[LTO]/2006/01

International Energy Agency Working Paper Series

A WORKING PAPER

Raising the Profile of Energy Efficiency in China

- Case study of standby power efficiency

October 2006

Richard Bradley and Ming Yang

www.iea.org

Report Number [LTO]/2006/01
Paris, October 2006

Raising the Profile of Energy Efficiency in China

- Case study of standby power efficiency

Richard Bradley and Ming Yang

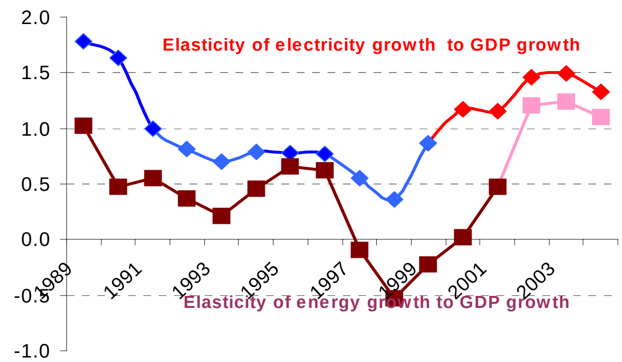
Abstract

In its 11th Five Year Programme, the Chinese government has given priority to energy efficiency to achieve its economic goal. However, detailed action plans and activities to implement this plan are not clear. The objective of this paper is to demonstrate, with the experience of OECD, how China can go forward with concrete activities and actions to improve energy efficiency. This paper reviews the most recent policies, programmes and activities in the field of energy efficiency in typical OECD countries and in China. With a quantitative case study using standby power as an example, we show how China (and Shanghai) will save electricity and capital investment in the power sector. Various data have been collected from literature review, the Chinese statistics bureau, on-site auditing and interviews with the China Standard Certification Center. A brief economic and financial analysis was undertaken for the case study. This paper concludes that promoting energy efficient standby devices in China will be financially and economically viable. It will avoid or postpone investments of 8 or 9 large power plants with the capacity of 1 GW each in China up to 2020.

1. Introduction

In its long-term social and economic development goal, China aims at achieving USD 4 trillion of GDP (constant 2000 price) by 2020, quadrupling the value of GDP in 2000 in 20 years. In the meantime, the Chinese government has set an energy supply target: only doubling energy consumption, namely increasing from 1.30 billion tons of coal equivalent or 0.92 billion tons of oil equivalent (toe) in 2000 (China Statistical Yearbook, 2004) to 1.83 billion toe in 2020 (Zhang, 2005).

Figure 1 Elasticity of energy to GDP



Source: Calculated from NBS (2004) and Zhang (2005)

Unfortunately, statistical data show that energy use is growing much faster than planned. China's energy elasticity to GDP was greater than 1 between 2002 and 2005. See Figure 1. If this indicator stays above 1, China will need at least 3.67 billion toe of final energy supply, 100% more than the expected demand to achieve its economic development goal in 2020.

In order to meet the long-term energy supply and energy conservation target, the Chinese government has given priority to energy conservation. In November 2004, the government approved "The Medium and Long-Term Special Plan for Energy Conservation" (Energy Conservation Plan) (Zhang, 2005). In that plan, the government set specific targets to reduce energy intensities for various sectors by 2020. For instance, energy intensity in the industrial sector must be reduced by an additional 14% (Zhang, 2005).

On 27 June 2005 Mr Hu Jintao, the Chinese President made a speech at the Politburo of the Chinese Communist Party, stressing that China has to make greater efforts in energy conservation (China CCTV 2005). There were eight key points in his speech and seven of them were about energy efficiency and technology[1]. These seven points can be briefly summarized as follows:

1. *Reform the structure of the economy. China must use advanced energy efficiency technologies to substitute the out-of-date technologies, speed up the development of high-tech and service industries, change the old mode of economic development with high investment, high consumption, high pollution and low efficiency.*
2. *Speed up the establishment of an energy resource technical support system. China will enlarge its national budget and investment in energy technology development and R&D in energy technologies that will substantially affect energy consumption in the future. China will also make great efforts in R&D for energy saving technologies.*
3. *Pay great attention to energy savings in end-use. China will promote energy saving technologies and products in all walks of life, guide and encourage end-users to use energy efficient products, gradually making China an energy efficient country.*
4. *Build an energy conservation system, mechanism and capacity. China will implement energy efficiency standards, phase out inefficient technologies and products, establish and promote the energy conservation system and mechanism on the basis of the market, and develop government macro-regulation systems to guide the market.*
5. *Strengthen government planning and policy guidance. China will project energy demand and make a goal of energy savings. China will then adopt an energy tax, investments, pricing and trading policies which are good for energy conservation.*

[1] The other point is about reusing and recycling materials.

6. *Establish laws and regulations and standard systems for energy conservation. China will implement relevant energy conservation laws, enlarge the law enforcement and surveillance inspection dynamics, formulate and implement compulsory standards, and promote energy efficiency in production, construction and transportation.*
7. *Strengthen propaganda and education in energy savings. China will conduct diversified energy saving activities to enhance people's awareness, especially of the young, to save energy, so that the Chinese will be motivated to save energy.*

According to the government's Energy Conservation Plan and the speech of the Chinese President, China has already set a target to reduce energy intensities in various sectors, and a comprehensive policy has also been developed to facilitate its achievement (China CCTV, 2005). However, to actually achieve the target and implement the policy, a large number of concrete energy conservation activities or actions that are related to various specific technologies and all kinds of end-user should be developed and implemented. The concrete actions will drive China from its current status of an inefficient energy user to that of an energy efficient user over the next 15 years.

This study's objective, using a case study, is to help China develop concrete activities and actions that will comply with the government's Energy Conservation Plan and Policies. These concrete actions, which are taking place in a number of OECD countries, will greatly improve energy efficiency with net negative costs. Through a large number of such activities and actions, China may be able to really reduce its elasticity of energy with regard to GDP from more than one to 0.5 and hence achieve its energy conservation goal by 2020.

In this paper, we briefly review energy efficiency activities and actions in OECD countries, select one of the actions, energy efficient standby power promotion, and apply this action to China and Shanghai in a case study. We designed two scenarios: BAU scenario and EE scenario. In the BAU scenario, we assume that the Chinese government and people will not do very much about standby power; we calculate energy consumption and standby power demand in households all over China and in Shanghai by 2020. In the EE scenario, we assume that the government and the Chinese people will actively participate in energy conservation campaigns, set mandatory regulations and participate in energy efficient standby power activities by 2020; we then calculate the energy consumption and standby power demand. By comparing the results from the two scenarios, we see the benefits of this concrete action for energy efficient standby power in China.

This paper consists of five sections. After the introductory section, we briefly review the most recent energy efficiency policies and actions in the OECD countries, focusing on actions taken by the G8. In Section 3, we review the development of energy efficient standby power technology and present state-of-the-art developments worldwide. Section 4, which is the core of this paper, presents a quantitative case study of energy efficient standby power in China. This includes methodology description, data collection, assumptions, and result presentation. Section 5 concludes the study.

2. Brief update on energy efficiency actions in OECD

From 6-8 July 2005, the G8 Summit, with the Heads of Government of Brazil, China and India, Mexico and South Africa (the "plus five" countries), took place at the Gleneagles Hotel, Perthshire, Scotland. The main agreements reached covered development in Africa and tackling global climate change. This is particularly significant as the plus five countries are set to have substantial increases in their greenhouse gas emissions as they develop and as their economies grow. In particular, energy efficiency was cited as a useful means to mitigate greenhouse gas emissions and to deal with global climate change.

The first ministerial level meeting of the new Dialogue was held in London on 1 November 2005. At this meeting, ministers from 20 countries[2] agreed on the future shape of the Dialogue and agreed to work together on such areas as the deployment of energy efficiency, clean technologies, large-scale private sector investment in low carbon technologies, increased co-operation between the developed and developing countries and adapting to the impacts of climate change. Ministers also heard reports from the World Bank and the International Energy Agency (IEA.) They discussed progress on the work programmes they are taking forward at the request of the G8 as part of the Dialogue: the World Bank on frameworks for clean energy and development, including investment and financing; and the IEA on alternative energy scenarios, strategies to create a clean, clever and competitive energy future and work on many specific areas of the Plan of Action. Progress on the Dialogue will continue leading to further ministerial level meetings.

The role of the IEA in the Gleneagles Plan of Action is to provide the review of the best practice for policy and regulations, and advise on energy scenarios and strategies for a cleaner energy future for OECD and the plus five developing countries. The means at the disposition of the IEA include a major international programme of analysis, workshops, sharing knowledge and experience and partnership with other international organisations such as the World Bank. The IEA is willing to work with the governments of the developing countries. In this paper, we focus only on energy efficient standby power technology and its application to China.

3. The IEA and standby power

In January 1999, the IEA initiated an international collaboration to address the growing concern about the energy consumed in standby mode by numerous electrical and electronic products. By organising three workshops, starting in 1999, the IEA facilitated international discussion and co-operation on standby power issues. The workshops explored the benefits of international collaboration to encourage national efforts. They showed the importance of co-ordinating efforts internationally to facilitate participation by industry, and the risk of proliferation of national and regional initiatives on regulating standby power use.

One very important result of the IEA workshops was that standby power would soon be included in energy test protocols and energy efficiency policies for all products consuming significant amounts of standby power. The International Electrotechnical Commission (IEC) TC59, created an *ad hoc* working group to examine test procedures for standby power of appliances and electrical equipment.

It was recognized that successful collaboration would need a widely accepted definition of “standby power”, which did not exist at the time. Standby power is defined as the power used by modern appliances in order to maintain them in a convenient 'ready' state for instant use, or keep them to communicate with other parts of an integrated network system that thus enhances their services provided. Whenever it is connected to the power grid, an appliance may consume standby power if it is switched on or even if it is not switched on. The most common appliances with standby power use are computers, washing machines, televisions, VCRs, microwave ovens, gas-fired hot water system, gas-stoves with electrical ignitions, and all devices with external power supplies (such as chargers for mobile telephones). Any appliance with a remote control, such as room air conditioners and many audio products, will certainly consume standby power. Machines connected to networks (internet, intranet and wireless networks) such as internet phones and mobile phones consume standby power.

Standby power use is significant but usually invisible. According to Meier et al. (2003), standby power is about 20-90 Watts per household in OECD countries and 20-50 Watts in

[2] G8 + 5 large developing countries (China, India, Brazil, Mexico and South Africa) together with Indonesia, Australia, Spain, Poland, Nigeria, South Korea, the European Commission and key international organisations including the World Bank and the International Energy Agency.

China, ranging from 4% to 10% of total residential power consumption. Meier estimated that standby power accounted for approximately 5% of total residential electricity consumption in the United States, "adding up to more than USD 3 billion in annual energy costs". According to the US Department of Energy, national residential electricity consumption in 2004 was 1.29 billion megawatt hours (MWh) - 5% of which is 64 TWh. In other words, the wasted energy is equivalent to the output of 18 typical power stations with the capacity of 500MW each!

Meier (2005) also revealed that standby power accounted for 7% of total residential consumption in France. Further studies have since come to similar conclusions in other developed countries, including the Netherlands, Australia and Japan. Recent research has estimated that around 10% of electricity consumed in Australian households is attributed to appliances that are in standby mode[3]. It means that around 10% of a typical residential electricity bill may be going towards appliances doing nothing. Some estimates put the proportion of consumption due to standby power as high as 13% in these countries.

Standby power consumes more energy in terms of per unit of appliance in the developing countries than in the developed. According to *The Hindu* (2006) in India, while standing-by, an Uninterruptible Power Supply (UPS) system with its inverters consumes about 40 Watt, a water filter can consume up to 35 W. Similarly, TVs and audio systems can consume between 22 and 27 Watt on standby mode. A mosquito repellent, a mobile charger and a VCD player could end up accounting for 10, 5 and 12 Watt respectively. See Table 1. When added up, these appliances in Delhi at their standby mode consume about 175 MW, more than 25% of the total power use in the city.

Table 1 Standby power in India

Appliance Category	Standby Power (W)
TV	22
Mobile charger	5
Microwave oven	6
UPS/inverter	40
DVD CD / VCD player	12
Mosquito repellent	10
Compact audio system	27
Water filter	35

Source: The Hindu (2006)

The IEA has helped its member countries to co-ordinate a common approach to this problem. It advocates that they develop long-term plans to reduce standby over time. Under IEA's initiative, some IEA member countries have made concrete action plans to reduce standby power consumption to 1 Watt, 0.75 Watts and 0.5 W. For example, in August 2000, all Australian jurisdictions agreed to: *"...pursue efficiencies in standby power consumption of energy-consuming products, through support for the International Energy Agency's One-Watt program, and endorse its incorporation into the...program of work."*

In addition to various voluntary schemes, there have been some mandatory measures. One of them was introduced by the US President George Bush, as a result of the California energy crisis of 2001. That year, Mr Bush issued Executive Order 13221, which states that every government agency, "*when it purchases commercially available, off-the-shelf products that use external standby power devices, or that contain an internal standby power function, shall purchase products that use no more than 1 Watt in their standby power consuming mode*."

In 2000, Australia became the only country to adopt this 1 Watt standby power standard nationally. In 2002, a voluntary scheme began throughout the country. In 2005, Australia's Standby Power Strategy was to reduce standby power for appliances to 0.2 Watts – 1 Watt by 2012[4].

[3] http://www1.sedo.energy.wa.gov.au/pages/standby_power.asp
[4] Except security systems at 1.2 W. http://www.energyrating.gov.au/pubs/standby-summary.pdf

In late 2004, the California Energy Commission went even further by imposing limits on standby power consumption for various consumer electronic devices, including DVD players, external power adapters and stereos. This legislation took effect in January 2005, so "*it is now illegal in California to sell a television or DVD player that consumes more than 3 Watts in standby mode*". Power adapters will be limited to a standby consumption of 0.75 Watts from next year, falling to 0.5 Watts from January 2008. And new limits will apply to stereos and set-top boxes.

The governments of Norway, Korea and Japan also stated publicly that they would pursue the '1 Watt' target under the banner of the IEA standby power initiative. This target sought to raise awareness of excessive standby not only amongst suppliers but also amongst product purchasers. It was meant to demonstrate to suppliers internationally that excessive standby should be redressed through better design practice and other strategies. It was meant to demonstrate to consumers that governments were acting to reduce excessive standby on their behalf.

Fortunately, under the G8 agenda, the IEA's standby power initiative and the OECD's experience and technologies are available to China and the four other developing countries. In addition, an IEA staff member was involved in surveying energy efficient standby power in China back to 2000. The IEA has already accumulated experience and collected data on standby power in China.

4. Case study of standby power in China

Methodologies and approaches used in the case study

The methodology is designed according to the availability of the data to accomplish various analyses under the business as usual (BAU) and energy efficiency (EE) scenarios. Our quantitative analyses methodology covers energy savings, power demand avoidance, pollution reductions, and cost-benefit estimations from the perspectives of the national government and the individual customers of the energy efficient standby devices.

In this study a number of methods are used for data collection, including literature review, interviews and on-site data measurement. We reviewed the literature on standby power development in China, interviewed Dr Alan Meier, the pioneer of energy efficient standby power, and a professional from the China Standard Certification Center who undertook a survey in China in 2001 and analyzed the standby power consumption by appliances in China. The author also undertook auditing for appliances in a family in Beijing to verify the collected data.

The quantitative calculation was based on Chinese households. In order to project the number of households by 2020, we collected the data on China's population growth from the Chinese government, and used a linear regression method to calculate the number of households in urban and rural areas respectively. With a simple calculation, we found that if China keeps its current trend of urbanization to 2020, China's rural population will still be over 40%, much higher than in OECD countries. It means that by 2020, China's urbanization process will not be completed.

We did not measure the energy consumption by appliances in a typical rural household on-site. To estimate the standby power consumption by rural households, we used the share of appliance ownership in a rural household over that of an urban household. For example, according to the statistical data of the Chinese government, the number of appliances owned by a rural household is 30% of that of an urban household. Under this method, we assume the standby power consumption in a rural household to be 30% of that in the urban household.

While undertaking programme economic and financial analyses, we used different approaches because of the difficulties to collect the data for the analyses. While undertaking the economic cost-estimation, we only took into account the costs of the device production, rather than costs of policy development and information campaigns because of the difficulties to quantify these costs. In the financial analysis, from the perspective of the owners of the appliances, the analysis was based on one piece of the device. This method will simplify the analysis and will not harm the results.

Literature review and data survey

Urban Chinese households are now well equipped with appliances. According to the State Statistical Bureau (SSB, 2004), by 2002 each urban household had more than one colour TV set, and the ownership of refrigerators and room air-conditioners stood at 89% and 62%, respectively. In December 2000, an expert team undertook an informal survey of 28 homes in Guangzhou, China to investigate standby power consumption (Meier et al., 2004). Their on-site survey data showed that standby power consumption is significant in China. The highest standby power uses recorded were 45 Watts for amplifiers, 22 Watts for VCDs, 21 Watts for television sets, and 20 Watts for stereo systems. Due to their prevalence and high average standby power ratings, televisions and video players were the top two appliances that contribute to most of the standby power in these homes. The average standby power per household is 29 W, and the highest is 100 W. The majority of the households in this sample have a standby power between 20 and 50 W. Table 2 presents the survey results.

Table 2 Summary statistics of standby power measurements

Product	Count	Standby Power (W)		
		Minimum	Average	Maximum
Air conditioner	32	1.0	3.1	9.3
Amplifier	2	19	31.7	45
Audio system	5	3.6	10.0	20
Cooking fan	1	1.2	1.2	1.2
Digital video disk (DVD)	1	3.6	3.6	3.6
Microwave oven	5	0.5	2.9	3.7
Refrigerator	12	0.5	4.1	12
Rice cooker	1	5.2	5.2	5.2
Television (TV)	31	2.4	9.6	21
Video compact disk (VCD)	16	3.4	12.9	22
Video cassette recorder (VCR)	1	13	12.8	13

Source: Meier et al. (2004)

In 2001, a group of Chinese experts undertook an on-site survey in Beijing and Guangzhou to audit the standby power consumption of colour TV sets in urban households (Fridley et al., 2001). They issued 700 questionnaires and received more than 500 responses. Their survey results show the following: (1) the average of standby power in TV sets is 8.1 W; 13.4% of the TVs consume less than 3 W, 54.3% of them consume over 7 W, some of them reached over 20 W, (2) the technical lifetime of the TVs is about ten years; (3) the average time used is 5.3 hrs/day; (4) the standby time is 2 hrs/day; (5) the targeted energy efficient standby power was to achieve 3 Watts by 2010; (6) the marginal cost to produce the 3 Watts standby power device was estimated at about USD 1.2/unit in 2001.

In order to verify the above survey data, in March 2006 the author also undertook an on-site auditing survey of the appliances in a typical middle class family in Beijing, with most of the appliances made in China in 2005. The survey results generally support the technical data given above. See Table 3. When all the appliances are plugged in but not switched on, the total power consumption amounts to about 24 W. While these appliances are switched on but not in full operation, i.e. in standby mode, the total standby power consumption reaches about 40 W. The total energy consumption by both standby mode and plugged-in mode is over 0.5 kWh per day. This measured information is consistent to the survey results of Meier et al. (2004) and Fridley et al (2001). In the forthcoming analysis, we assume that standby power in each urban Chinese household will account for about 40 Watts and 0.5 kWh/day (with weighted average hours of standby power of 12.5/day)[5].

Table 3 Auditing results of standby power in a typical middle family in Beijing

Appliances	Plugged in (W)	Plugged in time (hrs/day)	Standby power (W)	Standby time (hrs/day)	Energy use by standby (kWh/day)	Energy use by plugged-in (kWh/day)
Audio system (made in Korea)	2.0	24	2.0	10	0.02	0.03
Cooking fan (made in China)	0.0	24	0.0	5	0.00	0.00
Digital video disk (DVD) (made in China)	11.6	2	11.6	2	0.02	0.00
Washing machine (made in China)	1.0	24	2.0	24	0.05	0.00
Microwave oven (made in China)	2.2	24	2.2	24	0.05	0.00
Refrigerator (made in China)	2.0	24	2.0	24	0.05	0.00
Television 1 (made in China)	0.0	24	5.5	8	0.04	0.00
Television 2 (made in UK)	0.0	24	1.1	8	0.01	0.00
Battery charger (made in China)	1.0	12	1.0	10	0.01	0.00
Gas water heater (made in France)	0.0	24	4.5	24	0.11	0.00
Desktop computer machine (made in China)	2.1	24	2.5	8	0.02	0.03
Desktop computer screen (made in China)	1.2	24	2.9	8	0.02	0.02
Laptop computer (made in Ireland)	0.8	24	2.6	8	0.02	0.01
Sum	23.9		39.9		0.43	0.10

Rural household appliance ownership

Appliance ownership in a rural household is far less than in an urban household with the shares ranging between 6% (air conditioner) and 52% (colour TV). According to the Chinese statistics (SSC, 2004), the weighted average share of appliance ownership in a rural household over an urban household is 30%. See Table 4. In the following analysis, we assume that between 2006 and 2020, the standby power consumption in a rural household will also be 30% of that of an urban household, i.e. 12 Watts and 0.16 kWh/day.

Table 4 Appliance ownership per 1000 rural and urban households in 2002

Each 1000	Refrigerator (units)		Air conditioner (units)		Color TV (units)		VCR (units)	
households	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
National Average	887	159	618	35	1305	678	179	35
Share of rural over urban	18%		6%		52%		20%	
Weighted average share of rural over urban:								30%

Source: calculated on the basis of NBS (2004).

In order to quantify the impacts of standby power on Shanghai's energy savings, on the basis of the Chinese statistics we calculated the appliance ownership of Shanghai. Table 5

[5] Due to the constraints of time and financial resources, we could not afford more on-site survey or auditing for the standby power consumption in wider and more Chinese homes. The assumed data may be bias. Nevertheless, this auditing will allow us to undertake quantitative analysis for the case.

shows that a typical household in Shanghai owns 64% more appliances than an average urban household in China. As such, in our forthcoming analysis, we assume that standby power consumption in Shanghai will be 164% of that in an urban household in China.

Table 5 Appliance ownership per 1000 households in Shanghai and China in 2002

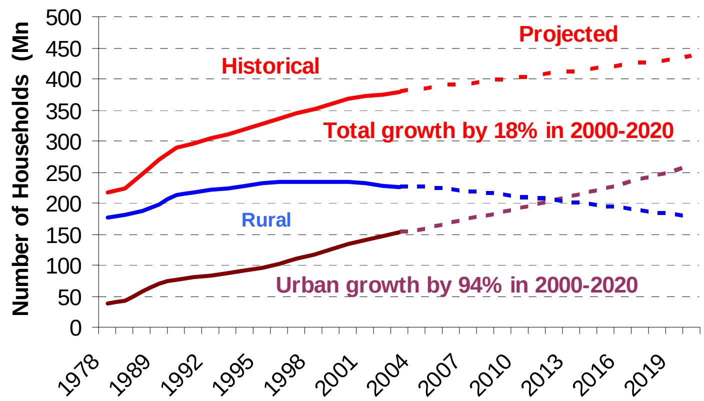
Region	Refrigerator (unit)	Freezer (unit)	Color TV (unit)	DVD (unit)	VCR (unit)	Computer (unit)	Hi-Fi system (unit)	Musical instruments (unit)
China average	887.3	69.7	1305	586.9	179.1	278.1	268.9	68.8
Shanghai	1020	32	1676	738	334	604	396	68
Share of Shanghai over China	115%	46%	128%	126%	186%	217%	147%	99%
Region	Oven (unit)	Freezer (unit)	Room heater (unit)	Ventilation fan (unit)	Dishwasher (unit)	Water cooler/heater (unit)	Telephone (unit)	Fax machine (unit)
China average	369.6	617.9	322.6	635.5	5.9	319.4	954.1	7.2
Shanghai	876	1358	732	768	14	556	1020	34
Share of Shanghai over nation	237%	220%	227%	121%	237%	174%	107%	472%
Weighted average share of Shanghai over China:								164%

Source: calculated on the basis of NBS (2004)

Estimation of the number of Chinese households by 2020

In this study, we estimated the numbers of rural and urban households on the basis of the historical population data and a simple linear regression. According to a report prepared by the Chinese Academy of Social Sciences (CASS)[6], China's population is likely to increase from 1.29 billion in 2004 to hit a peak of 1.38 billion in 2025. We assume that in 2020, the Chinese population will reach 1.35 billion. In addition, NBS(2004) showed that the average size of a Chinese family had been decreasing from 4.45 people in 1978 to 3.40 in 2004. Using this trend, we projected that by 2020 a Chinese family will have 3.2 people on average. Then, we further projected the number of households in the urban and rural areas respectively between 2005 and 2020. Due to the rapid economic development and urbanization in China, the number of urban households is expected to increase from 156 million (SSC, 2004) to 259 million, while the rural households are to decrease from 226 million to 179 million. Figure 2 shows the changing trends of the households in urban and rural areas respectively.

Figure 2 Number of households in China



Source: Calculated from: (NBS, 2004).

6 http://www.china-embassy.org/eng/gyzg/t228473.htm

While estimating the number of households in Shanghai, we used different methodology because of the different kinds of data available. According to NBS (2003 p101), the total population in Shanghai in 2002 was 16 million and the number of people per household was 2.89. As such, there were about 5.54 million households in Shanghai in 2002. To make the calculation conservative and simple, we assume the number of people per household remains the same, but the total population or the number of households in Shanghai will increase 1% each year until 2020[7]. By 2020, the number of households in Shanghai will be about 6.5 million, the entire urban area.

Government efforts in energy efficient standby power

The Chinese government has made efforts in promoting energy efficient standby power technology. Since 2000, the China Standard Certification Center (CSC) has done a couple of surveys on standby power consumption in China and suggested the government to implement energy efficiency procurement scheme. On 17 December 2004, the Ministry of Finance of China and the National Development and Reform Commission of China jointly issued the Procurement Policy for Energy Efficient Products[8]. Under this policy, the any government agency which purchases appliances should select those within the List of Energy-Efficient Products provided by CSC. Besides compiling the list, CSC also provides technical supports. According to the requirements of CSC, the standby power for TV and off-mode for computer was 3 W, and the off-mode for printer was 1W.

More efforts and more strict policies are required in promoting energy efficient standby power technologies in China. This is due to at least two reasons. First, the 2004 Chinese policy only covered the appliances that are used by the government agencies. The impacts, according to the expert of the CSC, would cover about 30% of the total appliance population. Second, the standards of the standby power consumption were very lenient, 3 Watts for TV in China while the Australian government requires 1 Watt or 0.75 Watts in standby power consumption.

Assumptions of business as usual and energy efficiency scenarios

In this study, we made two scenarios: business as usual (BAU) and energy efficiency (EE). In the BAU, we assume that the government, the appliance manufacturers and customers will not do much about energy efficiency improvement in standby power. Specifically, the BAU scenario contains the following features:

1. The standby power consumption in a typical urban household will increase from 35 Watts (the average of 20 Watts and 50 Watts) in 2004 to 39.5 Watts in 2020. By 2020, 30% of the appliances will be equipped with 1 Watt devices[9].
2. The standby power consumption in a typical rural household will increase from 10.5 Watts (30% of the amount in an urban household) in 2004 to 11.9 Watts in 2020. This is calculated on the basis of the fact that the appliance ownership of a rural household is about 30% of an urban household. See Table 4.
3. The average duration of standby power consumption, as observed in a Chinese household, is 12.5 hours per day.
4. By 2020, a typical urban household will acquire 20% more appliances than the household in 2004 but the average hours of standby power use will remain the same.

[7] According to the Chinese Academy of Social Science, the growth rate of the national population will be close to 3% in this period.
[8] Source: Personal interview with Ms Li Anzhen of the China Standard Certification Center in April 2006.
[9] This was calculated on the basis of the interview with Ms Li Aizhen, Director of the International Cooperation Department of the China Standard Certification Center.

This means that the urban household will consume 50 Watts and 0.625 kWh/day for standby power consumption in 2020.

5. The number of households in rural and urban China and in Shanghai will change as indicated in the above section.

In the EE policy scenario, we assume that the government, the appliance manufacturers, and consumers will take actions similar to those taken by OECD member countries to promote energy efficient standby power technologies. Specifically, the following key features describe the EE scenario:

1. The national government will invest in institutional development and building staff capability to support energy efficient standby power technologies.
2. The marginal cost of energy efficient standby power technologies is USD 0.69/piece (2005 price). According to Analog Device, a US firm manufacturing economic products, it can produce ADA4850, a low-power video amplifier minimizing operating current to 2.7 mA maximum. This means that the firm can produce a standby power device that only consumes 0.64 W. The single ADA4850-1 is priced at USD 0.55/piece, and the dual ADA4850-2 is priced at USD 69/piece in 1 000-unit quantities)[10].
3. Under the government effort, appliance users are willing to pay the additional costs of energy efficient standby power technologies (USD 0.69/piece). Actually, many energy experts believe that the installation of energy efficient standby power devices in the next 15 years will have net negative costs due to technology progress. To be conservative in our analysis, we still assume that the energy efficient standby power technologies will have a positive marginal cost.
4. Between 2004 and 2020, all the current Chinese appliance stocks will be updated in two stages. (According to Chinese experts' survey results, the turnover time of the major appliances in China is between five and ten years.) In the first stage, all the appliances will be equipped with 1 Watt devices by 2012. From 2013 to 2020, because of technology progress, 0.75 Watts/piece standby devices will be widely available in China. By 2020, all appliances will be equipped with the 0.75 Watts devices.
5. All rural households will also be equipped with 1 Watt standby power devices by 2012 and 0.75 Watts devices by 2020. However, the number of appliances is estimated at 30% of the urban household. Thus, the standby power will be approximately 15 Watts and 0.188kWh/day in each of the rural households by 2012, and 11.25 Watts and 0.14 kWh/day.

Analysis results

Business as Usual Scenario

We calculated the energy and power consumptions by standby power for China and Shanghai, the largest city in China, under the BAU scenario and the EE scenario. Table 6 and Table 7 show the results under the two scenarios. Under the BAU scenario, the total energy consumption by standby power in China between 2006 and 2020 will amount to 815 TWh and demand for generating capacity will rise from 8.6 GW in 2006 to 15.6 GW in 2020. If we assume that the elasticity of total power consumption in China with respect to the country's GDP is greater than 1 during 2000-2020 as actually happened during 2000-2005

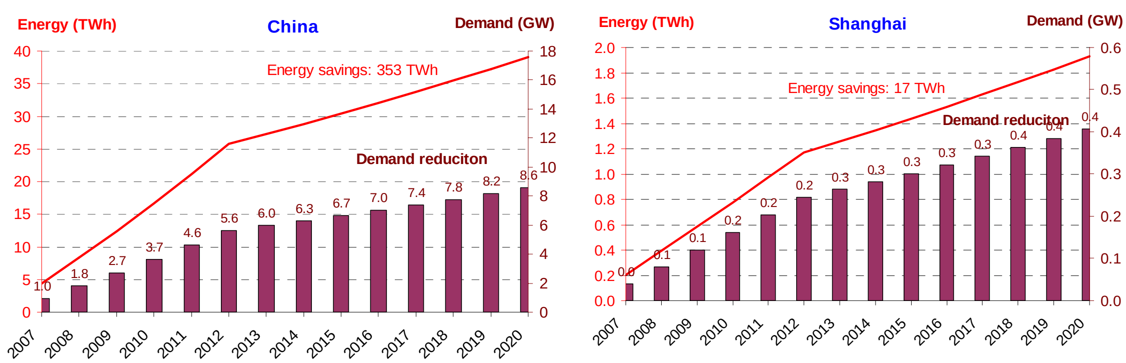
[10] Source: Sue Martenson, Analog Devices, Inc. USA. Tel. 01- 781-937-1989 or 01-781-937-1026, email: Sue.martenson@analog.com. Circuit claimed that it even sells the 1 Watt chip at price of USD 0.43/uint. See http://news.thomasnet.com/fullstory/27361/612.

(See Figure 1), and that GDP in China will quadruple during this period, then total electricity consumption in China will reach over 5 496 TWh. As a result, electricity consumption by standby power in 2020 will be 1.3% (71 TWh divided by 5 496 TWh) of the total electricity consumption of the country. In Shanghai, the total electricity consumption by standby power between 2006 and 2020 will be 29 TWh. Standby power demand in the city will be over 500 MW by 2020.

Energy Efficiency Scenario

Quite different stories can be found under the EE scenario. In China, the total energy consumption by standby power between 2004 and 2020 will be about 513 TWh, reducing by 42% when compared to the BAU scenario. The capacity demand will decrease from 8 GW in 2006 to 5 GW instead of increasing to 15.6 GW as in the BAU scenario by 2020. In Shanghai, the accumulated savings will reach 12.8 TWh (32-19 TWh) during 2004-2020. The capacity demand will be reduced by about 72%, from 510 MW under the BAU scenario to 150 MW under the EE scenario. Figure 3 shows energy and power demand savings under different scenarios for the country and the city respectively.

Figure 3 Savings of energy efficient standby power in China and Shanghai



The standby power efficiency programme can avoid or postpone 8 or 9 large power plants with 1 GW each by 2020. On 3 January 2006, China[11] announced its plans to build 32 nuclear power plants in the next 15 years to meet the country's burgeoning energy needs. By 2020, with the nine old nuclear power plants, the country's total nuclear generating capacity will reach 40 GW and account for 4% of the nation's total (State Power Corporation, 2006). On average, the capacity of each of the new nuclear power plants will be about 1 GW. The standby power programme in China will thus avoid or postpone the installation of over ten large nuclear power plants if the government and the Chinese people make an effort to avoid the BAU scenario and achieve the EE scenario.

[11] Mr Shen Wenquan, Vice Director of the state-run China National Nuclear Corporation.

Table 6 Energy consumption and power demand under the BAU scenario

	China						Shanghai	
	Energy consumption (TWh)			Capacity demand (GW)			Energy consumption	Capacity demand
	Urban	Rural	Total	Urban	Rural	Total	(TWh)	(GW)
2004	24.9	10.8	35.8	5.5	2.4	7.8	1.4	0.3
2005	26.1	10.8	36.8	5.7	2.4	8.1	1.5	0.3
2006	27.2	10.7	38.0	6.0	2.4	8.3	1.5	0.3
2007	28.4	10.7	39.1	6.2	2.3	8.6	1.6	0.3
2008	29.6	10.6	40.3	6.5	2.3	8.8	1.6	0.3
2009	30.9	10.6	41.4	6.8	2.3	9.1	1.7	0.4
2010	32.1	10.5	42.6	7.0	2.3	9.3	1.7	0.4
2011	33.4	10.5	43.9	7.3	2.3	9.6	1.8	0.4
2012	34.8	10.4	45.1	7.6	2.3	9.9	1.9	0.4
2013	36.1	10.3	46.4	7.9	2.3	10.2	1.9	0.4
2014	37.5	10.2	47.7	8.2	2.2	10.5	2.0	0.4
2015	39.0	10.1	49.1	8.5	2.2	10.8	2.1	0.4
2016	40.4	10.0	50.4	8.9	2.2	11.1	2.1	0.4
2017	41.9	9.9	51.8	9.2	2.2	11.4	2.2	0.5
2018	43.4	9.8	53.2	9.5	2.1	11.7	2.3	0.5
2019	45.0	9.7	54.7	9.9	2.1	12.0	2.4	0.5
2020	46.6	9.6	56.2	10.2	2.1	12.3	2.4	0.5
Total 2006-2020	546.4	153.6	700.0				29.1	

Table 7 Energy consumption and power demand under the EE policy scenario

	China						Shanghai	
	Energy consumption (TWh)			Capacity demand (GW)			Energy consumption	Capacity demand
	Urban	Rural	Total	Urban	Rural	Total	(TWh)	(GW)
2006	26.8	10.6	37.4	5.9	2.3	8.2	1.5	0.3
2007	25.2	9.5	34.7	5.5	2.1	7.6	1.4	0.3
2008	23.5	8.4	31.9	5.2	1.9	7.0	1.2	0.3
2009	21.6	7.4	29.0	4.7	1.6	6.4	1.1	0.2
2010	19.6	6.4	26.0	4.3	1.4	5.7	1.0	0.2
2011	17.3	5.4	22.8	3.8	1.2	5.0	0.8	0.2
2012	14.9	4.5	19.4	3.3	1.0	4.2	0.7	0.1
2013	14.9	4.3	19.2	3.3	0.9	4.2	0.7	0.1
2014	14.9	4.1	18.9	3.3	0.9	4.2	0.6	0.1
2015	14.8	3.9	18.7	3.3	0.8	4.1	0.6	0.1
2016	14.7	3.7	18.4	3.2	0.8	4.0	0.6	0.1
2017	14.6	3.5	18.1	3.2	0.8	4.0	0.6	0.1
2018	14.5	3.3	17.8	3.2	0.7	3.9	0.6	0.1
2019	14.3	3.1	17.4	3.1	0.7	3.8	0.5	0.1
2020	14.2	2.9	17.1	3.1	0.6	3.7	0.5	0.1
Total	239.2	70.2	309.3				10.8	

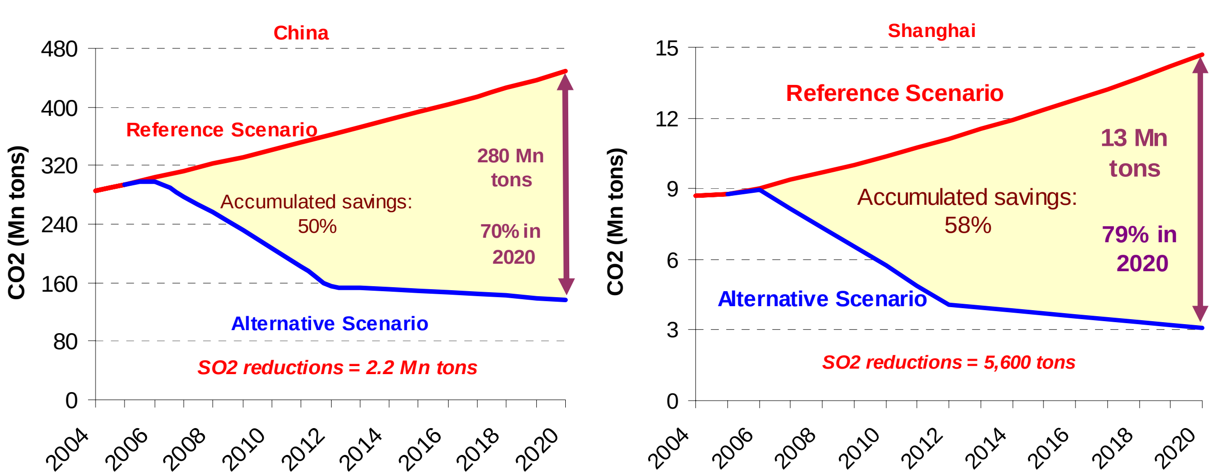
Environment benefits

We made a rough estimate of the environment benefits achieved by promoting energy efficient standby power technologies in China and Shanghai. In 2002, China's shares of electricity production were 80.7% from coal, 2.8% from oil and 1.5% from natural gas. By 2020, these shares will become 78.9%, 1.62% and 4.9% respectively (WEO, 2005). According to the Energy Research Institute of the National Development and Reform Commission, China will mainly use critical and supercritical technologies in power generation in the next 15 years (ERI, 2005). The emission factors for such technologies are: 833 gCO_2/kWh, 6.7 g SO_2/kWh, and 2.6 g NO_x/kWh. For oil-fired power plants, we assume the emission factors are half those from the above-mentioned coal-fired plants. For natural gas-fired plants, the emission factors are 174.2 g CO_2/kWh, none for SO_2 and 0.3 g NO_x/kWh (ERI, 2005). Then, by 2020, energy efficient standby power will bring about a reduction of 250 million tons of CO_2 in China including 9 million tons in Shanghai, 2 million tons of SO_2 in China including 73 thousand tons in Shanghai, and 780 thousand tons of NO_x in China including 6 thousand tons in Shanghai. See Table 8 and Figure 4.

Table 8 Emission reductions in China and Shanghai

	China			Shanghai		
	Pollution reduction (k ton)			Pollution reduction (k ton)		
	CO_2	SO_2	NO_x	CO_2	SO_2	NO_x
2006	486	3.9	1.5	12	0.0	0.0
2007	3,538	28.1	10.9	164	0.1	0.1
2008	6,716	53.3	20.7	317	0.2	0.2
2009	10,020	79.5	30.9	472	0.2	0.3
2010	13,453	106.6	41.5	627	0.3	0.4
2011	17,017	134.7	52.5	784	0.4	0.5
2012	20,715	163.9	63.9	943	0.4	0.6
2013	21,897	173.1	67.5	1,011	0.5	0.7
2014	23,114	182.5	71.2	1,081	0.5	0.7
2015	24,365	192.3	75.0	1,153	0.5	0.7
2016	25,652	202.3	78.9	1,227	0.5	0.8
2017	26,975	212.5	83.0	1,302	0.5	0.8
2018	28,335	223.0	87.1	1,380	0.5	0.9
2019	29,731	233.8	91.3	1,459	0.5	0.9
2020	31,164	244.9	95.7	1,541	0.5	1.0
Total	283,179	2,234.3	871.7	13,473	5.6	8.7

Figure 4 Summary of Emission Reductions



Cost-benefit analyses

In this study, a simplified cost-benefit analysis was undertaken. Due to the shortage of data, we only calculated economic benefits (not taking into account the full economic costs such as government expenditure on information campaigns) from the perspective of the Chinese government. For the programme financial analysis, we took into account both costs and benefits from the perspective of the investors or owners of the appliances. This analysis is performed on the basis of one piece of standby power appliance/device. By multiplying the total population of the appliances/devices, one can easily calculate the total benefits or costs of the project or programme in China and/or in Shanghai.

While estimating the economic benefit and undertaking financial cost-benefit analysis, we made the following assumptions:

1. The discount rate for the economic analysis is 12%. It is set on the basis of the rate used by the World Bank and the Asian Development Bank for project economic analyses.
2. The discount rate for financial analysis is set at 20%. This rate was calculated on the basis of experience: (1) the payback period of energy efficient products is expected to be less than three years; (2) the economic lifetime of the appliance is seven years.
3. The cost per piece of the 1 Watt device in the financial analysis is USD 0.69/piece. The device will be manufactured in China.
4. The combined corporate tax rate (national and local) for a firm to make appliances in China is 30%. Thus, the economic cost for the energy efficient standby technology is USD 0.48/piece (USD 0.69 multiplied by 70%).
5. In 2003, the electricity prices in China's household sector averaged 0.539 yuan/kWh or USD 0.0627/kWh (China Electrical Power, 2006). China is implementing electricity price reform from a government controlled price system towards a market based price system. We assume that between 2006 and 2020, general electricity prices will gradually increase to USD 0.10/kWh in 2003 constant price.
6. One appliance will use only one price of electronic chip for efficient standby power. It means that the total number of the devices will be same as the total number of newly penetrated appliances.
7. Electricity savings by the energy efficiency standby device are 0.5 kWh/day-unit, calculated on the basis of the survey data of Table 3.

National economic analysis

The direct economic costs during 2006-2020 to China and Shanghai are calculated and listed in Table 9. We call these direct costs because they are national expenditure to produce the electronic chips for energy efficient standby power, but they do not include the national government expenditure on policy development and information campaigns. The total present values discounted to year 2006 are

Table 9 Economic costs of energy efficient standby devices

	China (million $)			Shanghai
	Urban	Rural	Total	(million $)
2006	506	200	706	27
2007	786	296	1,082	28
2008	1,085	390	1,475	29
2009	1,402	481	1,883	30
2010	1,738	569	2,307	31
2011	2,094	655	2,749	33
2012	2,470	737	3,207	34
2013	2,866	817	3,683	35
2014	3,283	893	4,177	36
2015	3,721	966	4,688	37
2016	4,181	1,036	5,218	39
2017	4,663	1,103	5,766	40
2018	5,167	1,166	6,333	41
2019	5,694	1,225	6,920	43
2020	6,245	1,281	7,526	44
PV	15,335	4,282	19,617	224

19.6 billion for China and 224 million for Shanghai.

The national benefits from energy efficient standby power can be calculated by the delayed investment of national expenditure in the power industry. As indicated in the introductory section, China plans to invest in 32 large nuclear power plants by 2020. In OECD, the annualized generation costs of nuclear power plants at the discount rate of 10% will be USD 40/MWh (except in the Netherlands and Japan), and the average capital investment costs for nuclear power in 2003 constant price is USD 1 679/kWe[12] (IEA 2005). Let us assume that the economic electricity generation costs and the capital investment in Chinese nuclear power plants are USD 40/MWh and USD 1 679/kWe respectively. Then, the energy efficient standby devices will save 353 TWh of electricity and avoid 8.6 GW of power demand in China (see Figure 3). The total savings will be USD 14.1 billion in electricity generation and the avoidable capital investment will be USD 14.4 billion. The above calculation does not include the environmental benefits. Evidently, the total benefits are greater than the total discounted national economic costs. Thus, the energy efficient standby power programme in China is economically viable.

Financial analysis

As stated before, the financial analysis is carried out on the basis of one piece of energy efficient standby device. The marginal overnight investment cost is USD 0.69/unit (this cost may actually be negative). Electricity prices at the constant price of 2006 will gradually increase with the price reforms carried out by the Chinese government. Our financial analysis shows that the payback period of the device is less than one year and the net present value during seven years under the discount rate of 20% is more than USD 2 if the customer invests USD 0.69 for one piece of energy efficient standby device. Consequently, the investment is financially viable. See Table 10. Although this number may be too small for most consumers to pay attention to, from the nationwide, the accumulated cost savings are huge.

Table 10 Financial analysis results

	Cost	Electricity price	Electricity savings	Savings	Net values
	$/unit	$/kWh	kWh/day	$/unit	$/unit
2006	0.69	0.06	0.03		-0.69
2007		0.07	0.03	0.78	0.78
2008		0.07	0.03	0.82	0.82
2009		0.07	0.03	0.85	0.85
2010		0.07	0.03	0.88	0.88
2011		0.08	0.03	0.91	0.91
2012		0.08	0.03	0.94	0.94
2013		0.08	0.03	1.20	1.20
NPV					$2.05

Collaboration between IEA and China

China's adoption of energy efficient standby power technology will be of great benefit. As indicated above, the IEA is committed to encouraging improvement in energy efficient standby power technologies in OECD countries and worldwide. We will encourage co-ordination among industry and governments to reduce the burden on manufacturers of globally marketed products, encouraging support for greater reductions in standby power consumption. The IEA's approach would eliminate the confusion created by redundant energy efficiency labels in different countries. A uniform international policy could simplify the process of educating and informing consumers and stimulate greater demand for energy-efficient products and appliances. Examples of the IEA's work in energy efficient standby technology include the following areas:

[12] USD 1 805/kWe in Russia.

1. Promote the update of appliance energy labels to include an indication of standby power consumption. Appliance energy labels are used in most OECD countries and China. Unfortunately, most of these labels do not indicate how much energy is consumed while the appliance is on standby. For some appliances, such as electric ovens in some countries, and DVD machines in China, the annual standby consumption is as high as the on-mode consumption. The IEA would facilitate the new labels so that the consumers are well aware of it.

2. Encourage research on new low-standby technologies. Research and development activities on new and efficient chips for standby power technologies should be stimulated at all levels, especially to help manufacturers. The IEA's technology collaboration among the OECD countries and manufacturers will save time and money.

3. Facilitate an international network of accreditation organisations. An international network of accreditation organizations would be able reduce the costs to manufacturers of qualifying products with low standby consumption under multiple different regional programmes.

As mentioned before, the Chinese government has introduced its schemes to encourage government procurements of equipment with low standby power consumption. This is great progress towards the implementation of energy-efficient standby power technologies. However, it is important to ensure that the criteria are consistent with the world's best standby power technologies. For example, after attending the workshop in Korea in November 2005, the China Standard Certification Center (CSC) has recommended 1 Watt standby power technologies be used in most appliances by 2012. By joining the IEA's energy efficient standby power technology initiative, the Chinese will be kept up-to-date on technology progress and innovation in standards worldwide, and make more energy efficient standards for standby power technologies.

With many such successful energy efficiency activities and actions implemented in the next 15 years, China may be able to really reduce its elasticity of energy consumption with respect to GDP below 0.5 and achieve its energy conservation goal.

5. Conclusions

Energy efficiency has become a national important issue in China. In order to achieve its economic development target in a sustainable way, China has set up two strict energy saving targets: cutting energy intensity by 20% from 2006-2010, and only doubling energy consumption while quadrupling GDP between 2000 and 2020. Unfortunately, the historical economic development and energy consumption data during 2000-2005 showed that the energy consumption growth rate was faster than the economic growth rate. If China does not take effective energy efficiency measures, energy consumption in 2020 will be more than four-fold of the level in 2000. There are many areas where China will be able to improve energy efficiency and standby power is one of them.

Energy efficient standby power offers large potential for China to cost-effectively implement energy efficiency. If the government does not take any further actions, i.e. under the BAU scenario, electricity consumption by Chinese household appliances in standby mode will increase from 38 TWh in 2006 to 56 TWh in 2020, representing about 1.5% of the total national electricity consumption. Between 2006 and 2020, there will be a total of 700 TWh of electricity consumed by standby devices. In 2020, power demand by standby devices will be more than 12 GW, equivalent to the total capacity of 12 large nuclear power plants with capacity of 1GW each. However, this situation can be changed by government policy, mandatory programmes and information campaigns to promote energy efficient standby technologies.

Total electricity consumption and power demand by standby power will be cut from 56.1 TWh and 12.3 GW under the BAU scenario to 17.06 TWh and 3.74 GW under the EE scenario in 2020. Compared with the two scenarios, the EE scenario will be able to save 353 TWh of electricity between 2006 and 2020, and avoid the investment of 8.6 GW of power plant for China, which is equivalent to the total capacity of eight large nuclear power plants. The energy efficient standby power programme will also mitigate about 280 million tons of CO_2, two million tons of SO_2 and 870 thousand tons of NO_x in China.

In particular, the energy efficient standby power promotion programme in China will be both financially and economically viable. Even under the most conservative assumptions, the economic benefits which do not take into account the environment benefits will be far beyond the marginal costs which may actually be negative. In addition, the results of the financial analysis show that the payback period for investors in energy efficient standby technologies will be less than one year. The net present value of the investment is about USD 2. Energy efficient standby technologies are powering China towards more energy efficiency.

The Chinese government and manufactures will receive huge benefits if China adopts one-Watt, 0.75 Watt and 0.5 Watt technologies as OECD does. We can help China to access the updated information, technologies and avoid considerable investments in R&D for the new standby power technologies.

It should be noted that the scope of the analysis in the case study only covers the household sector. It does not include appliances in other sectors. Thus, the actual potential of energy and power savings in China under the standby power programme will be larger than indicated above.

Finally, it is worthy noting that there is a limitation in this study. The quantitative analysis was on the basis of limited survey data. Statistically, a robust analysis requires that the share of sample data over the total population should be 1-5%. Since there are about 400 million households in China in 2006, we should have carried out on-site surveys to at least 4 million households in China. Unfortunately, our time and resources do not allow us to do so. Our analysis was based on the household auditing data from very limited number of families.

Acknowledgements

Acknowledgement is due to Dr Alan Meier and to Dr Jonathan Sinton of the International Energy Agency for providing valuable comments on this article. The author wishes to thank Ms Li Aizhan of the China Standard Certification Center for data collection and comments on this article. The viewpoints expressed in this article are solely those of the authors, and they do not necessarily represent any those of the IEA and the persons mentioned above.

References

1. The Hindu (2006) Now you know what inflates your power bill. Online edition of India's National Newspaper. Monday, Apr 03, 2006. http://www.hinduonnet.com/2006/04/03/stories/2006040308520200.htm.

2. NBS (National Bureau of Statistics), China Statistical Yearbook, Beijing, 2004.

3. Zhang X. Q. Strengthen Energy Cooperation and Achieve Common Development - Remarks at the 2005 IEA Ministerial Level Meeting, Paris, 2 May 2005.

4. Meier A. Lin J. Liu J. and Li T. (2004) Standby power use in Chinese homes, Energy and Buildings, Vol (36) pp1211-1216.

5. Meier A. Standby: Where are we now? Proceedings of ECEEE 2005 Summer Study – What works & Who Delivers? pp 847-854, Paris, France. 2005

6. Fridley D. Koomey J. Webber C., Chen H. H., Chui H., Zhang G. Q. and Lui J. (2001), Technical and Economic Analysis of Energy Efficiency of Chinese Color Television Receivers. Lawrence Berkeley National Laboratory, University of California, USA.

7. State Power Corporation of China (2006). China announces its plans to build 32 nuclear power plants in next 15 years. http://www.sp-china.com/news/powernews/200603010002.htm

8. WEO (2005), World Energy Outlook, IEA, Paris, France p483.

9. ERI – Energy Research Institute of the National Development and Reform of China, Strategies for Promotion of Energy Efficient and Cleaner Technologies in the Power Sector – Implications of Carbon and Energy Taxes as Instrument for GHG Reduction in the Power Sector and Decomposing of Economy-Wide Changes in Emissions with Taxes using an Input-out Analysis. B-1407, Jia No. 11 Muxidibeili, Beijing, 100038, China. June 2005.

10. IEA (2005) Projected Costs of Generating Electricity. The International Energy Agency, Paris, France.

11. China Electrical Power – A Newspaper published by the State Power Corporation of China (2006), Projection of China's Electricity Price Reforms by 2010. 21 March 2006.

12. China CCTV (2005) Hu Jintao's Speech at the 23rd collective meeting of the Political-bureau of the Chinese Communist Party. 28 June.