

## TECHNICAL SPECIFICATIONS FOR ENERGY AUDIT

- Note: (i) These specifications are comprehensive ones. Given that each site, where an energy audit is to be carried out, is specific, only those sections/sub-sections of these specifications, which are relevant to the site, should be used by the energy auditor to know the extent of the audit exercise to be carried out and tests/measurements/analyses to be made.*
- (ii) In these specifications, 'energy auditor' also means an energy audit firm.*
- (iii) In these specifications, 'building', 'facility' and 'site' are used interchangeably and have the same meaning. They include all buildings on the site and all facilities found within the site, whether indicated or not in these specifications.*

### 1 SCOPE OF ENERGY AUDIT

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The energy audit shall cover all energy using systems found within the whole site and shall include the vehicle fleet used, and activities performed, within the site.

The energy audit shall necessarily cover the following areas where these are present on the site where the energy audit is to be carried out:

- building envelope;
- heating and cooling;
- ventilation and air conditioning;
- water supply and distribution systems (where water pumps are used in the systems);
- electrical systems (lighting, appliances, computers, servers, etc.);
- building automation and control system;
- transportation systems in the building, in particular lifts, escalators and moving walkways;
- processes within the building, such as kitchen, laundry, cold storage;
- UPS;
- generators;
- water heating
- steam boilers/steam systems and hot water boilers;
- compressed air systems;
- fans and blowers;
- pumps;
- motors;

- renewable energy systems;
- building envelope (heat transfer)
- shading equipment (e.g. blinds, active windows); and
- vehicle fleet

The energy auditor is expected to, as part of the energy audit exercise, examine and report on the following with respect to the site being audited:

- comfort criteria, including thermal comfort, air quality (CO<sub>2</sub>), relative humidity, acoustics;
- illuminance levels and lighting quality;
- operation and maintenance;
- health, safety and productivity;
- controls that combine services like HVAC, light and blinds (e.g. avoidance of unnecessary heat gains, daylight controls and glare protection).

Energy performance indicators shall be developed by the energy auditor for the site according to its purpose, type and age. This information shall be used in an analysis to provide comparative energy performance evaluation.

## **1.1 MANNER OF EXECUTION**

The energy audit shall be carried out in the manner set out in this document or where not set out, to the satisfaction of the Energy Efficiency Management Office.

The general procedure for execution of the energy audit shall be as listed below:

- understanding the strategic role of energy at the site and the specific objectives of the users on the site for implementing energy efficiency projects, including the financial criteria for implementation; planning of energy audit activities, timeframes, and required resources;
- interview of end-users for data collection;
- survey and analysis of energy flows, for energy conservation at the site;
- carrying out data-collection activities and an analysis with iteration, and reasonable assumptions, where necessary to improve accuracy;
- examination of the technical installations – lighting, appliances/equipment, networks/ distribution systems, piping distribution systems (water, compressed air, steam, gas, etc.);
- identification of energy saving/energy efficiency potential and opportunities at the site through a review of the outcomes from the energy analysis, operations and maintenance practices, and condition of systems relevant to the scope of the audit;
- development of recommendations based on not only the integrated technical, economic and operational merits, but also strategic feasibility;

- identification and prioritising energy saving/energy efficiency measures on the basis of life cycle costs and return of investment, and make recommendations; and
- submission of a report covering all the above for the site.

## **1.2 THOROUGHNESS OF THE ENERGY AUDIT**

The energy auditor is expected to carry out checks on all energy using systems and equipment on site and perform measurements on temperatures, air flows, electricity use, etc. and spend on site as much time as required for a thorough measuring scheme and survey of all systems. Time and effort should be optimally applied to measure SEU's at an appropriate level of detail and for an appropriate duration in order to derive at a business case within 10 – 15 % accuracy. Simulation of building/site energy performance by using dynamic calculation tools shall be carried out by the energy auditor in the event the energy auditor is recommending a level 3 energy audit

## **1.3 STANDARD**

The energy audit shall be carried out to Level 2 in compliance with the “ISO 50002:2014 Energy Audits - Requirements and guidance for use” standard or latest version, if any, for all ‘objects’ at the site.

*Note: ‘objects’ means the site, building(s), equipment, system, process, transport system, service or such other thing that uses energy or affects energy consumption.*

## **2 TECHNICAL SPECIFICATIONS**

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### **2.1 ENERGY AUDIT**

This section provides a brief description of the tasks to be carried out during the energy audit.

### **2.2 BUILDING DESCRIPTION AND ENVELOPE**

#### **2.2.1 General building function, occupancy, general services provided**

The energy auditor shall provide a description of the building function, occupancy and general services provided. The energy auditor shall carry out measurement to ascertain occupancy profile of the building/site. This shall also include occupancy schedules.

#### **2.2.2 Building orientation and footprint**

The energy auditor shall provide the geographical location of the site with details of the immediate surrounding and indicate the North direction on a location map. The energy auditor shall include in the energy audit report pictures of the building – for all elevations as well as of the site.

For each building on the site, the following information shall be provided.

Name of building	Gross floor area	Air conditioned area	Height of building (no. of floors)
...			

### 2.2.3 Natural lighting and cooling

The energy auditor shall investigate and include in the energy audit report daylighting opportunities, natural ventilation, ceiling – height, material and colour, floor material and colour and landscaping affecting solar heat gain and building shading present on site. Observation and findings shall be commented upon by the energy auditor.

### 2.2.4 Building envelope and thermal weight

The energy auditor shall calculate the Overall Thermal Transfer Value (OTTV) and Roof Thermal Transfer Value (RTTV) for the building if heat transfer of the building is a Significant Energy Use (SEU). The energy auditor shall pay attention to opaque and glazing elements and shall comment on the overall building design with respect to energy efficiency.

#### 2.2.4.1 Walls

A description of the wall constructions, types of insulation and material colour used in the building (inner and outer) shall be provided. An example of a table that may be used to summarise wall characteristics is provided below:

S/No.	Description	Thickness (mm)	U-Value (W/m <sup>2</sup> .K)
	<b>Building A</b>		
1	<i>Wall A</i> 15cm Hollow block Cement rendering 15mm external Colour (inner) white, (outer) white		
2	<i>Fenestration</i> Single glazed aluminium opening		
3	<i>Roof</i>		

	Bituminous waterproofing membrane		
	Reinforced concrete slab 150mm		

The Window to Wall Ratio (WWR) shall be calculated through on site measurement. Any measures provided in the design of the building concerning shading/glazing level shall be mentioned in the energy audit report. Attention shall be given to the design and operation of openings. The OTTV value for each wall shall be calculated. Example of tables to be used for providing the data requested is provided below:

Wall	Total glass area (m <sup>2</sup> )	Total façade area (m <sup>2</sup> )	WWR
North wall			
East wall			
West wall			
...			

OTTV of each wall

OTTV (North)	OTTV (East)	OTTV (West)	OTTV (...)	Total OTTV

#### 2.2.4.2 Roof

The energy audit report shall provide details of the exposed roof construction. Pictures depicting the surface of the roof along with any type/means of insulation (thermal and others) provided shall be included in the energy audit report together with material colour and roof area.

Material	Thickness (m)	Density (kg/m <sup>2</sup> )	k-value (W/m.K)	Resistance (m <sup>2</sup> .K/W)
Outside air film				
Waterproofing membrane				
Roof tile				

Inside air film				
...				
Total Resistance				
U Value				

**2.2.5 Observations, findings and recommendations**

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and make recommendations to reduce energy consumption.

**2.3 ENERGY SUPPLY INFORMATION**

The energy audit report shall include data for the past (latest) two calendar years for all energy sources used on site.

**2.3.1 Tariff**

The energy auditor shall carry out a comprehensive analysis of the electricity tariff applied for the electricity supply to the site and comment on the appropriateness of such tariff for the site. A table summarising information for electricity supply shall be provided as follows:

	Business Partner No.	CEB Meter No.	Tariff applied	Total Annual Consumption - Units (kWh)	
				Year (201...)	Year (201...)
1					
2					
TOTAL					

**2.3.2 Historical electricity consumption**

Data for the past (latest) two calendar years shall be analysed by the energy auditor and included in the energy audit report. The analyses shall cover:

- electricity consumption and cost for the site;
- electricity consumption, maximum demand and costs;
- the load factor and evaluation
- power factor
- regression analysis to establish a relationship between seasonality or other dependent variables on energy consumption

using tables and graphs/charts to enhance readability.

The energy auditor shall comment on any measures taken for power factor correction and on the current state/condition of these equipment. The energy auditor shall also comment on scope of correcting / further correcting power factor at the site, with due consideration to economical/financial aspects.

### 2.3.3 Fossil fuels

The energy audit report shall include data for fossil fuels used on site for the past (latest) two calendar years. The end use of the energy source shall also be mentioned. A table summarising the data for fossil fuels, as applicable, shall be provided as follows:

Fossil Fuels	Unit (tonne, litres, etc..)	End use	Amount consumed per year	
			Year ....	Year ....
Diesel	(i) (ii)	(i) Generator (ii) hot water (iii) vehicle	(i) 500 L (ii) 450 L (iii) 700 L	
Coal		...		
Fuel Oil				
Liquified Petroleum Gas (LPG)				
Gasoline (Mogas)				
Other (please specify)				

### 2.3.4 Renewable Energy Sources

The energy audit report shall include data for electricity generated on site from renewable energy sources for the past (latest) two years, where applicable. A table summarising the data shall be provided as follows:

Renewable Energy Source	Installed capacity	Year 20....			Year 20....		
		Total generated (kWh)	Total own use (kWh)	Total electricity sent to CEB grid (kWh)	Total generated (kWh)	Total own use (kWh )	Electri city sent to CEB grid (kWh)
Solar PV							
Wind							
Biomass (please specify)							

Biogas (please specify)							
Other (please specify)							

*Use the appropriate unit of measurement for non-electricity generating systems*

### 2.3.5 Solar Water Heating

The energy audit report shall include data for solar water heating used on site, where applicable. A table summarising data on solar water heating shall be provided as follows:

	Year 20...	Year 20...
Installed capacity of Solar Water Heater (in litres)		
Area of collectors		
Hot water requirement at the site (m <sup>3</sup> )		
% contribution of solar energy for total water heating requirements of the building/site		

The current state/condition as well as the maintenance carried out on all the renewable energy systems shall be commented upon.

### 2.3.6 Observations and findings

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and make recommendations to reduce energy consumption.

## 2.4 ELECTRICAL

### 2.4.1 Load profile - Electrical

The energy auditor shall describe the load profile and provide observations for all SEUs. Baseload readings shall be highlighted. Where a UPS system is a SEU, the energy auditor shall investigate how efficient the UPS system is and how it can be improved through upgrades, changed load requirements, or by replacing with new UPS.

### 2.4.2 Observations, findings and recommendations

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and make recommendations to reduce energy consumption.

## 2.5 CHILLED WATER SYSTEM

### 2.5.1 System description

The energy audit report shall provide a description of the chiller system used on site and maintenance carried out. This shall include the make, date installed, capacity, current



condition, maintenance record etc. A schematic diagram for the chiller system shall be included in the energy audit report.

**2.5.2 Load profile – Chilled water**

Graphs/ charts showing the load profile for the chilled water cooling load shall be included in the energy audit report. A graph of chilled water temperature vs delta T shall be provided.

**2.5.3 Description of chilled water system and operation**

A description of the chilled water system and its operation shall be provided by the energy auditor, as shown in the table below:

Day	Average load factor (%)	Average COP
1	77	3.7
2		
3		
Overall		

**2.5.4 Chiller Coefficient of Performance (COP) and system COP**

The energy auditor shall evaluate the chiller COP and system COP. Possible avenues for performance improvement shall be detailed as well as a comparison with new technology systems.

**2.5.5 Pipe lagging/insulation**

The energy auditor shall carry out an assessment of the laggings/insulations of the pipes of the chiller system and maintenance.

**2.5.6 Observations, findings and recommendations**

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and make recommendations to reduce energy consumption.

## 2.6 AIR CONDITIONING AND MECHANICAL VENTILATION SYSTEM

### 2.6.1 System description

The energy audit report shall include a description of the air conditioning and mechanical ventilation system on the site. The report shall also include observations and findings with respect to maintenance and history of repairs of the individual units.

A separate table shall be provided for split type air conditioning and VRF systems, mechanical fans systems and central/package HVAC systems. This may be provided in a table as shown below:

Site section served	Location	Equipment	Power (kW)	Quantity	Total power (kW)
Entrance	Ground floor	Split type AC			
Administration section	First floor				
...					

### 2.6.2 Efficiency of Air Conditioning

The report shall also include an assessment of efficiency and performance of all air conditioning units, indicating target temperature, actual supply temperature and return temperature (or room temperature), electricity consumption, with appropriate recommendations.

Approximations and assumptions, where employed, should be fully justified.

### 2.6.3 Fan specific power

The fan specific power of Air Handling Units (AHU) and extractor fans shall be determined and listed in the form of tables in the report. A description on the findings and maintenance as well as the state/condition of the AHUs and extractor fans shall be provided in the energy audit report.

No.	AHU	State/condition	Air flow rate (m <sup>3</sup> /hr)		Fan power (W)	Fan efficiency (W/(m <sup>3</sup> /hr))
			Design	Running		
1						
...						

No.	Extractor Fan	State / condition	Air flow rate (m <sup>3</sup> /hr)		Fan power (W)	Fan efficiency (W/(m <sup>3</sup> /hr))
			Design	Running		
1						
...						

#### 2.6.4 Air change rate (ACR) and AHU / extractor fan capacity analysis

Parameters such as Air Change Rate (ACR) shall be investigated and commented upon in the report. The findings may be presented in the form of a table as follows:

No.	AHU	Air flow rate (m <sup>3</sup> /hr)		Served Area (m <sup>2</sup> )	Air Change per Hour (ACH)	
		Design	Running		Design	Running
1						
...						

No.	Extractor fan	Air flow rate (m <sup>3</sup> /hr)		Served Area (m <sup>2</sup> )	Air Change per Hour (ACH)	
		Design	Running		Design	Running
1						
...						

#### 2.6.5 Indoor air quality

Indoor air quality parameters such as CO<sub>2</sub> level (ppm), temperature vs frequency analysis, daily temperature & Relative Humidity shall be measured for a sample of air conditioned room/area. Graphs/charts shall be used to facilitate inference. The energy auditor shall describe the findings made in the report and provide comments.

#### 2.6.6 Observations, findings and recommendations

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and make recommendations to reduce energy consumption.

## 2.7 LIGHTING SYSTEM

### 2.7.1 System description

The energy audit report shall include a list of lighting types and quantity and a description of the lighting system, operation, maintenance, operating times and current state/condition. The power rating of each light fitting type shall be listed. All interior building sections and exterior lighting shall be surveyed.

### 2.7.2 Lighting conditions

Measurement on the illumination level for indoor areas, offices as well as outdoor on the site shall be carried out and presented in the form of a table in the energy audit report. The energy auditor shall compare the lighting levels with applicable standards. The energy auditor shall investigate the possibility of maximising the use of natural lighting and lighting controls to reduce energy consumption.

### 2.7.3 Observations and findings

Observation and findings on all the above shall be commented upon by the energy auditor. Appropriate recommendations shall be made to reduce energy consumption and also in case of low lighting levels par rapport to applicable standards, natural lighting and use of lighting controls.

## 2.8 LIFTS, ESCALATORS AND MOVING WALKWAYS

### 2.8.1 System description

A list of all lifts, escalators and moving walkways installed on site shall be provided in the form of a table as shown below;

Section serviced	Equipment description	Make	Rated power (kW)	Quantity
Administration section	Lift, Machine roomless 3 stops 5-8 persons		11	2
...				

If the lift systems, escalators and moving walkways are classified as a SEU, the energy auditor shall make necessary measurements and comment on the energy use of the lifts and potential for energy saving/efficiency. The current state/condition as well as the maintenance carried out on all the lifts shall also be commented upon.

### **2.8.2 Observations, findings and recommendations**

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and propose recommendations to reduce energy consumption.

## **2.9 GENERAL EQUIPMENT AND PLUG LOADS**

### **2.9.1 General equipment and plug loads**

In this section all energy-using equipment including office and IT equipment, specialized equipment, surveillance (CCTV) and security system, access control, automatic gates equipment installed as well as other equipment installed for energy management and saving shall be detailed and listed, with information on their operation and maintenance and current state/condition. A summary of total energy consumption measured from instantaneous power readings shall also be included in the report.

### **2.9.2 Observations, findings and recommendations**

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and propose recommendations to reduce energy consumption.

## **2.10 BUILDING CONTROL SYSTEM**

### **2.10.1 System description**

The energy auditor shall investigate all building control system(s) installed on site and describe the system operation and current state/condition.

### **2.10.2 Observations, findings and recommendations**

The energy auditor shall comment on the observations and findings as well as indicate how best the building control systems may be used to bring about energy performance improvement at the site.

## **2.11 STANDBY GENERATOR SET**

### **2.11.1 System Description**

The energy auditor shall provide a description of the standby generator set present on site and a cost estimate per kWh generated inclusive of maintenance costs

## **2.12 COMPRESSED AIR SYSTEMS**

### **2.12.1 Systems description**

The energy auditor shall identify all the compressed air end-uses in the facility, identify the demand, analyze performance of the compressed air system, identify the potential energy savings and provide sound recommendations for implementation of energy efficiency measures.

The energy auditor shall investigate on the distribution network of the compressed air system identifying the configuration of the driers, receivers, filters, pipework size, moisture separators, end-use equipment and any other associated equipment. The energy auditor shall record key characteristic of the compressed air system supply side, giving consideration to the following:

- nameplate information of each air compressor, including model, type, rated air flow;
- air compressor motor information, including kW rating;
- air compressor motor electrical logging for the period audited;
- air compressor environment, including intake, exhaust and ambient air temperatures and description of compressor room ventilation;
- system pressure, pressure at the furthest point of the distribution, pressure at the critical application, pressure at the largest consumer, pressures before and after treatment
- compressor operation scheduling and compressor control;
- maintenance being carried out on the air compressor;
- condensate drains / oil separators - suitable installation, type and control, leakage; and
- dryer information - type, rated capacity, other relevant information such as dew point.
- critical compressed air end-users, OEM performance parameters
- compressor control philosophy
- control type for each compressor (L/UL, modulating, variable displacement, VSD)
- heat recovery potential
- description of distribution system (diameters, loop type, length, material type)
- storage volume

### **2.12.2 Analysis**

The energy auditor shall carry out appropriate measurements such as electricity usage measurements, pressure measurements, air flow measurements and air leak detection, depending on the particular compressed air installation and technologies being used.

These measurements shall enable the energy auditor to develop suitable performance indicators such as total air compressor electricity consumption per unit of productivity output (kWh/kg of production output). Proper consideration shall be given to pressure drops identified between the air compressor and the point of use and to the total amount of leaks identified while specifying priority in repairs of those leaks.

### **2.12.3 Observations, findings and recommendations**

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and propose recommendations for an overall efficient compressed air system.

The energy audit report shall include comments on the following opportunities for performance improvement:

- eliminating inappropriate uses of compressed air;
- minimising compressed air systems leaks;
- minimising artificial demand
- minimising pressure drops and controlling system pressure;
- storage assessment and volume requirements based on actual operation
- optimising compressed air system configuration;
- optimising compressed air system control strategy.

## **2.13 FANS AND BLOWERS**

### **2.13.1 Systems description**

The energy auditor shall identify the purpose of the fan/blower systems used at the site. The energy auditor shall record key characteristic of the fan/blower system, giving consideration to the following:

- nameplate information of each fan/blower, including model, type, rated air flow;
- fan/blower motor information, including kW rating;
- fan/blower performance curve data and manufacturer's specifications;
- fan/blower motor electrical logging for the period audited;
- fan/blower environment, including intake, exhaust and ambient air temperatures and description of blower room ventilation;
- current fan control philosophy
- current state/condition of the fan/blower system; and
- maintenance being carried out on the fan/blower;

### **2.13.2 Analysis**

The energy auditor shall carry out appropriate measurements such as electricity usage measurements, pressure measurements and air flow measurements in respect of the fan/blowers. From these measurements, and using the relevant fan/blower performance curve, the input power to the fan/blower shall be determined. The energy auditor shall comment on how well the fan/blower is operating relative to its Best Efficiency Point (BEP).

These measurements shall also be used by the energy auditor to develop suitable performance indicators such as total fan/blower electricity consumption per unit of productivity output (kWh/kg of production output) or hours of operation. Proper consideration shall be given to pressure drops identified between the fan/blower and filters and to the total amount of leakage and other areas of wastage identified while specifying priority in repairs of those leaks.

### **2.13.3 Observations, findings and recommendations**

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and propose recommendations for an overall efficient fan/blower system.

The energy audit report shall include comments on the following opportunities for performance improvement:

- eliminating inappropriate end uses;
- trimming or shifting of peak demand of air flow;
- pressure and flow reduction;
- minimising leaks and wastage;
- minimising pressure drops and controlling system pressure through duct/pipe sizing;
- optimising fan/blower system configuration using either automatic or manual dampers;
- optimising fan/blower control system using VSDs and PLC.

Proper care shall be taken by the energy auditor when recommendations are made for fan/blower systems which are coupled with other processes to ensure fan/blower power change do not result in unintended failure or impairment of the associated processes.

## 2.14 BOILER SYSTEM

### 2.14.1 System description

The energy audit report shall include a description and performance of the boilers being used on the site. The list below is an example of information to be provided for each boiler:

- Configuration, Make, Type, and Model
- Capacity (BTU, kW, tonnes/hour)
- Electricity used (kWh/year)
- Other Fuel used (kWh/year)
- No. of passes
- State/Condition (including but not limited to strainer, pump, nozzle and valves)
- Make and Model of Burner
- makeup water temp and flow,
- feedwater temp and flow, combustion analysis, boiler efficiency, steam temp, flowrate and pressure, de-aerator pressure if applicable, condensate return, number of headers, header pressure, steamtrap number and condition, insulation, blow down philosophy

### 2.14.2 Efficiency of Boiler

The report shall also include the Combustion Efficiency and Fuel to Steam Efficiency, designed and actual, of each boiler.

The table below is an example of data to be provided for calculating the Fuel to Steam Efficiency:

Boiler No.	Quantity of steam flow in minimum 1 hr (kJ/kg)	Quantity of fuel in minimum 1 hr (kJ/kg)	Feedwater flow (kJ/kg)	Gross calorific value of fuel/net	Fuel to steam efficiency calculated



				calorific value (kJ/kg)	using direct method
1					
...					

The information below shall be provided in the energy audit report when determining the Combustion Efficiency:

- visual verification of smoke emitted and any deposits near the combustion area;
- oxygen content;
- ambient temperature;
- humidity;
- amount of excess air; and
- amount of unburnt fuel

Other information to be included in the report, which can affect the energy efficiency of the boiler, is:

- Carbon Monoxide content of flue gas
- presence of forced draft system
- controls used for burner airflow and fuel flow
- scale deposits if any
- maintenance schedule

The current state/condition of the boiler and steam system shall be indicated in the report.

### 2.14.3 Observations, findings and recommendations

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and propose recommendations for an overall efficient boiler system.

## 2.15 PUMPS

### 2.15.1 Pumps description

The energy auditor shall investigate all pumps installed at the site which represent an SEU. A brief description of the pumping arrangement, distribution system and data such as the type of pump, the quantity and type of fluid being pumped shall be provided in the report. Electrical and control systems driving the pumps shall be described in detail.

Investigations on the aspect matching of pumps to loads shall be clearly evidenced in the report. The current state/condition of the pumps and any maintenance carried out shall be mentioned. The energy auditor shall investigate other aspects such as labour and parts to maintain the pumps.

The distribution network arrangement shall also be examined to ensure that piping dimension is appropriate for the volume of liquid being pumped and the rating of the pump and there are no leakage leading to unnecessary running of the pumps.

Abnormal water consumption values shall be investigated and commented upon as it has a direct incidence on the usage of pumps.

**2.15.2 Data collection**

The energy auditor is expected to undertake measurements which shall allow determination of the flow rate, total pressure and overall pump efficiency.

**2.15.3** The energy auditor shall ensure that measurements are taken in a sufficiently long length of pipe free from flow disturbance due to bends, tees and other fittings, and factors such as presence of scale and rust in pipes which have a direct bearing on the accuracy of measurements are taken into account. The energy auditor shall assess all inlet conditions with due regard to cavitation,  $NPSH_r$  and  $NPSH_a$ . **Analysis**

Suitable indicators shall be developed, for example, kWh/m<sup>3</sup> of fluid pumped. The energy auditor shall state whether or not the duty point of the pumps are located near at their BEP and what conditions need to be met for this condition to be achieved.

**2.15.4 Observations, findings and recommendations**

Observation and findings on all the above shall be commented upon by the energy auditor. Relevant practical recommendations, in terms of alternatives and modifications to the current set up including replacement of pumps, which would allow energy efficiency gains, shall be provided.

The following table may be used to summarise the proposed energy saving measures.

Location	Pump model	Design duty point	Pump flow (m <sup>3</sup> /h)	Estimated kWh/m <sup>3</sup>	Existing % of BEP	Proposed % of BEP	Estimated savings (kWh/yr)
...							

## 2.16 ELECTRIC MOTORS

### 2.16.1 System Description

The energy audit report shall include a description of all electric motors on the site which represent an SEU, excluding:

- those already reported under relevant sections for chilled water systems, pumps, air conditioning and mechanical ventilation system; and
- motors in close-coupled pumps and other close-coupled equipment.

This may be provided in a table as in the example shown below:

Site section	Location	Equipment	Type of motor	Rated power (kW)	Eff. Class	Qty (No.)	Total power (kW)	Motor starter	Operating sequence and hours of use
Pump Room	Ground floor	Dry-installed submersible pump with cardan shaft	3 Phase SQIM	50	IE3	2	100	Soft starter	1 duty 1 stand-by  6.5 hours/day/motor
...									

### 2.16.2 Condition & Efficiency of Motors

The energy audit report shall comment on the condition of the motors, maintenance carried out and appropriateness of existing preventive maintenance schedule and asset replacement schedule.

The report shall also include an assessment of the efficiency and performance of the electric motors.

Investigations on the appropriateness of motor starting method as well as aspect matching of electric motors to loads shall be clearly evidenced in the report, taking into consideration manufacturers' recommendations.

### 2.16.3 Observations, findings and recommendations

Observation and findings on all the above shall be commented upon by the energy auditor. The energy audit report shall mention any opportunity for:

- decreasing the hours of use of the motors without affecting productivity;

- down-sizing the motors if full-load is not reached, taking into consideration remaining lifetime and asset replacement schedule;
- reducing the starting current, power and energy consumption by appropriate motor starting method; and
- replacement of inefficient motors by more efficient ones, taking into consideration remaining lifetime and asset replacement schedule.

The recommendations shall include an estimation of the potential energy savings and cost of replacement (supply and installation) and of any required modifications to existing equipment/system.

## 2.17 TRANSPORT

### 2.17.1 System description

The energy auditor shall examine the transport logistics used by the Client at the site to deliver its services. Attention shall be given to the different ranges (short to long distance) and what is transported (people and freight). The situation in which a displacement is made shall also be considered.

**IMPORTANT NOTE:** In the event that the energy consumption for transport purposes is 40 % or less of the total energy consumption of the organisation, the transport system shall not be audited. Only the total energy consumed for transport purposes shall be presented in the energy balance together with a brief on the transport logistics used by the Client at the site to deliver its services.

In the event the energy consumption for transport purposes is more than 40 % of the total energy consumption of the organisation, the transport system shall be audited as detailed below. Advice on both the optimisation of energy within every mode of transport, as well as selecting the best mode of transport in every situation shall be provided. The Client will, to the extent possible, provide the energy auditor with access to relevant personnel, records and documentation to ensure that transport operations are audited without affecting its final results.

### 2.17.2 Data collection

The following data shall be collected by the energy auditor:

- energy consumption for every vehicle during the past 2 years, with intervals that allow for a useful analysis;
- fleet and vehicle composition: list of all available vehicles along with their age and main technical features i.e. vehicle category, fuel type, engine size;
- distance travelled and hours of operation;
- description of routes taken and planning policy;
- maintenance programmes, service and inspection checklists.

This may be presented in a table as per template given below:

***Passenger Transport***

Type of Vehicle (Vehicle s should be grouped accordi ng to type)	Qty	Age	Engi ne capa city	Fuel used	Seati ng capa city	Type of route allocate d (urban/r ural/mi xed)	Aver age trip dista nce (km)	No · of trip s/ yea r	Trip durat ion (hr)	Fuel consu med/y ear (l)	Maintenance costs / year (Rs)

***Freight Transport***

Type of Vehicle (Vehicle s should be grouped accordi ng to type)	Qty	Age	Engi ne capac ity	Fuel used	Load capa city (ton nes)	Type of route allocate d (urban/r ural/mix ed)	Aver age trip dista nce (km)	No · of trip s/ yea r	Trip durat ion (hr)	Fuel consu med/y ear (l)	Maintenance costs / year (Rs)

The energy auditor shall also look at the following:

- operator training conducted for energy consumption reduction, including documented records of any resultant reductions;
- criteria for transport operations assignment;
- policies for vehicle specification, operation, purchase, maintenance, refurbishment and replacement;
- methods of refuelling, where appropriate;
- evidence of the fuel or electricity consumption metering (in case of plug-in hybrid or electric vehicle) and relevant training given to key operators.

### **2.17.3 Analysis**

The energy auditor shall take into account the following in order to make final recommendations:

- efficiency in every period of the year (12 months);
- improvement capabilities concerning staff (training);
- vehicle maintenance;
- vehicle refurbishment, replacement and selection;
- routes / timetables issues;
- factors affecting customer comfort/satisfaction (e.g. use of air conditioning);
- vehicle speed;
- assessment of the recording of distance travelled, energy consumption and their impact on the accuracy of the available data;
- other factors that may affect energy consumption.

Suitable indicators shall be developed such as consumed energy/distance covered, consumed energy/(distance x number of passengers) for passenger transport, consumed energy/(distance / net weight) for freight transport.

Where data or information is not available, the energy auditor is expected to make reasonable assumptions after discussions with the Client.

The energy auditor shall investigate other aspects that can influence decision making, such as maintenance costs, acquisition cost, the use of different energy sources or fleet concepts etc.

### **2.17.4 Observations, findings and recommendations**

Observation and findings on all the above shall be commented upon by the energy auditor. Within the recommendations offered to reduce energy consumption, the following points shall be considered by the energy auditor:

*Vehicles:*

- improvements on the maintenance program;
- optimal configuration of the current fleet so as to reduce energy consumption;

- specifications to be applied on future purchase decisions; and
- criteria for fleet renewal.

*Operators:*

- training program to be carried out. The program will prioritize the different aspects the operator is in control of, so that they can be applied according to their importance.

*Routes/Timetables:*

- points to be considered within the operations department when organising the transport;
- trip justification and optimisation; and
- real time fleet monitoring.

Where data or information is not available, the energy auditor is expected to make reasonable assumptions after discussions with the Client.

The energy audit report shall include an estimate of the optimal amount of energy required to do the transport duties as opposed to the current usage, to facilitate decision making and to enable the Client to address the shortcomings.

## 2.18 LAUNDRY EQUIPMENT

### 2.18.1 System description

If laundry equipment being used at the site is an SEU, a detailed description of the equipments shall be provided in the energy audit report, together with a description of the environment in which they are installed (well ventilated, cramped, etc.).

The table below is an example of technical information to be provided:

No.	Description	Quantity	Capacity (kg, litres, kW)	LPG being used kWh <sub>eq</sub> /year	Other fuel used (please specify) kWh <sub>eq</sub> /year	Electricity used kWh / year	State / condition <sup>1</sup>
1	Washing Machine						
2	Dryer						

<sup>1</sup> The column defined 'Condition' should include, but not limited to, the condition of each apparatus, such as pumps, exhaust systems, filters, presence of leakage and number of years of operation of the apparatus.

3	Dry Cleaning Equipment						
4	Tunnel Finisher						
5	Ironers						
...							

Other information to be provided in the report is as follows:

- usage of hot water/steam by the washing machines
- maintenance carried out
- hot water requirements
- use of compressed air
- quantity of linen processed

### 2.18.2 Observations, findings and recommendations

The energy auditor shall comment on the observations and findings as well as identify performance improvement opportunities and propose recommendations for an overall efficient fan/blower system.

## 2.19 ENERGY BASELINE

The energy auditor shall provide a baseline figure for energy consumption for the premises taking into consideration energy consumption during at least the last two calendar years. The baseline shall be determined following the methodology of IPMVP or ISO50001 and shall be suitable for use to calculate energy savings brought about by the implementation of the energy audit recommendations.

The energy auditor shall provide full details on the measurement, calculation and verification methods used to determine the baseline energy consumption to enable replication for the purposes of monitoring of the evolution of the energy consumption figures during succeeding years. Any recommendations concerning measurement systems to be installed on site that would improve the accuracy of the baseline figure shall be provided in the energy audit report.

If external energy influencing conditions change within the energy audit period, the Energy Auditor shall calculate an adjusted base-line to incorporate the influence of the external conditions. Examples of these are change in average ambient temperatures, changes in production quantities etc.



## 2.20 ENERGY BALANCE AND ENERGY INDEX

### 2.20.1 Energy balance

A breakdown of the energy consumption by each end use load category shall be depicted in the form of a chart along with a table. The energy auditor shall describe the chart and provide his observations. The different end use categories shall be defined so that overlapping is avoided.

A separate chart for thermal and electrical loads shall be provided.

### 2.20.2 Energy indices

Energy indices shall be developed for each end use category per unit area of air conditioned/occupied/treated space or per unit output, as per example given in the table below:

#### *Building (excluding transport) indices*

Name of index	Value	Unit
Building energy intensity index (BEI)		kWh/m <sup>2</sup> /year
Lighting energy intensity index		kWh/m <sup>2</sup> /year
Air conditioning energy intensity index		kWh/m <sup>2</sup> (or kWh/m <sup>2</sup> where applicable) /year
Building power baseload		kW
Lighting power density		W/m <sup>2</sup>
Air conditioning power density		W/m <sup>2</sup>
Equipment power density		W/m <sup>2</sup>
Energy cost per floor area		Rs/m <sup>2</sup> /year
CO <sub>2</sub> emissions		kgCO <sub>2</sub> /m <sup>2</sup> /year
Maximum occupancy		Person/m <sup>2</sup>
Energy use per occupant		kWh/person/year
Energy use per unit of production		kWh/unit (unit to be specified)

% share of energy bill to total expenditure		%
Energy used per Rs turnover		kWh/Rs

### ***Transport indices***

Name of index	Value	Unit
Fuel use by fuel type		km/L, L/hour, tkm/L (tonne-km per L) as applicable
CO <sub>2</sub> emissions		kgCO <sub>2</sub> /km
Energy use per passenger		L/person/year, kWh <sub>eq</sub> /person/year

*Note: conversion factors for different units and types of fuel may be obtained at the following link <http://emo.govmu.org/English/report/Pages/default.aspx>*

### ***Energy – value added indices***

Energy use per unit of production		kWh/unit (unit to be specified)
% share of energy bill to total expenditure		%
Energy used per Rs turnover		kWh/Rs

Any other indicator(s) pertinent to the specific activity and output of the building/site is/are to be included by the energy auditor for energy use assessment and comparison with standards.

## **2.21 ENERGY MANAGEMENT OPPORTUNITIES**

The energy auditor shall recommend EMO (Energy Management Opportunities) Energy Saving Measures (ESM) for all objects covered in the energy audit exercise of the building/site and explain each ESM in detail showing the basis of calculations and any assumptions made. The energy auditor shall state the limits of accuracy for savings and costs.

The energy auditor shall hold discussions with the Client when developing the EMOs to ascertain the feasibility of implementation and that the EMOs do not negatively impact on productivity, comfort (including thermal comfort), air quality, acoustics, health and safety. The energy auditor shall also consider any regulatory or other agreed

schemes or constraints that would impact on opportunities for improving energy performance.

The EMOs shall be listed in three categories, and the information to be provided shall be, as follows:

**2.21.1 No cost/Low cost measure/short term measure (< 1years)**

- Findings
- Energy saving recommendation/measure
- Estimated investment cost
- Simple payback period analysis

**2.21.2 Medium cost measure/ medium term measure (1 to 3 years)**

- Findings
- Energy saving recommendation/Measure
- Estimated investment cost
- Return on Investment
- NPV or IRR

**2.21.3 High cost measure/ long-term measure (> 3 years)**

- Findings
- Energy saving recommendation/Measure
- Estimated investment cost
- Return on Investment

NPV or IRR

An EMO summary table shall be provided in the energy audit report. With regard to estimated energy savings, the energy auditor shall ensure double counting does not occur. The table format may be as follows:

No.	EMO	Estimated saving / year			Estimated investment cost, inclusive of labour cost and materials (Rs)	Payback period / ROI / NPV/IRR (year)	Estimated CO <sub>2</sub> reduction / year
		Energy (kWh)	Energy (%) <sup>1</sup>	Cost (Rs)			
No cost / Low cost measure / short term measure (< 1years)							
L1							
..							

Medium cost measure / medium term measure (1 to 3 years)							
M1							
..							
High cost measure/ long term measure (> 3 years)							
H1							
..							

*1. To be represented as a percentage of baseline energy consumption*

## 2.22 LEVEL 3 ENERGY AUDIT

The energy auditor shall advise on the objects for which a Level 3 energy audit has to be carried out. This shall be supported by economic and technical justifications. A cost estimate for the Level 3 energy audit of each concerned object shall be indicated by the energy auditor in the energy audit report.

## 2.23 FINANCING OPTIONS/INCENTIVES AVAILABLE

The energy auditor shall provide advice on any appropriate financing option or incentive (if any) that the organisation may have recourse to in order to implement the ESMs proposed. Such advice shall be accompanied by a proposed action plan to implement each measure. The time required for implementation of an ESM shall be taken into consideration in the action plan.

A résumé shall be provided in the form of a table as per example below. The detailed action plan shall be provided as an annex to the energy audit report.

Year		Energy consumption (kWh/yr)	% reduction in energy consumption	BEI (kWh/m <sup>2</sup> /yr)	ESM	Investment cost (Rs)	Saving (Rs)
Year	2018	600000		100			
(baseline)							
Yr 1	Q1	580200	3.3	96.7	L1		
	Q2				L2, H2		
	Q3				M2		

	Q4				H3		
Yr 2							
.....							
Yr 3							
.....							

## 2.24 ENERGY MANAGEMENT SYSTEM REVIEW

The energy auditor shall review the aspect of energy management on site and provide relevant/realistic recommendations for improved energy management. The proposal shall include an energy management team and an energy management matrix (if not found on site).

The current practices regarding Operation and Maintenance of energy consuming equipment shall also be examined by the energy auditor and recommendations for improvement in energy saving/energy efficiency shall be provided in the energy audit report.

## 3 CLOSING MEETING

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Notwithstanding any consultation meeting(s) the energy auditor may have with the Client, he shall have a closing meeting with the Client after completion of the energy audit. A copy of the energy audit report shall be provided to the Client before this closing meeting.

At the closing meeting, the energy auditor shall:

- present the results of the energy audit in a way that facilitates decision making by the Client;
- explain the results and address questions; and
- if applicable, identify items requiring further analysis or follow up;

The energy audit report may have to be amended taking into considerations comments received from the Client at the closing meeting.

## 4 THE ENERGY AUDIT REPORT

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### 4.1 GENERAL NOTES ON THE ENERGY AUDIT REPORT

- The energy auditor shall ensure completeness of, and consistency in data/information provided in the energy audit report.
- The energy auditor shall proofread the energy audit report, even draft ones, before its submission to the Client. All calculations in the report shall be checked for mathematical accuracy.
- All numbers related to the results shall be supported by information showing how they were derived. This includes all energy savings, cost savings, investment and payback / ROI / IRR information. They shall include, where applicable, the adjusted base-line assumptions and associated calculations.
- SI units must be used in all parts of the report.
- Measurement and instrumentation accuracy shall be stated.
- The report should be written in proper prose. The language should be clear, concise and understandable.
- All graphs and plots should be properly labelled and the dates when the readings were taken shall be indicated.
- The report should be printed on both sides to save paper.
- A soft copy of the report in Pdf version shall be provided, with data measured/collected as well as a copy of the database used by the energy auditor.
- Sources of reference shall be indicated.

**4.2 FORMAT / CONTENT OF THE ENERGY AUDIT REPORT**

The energy audit report shall cover all sections and sub-sections from 1 to 3 above, as applicable, and shall also include the following:

**4.2.1 Cover Page**

- Report title;
- Name of Client;
- Name and location of building/site audited; and
- Date of the report

**4.2.2 Energy Auditor / Energy Audit Team**

- Name of Energy Auditor or Energy Audit Firm, as applicable;
- Audit team and their qualifications, with Lead Auditor clearly indicated; and
- Quality Assurance Declaration Form, as provided hereafter, to be signed by the Energy Auditor or the registered Energy Auditor of the Energy Audit Firm, as applicable.

***QUALITY ASSURANCE DECLARATION FORM***

*I have conducted an energy audit as set out in the Energy Efficiency (Energy Consumer and Energy Audit) Regulations 2017, in respect of ..... of ..... and which was (name of the energy consumer) (address) completed on ..... (date)*

***Auditor's responsibility***

*My responsibility is to express an opinion on the energy supply and end use based on my audit. I conducted the audit in accordance with ISO 50002 Energy Audits standards. Those standards require that I comply with ethical requirements and plan and perform the audit to obtain reasonable assurance whether the energy audit and investment plan are free from material misstatement.*

*An energy audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the energy and financial statements. The procedures selected depend on my judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, I considered the internal controls relevant to the company's preparation and fair presentation of the Energy Audit Report in order to design audit procedures that were appropriate in the circumstances, but not for the purpose of expressing an opinion on the company's internal controls.*

*I believe that the audit evidence I have obtained is sufficient and appropriate to provide a basis for my audit opinion.*

**Opinion**

*In my opinion, the accompanying Energy Audit Report gives a true and fair view of the possible intervention to improve energy efficiency and conservation of the company as at ..... (date) in accordance with the Energy Efficiency (Energy Consumer and Energy Audit) Regulations 2017.*

*I confirm that –*

- (a) I have obtained all the information and explanations which, to the best of my knowledge and belief, were necessary for the purposes of my audit;*
- (b) in my opinion, proper energy and financial records have been kept by the company, so far as appears from my examination of those records; and*
- (c) the company's energy supply and end use are in agreement with the records.*

.....  
*Name of energy audit firm  
(if applicable)*

.....  
*Registration number of energy  
audit firm (if applicable)*

.....  
*Name of energy auditor*

.....  
*Registration number of energy auditor*

.....  
*Signature of energy auditor or representative of energy audit firm, as applicable*

#### **4.2.3 Table of Contents/ List of Figures/ List of Tables/ List of Annexes/ Abbreviations/Assumptions**

#### **4.2.4 Executive Summary**

All information in the Executive Summary shall be drawn from the detailed information in the full report. The Executive Summary shall include the following:

- Name of client;
- Name and location of building/site audited;
- Objectives and scope of the energy audit;
- Brief on methodology used in carrying the energy audit;
- Dates of the energy audit;
- Key systems and equipment analysed;
- Summary of energy use and consumption;
- Energy balance of the building/site audited;
- Key observations and findings;
- Ranking of opportunities / energy conservation measures for improving energy performance using the table format below: and

<i>Ranking.</i>	<i>Reference section in the report</i>	<i>Recommended Measure</i>	<i>Estimated Implementation Cost (inclusive of labour and materials)</i>	<i>Estimated annual energy savings (kWh/unit of production and/or kWh/square foot)</i>	<i>Estimated Annual Monetary Savings</i>	<i>Estimated annual CO<sub>2</sub> reduction (kg/kWh)</i>	<i>Simple Payback period (as applicable)</i>	<i>Return on Investment (ROI) (as applicable)</i>	<i>Implementation period of the measure</i>
1									
2									
...									
Total									



- Suggested implementation programme.

#### **4.2.5 Introduction**

- General information on, including services provided by, the Client/building/site;
- Brief information on the energy audit methodology used;
- Statement of confidentiality;
- Context, objectives, scope, level, boundaries and timeframe of the energy audit;
- The financial criteria and technical/operational limitations;
- Previous 2 year's energy consumption and costs, including tariff rates;
- Breakdown of energy supply and end use (electricity, fuel and renewable energy).

#### **4.2.6 Methodology**

- Measurement plan;
- List of instruments used and measurement procedure (acquisition frequency and measurement period);
- Calibration certificates of instruments used (copies to be in annexes)
- Pictures and maps showing the locations of the instruments and sensors in use during the audit;
- Data measured and data estimated; and
- Measurement error analysis (mandatory).

#### **4.2.7 Assumptions**

- Clearly state all the assumptions made in taking measurements, calculations, and financial and economic analysis

#### **4.2.8 Data Analysis, Observations and Findings**

- Inventory of energy consuming equipment and systems;
- Description of systems and equipment audited, their capacities and ratings, design and operating conditions, years of service/use, maintenance and current state/condition;
- Review of energy, production and service level data for the last two years;
- Work out the baseline figure for energy consumption. The energy auditor shall provide full details on the measurement, calculation and verification methods used to determine the baseline figure for energy consumption to enable replication for the purposes of monitoring of the evolution of the energy consumption figures during succeeding years;
- Heat and mass balance where applicable;
- Analysis of energy performance and any energy performance indicators;
- Appropriate economic analysis, including known financial incentives and any non-energy gains;
- Basis for calculations, estimates and assumptions and the resulting accuracy;
- Criteria for ranking opportunities for improving energy performance; and

- Findings and observations;

#### **4.2.9 Identified Energy Saving Measures**

- Recommended energy saving measures with detailed and clear calculations of the predicted annual energy and cost savings, investment cost and investment indicators (payback, IRR, etc as applicable) for each measure. All numbers should be supported by data. Assumptions must be stated. Resulting accuracy of calculated energy savings and benefits shall be stated;
- Potential interactions with other proposed recommendations.

#### **4.2.10 Energy Investment Plan**

- Details on the closing meeting held with the Client.
- Summary of recommendations to include: projected annual kWh savings, estimated cost savings, projected investment cost (investment cost to include labour and materials) and investment indicators such as payback period, return on investment and/or internal rate of return (IRR), as applicable. Resulting accuracy of calculated costs of implementation shall be stated; and
- Show clearly the agreed energy investment plan the Client intends to take in order to improve efficiency and conserve energy. The Plan should show time required for completion, and resources to be used i.e. labour, materials, finances and anything else which is relevant for the project

#### **4.2.11 Monitoring and verification**

- Measurement and verification methods recommended for use in post-implementation assessment of recommended opportunities for improving energy performance.

#### **4.2.12 Appendices**

Information of significant importance, which cannot be presented as a part of the text report (because of number of pages, quality of presentation, etc.) should be presented in appendices.

The appendices may include:

- schematics and layout drawings of building/site audited;
- details of instrumentation used, parameters monitored and duration of monitoring for each parameter;
- copy of calibration certificates of equipment used during the energy audit;
- data plots of performance of systems or equipment audited;
- energy efficiency of equipment compared against industrial benchmarks;
- CD-ROM containing a soft copy of the energy audit report, the raw measurement data and database used for the energy audit.