evaluating the adopted energy conservation measures; and (3) assessing the key drivers and barriers to energy conservation. The following section provides a review of the literature that has guided this research. Then, the Ten-Thousand Enterprises Program is explained and the method is described. This is followed by discussions about the energy conservation measures, drivers, and barriers. This paper concludes with recommendations for China's energy conservation policy.

## Measures, drivers and barriers

Enterprises can improve their energy efficiency by technical and non-technical measures. Technical measures include, but are not limited to, reusing and recycling materials, retrofitting and replacing old equipment,

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reducing heat loss, reusing heat, changing to energy efficient processes, and increasing productivity (Tanaka, 2011). More specifically, energy conservation technologies commonly found in energy-intensive enterprises include variable-speed drive, waste heat recovery by economizer, high-efficiency motors, and leak prevention in air compressors (Abdelaziz et al., 2011). Non-technical energy conservation measures include energy performance measurement, energy consumption monitoring, energy auditing, and energy training for employees (Nisiforou et al., 2012; Sivill et al., 2012). Industrial energy conservation is context-specific because the choice of measure depends on firm-level factors such as product design, process choice, energy sources, and company size (Vikhorev et al., 2013). Large and energy-intensive enterprises by their very nature have more room for improvement than small- and medium-sized enterprises (SMEs). Geography is also a factor. Studies from developed countries, such as Greece (Markis and Paravantis, 2007), Italy (Cagno and Trianni, 2013), and Sweden (Thollander and Ottosson, 2010), often report the use of more energy conservation measures than studies from developing countries, such as India (Gielen and Taylor, 2009), Ghana (Apeaning and Thollander, 2013), and China (Kostka et al., 2013).

Governments are a key driving force of industrial energy conservation (Ke et al., 2012a; Kostka and Hobbs, 2012; Price et al., 2001; Price et al., 2010; Zhao et al., 2014). Tanaka (2011) reviewed over 300 energy efficiency policies worldwide and found that although negotiated agreements are the most common approaches, economic instruments such as carbon tax and emissions trading are increasingly used. There are significant variations among countries and within countries. For example, the United States federal government has taken a minimalist approach to industrial energy efficiency, mainly relying on support mechanisms such as loan guarantees and research and development (Dixon et al., 2010). Nevertheless, several emissions trading schemes are operating at the subnational level, such as the Regional Greenhouse Gas Initiative and the Western Climate Initiative (Lutsey and Sperling, 2008). The European Union Emissions Trading Scheme coexists with national schemes in Denmark, Finland, the Netherlands, Sweden, and the United Kingdom (Rezessy and Bertoldi, 2011). China has adopted a multifaceted approach mainly consists of negotiated agreement and financial support (Li and Wang, 2012; Lo and Wang, 2013; Price et al., 2010). Furthermore, China recently began to experiment with carbon trading by establishing regional markets in Beijing, Chongqing, Shanghai, Shenzhen, Tianjin, Guangdong, and Hubei that accounted for 27% of the national GDP in 2010 (Lo, 2012).

The literature has also identified the market as a key driver of energy efficiency (Apeaning and Thollander, 2013; Hang and Tu, 2007). Because energy costs typically account for 10–30% of the total production costs in energy-intensive enterprises (Sivill et al., 2012), these enterprises often focus on energy conservation. Thollander and Ottosson (2008) found that cost reduction significantly motivates energy efficiency in the Swedish paper and pulp industry. Cagno and Trianni (2013) found that increasing competition from developing economies that benefit from lower labor costs is a key driver of energy efficiency in the Italian manufacturing sector. Liu et al. (2012a) discovered that energy conservation among Chinese SMEs occurred primarily in response to market competition. Chen et al. (2013) studied a large state-owned enterprise (SOE) in the resource sector that reduced its energy consumption by more than 10%. The authors cited market conditions as the force encouraging energy conservation. However, other studies have found that energy efficiency does not necessarily lead to cost saving (Zhang et al., 2012) and energy-intensive enterprises may choose to pursue other priorities over energy efficiency (Thollander and Ottosson, 2010).

The literature on barriers to industrial energy efficiency is quite extensive, driven by the paradox that enterprises fail to adopt energy efficiency measures that appear to be cost-effective. In a recent review by Sorrell et al. (2010), the authors identified six categories of barriers: (1) risk, (2) imperfect information, (3) hidden costs, (4) access to capital, (5) split incentives, and (6) bounded rationality. Empirical studies in

both developing and developed countries (Apeaning and Thollander, 2013; Sardanou, 2008; Trianni et al., 2013) suggest that enterprises everywhere face similar barriers, particularly with access to capital, imperfect information, and hidden costs. However, barriers may be more pronounced in developing countries (Sorrell et al., 2010). Furthermore, smaller enterprises may exhibit a greater perception of barriers than larger ones and are more likely to downgrade energy efficiency to a peripheral issue (Trianni et al., 2013). Zhao and Ortolano (2010) investigated a Chinese state-owned power plant that fell behind schedule for meeting its energy conservation targets in 2006 and 2007. Financial obstacles, bureaucratic red tape, and an unhelpful municipal government were identified as the key impediments. In another study from China, Kostka et al. (2013) surveyed 480 SMEs in Zhejiang province and found that information barriers are significant.

### The Ten-Thousand Enterprises Program

The Ten-Thousand Enterprises Program regulates the energy consumption and energy conservation behavior of enterprises. In contrast to overseas experience where similar objectives are usually achieved through voluntary agreements or market-based instruments, the Ten-Thousand Enterprises Program takes a command-and-control approach which remains the preferred policy instrument in China. The program not only allocates energy-saving targets to the regulated enterprises but also demands the enterprises to meet a number of energy management requirements, such as conducting energy auditing, collecting, analyzing, and reporting energy statistics, hiring qualified energy management professionals, and the long-term planning of energy conservation. The program defines energy-intensive enterprises as those that consume 10,000 tce (ton of coal equivalent) or more annually. Using this benchmark, the program regulates 16,018 enterprises that collectively account for approximately 60% of the country's total energy consumption (in comparison, the European Union Emissions Trading Scheme regulates approximately 11,000 entities and 40% of total energy consumption). Enterprises can fail their assessment by either achieving less than 60 marks in total or failing to meet the energy saving targets, which is a veto criterion. However, the central government has not made the punishment clear, thereby leaving room for local variations. Overall, the program is expected to deliver an energy saving of 250 Mtce over five years.

### Method and data

The fieldwork for this study was conducted in Changchun, the capital of Jilin province, from September to November 2012. Changchun was chosen because it is a large industrial city with a high concentration of energy-intensive enterprises, with 45 industrial enterprises enlisted in the Ten-Thousand Enterprises Program, and because of the availability of contact.

A key design feature of the study is the selection of samples that are large enough to reflect the diversity of energy-intensive enterprises in Changchun but small enough to allow for in-depth qualitative analysis. To this end, we adopted theoretical sampling, which stresses the iterative nature of data collection and analysis, both of which are guided by the emerging theory. Following this method, we examined 11 enterprises that we believed sufficiently reflect the diversity of energy-intensive enterprises in Changchun. Our data are primarily drawn from interviews with managers from these enterprises. The semi-structured interviews lasted approximately one hour and focused on the following topics: characteristics of the enterprise, energy conservation practices, driving factors, and key challenges. Interviews were also conducted with government officials in charge of the implementation of the Ten-Thousand Enterprises Program to gain an understanding of energy conservation from the government's perspective. Additional information was collected from corporate and government documents and media reports.

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