China Green Lights Program:
A Review and Recommendations

by

Jiang Lin
Energy Analysis Department
Lawrence Berkeley National Laboratory

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Abstract

This report reviews the development of China's Green Lights Program in the last two years, and discusses the remaining barriers to the widespread adoption of efficient lighting technologies in China: chiefly quality, high initial costs, and lack of accurate information. A variety of policy options are recommended for the future expansion of China's Green Lights Program.

Executive Summary

Since its launch in 1996, the China Green Lights Program (CGLP) has been very successful in raising the awareness of available energy efficient lighting technologies, and has significantly contributed to the substantial increase in the production and use of these efficient lighting technologies. For example, compact fluorescent lamp (CFL) production has grown from 38 million units in 1993 to almost 100 million in 1997, while the number of lighting manufacturers has grown from roughly 400 in 1993 to nearly 1000 in 1997.

China's early success in promoting CFL and other efficient lighting technologies are due to several factors. First, the Chinese are very conscious of their energy consumption, and the proportion of income spent on electricity bill is substantial. Thus Chinese consumers are more receptive to new means to reduce their electricity bill. Secondly, the shortage in electric capacity and China's challenge to meet its ever-increasing demand up to the mid-90's provided strong societal incentive to seek energy efficient technologies. Thirdly, the technologies have been tested in mature markets and the Chinese are ready to accept it. Fourthly, the barriers to entry for Chinese producers in CFL market are fairly low, and there are no dominant players. The response to the establishment of China's Green Lights Program was overwhelming: government regulators have a hard time to keep track numbers of producers and sales. China's low labor cost is also an incentive to producers who are aiming at export market for high efficiency lighting products. In addition, support from UNDP has enabled the Chinese program to benefit from the experience of other countries in their effort to promote energy efficient lighting technologies, as well as committing significant local resource which led to much stronger local participation and higher penetration of the efficient technologies.

There have been many innovative and successful pilot projects conducted during the initial years of the Chinese Green Lights Program implementation, and many of the lessons learned through these pilots can be used in future expansion of China's Green Lights Program.

Experience during the initial implementation of the Green Lights program has highlighted two major barriers to greater use of more efficient lighting equipment in China: high initial cost of more efficient technologies, and poor quality of some of the efficient products made in China. As a result, there is now a perception of poor quality of efficient lighting equipment that needs to be overcome in future activities.

The quality and price/cost issues are to some extent inter-related. While Chinese-made components and raw material and production process (both the machinery and process control) remain problematic, the poor quality of the final products is more often the victim in manufacturers' drive to reduce product costs, in the absence of product quality standards, rigorous monitoring and an enforcement mechanism. Thus, developing and implementing product standards will be the necessary step in improving the quality of Chinese-made lighting products.

Higher costs of the efficient lighting products are a major barrier to their diffusion in every market. In the developed economies, utility-based demand-side management programs have been the major vehicles to reduce end-user cost. While there has been interest expressed by the Green Lights Program Office about experience with Western Countries in utility sponsored demand-side management (DSM) activities, it appears that now is a very difficult time to attempt to initiate such programs in China. The electric utility sector in China is going through a major restructuring to a more market based system, and there is no real incentive or interest for utilities to initiate ratepayer funded energy efficiency programs at this time. Moreover, due to industrial restructuring in State owned industries, demand growth has been weaker than expected, and thus electricity shortage has been alleviated, further dampening utilities' interest in pursuing energy conservation. In addition, current electricity tariff regulations in China do not provide for any mechanisms to allow utilities to profit from or recuperate costs of any demand-side management programs. However, there remain strong interests both in the central and local governments in pursuing energy conservation programs. And the recently enacted Energy Conservation Law should provide more impetus to establishing new conservation programs. An example could be a rebate program for high efficiency lighting equipment.

Another first cost reduction concept is to lease finance CFL purchases through local utilities or their affiliates. Utilities were in a unique market position to operate a compact fluorescent lamps (CFL) financing and distribution program, because monthly utility bills could be the vehicle for repayment of a leased CFL. In much of China, though, there are not monthly utility bills distributed, and the other systems that are in place for determining and paying bills are not conducive to the types of programs that have been developed elsewhere.[1]

The prospect of some type of CFL leasing or other financing program (outside of commercial sector), where the cost of the lamp is spread out over a period of time so that the consumer is saving more than the cost of lamp payments, will be difficult to implement as most Chinese seem unfamiliar and uncomfortable with installment sales. Unlike the US and other Western countries, where consumer financing is a widely accepted form of paying for purchases, in China consumers mostly purchase goods with full payment up front, with the exception of the nascent mortgage payment for housing.

[1] Utility payments are collected in a variety of channels. The discussion here is in no way a complete enumeration of all existing channels. Where housing is built on the premise of work units, the utility charges are often deducted from the wages directly. In other housing arrangements, the payment mechanisms are more complex. Some residents pay their individual accounts at dedicated bank or post offices. In apartments, a cooperative fashion is more common. For example, a group of households that share a common stairway would rotate the responsibility of collecting individual payments and then deposit such payments to a dedicated bank account at local bank branches. In certain new housing development, individual households pay the property management company or the developers, which in turn pay the utility company, while others pre-pay for a certain amount of electricity in an IC card, which fits into the special meters.

Much of the advertising campaign to date, and development of sales has focused on screw-in CFLs with permanently attached ballasts. While the public is generally aware of the energy saving potential of CFLs, little information are available to help the end-users to understand lighting quality issues in lighting retrofit as well as the economics of lighting retrofit. For example, the economics of modular CFLs, in which the lamp can be replaced at burnout, while the original ballast continues to function, appear to be significantly superior, and there should be efforts to promote the manufacture and awareness of these modular CFLs.

Another example of information need relates to lighting fixtures, which are a key part of the lighting efficiency equation. Inappropriate fixture installation and design could result in the loss of half of the light output, even though a high efficiency lighting source is used. Many of the CFLs in China have been installed in downlight fixtures where a large portion of the light produced is lost in the fixture itself, and/or not distributed to the intended area to be lit. There is a need to develop products that can better retrofit these existing downlight fixtures with reflectors to direct the light, and to have new downlight fixtures specifically designed for CFLs that make better use of the light produced.

The focus on CFLs in the last few years has meant that many other opportunities for the use of higher efficiency lighting products have been neglected. For example, HID light sources (such as metal halide) could be a significant source of energy savings in industrial lighting and outdoor lighting. There are new types of metal halide lamps that are probably better solutions for some of the applications where CFLs are presently being used. Thus, design applications guides should be developed to educate lighting designers and consumers about these more efficient options.

Despite the problems enumerated above, China's Green Lights Program still hold great potential for reducing energy consumption and green-house gas emission in the near future. The next stage of Green Lights initiatives should build upon the Program's initial success -- great visibility and manufacturing infrastructure for high efficiency lighting products, and address more specifically the problems – poor quality and high initial cost --discovered in the initial phase of the Program.

Quality assurance should be a top priority of future Green Lights initiatives. These should include issuing performance standards for high efficiency lighting products, implementing mandatory warranty programs to protect consumers, and developing an enforcement mechanism to penalize manufacturers that produce below-standard products.

Targeted information should be developed for specific market niches. Labels should be developed to help consumers differentiate products by their performances. Application guides should be developed to illustrate appropriate applications for different lighting technologies. Retrofit case studies should be distributed to educate end-users of the economic benefits of switching to high efficiency lighting products.

China's Green Lights Program should also initiate market transformation activities that will eventually lead to healthy market conditions for high efficiency lighting products. These could include a government purchase program that requires all government buildings adopt high efficiency lighting products from qualified manufacturers, and promoting various financing mechanism for commercial lighting retrofit project through standardized contracting protocols.

China Green Lights Project:
A Review and Recommendations

Introduction

The purpose of this review is to understand the current market condition for efficient lighting products and to investigate new mechanisms to increase the market penetration of such products. In this report, a review of the current development of China's Green Lights Program is provided, followed by a discussion of market conditions and competitive forces affecting China's lighting market. And finally, a variety of options that could help to transform the Chinese lighting market are elaborated for their applicability to Chinese market conditions.

China's Green Lights Program

China's Green Lights Program is one of the key national energy conservation programs initiated by the Chinese government for the ninth Five-Year Plan period (1996-2000). The State Economic and Trade Commission (SETC), in coordination with a host of other Chinese government agencies, is leading this effort through the Green Lights Program Office. The Program Office relies mainly on the Beijing Energy Efficiency Center (BEcon) and an external expert committee for technical support.

China's Green Lights Program is a very ambitious and comprehensive government effort, with multiple goals of saving energy, reducing carbon emission, alleviating shortage of electricity and avoiding costly investment in electric generating assets, and establishing environmental friendly industries. The Program hopes to achieve the adoption of 300 million units of high efficiency lights by 2000, 200 million compact fluorescent lamps (CFL) and 100 million thin-tube fluorescent T8 and T5 lamps (Zhou et al, 1997), respectively. Such an achievement would translate into electricity savings of 26.8 TWh and peak load savings of 7.2 GW. At such a rate, the avoided costs of building new generating assets would amount to 30 to 40 billion Yuan (US $3.6 to 4.8 billion).[2]

There would also be significant climate change benefits for the environment. It is estimated that 200,000 tons of sulfur and 7.4 million tons of carbon emissions will be avoided annually by 2000 (Zhou et al, 1997).

To achieve such ambitious targets, the Chinese Green Lights Program hopes to stimulate both the supply of and demand for high efficiency lighting products. On the supply side, the Program sets the target of 300 million high efficiency lamps by 2000. To this end, SETC has set aside a 500 millions yuan (US $60 million) low-interest loan and grants program to finance capacity expansion for manufacturing high efficiency lamps domestically. So far, approximately 150 million Yuan has been dispersed. To this date, there are nearly 1000 lighting manufacturers in China, compared to about 400 in 1993.

[2] One US dollar is equal to 8.3 Chinese Yuan, approximately.

Annual production of CFLs has grown from 38 million units in 1993 to 100 million units in 1997. In fact, the current capacity for making CFLs well exceeds the current production level of 100 million units per year. Unfortunately, the rush to build new capacity and the lack of product standards has caused serious quality deficiencies, which in turn dampens consumer demand.

On the demand side, the Chinese Green Lights Program initiated a public education and information dissemination campaign to raise consumers' awareness of the environmental, energy conservation, and economic benefits of high efficiency lighting products. It has also experimented with a variety of pilot programs to demonstrate such benefits. As a result, sales of CFLs within China have taken off since the start of the Green Lights Program. After a steady growth from 3 million CFLs sold in China in 1990 up to 9 million CFLs sold in 1995, sales soared to 15 million in 1996 and 37 million 1997 (reported in the newsletter of the International Association for Energy Efficient Lighting), the first two years of China's Green Lights Program.

The Chinese Green Lights Program has benefited from substantial support from the United Nations Development Program (UNDP). In particular, the support from UNDP enabled the Chinese Green Lights Program to access international expertise and to learn from the experience of other countries in promoting high efficiency lighting products. For example, three workshops on a variety of policy and technical topics were conducted in 1997.

In addition, the Chinese Green Lights Program has also sponsored development of standards for certain high efficiency products that will facilitate the improvement of product quality and provide the basis upon which product performance can be objectively measured.

Success and Challenges

To this date, the Chinese Green Lights Program has succeeded in raising consumers' awareness of and in increasing the domestic production capacity of high efficiency lighting products. The penetration of such products is extremely high in certain sectors. For example, in the newly built large shopping malls, high efficiency lights account for 90% of the installed lighting load in 1997.[3]

However, there are still significant barriers to widespread usage of high efficiency lighting equipment in China. Most notable among such barriers are high initial cost, poor quality, and lack of accurate information. Such problems are not unique to China. Even in more developed nations, CFLs have very low market penetration due to their high initial costs. In China, CFLs made by Chinese manufacturers cost typically 30 yuan and above, and those by foreign manufacturers (or their joint ventures) cost 70 to 130 yuan;

[3] See, "Green Lights Survey and Policy Recommendations for Large Shopping Malls in China," by Green Lights Office, Ministry of Domestic Trade, and China Coal Information Development Corporation, 1998.

while incandescent lamps cost about 1.5 yuan if made by Chinese manufacturers and 10 yuan if made by foreign manufacturers.

While quality issues such as lifetime and color rendering have been adequately dealt with in the developed nations, they remain major problems in China. For example, the lifetime for foreign/internationally-made CFLs tends to be above 8000 hours, the majority of the Chinese-made CFLs probably have lifetime less than 3000 hours, despite the claim to the contrary by many Chinese manufacturers.

Inspite of high public awareness of high efficiency lights in China, accurate information about the performance and quality characteristics of such lighting products is not easy to obtain. Thus, it is difficult for consumers to distinguish one product from another by their performance. There is also limited lighting education/design material available to help consumers make appropriate choices about lighting level and equipment. Further, there are few easy-to-read brochures or case studies on lighting retrofits to help consumers understand the economics of such retrofits.

Poor quality, high initial cost, and lack of accurate information are the most salient challenges facing the Chinese Green Lights Projects in the next phase. In the sections below, observations from a series of informal market surveys and visits to Chinese lighting manufacturers are discussed. Based on such observations, a multi-prong strategy to address market barriers to efficient lighting products in China is recommended.

Findings from informal market surveys

Market share: High efficiency lighting has a very high penetration rate in the commercial sector, while usage in the residential sector is still rare. In an informal survey of about ten retail shops and shopping malls in Beijing, it is observed that T8 thin-tube fluorescent lamps and compact fluorescent lamps dominated the lighting usage. In small to medium sized retail shops, lighting is typically provided byT8 lamps (the types of ballast are not known), with limited spotlight using incandescent lamps. In restaurants, compact fluorescent lamps in downlight fixtures dominate, except signs/display and outdoor lighting. In large shopping malls, T8 fluorescent lamps provide most of the ambient lighting, complimented by compact fluorescent, while incandescent lamps provide most of spot and flood lighting.

In hotels, incandescent lamps still dominate, though they are increasingly being replaced by compact fluorescent lamps in the lobby, hallway, and even in guest rooms. However, in government buildings, very few compact fluorescent lamps were installed. No doubt this is partly due to the budgetary constraints of government organizations. In addition, lighting usage seems to be very low in the traditional government office buildings: for example, many lights were not on even when offices were occupied, and daylight (in the summer days when the visits were conducted) seems to be the only light source. However, in the offices at many quasi-government institutions such as China Energy

Conservation Investment Corp. and Guangdong Yueneng Energy Science and Technology Company, lighting levels are comparable to that of commercial office buildings.
Market shares of lighting technologies in Shanghai and Guangzhou are similar to that seen in Beijing. However, lighting levels in new retail shops are noticeably higher in Shanghai and Guangzhou than those observed in Beijing. It is likely that such new shopping malls were built with foreign capital, and possibly designed by foreign architects. To the extent that such commercial buildings are likely to grow, the energy saving potential of adopting efficient lighting technology will grow as well.

Availability and Prices: in most department stores in Beijing, Shanghai, and Guangzhou, compact fluorescent lamps are available for sale. However, most of products on display are incandescent fixtures such as desk lamps and ceiling and wall fixtures for incandescent lamps. Small dimension fluorescent lamps such as circular lamps are also available, while 4-foot fluorescent lamps are less common. Domestically made compact fluorescent lamps typically cost 30 yuan and above, while those made by foreign manufacturers (Phillips and Panasonic are the most commonly seen foreign brands) cost between 70 to 130 yuans. The foreign-branded products usually have clear labels about products' lifetime, lumen output, and wattage, while labels on the Chinese products for the most part have only wattage information with lifetime noted on some products.

In a lighting specialty shop which serves mostly as a distributor (Shanghai Lighting General Store, just off Nanjing road), a wide range of indoor and outdoor lighting products are available, for example, incandescent decorative fixtures, outdoor fixtures with high-intensity discharge lamps, linear fluorescent lamps (mostly T8) and fixtures, and compact fluorescent lamps and downlight fixtures. This store is one of the first lighting stores which started a quality assurance program for its customers, typically guaranteeing the lifetime of compact fluorescent lamps up to 6 months for commercial users. Sales revenue comes mostly from wholesale (60 million-yuan in 1997) and installation contracts (20 million), with retail sales totaling 8 million-yuan in 1997. Among the product sales, lamps and fluorescent tubes are about 40% each, with balance coming from ballasts and other sales.

It is interesting to note the changes in merchandise distribution in China. The Shanghai Lighting General Store used to be one of the "first-level" distributors in China's old supply and distribution network (China Supply and Marketing Cooperative, which was later incorporated into the Ministry of Domestic Trade). It supplied goods and merchandises to over 20 provincial distributors in the past. In the 1980s, the Shanghai store was split from the old system and incorporated as an independent but state-owned corporation. It has gained freedom to represent and market lighting products of its choosing, but has lost its traditional distribution network in other provinces. Similar change occurred across China. Therefore, few companies have a national sales network, which makes it hard for any lighting manufacturers to gain dominant market position across China even though it might have superior products. Many Chinese lighting

manufacturers have started to build their own sales network, including the Bolitong in Shanghai and Huaming in Beijing. However, building a sale network is a costly and slow process.

One of the largest lighting markets in China is located in Guozhen, a small town two hours outside of Guangzhou. In the commercial district of Guozhen, there is nothing but lighting equipment shops, totaling over 300 vendors spread over the two main streets. Light fixtures, compact and linear fluorescent lamps, high-intensity lamps, and ballasts of all variety are sold there. Decorative fixtures for incandescent lamps, compact fluorescent lamps, and commercial light fixtures such as downlight and louvers seem to be the volume sales leaders. The most surprising finding was the low prices (from a sample of 15 vendors) for compact fluorescent lamps: most are selling for between 6 to 8 yuans (US $ 0.73 to 0.96).[4] There was only one exception: one shop was selling Phillips compact fluorescent lamps for 130 yuan. Although most vendors promise 3000 or more hours of lifetime, it is highly questionable that these compact fluorescent lamps (many made or assembled around Guozhen) could achieve such a lifetime target.

Of more critical importance is the fact that no vendors were able to sell their compact fluorescent lamps above US $1.00, due to fierce price competition among the vendors. There are two ramifications: first, quality products, which usually cost more (say around 30 yuan, or US $3.6), are pushed out of the market; and secondly, manufacturers who want to remain price competitive in this market have to cut their production costs so severely that the quality of their products is compromised. The result is a market flooded by poor quality and low cost compact fluorescent lamps, leading to a view that CFLs offer poor overall performance. And this is precisely the perception of many Chinese consumers on compact fluorescent lamps.

Chinese-made electronic ballasts for linear fluorescent lamps also have similar but less severe quality and cost problems. One shop owner in Guozhen suggested that he could supply a electronic ballast for a two-lamp fixture at an additional cost of 10 yuan (US $1.20) over a similar magnetic ballast, but would not recommend that switch due to reliability problems associated with domestically made electronic ballasts. It is interesting to note that some of the best electronic ballasts are manufactured in China today, mostly by foreign manufacturers and at a higher cost. The reliability problems with domestically made electronic ballasts are often associated with lower-end products.

China Green Lights Program Exhibition Center, located in the southwest corner of Beijing, was established by China's Green Lights Program to provide education and training on efficient lighting products, and to serve as a central point for exhibiting various efficient lighting products available in China. Currently, there are between 50 to 60 manufacturers renting exhibition space at the Center (which has about 1200 meters of exhibit space available), and most have staffs on site to provide detailed information about their products. The Center opened in October 1996, and several manufacturers have remodeled their exhibit space since then. There is no ongoing cost to China's Green

[4] Minimum quantity is 50 units for CFLs.

Lights Program Office for the operation of the Center; there are four shareholders that own the space and subsidize the operating costs when rent revenue falls short.

The Center provided an excellent opportunity to demonstrate the wide variety of efficient lighting products available in the domestic market. It was quite evident that there is an opportunity for significant promotion of modular (or "pin-base") CFLs, where lamps can be replaced while ballasts stay in place (as compared with screw in, or integral, CFLs, where ballasts are discarded when lamps fail). These modular lamps were exhibited with prices ranging from 6 yuan (less than US$0.75) for an 11-watt lamp, to 11 yuan (US $1.33) for a replacement 28-watt double D lamp (for which the lamp and ballast combination cost 40 yuan). Assuming that ballasts should last at least twice as long as lamps, the economics of the modular CFLs should be far superior to the screw-in CFLs which seemed more widely available.

Until recently no sales of lighting products were allowed at the Center. It appears that at first the Chinese Green Lights Program Office was uncertain about quality of the products exhibited there and thus would not want to lend the legitimacy of the Office to such products. Apparently this has just been changed due to strict screening of the manufacturers over the last two years, and manufacturers can now sell products. Prior to this change, however, the Center had only served as an information center.

Manufacturers' survey: at the China Green Lights Exhibition Center, several exhibiting manufacturers of CFLs claimed that their products could pass the quality test (generally 5000 hours of lifetime). In term of sales effort, one manufacturer felt that the government has not provided adequate promotion for efficient lighting products through mass media. He stated that people are looking for the government to recommend quality products, given the quality problem and confusing claims by numerous manufacturers. However, the reform-minded Chinese government has adamantly declined to provide recommendations in the name of fair competition and not interfering with the market! This manufacturer viewed the Center as a place to disseminate information about his products, and an opportunity to learn more about his competitors.

Another manufacturer (Sunlite, one of the largest CFL exporters in China) had on display a new line of T-5 linear fluorescent fixtures that they had introduced in April 1998. This company had produced 15 million CFLs (90% for export), and 30 million T8 and T5 linear fluorescent lamps in 1997. It had received an 80 million yuan (US $9.6 million) loan from SETC to upgrade its CFL production lines. It expect its domestic sales to rise to 30% of their total sales in 1998, mainly due to the economic slowdown throughout Asia, where its largest export markets have historically been. This manufacturer feels that it has been quite useful to have a presence at the Center, because numerous domestic and international delegations visit the Center every year and are exposed to their product lines.

A third manufacturer discussed how they have set up 120 retail outlets throughout Beijing, and 47% of their 1997 sales of 700,000 CFLs were made through these retail

outlets in Beijing and the area near their production facility in Northern China. This manufacturer said that his products have some of the highest prices and quality levels in China, but the present market conditions in China are chaotic: low quality products are flooding the market at very low prices, an unsustainable situation. He felt that it is difficult to enforce quality standards in China, because safety is not at stake.[5]

This manufacturer felt that there is an opportunity to promote CFLs through utilities in rural areas, where electricity prices are higher, voltage fluctuations are wider, and sometimes shortage of electricity still exists. He noted two different cases where the local utility worked together with the manufacturer to promote CFLs. One case was in Yuncheng prefecture in Shanxi province, where 100,000 CFLs were distributed through the utility. Another case was in Linyi prefecture, a remote mountainous area in Shandong province; before the Green Lights pilot project was implemented, the voltage was so low that the televisions would not work if the lights were turned on. After the utility cooperated with the manufacturer to promote CFLs in this area, the residents are now able to use both lights and televisions at the same time. He noted that these pilot projects have been successful where the manufacturer is local, and has good relationships with the local officials to make such programs work.

Established by the China Energy Conservation Investment Corp three years ago in support of China's Green Lights Program, Huaming Lighting Corporation in Beijing has become one of the largest lighting manufacturers in China, through aggressive acquisition. Its products include compact fluorescent lamps, ballast, and linear fluorescent lamps. It is looking to expand into fixture and luminaires as well. Huaming is focusing on the domestic market in the near future and is undertaking an ambitious effort to establish its own national sales network, to compensate for the lack of national scale distributors in China.

Bolitong Lighting Corporation in Shanghai is a reputable CFL manufacturer with a production capacity of 2 million units per year. Its production line is a mixture of automated equipment and workstations manned by skilled workers. Bolitong has invested significantly (buying and developing specialized machinery) in improving its production process in the last few years. As a result, the quality of its CFLs has improved substantially.

However, Bolitong is also affected by the ongoing economic crisis in Asia: 40% of its sales used to go to South Korea, but that market has since evaporated. Erosion in export market has forced Bolitong to explore Chinese domestic as well as other international markets. The president of Bolitong was pessimistic about the international market, however. The fierce competition among Chinese CFL manufacturers in the international markets has driven down the prices so much that it is hardly profitable to pursue international sales. He related his experience at the Hannover Exhibition in 1998: four groups of Chinese delegations representing some 60 Chinese manufacturers attended;

[5] All products have to pass mandatory safety tests before being introduced to market. However, product performance standards are typically voluntary, thus leaving government agencies little authority to control product quality issues, such as the lifetime and lumen outputs of CFLs.

international buyers were able to make Chinese manufacturers bid against each other and obtained sales prices as low as US $1.80 per CFL. In his opinion, this is shortsighted and self-destructive behavior, since at this pricing level, the quality of the product will be eventually compromised, and the reputation of Chinese-made CFLs will be destroyed. As a consequence, sales of Chinese-made CFLs will suffer.

Bolitong is taking a serious look at the domestic market, including building its own sales network. One measure to deal with the poor quality issue, suggested by the president of Bolitong, is to have either government or an industry association establish a floor in CFL prices, so that manufacturers have a decent chance to make quality products profitably. He also proposes that government agencies should do more to promote CFLs, particularly through rebate programs.[6]

Program survey: the **China Green Lights Program (CGLP)** has received substantial support from the United Nations Development Program (UNDP). UNDP's technical assistance to China Green Lights Program is led by Mr. Zhou Dadi and Ms. Yu Cong (both of the Beijing Energy Efficiency Center, BECon). The China Green Lights Program officially began in 1996. Under the leadership of the State Economic and Trade Commission (SETC), the China Green Lights Program Office (CGLPO) and Expert Team are set up, comprised of representatives from various relevant ministries, departments and institutes throughout China. In addition to the Central government Program offices, certain provinces have also set up parallel organizational structures to implement various activities to promote Green Lights technologies and applications.

The Green Lights Program Exhibition Center was opened in October 1996 as a source of education, information dissemination, and training regarding Green Lights technologies and programs. Approximately 50-60 manufacturers displayed efficient lighting products at the Exhibition Center, and over 150,000 people have visited the Center. It is estimated that products valued at over 10 million yuan have been sold there.

The CGLPO has worked with various experts inside and outside of China to develop standards for single-end fluorescent lamps and self-ballasted fluorescent lamps, and lighting design standards for hotels and shopping centers, two of the largest commercial lighting energy use market sectors. These standards went through a review process in early 1998, and it is expected that they will come into effect in late 1998. The CGLPO has also held several training workshops on the experience that other countries have had in promoting efficient lighting technologies, standards, and policies and programs.

CGLPO is very concerned about quality problems associated with domestically made compact fluorescent lamps (CFLs), and has launched two new initiatives to address the

[6] The idea of minimum pricing has not gained much momentum in China. However, China's Green Lights Program is interested in government purchase program where minimum performance/quality indices are specified and prices are determined through competition.

quality issue. CGLPO is working with a small group of CFL manufacturers that will guarantee the lifetime and quality of their products. These products will then have a special label or sticker affixed to the CFL by the sales agent at the retail outlet where the lamp is purchased, indicating the date of purchase. If the lamp fails within a specified period of time, the consumer can return the lamp to the retail outlet to be replaced, and the manufacturer will reimburse the retailer. CGLPO has also set up a general testing program for CFLs, in which initially the 60 largest manufacturers will have their products tested, and CGLPO will select the top performers from this group and publicly recognize the quality of their products. CGLPO is likely to help top performers market their products as well.

CGLPO has also held three international symposiums on Green Lights. Over 300 attendees participated in the three symposium, held in October 1996 (with general information on green lighting technologies and policies) and November 1997 (focused on electronic ballasts), and October, 1998 (focus on lighting fixtures and luminaires).

An important element in the development of Green Lighting manufacturing capability in China has been the provision of subsidized loans to manufacturers by SETC. During the past three years, over 150 million yuan (US $18 million) has been provided in the form of loans and grants by SETC to efficient lighting equipment manufacturers, much of it to CFL manufacturers to purchase automated production equipment. Unfortunately, owing to quality problems with some of the raw materials used in CFL production, many of the automated production lines have not been operating and are presently out of commission.

The success of the program was summed up by noting the change in the relative level of production of fluorescent lamps compared with general service incandescent lamps. In 1993, prior to any Green Lights promotion activity, approximately 8.9 incandescent lamps were made for each fluorescent lamp made. By 1996, the last year for which valid data are available, this ratio had dropped down to 5.6 incandescent lamps for each fluorescent. In 1996, around 100 million CFLs were produced in China; around 80% of these were exported out of China.

Professor Meng Zhaoli of **Tsinghua University** has served on the Expert Committee for China's Green Lights Program in the past three years, and is a recognized energy efficiency expert in China. Meng Zhaoli presented information from several small-scale surveys conducted for the CGLPO, demonstrating high penetrations of efficient lighting technologies in the commercial sector.

In another survey, about 200 households from four cities in China (Guangzhou, Suzhou, Dalian, and Beijing were interviewed. The consumers were asked about their opinions about efficient lighting and the Chinese Green Lights Program, their knowledge of available CFL products, and their electricity costs per month. The perceived importance of the Program was very high, and most people believed that CFLs provide good benefits, though a significant percentage expressed concerns about shorter-than-expected

lifetime of CFLs. The survey found that most families spend approximately 30 yuan (US$3.60) per month for their electricity.

The survey also collected data on the number of fixtures and types of lamps in different rooms, and also about other electrical equipment and appliance usage in an attempt to estimate the percentage of the electric bill that is lighting. While these data have not yet been compiled, it appears to be a rich data source for lighting usage patterns in Chinese households. However, the sample of this survey is not randomly drawn and many questionnaires were not completely filled out. Nonetheless, given the lack of data on lighting energy usage, it would be very valuable to compile the collected information into a computerized database for additional analysis.

Regarding quality problems with CFLs, he felt that if manufacturers did better testing before final packaging of their products, the quality and lifetimes would dramatically improve. He also spoke very highly of the newer helix designs of CFLs, saying that this type of design made it easier to solve some of the more troublesome design areas causing product failure: the tight bends of tubing, and the multiple tubing ends of the twin, tri- and quad-tube designs.

He mentioned that one manufacturer has established a novel warranty for its helix CFLs: for example, residential customers who bring back a failed CFL within the warranty period will be given two replacement CFLs. In part, this manufacturer is trying to use this warranty to expand its market share in China, after witnessing significant erosion in its export market.

Meng Zhaoli has also prepared a paper presenting the major barriers that prevent Chinese facilities from implementing demand-side management (DSM), and some proposed policy changes to address this. In sum, until quite recently the electric supply in China could not meet the growing demand. Owing to industrial production cutbacks resulting from the Asian economic crisis, Chinese electricity demand growth has slowed, and energy efficiency as a measure to alleviate capacity shortages is no longer necessary. He suggests some of the same policies that have been effective in North America to overcome these barriers, including separating profit levels from the volume of power sales, a profit-sharing mechanism where the utility could share some of the savings from energy efficiency upgrades, and incentives to reward utilities and customers for successful DSM activities.

A long discussion ensued about the viability of some type of CFL leasing or financing program in China. After many questions about what might make such a program attractive to Chinese consumers, it became evident that paying for anything over time is a very foreign concept, as Chinese cultural practice has always being to pay fully in cash. Consumers in China are just being offered mortgage plans to pay for their residence, loans or installment plans for major household appliance are still rare, so the idea of paying for something as small as a CFL over time is not appreciated much.

As an alternative, Meng Zhaoli returned to the prospect of Energy Management Company (or ESCo) providing CFLs to consumers, with payment in up to three installments, but more importantly, including some service guarantee such that the ESCo, and not the purchaser, would be responsible for all technical risks. The challenge will be how to get ESCos to focus on the residential lighting market when there are so many more lucrative opportunities in industrial energy efficiency improvements.

Beijing Huadu Chicken Farm

The Huadu Chicken Farm, located in the suburb of Beijing, has about 300,000 chickens producing eggs. It is the first large-scale chicken farm in Beijing, and has the highest technology and lowest operating cost of all chicken farms around Beijing. Since the mid 1980s, Huadu has undertaken three major modernization projects: new feeding systems, enhanced ventilation systems that reduced energy consumption by 50%, and beginning in 1994, retrofitting lighting with CFLs.

For their initial lighting retrofit projects, lighting management companies and CFL manufacturers financed the retrofits and were repaid out of savings. Because the management of the farm felt that they would have to pay a good deal more in terms of shared energy savings, they subsequently purchased the lighting equipment outright for most of remaining work. They find that the average lighting energy savings from retrofitting with CFLs is about 78%.

They had done experiments to see if there were any differences in productivity or quality of eggs under the new lighting, but found none. To date, about 20% of the chicken farms in the Beijing area have changed their lighting, with the majority being done since 1997. They expect that it will take a little longer for the chicken farms around Beijing to shift to a CFL based lighting system, because many farmers are still uncertain about the effect that CFLs might have on egg production.

In Shanghai, electricity prices are generally higher in Shanghai than in most Chinese cities. The average tariff is 0.67 yuan/kWh (US $0.081/kWh) for commercial users such as hotels and retail shops (with peak tariff at 1.0 yuan/kWh, US $0.12/kWh), and 0.65 yuan/kWh (US $0.078/kWh) for residential users. Interestingly, there are no multi-tiered tariff structures in Shanghai as in most of China.[7] Owing to rapid development of generating capacity and a shift toward a less energy-intensive economic structure, electricity supply in Shanghai roughly meets demand, though there is still a slight shortage of peak capacity. In fact, the Shanghai Municipal utility is finding ways to encourage electricity sales, in sharp contrast to just a few years ago.

Energy conservation efforts have been primarily encouraged through government mandate such as *Standard of Reasonable Electricity Consumption for Hotels* and

[7] The traditional tariff structure allows for lower prices under a "base load" and higher prices above the "base load," which is set according historical usage.

Lighting Electricity Usage Standard. The Energy Conservation Division of Shanghai Municipal Economic Commission also controls an energy conservation fund (about 20 million yuan) that makes low-interest loans to energy conservation retrofit projects and grants to public education campaigns. A recent example was a lighting retrofit project in an office building for China Electricity Daily. The energy conservation fund was collected from a utility surcharge on non-production-related air-conditioning usage, however, this surcharge has been discontinued several years ago.

The Energy Conservation Office of Shanghai Municipal Utility is applying for funding to set up a CFL rebate program in Shanghai. The expected rebate will be 10 yuan/CFL (about one third of the retail price) for residential customers, 2 yuan/CFL for commercial customers, and 5 yuan per electronic ballast for linear fluorescent lamps. Such rebates will be distributed through special retail outlets selected by the Shanghai utility and coupled with warranty programs.

A scheme of CFL leasing program managed by the utility or an affiliate was presented to the Energy Saving Office of Shanghai utility for feedback. The basic concept is to give residential customers "free" CFLs in return for a monthly surcharge on their electricity bills, with the surcharge lower than the expected electricity savings from replacing an incandescent bulb with a CFL. The utility will keep replacing the CFLs for customers whenever they fail, as long as the customers stay in the program and pay the monthly surcharges. This could be a win-win situation for consumers (getting positive cash flow) and the utility that could make a decent profit on such a leasing service, assuming that administrative costs were minimal.

However, the idea was not well received for a variety of reasons. In Shanghai, utility customers do receive bills, this is not true for most of China. However, bill collection and payment are comprised of a myriad of systems: a customer could pay its bill at a local bank branch or a local utility payment office, or pay someone in the neighborhood who serves as the collection agent. Collecting the CFL surcharges in the absence of full participation in the program presents an administrative challenge. It would be nearly impossible to track a utility customer who changes address in order to recover the remaining payment on the original CFL lease. In addition, utility bill and payment accounts have to be balanced monthly, and lease payment will present a serious problem for utility's accounting system. In general, people in China are uncomfortable with installment payment. And almost every purchase is paid in cash. China is introducing a mortgage system only for its nascent housing market. The prospect of making profits on CFL leasing program for residential customers seemed rather inconsequential to the utility compared to its regular revenue streams.

Guangdong Energy Conservation Technology Center and **Guangdong Yueneng Energy Science and Technology Corp**. are the dual identities of the same spin-off of the Energy Department of **Guangdong Provincial Economic**, the former serves as an NGO and the latter serves as an ESCO. Guangdong has traditionally had the highest electricity tariff in China, a status related to its high-growth economy and scarcity of

local fuel sources. As a consequence, energy conservation efforts began early. Currently, the average electricity tariff is over 1.0 yuan/kWh (US $0.12/kWh) for the commercial sector, over 0.80 yuan/kWh (US $0.096/kWh) for the industrial and government sector, and 0.65 yuan/kWh (US $0.078/kWh) for the residential sector.

A variety of standards for controlling electricity consumption have been put into place, such as standards for large electricity-consuming machinery, and regulations for large electricity users such as hotels and certain industrial users. In addition, energy efficiency standards have been issued for mass-market home appliances such as refrigerators, air conditioners, washing machines, and water heaters. Standards for CFLs and electronic ballast have also been developed to ensure quality. However, among some 200 local lighting manufacturers, many produce low-end products with questionable quality.

According to the Guangdong Energy Conservation Technology Center, quality problems associated with CFLs and electronic ballasts are mostly attributed to poor component quality, such as transistors and rare-earth material. The Guangdong Economic Commission intends to introduce an Energy Conservation Label for high quality lighting products. Government officials and manufacturers see such a label as a great marketing tool for quality products.

Recommendations

The successes of China's Green Lights Program are easy to identify: CFLs are widely available, and consumers are well aware of the energy saving benefits of CFLs. However, barriers to a vibrant market for efficient lighting products remain. Quality of Chinese-made CFLs, though improving, is still poor for the most part, despite that the technical capability of CFL manufacturing in China is improving.[8] Low-price and poor-quality CFLs continue to flood the market and undercut high-quality CFLs. The poor quality of CFLs and other "Green Lights" products creates a perception that "Green Lights" products save energy but are financially costly, a perception that seriously undermines CGLP's promotional effort. Quality CFLs will continue to have higher initial costs than incandescent lamps, although over the product's lifetime quality CFLs cost much less than the poor-quality ones. Thus consumer education in the future need to be more focused on the lifecycle cost. CGLP also needs to initiate financing programs to overcome the first cost barrier associated with CFL purchase. In addition, promotional effort should expand beyond CFLs and electronic ballasts to include other efficient light sources and lighting designs, and into commercial and industrial sectors where near-term opportunities are probably greater. Outlined below are a variety of policy options intended to address the remaining market barriers to efficient lighting products in China. They are grouped into three main categories: Information, Quality Assurance, and Market Transformation.

[8] An increasing number of Chinese manufacturers could make CFLs whose quality approaches international standard. In a recent quality test of CFLs available in China, the government has identified five manufacturers whose CFLs meet China's CFL performance standard (with a lifetime requirement of 5000 hours).

Information:

A common barrier to the penetration of newer and higher efficiency products is lack of objective and accurate information. Although much public education effort has been undertaken in the initial years of China's Green Lights Program, more *targeted* information needs to be provided to enhance consumers' understanding of the benefits and the appropriate applications of various efficient lighting products:

> **Label:** There are two types of labels: informational and endorsement. The *informational label* aims at providing accurate performance characteristics, so consumers can make an informed choice among different lighting products. One of the many complaints about CFLs in China is that consumers do not know which brand and type to choose, even if they decide to purchase CFLs. A *mandatory* informational label for all CFLs on sale in China could include key performance indices such as lifetime, total lumen output, watts, and color rendering index. Printed on the packaging, such information would enable consumers to distinguish among the variety of CFLs available on the market. However, such performance characteristics have to be certified by an independent testing laboratory accredited by the national authority and following standard testing procedures.
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> The *endorsement label* aims at identifying products that meet certain specified performance requirements. In the example of CFLs, such requirements could include a minimum rated lifetime (such as 5000 hours), minimum color rendering index, minimum efficacy (lumen/watt), and maximum total harmonic distortion (THD). The endorsement label goes one step further to help consumers identify best products, and is usually reserved for top performing products. For example, the Energy Star label in the US is issued usually for products in the top 25 percentile of efficiency range.[9]
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> **Purchase Guide:** there are a variety of high efficiency lighting products beyond compact fluorescent lamps that have great potential in reducing lighting energy consumption. These include electronic ballasts, HID lamps (such as metal halide and high pressure sodium lamps), thin-tube fluorescent lamps (mostly T8 and T5), lighting controls, and high reflectance fixtures. However, consumers in China may not be familiar with their appropriate applications. This is even true for CFLs. For example, most of downlight fixtures fitted with CFLs do not take into account the light distribution of CFLs; as a result most of the light is lost inside the fixture, rather than being directed to the space below. Most such fixtures do not have appropriate ventilation, further reducing the light output of CFLs due to overheating. In the majority of office space, linear fluorescent lamps are better at

[9] The State Economic and Trade Commission has established an Energy Conservation Products Certification Committee to undertake similar initiatives. Products that will be first considered by the Committee include CFLs and fluorescent lamps, and the certification process is expected to start in the near future.

providing ambient lighting than CFLs in downlight fixtures. Information brochures should be developed to help consumers choose better lighting installation for their specific applications.

Case Studies: the initial implementation of the World Bank funded Energy Conservation Project, which supports the establishment of three energy management companies in China, has many successful lighting efficiency upgrade projects. However, there are numerous potential customers for such upgrades, who are unaware of this innovative approach to financing lighting retrofits. Thus, case studies of the successful projects should be developed and widely distributed to potential customers. Such information has the potential to stimulate much higher demands for lighting retrofit projects.

Building Codes: in addition to the application guides, lighting design guidelines should be developed as part of building codes, which have been in development for some time. The Green Lights Program Office should work with agencies in charge of developing building codes to accelerate the section on lighting guidelines. Such stand-alone lighting guidelines have been implemented in some cities in China (Shanghai has published its own Lighting Energy Consumption Standard for Buildings, for example). Such lighting design guidelines for buildings could have great impact on energy consumption, given the vast scale of construction particularly in Chinese cities.

Market Survey: there is a strong need for better market data on the sales and use of lighting technologies and systems in China, given the wide range of lighting products available in China and lighting usage levels. Examples include better electricity end-use data by different sectors, which would help to target the market segments with the most potential for efficiency improvements; better market and sales data about the types of lighting equipment being manufactured and sold in China (including information about sales by product quality level); and better information about how lighting design and purchasing decisions are made. All of this information is critically important to optimize the efforts that can be performed with the limited resources available.

Technology: Much of the focus of the Green Lights promotion to date has been to increase the number of CFLs produced and sold in China. There are other technologies and lighting design options that hold as much, if not more, promise to reduce lighting energy consumption in China. These options include, but not limited to, better fixture/luminaires design (for maximizing the distribution of the light produced by the lamp in the fixture), widespread use of high-intensity discharge (HID) lamps such as metal halide, greater use of efficient linear fluorescent lighting fixtures with efficient ballasts that power more than one lamp, and the development of dedicated fixtures for CFLs.

Quality Assurance Program:

Standards: much of the quality problems of Chinese-made CFLs are due to the lack of national standards for such new products. The recently developed standard for CFLs will help to guide manufacturers to improve the quality of their products. Similar standards should be developed for other types of efficient lighting products as well. In addition, there should be minimum requirements for certain key performance indices such as lifetime, efficacy (lumen/watt), color rendering index, and power factor, to ensure a minimum level of quality.

Warranty: As part of market promotion programs for high efficiency lighting products, customary warranty requirements should be developed. The Chinese Green Lights Program Office is planning a similar activity.

Enforcement: any standards or quality requirement has to be backed up by a more rigorous enforcement scheme. The establishment of information labels would provide a good mechanism for monitoring product quality, since information on the label has to be certified by independent testing laboratories following national standards. A penalty should be established to discourage cheating and violation. Also, labels provide a mechanism for manufacturers to check on their competitors, thus reducing the monitoring and enforcement burden of government agencies.

Market Transformation Programs

The policy options outlined above are designed to reduce transaction costs by providing more information to potential consumers. The options recommended below are aimed at stimulating demand through volume purchasing and financing.

Mass purchase: the purpose of mass purchase programs is to reduce consumer costs by buying in volume. Larger users typically pay lower prices than retail customers. By bundling retail customers together, the mass purchase program will act as the purchasing agent for the group, and is likely to get better prices and warranties. The latter is very important in China, given the preponderance of low-quality lighting products. The lower prices and better warranties are likely to make efficient lighting products more attractive to consumers, thus increasing the demand for such products.

By incorporating technical specifications into the bid document, mass purchase programs could usually ensure a certain quality level – resulting in a level playing field for competing manufacturers. This will help to address the problem of competition on price alone, which tends to hurt quality and damage consumer confidence in the product – a complaint often voiced by government officials and top manufacturers in China.

The large volume of the purchase would also make such latent demand for quality high efficiency products more visible to the manufacturers, thus attracting manufacturers to compete at the high end of the market as well – effectively increasing the supply of the high quality products. By stimulating both demand and supply of high quality products, competitive market forces will lead to increased supply of high quality products at lower prices; lower prices in turn will continue to increase demand, thus breaking the vicious cycle of competing at the lower end of the market.

Government purchase: this is a subset of mass purchase programs discussed above. Governments around the world are typically the largest buyers of a variety of products, including light bulbs. In addition to the reasons discussed above, government should set an example for the average consumer in adopting more efficient lighting technologies, for both the environmental and economic benefits that such practices are likely to bring. The economic rationale could be particularly attractive to government agencies and organizations (including schools and hospitals for example) because of their tight budgetary constraints. There is little public information on the protocols of government procurement. An assessment of the political sensitivities and other barriers to a more open and transparent government purchase program would be very valuable.

Rebate program: a further step in the direction of reducing consumer costs and thus increasing demand for high efficiency lighting products is to initiate rebate programs for promoted products. Such programs have been popular with consumers as well as electricity utilities that typically sponsor such programs in other countries (e.g. Ilumex project in Mexico). The concept and the implementation are very simple, thus easily understood and accepted. And typically such rebate programs often incorporate features of mass purchase programs: that is, better prices and quality assurance.

Lighting Service Company/ESCO: energy service companies (ESCO) have been shown as an effective mechanism to finance lighting efficiency upgrades, both in China and elsewhere. The China EMC program supported by the World Bank and Global Environmental Facility has been very successful in its initial implementation. Expansion is recommended to other areas of China beyond the first three localities (Liaoning and Shandong Province, and the city of Beijing). The projects undertaken by the first three EMCs have been focused on larger commercial customers such as tourist hotels, large shopping malls, and chicken farms. However, there are many more small- and medium-sized commercial customers such as retail outlets and restaurants that are bypassed by the EMCs. These market segments represent the next potential targets for promoting the EMC model, possibly through dedicated lighting service companies.

Summary

The Chinese Green Lights Program has achieved a great deal in the first two years of its implementation. There is high public awareness of high efficiency lighting products and their energy saving potential. There are a wide variety of such products available to Chinese consumers. Both production and sales of high efficiency lighting equipment have increased tremendously in the past few years. There is a very high penetration of efficient lighting equipment in certain commercial sectors (for example, large shopping malls and hotels). However, much needs to be done to address the remaining barriers to widespread adoption of high-efficiency lighting equipment in China: higher first costs, poor product quality, and lack of accurate information on technology and financing options. The recommendations discussed in this review only highlight some of the options to be considered for the expansion of China's Green Lights Program.

List of Acronyms

CFL	Compact Fluorescent Lamps
CGLPO	China Green Lights Program Office
CGLP	China Green Lights Program
DSM	Demand Side Management
EMC	Energy Management Company
ESCO	Energy Services Company
HID	High Intensity Discharge
SETC	State Economic and Trade Commission
UNDP	United Nations Development Program