

Study on Energy Efficiency Regulations and Standards for LED Lighting Products in China

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Abstract: This paper analyzes the energy saving certification system for LED lighting products, government procurement system for efficient lighting products, energy efficiency "Top Runner" system for lighting products and other energy efficiency policies and regulations in China; introduces the index system and main content of energy efficiency standards for LED lighting products in China, analyzes the implementation of energy efficiency labeling system for non-directional self-ballasted LED lamps, and provides recommended values for energy efficiency indexes of all grades; and puts forward the suggestions that the focus of energy efficiency standards for LED lighting products in China should be shifted from products to systems and a comprehensive evaluation system and technical standards for efficient, high-quality, green lighting products should be established.

1. Background

Under the background of global energy shortage currently, energy saving, emission reduction and green development have become the common concerns of countries in the world. According to statistics, global lighting accounts for about 20% of total power consumption while lighting in China accounts for about 14% of total power consumption. Therefore, lighting has always been the key area of energy conversation in China and the world. LED lighting as a new energy-saving green lighting product is featured with low energy consumption, high controllability, rich color, long service life and so on. Its development, application and promotion have been expanded constantly in recent years.

Therefore, making clear the energy efficiency policy context and implementation effect of LED lighting, comparing and analyzing performance indexes and test methods of various product energy efficiency standards, putting forward scientific, reasonable and targeted policy suggestions, improving the standard system and making key suggestions on standard formulation and revision are of great importance to promoting upgrading of LED lighting industry in China.

2. LED Lighting Energy Efficiency Policies in China

2.1 LED lighting policies in China

China launched the "LED lighting project" in 2003. In 2004, the Ministry of Science and Technology first approved 50 projects of "national LED lighting" to support LED industrial development greatly. In 2009, 5 ministries and commissions including National Development and Reform Commission released the *Opinions on the Development of LED Lighting Energy Saving Industry* requiring vigorous implementation of green lighting projects in various places. Then the Ministry of Science and Technology launched the pilot project of LED lighting application "Ten Cities with Ten Thousand



Lights". The National Development and Reform Commission, Ministry of Housing and Urban-Rural Development and Ministry of Transport organized and carried out the demonstration of multiple projects of LED lighting application in rooms, roads and tunnels.

The implementation of the energy saving policy *Roadmap for Phase-out of Incandescent Lamps* in 2011 started a new transformation age of replacing incandescent lamps and even CFLs with LED products. In 2011, the Comprehensive Work Plan on Energy Conservation and Emission Reduction for the 12th Five-Year Plan Period put forward green lighting and other key energy saving projects once again. In 2016, the Outline of the 13th Five-Year Plan put forward the requirement to carry out lighting system upgrading and transformation and other key projects, and the Comprehensive Work Plan on Energy Conservation and Emission Reduction for the 13th Five-Year Plan Period put forward the requirement to promote lighting system optimization and upgrading. In 2017, the *Development Plan for LED Lighting Industry in the 13th Five-Year Plan Period* made specific arrangements for advancing energy saving of LED lighting and guiding healthy and sustainable development of the industry.

Under the guidance of relevant policies, China has constantly increased the capability of developing and innovating in core technologies of LED lighting. LED lighting products have been growing rapidly and gradually becoming the mainstream lighting source.

2.2 Energy saving certification

Energy-saving product certification is a voluntary certification program for ensuring energy saving quality of products. For products with energy-saving product certification, certification marks can be used in energy-using products or their packages.

China has implemented energy saving certification for LED lighting products since 2011. Presently, energy saving certification covers the following products: LED road/tunnel lighting products, LED downlights, LED flat panel luminaires, self-ballasted LED reflector lamps, non-directional self-ballasted LED lamps for general lighting services and double-capped retrofit LED lamps. It is of great significance for regulating the market of LED lighting products in China, promoting the application and popularization of LED lighting products and enhancing energy saving awareness of the whole society.

2.3 Government procurement of efficient lighting products

China has implemented the government procurement system for efficient lighting products since January 2013, including 3 types of LED lighting products, i.e. LED lighting products for road / tunnel lighting, LED downlights and self-ballasted LED reflector lamps, into the government procurement list of energy-saving products and requiring government bodies at all levels to give priority to procurement of efficient lighting products, so as to promote energy saving and emission reduction through the exemplary role of government bodies.

Beijing, Guangdong, Shanxi and other places have been active in carrying out promotion and public bidding projects for efficient LED lighting products, and promoting the application of efficient LED lighting products in public institutions including schools and hospitals and large public buildings such as transportation and cultural venues.

2.4 Energy efficiency Top-Runner

Energy efficiency "Top Runner" refers to the product, enterprise or unit with the highest energy utilization efficiency within the range of comparable products, enterprises or units of the same type. Establish and carry out the energy efficiency "Top Runner" system for energy-using products, release the catalog of end-use products with the highest energy utilization efficiency and energy efficiency indexes on a regular basis, facilitate the establishment of a long-effect mechanism which promotes the energy efficiency improvement of end-use products and promote energy saving and emission reduction through benchmark establishment, policy incentives and standard improvement.

In December 2017, the National Development and Reform Commission released the *Implementation Rules for Energy Efficiency "Top Runner" System of Lighting Products*, setting up the energy efficiency "Top Runner" system for LED lamps for road and tunnel lighting. Products with the label of energy

efficiency "Top Runner" will be included in the government procurement list of energy-saving products and purchased preferentially. Energy efficiency "Top Runner" products will be used preferentially in fixed assets investment projects and energy saving transformation projects with central government investment in capital construction and government funds support.

3. Energy Efficiency Standards for LED Lighting in China

3.1 Significance and principles of formulating energy efficiency standards for LED lighting in China

As the foundation for carrying out energy efficiency management of end-use products, mandatory energy efficiency standards can provide a basis for implementing energy saving certification, energy efficiency labeling, fiscal subsidies and other energy saving policies of corresponding products. On the basis of being adapted to the development of efficient lighting technologies, the research of development of energy efficiency standards for LED lighting products will further increase energy utilization efficiency of lighting products, guide enterprises in energy saving technological progress, regulate the market of LED lighting products to ensure its healthy development, and enhance international competitiveness of Chinese efficient lighting products.

In China, energy efficiency of LED lighting products has 3 grades. Grade 1 means the highest energy efficiency, followed by Grade 2 and Grade 3 in turn. Phase out products with low energy efficiency by Grade 3 index, thus to promote energy efficiency improvement for low-efficiency products; expand the market share of energy-saving products by Grade 2 index; reinforce the leading role of ultra-efficient products by Grade 1 index, so as to drive further energy efficiency improvement of high-efficiency products. Achieve a benign cyclical rise at the same time of proper revision of energy efficiency standards, constantly promoting sustainable energy efficiency improvement of LED lighting products in China.

3.2 Technical index analysis of energy efficiency standards for LED lighting in China

China has formulated 13 national energy efficiency standards for lighting equipment successively since the development of the first energy efficiency standard concerning lighting equipment in 1999. GB30255-2013 *Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of Non-directional Self-ballasted LED Lamps* is the first national energy efficiency standard for LED lighting products issued and implemented by China. Currently, two national energy efficiency standards concerning LED luminaires for road / tunnel lighting and LED products for indoor lighting have been developed and reported to relevant authority for approval. So far, national energy efficiency standards for LED lighting products in China have covered the following products: LED luminaires for road / tunnel lighting, LED downlights, directional integrated LED lamps and non-directional self-ballasted LED lamps. Additionally, industrial, local and association energy efficiency standards have been formulated for 5 kinds of lighting products including LED road and tunnel lamps and exit marking LED lamps.

The energy efficiency index system for LED lighting products mainly includes luminous efficiency, correlated color temperature, color rendering index, lumen maintenance and other technical indexes. Table 1 shows main technical indexes in energy efficiency standards for LED lighting products which have been released in China.

Table 1. List and Scope of Energy Efficiency Standards for Semiconductor Lighting Products in China

Standard Title	Category	Color Rendering Index	Lumen Maintenance	Luminous Efficiency						
GB30255-2013 <i>Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of Non-directional Self-ballasted</i>	National Standard	--	Not less than the value calculated based on the claimed service life	Color code (correlated color temperature, color number)	Grade 1		Grade 2		Grade 3	
					Ominidirectional light distribution	Semispatial light distribution / Quasi-omnidirectional light distribution	Ominidirectional light distribution	Semispatial light distribution / Quasi-omnidirectional light distribution	Ominidirectional light distribution	Semispatial light distribution / Quasi-omnidirectional light distribution
				65/50/40	110	115	90	95	60	70

LED Lamps				35/30/27/P27	100	105	80	85	59	65
T/CECA-G0010-2016 Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of LED Luminaires for Tunnel Lighting	Associa-tion Standar-d	Not less than 70	Not less than 97% for 3000h; Not less than 94% for 6000h	CCT≤3500K	140		110		95	
				3500K<CCT≤5000K	150		120		100	
T/CECA-G0012-2016 Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of LED Luminaires for Road Lighting	Associa-tion Standar-d	Not less than 70	Not less than 97% for 3000h	CCT≤3500K	120		100		90	
				3500K<CCT≤5000K	125		105		95	
				5000K<CCT≤6500K	130		110		100	
DB-35T-1210-2011 Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of LED Lamps for Road Lighting	Local Standar-d	--	Not less than 96% for 3000h; Not less than 92% for 6000h	CCT≤3500K	85		75		65	
				3500K<CCT≤6500K	90		80		70	
SN/T 3326.5-2013 Technical Requirement-s for the Inspection of Lighting Appliances for Import and Export – Part 5: Energy Efficiency of LED Lamps	Industri-al Standar-d	Not less than 77	Not less than 92% for 3000h; Not less than 88% for 6000h	Imported self-ballasted LED lamps	RZ/RR/RL	1-5W	60	50	40	
					RB/RN/RD		55	45	35	
					RZ/RR/RL	6-25W	65	55	45	
					RB/RN/RD		60	50	40	
					RZ/RR/RL	≥26W	60	50	40	
					RB/RN/RD		55	45	35	
				LED lamps exported to the US	Requirements of Energy Star					
				LED lamps exported to the EU	Requirements of EU Energy Efficiency Directive					

3.3 Implementation of energy efficiency standards for LED lighting in China

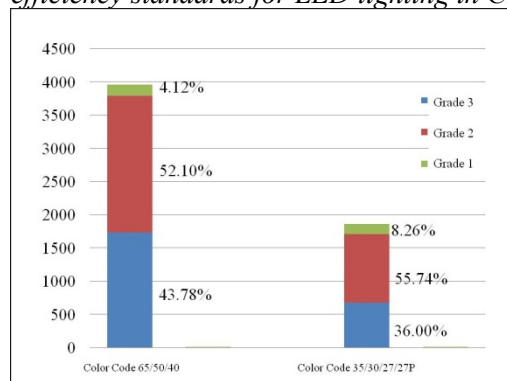


Figure 1. Proportion of non-directional self-ballasted LED lamps of each energy efficiency grade

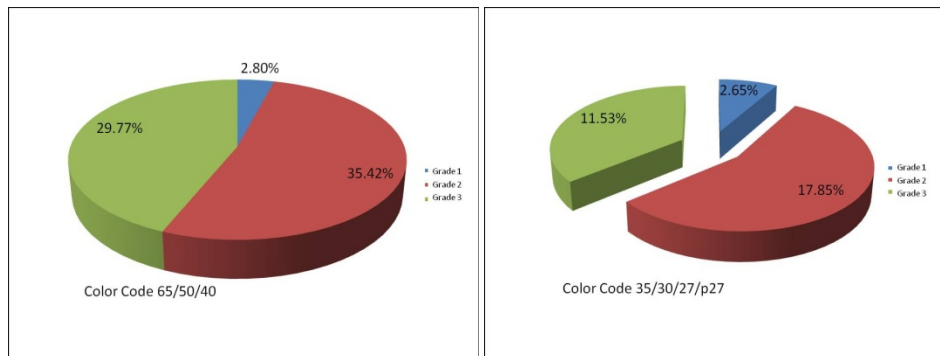
**Figure 2 (a)****Figure 2 (b)**

Figure 2. Proportion of non-directional self-ballasted LED lamps of each grade in all non-directional self-ballasted LED lamps with registered energy efficiency labels

The energy efficiency labeling system is a measure taken to implement and extend energy efficiency standards. It is an energy saving management measure universally taken by countries in the world. The data since the implementation of the energy efficiency label registration system for non-directional self-ballasted LED lamps are analyzed with the results shown in Figures 1 and 2. According to Figure 1, now products with Color Code 65/50/40 are the mainstream products in the market, accounting for about 70% of all registered products. Products with Color Code 35/30/27/p27 account for nearly 30% of the total. Among the products with Color Code 65/50/40, products of Grade 1, Grade 2 and Grade 3 account for 4.12%, 52.08% and 43.77% respectively. Among the products with Color Code 35/30/27/p27, products of Grade 1, Grade 2 and Grade 3 account for 8.26%, 55.74% and 36.00% respectively.

It can be seen that the energy efficiency of non-directional self-ballasted LED lamps has increased steadily over the 2 years. Products of Grade 2 above have become the mainstream products. The Grade 2 index in GB 30255-2012 has no longer been able to meet the requirement of "evaluating values of energy conservation". Thus, the implementation of the energy efficiency labeling system for non-directional self-ballasted LED lamps has played a very active role in enhancing the energy utilization efficiency of non-directional self-ballasted LED lamps and guiding enterprises in energy saving technological progress.

3.4 Formulation of energy efficiency standards for LED lighting products in China

In view of the division principle of energy efficiency grades in mandatory energy efficiency standards, it is recommended to revise energy efficiency indexes for non-directional self-ballasted LED lamps of all grades as shown in Table 2.

Tabel 2. Energy Efficiency Grades of Non-directional Self-ballasted LED Lamps

Type of Light Distribution	Rated Correlated Color Temperature (CCT) K	Luminous Efficiency lm/W		
		Grade 1	Grade 2	Grade 3
Ominidirectional light distribution	CCT<3500	105	85	60
	CCT≥3500	115	95	65
Semispatial light distribution / Quasi-ominidirectional light distribution	CCT<3500	110	90	70
	CCT≥3500	120	100	75

Re-divide the registered data of energy efficiency labels according to requirements of minimum allowable values of energy efficiency and energy efficiency grades for non-directional self-ballasted LED lamps. The results are shown in Figures 3 and 4.

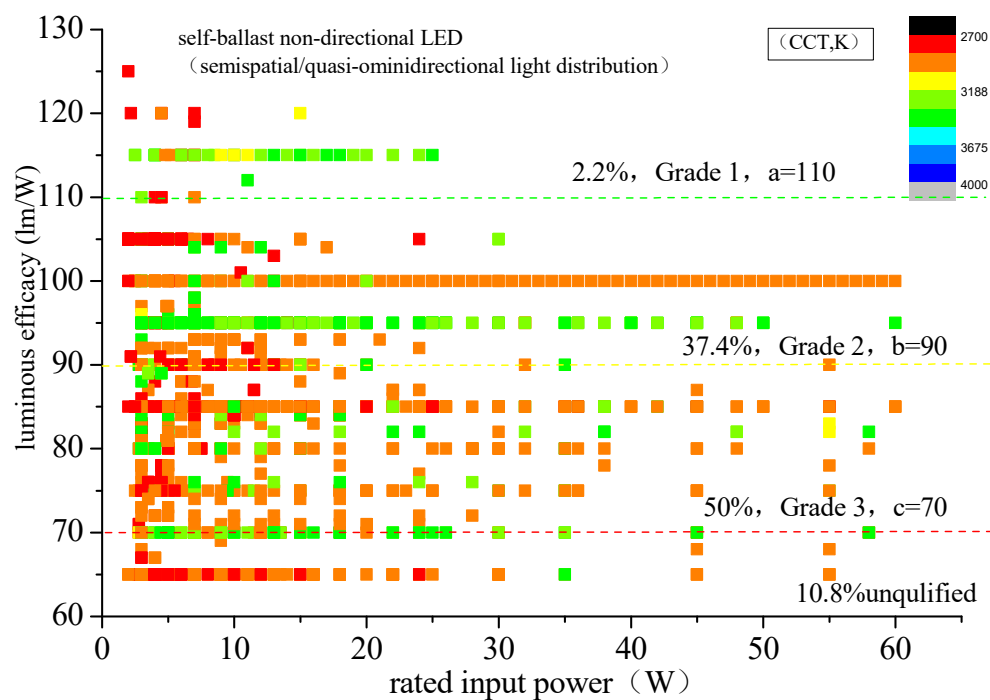


Figure 3. Luminous efficiency of non-directional self-ballasted LED lamps with semispatial light distribution / quasi-ominidirectional light distribution (CCT<3500K)

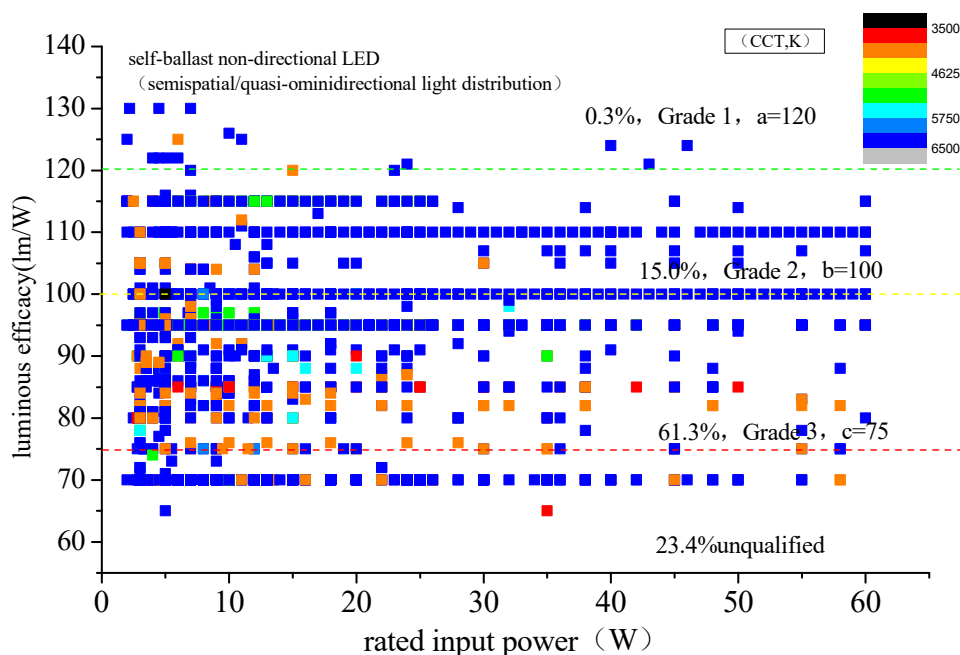


Figure 4. Energy efficiency grades of non-directional self-ballasted LED lamps with semispatial light distribution / quasi-omnidirectional light distribution (CCT \geq 3500K)

According to Figures 3 and 4, after the adjustment of energy efficiency grade indexes, among non-directional self-ballasted LED lamps with correlated color temperature of less than 3500K, products of Grade 1 account for about 2.2%; products of Grade 2 account for about 37.4%; products of Grade 3 account for about 50%; and about 10.8% of products should be phased out. Among non-directional self-ballasted LED lamps with correlated color temperature of 3500K at least, products of Grade 1 account for about 0.3%; products of Grade 2 account for about 15.0%; products of Grade 3 account for about 61.3%; and about 23.4% of products will be phased out if the energy efficiency labeling system is carried out according to the revised energy efficiency standards.

4. Suggestions on Development Direction of Energy Efficiency Standards for LED Lighting in China

(1) Shift from lighting products to lighting systems

As the application of lighting systems is related to environmental factors, installation factors and operation and maintenance methods of systems apart from the performance and energy efficiency of lighting products, comprehensive evaluation should be carried out. Due to the lack of scientific, reasonable and user-friendly evaluation standards of lighting system application effect, on-site system evaluation cannot be carried out. In many places, projects of energy saving transformation for lighting systems have failed to obtain desired results. The application effect cannot be guaranteed, and the potential for energy saving needs to be tapped. Therefore, it is recommended to shift the focus from equipment to systems for the development and implementation of energy saving standards in the lighting field in future. It is urgently needed to explore the establishment of a comprehensive evaluation index system and formulation of evaluation standards for the lighting system application effect.

(2) Comprehensive evaluation of efficient, high-quality, and green lighting products

With the enhancement of consumption ideas and increase in demands for lighting environment, both project users and common consumers have higher requirements for product quality. Currently, the luminous efficiency has been very high relative to traditional light sources. Though it can still be higher,

it is not the only focus. People have paid more attention to the improvement of light quality, and health, ecology and safety of light environment. For example, the health issues of light environment such as stroboflash and blue light hazards have received more and more attention. Therefore, it is recommended to establish a comprehensive evaluation index system for semiconductor lighting products which will cover energy, resources, environment and quality of products, and explore the establishment of technical standards for efficient, high-quality and green lighting products.

Acknowledgment

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Reference

- [1] GB30255-2013 *Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of Non-directional Self-ballasted LED Lamps*
- [2] T/CECA-G0010-2016 Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of LED Luminaires for Tunnel Lighting
- [3] T/CECA-G0012-2016 Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of LED Luminaires for Road Lighting
- [4] DB-35T-1210-2011 Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades of LED Lamps for Road Lighting
- [5] SN/T 3326.5-2013 Technical Requirements for the Inspection of Lighting Appliances for Import and Export – Part 5: Energy Efficiency of LED Lamps