

Code of Practice for Building Energy Audit



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<u>Table of Contents</u>	<u>Page No.</u>
1. Introduction	1
2. Interpretations	1
3. Application	4
4. Technical Compliance with the Ordinance	4
5. Objectives of Energy Audit	5
6. Overview of Energy Audit	5
7. Energy Audit Requirements	5
8. Energy Audit Report	11
9. Energy Audit Form	13

1. Introduction

- 1.1 This Code of Practice titled “Code of Practice for Building Energy Audit”, hereinafter referred as the “Energy Audit Code” or “EAC”, is issued under Part 9 of the Buildings Energy Efficiency Ordinance, Chapter 610 (hereinafter referred as “the Ordinance”).
- 1.2 This EAC sets out the technical guidance and details in respect of the energy audit requirements governing the central building services installation under the Ordinance. Energy audits conducted in accordance with this EAC are deemed to have satisfied the relevant requirements of the Ordinance in the technical aspects.
- 1.3 This EAC is developed by the Electrical and Mechanical Services Department (EMSD) in conjunction with various professional institutions, trade associations, academia and government departments.
- 1.4 This EAC may be updated from time to time by appropriate notices to cope with technological advancement and prevalent trade practices, and the update will be publicized and given in the homepage of the Ordinance (<http://www.emsd.gov.hk/beeo>).

2. Interpretations

‘air-conditioning’ means the process of cooling, heating, dehumidification, humidification, air distribution or air purification.

‘air-conditioning system’ means the fixed equipment, distribution network and terminals that provide either collectively or individually the processes of cooling, dehumidification, heating, humidification, air distribution or air-purification or any other associated processes to a conditioned space.

‘air handling unit (AHU)’ means an equipment that includes a fan or blower, cooling and/or heating coils, and provisions for air filtering and condensate drain etc.

‘building services installation’ has the same meaning in the Ordinance, which means - (a) an air-conditioning installation; (b) an electrical installation; (c) a lift and escalator installation; or (d) a lighting installation.

'central building services installation' has the same meaning in the Ordinance, which means –

- (a) a building services installation in a prescribed building that does not solely serve a unit of that building; or
- (b) a building services installation in a prescribed building that has no common area except an installation that –
 - (i) solely serves a unit of that building; and
 - (ii) is owned by a person who is not the owner of that building.

<u>Examples of central building services installation</u>		
<u>Building</u> <u>Individual</u> <u>installation</u>	<u>Building with designated</u> <u>common area</u>	<u>Building without designated</u> <u>common area</u>
Lighting installation	located in the common area	located anywhere in that building unless it is in an individual unit and is separately owned by the responsible person of the unit who is not the owner of that building
Air-conditioning installation	not separately owned by the responsible person of an individual unit	located anywhere in that building, unless it is separately owned by the responsible person of an individual unit who is not the owner of that building
Electrical installation	on the incoming side of an electricity supplier's electricity meter for an individual unit	located anywhere in that building unless it is on the outgoing side of an electricity supplier's electricity meter for an individual unit with its responsible person not being the owner of that building
Lift and escalator installation	located in the common area, unless solely serving an individual unit	located anywhere in that building, unless it is solely serving an individual unit and is separately owned by the responsible person of that unit who is not the owner of that building

'chilled/heated water plant' means a system of chillers/heat pumps, with associated chilled/heated water pumps and if applicable associated condenser water pumps, cooling towers and/or radiators.

'chiller' means an air conditioning equipment that includes evaporator, compressor, condenser, and regulator controls, which serves to supply chilled water.

'conditioned floor area' means the internal floor area of a conditioned space.

'conditioned space' means a space within boundaries maintained to operate at desired temperature through cooling, heating, dehumidification or humidification, using means other than only natural or forced fan ventilation.

'Director' means the Director of Electrical and Mechanical Services.

'energy management opportunities (EMO)' means the ways to achieve energy efficiency and conservation.

'energy utilization index (EUI)', in relation to the total energy consumption of the central building services installations in a building, means dividing total energy consumption for a specific period by the total internal floor area of the building.

'internal floor area', in relation to a building, a space or a unit, means the floor area of all enclosed spaces measured to the internal faces of enclosing external and/or party walls.

'lighting power density (LPD) (unit : W/m²)' means the maximum circuit wattage consumed by fixed lighting installations per unit floor area of an illuminated space.

(In equation form, the definition of LPD is given by:

$$\text{LPD} = \frac{\text{Total circuit wattage of the fixed lighting installations}}{\text{Internal floor area of that space}}$$

, where the total circuit wattage should be taken at the full lighting output condition)

'luminaire' means a lighting device, which distributes light from a single lamp or a group of lamps; a luminaire should include controlgears if applicable, and all necessary components for fixing and mechanical protection of lamps.

'space' in the context of lighting installation means a region in a building that is illuminated by artificial lighting installation and is bounded by a physical floor, a physical ceiling and physical walls.

'unit' when not referring to dimensions (of length, area, volume, mass, time, power, energy etc.) has the same meaning in the Ordinance, which in relation to a building, means –

(a) a unit or a part of the building; or

(b) 2 or more units or parts of the building that are –

(i) occupied by the same occupier for the purpose of the same undertaking; and

(ii) interconnected by an internal corridor, internal staircase or other internal access;

but does not include a common area of the building.

'unitary air-conditioner' means an air conditioning equipment with one or more factory-made assemblies that includes evaporator, compressor, condenser, cooling or heating coil, air re-circulation fan section, and regulator controls, with single or multiple indoor units, which serves to supply cooled or heated air.

3. Application

3.1 Scope of Application

This EAC is applicable to energy audits carried out for the central building services installations in a building of a category prescribed in Schedule 4 of the Ordinance.

3.2 Limit of Scope of Application

This EAC is not applicable to –

- (a) the categories of buildings not prescribed in Schedule 4 of the Ordinance;
- (b) the categories of buildings specified in section 4 of the Ordinance; and
- (c) the categories of building services installations specified in Schedule 2 of the Ordinance.

4. Technical Compliance with the Ordinance

- 4.1 To satisfy the relevant requirements of the Ordinance, an energy audit should be conducted in accordance with this EAC for the central building services installations as a minimum in a prescribed building, save for exclusion or exemption under the Ordinance.
- 4.2 In the case of a composite building, the energy audit requirement specified in clause 4.1 should only be applicable to the central building services installation solely serving the commercial portions.
- 4.3 The building owners may, pursuant to section 25 of the Ordinance, apply to the Director in writing for an exemption of the relevant central building services installation from the requirement of carrying out energy audit under section 22(4) of the Ordinance if they consider that it is technically or operationally undesirable to carry out energy audit provided that the total rating of all the circuit protective devices (whichever are nearer the supply side) solely governing the electricity supply of the relevant central building services installation in a commercial building or the commercial portion of a composite building does not exceed 100A, 1-phase.
- 4.4 The Energy Audit Form, accompanied by the documents specified in the Form, should be submitted to the Director to demonstrate compliance with the energy audit requirements.

5. Objectives of Energy Audit

- 5.1 An energy audit involves the systematic review of the energy consuming equipment/systems in a building to identify energy management opportunities (EMO), which provides useful information for the building owner to decide on and implement the energy saving measures for environmental consideration and economic benefits.

6. Overview of Energy Audit

- 6.1 An energy audit commences with the collection and analysis of relevant information that may affect the energy consumption of the building, followed with the reviewing of the collected information, the analyzing of the conditions and performances of existing equipment, systems and installations, and the energy bills, and the comparing with performances at relevant energy efficient modes of operation, and finally the identification of areas of energy inefficiency and the means for improvement.
- 6.2 Energy audit can achieve energy efficiency and conservation through the implementation of EMO identified in the audit. EMO should be classified into three categories -
- (a) Category I – involving housekeeping measures which are improvements with practically no cost investment and no disruption to building operation;
 - (b) Category II – involving changes in operation measures with relatively low cost investment; and
 - (c) Category III – involving relatively higher capital cost investment to attain efficient use of energy.

7. Energy Audit Requirements

7.1 General

In conducting the energy audit, a checking of the energy consuming equipment/systems of the central building services installations should be carried out, followed with an evaluation of their operation characteristics and controlling parameters, leading to the identification of as many EMO as possible and their categorization. The following auditing steps should be followed.

7.2 **Step 1** – Collection of Building Information

Information on building operation characteristics and technical characteristics of various energy consuming equipment/systems relevant to the central building services installations should be collected. The essential information should include the following

-

- (a) record of EMO already implemented in the last 36-month or to be implemented, and corresponding energy audit report if available;
- (b) inventories of the energy consuming equipment, and manuals or technical brochures indicating their configurations and characteristics;
- (c) drawings and system schematics showing the layouts of the energy consuming equipment and systems, and drawings showing the layout of the building;
- (d) equipment day-to-day operation records, including room temperature settings and corresponding room temperatures, chilled water supply & return temperature settings and corresponding water temperatures, supply & return air temperature settings and corresponding air temperatures, building & equipment operation hours etc.;
- (e) energy consumption data in last 36-month or since operation of the building should such period be less than 36-month;
- (f) operation & maintenance programmes including timing of major alterations, additions or replacements for the building;
- (g) areas of relevant spaces attributing to the internal floor area of the building; and
- (h) total internal floor area of the building.

7.3 **Step 2** – Review of Energy Consuming Equipment

7.3.1 Study the information collected and conduct site inspections for an appreciation of the applicable energy consuming equipment and systems of the central building services installations. Based on the findings in the study and inspections, compile records of the characteristics of the energy consuming equipment and systems including -

- (a) types of air conditioning systems and their components;
- (b) types of chillers/variable refrigerant flow (VRF) systems and/or unitary air-conditioners, their capacity ratings and operating characteristics;
- (c) types of air handling units (AHU) and fans, their capacity ratings and operating characteristics;
- (d) types of air conditioning water pumps, their capacity ratings and operating characteristics;
- (e) types of luminaires, their ratings and operating characteristics;

- (f) utilization pattern of the areas served by the energy consuming equipment/systems (e.g. hours of operation, occupant density (quantity per m²), equipment in operation at different hours of the day and days of the year);
- (g) control mechanisms for various equipment/systems;
- (h) electrical power quality and metering provision;
- (i) types of lift and escalator installation, their capacity ratings, and operating characteristics;
- (j) energy consumption by charging facilities of electric vehicles through separated metering;
- (k) operating characteristics of other building services energy consuming equipment/systems e.g. plumbing & drainage (pump motors);
- (l) characteristics of the building affecting building energy consumption (e.g. external shading, shading coefficient of glazing); and
- (m) implementation progress and status of Energy Management Opportunities (EMOs) suggested in previous energy audit(s).

- 7.3.2 (a) Based on the operation records and equipment rated power consumptions, identify and calculate the power and energy consumptions of the building services energy consuming equipment/systems, including chillers, VRF systems, unitary air-conditioners, air handling units, fans and pumps, motors, lifts & escalators etc. The power and energy consumption values can be calculated based on available consumption values shown in technical brochures with adjustments to suit the actual operating conditions such as operation hours reflected in the operation records.
- (b) Should the operation records and equipment rated power consumptions not be able to provide the information or not be available, take measurements, at representative instants that can reflect the operation conditions and at appropriate time intervals, of the power inputs and/or energy consumptions, or take measurements of parameters such as flow and temperature difference from which the power or energy can be calculated. The methodology of the measurement should be properly described and recorded in the energy audit report.
- (c) Should the operation records and equipment rated power consumptions are considered not of the level of adequacy in reflecting the actual operating conditions of the building services energy consumption equipment/systems, the approach as mentioned in (b) above by taking measurement and calculation should be applicable. The due considerations of taking such approach should be properly elaborated in the energy audit report. The operation records and equipment rated power consumptions available should be properly documented in the energy audit report as reference.
- (d) Based on any in-situ metering facilities or BMS available data, identify and calculate the energy efficiency of the chiller with cooling capacity of 350kW or above. The

energy efficiency values can be calculated based on the data collected by existing monitoring equipment such as temperature sensor, flow meter, energy meter etc.

- (e) Based on any in-situ metering facilities or BMS available data, identify and calculate the total power factor and total harmonic distortion for the electrical circuits.
- (f) External metering for the measurements should be used in case of an inadequacy of in-situ metering facilities for the necessary measurements in (b) and (c) above.

7.4 Step 3 – Identification of EMO

7.4.1 Based on the findings in clause 7.3, an evaluation and appraisal should be conducted on the energy consuming equipment/systems, focusing on their energy performances against their corresponding operating conditions and EMO(s) implemented in respect of previous energy audit(s), including but not limiting to -

- (a) chiller/heat pump energy consumption (kWh per annum);
- (b) VRF system (kWh per annum);
- (c) air distribution system (e.g. primary air handling unit (PAHU) and typical AHU, car park ventilation) - fan power consumption (W per litre/s);
- (d) water distribution system – pump power consumption (W per litre/s);
- (e) lighting power density (W/m²);
- (f) energy performance of other equipment/systems;
- (g) energy performance of the EMO(s) implemented in respect of previous energy audit(s); and
- (h) EUI of the building.

7.4.2 A comparison with original design with due consideration of relevant operating conditions should be conducted to identify any deviations from efficient operation and to identify accordingly the potential EMO for improving energy efficiency. The energy performances of energy consuming equipment/systems, in association with applicable operating conditions and system configurations, can be referenced to codes, guidelines and practices of international standards (such as ASHRAE, CIBSE) or established local standards or trade good practices, for identification of potential EMOs.

7.4.3 The findings may also identify certain potential EMO contributing to the reduction of energy consumption of the central building services installations through improving the behaviours of responsible persons of units outside the common area, an example being the adjustment of operating hours of air handling units operated by these responsible persons. These potential EMOs may be recorded and conveyed to the relevant responsible persons for follow-up or further study.

7.4.4 Study and state the viability of –

- (a) replacing the energy consuming equipment/systems with more efficient models or configuration or the addition of equipment/systems;
- (b) exploring more efficient means to operate the existing energy consuming equipment/systems;
- (c) deploying energy recovery system(s); and
- (d) applying on-site renewable energy system(s).

7.4.5 Illustrate the results of the site inspections in respect of identifying obvious opportunities for energy saving, including but not limited to –

- (a) good operating condition of equipment through proper maintenance works including repairing or replacing deteriorated equipment or system component e.g. damaged insulation, leaking pipework or ductwork etc.;
- (b) avoid excessive provisions on space temperature, lighting level and volume flow etc.;
- (c) introduce occupants' behaviour change including switching off light or equipment once not in use; and
- (d) match equipment operating schedule and set point with the operation requirement of the served areas.

7.4.6 Based on the energy consumption pattern of the equipment and system consolidated in Step 2 prescribed in Clause 7.3, identify EMO in respect of –

- (a) enhancement of automatic control including modification / supplementing of control algorithm and associated control set point / control parameter to increase the equipment and system operating efficiency;
- (b) system balancing to achieve distribution of media (air / water) as desired; and
- (c) optimization of matching between equipment capacity / plant configuration and system load profile.

7.5 **Step 4** - Cost Benefit Analysis of EMO

7.5.1 For each potential EMO identified for the central building services installations, an estimate should be made on the energy saving that can be achieved if the EMO is implemented. For Cat II and Cat III EMO in which capital cost is involved, a cost benefit analysis should be carried out, giving an estimate of the cost for the EMO against its estimated energy saving.

7.5.2 The energy saving should be determined by comparing the measured energy use or the collected energy use under clause 7.3 before implementation of each potential EMO and the estimated energy use after implementation of each potential EMO.

- 7.5.3 For ensuring that the comparison is made on a consistent basis, the various conditions (e.g. the operation records, duration of measurement, utilization patterns etc.) affecting the measured energy use should be properly recorded allowing for the appropriate adjustments due to the changes in any of such conditions during the EMO implementation stage. Depends on the nature of the EMO, such conditions including operation records and utilization pattern to be monitored and recorded in the energy audit could cover the outdoor or ambient temperature, amount of space being air-conditioned, indoor environmental standard in terms of lighting levels and ventilation rate, occupancy type and schedule etc.
- 7.5.4 Estimation of energy saving and payback for each EMO should take into consideration the following in respect with that particular EMO related equipment –
- (a) service life; and
 - (b) degradation on energy efficiency of EMO related equipment during the payback period.
- 7.5.5 Specify the energy prices for evaluating the cost benefit due to the energy saving.
- 7.5.6 For each of the potential EMO, the energy audit report should indicate either-
- (a) the period of time for energy use measurement which should cover a complete operating cycle as far as possible; or
 - (b) the methodology of projection of measured energy use to complete operating cycle
- 7.5.7 Metering point, metering information and measurement interval for arriving at the measured energy use during the energy audit period should be recorded.

7.6 **Step 5 – Recommendations**

- 7.6.1 Recommendations of the EMO to be implemented should be made, with due regard to the energy savings, cost benefits and the robustness of the energy data for facilitating the determination of the energy saving during the EMO implementation period.
- 7.6.2 Describe each of the EMO, the intended result and procedure to implement/install the EMO under proper condition to achieve the expected energy savings potential and target. Such procedure may involve inspection, functional performance testing, and/or data trending with analysis and with the required measurement duration specified. Indicate and highlight also any specific function tests (e.g. automatic lighting control with multiple dimming levels in response to available daylight).

- 7.6.3 For each of the potential EMO, summarize the metering point and measurement device / parameter / time interval for arriving at the measured energy use of the involved energy consuming equipment/system as indicated in the energy audit period.
- 7.6.4 Recommendations should highlight the known programmed operation & maintenance activities of the building, if carried out in parallel with certain EMO would lower the EMO's implementation cost, such as an EMO of lighting retrofit tying in with a programmed false ceiling renovation.
- 7.6.5 Recommendations may include suggestions for further studies of equipment or components lacking the depth of study at the time of the audit as a result of a limitation of time or financial resources.

7.7 **Step 6** - Compiling Energy Audit Report

- 7.7.1 The energy audit report should outline the objectives and scope of audit, description of operating characteristics of equipment/systems audited, findings in the audit, potential EMO identified and corresponding energy savings and implementing capital costs with cost benefit analyses and above all the recommendations on EMO implementation with due regard to the building's overall operation & maintenance programme, and any other follow-up actions.
- 7.7.2 The energy audit report should have the detailed record on the energy data measured or collected from the operation records so robust enough allowing for the subsequent comparison with the energy use during the EMO implementation period to facilitate the verifying process on the anticipated energy saving.

8. Energy Audit Report

8.1 Information for Report

The following information should be included in the report -

- (a) energy audit scope, including –
 - a summary of the installations, equipment and systems audited;
 - a summary of the assumptions and estimating methods supplementing any non-availability of data essential to the determination of EUI; and
 - a comparison between the EUIs of current and the previous energy audit and explanation of the differences
- (b) building characteristics including type of building (commercial or composite), numbers of floors, internal floor area of the common area, total internal floor area

- of the building, usage (office, retail etc.), occupant density, hours of operation per day, days of operation per week, date of issue of occupation approval, etc.;
- (c) general description of equipment/systems audited, including their corresponding capacity ratings, operation hours etc.;
 - (d) energy consumption and performance evaluation of equipment/systems;
 - (e) for the air-conditioning equipment/systems the identification of –
 - i) for chiller / VRF system / unitary air-conditioner : their cooling capacity and corresponding type of condenser cooling (air-cooled, evaporative water-cooled, or sea water-cooled);
 - ii) for heat pump : their heating capacity and type of evaporator side heat input (air or water); and
 - iii) system types (fan coil unit system, constant volume all air system, or variable air volume all air system etc.);
 - (f) for the lighting installations the total lighting power (kW);
 - (g) analysis of historical energy consumption of the building, including -
 - i) total energy consumption of the central building services installations over the past consecutive 36 months,
 - counting backwards over 36 consecutive months from and including the energy bill reference month (which is the month for which the most recent energy bill has been issued by the energy supply utility prior to commencement of energy audit), and
 - for building with operation less than 36 months counting backwards to the first day of operation of the building;
 - ii) indication of the EUI per annum ($\text{MJ}/\text{m}^2/\text{annum}$) (based on the total energy consumption data in item i)), respectively for -
 - the past 1st 12-month period (starting from the energy bill reference month and counting backwards for 12 consecutive months), which is also the period covered by the EUI shown in the Energy Audit Form,
 - the past 2nd 12-month period (the consecutive 12 months immediately before the past 1st 12-month period), and
 - the past 3rd 12-month period (the consecutive 12 months immediately before the past 2nd 12-month period); and
 - iii) indication, based on the total energy consumption data in item i), of the monthly EUI ($\text{MJ}/\text{m}^2/\text{month}$) for each month of the past 1st 12-month period;
 - iv) indication of percentage breakdown of the total energy consumption of the past 1st 12-month period, differentiating the consumptions among the major installations, such as air-conditioning installation, lighting installation, lift and escalator installation, plumbing & drainage (pump motors) etc.;
 - v) graphical presentation of figures in ii), iii) & iv); and
 - vi) comparison between the EUI of the previous energy audit and the EUI in ii).

- (h) indication of the energy supply from the central building services installations to the building's units as a percentage of the total energy consumption of the past 1st 12-month period, such as for chilled water supply or cool air supply (excluding the electricity supply via electricity supplier's meters for the individual units);
- (i) findings from the information review and site inspections (in Step 2), with focus on the items leading to identification of potential EMO;
- (j) evaluations of potential EMO, including corresponding justifications, and cost benefit analyses with consideration of service life and degradation of energy efficiency of the related equipment;
- (k) drawing reference of above items to corresponding relevant items in past energy audit report, if available;
- (l) EMO
 - i) recommendations with classifications of EMO into categories I, II or III, and their grouping into common headings,
 - ii) suggestions for further studies; and
 - iii) suggestions or viability of implementing any energy recovery system(s) and/or on-site renewable energy system(s)
- (m) energy consumption and performance evaluation of EMO(s) implemented in respect of previous energy audit(s); and
- (n) the following administrative information –
 - date of commencement of energy audit,
 - commencement & end dates of energy bill reference month,
 - date of completion of energy audit, which should not be later than 6 months after the energy bill reference month,
 - date of issue of Energy Audit Form,
 - name and address of building (English and Chinese),
 - name and Registration No. of Registered Energy Assessor who has carried out the energy audit, and
 - energy audit report reference no.

8.2 Executive Summary

The energy audit report should include an executive summary at the beginning. This summary should at least include a brief account of items (b), (e)i), (e)ii), (f), (g)ii), (g)iii), (g)iv), (h), (l)i) and (m), in clause 8.1 above.

9. Energy Audit Form

The EUI per annum of the past 1st 12-month period of the building should be indicated in the Energy Audit Form, to reflect the energy usage intensity of the central building services installations. The Energy Audit Form is a specified form under the Ordinance.

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