ENERGY AUDIT TEMPLATE

Index

1. Cover Page

Main components:
a) Report title (with Building/Facility Name)
b) Entity for which Building/Facility has been audited
c) Location of Building/Facility
d) Building type (hospital, school etc.)
e) Building picture
f) Date of report
g) The firm responsible for the Audit
h) Consultants certificate numbers

2. Table of Contents, Tables and Figures

Table of Contents should include all significant headings, sub-section headings and appendix sections. Ensure that the table of contents is updated when the report is finalized. It is also desirable to add tables for relevant figures and tables. The abbreviations and acronyms used should also be indicated and explained in a friendly format, and the conversions and reference values should be presented, either at the beginning of the report or in the first Appendix.

General Information Tables

- Audit Team with their profession and energy manager certificate numbers
- References, Reference Values including:
    a. Energy conversion coefficients,
    b. Primary energy conversion coefficients,
    c. Green house gas coefficients,
    d. Calorific values,
    e. Electricity and fuel unit prices,
    f. Currency exchange rates,
    g. Energy unit price inflation rate,
    h. Discount rate,
    i. Other
- Abbreviations
- List of equipment used in audit and their calibration details

3. Executive Summary

All information in the Executive Summary should be drawn from the detailed information of the full report. Must be concise and up to a point. The minimum contents should be as follow:

3.1. Short building description (owner, size, type of use, systems, etc.), using a table:

Ref	Category	Description
1	Name of Building/Building Group	
2	Owner	
3	Year of Construction	
4	Purpose of Use	
5	Number of Buildings in Building Group	
6	Enclosed Volume [m^3]	
7	Construction Area [m^2]	
8	Building Floor Area [m^2]	
9	Annual Heating Degree Days (3-year average)	
10	Annual Cooling Degree Days (3-year average)	
11	Heating/Cooling System Summary Description	
12	Insulation Summary Description	
13	Number of employees	
14	Number of other building users (patients, students, etc.)	
15	City / District	
16	TS 825 Climate Zone	
17	Building Address	
18	Postal Code	
19	Phone number	
20	Fax Number	
21	Building Owner E-mail address	
22	Energy manager	
23	Certificate number of the energy manager	
24	Energy Manager Phone number	
25	Energy Manager Fax Number	
26	Energy Manager E-mail address	
27	Energy Performance Certificate number (if any)	

3.2. Buildings List:

No	Building/Block	Year of Construction	Construction Area [m^2]	Within Energy Audit Scope	Connected to Campus Heating Center*
1				Y/N	Y/N
2					
3					
4					
5					
(…)					
		Total			

* Please use this column in case heating energy of a multiple blocks or buildings is supplied by a central heating system or a campus heat center. (i.e. university campus heat centers, central boiler room for a multi block healthcare facility.)

3.3. Baseline (Reference) Energy Consumption:

Year	Total Annual Electricity Use [TOE]	Total Annual Fuel Use [TOE]	Total Annual Site/Final Energy Use [TOE]	Total Annual Primary Energy Use [TOE]
Year #1				
Year #2				
Year #3				
Year #(…)				
Baseline (Reference) Energy Use				

3.4. General Indicators:

#	Indicator	Units	Year #1	Year #2	Year #3	Year #(...)	Average
1	Energy Consumption per m^2	kWh/m^2 year					
2	Emissions per m^2	kg CO_2 eq. /m^2 year					
3	Emissions per person / user / patient / student	kg CO_2 eq. /person year					
4	Fuel Consumption per HDD	Wh / HDD m^2 year					
5	Electricity consumption per CDD	Wh / CDD m^2 year					

3.5. Key systems and equipment analysed in a list or table format.

Please list the systems and equipment to be analysed within the scope this audit report.

3.6. Baseline Energy Use vs Energy Savings based on Mix-Scenario

Energy use	Electricity [TOE]	Fuel [TOE]	Total Site/Final Energy [TOE]	Total Primary Energy [TOE]
Annual Baseline (Reference) Energy Use				
Total Annual Energy Savings				
Annual Proposed Energy Use				

3.7. Building energy consumption breakdown, through a table and a graph:

	Electrical				Fuel #(…)				Total		
year/month	Consumption [kWh]	Consumption [TOE]	Share of Total Consumption [%]	Total Cost [TL]	Consumption [kWh]	Consumption [TOE]	Share of Total Consumption [%]	Total Cost [TL]	Consumption [kWh]	Consumption [TOE]	Total Cost [TL]
Year #1 total											
Year #2 total											
Year #3 total											
Average											

Insert a slice graph of the last table for easy reading of the total values.

3.8. Summary of recommended energy efficiency measures

Should include cogeneration and renewables opportunities, annual energy savings and cost savings. There should always be four tables:

i) base scenario,

ii) deep renovation scenario,

iii) recommended package and

iv) measures that were studied but not taken into account.

Refer to the Energy Efficiency Measures (EEM) chapter for scenario detail. The tables for all scenarios should follow this format:

Base Scenario

No.	Energy Efficiency Measure [EEM]	Type of energy [eletr. gas etc.]	Estimated annual energy savings [kWh]	Estimated annual energy savings [TOE]	Saving % (of total consumption)	Estimated annual cost savings [TL]	Emissions reduction [ton CO_2e]	Estimated implementation cost [TL]	Payback period [years]	IRR (20-year) %	20-year NPV [TL]
1		Elect.						12.500.000,00	5.68	%12.55	123.456.567,98
2		N. Gas									
(3)		Elec.									
		N.Gas									
(4)											
(5)											
(…)											
Total Savings		**Elec.**									
		N. Gas									
		Total									
Total Site/Final Energy Savings %											
Total Primary Energy Savings %											
Reference Site/Final Energy Consumption [TOE]											
Reference Primary Energy Consumption [TOE]											

Deep Renovation Scenario

No.	Energy Efficiency Measure [EEM]	Type of energy [eletr. gas etc.]	Estimated annual energy savings [kWh]	Estimated annual energy savings [TOE]	Saving % (of total consumption)	Estimated annual cost savings [TL]	Emissions reduction [ton CO_{2e}]	Estimated implementation cost [TL]	Payback period [years]	IRR (20-year) %	20-year NPV [TL]
1		Elect.									
2		N. Gas									
(3)		Elec.									
		N.Gas									
(4)											
(5)											
(…)											
Total Savings		**Elec.**									
		N. Gas									
		Total									
Total Site/Final Energy Savings %											
Total Primary Energy Savings %											
Reference Site/Final Energy Consumption [TOE]											
Reference Primary Energy Consumption [TOE]											

Mix Scenario

No.	Energy Efficiency Measure [EEM]	Type of energy [eletr. gas etc.]	Estimated annual energy savings [kWh]	Estimated annual energy savings [TOE]	Saving % (of total consumption)	Estimated annual cost savings [TL]	Emissions reduction [ton CO_2e]	Estimated implementation cost [TL]	Payback period [years]	IRR (20-year) %	20-year NPV [TL]
1		Elect.						12.500.000,00	5.68	%12.55	123.456.567,98
2		N. Gas									
(3)		Elec.									
		N.Gas									
(4)											
(5)											
(…)											
Total Savings		**Elec.**									
		N. Gas									
		Total									
Total Site/Final Energy Savings %											
Total Primary Energy Savings %											
Reference Site/Final Energy Consumption [TOE]											
Reference Primary Energy Consumption [TOE]											

3.9. The EEMs that were studied but not proposed

The analysis for the details may be provided in the annex, but the reason for not being proposed has to be carefully explained. The table should follow this format:

No.	EEM	Estimated annual energy savings [kWh]	Estimated annual cost savings [TL]	Estimated implementation cost [TL]	Payback period [years]	Data based on base or deep renovation	Comments
1							
2							
(…)							

3.10. Green and Innovative Technologies

The Consultant shall develop innovative and green solutions derived from the energy efficiency measures applied in the buildings such as PV powered mobile device and electric vehicle charging station, occupant information screens that shows the current energy consumption data of the building, etc. that can help awareness raising towards energy consumption and have high impact on user behaviours. The proposed innovative visibility technologies shall be building specific and have an impact assessment for each proposal. Additionally, the estimated cost for the proposed innovative technologic solutions shall be calculated and provided in a separate table other than the table prepared for energy efficiency measures.

No.	Green and Innovative Technology Measure	Estimated implementation cost [TL]	Comments about estimated impacts
1			
2			
(…)			

3.11. No Cost, Operations and Maintenance (O&M) or energy management opportunities, if any.

Please explain no cost or low cost operation and maintenance related or energy management opportunities which may not be suitably shown EEM tables. Explain why they cannot be presented in conventional EEM table and how they may be implemented.

3.12. Energy Performance Contract (EPC) Model Assessment

Briefly evaluate whether this building/group of buildings may be considered for energy performance contracting or ESCO model tender in terms of implementation of proposed energy efficiency measures outlined in the executive summary section.

The criteria may be as follows (not limited to below):

Assessment Criteria	Status / Performance	Notes
Construction Area [m^2]		Whether it's too big or too small for an EPC model contract
Baseline (Reference) Energy Use [TOE]		Whether it has too few or much energy use (for instance, >250 TOE or not)
Mix Scenario Savings %		Whether it presents a relatively high savings% opportunity or not (compared to other buildings in the same lot)
Mix Scenario Implementation Cost [TL]		Whether the implementation cost is too big or small for an EPC model contract OR it represents an interesting opportunity for ESCOs
Net Present Value [TL]		Whether it has a relatively high or low net present value (compared to other buildings in the same lot)
IRR [%]		Whether it has a relatively higher or lower internal rate of return (compared to other buildings in the lot)
Simple Payback Period [years]		Whether it has a relatively shorter or longer simple payback period (compared to other buildings in the same lot)
Building End Use		Whether it's a hospital or school or university or dormitory or admin building and assessing the easiness of working on site
Complexity of EEMs		Assessing the complexity of implementation of EEMs on site depending on the nature of EEMs, no of various EEMs,type of EEMs or structural retrofit requirements

3.13. Nearly Zero Energy Building (nZEB) Assessment

Briefly evaluate whether this building/group of buildings may be retrofitted as a nearly zero energy building* based on:

- building's existing physical shape,
- architectural constraints including administrative or bureaucratic issues (architect's consent for a change or insulation implementation on façade),
- beneficiary institution's positive approach, cooperation or motivation or demotivation,
- baseline (reference) energy consumption level,
- whether deep energy efficiency measures can be implemented.
- Level of implementation cost and simple payback period being too long (over 30 years)

* Please refer to *NZEB definition* in the annex.

4. Energy Audit

In this chapter, there should be clearly stated all the information regarding the existing systems, from their basic characteristics to their energy consumption and their role in the energy profile of the installation.

4.1. Meteorological data

Present the monthly average ambient temperature and humidity, monthly HDDs and/or CDDs for 3 consecutive years for the area where the building is situated. The data should preferably be sourced from the National Meteorological Service.

4.2. Energy consumption data

4.2.1. Energy consumption Profile

This table has to be made with the actual energy and utility provider data and should reflect an overview of the total consumption and cost of energy on a yearly basis.

	Electricity				Fuel #(…)			
Year/month	Maximum Demand [kW] (if available)	Consumption [kWh]	Consumption [TOE]	Total Cost [TL]	Maximum Demand [kW, [m3, ton]	Consumption [kWh]	Consumption] [TOE]	Total Cost [TL]
(January… December)								
Year #1 total								

	Electricity				Fuel #(…)			
Year/month	Maximum Demand [kW] (if available)	Consumption [kWh]	Consumption [TOE]	Total Cost [TL]	Maximum Demand [kW, [m3, ton]	Consumption [kWh]	Consumption] [TOE]	Total Cost [TL]
(January… December)								
Year #2 total								

	Electricity				Fuel #(…)			
Year/month	Maximum Demand [kW] (if available)	Consumption [kWh]	Consumption [TOE]	Total Cost [TL]	Maximum Demand [kW, [m3, ton]	Consumption [kWh]	Consumption] [TOE]	Total Cost [TL]
(January… December)								
Year #3 total								

Add a column for each different type of fuel.

The Time Period should include (if available) at least three years of consecutive monthly data and three-year average. Be sure to include all-electric/gas/fuel meters if there are more than one.

Year	Consumption [TOE]	Ton CO_{2e}	Total Cost [TL]	TOE/cost [TL]	CO_{2e}/cost [TL]
Year #1 total					
Year #2 total					
Year #3 total					
Average					

The reports should offer some explanation for the presented data on energy use. For example, if gas use increases over 10%, or energy unit prices change significantly from year to year. Year to year changes (from each of the previous energy consumption data) should be presented and add the narrative to explain fluctuations.

Energy Use [TOE]	YY1-2	YY2-3	YYn-n+1
Variation change [%]			

If there are large differences between years (e.g. changes not explained by simple economic cycles), the Consultant must explain the possible reasons carefully. Ensure that units are correct.

4.2.2. Energy Consumption Graphs

Display three years of consumption data graph (time on the x-axis). If available, show monthly values for all three years. All electricity, natural gas, and other fuels used at the facility need to be

graphed (each on the separate chart). The graph could be line or bar graphs or any form that visually shows patterns. It has to be properly scaled for relevant information.
Include a brief narrative describing seasonal utility usage patterns and anything that stands out (e.g., note and explain any anomalies, etc.). Explain any trends.
As relevant, correlate with features that may drive consumption profiles (e.g., occupancy, use patterns, degree days, etc.), and introduce them in a secondary axis to each graph

4.3. Standards for indoor comfort and building operation

Present the national standards for indoor comfort and building operation, i.e., internal temperature and humidity, required fresh air requirements in different spaces (e.g., separately for ICUs, patient rooms), lighting, domestic hot water)

4.4. Building Structural Systems and Operation Plans

The building description must contain sufficient baseline details about the building (e.g., year built, number of remodels, type of construction), including measured and/or verified area.

4.4.1. General

Building layout (show sections and years if remodelled), general construction, types of spaces/general layout, floor area. Explain, if needed, the different areas used (e.g. net, built, etc.).

4.4.2. Building Envelope

a) Exterior Walls, Roof and Floors

System Description and Table of Building Components (layer by layer):
Describe the components/layers of the envelope (construction materials used for the exterior walls, roof and floors), including insulation material and its thickness, R-values/U-values of the envelope, condition, wall/roof/floor areas, and presence of asbestos or other materials.

Measurements, Calculations and Assessment:
Indicate if the U-Values of the envelope components are relevant for the TS 825 Building Insulation Code for the region of the building. A table for comparison with TS 825 recommended U-values shall be provided.

b) Windows and Doors

System Description and Table of Building Components (layer by layer):
Glazing type, frame type, location and dimension (area) of each unique type, shading, orientation, operability, weather-stripping, and condition. Include U or R-values of the fenestration assembly (glass+frame), approximate Solar Heat Gain Coefficient (SHGC), and window tint description. Note if specific windows are left open for purposes of ventilation or comfort issues. Indicate also areas per different glazing/construction solution.

Summary of Measurements, Calculations and Assessment
Indicate if the U-Values of the windows are relevant for the TS 825 Building Insulation Code for the region of the building. A table for comparison shall be provided. Use TS 825 Local Building Insulation Code, when possible.

Building Envelope Energy Efficiency Measures Summary Description:

Propose two different building envelope (walls, roof, floors, windows and doors as a package) improvement measures:

- Building component thermal performance improvement measures which will meet TS 825 local building thermal insulation standard in case the building does not meet TS 825 requirements (for base scenario)
- Building component thermal performance improvement measure which will by far exceed TS 825 minimum thermal performance requirements (for deep renovation scenario)

Share the summary of TS 825 building heating demand calculation results for both existing status of the building, base scenario improved status and deep renovation scenario status. Compare annual heating demand (kWh/m^3) of those scenarios among themselves and show heating energy saving percentages of each scenario compared to existing status. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

Base Scenario EEM Savings				
Existing Heating Demand	Improved Heating Demand	Estimated Heating Demand Saving	Heating Energy Saving	Heating Energy Saving
[kWh/m^3]	[kWh/m^3]	[kWh/m^3]	%	[kWh]

Deep Renovation Scenario EEM Savings				
Existing Heating Demand	Improved Heating Demand	Estimated Heating Demand Saving	Heating Energy Saving	Heating Energy Saving
[kWh/m^3]	[kWh/m^3]	[kWh/m^3]	%	[kWh]

Based on energy savings, provide a summary analysis table of this EEM for each scenario in such a format:

Ref.	Subject / Description – Base Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Ref.	Subject / Description – Deep Renovation Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Please refer to the relevant section or annex in the audit report for detailed analysis including assumptions, measurements, energy saving calculations, investment cost calculations, financial analysis (IRR, NPV, etc.)

4.4.3. Observable deficiencies

Indicate the existence of wall cracks, observable structural elements, leakages, mould or other observable building pathologies. If any major deficiencies are observed, propose a corrective action within an energy efficiency measure related to building envelope.

4.4.4. Other

Insert representative floor plans that include all buildings.
Pictures of major building elevations and exterior façades, parking lots, etc. Include additional photos and descriptive captions of all building elements, systems, or conditions that are related to the proposed EEMs (included in EEM Section or Appendix).

4.4.5. Building occupancy and operation

Provide a brief narrative describing typical daily, weekly, and annual occupancy and operation patterns. Be sure to note unusual patterns, weekend or summer occupancy, especially if they affect total or seasonal energy usage. This information is also useful when comparing to Heating, Ventilation, and Air Conditioning (HVAC) schedules and understanding opportunities or limitations for certain EEM savings. Use a table format like this:

Building/Area	Hours/day	Days/ week	Annual hours	# during normal occupancy	% of the building used
e.g. lobby					
e.g. patient rooms					
e.g. operation rooms					
e.g. classrooms					
e.g. dorm rooms					
(…)					

System / Equipment Operation	Hours/day	Days/ week	Annual operation hours	# during normal occupancy
Heating System				
Cooling System				
Ventilation System				
Domestic Hot Water				
Lighting System - Interior				
Lighting System - Exterior				
(…)				

4.5. HVAC Systems and Equipment

a) Description of systems or equipment audited, their capacities and ratings, design and operating conditions, equipment schedules, etc., including information such as the type of systems, controls, type and number of auxiliary equipment, etc. Performance of systems or equipment audited (e.g., COP, SCOP, EER, SEER).

b) The system descriptions must contain sufficient detail to understand the building's major energy-using systems, including HVAC, Domestic Hot Water, Lighting, Plug Loads, and other.

The narrative should include explanations on the system type, age, nameplate capacity, condition, controls, the area served by each unit, operating schedules and sequence of operation/controls overview, current capabilities and limitations, and any significant known or suspected issues. This information should provide the necessary background to understand each EEM proposed.

All equipment information (e.g., brand, model, year of manufacture, power, capacity, nameplate power, quantity, duty/spare, constant/variable speed, heat recovery/no heat recovery, 100% outdoor air/mixed air, IE2/IE3/IE4 motor, etc.) must be provided, as well as a citation of data sources (e.g., data logging, cut sheets, design drawings, engineering assessment, etc.) for each critical value and condition.
Summary findings from the equipment surveys should also be included in the narrative. **The full equipment surveys must be included in the Appendix.**

Include a description of any operation or conditions that are outside of recommended or standard ranges (e.g., excessive run times, over or under-lit areas, high or low setpoints, etc.).

4.5.1. Heating System

System Description and Equipment Inventory:
Include a summary description of the heating system and HVAC zone(s) floor plan. Include a summary of the sequence of operations and equipment schedules (detailed documents/tables to be included in the Appendix). Descriptions can be grouped into the following categories:

a) Boiler Plant

Include a description of boiler plant(s) along with the distribution/circulation pumps and burners, heat exchangers, radiators and heating water control valves, fan-coil units and heating water control valves, VAV units and heating water control valves, air handling unit heating coils and heating water control valves, where applicable. Describe the air handling or terminal units served by each plant and the zones they serve. Include a schematic diagram in the form of a functional process flow or a single line diagram to describe the heating system including:

- boiler plants
- primary loop/secondary loop
- heating water header (show to which zones the header supplies heating water)
- heating water circulation pumps (primary/secondary)
- estimated heating capacity of each header and secondary loop/circuit

Include equipment surveys and refer to their relevant section in the Appendix. Equipment surveys shall include the following data/information depending on the nature of the equipment:

- brand / model,
- year of manufacture,
- heating/cooling capacity,
- COP / SCOP / EER / SEER / efficiency,
- flow rate / head / pressure,
- nameplate power,
- quantity (duty/spare),
- constant/variable speed,
- heat recovery/no heat recovery,
- 100% outdoor air/mixed air,

Equipment info should include an explanation for the assumption of working hours. It should also note any deficiencies with the current operations – under/overheating, unused equipment, broken/missing lights, equipment capacity too big/small.

Summary of Measurements, Calculations and Assessment

Indicate any measurements (flue gas analysis, supply/return water flow rate and temperature, etc.), relevant calculation results (thermal efficiency, etc.) and assessments of the current situation.

Energy Efficiency Measures Summary Description:

Propose two (if applicable) different improvement measures:

- Describe performance improvement measure for base scenario (economizer, oxygen trimming of burner, condensing boiler replacement, etc.)
- Describe performance improvement measure for deep renovation scenario (heat pump replacement, hybrid system of heat pumps backed up by condensing boilers, etc.)

Share the summary of heating energy saving calculation results for both base scenario and deep renovation scenario. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

Base Scenario EEM Savings			
Existing Heating Energy	Improved Heating Energy	Estimated Heating Energy Saving	Heating Energy Saving
[kWh]	[kWh]	[kWh]	%

Deep Renovation Scenario EEM Savings			
Existing Heating Energy	Improved Heating Energy	Estimated Heating Energy Saving	Heating Energy Saving
[kWh]	[kWh]	[kWh]	%

Based on energy savings, provide a summary analysis table of this EEM for each scenario:

Ref.	Subject / Description – Base Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Ref.	Subject / Description – Deep Renovation Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

b) Heating Water Circulation Pumps and associated heating energy emitters

Include a description of heating water circulation pumps (e.g., primary pumps, secondary pumps, tertiary pumps, etc.) along with the radiators and their control valves, fan-coil units and heating water control valves, VAV units and heating water control valves, air handling unit heating coils and heating water control valves, where applicable. Describe the air handling or terminal units served by each pump group and the zones they serve. Include equipment surveys and refer to their relevant section in the Appendix.

Summary of Measurements, Calculations and Assessment

Indicate any measurements (energy analyzer, flow rate and pressure, speed, etc.), relevant calculation results (efficiency) and assessments of the current situation.

Energy Efficiency Measures Summary Description:

Propose two (if applicable) different improvement measures:

- Describe performance improvement measure for base scenario (variable speed implementation to relevant pumps in combination with thermostatic radiator valves or 2-way motorized FCU valves)
- Describe performance improvement measure for deep renovation scenario (replacement of all pumps with integrated frequency converter pumps in combination with smart thermostats and balance valves or thermostatic radiator valves, etc.)

Share the summary of energy saving calculation results for both base scenario and deep renovation scenario. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

Base Scenario EEM Savings			
Existing System Energy	Improved System Energy	Estimated Energy Saving	Energy Saving
[kWh]	[kWh]	[kWh]	%

Deep Renovation Scenario EEM Savings			
Existing System Energy	Improved System Energy	Estimated Energy Saving	Energy Saving
[kWh]	[kWh]	[kWh]	%

Based on energy savings, provide a summary analysis table of this EEM for each scenario:

Ref.	Subject / Description – Base Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Ref.	Subject / Description – Deep Renovation Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Include equipment surveys and refer to their relevant section in the Appendix. Equipment surveys shall include the following data/information depending on the nature of the equipment:

- brand / model,
- year of manufacture,
- heating/cooling capacity,
- COP / SCOP / EER / SEER / efficiency,
- flow rate / head / pressure,
- nameplate power,
- quantity (duty/spare),
- constant/variable speed,
- heat recovery/no heat recovery,
- 100% outdoor air/mixed air,
- IE2/IE3/IE4 motor, etc.

Equipment info should include an explanation for the assumption of working hours. It should also note any deficiencies with the current operations – unused equipment, equipment capacity too big/small.

4.5.2. Domestic Hot Water (DHW) and Solar Thermal Hot Water System (if any)

System Description and Equipment Inventory:

Include a summary description of equipment, fuel type, capacity, the area served, and settings. This should include a description of tank and distribution, end-uses (e.g., showers for PE class and

sports, kitchen, laundry, etc.). Note the major end-use fixture types (e.g., faucets, showers, dishwashers, etc.) and if any end-use equipment has unexpectedly high hot water usage or leaks. Include equipment survey and refer to their relevant section in the Appendix.

Summary of Measurements, Calculations and Assessment
Indicate any measurements (flue gas analysis, etc.), relevant calculation results (thermal efficiency) and assessments of the current situation.

Energy Efficiency Measures Summary Description:
Propose two different improvement measures (if any):

- Describe performance improvement measure for base scenario (solar thermal hot water systems, etc.)
- Describe performance improvement measure for deep renovation scenario (heat pump systems, DHW heating supported by waste heat of cooling systems condenser loop, etc.)

Share the summary of DHW energy saving calculation results for both base scenario and deep renovation scenario as explained in previous sections. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

4.5.3. Cooling

System Description and Equipment Inventory:
Include a summary description of the cooling system and HVAC zone(s) floor plan. Include a summary of the sequence of operations and equipment schedules (detailed documents/tables to be included in the Appendix). Descriptions can be grouped into the following categories:

a) Chiller Plant

Include a description of chiller plant(s) along with the distribution/circulation pumps and heat exchangers, fan-coil units and chilled water control valves, VAV units and chilled water control valves, air handling unit heating coils and chilled water control valves, where applicable. Describe the air handling or terminal units served by each plant and the zones they serve. Include a schematic diagram in the form of a functional process flow or a single line diagram to describe the cooling system including:

- chiller plants and cooling towers (if any),
- primary loop/secondary loop
- chilled water header (show to which zones the header supplies chilled water)
- chilled water circulation pumps (primary/secondary)
- condenser water circulation pumps (if any)
- estimated cooling capacity of each header and secondary loop/circuit

Include equipment surveys and refer to their relevant section in the Appendix. Equipment surveys shall include the following data/information depending on the nature of the equipment:

- brand / model,
- year of manufacture,
- heating/cooling capacity,
- COP / SCOP / EER / SEER / efficiency,
- flow rate / head / pressure,

- nameplate power,
- quantity (duty/spare),
- constant/variable speed,
- heat recovery/no heat recovery,
- 100% outdoor air/mixed air,
- IE2/IE3/IE4 motor, etc.

Equipment info should include an explanation for the assumption of working hours. It should also note any deficiencies with the current operations – under/overheating/cooling, unused equipment, broken/missing lights, equipment capacity too big/small.

Summary of Measurements, Calculations and Assessment

Indicate any measurements (energy analyzer, water temperature, flow rate, etc.), relevant calculation results (COP) and assessments of the current situation.

Energy Efficiency Measures Summary Description:

Propose two different improvement measures:

- Describe performance improvement measure for base scenario (chiller replacement, evaporative cooling at condensers, outdoor air temperature compensation, insulation repair, heat recovery VRF units, etc.)
- Describe performance improvement measure for deep renovation scenario (heat pump systems, 4-pipe chillers, etc.)

Share the summary of cooling energy saving calculation results for both base scenario and deep renovation scenario. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

Base Scenario EEM Savings			
Existing Cooling Energy	Improved Cooling Energy	Estimated Cooling Energy Saving	Cooling Energy Saving
[kWh]	[kWh]	[kWh]	%

Deep Renovation Scenario EEM Savings			
Existing Cooling Energy	Improved Cooling Energy	Estimated Cooling Energy Saving	Cooling Energy Saving
[kWh]	[kWh]	[kWh]	%

Based on energy savings, provide a summary analysis table of this EEM for each scenario:

Ref.	Subject / Description – Base Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Ref.	Subject / Description – Deep Renovation Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

b) Chilled Water Circulation Pumps and associated cooling energy emitters

Include a description of chilled water circulation pumps (e.g., primary pumps, secondary pumps, tertiary pumps, etc.) along with the fan-coil units and chilled water control valves, VAV units and chilled water control valves, air handling unit cooling coils and chilled water control valves, where applicable. Describe the air handling or terminal units served by each pump group and the zones they serve. Include equipment surveys and refer to their relevant section in the Appendix.

Summary of Measurements, Calculations and Assessment

Indicate any measurements (energy analyzer, flow rate and pressure, speed, etc.), relevant calculation results (efficiency) and assessments of the current situation.

Energy Efficiency Measures Summary Description:

Propose two (if applicable) different improvement measures:

- Describe performance improvement measure for base scenario (variable speed implementation to relevant pumps in combination with 2-way motorized FCU control valves)
- Describe performance improvement measure for deep renovation scenario (replacement of all pumps with integrated frequency converter pumps in combination with smart thermostats and balanced FCU control valves)

Share the summary of energy saving calculation results for both base scenario and deep renovation scenario. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

Base Scenario EEM Savings			
Existing System Energy	Improved System Energy	Estimated Energy Saving	Energy Saving
[kWh]	[kWh]	[kWh]	%

Deep Renovation Scenario EEM Savings			
Existing System Energy	Improved System Energy	Estimated Energy Saving	Energy Saving
[kWh]	[kWh]	[kWh]	%

Based on energy savings, provide a summary analysis table of this EEM for each scenario:

Ref.	Subject / Description – Base Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Ref.	Subject / Description – Deep Renovation Scenario	Value	Unit
A	Investment / Implementation Cost		TL
B	Energy Saving		kWh
C			TOE
D	Energy Unit Price		TL/kWh
E = B x D	Energy Cost Saving		TL
F = A / E	Simple Payback Period		Years

Include equipment surveys and refer to their relevant section in the Appendix. Equipment surveys shall include the following data/information depending on the nature of the equipment:

- brand / model,
- year of manufacture,
- heating/cooling capacity,
- COP / SCOP / EER / SEER / efficiency,
- flow rate / head / pressure,
- nameplate power,
- quantity (duty/spare),
- constant/variable speed,
- heat recovery/no heat recovery,
- 100% outdoor air/mixed air,
- IE2/IE3/IE4 motor, etc.

Equipment info should include an explanation for the assumption of working hours. It should also note any deficiencies with the current operations – unused equipment, equipment capacity too big/small.

4.5.4. Packaged Units

System Description and Equipment Inventory:

Include a description of packaged unit equipment (e.g., DX, Heat pumps, Rooftop Units, etc.) and the zones they serve. Include equipment surveys and refer to their relevant section in the Appendix. Descriptions can be grouped into the following categories:

a) VRF Units
b) Multi Split Units
c) Split Units
d) Rooftop Units

Summary of Measurements, Calculations and Assessment
Indicate any measurements (energy analyzer, refrigerant gas, air temperature and flow rate, etc.), relevant calculation results (COP, SCOP, EER, SEER, etc.) and assessments of the current situation.

Energy Efficiency Measures Summary Description:
Propose two (if applicable) different improvement measures:
- Describe performance improvement measure for base scenario
- Describe performance improvement measure for deep renovation scenario

Share the summary of energy saving calculation results for both base scenario and deep renovation scenario. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

4.5.5. Mechanical Systems (Piping Systems and Components) Insulation

System Description and Equipment Inventory:
Refer and describe all insulation used in mechanical systems (heating / cooling / domestic hot water, ventilation systems, etc.)

Summary of Measurements, Calculations and Assessment
Indicate any measurements (thermal camera images, etc.), relevant calculation results (surface temperature loss, etc.) and assessments of the current situation.

Energy Efficiency Measures Summary Description:
Propose an improvement measure:
- Describe performance improvement measure both for base and deep renovation scenarios (insulation throughout the piping systems and components)

Share the summary of energy saving calculation results. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

4.5.6. Ventilation Systems and Other Airside HVAC System Equipment

System Description and Equipment Inventory:
Include a description of system equipment (e.g., air handling units, unit ventilators, exhaust fans, heat recovery units, etc.) and the zones they serve. Include equipment surveys and refer to their relevant section in the Appendix. Descriptions can be grouped into the following categories:

a) Air Handling Units
b) Heat Recovery Units
c) Unit ventilators
d) Exhaust fans

Summary of Measurements, Calculations and Assessment
Indicate any measurements (energy analyzer, supply/return water temperature, supply/return air temperature, flow rate, pressure, etc.), relevant calculation results (fan energy, heating/cooling energy, etc.) and assessments of the current situation.

Energy Efficiency Measures Summary Description:
Propose two different improvement measures:

- Describe performance improvement measure for base scenario (fan type change, belt replacement, variable speed drive implementation, demand control ventilation, etc.)
- Describe performance improvement measure for deep renovation scenario (heat recovery air handling unit replacement, heat recovery unit implementation, etc.)

Share the summary of energy saving calculation results for both base scenario and deep renovation scenario as mentioned in previous sections. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

4.6. Electrical Systems and Equipment

4.6.1. Electrical Installation, Power Generation, UPS

System Description and Equipment Inventory:
A full description of the electrical installation of the hospital (transformers, network, etc), of the possible power generation (i.e. generators) and of the installed UPS.

Equipment info should include an explanation for the assumption of working hours. It should also note any deficiencies with the current operations – under/overheating/cooling, unused equipment, broken/missing lights, equipment capacity too big/small.

Summary of Measurements, Calculations and Assessment
Indicate any measurements (thermal camera images, energy analyzers, etc.), relevant calculation results (transformer loss, etc.) and assessments of the current situation.

Energy Efficiency Measures Summary Description:
Propose an improvement measure:

- Describe a performance improvement measure both for base and deep renovation scenarios

Share the summary of energy saving calculation results as mentioned in previous sections. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

4.6.2. Pumps and Fans (Electrical Motors)

System Description and Equipment Inventory:
Include a summary description of equipment if not addressed in the HVAC chapter. Include equipment surveys and refer to their relevant section in the Appendix.

Summary of Measurements, Calculations and Assessment
Indicate any measurements (thermal camera images, energy analyzers, etc.), relevant calculation results (electrical efficiency, etc.) and assessments of the current situation.

Energy Efficiency Measures Summary Description:
Propose an improvement measure:

- Describe a performance improvement measure which may be used in both base and deep renovation scenarios

Share the summary of energy saving calculation results as mentioned in previous sections. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

4.6.3. Lighting (Interior and Exterior)

System Description and Equipment Inventory:
Include a summary description of lighting fixtures, power, lumen, lux levels, areas served, and control types. Include lighting survey and refer to their relevant section in the Appendix.

Summary of Measurements, Calculations and Assessment
Indicate any measurements (lux levels, energy analyzers, etc.), relevant calculation results (efficacy, lighting power density, etc.) and assessments of the current situation.

Energy Efficiency Measures Summary Description:
Propose two different improvement measures:

- Describe performance improvement measure for base scenario (LED replacement and sensors)
- Describe performance improvement measure for deep renovation scenario (solar tubes, daylight harvesting, daylight automation, enhanced lighting automation, etc.)

Share the summary of energy saving calculation results as mentioned in previous sections. (Details of the energy saving calculations shall not be provided in this section but referred to the relevant annex of the audit report.)

4.6.4. Plug loads and Other Equipment

Only include data if it is relevant for the audit work. If so, include a summary description of the location, type, and quantity. In case of hospitals, the data should be separated into medical and non-medical equipment. Include equipment survey and refer to their relevant section in the Appendix.

4.7. Energy Rates Analysis and Providers

In this section should be stated the actual tariffs and utility providers for the facility. The cost should be separated between the fixed tariff (e.g. power) and the net energy (e.g. kWh) tariff. Tariff analysis should be carried out to explore further advantageous energy supply opportunities.

		Year #1	Year #n
Electric Utility Provider	Type of tariff		
	TL/kWh		
	Yearly average spending		
Natural Gas Provider	Type of tariff		
	TL/kWh		
	Yearly average spending		
Other energy Provider	Type of tariff		
	TL/kWh		
	Yearly average spending		

In the “Other Energy Provider”, all different types and amount of fuels have to be clearly specified.

4.8. Power Compensation System

Analyze the final year’s energy consumption break down and see if the building exceeds the electricity grid’s power factor thresholds and therefore penalized. Based on the analysis, relevant improvement measures shall be developed and proposed.

5. Energy Management and no/low-cost opportunities

a) Energy Management or O&M Measures

Include any relevant operational or maintenance measures. Follow the same instructions and template used for EEMs. This section would also include any negative energy savings measure that may be necessary for the implementation of an EEM or needed to help meet a specific operation or maintenance requirement (e.g., increased ventilation or lighting levels).

b) Low and No-Cost EEMs

Include a list of any important Low or No-cost EEMs applicable to the facility.
Please include a brief note for any measures analysed, but not included in EEM section of the report. Also, explain if any measure was not analysed, but sections of the audit report may suggest a measure might be needed (e.g., uninsulated shell but payback would have been over 50 years).

6. Building Management Systems (BMS) and metering systems

Individual equipment controls should be included with notations of the related equipment that they control. Building level/global controllers should be explained in the narrative. Include existing control configuration(s) and operating sequence(s).

Add BMS if needed in the EEM list. As a general rule present a monitoring system with central control in the deep renovation scenario if the facility can manage it and only recommend it if payback for this measure is less than 20 years.

Please note that basic building-level metering should be a mandatory measure in all scenarios if does not exists and if exists has to be described even if briefly in the systems description. The basic version should be aimed at primary level energy and to Install new or use existing base building-level energy meters, or submeters that can be aggregated to provide base building-level data representing total building energy consumption (electricity, natural gas, fuel oil, propane, etc.). Utility-owned meters capable of aggregating base building-level resource use are acceptable. The basic system can be standalone (e.g. without automated report capabilities or software aggregation).

7. On-site Generation and Renewable Energy Systems

Include data and assessment about on-site generation:

- cogeneration/trigeneration systems

and renewable energy systems:

- rooftop photovoltaic solar systems,
- over canopy solar photovoltaic systems in open parking lots (probably along with electric vehicle charging stations)
- rooftop solar thermal systems.

Some issues have to be addressed in the narrative, in text and table or schematic format:

- total installed power,
- total energy production,
- installation summary description,
- schematic representation on site layout plans or roof plans
- connection point, if there is an off-site sale of energy (etc.).

Include some schematics (e.g. drawings for Photovoltaic (PV) panel installation site). Present in the Appendix calculation sheet for forecasted/simulated energy production.

8. Energy Efficiency Measures Bundling and Details

The EEMs list will be presented in scenarios tables. The tables should follow this format:

No.	EEM	Type of energy [eletrical, gas etc.]	Estimated annual energy savings [kWh]	Estimated annual energy savings [TOE]	Saving % (of total consumption)	Estimated annual cost savings [TL]	Emissions reduction [tonCO_2e]	Estimated implementation cost [TL]	Payback period [years]	IRR (20-year)	NPV (20-year)
1											
2											
3		Elec.									
		N. Gas									
(…)											
Total Energy Saving		Elec.									
		N. Gas									
		Tot.									
Total Energy Savings [%]											
Total Primary Energy Savings [%]											

As indicated in the executive summary, three scenarios (along with three tables) will be presented:

a) **Base scenario** with measures that save a minimum of 20% and the average payback period as a bundle will not exceed 12 years.

b) **Deep renovation scenario** with measures that will have a minimum of 40%* and the average payback period as a bundle will not exceed 20 years.

c) **Recommended bundle of measures** (**Mix scenario** - this could be a selection of measures from the base scenario, a selection of measures from the deep renovation scenario, or a mix of measures from the base and deep renovation scenario).

***** Primary energy efficiency improvement percentage may be used for calculating overall energy efficiency calculation of the deep renovation scenario in case on-site electricity production measures are proposed such as cogeneration/trigeneration, etc.

Provide an extra line for each type of energy vector that is saved in each measure.

After the table section, provide a complete description of each individual EEM proposed under a sub section. Description of each EEM shall include at least the following three paragraphs enriched with simple schematic representations where necessary:

- existing status/application before the proposed EEM

- targeted status/application after the proposed EEM
- how the proposed EEM will be implemented, how the system/operation would be made more efficient or how the new equipment would reduce energy use. The EEM implementation description must be sufficient to ensure facility staff understand how proposed EEM can be implemented or how this information will be used by an engineer/contractor for design and specification work. (be specific, detailed, thorough)

If there are differences between the base scenario and the deep scenario for the same EEM due to cross-effects, please describe the rationale (e.g., different savings values for the same piping insulation measure).

The EEM presentation and analysis are detailed in the Appendix sections (under “General notes regarding EEMs”).

Each EEM’s individual summary financial analysis along with their 20-year cash flows, net present value and IRR calculation tables shall be included in this section of the report. Detailed calculation sheets, assumptions, investment cost calculations may be referred to the relevant annex section of the audit report.

9. Energy Performance Class (EKB)

The building energy class should be stated in a short table:

Current Energy Performance Class	Energy Performance class under Proposed Scenario

Please embed the Energy Performance Certificate (EPC) front page or Preliminary EPC Calculation Report for both current status and proposed status of the building.

10. Measurement & Verification Methodology

This chapter shows the approach to be used as a basis for measurement and verification plan to be prepared right after this audit report is approved. Hence, measurement & verification methodology to be laid out in this chapter can be assumed as preliminary version of M&V plan to be prepared by the Consultant. There should be a clear path and hard data for reference energy consumption data (baseline), reference conditions for measurement and verification (M&V) accordingly with International Performance Measurement and Verification Protocol (IPMVP) and a general description of what events will be accepted for baseline change.
The general information should be given in a table format:

Proposed EEM	**Energy Type**	**M&V Option based on IPMVP**	**Reliability (%)**	**Sensitivity (%)**	**Energy Savings [kWh]**	**Energy Savings [TOE]**
EEM #01	Elect.	Option A				
EEM #02	N. Gas	Option B				
EEM #04	N. Gas					
EEM #03						
EEM #05						
(…)						

Proposed EEM	Total Usage Area that Project will affect	Electricity Consumption	Natural Gas Consumption	Other Fuel (Please Specify) Consumption	Total Energy Consumption	Total Energy Cost	Reference O&M Cost	Total Emissions
	[m2]	[TOE/Year]	[TOE/Year]	[TOE/Year]	[TOE/Year]	[TL/Year]	[TL/Year]	[Ton CO2 Eq.]

10.1. Baseline Energy and Calculation of Energy Indicators

Based on the available data on electricity and heating fuel consumption, energy baselines should be constructed for:

(i) electricity and
(ii) heating fuel by correlating the electricity or heating fuel consumption with the average monthly outdoor temperatures, preferably over a period of 3 calendar years.

For the baseline energy generation, a calendar year should be divided into three zones:

- Winter zone, with temperatures $T_{ex} \leq 15.0\ ^oC$,
- Intermediate zone, with temperatures $15.0 < T_{ex} \leq 22.0\ ^oC$ and the

- Summer zone, with temperatures T_{ex}> 22.0 ºC.

An example of the construction of an electricity baseline is shown below, using the following definitions:

- Electricity consumption E = b1 * T + b0
- b1: Regression coefficient
- T: Monthly average ambient temperature
- b0: Regression coefficient
- a/a: Number of the month
- RMSE: Root mean square error – the standard deviation of the residuals (prediction errors), where residuals measure the distance between the data points and the regression line.
- Min. target EE = RMSE / (average of the expected electricity consumption [baseline] of the zone)^2

Month - Year	A/A	Temperature (°C)	Electricity cons (kWh)	
Jan 19	13	9,7	144.018	
Feb 19	14	10,1	129.874	
Mar 19	15	13,6	173.838	
Apr 19	16	15,4	158.064	
May 19	17	19,9	165.948	
Jun 19	18	26,8	173.279	
Jul 19	19	28,2	205.729	
Aug 19	20	29,3	202.823	
Sep 19	21	24,8	162.341	
Oct 19	22	21,3	154.332	
Nov 19	23	17,7	138.543	
Dec 19	24	12,2	154.641	

Observed data

SUMMER ZONE	A/A	Temp .(°C)	Electricity (kWh)	Baseline
Jun 19	18	26,8	173.279	181.131,7
Jul 19	19	28,2	205.729	195.607,1
Aug 19	20	29,3	202.823	206.980,6
Sep 19	21	24,8	162.341	160.452,6
b1	b0	Average	186.043	186.043,0
10.339,5	-95.968,1	RMSE	9.616,9	Min. target EE
3,62	-1,23	< -t Stud/R2->	0,867	10,34%

Calculated data

WINTER ZONE	A/A	Temp .(°C)	Electricity (kWh)	Baseline
Jan 19	12	9,7	144.018	145.934,5
Feb 19	13	10,1	129.874	146.238,3
Mar 19	14	13,6	173.838	148.896,8
Nov 19	15	17,7	138.543	152.011,0
Dec 19	24	12,2	154.641	147.833,4
b1	b0	Average	148.183	148.182,8
759,6	138.566,7	RMSE	19.332,7	Min. target EE
0,25	3,57	< -t Stud/R2->	0,021	26,09%

INTEMEDIATE	A/A	Temp .(°C)	Electricity (kWh)	Baseline
Apr 19	17	15,4	158.064	159.618,4
May 19	22	19,9	165.948	159.397,2
Oct 19	23	21,3	154.332	159.328,4
b1	b0	Average	159.448	159.507,8
-49,2	160.375,5	RMSE	8.384,1	Min. target EE
-0,03	4,38	< -t Stud/R2->	0,001	10,51%

BASELINE CONSTRUCTION

ALL ZONES	A/A	Temp .(°C)	Electricity (kWh)	Baseline
Jan 19	13	9,7	144.018	145.934,5
Feb 19	14	10,1	129.874	146.238,3
Mar 19	15	13,6	173.838	148.896,8
Apr 19	16	15,4	158.064	150.264,0
May 19	17	19,9	165.948	153.682,0
Jun 19	18	26,8	173.279	158.923,0
Jul 19	19	28,2	205.729	159.986,4
Aug 19	20	29,3	202.823	160.821,9
Sep 19	21	24,8	162.341	157.403,9
Oct 19	22	21,3	154.332	154.745,4
Nov 19	23	17,7	138.543	152.011,0
Dec 19	24	12,2	154.641	147.833,4
TOTAL			**1.963.430**	**1.836.740,7**

Calculated data

Diagram 1 shows the monthly electric consumption in relation to the average monthly outdoor temperature and the corresponding baselines for the different temperature zones.

Diagram 1. Correlation of monthly electricity consumption to the mean average outdoor air temperature for the period January to December

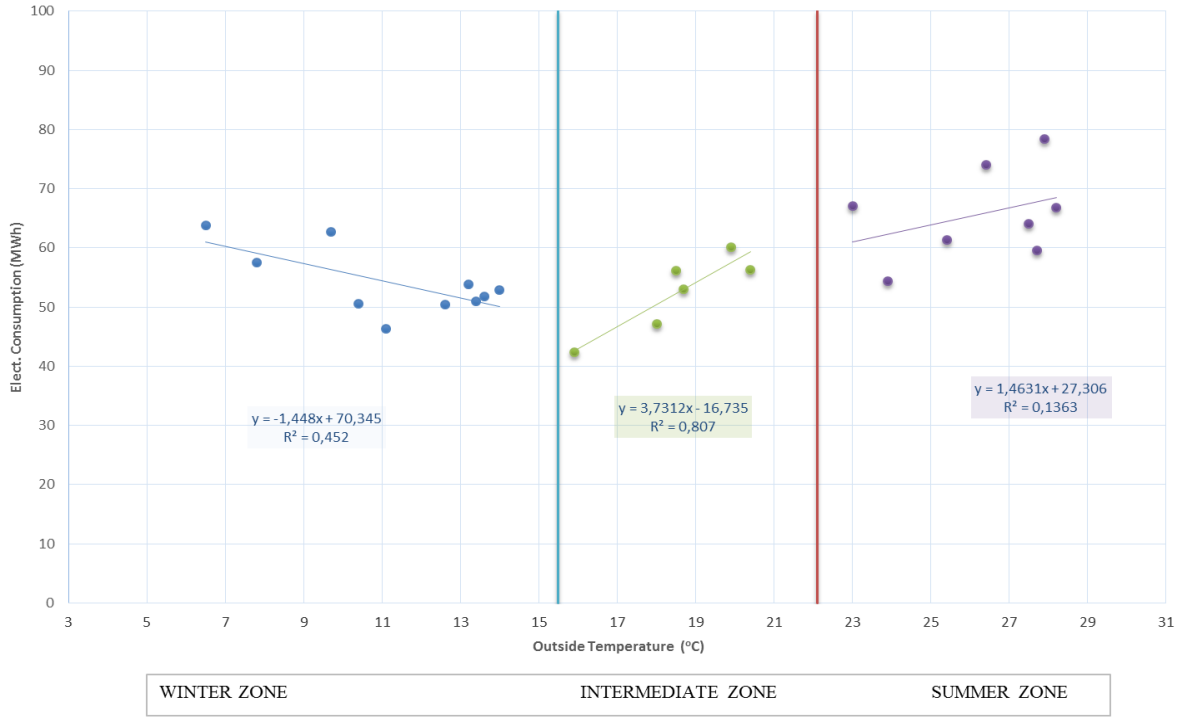

Table 1 provides details on the monthly actual consumption and expected corresponding values calculated from the baseline for the period from January December. Data are split into three zones based on the ambient temperature (as described above). The table also presents the estimated energy performance indicators, evaluation of the current situation, and the possibility of energy saving interventions.

- Divergence of balance = (monthly electric consumption recorded in bills) – (monthly expected electric consumption, baseline)
- CUSUM: Cumulative SUM of deviation between monthly electricity consumption and expected consumption. If m samples are collected, each of size n, compute the mean of each sample. Then the cumulative sum (CUSUM) is formed by one of the following equations.

$$S_m = \sum_{i=1}^{m} (\bar{x}_i - \hat{\mu}_0) \quad \text{or} \quad S'_m = \frac{1}{\sigma_{\bar{x}}} \sum_{i=1}^{m} (\bar{x}_i - \hat{\mu}_0)$$

  - where μ^0 is the estimate of the in-control mean
  - σx¯ is the known (or estimated) standard deviation of the sample means

The choice of which of these two quantities is plotted is usually determined by the statistical software package (see regression in EXCEL). In either case, as long as the

process remains in control centred at μ^0, the CUSUM plot will show variation in a random pattern centred about zero.

- Energy Performance Indicator, EPI = (consumed energy) / (monthly average ambient temperature)
- Energy Target Coefficient, ETC = (consumed energy) / (expected energy consumption)

Table 1. Estimation of energy indicators for January to December

	Month / Year	Divergence of Balance (MWh) Divergence per zone						CUSUM (MWh)						Energy Performance Indicator, EPI (MWh/Month)	Energy Target Coedfficient, ETC
								1					2	3	
WINTER ZONE	Jan 18	0,00						0,00							0,000	0,000
	Feb 18	0,00						0,00							0,000	0,000
	Mar 18	0,00						0,00							0,000	0,000
	Nov 18	0,00						0,00							0,000	0,000
	Dec 18	0,00						0,00							0,000	0,000
	Jan 19	-1,92						-1,92							1,485	0,987
	Feb 19	-16,36						-18,28							1,286	0,888
	Mar 19	24,94						6,66							1,278	1,168
	Nov 19	-13,47						-6,81							0,783	0,911
	Dec 19	6,81						0,00							1,268	1,046
INTERMEDIATE ZONE	Apr 18		0,00						0,00						0,000	0,000
	May 18		0,00						0,00						0,000	0,000
	Oct 18		0,00						1,55						0,000	0,000
	Apr 19		-1,55						-5,00						1,026	0,990
	May 19		6,55						0,00						0,834	1,041
	Oct 19		-5,00						0,00						0,725	0,969
SUMMER ZONE	Jun 18			0,00						0,00					0,000	0,000
	Jul 18			0,00						18,46					0,000	0,000
	Aug 19			0,00						15,06					0,000	0,000
	Sep 18			0,00						21,16					0,000	0,000
	Jun 19			-7,85						18,00					0,647	0,957
	Jul 19			10,12						16,23					0,730	1,052
	Aug 19			-4,16						7,94					0,692	0,980
	Sep 19			1,89						0,00					0,655	1,012

Diagram 2 shows the correlation of the monthly electric consumption and electric baseline for the period January to December.

Diagram 2. Correlation of monthly electricity consumption and electricity energy baseline for the period of January to December

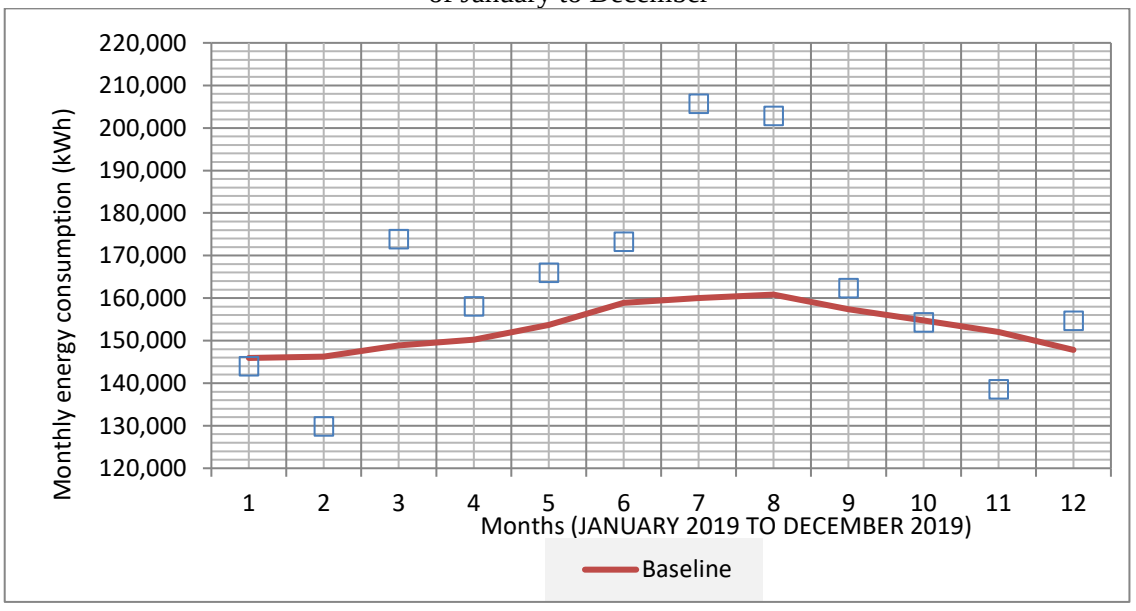

Table 3 presents a summary showing the minimum values of EPI and ETC for each of the three zones.

Table 3. Energy indicators

Winter		**Temp (ºC)**	**Electr (MWh)**	**Month**	**EPI**	**ETC**
EPI_{min}	0,783	17,7	138,5	Nov 19	-	0,91
ETC_{min}	0,888	10,1	129,9	Feb 19	1,29	-
$RMSE_{max}$=	19332,69					

Intermediate		**Temp (ºC)**	**Electr (MWh)**	**Month**	**EPI**	**ETC**
EPI_{min}	0,725	21,3	154,3	Oct 19	-	0,97
ETC_{min}	0,969	21,3	154,3	Oct 19	0,72	-
$RMSE_{max}$=	8384,09					

Summer		**Temp (ºC)**	**Electr (MWh)**	**Month**	**EPI**	**ETC**
EPI_{min}	0,647	26,8	173,3	Jun 19	-	0,96
ETC_{min}	0,957	26,8	173,3	Jun 19	0,65	-
$RMSE_{max}$=	9616,91					

11. Audit Appendices

The report appendixes must contain useful information to understand the narrative of the EEMs choice, but also to keep all this information form the main body of the report, for simplicity of analysis. The appendixes can be the following:

a) General Audit Appendices
   - Energy End-Use Calculations
   - Energy Modelling Documentation (if energy modeling approach is preferred for EEM calculations by the Consultant)
   - Equipment Surveys
   - Sequence of Operation of Major Equipment and Systems

b) EEM Related Appendices
   - EEM Specific Requirements and Assumptions
   - EEM Energy Calculation Sheets
   - EEM Cost Estimation and Proforma Invoices
   - EEM Technical Data Sheets, Brochures or Cut Sheets

c) Site Measurement Appendices
   - Onsite Visits and Monitoring
   - Data logging and Monitoring Results
   - Site pictures

12. General Information Appendixes

12.1. General Notes

General requirements are items that the energy Consultant must use based on the information gained during the audit. Energy Audit Reports must follow this template report:
Energy Efficiency Measures (EEMs) and Simple Payback (SP) Requirements.

a) All potential EEMs with a *likely* SP less than 20 years (or insulation measures with any SP) must be analyzed.
b) All analyzed EEMs must be included in the Energy Audit Report.
c) Alternate formats may be used only after requesting and receiving prior written approval. If used alternate formats must still include all Sections Headings and required information, be presented in a concise manner, and include all supporting data and documentation.

Energy Audit Reports must be complete and well written. The report should demonstrate sufficient clarity to persons possessing moderate facility knowledge and an average understanding of energy engineering principles. They must be consistent and accurate. Values and measurements for a specific item or usage should be consistent across the entire Energy Audit Report and all supporting documents, including spreadsheets, modelling files, and other related documents.
Information on data collection for the principal energy systems and end uses, should be presented if needed with on-field interviews:

a) What is, if any, the current metering setup.
b) Data source. Statement about which data was used and which was measured, and which was estimated.
c) Provide a complete description of existing conditions. Provide a summary of all related measured site data, including monitoring results, measurements, light levels, and other relevant information. Include sketches, photographs, and expanded narrative for clarity where applicable or required.

12.2. Calculations and Energy Modelling Requirements

Calculations used in analyses must be supported with sufficient detail and include justification of all assumptions. Calculations completed in spreadsheets must not hide any cells or contain any data, formulas, or referenced cells that are not relevant to the particular audit.
Consultants must use industry-accepted calculation methods to predict achievable energy savings (e.g., ASHRAE Guideline 14, TS 825, etc.). Calculation methods and assumptions must be clearly stated and supported. Accepted sources and citations may include metered data, peer-reviewed and industry-recognized white papers, energy clearinghouses, textbooks, and other similar sources. Use of such sources must be cited and clearly presented.
In case energy modelling approach is followed by the Consultant, use building annual energy or use hourly simulations of energy use by energy source suitable for determining both load analysis and the proposed energy use for each proposed EEM.
The Energy Audit Report must clearly and separately list the baseline and proposed (post-EEM) parameters and inputs. All modelling inputs should reflect actual building characteristics and conditions as described in the Energy Audit Report.

12.3. Energy Modelling Documentation (If Energy Modeling Approach is preferred or used for EEM calculations by the Consultant)

If completing energy modelling using whole-building energy simulation computer programs, the Consultant must use annual energy use hourly simulations. Guidance and requirements for modelling done with annual energy use hourly simulations can be found in the ASHRAE 90.1-2016 Appendix G.
The firm must include all the following documentation in this Appendix:

a) Which modelling software and version was used.
b) How the model was calibrated to utility data to be within ± 10 per cent.
c) Key model inputs and outputs for each modelling run. (all inputs and outputs shall be provided in the form of a MS Word or Adobe pdf document so that energy model's compliance with the current facility conditions can be confirmed.)

All inputs and outputs should match narrative and data presented in the Energy Audit Report (e.g., equipment survey, data logging results, building characteristics narrative, etc.).
It is still necessary to provide a summary of how the EEMs save energy along with the details as to how estimated energy savings were calculated. Energy auditing firms should fully understand the methodology behind any energy-savings calculations provided by the model, detail this methodology in the Energy Audit Report, and be able to explain the accuracy and reasonableness of any savings estimates.

12.4. Equipment Surveys

A simple template for an equipment survey has to be used for the survey. One example is below (chillers). Complete the tables and provide any additional information to document all equipment at the facility fully. Any necessary information or system characteristics that cannot be fully incorporated into the tables should be included in alternative tables and narrative within the report.

General Information								
Ref.	Area Served	Year	Manufacturer	Model	Capacity [kW]	Refrigerant	Type	Air or water-cooled

Ref.	Efficiency			Controls		
	COP 100% load	COP 50% load	Eurovent	supply setpoint	Return Setpoint	Recovery setpoint

Ref.	Measurements				
	Water supply temp	Water return temp	Intake power [kW]	Water flow [l/h]	Outside temperature

12.5. HVAC Controls

If applicable, provide a detailed narrative for building-level/global controllers. The narrative for controls should include:

a) Age and condition
b) Type (electronic, pneumatic, combination)
c) Manufacturer and model number
d) Areas and equipment controlled
e) Control configuration and operating sequence
f) Control capabilities and limitations (e.g., optimized start, web interface)
g) Maintenance or operational issues.

12.6. Equipment Survey: Domestic Hot Water

Provide a detailed narrative for Hot Water production and distribution systems and controls. Include a brief explanation of the end uses locations and needs in terms of power and temperature. The actual system behaviors should also be analysed from user feedback in terms of flow availability and temperature.

12.7. Equipment Survey: Lighting

Include all interior and exterior lighting showing specific locations by area, space, room number, or other individual space identification with the actual number and type of existing fixtures. Survey the building to determine connected interior and exterior lighting power and energy usage. Document existing lighting levels, lamp and ballast types, wattages, and controls. Use sampling if more efficient. Document the existence of any hazard's materials, including PCBs and mercury.
It is important to refer if the actual lighting levels are not satisfactory or if there are an important percentage of the lighting fixtures not working or disconnected from the occupants or facility manager feedback.

13. EEM Related Appendices

13.1. General notes regarding EEMs

a) EEMs Scenarios

As already stated in the main template body, the EEMs list will be presented in scenarios tables.
The objective is to show the bundling effect of EEMs. The bundling scenario will be treated as one stand-alone EEM, with the totals being the cross-effect value from the whole bundling analyzed together.
As guidance, the recommended package should not include i) measures with payback periods longer than 20 years except for building envelope measure and ii) measures with paybacks longer than the lifetime of the equipment.
If no EEMs can match the conditions, the table will be empty.
If there are obvious problems for improved insulation application, the Consultant can skip the analysis stating the technical rationale in the narrative.

There should be different formatting (e.g., font color) to highlight what insulation is added in the basic and deep renovation scenario compared to the existing situation.

b) EEM Description

Provide a complete description of each EEM proposed. Describe how the system/operation would be made more efficient or how the new equipment would reduce energy use. The description must be sufficient to ensure facility staff understand how proposed EEM can be implemented or how this information will be used by an engineer/contractor for design and specification work.
Recommendations must meet current code requirements and standard design recommendations:

1. Describe any repairs or operational changes required for the EEM to be effective. Outline how the implementation of EEM may impact operations and maintenance (O&M) procedures and cost, any new operating skills required, recommended training & hiring, and any impact on existing equipment life;
2. Briefly describe any other impacts on occupant health, comfort or safety, as well as non-energy benefits, especially improvements to health, safety and environment, decreases in equipment run time, and maintenance labor hours. This should also include: Hazardous material disposal issues (e.g. PCB ballasts, asbestos) and ventilation and indoor air quality (IAQ) issues (e.g. new equipment may increase ventilation);
3. Commissioning Requirements. Include documents related to commissioning and scope of services in the Appendix;
4. The Systems/Equipment responsible for any meaningful consumption has to be addressed the EEM list to avoid having large consumption vectors without any intervention. If they are not addressed, the Consultant should briefly explain why.
5. A detailed explanation should also be given in the case that one particular equipment is not changed by not only more efficient but also for smaller capacity systems due to heat/cooling supply from trigeneration and reduced loads from insulation/window upgrade, for example

c) EEMs Cross Effect

When considering multiple EEMs with interactive effects between measures, the order of analysis must start with load reduction measures and proceed with distribution systems and associated equipment efficiencies, and then plant and heat rejection systems.
For EEMs that involve system interactions within a single EEM (e.g., lighting retrofits that affect HVAC loads), those system interactions should be considered within that particular EEM analysis.
When analyzing measures with interactive effects, include in the analysis:

1. Explanation of how EEMs interact with one another;
2. If and why savings from this EEM may be more or less effective depending on other EEMs;
3. Note if EEM is independent of all other EEMs in terms of savings or its practical application.
4. Interactions within lighting EEMs should be shown on the same row in the table (i.e., electrical savings entered as a positive value (net of cooling savings if any) and any non-electric heating should be entered as a negative value in appropriate heating fuel column. Assumptions on heating/lighting interactions (e.g. percentage of heat loss to conditioned space) should be explained in the EEM Section of the report.

5. If including mutually exclusive EEMs, list each as an individual row on the tables. Only one of the mutually exclusive EEMs should be included in the TOTAL EEM Energy Savings calculation (e.g., include only the recommended EEMs as to not "double count" measures in the total).

For each EEM, note if any significant variance in savings (+/- 20%) would occur if that measure is performed stand-alone, without the other proposed EEMs (for example, boiler replacement without other load reduction EEMs).

d) Cost-Benefit Analysis

Include a Cost-Benefit Analysis (e.g., payback, NPV and IRR) for each individual EEM and for the bundle total.

1. Energy Savings: Calculate estimated energy savings and energy cost savings associated with each proposed EEM. When estimating energy cost savings, use and display current energy prices and rates, or refer to the report.
2. Cost Estimates: Provide summary cost estimates in the table, with detailed cost estimates located in the Appendix.
3. O&M savings are included in the EEM cost and should be described in the EEM section.
4. There must exist a clear indication (on the table, on footnote etc.) of the reference prices used for energy.

13.2. Cogeneration/Trigeneration details

If cogeneration (or trigeneration) is evaluated as energy efficiency improvement, then natural gas increase and electricity reduction should be given in details in a table format.

Fuel Consumption at Full Load [kw]	Max.Electricity Generation [kWe]	Max. Heat Generation [kWt]	Annual Expected Electricity Generation [kWh]	Annual Expected Heat Generation [kWh]	Annual Operation and Maintenance Cost [TL]	Annual Fuel Cost [TL]	Total Electricity and Heat Savings [TL]	Investment Cost [TL]	Pay Back [Year]

13.3. Financial analysis and legal requirements

The discount rate for NPV calculations (TL based) is 15%.
The USD/TL and EUR/TL exchange rates for the investment/maintenance cost conversion of imported goods/services will be determined by PIU at the beginning of the energy audit process.
Energy unit prices in TL will be assumed to be inflated by 12.75% per year regarding NPV calculations.
The NPV analysis is made over 20 years.
For NPV calculations investment expenses should occur in Year 0 and the first annual energy cost savings should then be accounted for in Year 1. The re-investments should be accrued in the year they are expected to occur. The O&M and other recurring yearly costs should be stated when they occur at today's prices.
The average life span of the EEMs, is the following:

EEMs	Working life [years]
Building insulation	35
Building windows	35
LED Lighting fixtures	12
Controls (BMS. Lights etc.)	10
Distribution systems (air&water)	20
Solar PV	25
Chillers and boilers	20
Other heat generation devices	20

LED working life is based on 50 000 hours. The 12 years of working life assume roughly 4150 hours per year. If the usage is significantly different, please adjust the working life, based on the actual working life of the proposed LED.
If other values are used, or if there are systems not referred to in the table, please describe the rationale, as a footnote of the EEM table.
If the NPV period analysis is larger than the EEMs useful life, some reinvesting funds have to be considered for the savings to be considered over the full NPV time analysis. If the economic lifetime of an equipment which is proposed to be installed in an energy efficiency measure is less than 20-year NPV timeframe (i.e. 8 years), reinvestments (i.e., at the 9^{th} year and 17^{th} year) of that equipment shall be included in the 20-year cash flows, net present value and internal rate of return calculations. Reinvestment costs are not included in the first investment cost and simple payback period of the energy efficiency measure which is shown in the EEMs list (base scenario, deep renovation scenario, recommended or mix scenario).

13.4. Lighting Measures (Interior and Exterior)

a) Provide a detailed lighting schedule showing specific locations (by area, space, room number, or other individual space identification) with the proposed number and type of new lamps, luminaires, ballasts and fixtures. Should be in table format.
b) When adding or upgrading lighting controls, detail the proposed operation scheme. Include the number, type, and location of new controls. Include explanation, assumptions, or data-logging to support any reductions in light levels or operating hours.
c) Recommend using sketches of new fixture layouts or controls to explain proposed measures.
d) Calculate the reductions in lighting energy and include any increases or decreases in other forms of energy use, such as increased heating, associated with installing the EEM.
e) For calculations, include all results, explain methodology and assumptions, and document all key input variables.
f) Use lighting simulation software (Dialux or equivalent) to verify the new fixture layout or fixture distribution. Verification must be used when minimum light levels and uniformity are a safety concern (e.g. parking lots, pedestrian areas, stairways, etc.).

13.5. EEM Investment Calculations

Include all supporting documentation for EEM Energy Calculations. Include key documents:

a) Materials & Equipment: Identify vendor and contact person who provided material and equipment estimates. Include dates and sources of information.
b) Labor: Must use prevailing wage rates. Include separate "Hours" and "$/Hour" rate. If vendor quotes are used, including dates and sources of information.
c) Itemize specific costs related to design and engineering, contractor overhead and profit, and contingency, if any. Document the source of estimates, amount, and a brief description that includes assumptions and data sources.
d) Disposal & Salvage: Indicate any required or expected disposal costs, including hazardous materials or abatement. Include any salvage value or possible reuse of materials. Document the source of estimates, amount, and a brief description that includes assumptions and data sources.
e) Commissioning: Include estimated commissioning cost for EEMs that require commissioning.
f) Add any additional explanation in the narrative below the table.

13.6. EEM Data Sheets, Brochures and Cut Sheets

Include all manufacturer or vendor cut sheets and performance data for recommended equipment and systems. Indicate or highlight key specifications (e.g., efficiency rating, wattage, size, etc.) used in developing the EEM and EEM savings.

14. Site Measurements Appendixes

14.1. Onsite Visits and Monitoring

a) For each visit, list:
   - Date,
   - Purpose
   - Critical notes or findings.
b) For each dataset/parameter, list the following:
   - Dates (Installed and removed);
   - Logging period (if different):
   - For instantaneous/point measurements: List date, time, location
   - Purpose and Measured Parameter(s)
   - Placement (equipment, location, etc.)
   - Quantity and type
   - Logging Interval(s).
c) Any issues or abnormalities that may have affected monitoring data.

14.2. Data Logging and Monitoring Results

Include a summary description of data logging and monitoring methodology. Include monitoring type (e.g., instantaneous, load profile, periodic total) and general approach. Trend data should indicate duration and intervals, with key monitoring graphs and charts included.

Must include all key results that support the assumptions and recommendations made in the Energy Audit Report.
All charts and graphs should include a brief explanation of results and significance to the Energy Audit Report findings. Include annotations to graphs and charts as needed to illustrate key points or explain anomalies.