Overview of Current Industrial Energy Efficiency Landscape in China and the U.S.

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ABSTRACT

The objective of the following paper is to 1) discuss industrial energy use trends in the U.S. and China, 2) provide an overview of the policy instruments, and 3) discuss opportunities for both countries moving forward.

The energy mix and consumption pattern in the U.S. and China are largely shaped by industrial activities and economic development. As the global leader in research and development activity, the U.S. remains focused on driving innovation in technology to maintain global competitiveness, while also deploying market-based instruments to support energy efficiency technologies in industrial applications.

Unlike the U.S., the industrial sector accounts for around 70% of total energy consumption in China, and as the industrialization of China progresses, that number is only expected to increase. China continues to drive energy efficiency through both centralized government efforts and market approaches such as the proliferation of energy service companies and green credit policy.

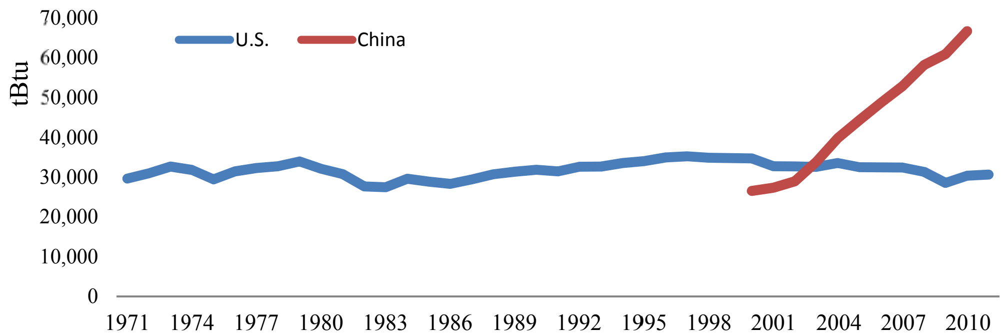
As the world's two largest economies, significant opportunity exists for U.S. and China to work with each other and achieve energy efficiency through both technology development and the deployment of policy instruments.

Industrial Energy Consumption

This chapter aims to present the background information on industrial energy consumption in both the U.S. and China, which is essential for understanding the policy instruments being deployed and the opportunity moving forward in each country.

Comparing annual energy use, the industrial sector accounts for 31% of total U.S energy consumption while in China it accounts for 70%. However, although the industrial sector in U.S. has grown by two-thirds in economic output since 1970, growth in energy consumption has been rather flat (Fig. 1, p. 2). This is partly due to continuous technology innovation and policy deployment that drives increased energy efficiency activity.

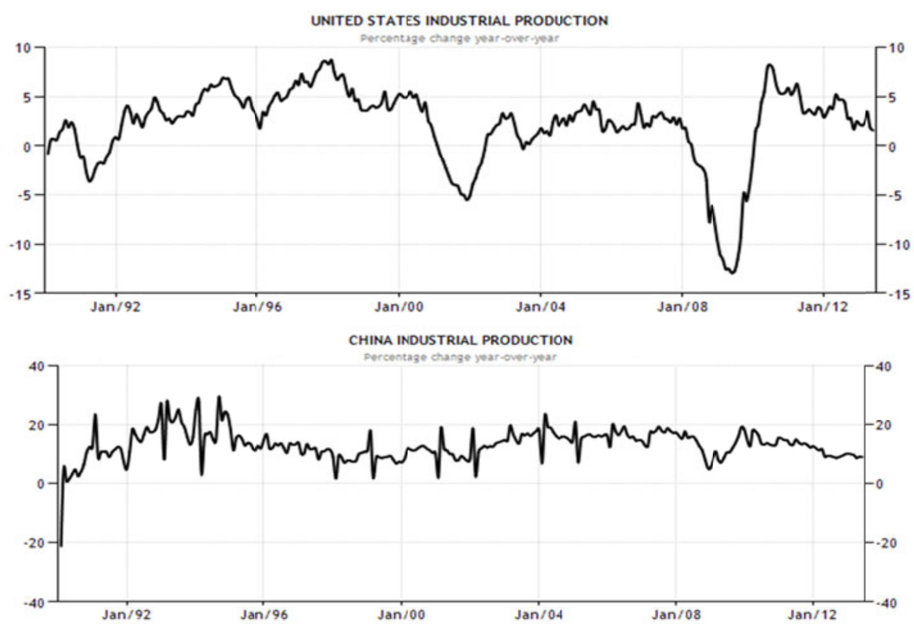
Figure 1. Industrial Energy Consumption of U.S. and China[1]



Source: U.S. Energy Information Administration & China Energy Statistical Yearbooks

China, on the other hand, presents a contrasting situation. As a country undergoing a rapid economic boom, industrial energy consumption has almost tripled in the last decade (Fig. 1). In addition, industrial production in China has significantly outpaced the United States on a year-over-year basis (Figs. 2 &3). Much of this activity is a result of the fact that over the last few years, China has, at times, produced 50% of the world's crude steel, 59% of the world's cement, and 45% of the world's aluminum[2].

Figure 2 and 3. U.S. and China Industrial Production from 1992 to 2012

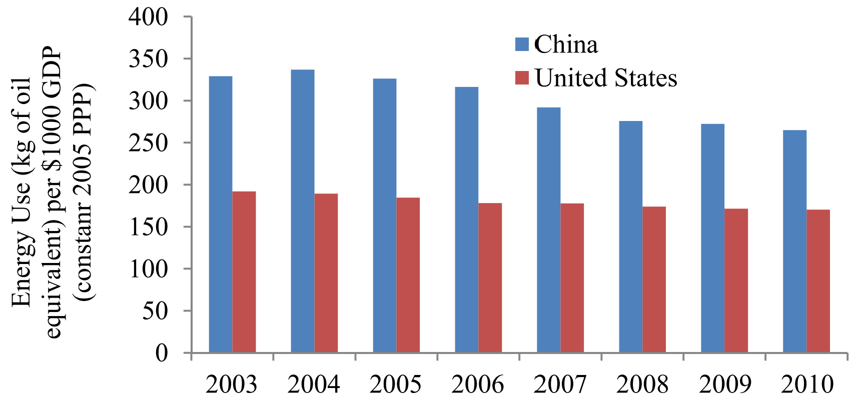


Source: www.tradingeconomics.com – Federal Reserve & National Bureau of Statistics of China

[1] The most recently publicly available data for China's industrial energy consumption begins in 1999.
[2] The most recently available data for China's industrial production was retrieved from the World Steel Association, U.S. Geological Survey, and International Aluminum Institute.

Despite the dramatic increase of industrial energy use in China, it is also worthwhile to assess the energy intensity per GDP in both countries. Looking at Fig. 4, it is evident that China was significantly more energy intensive per GDP from 2003 to 2010, but has closed the gap during that same period. As goods are produced and traded on a global scale, higher energy intensity per GDP presents an economic disadvantage and a higher cost of doing business. However, the gap is closing and a more globally competitive situation is emerging.

Figure 4. Comparing Energy Use per GDP from 2003 to 2010 of China and the U.S.



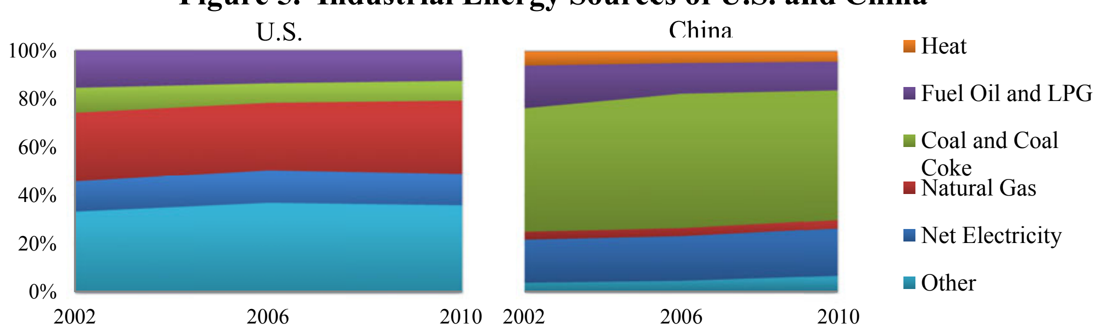
Source: World Bank

In addition to evaluating energy use patterns, it is also important to understand the context of sources of energy supply in each country. Fig. 5 shows that the relative shares of major U.S. energy sources have not changed significantly since 2002. However, U.S. Energy consumption can often be influenced by factors such as economic conditions, technology advances, and policy shifts. The recent boom of natural gas exploration is a prime example, where the introduction of hydraulic fracturing and directional drilling has increased unconventional gas supplies, resulting in falling prices and rising consumption.

China, on the other hand, which is deficient in oil and gas, depends on its abundance of coal for supply. This is evident in China's increased use of coal and coal coke sources in Fig. 5 below. However, escalating environmental issues such as air and water pollution as well as climate change have pressured China to take aggressive policy measures including retrofitting old coal fire-plants with pollution control technologies.

It is important to keep in mind these different energy sources as energy efficiency policy instruments are discussed later in the paper.

Figure 5. Industrial Energy Sources of U.S. and China



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Policy Instruments in the U.S. and China

The energy mix and consumption pattern in the U.S. and China are largely shaped by industrial activities and economic development. Given the scope of this paper, a number of policy instruments are discussed that have been instrumental in driving industrial energy efficiency activity in each country. In a following section, this paper will explore how technology development is also driving notable impact in industrial energy efficiency.

Both the U.S. and China have implemented energy efficiency policy instruments. However, instruments in the U.S. are more market based, while instruments in China are driven by the central government. The discussion below contains information on policy instruments of each country, but is not meant to be an exhaustive list.

U.S. Policy Instrument Discussion

As the manufacturing sector in the U.S. faces increasing competition from the global market, particularly from countries such as China, Brazil and India, and as concerns about reviving the U.S. economy have become more central to government officials since the 2008 recession, the goal of job creation has taken a central role in policy design in recent years and have proven to serve as strong arguments for investments in energy efficiency.

Better plants challenge. One of the key policies designed to achieve this goal is the American Recovery and Reinvestment Act (ARRA) which included the deployment of a policy instrument, the Better Buildings Initiative. The program was introduced in February 2011 by President Obama to make commercial and industrial buildings 20% more energy efficient by 2020 and to accelerate private sector investment in energy efficiency. Under the Better Buildings Initiative is the Better Plants Challenge where the U.S. Department of Energy (DOE) recognizes industrial companies for their commitment to reducing the energy intensity of their U.S. manufacturing operations by 25% or more within 10 years. This voluntary program requires participating companies to develop an energy use baseline and track the change in energy intensity, designate a corporate energy manager, have an up-to-date energy management plan for internal use within one year and annually update the DOE with the progress made. However, participants are also able to share best practices and benefit from resources and technical assistance. Industrial partners participating as of June 2013 include 3M, Alcoa, Cummins Inc., Ford Motor Company, GE, Johnson Controls and Nissan North America Inc.

Industrial assessment centers. The DOE has also established and sponsored the Industrial Assessment Centers (IAC) with the purpose of stimulating near-term adoption of energy management best practices and technologies. These centers, located at 26 universities throughout the country, provide eligible small and medium-sized manufacturers with comprehensive industrial assessments performed at no cost to the manufacturer. The assessment teams are made up of engineering faculty and students who provide recommendations to manufacturers to help them identify opportunities to improve productivity, reduce waste, and save energy. The IAC strategy has two key implications in strengthening the global competiveness of U.S. industries. First, it was designed to streamline the upgrade of manufacturing facilities in energy-consuming industries, and at the same time, provide learning and training platform for young energy management professionals, which is a niche and yet high demand talent source globally. Furthermore, IACs create a platform for public-private partnerships, and in this case, that allow the private sector to tap into the research and development capability in some of the most prestigious universities in the world.

Tax incentives. As the U.S. continues to make investments in the new, capital intensive technologies, it has deployed critical financing and incentive solutions that allow for market driven demand. Such solutions exist in the Qualifying Advanced Energy and Business Energy Investment tax credits as well as the Section 179d tax deduction. The Qualifying Advanced Energy tax credit is equal to 30% of the qualified investment that establishes, re-equips or expands a manufacturing facility that makes resources for the production of energy-conservation equipment and technology. On the other hand, while the Business Energy Investment tax credit is applicable to renewable energy investments, it is also suitable for energy efficiency expenditures, like combined heat and power systems. With a focus on facilities, Section 179D allows an immediate first year tax deduction for specific energy-efficient portions of a new or remodeled building including interior lighting systems and HVAC systems.

National action plan for energy efficiency. Lastly, much of the U.S. activity is supported, but not regulated, by the National Action Plan for Energy Efficiency that was established in November 2008. With the commitment and leadership from more than 60 organizations throughout the country, the plan was created as a living document that outlines goals and key steps for energy efficiency in residential, commercial and industrial sectors. Plans identifying and achieving energy savings of 10 percent or more for the industrial sector include equipment specific programs, systems optimization assistance, performance contracting, financial incentives, and low-interest financing. Specifically, high energy consuming equipment like air compressors, motors, cooling towers, and pumps are targeted as areas for improved energy efficiency. Some policy instruments also help utilize waste heat through combined heat and power applications and industrial process optimization

Whether it is a voluntary, market-based programs or incentives aimed to spur activity, much of the U.S. industrial energy efficiency activity is focused on enabling advancement in the market. The next section will explore industrial energy efficiency policy instruments deployed in China, which follow a more centralized model.

China Policy Instrument Discussion

China's five year plan (fyp). Similar to the concept of blueprints that architects rely on to represent the design and framework of a building, China's Five Year Plan FYP serves the same purpose to lay out the social and economic development initiatives that determine the country's future, and energy efficiency has been a key policy focus since the 11th FYP (2006-2010). China's industrial energy efficiency landscape was greatly shaped by a few key milestone projects in the 11^{th} FYP and, while many of the current policies in the 12th FYP (2011-2015) are a continuation of those established in the 11th FYP, there are also policy instruments new to the 12th FYP.

One of the programs from the 11th FYP that set the tone of the Chinese government's ambition to curb consumption is called the Top-1000 Energy Consuming Enterprise Program. The Chinese government launched this program to drive energy conservation among top 1,000 most energy intensive enterprises[3], resulting in an energy savings equivalent to 6.2 tBtu, equivalent to 150 million tons of standard coal. As a result, China's energy consumption per unit of gross domestic product (GDP) dropped 19.1% during its 11th FYP period (2006-2010).

Another major policy program is the Ten Key Energy Conservation Projects[4]. This program focused on making a comprehensive plan for energy intensive sectors such as heavy industry, construction and transportation. The reported conserved capacity was 9.4 tBtu, the equivalent of 340 million tons of standard coals which included projects such as coal-fueled industrial boilers (kilns), surplus heat and pressure utilization, and energy saving in electrical motors. In addition to driving the adoption of innovative technologies, this program also introduced incentive-based programs that provided financial awards to companies that achieved allocated reduction targets. When speaking of potential improvements to this program, the National Development and Reform Commission (NDRC)[5], China's top policy-making entity, noted the need for participation of more small to medium sized companies in the future.

A continuing policy instrument from the 11th FYP actively promotes the energy service company (ESCO) model as a key financing model for realizing energy savings in large industrial companies. The following section describes the market-based approaches of the ESCO model and the green bond program, both of which leverage the private sector to finance projects.

Turning to the power of the market: ESCO and green-credit policy. Creating and demonstrating the viability of market driven approaches in energy efficiency has been one of China's focuses in recent years. As China continues to make investments in new, capital intensive technologies, market-based financing solutions are critical to facilitate such deployment. Supported by the collaboration between the World Bank (WB), NDRC and Global Environment Facility (GEF), the Chinese government introduced and actively promoted the concept of ESCO financing between 1994 and 1996 by providing technical and financial support. During the 11th FYP, the government aggressively spurred the development of the ESCO sector from 3 companies in 1996 to more than 800 ESCO companies. This occurred by increasing awareness and creating market conditions vital for the scaling of ESCO projects. In 2010, Energy Conservation Service Industry Committee of China Energy Conservation Association (EMCA) reported that the entire ESCO workforce employed around 175,000 professionals, 10 times more

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[3] The top 1000 enterprises accounted for 33% of national and 47% of industrial energy usage in 2004.

[4] In 2004, China launched its "Ten Key Projects" program, and earmarked about $1 billion for incentives in energy-saving projects ranging from power sector to construction. The Project includes 1. Renovation of coal-fired industrial boilers, 2 district level combined heat and power projects, 3. Waste heat and pressure utilization, 4. Oil conservation and substitution, 5. Motor system energy efficiency, 6. Energy systems optimization, 7. Energy efficiency and conversation in buildings, 8, energy –efficiency lighting saving, 9. Government procurement energy efficient products, 10. Monitoring and evaluation system.

[5] National Development and Reform Commission is the highest policy-making entity in China, and is responsible for establishing policy guidelines and measures across various sectors and industries.

than the 2005 number. Sustainable financing models, such as the ESCO model that already exists in the U.S. and other countries, is essential to the scaling and overall market investment.

In addition to the ESCO model, the green credit policy, first introduced in 2007, is another prominent program that leverages the potential of a market-driven approach.

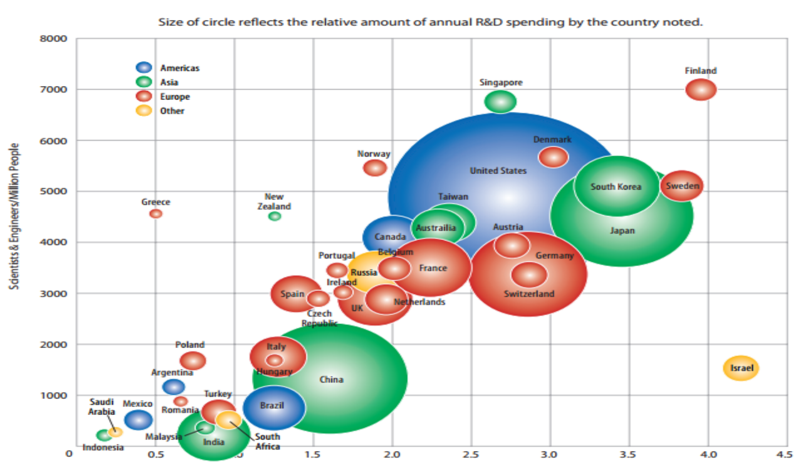
In early 2012 the China Banking Regulatory Commission issued its first guidelines for Green Credit, which has been advocated by international organizations such as the International Finance Corporation (IFC) for years. The goal of this policy is to promote green industries and projects by using loans, while requiring banks to deny loans to energy inefficient and polluting enterprises. Many Chinese banks have taken the initiative to implement their own green credit strategy. For example, Shanghai Pudong Development (SPD) Bank launched an “Integrated Service Programs of Green Finance 2.0” in late 2012 and claimed that it is the first program that services the entire low-carbon industry value chain.

In recent years, China has been deliberately tackling industrial energy efficiency through centrally driven government techniques and complimented by market driven approaches. These combined approaches have helped China drive industrial energy efficiency activity and establish a more competitive position in the global market.

Technology Discussion

A central theme and apparent competitive advantage of the U.S. is the continuous focus on driving innovation in technology development as a way to maintain global competitiveness. As a global leader in research and development investments, the U.S is continually sought after for its technology development capabilities and unique entrepreneur eco-system. Therefore, many countries try to emulate these characteristics. In 2011, compared to China, the U.S. spent more on R&D when measured in dollars, and nearly twice as much when measuring R&D as a percentage of GDP. The U.S. also had more scientists and engineers per million people, which can be seen in Fig. 6 on p. 8. In addition to its distinctive resources, a few key initiatives exist in the U.S. that demonstrates its leadership as a technology developer.

Figure 6. 2011 R&D Investments by Country



Source: Battelle, R&D Magazine, International Monetary Fund, World Bank, CIA World Book,OECD

While there are many technologies that have been widely adopted and demonstrated notable outcomes, combined heat and power (CHP) has been chosen by the U.S government as one of the key technologies to receive extensive support. In recent years, the DOE announced several programs to promote CHP systems. CHP is a good example of technologies that have a universal applicability to the industrial sectors and can be deployed both on a small scale such as in a paper making factory and aluminum smelters, or on large scale projects such as industrial district heating. After the Department of Energy received more than $3.8 billion in project proposals for a $156 million funding solicitation subsidizing CHP systems under ARRA, both public and private sectors have demonstrated a strong interest in the demonstrated capability for CHP and waste heat recovery to reduce energy consumption. President Obama also issued an Executive Order in August 2012 to further boost the application of CHP. It is estimated that increasing the use of combined heat and power to 20% in the total generating capacity of by 2030 would save 0.53 tBtu of fuel per year. From the business perspective, accelerating such investments is also an essential way to improve the competitiveness of U.S. industries.

With the help of federal efficiency standards, the cost of innovative energy efficient technology like CHPcan be lowered by facilitating their entry into the market and providing economies of scale. They also reduce regulatory problems suffered by manufacturers because they prevent the potential of having numerous and varying state standards by enforcing a single federal standard. DOE's Building Technologies Office (BTO) implements minimum energy conservation standards for over 50 categories of residential, commercial and industrial appliances and equipment. Products covered by standards represent about 90% of home energy use, 60% of commercial building use, and 29% of industrial energy use. Users have gained energy savings of about $40 billion since 2010 as a result of these standards. By 2030, cumulative operating cost savings from all standards will reach $1.7 trillion, with a reduction of 6.5 billion tons of carbon dioxide emissions, equivalent to the annual greenhouse gas emissions of 1.4 billion automobiles.

Despite the fact that the U.S. is the leader in investments, from a manufacturing R&D perspective, China is gaining ground. China's profile as the second-largest sponsor of global R&D continues to increase, whether measured in terms of funding or generation of intellectual capital. However, as the U.S. continues to emphasize innovation through various standards and programs, China chooses to focus on tackling some of its most pressing energy issues in coal usage and heavy industry.

With the rising power of China as a world manufacturer, many experts see surging industrial energy use as a key driver of China's goal to develop an energy efficient economy. And, as the industrialization of the country continues, China has a great need for energy saving technologies. Given the fact that China has an abundance of coal reserves and that China is relatively deficient in other resources such as oil and gas, it is among the nation's top priorities to develop the coal chemical industry and improve the efficiency of coal to sustain the growth of manufacturing industries in China. The achievement of promoting gasification technology and its large-scale application during the 11th FYP can be summarized into three aspects: first, through increased investment in R&D, China has managed to develop a large number of independent intellectual property (IP) rights with systems that would work well with the unique characteristics of China's coal; secondly, the promotion of gasification also accelerated the elimination of a large number of outdated production capacity; and finally, relevant policies have helped to create market conditions for adopting gasification technology. During 11th FYP, a total of 51 gasification technologies - with independent intellectual properties - were deployed, and China plans to further this upgrade to a capacity equivalent of 18 million tons of ammonia production per year.

Since major reduction goals exist for energy intensive industries, such as steel and petroleum, to realize an average of 16% energy consumption per industrial added value by 2015, China has also been pursing another technology. The steel and petroleum industries together consume more than 30% of China's total industrial energy use. Therefore, top pressure recovery turbine (TRT), an energy saving equipment used for the blast furnace of steel plants, with potential saving of 20 – 40 kWh of electricity per ton of steel production, has been widely deployed in major steel works in China[6]. As a major energy recovery technology in the iron and steel industry, the government has announced mandates to encourage industries to develop local IPs and to spur local innovation rather than relying on imports of the technology. In recent years, systems developed locally have demonstrated energy reduction of approximately 120 tBtu per year. Technology advancements such as this one are of significance to China as it not only helps to achieve high energy efficiency, but strengthen the country's innovation capability through large scale deployment and government support.

Conclusion

Cleary, both countries have focused resources on driving industrial energy efficiency activity as a means of staying competitive in the global manufacturing environment. The U.S. has deployed policy instruments aimed at advancing technology and mechanisms serving as enablers for the market. Meanwhile, in addition to deploying market enablers, China has developed instruments that have been driven and regulated by the central government.

From a technology perspective, it is clear that most research and development innovation occurs in the U.S. Yet, China has gained ground in both intellectual capital and funding. Meanwhile, the energy use of each country is significantly different and has been changing in recent years. China's tremendous amount of use and rate of growth has dwarfed that of the U.S.

Since China's growing industrial sector is a heavy user of energy and most technology development occurs in the U.S., a promising opportunity exists for U.S. companies to deploy innovative technologies and use China as the landing pad for deployment. Or, given the fact that the energy intensity per GDP gap is closing and more research and development dollars are being spent in China than historically, maybe the race is on to industrial energy efficiency in the global market.

[6] This program achieved 100% adoption rate in furnaces with capacity larger than 2000 m^3 and 97% in those larger than 1000 m^3.

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