

Regulatory Control of Energy Efficiency of Lighting Installations in Buildings

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ABSTRACT

With the new Buildings Energy Efficiency Ordinance (BEEO) enacted in late 2010, fixed electrical lighting installations in buildings will become one of the focusing items in energy conservation under the new legislation once its full operation becomes effective on 21 September 2012. The BEEO governs the energy efficiency standard of building services installations including lighting in prescribed types of buildings, requiring the compliance with the Building Energy Code (BEC) for new construction and major retrofitting works, and requires the conduction of energy audit for central building services installations including lighting in commercial buildings and commercial portions of composite buildings in accordance with the Energy Audit Code (EAC).

This paper introduces the requirements and standards of the BEEO and its codes, with brief highlights on the development and contribution of the mandatory approach and other related approaches taken by EMSD in promoting building energy efficiency, lighting installation in particular, in Hong Kong.

KEYWORDS: Lighting; Building Energy Code; Energy Audit Code; Lighting power density

1. INTRODUCTION

Building services installations which are governed under the BEEO includes lighting installation, air-conditioning installation, electrical installation, and lift and escalator installation. The core parts of the BEEO, Cap. 610, i.e. Parts 2 to 6 regarding the scope of application and the compliance hierarchy of the legislative requirements, are now within the grace period. 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 BEC governs the design standards in respect of energy efficiency of its building services installations, whereas for building operation, the EAC governs the steps in conducting energy audit of its central building services installation (which refers to the building services installation not solely serving an individual unit of the building). The BEC and the EAC are developed and issued by Electrical and Mechanical Services Department (EMSD) to cope with the enforcement of the BEEO. The BEC governs lighting installation amidst the other building services installations. The energy consumption of lighting installations over the past decade accounts for

about 15% on average of Hong Kong's total electricity consumption; the percentage energy consumption would even be larger when accounting for the energy consumption in removing the thermal load resulted from lighting in air-conditioned space. 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). Taking another step further, Environment Bureau (ENB) and EMSD have launched in mid Aug 2011 a 3-month public consultation on the Restriction of Sale of Energy-inefficient Incandescent Light Bulbs (ILB).

2. SCOPE OF COVERAGE OF BEEO

2.1 Types of buildings

The BEEO governs most types of buildings of both government and private sector, 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.

2.2 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.

2.3 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 m² 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.)

2.4 Energy audit

The BEEO governs commercial buildings and commercial portions of composite buildings, in respect of EAC compliance. An energy audit of the central building services installation in such a building is to be conducted once every 10 years in accordance with the steps specified in the EAC, and after the audit the building's energy utilization index (in Mega Joule/m²/annum) that reflects the building's energy intensity or energy performance is to be identified.

3. 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.

3.1 Compliance with BEC

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.

3.2 Energy Audit

The owner of a prescribed building must cause an energy audit to be carried out at least once every 10 years in respect of the central building services installations (not solely serving an individual unit) of the building in accordance with the EAC. The first energy audit for the central building services installations of a building issued with a COCR (i.e. a new building) is to be carried out within 10 years after the issuance of COCR.

For a pre-enactment building (i.e. an existing building), the first energy audit for the central building services

installations is to be carried out according to a timetable within 4 years from 21 September 2012 as specified in the BEEO. Energy audit will be conducted in batches according to the age of buildings, the newer the earlier. The philosophy is that a newer building will have more available information, such as energy bills, technical data of building services installations, design drawings, operational records etc., so as to allow for the trade a smoother run-in of the first mandatory energy audit.

The owner of the building is required to:

- engage a REA to conduct the energy audit for the central building services installation in the building;
- obtain an Energy Audit Form and an energy audit report (with listing and recommendations of energy management opportunities identified in the audit) from the REA; and
- exhibit the valid Energy Audit Form bearing the building's energy utilization index (EUI) in MJ/m²/annum at the main entrance of the building.

By the disclosure of the EUI, pressure may be exerted on building operators to improve the building's energy efficiency, as the building's energy performance can be easily compared with that of other similar buildings. As for the energy management opportunities (EMO), the building owners will not be mandatorily required to have them implemented, in consideration of the wide variety of EMO in terms of scope and cost. Nevertheless, the energy audit report with the needed information about the EMO, will be conducive to the implementation of part or all of these EMO, as the energy saving from EMO is itself a paramount incentive.

3.3 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.

3.4 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.

4. **BEC – 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 following lighting installations are not regarded as lighting installations to which BEEO is applicable –

- lighting installation exterior to a building such as façade lighting installation, outdoor lighting installation, and lighting installation underneath canopy over a pavement or road;
- lighting installation not of fixed type, and connected to power supply via flexible cable with plug and socket;
- lighting installation integral to an equipment or instrumentation that is not a luminaire and with separate control switch; and
- lighting installation integral to a signage; and
- lighting installation 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 controlgear, if any) by fixed lighting installations per unit internal floor area of an illuminated space.

4.1 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.

4.2 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.

4.3 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 m² 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.

5. **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 when compared with the 2007 codes, the requirements in the new BEC are moderately and not drastically tightened. An example of tightening is the

LPD for office space, which is adjusted from 17 to 15 W/m². The BEC is now in final stage of finalization and the official copy will be gazetted well before the full implementation of the BEEO.

6. **ENERGY EFFICIENCY LABELLING SCHEME – CFL, ELECTRONIC BALLAST AND LED LAMP**

6.1 Mandatory Energy Efficiency Labelling Scheme (MEELS) - CFL

Other than the BEEO, EMSD is also the enforcing authority of the Energy Efficiency (Labelling of Products) Ordinance, Cap. 598, which came into operation in Nov 2009. Under the Ordinance, a prescribed product being supplied by a manufacturer or importer shall be a listed model having a reference number assigned by EMSD and bear an energy label that complies with the specified requirements. The labeling scheme aims at saving energy by informing the public of the energy efficiency performance of the products, so that buyers can take these factors into consideration when making their purchasing decision. The MEELS currently covers 5 types of product including compact fluorescent lamp (CFL) and 4 types of household electrical appliances. For CFL, the label is a grading type energy label (Grade 1 to Grade 5), with Grade 1 being the most energy efficient. A CFL bearing the label shall conform with requirements on power consumption, lumen output, lumen maintenance, and life to 50% failure.

6.2 Voluntary Energy Efficiency Labelling Scheme (VEELS) – Electronic Ballast and LED Lamp

The MEELS above can be seen as an extension of the VEELS that commenced over 10 years ago. Currently the VEELS covers 19 types of household appliance and office equipment, including the electronic ballast and the LED lamp used in lighting installation. The attaining of energy label is on voluntary basis, and the labelled product shall comply with the energy efficiency requirements of the scheme. For electronic ballast, the product shall conform to the requirements of maximum allowable ballast-lamp circuit power.

LED has become one of the lighting sources of choice for general lighting applications. However, the use of LED in general lighting applications has only appeared in the past few years and the international standard for energy performance test of LED lamps is under development at present. In developing the requirements of LED lamp under VEELS, 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. It is noted that the testing of the claimed life of LED lamps will take years to complete, and in particular there is no available international testing method to accelerate the life test. Given the above limitations, the scheme only assesses the energy performance and life of the LED lamp up to 6,000 hours. The labelled product shall conform to the requirements on luminous efficacy, lumen maintenance, luminous flux,

correlated colour temperatures, general colour rendering index, power factor, power consumption, supply voltage switching, change of chromaticity, etc.

7. RESTRICTION OF SALE OF ENERGY-INEFFICIENT INCANDESCENT LIGHT BULBS (ILB)

ILB works by heating a tungsten filament with 90% of the consumed electricity lost as heat, and only 10% is used for lighting. Noteworthy for an air-conditioned space in summer time, the heat also poses as an air-conditioning load. Replacing ILB with more energy-efficient lighting products will achieve substantial savings in electricity consumption.

On 12 August 2011, Hong Kong Government's Environment Bureau in conjunction with EMSD have launched a three-month public consultation on the "Restriction of Sale of Energy-inefficient ILB".

In the consultation document, it is proposed to restrict the supply of non-reflector type ILB by phases through legislation, and the initial phase is to cover non-reflector type ILB that are 25 W or above, which operates at a single phase electricity supply of nominal voltage of 220 volts including general lighting service (GLS) lamps, candle-shaped, round-shaped and other decorative lamps, but excludes tungsten halogen lamps. In this initial phase, it is proposed that the supply of lamps that cannot meet a minimum energy performance standard (MEPS) will be prohibited, and the supply of lamps meeting the MEPS are to be governed by a registration system. The estimated electricity saving will amount to over 6% of the electricity consumption for lighting. The proposal also includes the suggestion of a grace period of 12 months to allow sufficient time for local manufacturers, importers and retailers to make adjustment to the market change.

The proposal has taken into account overseas experience and the availability of replacement options in Hong Kong. Currently, many countries and regions in the world including Australia, European Union, USA, South Korea etc. have implemented or planned for the phasing out of ILB. Most countries decided to phase out GLS lamps before phasing out other types of ILB. Regarding the local supply of substitutes, non-reflector type ILB can generally be replaced by more energy-efficient light bulbs (e.g. CFL, LED lamps, etc).

8. CONTRIBUTIONS OF MANDATORY 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. This paper mainly focuses on the mandatory option, and the strategic move is taken only after the other programmes have cultivated the preparations and the society at large has the preparedness for the mandatory option that will generate higher energy efficiency gains. It is estimated 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 and from EMO implementation in pre-enactment buildings. For the MEELS, the annual electricity saving is estimated to be about 175 million kWh, and the proposal on restriction of sale on energy-inefficient ILB can save up to 390 million kWh. (Hong Kong's electricity consumption in 2008 is about 40,900 million kWh.) Facilitating the energy saving, the mandatory option 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;
- encouraging EMO implementation based on findings in energy audits;
- 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.

9. CONCLUSION

Lighting installations in Hong Kong has undergone much development over the years. A simple indication of the development – we can see the commonality of CFL nowadays for lighting in market stalls, as contrary to the dominance by ILB some 15 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 or T10 tubes some 15 years ago. Contributing to the change, 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 commercial buildings, and the MEELS targets on the plugged-in loads, residential buildings 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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