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Journey of Energy Efficient Lighting Technology and Development of Energy Efficiency Requirements of Lighting Installation in Building Energy Code

Mr. George LIU Mr. L. C. SHEK Ms. S. F. LEE Mr. David LI
Electrical and Mechanical Services Department,
Government of the Hong Kong Special Administrative Region

ABSTRACT

Lighting is a critical component of every business operation and building indoor environmental quality. Occupiers must be able to see to perform their jobs, and objects and spaces must be safely and pleasantly lit to attract visitors flow. Depending on the type of business or building in operation, lighting accounts for some 15% of electricity consumption. This means that significant operating cost saving can be achieved with energy efficient lighting installations or retrofits, and due to continually improving equipment, energy efficient lighting normally provides reasonable return on investment in new installation or major upgrades.

This paper introduces (i) the journey of energy efficient lighting technology application and (ii) the development of energy efficiency requirements for buildings lighting installation under the Building Energy Code of the Buildings Energy Efficiency Ordinance (Cap. 610) (BEEO), taken by EMSD in promoting energy efficiency in lighting installation.

KEYWORDS: Lighting; LED; DALI; Building Energy Code; Lighting power density

1. INTRODUCTION

Invented in the 19th century, the electric light is one of the everyday conveniences that most affects our lives. Since then, incandescent light bulbs (ILB) have been used on a massive scale all over the world.

Lighting accounts for some 15% of the total electricity consumption in Hong Kong, and the enhancement of energy efficiency based on lighting technology is important in the combat of climate change. The way that lighting technologies have shaped the development in the design and use of lighting installations in our built environment in the past decades has clearly demonstrated how technology offers solutions for better energy efficiency. For example, compact fluorescent lamps (CFLs) have emerged since 1980s and are now suitable for direct replacement of the less energy efficient incandescent light bulbs (ILB) with luminous efficacy of only about 10 lumens per Watt which have been the basic lighting devices in homes for many years. Since 1990s, T5 fluorescent lighting has emerged and has now taken over the T8 fluorescent lighting as a proven and cost effective option for general lighting. The luminous efficacy of T5 fluorescent lamp exceeds 100 lumens per Watt. Nowadays, light emitting diode (LED) lighting is a new generation of lighting technology with luminous efficacy up to 90 lumens per Watt. LED is emerging to become one of the viable, green lighting solutions on the market, meeting our aspiration for lighting appliances energy efficiency and sustainability in the modern world.

Energy efficiency via the code approach was another area we tackled quite early on. In 1998 we launched the voluntary Energy Efficiency Registration Scheme for Buildings to encourage developers and building designers to comply with the energy efficient building design standards stipulated in the voluntary Building Energy Codes. Today building services installations of new construction or major retrofitting works in prescribed categories of buildings are governed by the Buildings Energy Efficiency Ordinance (BEEO) (Cap 610), covering lighting installation, air-conditioning installation, electrical installation, and lift and escalator installation. The BEEO is in full operation since 21 September 2012. The BEEO establishes energy efficiency standard of a building for its design and introduces means to evaluate its energy efficiency performance in operation. For building design, the Code of Practice for Energy Efficiency of Building Services Installation (BEC) governs the minimum design standards in respect of energy efficiency of its building services installations including lighting installation. The BEC is developed and issued by EMSD to cope with the enforcement of the BEEO. Serving to provide the guidance in the understanding of the BEC amidst the legislative background, a technical guidelines document on the BEC has also been developed and issued in Aug 2013 by EMSD.

Preceding and in parallel with the BEEO, EMSD has rolled out the Energy Efficiency Labelling Scheme for compact fluorescent lamp (mandatory), lamp electronic ballast (voluntary) and LED lamp (voluntary). We could pursue greener lighting for conserving energy and reducing greenhouse gas emissions. Taking another step further, we have launched the energy saving charter on the Restriction of Sale of Energy Inefficient Incandescent Light Bulbs (ILB).

2. ENERGY EFFICIENT LIGHTING TECHNOLOGY

Lighting is an indispensable part of modern city life. How to light up our city in an energy efficient way in line with the concept of sustainable development is a question that deserves much thought. Lighting affects the environment in a number of ways, including energy usage, and the materials used to produce lighting products. For example, energy efficient lighting demands less electricity, which reduces polluting power plant emissions.

One of ongoing pursuits for the Electrical and Mechanical Services Department (EMSD) is the exploration of the latest energy-efficient E&M technologies suitable for local applications. With almost two decades of experience in promoting energy efficiency and conservation in Hong Kong, Energy Efficiency Office (EEO) of EMSD has successfully promoted the application of a number of advanced energy efficient lighting technologies. Some of them have proved to be highly successful showcases for energy efficiency improvement opportunities, gaining wide acceptance by the public and the trade. Electronic ballast was the first type of lighting technology successfully introduced and promoted. Moreover, T5 fluorescent lamp was another important successful case. T5 technology has been increasingly adopted by the engineering profession, attracting the interests from both the manufacturers and users. Energy-efficient lighting technology in general has gained increasing popularity within the engineering profession following the success of our pilot projects, again attracting the interests of manufacturers and users. The rising market demand has further driven down product prices, making the technology even more accessible and attractive. It has become a norm for many major developers to specify the use of electronic ballasts and T5 tubes in new buildings. We have studied some energy efficient lighting technologies and published promotional pamphlets. We would like to share some lighting technologies listed below in the following paragraphs of this section.

- T5 fluorescent lamp
- Compact fluorescent lamp
- Electronic ballast
- LED lamp
- Digital Addressable Lighting Interface (DALI) lighting control system

The table below summarizes some key criteria for evaluating different lighting technologies.

Types of lamps	Luminous Efficacy (lumens per Watt)	Expected Lifetime (hours)	Color Rendering Index (CRI)
Incandescent lamps	10 – 17	750 – 2,500	98 – 100
Compact Fluorescent Lamp	50 – 70	6,000 – 10,000	70 – 90
Tubular Fluorescent Lamp (T5)	75 – 100	15,000 – 24,000	70 – 90
White LED lighting panels	60 – 90	25,000 – 50,000	70 – 90

2.1 Incandescent light bulb (ILB)

Incandescent light bulbs (ILB) have for many years been the most commonly used type of lighting. They work by heating an electric element (tungsten filament) to white hot. Incandescent lamps are the least energy efficient type of lighting, as 90% of the electricity consumed will be lost as heat whereas only 10% is used for lighting. Despite its prevalence, many incandescent lamps are currently being phased out of the market because they are so inefficient having regard to technological advancement and environmental concerns. Therefore, we have launched a charter scheme with suppliers and retailers to commit to stop selling the energy inefficient ILBs by the end of 2013, while stepping up our publicity efforts to educate the public and major lamp users on the benefits of using more energy efficient lamps such as compact fluorescent lamps (CFL).

To promote general awareness of the phasing out of ILBs, we have publicized the message through announcements in TV and radio, distribution of posters and publicity materials, and dedicated website. There is also a strong economic case for using more energy efficient lamps. For information, a typical household of 4 people could save up to $440 of electricity cost each year by using CFLs instead of ILBs.

2.2 T5 fluorescent lamp

Fluorescent lamps are operated with gas-discharge principle that uses electricity to excite mercury vapor. Electricity excites mercury atoms which then produces short-wave ultraviolet light which then causes a phosphor coating to fluoresce to produce visible light. Different types of phosphor emit different colour of light. By far the most common form of discharge lighting, fluorescent lamp is a developing technology and there have been many improvements in the performance of both tubular and CFLs in recent years.

T5 fluorescent lamps have improved efficiencies using electronic ballasts that offer high frequency output. They could save up to 80% of electricity compared to incandescent lamps and on average last 10 times longer or more. With the commonly used 1.2 metre long lamp, a T5 with electronic ballast saves 30% compared with a T8 fluorescent lamp fitted with electromagnetic ballast and saves about 15% compared with a T8 fluorescent lamp fitted with electronic ballast. T5 fluorescent lamps are by far the most widespread of all discharge lamp type used for general lighting nowadays. It is an efficient source, with typical efficacy around 100 lumens per Watt and typical lifetime of up to 24,000 hours.

2.3 Compact fluorescent lamp (CFL)

CFLs are compactly-designed fluorescent tubes with their ballast and gas-filled tubes assembled together. CFLs use

gases and phosphor inside the lamp to create visible light. The best of CFL is combining the energy efficiency of fluorescent lighting with the convenience and popularity of incandescent fixtures. CFLs save around 75% of electricity compared to incandescent lamps. They last up to 10,000 hours, which is 6 to 8 times longer than typical incandescent light bulbs. Thus allows them to be used in place of light bulbs.

To assist the public in choosing energy efficient appliances such as CFL, we have implemented the Mandatory Energy Efficiency Labelling Scheme (MEELS) via the Energy Efficiency (Labelling of Products) Ordinance (Cap. 598). The label is a grading type energy label from Grade 1 to Grade 5, with Grade 1 being the most energy efficient. For information, Grade 1 compact fluorescent lamps account for about 30% of total listed models of CFLs and save 14% of energy compared with Grade 3 lamps.

2.4 Electronic ballast for fluorescent lamp

In the early 1980s, advances in solid-state technology allow ballast manufacturers to replace the electromagnetic transformer with electronics components that operate lamps above 20 kHz, thus increasing luminous efficacy by about 10 % compared with 50Hz operation. As the solid state circuit of electronic ballast contains no copper windings, energy losses are reduced compared to conventional ballast. It generates less heat to the indoor space thus lowers the cooling load on air-conditioning.

All fluorescent lamps need a ballast to start them. Electronic ballasts start the fluorescent lamp more quickly, produce less flicker and make the lamp last longer. For fluorescent tubes, the ballast is separate and usually located in the light fitting. CFL ballasts are generally built into the lamp base. However, some CFLs have a separate tube and ballast. As the ballast is more expensive and lasts longer than the fluorescent tube, the tube is detachable and can be replaced when it fails.

Under the Voluntary Energy Efficiency Labelling Scheme (VEELS), the registered electronic ballast will bear a "Recognition Type" energy label which recognizes the product has met the minimum energy efficiency and performance requirements of the Scheme.

2.5 Light emitting diode (LED) lighting

Light Emitting Diodes (LEDs) provide a semi-conductor light source. LED lighting technology is rapidly developing in recent years, and the luminous efficacy of LED lighting is improving and catching up with the T5 fluorescent tubes for general lighting applications. They have longer life spans, do not contain mercury and operate at a very low (safety) voltage. They light up quickly and frequent switching does not reduce their life cycle. Colored LEDs are widely used commercially in exit signs, traffic signals, decorative light strings, or holiday lights, which can significantly reduce energy and maintenance costs. LEDs are highly regarded for their long life, energy efficiency, non-toxicity, and durability. Typical good quality LED lamps save 75% energy compared to incandescent bulbs and emit virtually no heat. They last up to 50,000 hours, which is 3 to 5 times as long as CFLs, and about 20 times longer than typical incandescent light bulbs.

LEDs have evolved into a major lighting technology that may change the future of general illumination. However, there is currently a wide range of claimed luminous efficacy levels on the market for LEDs and no widely agreed standard on how to measure the efficiency and light quality. The performance of some LED lamps is over-stated.

In order to promote the application and development of LED lighting technology, the Government launched a Voluntary Energy Efficiency Labelling Scheme (VEELS) for LED lamp in June 2011 after consulting the trade. The speed of LED technology advancement has been ahead of the pace of standardization. In the market, LED products have significant variation in performance from one product to the next. Therefore, in developing the requirements of LED lamp, we have made reference to the relevant international pre-standards, regional/national standards and energy performance requirements in the labelling schemes of other countries and have taken into account the market situation in Hong Kong. Some international lighting institutions and standardization bodies, such as CIE are actively working on performance standards for LED lighting. These standards will certainty help ensure the development of LED lighting products with more reliable and consistent lighting performance.

While its technology is still maturing and there is variation in quality of products on the market, we have been keeping up with the pace of lighting technology development and sparing no effort in actively promoting the use of energy efficient lighting in Hong Kong. To promote its applications, we have conducted trial installations of LED lighting in over 100 government venues and facilities such as museums, town halls, sport centres, schools and office buildings. LED lighting is also adopted in some public rental housing estates, street lighting and landscape lighting.

2.6 Energy Efficient Lighting Control

Energy-efficient lighting control based on a variety of technologies has been proven to reduce lighting energy consumption in commercial and industrial buildings by switching off the lighting when not needed. Examples of some common types of lighting controls include occupancy sensors, daylight sensors, time scheduling, bi-level switching, dimming technology, etc. In addition to traditional demand based control devices, the intelligent Digital and Addressable Lighting Interface (DALI) system has emerged since 2000s for smart control of lighting and related installations for an entire building. DALI is a digital communication standard (an addition to IEC60929) that guarantees the exchangeability of dimmable electronic ballasts from different manufacturers. It provides digital communication among intelligent components to achieve automatic dimming and switching control through photocell and occupancy sensors together with the simple wiring of

control lines, no separate conduit or trunking is needed. With the DALI, the lighting system in facilities can be designed to suit various dimming and functional requirements via building management systems.

3. SCOPE OF COVERAGE OF BEC under BEEO

3.1 Types of buildings

On the other hand, the BEC under the BEEO governs most types of buildings of both government and private sectors, including buildings for commercial (office, shopping complex etc.), hotel, municipal, community, education, hospital, railway station, airport passenger terminal usages, in respect of BEC compliance. For industrial building, residential building and composite building, the common area and the portion not for residential or industrial use are governed. Residential units are not governed, to avoid undue disturbance to the general public. Industrial units, which are normally compelled to remain in competitiveness through efficiency gains, are not governed, so as to avoid undue disturbance to industrial operations that may require specific energy inputs.

3.2 BEEO post-enactment buildings and BEEO pre-enactment buildings

The building services installations in a post-enactment building i.e. a building in respect of which a consent to the commencement of building works for superstructure construction is given after 21 September 2012, should comply with the requirements in the BEC, and the compliance should also be applicable to all subsequent retrofitting works irrespective of whether the works are regarded as major retrofitting works or not. As for a pre-enactment building, i.e. a building in respect of which a consent to the commencement of building works for superstructure construction is given on or before 21 September 2012, the BEC requirements have to be complied with only for major retrofitting works, which are defined in the BEEO.

3.3 Major retrofitting works

Major retrofitting works include addition or replacement of a building services installation in retrofitting works covering a floor area of aggregated 500 m^2 or above (under the same series of works within 12 months) in a common area or unit, or addition or replacement of a main component of central building services installations (including a chiller at rating 350 kW or above, or a complete electrical circuit at rating 400A or above, or motor drive and mechanical drive of a lift or escalator etc.).

4. COMPLIANCE HIERARCHY OF BEEO

The BEEO prescribes the responsibilities of the developer, owner or responsible person of a building or a unit of the building, and the Registered Energy Assessor (REA), involving the submissions and certifications to demonstrate the compliance with the BEEO at different stages of the building, from design to occupation approval and routine operation.

4.1 Compliance with BEC under BEEO

The BEC requirements are the energy efficiency standards at the corresponding design conditions, and not the actual operational settings such as lighting level, air-conditioning room temperature etc., which are left to the discretion of building operators to suit the operational needs of individual buildings and installations.

The developer of a building, at building design stage (within 2 months after obtaining the aforesaid consent to the commencement of building works issued by Hong Kong Government's Building Authority), is required to:

- submit to EMSD a "stage one declaration" certified by a REA to declare that the building services installations to be provided by the developer are designed and will be installed and completed in accordance with the BEC.

Subsequently at the occupation approval stage (within 4 months after obtaining of an "occupation permit" issued by the Building Authority when the building is ready for occupation), the developer is further required to:

- submit to EMSD a "stage two declaration" certified by a REA to declare that the building services installations provided by the developer in the building at or before the time when the declaration is made have been designed, installed and completed in accordance with the BEC and apply from EMSD a Certificate of Compliance Registration (COCR) for the building.

The declarations are to be in specified forms and be accompanied by supporting documents specified in the forms. Based on merits of the declarations, EMSD will issue accordingly the COCR to the developer and maintains a register of COCR.

During routine building operation of a post-enactment building, the owner of the central building services installation (usually the owner of the building) and the responsible person (usually the owner or tenant) of a unit or a common area in the building are required to ensure that when a building services installation (not falling under the scope of major retrofitting works) is repaired, replaced or added, its design complies with the standard in the BEC.

For all prescribed buildings, irrespective of post-enactment buildings or pre-enactment buildings, under the BEEO, the owner of the central building services installation in the building, and the responsible person (usually the owner or tenant) of a unit or a common area in the building, within 2 months after completion of major retrofitting works, are required to:

- engage a REA to certify that the replaced or additional installations in the major retrofitting works comply with the BEC; and
- obtain a Form of Compliance (FOC) for the major retrofitting works from the REA.

The aforesaid COCR for post-enactment building is subject to renewal every 10 years, and for the renewal the owner of the building is required to:

- engage a REA to certify that the design (but not the operational performance) in respect of energy efficiency of the central building services installation (no need to include installation only serving an individual unit) is maintained at a level not lower than the standard in the BEC version applicable to the COCR (issued by EMSD 10 years ago) of the building and, if a FOC has been issued for certain portion of the central building services installation, the design of the installation is maintained to a standard not lower than the BEC version applied in the latest FOC issued in respect of the installation; and
- submit application to EMSD for renewal of the COCR.

4.2 Registered Energy Assessor (REA)

The BEEO opens up a new role of professional engineer who upon appointment by the developer, owner or responsible person has the obligation to:

- certify the compliance with the BEC for application of COCR or issue of FOC;
- issue FOC to relevant owner or responsible person of a building or unit in a building;
- conduct energy audit and issue the Energy Audit Form and energy audit report to the building owner; and
- send a copy the FOC, Energy Audit Form and energy audit report to EMSD

EMSD maintains a register of the REA. The application as REA is opened up to Registered Professional Engineers (RPE) under the Engineers Registration Ordinance or corporate members of the Hong Kong Institution of Engineers (MHKIE), in electrical, mechanical, building services or environmental disciplines, who possess the knowledge and relevant post-qualification working experience, 2 years for RPE and 3 years for MHKIE, in the application of energy efficiency in buildings.

4.3 Penalties

Penalties will mainly be in the form of fine imposed on developers, building owners, responsible persons or REAs for non-compliance under the BEEO. Imprisonment penalty will only be applied to a person who is liable for obstructing an authorized officer in exercising the power under the BEEO or who provides any false or misleading information/document required under the BEEO.

5. BEC – ENERGY EFFICIENCY REQUIREMENTS FOR LIGHTING INSTALLATION

The BEEO and BEC define lighting installation as fixed electrical lighting system in the building including general lighting that provides a substantially uniform level of illumination throughout an area, or maintained type emergency lighting, but does not include non-maintained type emergency lighting. The BEEO is not applicable to the following lighting installations –

- exterior to a building such as façade lighting, outdoor lighting, lighting underneath canopy over a pavement;
- not of fixed type, and connected to power supply via flexible cable with plug and socket;
- integral to an equipment and with separate control; and
- integral to a signage; and
- solely used for illumination of an exhibit, decoration or visual production.

The detailed technical requirements for energy efficient design of lighting installations are set in the BEC with the purpose of reducing lighting power through imposing maximum allowable lighting power density (LPD) in a space, and reducing energy use through proper lighting control. LPD means the electrical power consumed (including loss in control gear, if any) by fixed lighting installations per unit internal floor area of an illuminated space.

5.1 LPD requirement

To reduce electrical power demand in a lighting space, the space should have its LPD not exceeding a maximum allowable value, unless the total electrical power consumed by the complete fixed lighting installation in the space does not exceed 100W. The maximum allowable LPD values are given in the BEC. The lighting power of the lighting installations not regarded as lighting installations to which BEEO is applicable may be excluded in the LPD calculation.

5.2 Lighting control requirement

The main purpose of the setting of lighting control point requirement is to allow adequate control points to switch off a certain zone of lighting not in use in order to achieve energy saving. In principal, besides conventional manual lighting switches, occupancy sensors or photo sensors may also be accepted as lighting control points provided that they can automatically switch off the target lighting when not in use.

Lighting control points for the lighting installations to which BEEO is applicable should be independent from those for the other lighting installations to which BEEO is not applicable, such that these two categories of lighting installation may be switched on/off independently.

For each functional activity in a multi-functional space, separate lighting control points should be provided to operate the luminaires for that activity, such that the operation of these luminaires should be independent of the operation of the luminaires not for the activity. A multi-functional space can usually be found in a hotel, where the space can be used at day time as a conference hall with illumination mainly relying on fluorescent lamps to suit the lower allowable LPD, and used as a banquet hall in the evening with luminaires at higher lighting power, to take credit of the higher allowable LPD for both general lighting

purpose and aesthetic purpose.

For an office space, the number of lighting control points should not be fewer than the corresponding value obtained using the formula tabulated in the BEC. For an office space with actual LPD lower than the corresponding value in the LPD Table, fewer no. of control points can be provided, the percentage reduction of which should not be more than the ratio given by the difference between allowable LPD and actual LPD to the allowable LPD.

5.3 Major retrofitting work

For major retrofitting work, the LPD requirement is to be followed only if the total circuit wattage of the additional or replacing luminaires in a works area not less than 500 m^2 is 3 kW or above, and for these luminaires the lighting control requirement is to be followed if the retrofitting area has no existing luminaires, or the sum of circuit wattage of additional or replacing luminaires is more than that of 50% of the original luminaires in the area.

6. DEVELOPMENT OF BEC

The BEC is developed by EMSD in collaboration with a Technical Taskforce with over 30 nos. representative organizations from professional institutes including the CIE(HK), trade associations, academia and Hong Kong Government departments. The broad and expertise representation is for purpose of maintaining a wide acceptability and upholding the credibility of the BEC contents. The BEC under BEEO is based on a set of codes (with similar contents to the BEC) issued in 2007 by EMSD for voluntary adoption by the private sector (Hong Kong Government buildings are administratively bound to comply though). In order not to incur an abrupt change, the uplifting of energy efficiency requirements in every new BEC edition are moderately in tandem with the journey of energy-efficient lighting technology and not drastically tightened. An example of tightening is the LPD for office space, which is adjusted from 25 W/m^2 in 1998, then 23 W/m^2 in 2005, 17 W/m^2 in 2007, and in 2012 to 15 W/m^2. The BEC has been finalised and the official copy had been published for the full implementation of the BEEO, with full text of the BEC available at the EMSD's website for the Ordinance.

7. CONTRIBUTIONS OF MANDATORY BEC APPROACH

It is estimated that buildings consume about 90% of the electricity in Hong Kong. As part and parcel of the impetus to high performance building design including lighting design, the Hong Kong Government with EMSD as the enforcing arm has taken forward a multi-pronged strategy to address to the barriers to energy efficiency gains. The strategic move involves a series of programmes ranging from setting of policy and demonstration of government commitment, dissemination of guidelines and best practices, encouragement and incentive schemes including funding provision, mandating the adoption of energy efficiency requirements through legislation, and publicity and public education. These programmes support and are complement to each other. It is anticipated that BEEO and the BEC will generate an energy saving of about 2,800 million kWh for post-enactment buildings in the first 10 years of implementation of the legislation, not to mention the saving from major retrofitting works in pre-enactment buildings. Facilitating the energy saving, the mandatory BEC is also characterized by the following contributions in addressing to the barriers to energy efficiency -

- coherent market force driving service providers to offer and consumers to use more energy efficient products & deliverables with performances over Government's mandatory standards and programs;
- pulling sub-standard designs (if mandatory standard not in place) to the level of the mandatory standard;
- removing the obstacle of split incentive where the energy saving from an energy efficient installation being only enjoyed by its user but not the owner who had paid for the installation;
- rendering more quality building services designs by qualified professionals, as only REAs can process certifications under the BEEO;
- stimulating wider promotion of energy efficient designs and products by service providers who would emphasize that their deliverables & products have performances over the mandatory standard;
- triggering paradigm shift of customers' expectations from service providers, from hoping to meet a certain level of energy efficiency to actually expecting as a norm a deliverable or product above the energy efficiency level specified in the mandatory standard; and
- arousing enhanced awareness on energy efficiency in the society and reinforcing & ascertaining Government's leading role in the pursue of energy efficiency : removing obstacles and paving the way for Government's promulgation of further energy efficiency programs for the society at large.

8. CONCLUSION

Energy efficient lighting technology and installation in Hong Kong has undergone much development over the past two decades. A simple indication of the development – we can see the commonality of CFLs and even LEDs nowadays for lighting in market stalls, as contrary to the dominance by ILBs some 20 years ago; another simple indication is that we can see the commonality of thin T5 fluorescent tubes nowadays in offices and commercial areas, as contrary to fat T12 tubes some 20 years ago. Thanks to the wide adoption of these technologies, the electricity consumption of lighting, based on statistics in EMSD's Hong Kong Energy End-use Data, has fallen from about 6,300 million kWh in year 2000 to about 5,246 million kWh in year 2010, representing about 16.7% reduction which is equivalent to about 738 thousand tonnes of carbon dioxide emission reduction.

However, we are still facing a critical climate change scenario, which must be taken into account in our pursuit of sustainable development. According to the same Energy End-use Data, the total electricity consumption in 2010

stood at about 41.9 billion kWh, of which about 12.5% was consumed by lighting installations. We need to continue to explore and use more energy efficient lighting products with a view to reducing our overall electricity consumption. To this end, LED, a fast developing lighting technology, and innovative energy efficient controls, have emerged to be some of the viable, green lighting solutions in the near future.

From the code perspective, today LPD requirement for office space in the BEC has been uplifted to 15 W/m^2 and become enforceable under BEEO, which is tightened up 40% comparing with the voluntary efficiency standard in 1998.

Contributing to the promotion of energy efficiency and conservation, EMSD has exercised much effort in its strategic programmes including the mandatory approach in recent years. As introduced above, the BEEO targets on the built-in loads in buildings, commercial in particular. Covering the key energy consuming equipment and appliances in both commercial and residential buildings, the mandatory approach will reinforce the roothold of the minimum energy performance standards in the relevant legislations and codes, and pave the way for future enhancement of the standards. With the mandatory mechanism in place, EMSD can review and tighten the standards at suitable time intervals, and the tightening will further trigger a new round of improvement.

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