New Baseline on Energy Efficiency of Electrical Installations for Low Carbon Development

Ir Dominic S.K. Lau, Senior Engineer; and
Ir David Li, Engineer
Electrical and Mechanical Services Department
Government of the Hong Kong Special Administrative Region

ABSTRACT: Taking a major step towards low carbon economy aiming at raising energy efficiency performance of buildings, the Buildings Energy Efficiency Ordinance (Cap 610) (Ordinance) came into full operation on 21 September 2012. The Ordinance governs energy efficiency standards of building services installations in buildings, requiring the compliance with the Building Energy Code (BEC) for new construction and major retrotitting works, and the conduction of energy audit for central building services installations in commercial buildings in accordance with the Energy Audit Code (EAC). This paper introduces the legislative framework of the Ordinance with brief highlights on the new baseline on energy efficiency standards on lighting and electrical installations as stipulated in the Codes, and in coupling with the wider use of innovative energy efficient devices and systems, the anticipated benefits that would be brought about.

I. INTRODUCTION

BEING an international metropolitan, Hong Kong (HK) is characterized by many high rise buildings to render the spaces needed for our work, living and recreation, and with these landscape buildings in HK account for a significant portion of our carbon footprint. Energy use has been globally identified as the culprit of climate change, and to this end HK buildings are a major energy consumer, notably consuming some 90% of HK's electricity. To combat climate change, the reduction of our buildings' carbon footprint would likely top our agenda in the years to come with aspiration towards a vision of low carbon development with state of the art energy efficient building designs that would generate green business opportunities for environmental industries and flourish a low carbon economy essential for sustainable development.

With this vision, the Electrical and Mechanical Services Department (EMSD) of the Government of HK Special Administrative Region (HKSAR) is tasked to promote building energy efficiency. Targeting at reducing building energy consumption, the Ordinance was enacted in late 2010 and comes into full operation with EMSD as the enforcing department on 21 Sep 2012. Building services installations which are governed under the Ordinance include lighting installation, air-conditioning installation, electrical installation, and lift and escalator installation. The Ordinance establishes the energy efficiency standards of a building for its design and introduces the means to evaluate its energy efficiency performance in operation. For building design, the BEC governs the design standards in respect of energy efficiency of building services installations, whereas for building operation, the EAC governs the steps in conducting energy audit of its central building services installations (which refer to the building services installations not solely serving an individual unit of the building).

II. SCOPE OF COVERAGE OF ORDINANCE

A. Types of buildings

The Ordinance governs most types of buildings in private and government sectors, including buildings for commercial (office, shopping complex etc.), hotel, municipal, community, education, hospital, railway station, airport passenger terminal usages etc., in respect of BEC compliance. For industrial buildings, residential buildings and composite buildings, 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.

B. Newly constructed buildings and existing buildings

The building services installations in a newly constructed 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 of the BEC. As for an existing 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.

C. Major retrofitting works

Major retrofitting works include the 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 a unit, or the addition or replacement of a main component of the 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).

D. Energy audit

The Ordinance requires energy audit to be carried out for the central building services installations of commercial buildings and commercial portions of composite buildings once every 10 years in accordance with the steps specified in the EAC. After the audit, the building's energy utilization index (EUI, in Mega Joule/m^2/annum) that reflects the building's energy intensity or energy performance is to be identified and exhibited.

III. COMPLIANCE HIERARCHY OF ORDINANCE

The Ordinance 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), with compliance hierarchy involving the submissions and certifications to demonstrate the compliance at different stages of the building, from design to occupation approval and during normal course of operation.

A. 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 the Building Authority of the HKSAR), is required to:

- submit to EMSD a "stage one declaration" certified by an 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 an 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 for a Certificate of Compliance Registration (COCR) from EMSD 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.

The aforesaid COCR for newly constructed buildings is subject to renewal every 10 years, and for the renewal the owner of the building is required to:

- engage an REA to certify that
  - the design (but not the operational performance) in respect of energy efficiency of the central building services installations (no need to include the 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 major retrofitting works have been undertaken for certain portions of the central building services installations, the design of the installation is maintained to a standard not lower than the latest BEC version applied to this part of the installation; and
- submit an application to EMSD for renewal of the COCR.

For all prescribed buildings under the Ordinance, irrespective of newly constructed or existing buildings, the owner of central building services installations in the building, and the responsible person of a unit or a common area in the building, within 2 months after completion of major retrofitting works, are required to:

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

In the course of operation of a building with COCR (i.e. a newly constructed building), the owner of the central building services installations (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 is replaced or added (even it is not major retrofitting works), its design shall comply with standards which are not lower than that applied in the original BEC for the installation.

B. Energy audit

The owner of a prescribed building must, in respect of the central building services installations of the building, cause an energy audit to be carried out in accordance with the EAC at least once every 10 years.

The first energy audit for the central building services installations of a building issued with a COCR (i.e. a newly constructed building) is to be carried out within 10 years after the issue of COCR.

For existing buildings, the first energy audit for the central building services installations is to be carried out according to the timetable within 4 years from 21 September 2012 as specified in Schedule 5 of the Ordinance.

The owner of the building is required to:

- engage an REA to conduct the energy audit;
- obtain from the REA an Energy Audit Form and an energy audit report (with recommendations of energy management opportunities (EMO) identified in the audit); and
- exhibit the valid Energy Audit Form bearing the building's EUI at the main entrance of the building.

By the disclosure of the EUI, it is expected a benchmarking effect will 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 EMO, the implementation will not be mandatory, in consideration of the wide variety of EMO in terms of scope and cost. Nevertheless, the REA's analysis and recommendations of the EMO in the energy audit report will be conducive to the implementation of part or all of these EMO, as the energy saving from EMO is itself a paramount incentive.

C. Registered Energy Assessor (REA)

The Ordinance opens up a new role of professional engineers who upon appointment by the developer, owner or responsible person have the obligation to:

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

D. Penalties

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

IV. ENERGY EFFICIENCY REQUIREMENTS OF LIGHTING AND ELECTRICAL INSTALLATIONS

In preparing the contents of the BEC, reference had been made to the development of energy efficiency technologies & products and good engineering practices in respect of design and operation of building services installations, both local and aboard. The building energy codes in other countries and Mainland China had also been referenced, which include ASHRAE 90.1 of USA, BCA 2010 of Australia, SS530 of Singapore, Approved Document L2A of UK, GB 50189 of Mainland China etc. With these references and the adjustments to suit local situations, it is aimed that the HK approach on building energy efficiency tallies with international practices. Locally, it is hoped that the mandatory BEC can, having its requirements above the average common norm, serve to pull up sub-standard designs, and by not entailing excessive cost in implementation, be widely acceptable to the stakeholders. The BEC requirements on lighting installation and electrical installation are summarized below for a quick appreciation.

A. Lighting Installation

- Max allowable lighting power density (LPD)
- Min allowable no. of lighting control points (i.e. switching devices) for office space
- Lighting control points for lighting to which the Ordinance is applicable to be independent from those for lighting to which the Ordinance is not applicable
- Not applicable to lighting exterior to building, lighting not of fixed type, signage lighting and lighting solely for decoration

B. Electrical Installation

- Allowable power distribution loss (e.g. max allowable circuit copper loss)
- Allowable motor efficiency
- Allowable motor sizing ratio (max 125%)
- Allowable design total power factor (min 0.85 for circuit at or above 400A)
- Allowable design total harmonic distortion of current (e.g. max 12% for designed circuit current at 400A to below 800A)
- Balancing of single-phase loads (max allowable unbalance 10%)
- Metering & monitoring facilities requirements (e.g. sub-main circuit at or above 400A to facilitate measuring V, A, kWh, kVA, TPF & THD)

The above requirements for lighting installations are set to reduce lighting power through imposing maximum allowable lighting power density in a lighting space, and to reduce energy use through proper lighting control. As

for electrical installations, the above requirements are set to achieve energy efficiency through both design and monitoring, design with the aim to select energy efficient components and monitoring with the aim to provide the information needed for better energy utilization and management. Whilst energy efficient design can minimize the various losses in the power distribution system such as due to iron losses, copper losses, phase current unbalance, harmonics, temperature rise etc., effective monitoring can enable the identification of possible power quality problems and the acquisition of energy consumption data for devising of methodologies for improvement and utilization management including energy audit.

Before the enactment of the new legislation, EMSD has a voluntary building energy code in 2007 with energy efficiency requirements on items similar to the BEC 2012. Comparisons of the standards on LPD and motor efficiency in the BEC 2012 with the voluntary code (2007) are given in Tables 1 and 2 below.

Table 1 – Comparison of LPD

Space type	Max allowable LPD (W/m^2)	
	Voluntary code (2007)	**BEC 2012**
Office	17 20 (drawing)	15 (tightened 18% on average)
Classroom / Lecture Theatre / Training Room	17	15 (tightened 12%)
Restaurant	23	20 (tightened 15%)
Retail	20	20
Atrium / Foyer with headroom over 5m	25	20 (tightened 20%)
Car Park	6	6
Conference / Seminar Room	18	16 (tightened 11%)
Corridor	12	10 (tightened 17%)
Exhibition Hall / Gallery	23	20 (tightened 14%)
Entrance Lobby	No	15 (new space)
Guest room in Hotel or Guesthouse	17	15 (tightened 12%)
Lift Lobby	No	12 (new space)
Loading & Unloading Area	No	11 (new space)
Plant Room / Machine Room / Switch Room	13	12 (tightened 8%)
Public Circulation Area	No	15 (new space)
Seating Area inside Theatre / Cinema / Auditorium / Concert Hall / Arena	25 16 (Arena)	12 (tightened 41% on average)
Staircase	8	8
Toilet / Washroom / Shower Room	13	13

Table 2 – Comparison of Motor Efficiency

Motor rating	Min allowable efficiency (single-speed 3-phase totally enclosed 4-pole)	
	Voluntary code (2007)	**BEC 2012**
1.1 to below 5.5 kW	76.2 – 84.2	81.4 – 86.6 (tightened 4.8% on average)
5.5 to below 7.5 kW	85.7	87.7 (tightened 2.3%)
7.5 to below 22 kW	87 – 90	88.7 – 91.2 (tightened 1.6% on average)
22 to below 55 kW	90.5 – 92.5	91.6 – 93.1 (tightened 0.9% on average)
55 to below 90 kW	93 – 93.6	93.5 – 94 (tightened 0.5% on average)
90 kW or above	93.9	94.2 – 95.1 (tightened 0.8% on average)

It can be seen from Table 1 that the LPD standard in the BEC 2012 under the Ordinance has much improvement over the 2007 voluntary standard. Nevertheless the 2012 standard is not as assertive as similar standards in ASHRAE 90.1 or BCA. A moderate level of stringency is set at the kick-in of the Ordinance, given the prevailing preference of HK's general public for a brighter environment, and that indoor spaces in buildings in HK, being a city crowded with tall buildings, have lower daylight penetration and have to rely more on compensation with electrical lighting.

For the motor efficiency standard in Table 2, the 2007 standard is tightened to the mandatory IE2 efficiency level of IEC60034-30 which is commonly adopted in Europe.

V. BENEFITS OF ORDINANCE

Energy efficient technologies are continuously introduced and adopted in HK irrespective of whether or not the Ordinance is in place, given the pursue of such technologies already being a worldwide trend to

counteract global warming. The Ordinance serves, however, as a catalyst to speed up the adoption of such technologies. The Ordinance first of all draws the attention of its various stakeholders, building owners, operators, designers, contractors, suppliers etc., on the minimum energy efficiency requirements and triggers the building up of the capacity of these stakeholders both on energy efficient technologies and the compliance hierarchy of the Ordinance. Of these stakeholders, while a few conservative ones would choose to move from not meeting to just meeting the minimum requirements, some assertive ones would go for standards above the bare minimums. In particular suppliers of energy efficient technologies would see the Ordinance as a green opportunity for them to promote products satisfying the minimum requirements and above all products with energy performances above the bare minimums.

The Ordinance having established the minimum requirements would pull up sub-standard designs to meet the minimum requirements, and at the same time generate a baseline against which assertive stakeholders could have their building designs benchmarked with the view to out-perform the minimum requirement.

In addition, the Ordinance having speeded up the adoption of energy efficient technologies also serves to cultivate the preparedness and capacity among the stakeholders for higher baseline standards, and based on the preparedness and capacity, EMSD may tighten at an opportune time the minimum requirements such as LPD and motor efficiency to achieve more energy saving.

VI. WAY FOWARD

Of the energy efficient technologies, studies have indicated that much energy saving can be achieved through building energy management system, BEMS in short. A BEMS is characterized by an information network through which a building's central control system supported with distributed localized controllers can communicate with the building's various energy-related components, the major energy consuming building services equipment in particular, in respect of energy management. Through the information network, the building operator's intention on how the building should operate, as reflected in the software programs input to the central control system and local controllers, is communicated to the modulation devices such as dampers, valves, on-off switches etc. of the building's various energy-related components, and likewise the feedbacks from the various sensing devices that monitor the relevant performance parameters such as levels of temperature, pressure, illumination etc. are communicated to the central control system and local controllers. Depending on the intelligence or capability of the central control system and its local controllers, these feedbacks are consolidated and analysed and constitute the base in commanding the modulation devices to respectively maintain the levels of performance or to effect the necessary changes for better energy performance. A BEMS with good logical control and supplemented with adequate and suitable sensing devices and modulating devices can harvest much energy saving through optimizing equipment operating hours, levels of operation, fresh air supply, operation temperatures etc. Adding to the benefit, software programs may be loaded to enable the logging of various operation parameters with the view to identify the more energy efficient modes of operating set points of time, illumination, temperature, pressure etc. based on the logged historical data. The requirements in the BEC of automatic control and energy metering of chillers and chiller plant, and of energy metering of electrical circuits can also be integrated in the BEMS. Needless to say, energy efficient lighting control can be integrated with the BEMS.

For lighting, the BEC has kicked off the requirement for an office space of adequate quantity of control points to switch off a certain zone of lighting when the zone is not in use in order to achieve energy saving. Apart from conventional manual lighting switches, smart controls such as occupancy sensors or photo sensors may be accepted as lighting control points in the BEC provided that they can automatically switch off the target lighting when not in use. Designers and suppliers may take the opportunity to promote these various smart lighting control technologies, which include multi-way switching that enables the occupant to control the lighting at more than one spot, photo sensor that turns off the lighting when sunlight is abundant, daylight sensor coupled with dimming that can gradually reduce the output from electric lighting when sunlight is gradually dominating, timer that can turn off the lighting at daytime, occupancy sensor that can turn off the lighting when there are no occupants, and digital lighting point control. Digital lighting control can interface with photo sensors, dimmers, timers and occupancy sensors etc. to effect different lighting scenes characterized by the different levels of illumination and grouping of operating luminaires to suit the different functions being performed in the lighting space. The integration of BEMS with digital lighting control offers more flexibility in the determination of the different lighting scenes, which constitute the "character" of the space in providing to its occupants its different functions.

EMSD will regularly review the minimum energy efficiency standards under the BEC with reference to the latest international standards and the advancement of relevant technologies. This is in line with the recommendation including the tightening of BEC standard, and the promotion of energy audit and BEMS made in the report of a public engagement on combating climate change published in 2012 by the Council for Sustainable Development of HK.

In respect of energy audit, the report also points out that it is believed that "what gets measured gets managed", and

that the audit will help to provide a baseline against which future performance can be benchmarked, and facilitate as a tool to identify measures to reduce energy consumption and associated costs. In addition, the data collected through the mandatory audit may help establish a benchmarking tool for buildings in HK.

VII. CONCLUSION

With the full implementation of the Ordinance to capture the above benefits, more energy efficient technologies would be introduced and adopted in HK to promote a low carbon economy. The mandatory approach will reinforce the roothold of the minimum energy efficiency standards in the BEC and the minimum energy audit requirements in the EAC, and pave the way for further enhancement of the standards. EMSD will review and tighten the standards at suitable time intervals, and the tightening will further trigger a new baseline of building services installations for low carbon development.

VIII. ACKNOWLEDGMENT

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