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China's Green Lights Program: A review and assessment

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ABSTRACT

Lighting accounts for 10–13% of China's electricity consumption. Triggered by the nationwide power shortage of the mid-1990s, the Chinese government launched its Green Lights Program in 1996. Since then, this program has been continuously highlighted in the nation's 9th–12th Five-Year Plans (1996–2015). This paper presents a review and assessment of this program during the past two decades. Based on available data, the achievements along with the implementation of this program are assessed by examining a set of indicators of electricity savings, consumer savings, market penetration, product quality, and production capacity expansion. The success of this programs can be attributed to several factors: 1) strong and sustained government commitment; 2) prioritized policy focus by program stages; 3) extensive efforts on product quality control; 4) a close symbiosis of energy efficiency policies with industrial development policies; and 5) the implementation of various incentive schemes. Nonetheless, several challenges are evident that the program needs to address in its next phase. These include: 1) promoting the use of efficient lighting products in rural China; 2) emphasizing the overall efficacy of lighting fixtures rather than focusing only on bulb efficacy; and 3) promoting the healthy development of an emerging semiconductor lighting industry in the nation.

1. Background

In the mid-1990s, China was facing a severe power shortage owing to its fast growing economy, population and standard of living. The need to build new power plants competed for insufficient government capital for infrastructure construction, putting significant pressure on the Chinese government (SETC, 1996; Guan et al., 1997; Lin, 1999). This context fostered strong incentives in the Chinese society at that time to seek energy efficiency improvements.

Lighting accounts for a quite stable share of about 10–13% of China's electricity consumption, and mostly represents peak demand (Lv and Lv, 2012; CNIS, 2011). Nonetheless, the absolute amount of lighting electricity use increased significantly over the past years along with China's fast economic growth. Fig. 1 shows a modeling projection of lighting demand in Chinese buildings, including residential, commercial and industrial buildings, till 2020 from a base year of 2002 (Liu, 2009). According to this projection, the lighting demand[1] in Chinese buildings in 2020 is projected to be about 2.2 times that in 2002. This implies an average annual growth rate of about 4.3%.

Inspired by a similar program initiated by the U.S. Environmental Protection Agency (EPA) in 1993, the Chinese central government launched its own 'Green Lights Program (GLP)' in 1996 as one of the key national energy efficiency activities of its 9th Five-Year Plan (FYP) (1996–2000). The FYP in China comprises the nation's chief social and economic development guideline for its five year implementation period.

China's GLP was initiated and led by the State Economic and Trade Commission (SETC) in coordination with some other Chinese central government agencies[2] (Liu, 2006). The program office was subsequently established, including a leader group, expert group and project office. Since then, this program has continued on through China's 10th, 11th, and 12th FYP as part of a key national campaign of energy efficiency improvement. The SETC was terminated in 2003 because of intuitional reforms of the government, and the lead responsibility for this program was subsequently assigned to the National Development and Reform Commission (NDRC).

As stated in the program launch document by the SETC (1996), the principal objectives of this program were to save electricity use in the nation and associated pollutant emissions, to slow down the rapidly rising investment needs for constructing new power generation

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[1] It is worth noting that the lighting demand in this projection is estimated in "lumen·hours" rather than in "kW h" of electricity consumption mainly because of uncertainties regarding the future development of emerging light-emitting diode (LED) lighting technologies.

[2] The involved central government agencies at that time included the State Planning Commission, Ministry of Science and Technology, Ministry of Information Industry, State Environmental Protection Administration, Ministry of Agriculture, and State Bureau of Quality and Technical Supervision.

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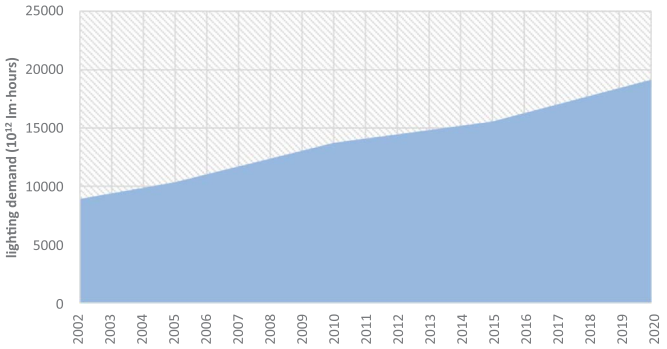

Fig. 1. Lighting demand in Chinese buildings 2002–2020. Source: based on Liu (2009).

3. Section 4 then summarizes the significant lessons learnt from this program, which can be referenced by other developing countries in designing similar programs. Section 5 provides concluding remarks.

2. Strategy changes of China's Green Lights Program by stages

Since its launch in 1996, China's 'Green Lights Program' has been implemented for two decades so far. Examining the changes in the program strategy, the progress of this program can be grouped sequentially in four stages: 1) Stage I (1996–1998) focused on raising the awareness of the general public on 'high-efficiency lighting products'; 2) Stage II (1999–2006) aimed to promote and regulate the quality of domestic lighting products; 3) Stage III (2007–2010) targeted expediting the diffusion of CFLs by means of financial and mandatory incentives; and 4) Stage IV (after 2010) started to shift the previous program priority from CFLs to emerging LED lighting technologies. A brief description of these four sequential stages of the program is presented below.

Table 1
Typical performance of various types of lamps.
Sources: based on U.S. DOE (2017, 2013), Aman et al. (2013), PNNL (2009), Liu (2009) and LRC-RPI (2002).

Lamp type	**Luminous efficacy** (lm/W)	**Color-rendering index (CRI)**	**Correlated color temperature (CCT)** (K)	**Lifetime** (hours)
Incandescent lamps (ILs)	15	95–100	2700–2800	1000
Compact fluorescent lamps (CFLs)	50–60	77–88	2700–6500	8000
High pressure mercury-vapor lamps	50	45	3300–4300	6000
Metal halide (MH) lamps	70–115	65–92	3000–4200	6000–30,000
High pressure sodium (HPS) lamps	100–140	23/60/85	1950/2200/2500	16,000–40,000
T12/T10 fluorescent lamps	70–80	65–80	2700–6500	15,000–18,000
T8 fluorescent lamps	80 – 90	75–90	2700–6500	20,000–24,000
T5 fluorescent lamps	95–105	75–90	2700–6500	18,000–20,000
LED lamps (present)	60–150	70–90	2700–6500	25,000–50,000

facilities, and to provide high-quality efficient lighting products to consumers. Along with the program's progress, expanding the manufacturing capacity of China's lighting industry for efficient products became an additional and important objective as well, although this was not explicitly indicated when the program was launched.

In practice, the core of this program aimed at replacing low-efficiency lighting lamps by so-called 'high-efficiency lighting products', including T8/T5 fluorescent tubes, compact fluorescent lamps (CFLs), and high pressure sodium (HPS) and metal halide (MH) lamps. The T8/T5 fluorescent tubes were used to replace T12/T10 tubes in large lighting areas of commercial and industrial buildings; CFLs were mainly for residential applications owing to their screw-in base design that is convenient for replacing incandescent lamps (ILs) in households; the HPS and MH lamps were primarily for outdoor lighting, such as road lights, and used to replace inefficient high pressure mercury-vapor lamps. A summary of the typical performance of these lamps is presented in Table 1.

Besides the use of the term 'high-efficiency lighting products', the term 'energy-saving lamps'[3] is also often used in the context of China's Green Lights Program. Technologically speaking, 'energy-saving lamps' represents only CFLs (Lv and Lv, 2012). It is also worth noting that the emerging LED lamps are not covered by either of the above two terms under this program, however both LED lamps and 'high-efficiency lighting products' are often called 'efficient lighting products' in Chinese literature.

In what follows, Section 2 presents a brief overview of this program with a focus on the changes in program strategy by stages. A program assessment based on a set of indicators regarding the main achievements and outstanding challenges of this program is included in Section

[3] In Chinese, 'high-efficiency lighting products' is referred to as 'Gao Xiao Zhao Ming Chan Pin', while 'energy-saving lamps' is referred to as 'Jie Neng Deng'.

2.1. Stage I - Raising public awareness about efficient lighting products (1996–1998)

Before the launch of this program, a household survey covering four regions from north to south China, namely Beijing, Suzhou, Dalian and Guangdong, was implemented to determine people's awareness and attitudes towards CFLs. The survey found that only about one-tenth of Chinese households at that time had ever used CFLs, and the popular public attitude to using CFLs was 'Saves Electricity but Not My Money' (Yu and Zhou, 2001).

The general public had little awareness of efficient lighting, and this was actually closely related to the reality of China's lighting industry and market in the mid-1990s. At that time, the production of 'high-efficiency lighting products' in China was in its very initial stage. Most Chinese producers were small-sized enterprises with poor manufacturing technology, such as manual assembly lines, and the industry was unable to provide consumers with high-quality products. Tables 2 and 3 shows that the 'high-efficiency lighting products' manufactured in China at that time lagged far behind similar international products, such as those manufactured by Philips and Osram, in performance.

In short, the Chinese lighting market in the mid-1990s was flooded by poor-quality lighting products mainly because of low manufacturing technology and the use of poor raw materials. Consequently, consumers at that time lost their confidence in efficient lighting, and had almost no incentive to buy CFLs.

To address this awareness barrier, the prioritized focus of China's GLP at this stage was, therefore, placed on raising public awareness of the benefits of applying efficient lamps. Various relevant publicity activities