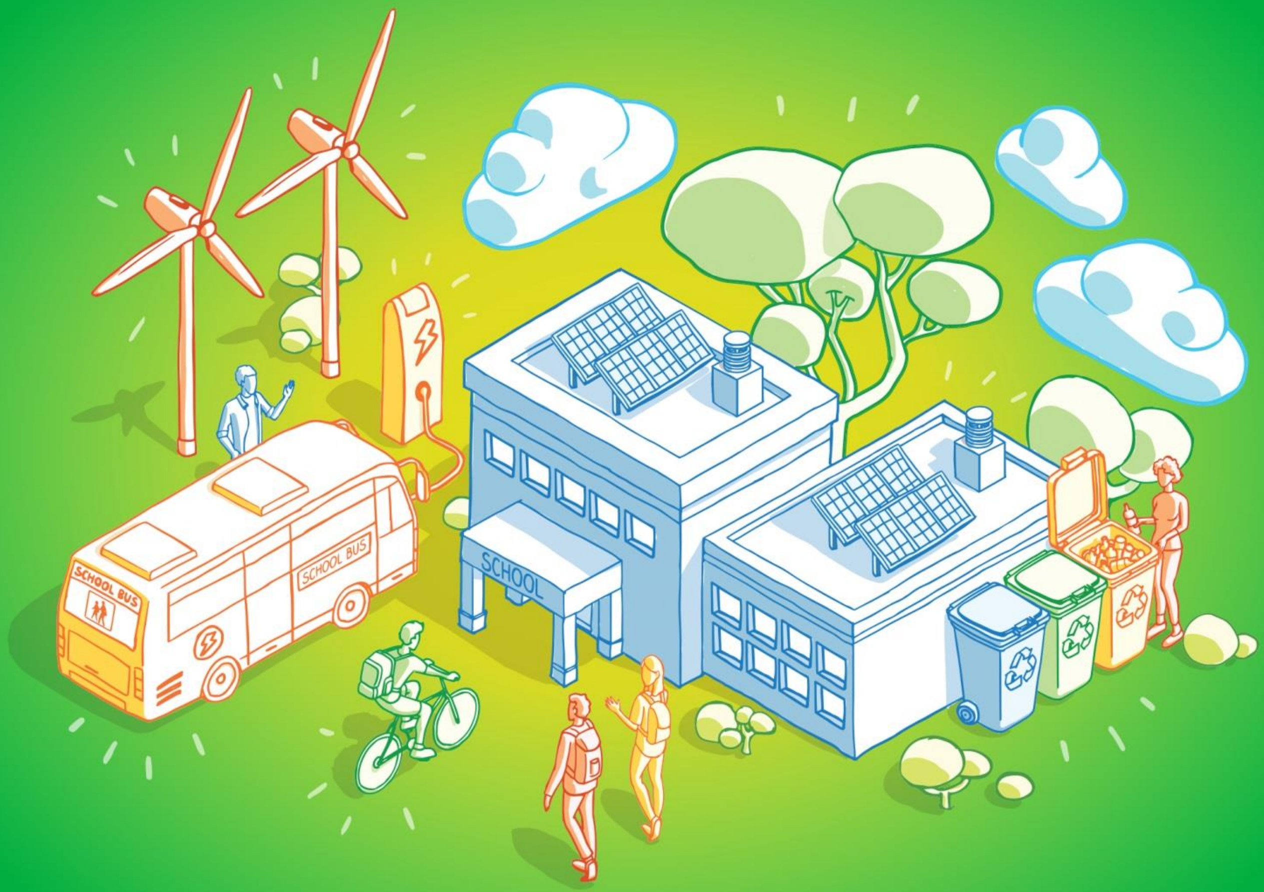

CLIMACT - ACTING FOR THE TRANSITION TO A LOW CARBON ECONOMY IN SCHOOLS – DEVELOPMENT OF SUPPORT TOOLS

Guidelines of Standard Methodologies to Conduct Energy and Environment Audits in Schools

March 2017

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CONTENTS

Executive Summary

This deliverable is part of the Activity 3.2 - Assessment baseline in energy, environment and CO^2 emissions performance, audits and benchmarking and shall contribute towards the objectives of the Activity 3.2 and the products of the WP3 - Implementation of a methodology conducting to a low carbon economy in 35 pilot schools.

Within the scope of Activity 3.2 the objective is to characterize the baseline energy and environment performance, that is, the current situation of each school. So, the energy audits to be performed under Activity 3.2 will be divided in three major parts: pre-audit, site assessment (audit) and data analysis.

A total of seven aspects related to environment and energy will be evaluated in the schools, namely:

- Energy
- Water
- Comfort and Indoor Air Quality (IAQ)
- Waste
- Transports
- Green spaces
- Green procurement

1 Introduction

The objective of the present document is to serve as a guideline of best practices for conducting energy and environment audits at the ClimACT schools. In order to standardize the energy and environment audits development, all the partners that are going to conduct audits in the schools should follow the procedures presented in this document.

Activity 3.2 involves the on-site survey of the project pilot schools to create a realistic and accurate performance baseline of their energy and water efficiency, waste generation, indoor air quality (IAQ), transport, use of green spaces and green procurement. Audits will be comprised of three phases:

a) Pre-audit phase with request of information from schools, analysis of this information and planning of a common methodology for conducting audits in order to guarantee harmonised results within the consortium;

b) Site assessment with on-site measurement, data collection, questionnaires and visual inspection to assess: energy and water use; level of efficiency of the existing equipment/systems/management strategies; amount of produced waste per typology; transport patterns of the school community; use of green spaces and green procurement policy. Chemical and physical IAQ parameters will be assessed using on-line methods for the measurement of CO_2, CO, PM and comfort parameters and passive methods for the measurement of VOCs and aldehydes;

c) Data analysis, uploading of results in the database of the ClimACT decision support tool, generation of KPI and audit report.

2 Energy and environment audits framework in ClimACT

The scope of energy and environment audits and their complexity may be handled in different ways and should be defined prior to beginning any audit activities (Thumann & Younger, 2007). This section provides an introductory description of the audit definition/approach and other aspects to be accessed within Activity 3.2 of the ClimACT project.

Within the scope of Activity 3.2 the objective is to characterize the baseline energy and environment performance, that is, the current situation of each school. The audits to be performed under Activity 3.2 will be divided in three major parts (Figure 1): pre-audit, site assessment (audit) and data analysis.

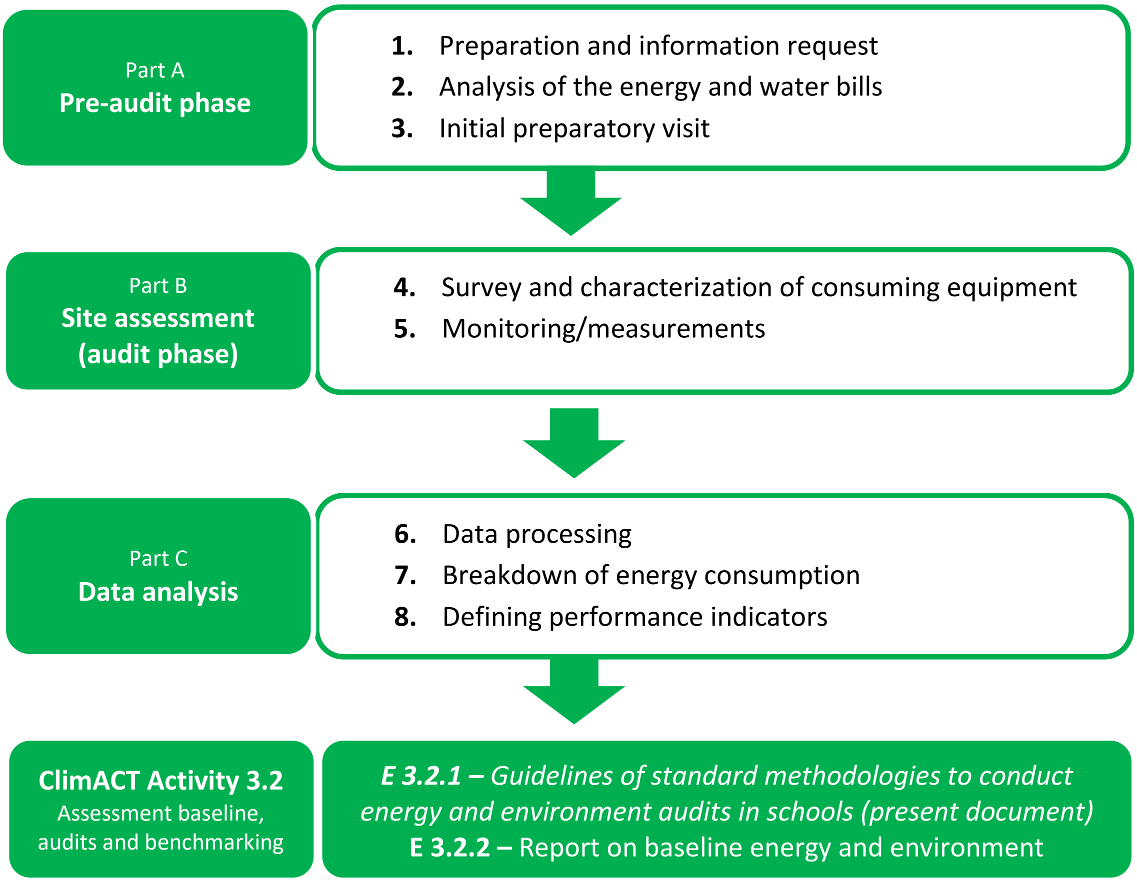

Figure 1 – Phases of the energy audits to be conducted within ClimACT A3.2.

These three phases will result in the “Report on baseline energy and environment performance” (E 3.2.2). The aim of the present document is to provide guidelines for conducting this process guaranteeing harmonised results throught applying a standardized audits methodology in the 35 schools that will be audited within ClimACT.

Activity 3.3 - Definition of targets and development of action plan will establish goals tohelpmaintaining momentum for energy/environment management activities. The next two activities of ClimACT will comprise the implementation of these measures and the results validation, respectively. Figure 2 provides a schematic representation of the integration of Activities 3.2 to 3.5.

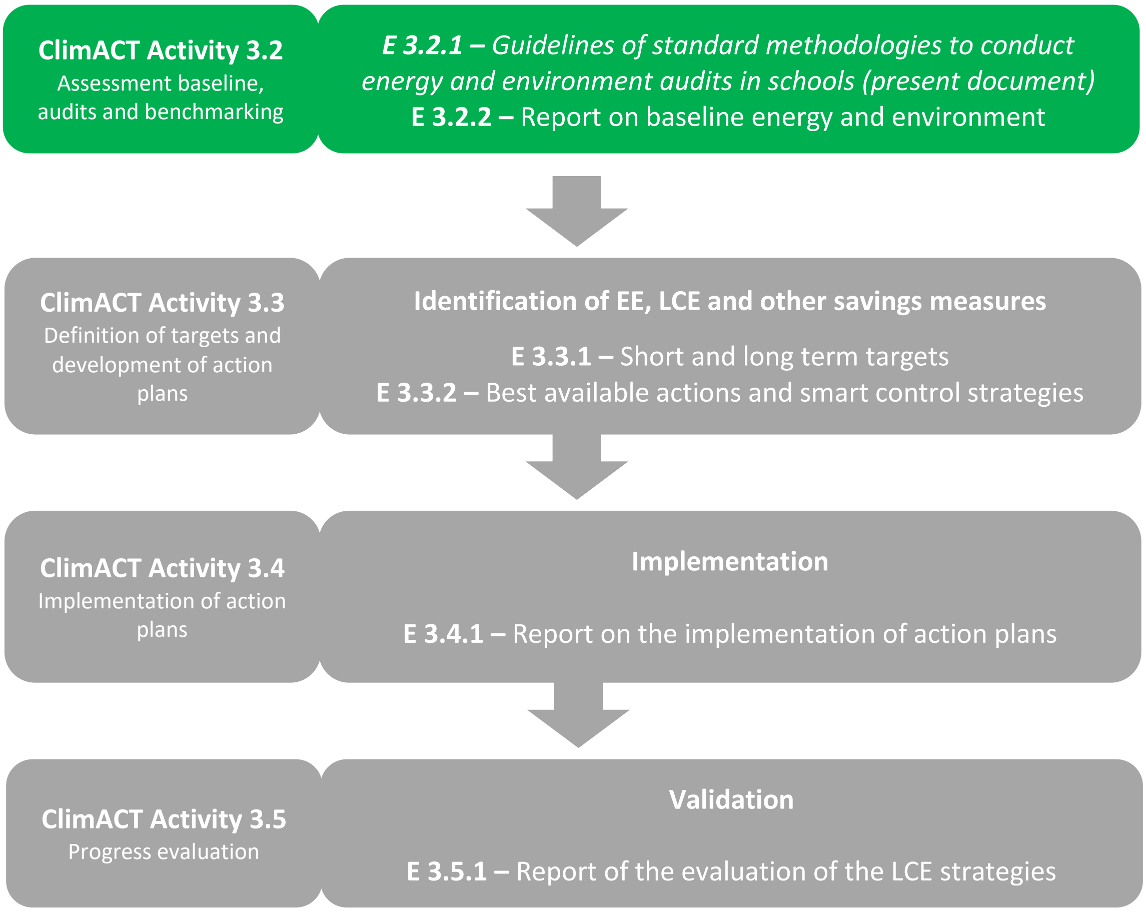

Figure 2 – Integration of ClimACT A3.2 with other tasks to be performed.

2.1 Energy audit

An energy audit is a survey performed by professionals and the school together where the current energy use in the building, installed equipment and scheduling are surveyed, as well as possible ways to improve them are analysed and reported. The aim of an energy audit is to reduce energy consumption and respective associated costs and CO_2.

Energy audit activities comprise the identification of all energy systems, along with the evaluation of the systems' conditions. Followed by the analysis improvements to those systems and corresponding impacts, compiled in an energy audit report. This report provides a description of the existing conditions of the building (baseline situation) in terms of envelope, equipment, lighting and occupancy, followed by possible measures to improve efficiency through improvements in operation and maintenance (O&M), implementation of energy conservation measures (ECM), low carbon economy (LCE) saving measures and other saving measures and also through changing behaviours of the occupants (Silvonen et al, 2006).

To conduct an energy audit, all structural and mechanic components affecting energy consumption, along with the operational characteristics of the building, have to be accessed.

The main goal of conducting an energy audit is to evaluate the current state of the building (baseline definition), the savings potential of energy efficiency and other measures suitable to be applied in the building and optimize the energy consumption by applying economic viable measures. Within the ClimACT project these tasks are divided between Activities 3.2 and 3.3.

The proposed approach to conduct the energy audit was based in documents from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the International Performance Measurement and Verification Protocol (IPMVP) and Investor Confidance Project (ICP) methodologies.

2.2 Environment audit

Within Activity 3.2, besides energy other aspects related to environment will be evaluated in the schools, namely:

- Water
- Comfort and Indoor Air Quality (IAQ)
- Waste
- Transports
- Green spaces
- Green procurement

The motivation to perform this environment audit is the following:

- Understand why, how, where, and when each of the aspects is used;
- Record/monitor data profiles;
- Gather data to make decisions;
- Act aiming optimization;
- Monitor and control the outcome of actions and investments.

The following scheme presents an overview of the approach to conduct the environment audits.

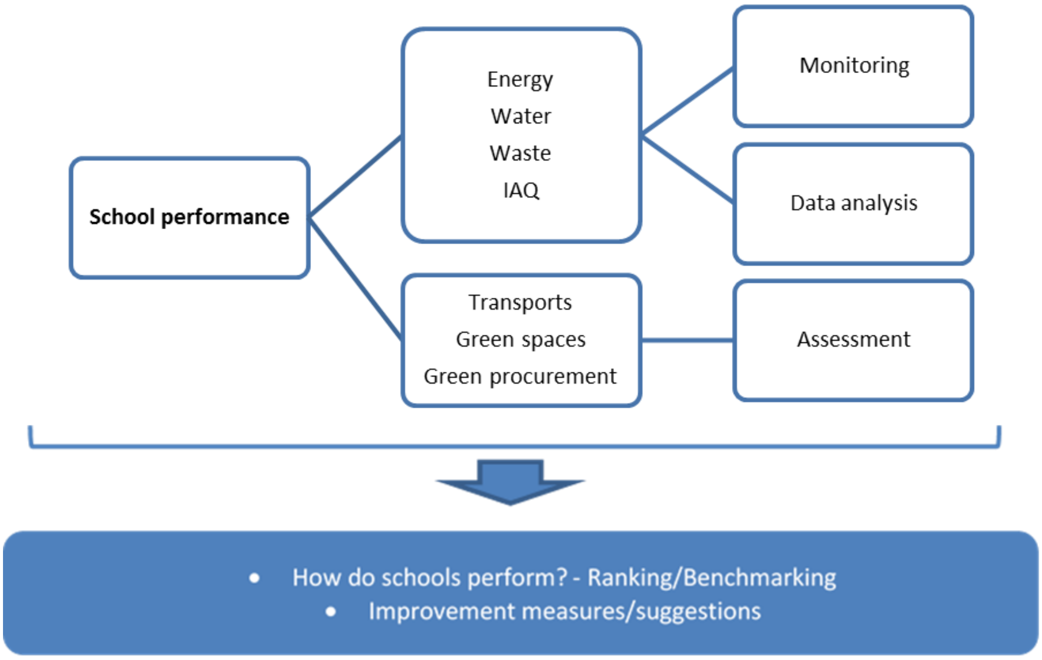

Figure 3 - Approach to conduct the environment audits.

3 Part A – Pre-audit phase

The pre-audit phase aims to establish the initial conditions of the building (baseline status) and comprises the following major parts:

1) Preparation and information request;
2) Analysis of the energy and water bills;
3) Initial preparatory visit.

The following subsections describe in detail the procedures to perform each one of this activities.

3.1 Preparation and information request

The first step is to request the necessary information to perform the audit. Gathering the right data with the appropriate amount of detail is a key component to achieving the maximum benefits of an energy audit. To facilitate the data collection effort a pre-audit checklist was developed, and the following data should be requested and accessed:

- **Architecture project (blueprints of the building);**
- **Monthly bills of 3 years (2014, 2015 and 2016) for all the types of energy consumed;**
- Lighting project;
- HVAC project and HVAC descriptive documents;
- Electric installations project;
- Gas installations project;
- **Monthly water bills of 3 years (2014, 2015 and 2016);**
- Construction details of the building envelope;
- Map of glazed areas;
- Characteristics of glasses and window frames;

Some of this data might not be available, but the points 1, 2 and 7 are indispensable to conduct the audit, which are respectively the architecture project and the energy and water monthly bills (detailing both consumption and price).

With the data identified above, there are some parts of the pre-audit checklist that can be filled in with this data (for example, some parts of section A and section D). Also the location of the building can be accessed (e.g., from the bills) and the building orientation can be easily obtained (e.g., from Google Maps).

3.2 Analysis of the energy and water bills

As referred, the bills are indispensable to perform the audit. Additionally, if available from the distribution system operator (DSO), the global electricity consumption with 15 minutes' intervals should also be accessed because this granularity of consumption data provides more details about the energy consumption profiles helping to better identify savings potential and the behavioural impact of the buildings' occupants. **Error! Reference source not found.** presents an example of the analysis of an electricity bill.

Table 1 – Example of an electricity energy bill analysis.

ELECTRICITY BILL														
				Active energy					Power		Reactive energy		Bill without VAT	
2015	Initial date of the bill	Final date of the bill	**No of days**	**kWh** TOTAL	**kWh** FULL HOURS	**kWh** PEAK HOURS	**kWh** OFF-PEAK	**kWh** SUPER OFF-PEAK	**kW** PEAK HOURS	**kW** HIRED	**kVArh** FULL/PEAK HOURS	**kVArh** OFF-PEAK	**€**	**€/kWh**
jan-15	20-12-2014	19-01-2015	31	**25.827**	11.938	6.077	4.887	2.925	49,01	232,50	5.356	0	3.747,72	0,145
fev-15	20-01-2015	19-02-2015	31	**29.074**	13.564	6.916	5.268	3.326	55,77	232,50	6.067	0	4.250,48	0,146
mar-15	20-02-2015	19-03-2015	28	**25.865**	11.555	6.523	4.795	2.992	58,24	232,50	5.765	0	3.853,91	0,149
abr-15	20-03-2015	19-04-2015	31	**27.856**	12.286	6.601	5.676	3.293	53,23	232,50	6.269	0	4.154,09	0,149
mai-15	20-04-2015	19-05-2015	30	**23.961**	10.210	5.655	4.944	3.152	47,13	232,50	5.965	0	3.674,87	0,153
jun-15	20-05-2015	19-06-2015	31	**22.730**	9.628	4.866	4.983	3.253	39,24	232,50	5.585	0	3.440,63	0,151
jul-15	20-06-2015	19-07-2015	30	**19.818**	8.555	3.896	4.427	2.940	32,47	232,50	4.303	0	2.947,94	0,149
ago-15	20-07-2015	19-08-2015	31	**6.977**	2.921	1.238	1.681	1.137	9,98	232,50	1.298	0	1.254,15	0,180
set-15	20-08-2015	19-09-2015	31	**14.699**	6.043	3.512	3.115	2.029	28,32	232,50	2.305	0	2.312,20	0,157
out-15	20-09-2015	19-10-2015	30	**16.489**	7.286	4.677	2.811	1.715	38,98	232,50	4.825	0	2.786,96	0,169
nov-15	20-10-2015	19-11-2015	31	**21.998**	10.528	5.931	3.441	2.098	47,83	232,50	5.293	0	3.468,62	0,158
dez-15	20-11-2015	19-12-2015	30	**24.494**	11.840	6.202	4.053	2.399	51,68	232,50	4.935	0	3.679,68	0,150
Total			**365**	**259.788**	**116.354**	**62.094**	**50.081**	**31.259**	**-**	**-**	**57.966**	**0**	**39.571**	**-**
Share			-	100%	44,8%	23,9%	19,3%	12,0%	-	-	-	-	-	-
Total for year 2015			**365**	**259.788**										

Electricity bills are composed by three main parcels: active energy, reactive energy and power:

- **Active energy (kWh)** is the energy actually consumed and its consumption is divided by different time periods depending on the hired tariff scheme.
- The consumption of **reactive energy (kVArh)** implies additional costs and can easily be offset with installation of power banks. So the reactive energy consumption and cost should also be evaluated.
- Regarding **power (kW)**, the hired value and the requested value in peak hours should be evaluated in terms of quantity and cost. Note that what is necessary to evaluate is the actual energy consumption and not estimates sometimes provided in the bill from the energy companies.

By compiling data for all the months of three years, we are able to evaluate: annual values, average monthly values per year and average value per year. This last should be considered as the baseline energy consumption, but there are some exceptions that imply corrections/adjustments to this baseline, namely:

- If there were some major renovations in one of the considered years, only the following years should be considered;
- If there were abnormal consumption during some period of a year, this period should be replaced by the average of the same period during the other two years.

In order to better evaluate the energy consumption, if possible data regarding the environment conditions at the building site (or the nearest possible) should also be accessed during the same three years that define the baseline – namely, outdoor temperature and relative humidity in an hourly or daily basis.

The same approach described above for electricity, should be followed to compile data for other types of energy consumption and water consumption. As for electricity, the analysis should be divided in:

- For natural gas – natural gas consumption (kWh and m^3) and its bill without VAT (€ and €/m^3).
- For propane - propane consumption (ton) and its bill without VAT (€ and €/ton).
- For diesel - diesel consumption (litre) and its bill without VAT (€ and €/L).
- For water - water consumption (m^3) and its bill without VAT (€ and €/m^3).

The following initial performance indicators should be assessed in this phase in order to compare the starting point of the different schools and giving guidance of which schools might have higher savings potentials:

- Energy use/cost per usable area and energy use/cost per student and per (usable area *x* student) - for electricity and other types of energy consumed
- Water use/cost per usable area and water use/cost per student

To support the energy and water accountancy and the initial KPIs calculation, four excel templates were developed:

- For electricity – excel file *“**2a - Energy accountancy – Electricity.xls**”*;
- For natural gas – excel file *“**2b - Energy accountancy - Natural Gas.xls**”*;
- For other fuels – excel file *“**2c - Energy accountancy - Other fuels.xls**”*. In this excel it is necessary to specify the fuel and the measurement units.
- For water – excel file *“**2d - Water accountancy.xls**”*.

These templates should be filled by each partner performing the audits and adapted for each school audited in order to obtain standard tables similar to **Error! Reference source not found.** and also standard graphics to include in the audit reports. All these excel files have a first sheet which is an example, followed by the sheets that should be filled in (grey cells should be filled in). The tariff periods and other aspects should be adapted for each school and/or for each country.

The amount of energy present in the bills refers to **final energy** which is energy that has been transformed into useful energy so it can be consumed by a final user. However, it does not give information on the energy that was spent to supply this amount of final energy. On the other hand, **primary energy** is the measurement of the energy amount that has not been subjected to any conversion or transformation process. The consumption of final energy (from electricity, natural gas...) correspondes to an amount of tonnes of oil equivalent (toe) of primary energy. In order to calculate the primary energy consumption associated with final energy consumption a conversion factor should be applied. The conversion factor depends on the energy sources that supply a country and should be assess in the legislation.

3.3 Initial preparatory visit

The objective of the first visit to the building is to understand its current status and to perform an initial evaluation of the major systems used being able to anticipate where is savings potential or retrofitting necessities and what energy efficiency measures should be considered.

As referred above, to facilitate the data collection during the initial visit a pre-audit checklist was developed (presented in detail in Annex 1). This pre-audit checklist should be filled in with the requested data and during the initial visit, being divided in the 23 topics presented in Table 2.

Table 2 - Pre-audit checklist organization topics.

General information	A) Administrative data
	B) Physical characteristics
	C) Use of the building
Energy	D) Energy consumption
	E) Energy production
	F) Lighting
	G) Heating
	H) Cooling
	I) Ventilation
	J) Other equipment
	K) Energy metering
	L) Energy management
	M) Energy audits
	N) Building envelope
Comfort and IAQ	O) Comfort
	P) Indoor Air Quality
Waste	Q) Waste management
Water	R) Water
Transports	S) Transports
Green spaces	T) Green Spaces
Green procurement	U) Green Procurement

4 Part B - Site assessment

The second phase of the audit is dedicated to the site assessment, comprising the following points:

4) Survey and characterization;
5) Monitoring/measurements.

The following subsections describe in detail the procedures to perform these activities regarding each one of the seven aspects to be evaluated in the schools during the audits.

4.1 Energy

It is very important to follow general good practice to correctly perform a site assessment (Thumann & Younger, 2007):

- Schedule the audit at a time when the school is in operation. All the measurements should be done with the school in its normal operation.
- Guarantee that the visit is accompanied by a person from the school who knows about the topics necessary to address and that can manage to facilitate access to technical areas.
- Plan to spend a day on-site for each building.
- Take pictures of all the building zones, different lighting and equipment and their technical plates.
- Have all necessary tools available on site:
  - Building construction plans;
  - Notebook;
  - Camera;
  - Pre-audit checklist.
- Before walking through the building, talk with the building manager to review energy consumption profiles and discuss aspects like occupancy schedules, operation and maintenance (O&M) practices and future plans that may have an impact on energy consumption.
- Confirm the floor construction plans and identify major changes. Annotate the location of boilers, chillers, domestic hot water (DHW) heaters, kitchen appliances, exhaust fans, etc., as well as lighting types, levels, and switching, room temperatures, general conditions and other observations.

During this phase of the audit the operational characteristics and the operating conditions should be accessed and measurements should take place.

Error! Reference source not found. provides a summary of the data required to identify and analyse possible EE measures.

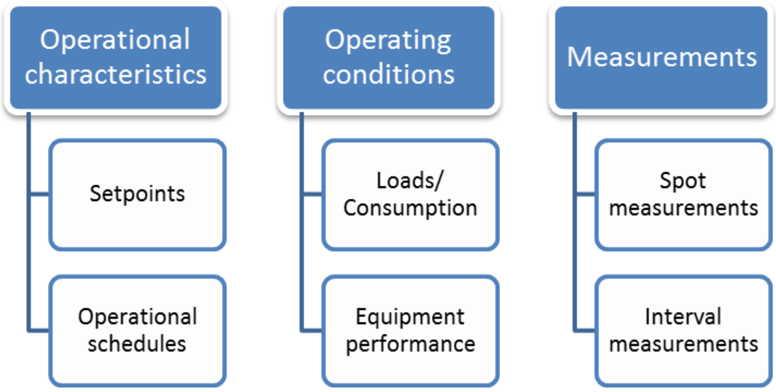

Figure 4 – Data required to identify and analyse EE measures.

Regarding operational characteristics, the following aspects should be observed:

- Set points:
  - For specific spaces (section 4.4.2.1): measurements of indoor temperature, relative humidity and light levels;
  - For specific equipment (sections 4.1.1.2-4.1.1.3): collect data by observation of the boiler temperature, chiller temperature and DHW storage and delivery temperatures.
- Operating schedules (section 4.1.1.1) – occupation schedules and heating/cooling schedules per space.

Regarding operating conditions, the following aspects should be observed:

- Loads/Consumption (section 4.1.2.1) – electricity consumption, thermal energy consumption, heating/cooling consumption and peak loads.
- Equipment performance (section 4.1.2.2) – combustion efficiency and cooling efficiency.

4.1.1 Survey and characterization

In order to evaluate energy consumption in the school, the global consumption should be disaggregated between the different types of uses. This breakdown serves to access the amount of electric and thermal energy used specifically for lighting, heating/cooling, production of DHW, ventilation and other equipment (e.g. computers, printers…). Other important disaggregation is between the different sectors, for example the global school is composed by the school sector itself and may have other buildings with different uses (e.g. a sports pavilion that is open to the general public).

4.1.1.1 Electric equipment, lighting and occupation

The first step is to attribute a reference number to each room of the school. Then walk through the building identifying all the electric equipment and lighting installed in each room and also the number of occupants. Along with the respective schedules of occupation and utilization of lighting, heating, cooling and ventilation.

In order to identify the **electric equipment** per room, it is necessary to access:

- Type (computer, photocopier, printer, fax, projector…);
- Number of equipment of the same type;
- Technology and electric power.

The **lighting** characterization per room, implies the collection of following data:

- Number of lamps per fixture;
- Number of fixtures;
- Type of lamp technology per fixture and ballast type;
- Electric power and type of ballast (in the case of the fluorescent lamps). To identify the type of ballast when turning the lights on observe if they turn on immediately (electronic ballast) or if they flash when turning on (ferromagnetic ballast);
- Quantity installed by type of lamp;
- Installed power by type of lamp;
- Hours of daily/weekly operation (utilization schedule);
- Control system (manual, sensor, timer, photocell…).

Regarding **occupation**, the following data should be collected per space:

- Type of use of the space (classroom, corridor, kitchen…);
- Number of occupants;
- Schedule of occupation.

To simplify and standardize the survey on equipment/lighting/occupation in each school, during the audit site assessment phase, the excel file ***"4 - Surveys.xls"*** was created identifying how data should be collected. Regarding electric equipment, this document has generic electric power data that can be used to estimate the electric power per equipment, but if there are other equipment please add them to the table. For lighting, it is only necessary to write the type of fixtures and lamps using the legend presented in Table 3 and count the number of fixtures per space: Examples:

- **FT (2x36)+BF** corresponds to a fixture with Tubular Fluorescent lamps with 2 lamps of 36W of electric power and a Ferromagnetic Ballast.
- **FC (1x18)** corresponds to a fixture with a Compact Fluorescent lamp: 1 lamp of 18W of electric power.

Table 3 – Legend for lighting description in excel file *"4 - Surveys.xls"*.

Acronym	Definition
FT	Tubular fluorescent
FC	Compact fluorescent
HL	Halogen
LED	Light-emitting diode (LED)
IM	Metal halide
IC	Incandescent
VS	Sodium vapour
BF	Ferromagnetic ballast
BE	Electric ballast

4.1.1.2 HVAC equipment

Regarding the **HVAC** (heating, ventilation and air conditioning) equipment characterization, the following aspects should be assessed:

- Survey of the types of air conditioning systems installed;
- Survey of the characteristics of installed equipment;
- Type of gas used;
- Temperature set points;
- Operating hours.

Figure 5 presents an example of the technical characteristics that should be collected for a chiller.

Equipment reference – Chiller 4
Brand – *Trane*
Model type – ERTTHCO3
Year – 2000
Type of refrigeration cycle – Compression
Refrigerant – R1344a
Electrical power (kW) – 271
Type of condenser – Water

Figure 5 – Chiller - Technical characteristics to collect.

4.1.1.3 DHW production equipment

Regarding the **DHW production** equipment characterization, the following aspects should be assessed:

- Survey of the types of systems installed;
- Survey of the characteristics of installed equipment;
- Type of gas used;
- Temperature set points;
- Operating hours.

Figure 6 presents an example of the technical characteristics that should be collected for a boiler.

Equipment reference – Boiler 1
Brand – *Viessmann Paromat Triplex RN*
Model type – RN089
Year – 1998
Thermal power (kW) – 895
Capacity (Liters) – 1353
Max. operating pressure (bar) – 6
Max. water temperature (°C) – 120

Figure 6 – Boiler - Technical characteristics to collect.

4.1.2 Monitoring/measurements

Measurements should be conducted in order to obtain analyse what/how/when is the the data previously identified. To perform these measurements and to monitor consumption there are several instrumentation options available as presented in the following subsections. The best option to further breakdown energy consumption is to perform measurements with suitable equipment, alternatively this breakdown can be done through estimates.

Error! Reference source not found. provides a summary of the energy measurements that should take place during the audit, specifying its importance, where/how it should be conducted, along with the duration of the measurement and the equipment needed.

Table 4 – Summary of the energy measurements to perform: importance, duration and necessary equipment.

Type of measurement	What to measure?					Importance	Minimum duration	Measurement equipment
	Sector	Use	Sub-use	Equipment	Condition			
Electricity consumption (section 4.1.2.1.1)	Global[1]	Global	Global			High	1 week	Energy analyser or multimeter clamp
	Sports pavilion[2]	Global	Global			Medium	1 week	
		HVAC	Global			High	1 week	
		HVAC	Heating/ Cooling			Medium	1 week	
			Ventilation			Medium	24 h	
	Exterior	Lighting				Low	1 week	
	Kitchen	Global				Medium	24 h	
Thermal energy consumption (section 4.1.2.1.1)		DHW production	In each hot water deposit			High	1 or 2 days	Ultrasonic flowmeter
Equipment performance (section 4.1.2.2)		DHW/HVAC (to specify depending on the school)		Boiler		High	Instantaneous	Gas analyser
				Chiller		High	Instantaneous	Energy analyser and ultrasonic flowmeter
				Heat pump		High	Instantaneous	

[1] This measurement will not be necessary if global electricity consumption with 15 minutes' intervals is available from the DSO.
[2] Or other building that has a different use and different schedule than the "school" itself.

4.1.2.1 Loads/Consumption

4.1.2.1.1 Electricity

The electricity monitoring is performed in the electrical boards or in equipment itself. Table 5 presents two options of equipment that can be used to measure electricity consumption in the electric distribution boards and explains the details of the measurements to perform during the audit.

Table 5 – Measurement and monitoring equipment - Electricity.

Equipment description		Where can it be bought? (example)	How to use it?
Energy Analyser		Link	Install the equipment in: 1) General electric distribution board of the school; 2) Partial electric distribution board dedicated to the sports pavilion (or other "special" sector/use); 3) A circuit of exterior lighting.
Multimeter clamp		Link	

The excel file "***5 - Measurements - Electricity***" () [3]can be used to obtain the load diagrams by copying data obtained from the measurements.

4.1.2.1.2 Thermal energy

Thermal energy will not be measured, but inferred by measuring the hot water production (flow rate and temperature). Table 6 presents the equipment that should be used to measure electricity consumption in the electric distribution boards and explains the details of the measurements to perform during the audit.

Table 6 – Measurement and monitoring equipment – Thermal energy.

Equipment description		Where can it be bought? (example)	How to use it?
Ultrasonic flowmeter		Link	Install the equipment in the pipe that takes hot water from the boiler to the hot water deposit.

[3] Downloaded from https://maxwell.ict.griffith.edu.au.

4.1.2.2 Equipment performance

4.1.2.2.1 Boiler performance

In order to measure the boiler performance, two methods can be used: direct method or losses method. The losses method can be used by measuring the losses at the boiler exhaust of flue gases, namely:

- Sensible heat in the dry combustion gases;
- Water vapor enthalpy in the combustion gases;
- Unburned in the combustion gases;
- Other (radiation, convection, purges).

The efficiency of the boiler is assessed by calculating *100% - losses.* Table 7 presents the equipment that should be used to measure the boiler performance and explains the details of the measurements to perform during the audit.

Table 7 – Measurement and monitoring equipment - Boiler efficiency.

Equipment description		Where can it be bought? (example)	How to use it?
Portable Flue Gas Combustion Analyser		Link	Insert the probe at the exhaust of flue gases from the boiler.

The gas analyser calculates the boiler efficiency by using a probe that aspires the exhaust gas and also has a thermocouple to measure their temperature. Usually, this equipment is able to measure O_2, CO, NO, NO_2 and SO_2.

4.1.2.2.2 Chiller and heat pumps performance

The energy efficiency ratio (EER) is the ratio of the cooling capacity ($\dot{Q}_{cold}$) to the power input ($P_{electric}$). The higher the EER rating, the more efficient the equipment.

$$EER = \frac{\dot{Q}_{cold}}{P_{electric}}$$

In order to calculate EER it is necessary to measure, at the same time, both the production of cold and the electricity consumption. In other words, this measurement implies to use the energy analyser and the ultrasonic flowmeter. Table 7 presents this equipment and provides guidance on how to install it during the audit.

Table 8 – Measurement and monitoring equipment – Chiller/heat pump efficiency.

Equipment description		How to use it?
Energy Analyser & Ultrasonic flowmeter	 	Both equipment should be installed at the same time in the chiller. This measurement is more complex than the previous ones. In case you need guidance to install these equipment please contact the energy sector leader.

4.2 Water

4.2.1 Survey and characterization

Regarding water, it is more difficult to characterize exactly how much water is being consumed in the school for each use or sector. So this assessment will not be done during the audit.

During the audit it should be observed if the school has already implemented some of these water saving options that can be simply applied in schools:

- Reducers of water flow in faucets/showers;
- Use of self-timer faucets/showers;
- Use of a deposit to collect rain water. This water could be filtered to remove leafs, and then be used for irrigation of the school's green spaces;
- Flushing with double discharge and/or a 1.5L water bottle in the flushing deposit to reduce the discharge.

Figure 7 – Flow reducers and self-timer faucet.

These measures present high potential for water savings in schools associated with fast payback periods, although it is very difficult to predict exactly how much water will be saved.

During the survey it should also be observed if there are water losses and leakages.

4.2.2 Monitoring/measurements

In order to access the water flow in bathroom faucets a portable flow meter can be used (Table 9). This flow meter should be placed below an open faucet to measure its water flow, allowing to determine if there is potential to save water by installing water flow reducers.

Table 9 – Measurement and monitoring equipment – Water.

Equipment description		Where can it be bought? (example)	How to use it?
Portable flowmeter		Link	Place the flowmeter below an open faucet to measure its water flow. At least 5 measurements per school in different bathrooms.

4.3 Waste

4.3.1 Survey and characterization

The volume of waste produced in the school should be accessed divided in the following categories (that are applicable to each school situation):

- Waste disposed
  - Organic
  - Waste electrical and electronic equipment (WEEE)
  - Undifferentiated
- Waste composted - Organic
- Waste reused
  - Paper
  - Plastic
  - Glass
  - Others
- Waste recycled
  - Paper
  - Plastic
  - Glass
  - Others

4.3.2 Monitoring/measurements

A recycle and waste management team should be pulled together in each school, composed for example by a group of students and a teacher. This team would be responsible to evaluate and register waste production in the school during two weeks, along with working together with the school workers responsible to collect waste (to assess the amount of different types of waste produced/separated for recycling) and also with the kitchen/bar workers (to assess the amount of organic waste produced).

The measurements should be done daily by assessing the volume of waste produced through estimates. Theses estimated would be based on the number of bags and containers filled (or percentage filled), knowing priory which is the volume of the respective bags and containers.

4.4 Comfort and Indoor Air Quality

Indoor air quality (IAQ) and comfort will be investigated from measurements in 2 classrooms of each pilot school. The survey and characterization stage will mainly consist in selecting those classrooms with the aim that they are representative of the occupants' exposure and comfort in the building.

4.4.1 Survey and characterization

The 2 classrooms where IAQ and comfort measurements will be carried out should be selected to be representative of the building in terms of size, number of occupants and activities, furnishings or equipment that can release pollutants to the indoor air. Although not a stringent condition, classrooms having a continuous occupancy should be preferred to classrooms that are occupied only few hours each day. The following characteristics of the selected classrooms must be noted (information to provide in the checklist):

- Dimensions (surface area, height);
- White or blackboard;
- Type of floor covering;
- Number and type of windows;
- Number of occupants and occupancy hours (see hereafter how to handle the case where the number of occupants can vary over time during a same day, and/or the occupancy pattern is different from one day to another);
- Proximity to a high, medium or low traffic street / road.

4.4.2 Monitoring/measurements

Table 10 provides a summary of the IAQ measurements that should take place during the audit, specifying its importance, where/how it should be conducted, along with the duration of the measurement and the equipment needed.

Table 10 – IAQ and comfort measurements to perform: importance, characteristics and necessary equipment.

Type of measurement	What to measure?	Importance	Where?	Duration	Measurement equipment
Thermal and visual comfort (section 4.4.2.1)	T/HR	High	In two classrooms (located in different facades)	2 weeks	Thermo-hygrometer
	Illuminance	High	In two classrooms	Instantaneous	Lux meter
IAQ (section 3.4.2.2)	CO	High	Two selected classrooms	Minimum 2 weekdays with room occupancy, if possible 5 weekdays (from Monday to Friday)	Online instrument for ambient air concentration measurements
	CO_2	High			
	TVOC	High			Graywolf sensor
	PM_{10}	High			Particle counter
	$PM_{2.5}$	High			
	9 selected aldehydes[1]	High		5 full week-days (from Monday to Friday)	Radiello® diffusive samplers ref RAD 165
	10 selected VOCs[2]	High			Radiello® diffusive samplers ref RAD 145

[1]Formaldehyde, acetaldehyde, acrolein, propanal, butanal, pentanal, isopentanal, hexanal, benzaldehyde

[2]Benzene, toluene, styrene, tetrachloroethylene, trichloroethylene, m-xylene, o-xylene, p-xylene, 1-4 dichlorobenzene, α-pinene

4.4.2.1 *Thermal and visual comfort*

Regarding thermal and visual comfort, presents the equipment and type of measurements required to assess during the audit.

Table 11 – Measurement and monitoring equipment – Thermal and visual comfort.

Equipment description		Where can it be bought? (example)	How to use it?
Thermo-hygrometer		Link	Install the equipment inside the classroom far from cold/heat sources and uncovered
Lux meter		Link	Place the equipment above 4/5 class desks with the lights on to measure illuminance

In order to evaluate the indoor temperature and relative humidity conditions we should also access the outdoor conditions for a location as near as possible from the school. Data from both the indoor and outdoor conditions should be inserted in the excel file "***5 – Measurements - T and RH***".

A **lux meter** allows the determination of the **Illuminance**, the total luminous flux incident on a surface per unit area (Figure 8). The area (work plane) is where the most important tasks in the room or space are performed. There are recommended illuminance levels (norms) for each site according the type of task. This way it allows measure the light levels in a room and to verify if it is suitable for the activities performed in that room, it may also enable making recommendations regarding energy savings.

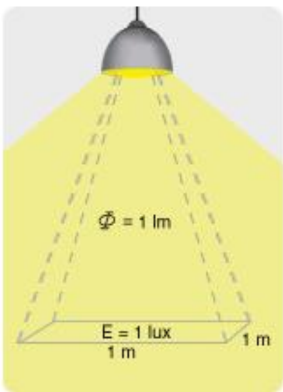

Figure 8 – Illuminance schematic representation.

4.4.2.2 *Indoor Air Quality*

Indoor air quality measurements divide into two categories:

<u>Monitoring of CO, CO_2, TVOC, $PM_{2.5}$ and PM_{10} concentrations</u>

CO, CO_2, TVOC, $PM_{2.5}$ and PM_{10} concentrations will be monitored during a minimum of 2 consecutive weekdays with occupancy of the classrooms. If possible, these parameters should be monitored for 5 consecutive weekdays, *i.e.* from Monday to Friday of a same week.

Table 12 presents the main features of the equipment needed to monitor these concentrations together with some important points to consider for the audits. The sampling time step of the instruments must be set according to the memory capacity and the duration of the measurement period. Typically, they should lie in the range from 1 to 5 minutes as a way to track short-lasting events, such as window openings, people coming or leaving the room, or short-lasting internal pollutant emissions in the classroom.

Table 12 – Measurement and monitoring equipment – Indoor air quality monitoring (time series of concentration)

Equipment description		Characteristics
CO and CO_2 sensor		Same or separate instruments to monitor CO and CO_2 but these instruments must be dedicated to ambient air quality measurements (not combustion analysis) : - Concentration range and accuracy for CO_2: 0-5000 ppm, $\pm$ 100 ppm max - Concentration range and accuracy for CO : 0-100 ppm, $\pm$ 3-5 ppm max The instruments must be recalibrated before starting the audits if not new
TVOC sensor		Two kinds of Graywolf sensors (http://www.wolfsense.com/directsense-tvoc-volatile-organic-compound-meter.html): - Graywolf VOC103L probe + tablet for data storage : TVOC, T, RH $\rightarrow \approx$ 2700 € WT - Graywolf IAQ 610 + micro PC : TVOC, T, RH, CO and CO2 $\rightarrow \approx$ 5400 € WT Return TVOC concentrations in ethylbenzene equivalent Instruments must be recalibrated each year (calibration kit, calibration contract or purchase of calibration service)

Particle counter ($PM_{2.5}$/PM_{10})		First monitoring of particle counts / air liter with either : - A scientific instrument (e.g. Grimm) - "low-cost" particle sensors (e.g. Alphasense OPC-N2 sensor, ≈ 450 € / unit) Then, conversion of $PM_{2.5}$ and PM_{10} counts in terms of mass concentrations using a reference particle density of 1.67. NB : particle sensors should be (re)calibrated using a scientific instrument as a way to ensure that measured concentrations are reliable

<u>Measurements of 9 selected aldehydes and 10 selected VOCs concentrations using passive samplers</u>

The Radiello® components needed to measure aldehyde and VOC concentrations is presented in Table 13. All components can be ordered at Sigma Aldrich (http://www.sigmaaldrich.com /analytical-chromatography/analytical-products.html?TablePage=18174977)

Table 13 – Measurement and monitoring equipment – Measurement of aldehyde and VOC mean concentrations

Equipment description		Characteristics / precautions
Triangular support plates		Reference : RAD121 Need of 2 plates / room investigated at a same time. Reusable as many times as needed Sold as packs of 20 pieces (120.50 € without taxes)
Diffusive bodies		**Aldehydes** : blue diffusive bodies (ref RAD1201), pack of 20 (198 €) **VOC** : yellow diffusive bodies (ref RAD1202), pack of 20 (304.50 €) A same diffusive body shouldn't be used more than 6 times without cleaning
Adsorbent cartridges		**Aldehydes** : ref RAD165, pack of 20 (610 €) **VOC** : ref RAD145, pack of 20 (1015 €) Each pack of 20 cartridges contains self-adhesive labels indicating the number and bar code of the

		cartridges. The number and bar code is unique

Passive samplers must be left in each classroom for 5 full week-days (Monday to Friday). This a necessary condition to adsorb enough pollutant mass on the cartridges, and to ensure a reliable assessment of the mean pollutant concentrations in the rooms.

Before sampling, aldehyde cartridges must be stored for a maximum of 6 months in the fridge. VOC cartridges can be stored for a maximum of 3 months in the fridge. After sampling, aldehyde and VOC cartridges must be stored in the fridge for a maximum of 4 weeks before analysis

The procedure to measure VOC and aldehyde concentrations in a classroom is described hereafter. More detailed explanations and illustrations on the way to use passive samplers can be found in the Radiello user guide (http://www.radiello.com/english/download_en.htm).

- Before sampling : 1/ Assemble all parts of the support plate, 2/ Stick the transparent pocket onto the support plate

- On field (Figure 9): 1/ Open the plastic bag and take the adsorbent cartridge out of its glass tube (keep the glass tube in the plastic bag), 2/ Put the cartridge inside the diffusive body (vertical position and without touching it with fingers!), 3/ Screw the diffusive body onto the support plate, 4/ Write down the date /time of the beginning of the sampling period on the adsorbent tube label and insert it in the pocket, 5/ Suspend the plate to the ceiling

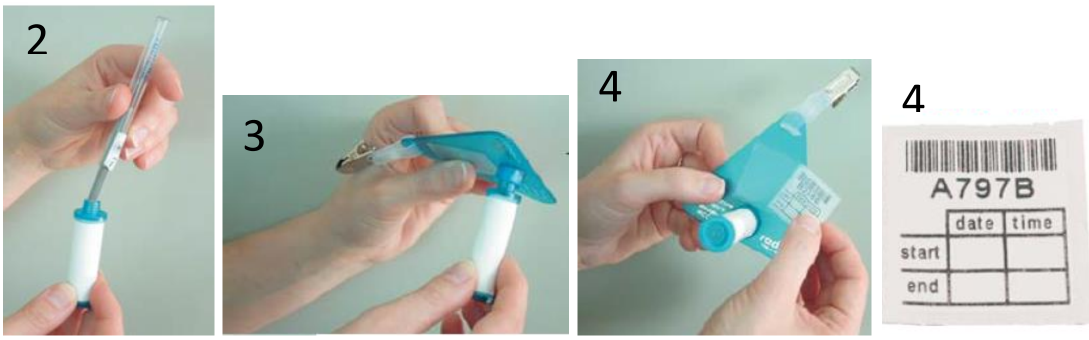

Figure 9 – On field installation of adsorbent cartridges

- On field, end of sampling : 1/ Unscrew the diffusive body from the plate and put the cartridge in its original glass tube (see cartridge number on the plastic bag), 2/ Retrieve the self-adhesive label from the plate, peel it off, and stick it on the glass tube such as the bar code is parallel to the axis of this tube (Figure 10), 3/ Keep track of the cartridge number, location (school / room), dates and times of the beginning and the end of the sampling period by filling the template Excel file (Figure 11).

Figure 10 – Illustration of the correct way of sticking the label on the glass tube containing the adsorbent cartridge after sampling

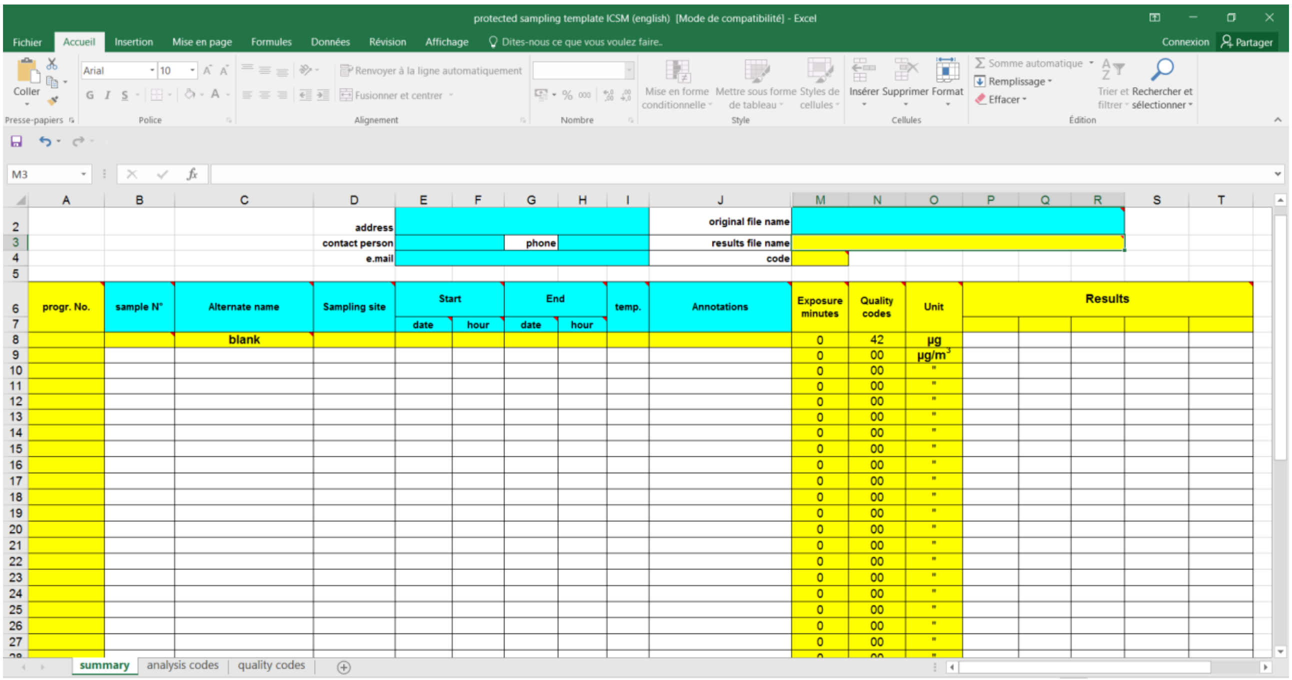

Figure 11 – ICSM Excel template file

- After sampling, analysis of cartridges: 1/ Keep cartridges in the fridge 2/ Send them to the lab for analysis, in express mode, within a maximum of 4 weeks. When ordering the analyses indicate the list of 10 VOCs and 9 aldehydes which concentrations must be determined and send the excel file containing the sampling information and coordinates to fsmpd@fsm.it. The results will be returned in this file, by e-mail, within 22 working days.

It is important to note that VOC cartridges can be reconditioned up to 5 times and returned by the lab after analysis. However, given the timetable of the ClimACT project, the storage time of VOC cartridges would be too long between the 1st and 2nd series of audits (max 3 months of storage in the fridge before use). Therefore, the option « analysis without return of reconditioned cartridges » must be selected when ordering the analyses to ICSM. Then, another pack of 20 cartridges will have to be ordered to carry out the 2nd set of audits.

Whatever the measurement method, pollutant concentrations will be monitored in only one location within the classroom volume, and homogeneous concentrations throughout the room volume will be assumed. Measurements must be as representative of the average concentrations in the room as possible. Consequently, the sensors/instruments must not be installed to close from potential pollutant sources, such as wall surfaces and white whiteboards or blackboards. Neither they should be installed in a corner of the classroom since these areas can be dead zones regarding ventilation, *i.e.* areas with little air movement and air change rate (in such a case the measured concentrations would probably be higher than the room average).

Practically, the particle sensor, TVOC sensor, T/RH probe and CO/CO2 sensor can be put on a table located in the middle of the classroom. If the table supporting the instruments has to be on the side of the room for convenience, children safety or instrument security reasons, it must not be to close from the windows since in this case the air movements resulting from infiltrations and/or window openings could lead to underestimate the room average concentrations. If the classroom has a mechanical ventilation system, another good solution is to monitor concentrations at the air outlet. But then the problem becomes to fix the instruments there.

The support plates holding the passive samplers can be hung from the ceiling with a string. Ideally, the diffusive bodies are located between the mid-height of the room and a distance of 40 to 50 cm from the ceiling as a way not to block the pupils' view on the one hand, and they cannot touch and damage the cartridges on the other hand.

In most elementary schools, the hours of occupancy as well as the number of occupants in the classrooms are the same every day of the week. However, in grammar schools, high schools and at university, classes most often change classroom each hour or one hour and a half. In such a case, as well as in classrooms where the number of occupants can significantly vary over time (computer rooms open to the students for instance), the teacher or any other person should be in charge of noting the number of people being in the room at each time of the measurement period. Since window openings can greatly influence IAQ, having information about the periods when windows are open may also prove to be helpful in interpreting the concentrations variations, and then possibly determine actions to improve IAQ. Consequently, teachers (or any other person) should also note the periods when the windows of the classroom are open each day of the measurement week. The beneficiaries conducting the audits will then input the data in a dedicated Excel file (under development). That way the occupancy and window opening patterns will be represented in a same and standard format for all pilot schools.

4.5 Transports

4.5.1 Characterization and assessment

The evaluation of the transport sector will consider 3 main factors:

1) **Parking characteristics**

- Number of parking spaces at school and periphery (up to a 100m radius);
- Number of parking spaces for disabled at school and periphery (up to a 100m radius);
- Number of parking spaces for electric cars at school and periphery (up to a 100m radius);
- Number of parking spaces for bicycles at school and periphery (up to a 100m radius).

The number of parking spaces should be collected during the audits considering not only the parking inside the schools but also outside within a radius of 100 m.

2) **Public Transport network**

This sector should make the characterization of the transport network. For each transport mean Bus/Subway/Train/Tram/Boat the following information should be collected:

- Number of stops in a 500m radius;
- Number of stops in a 1000m radius;
- Number of vehicles passing daily in a 1000m radius;
- Number of vehicles passing daily during rushing hour in a 1000m radius;
- Distance between the nearest stop and school.

For each transport mean (Bus/Subway/Train/Tram/Boat) a detailed analysis of the transport network for each school should follow the steps:

- Location of the school in the *Google Earth Software*;
- Definition of circular areas with 500 and 1000 meters radius with center on the location of the school also on *Google Earth Software*;
- Survey the type of public transport serving the areas defined above – this information can be obtained by the maps provided by the *Google Earth Software*, by a local assessment during the audits or by the online platforms of the transports' companies;
- For each city, rush hours and daily period should be defined. In the case of schools from Portugal the evaluation will be performed from Monday to Friday, daily period will be from 7h to 20h and the rushing hour will be from 7h to 9h and from 17h to 19h;
- Number of stops in a 500m/1000m radius – this information can be obtained by the maps provided by the *Google Earth Software*, by a local assessment during the audits or by the online platforms of the transports' companies;
- For each transport mean, number of vehicles passing daily and during rushing hour (1000 meters radius) – this information can be obtained by analysing the course and respective time schedules, available in the online platforms of the transports' companies operating in school areas;
- Distance between the nearest stop of each public transport and the school – information obtained by simulating the path from the stop to the school.

3) **Users' behaviours**

- Number of users that travel to school by foot/bicycle;
- Number of users that travel to school by public transports - bus/subway/train/tram/boat;
- Number of users that travel to school by private transports - car/motorcycle;
- Number of users practicing car sharing;
- Number of users that go back home and return to school more than once per day;
- Distance between school and home;
- Time spent during the trip from home to school;
- Money spent on home-school trips monthly;
- Number of users that would use a bike to travel between home and school if available;
- Number of users that use public transport when they go out with their families on the weekends.

The users' behaviour data is obtained through the analysis of the behavioural questionnaire.

Information should be documented with photos.

4.6 Green spaces

4.6.1 Characterization and assessment

The evaluation of the green spaces will consider 5 main factors:

1) **General information about the green spaces**

- Total school area
- Covered area – Area covered by buildings or shed plus area used for outdoor sport activities.
- Non-covered area – Total school area excluding the covered area (potential area that can be used for green spaces)
- Total garden area – Sum of all areas that have vegetation within the school area, excluding the ones with only lawns with no other major species (eg. trees and shrubs) and spaces with less than $1m^2$
- Total grassland area – Sum of all areas that has only lawn, excluding spaces with less than $1m^2$

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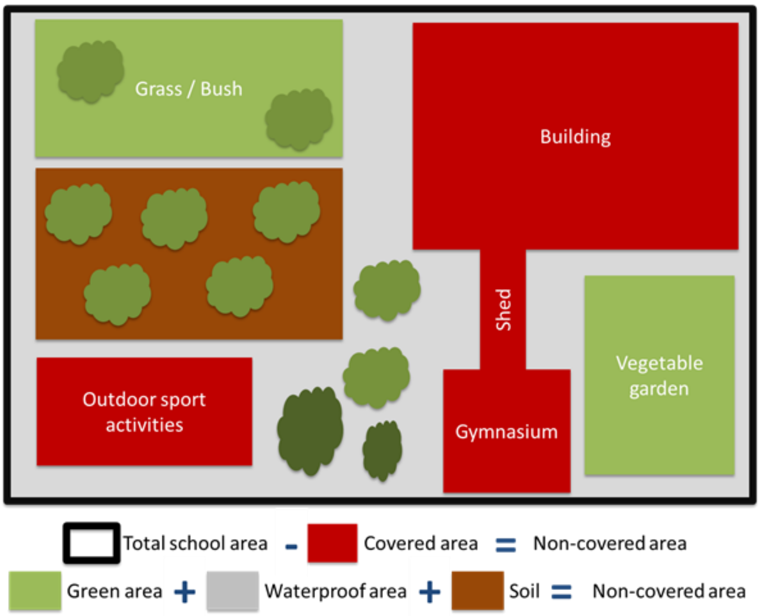

2) Energy

a. Type of fuel used in gardening activities – list all types of fuel used in the maintenance of green spaces
b. Annual consumption of diesel/gasoline/heavy fuel oil (in l/year) and electricity (in (kWh/year) used in the maintenance of green spaces
c. Power of the chains saw and mowers (kW) –information detailed by each equipment
d. Time of operation of the chain saw and mower – this information should be obtained from the entities responsible by the maintenance of the green spaces. Annual value should be estimated

3) Water

a. Type of irrigation system
b. Origin of the water
c. Water consumption in irrigation (m^3/year)

4) Gardening treatments

This information should be obtained from the entities responsible by the maintenance of the green spaces.

a. Name of pesticides used – enumeration of every pesticide used in the green space and for each one the following information should be given:
    i. Amount of pesticide used (Kg/year)
    ii. % of active ingredient of each pesticide
b. Name of each fertilizer used - enumeration of every fertilizer used in the green space and for each one the following information should be given:
    i. % of N – information available in the fertilizer's label
    ii. % of P2O5 of each fertilizer – information available in the fertilizer's label
c. % of K2O of fertilizer – information available in the fertilizer's label
d. Type of compost used
e. Amount of each compost used (Kg/year)

5) **Biome Information**
   a. Number of trees – total number of trees inside the school perimeter
   b. Predominant tree species – species of trees that exists in greater quantity
   c. Average age of trees – made through an estimation process.

The required information should be obtained during the audits using the long questionnaire. This information should be obtained from the entities responsible by the maintenance of the green spaces.

4.7 Green procurement

4.7.1 Characterization and assessment

The evaluation of the green procurement will consider 4 main factors:

1) **Certifications**
   - Existence of the ISO 14001: 2004 Certificate - Environmental Management Systems, taking into consideration environmental protection, pollution prevention, legal compliance and socio-economic needs or any other certification related with environment
   - Policies, objectives or a target for conserving the environment
   - Number of elements of the school staff with training in green procurement
   - Number of elements of the school staff with eco-driving

2) **Electronic equipment information**
   This information should be obtained from the entity responsible for school purchases
   Energy star level of efficiency
   - Number of equipments with A+++
   - Number of equipments with A++
   - Number of equipments with A+
   - Number of equipments with A
   - Number of equipments with B
   - Number of equipments with C
   - Number of equipments with D
   - Number of equipments without star level of efficiency

3) **Printers**
   This information should be obtained from the entity responsible for school purchases
   - No. of printers
   - No. of printers with optimum consumption
   - Amount of used paper (Kg/Month)
   - Amount of paper purchased directly to National producers (Kg/Month)
   - Amount of recycled paper used (Kg/Month)
   - Use of chlorine-free paper (Yes/No)

4) **Chemicals**
    - Concern about chemical information in the labels of detergents (Yes/No)
    - Concern about chemical information in the labels of Lab. Chemical products (Yes/No)

5) **Food products information**
   This information should be obtained from the entity responsible for school purchases
    - Total amount of purchased food per month (Kg/Month)
    - Total amount of purchased food with biological certificate per month (Kg/Month)
    - Purchase site of food products
        - No. of county providers
        - No. of district providers
        - No. of country providers
        - No. of international providers

The required information should be obtained during the audits using the check-list. This information should be obtained from the entities responsible by purchases and administration.

5 Part C – Data analysis

After the site assessment providing detailed measurements, we are able to further analyse the environment performance, consumption and costs, namely through:

6) Data processing;
7) Breakdown of consumption/production;
8) Definition of the Key Performance Indicators;

The following subsections describe in detail the procedures to perform each one of this activities.

5.1 Energy

5.1.1 Data processing

5.1.1.1 Energy consumption

Regarding energy consumption, data obtained through monitoring and measurement should be presented in graphics so it can easily be evaluated. Figure 12 provides an example of a load diagram obtained through electric energy monitoring.

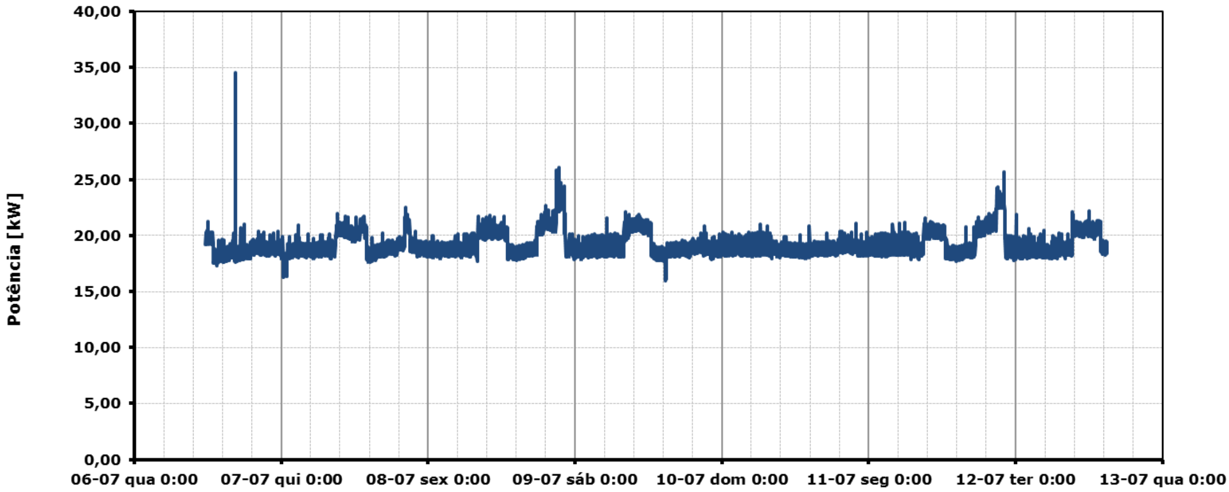

Figure 12 – Load diagram.

5.1.1.2 Equipment performance

Regarding equipment performance assessment, both the efficiency and other measured data should be presented in tables. Table 14 presents an example of results presentation for performance assessment of boilers.

Table 14 – Table of results for performance assessment of boilers.

Equipment	Boiler 1	Boiler 2
Fuel	Natural gas	Natural gas
O_2 (%)	6,2	6,1
CO_2 (%)	8,2	8,3
CO (ppm)	2	0
NO (ppm)	37	35
$T_{ambiance}$ (°C)	28	26
T_{gases} (°C)	159	149
Air excess (%)	41,9	40,9
Combustion efficiency (%)	91,1	91,7

Table 15 presents an example of results presentation for performance assessment of chillers/heat pumps.

Table 15 – Table of results for performance assessment of chillers.

Equipment	Chiller 1
T1 – flow (ºC)	7,9
T2 – return (ºC)	8,9
ΔT (ºC)	1
Thermal power (kW)	221,34
Electrical power (kW)	86,9
EER	2,55

5.1.2 Breakdown of energy consumption

In order to evaluate energy consumption in the school, the global consumption should be disaggregated between different types of energy, uses and sectors. This breakdown will allow to access the amount of electric energy used for lighting, heating/cooling, production of DHW, ventilation and other equipment (e.g. computers, printers,…).

Table 16 and Figure 13 provide two examples of energy consumption breakdown in schools from the United States of America.

Table 16 – Energy use in schools (Thumann & Younger, 2007).

Energy Use in Schools	*Range (%)*	*Norm (%)*
HVAC	45-80	65
Lighting	10-20	15
Food Service	5-10	7
Hot Water	2-5	3
Special Functions	0-20	10

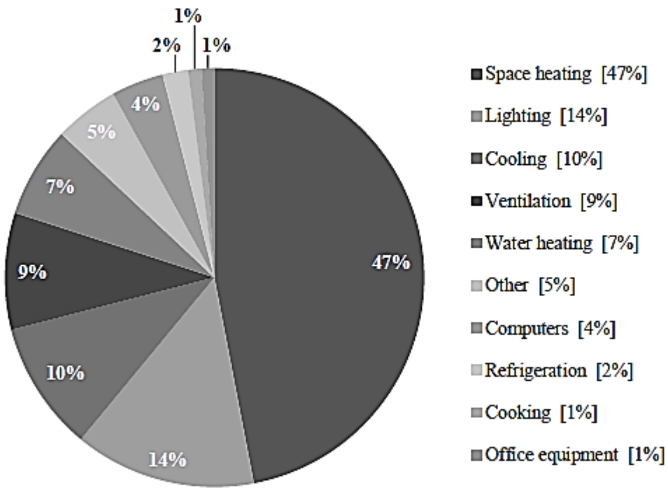

Figure 13 – Average use profile of schools in the USA (Pereira, 2016).

Within ClimACT framework, the breakdown of energy consumption in schools should be divided in the following sections.

Primary energy should be disaggregated by:

- Electricity
- Thermal
  - Natural gas
  - Propane
  - Diesel

Energy generated on site should be disaggregated by:

- Electricity
  - Photovoltaic
  - Wind
- Thermal
  - Solar
  - Biomass

Final energy should be disaggregated by use between:

- Electricity
    - HVAC
    - DHW
    - Lighting
    - Other
- Thermal energy
    - HVAC
    - DHW
    - Cooking
    - Other

5.1.3 Defining the Key Energy Performance Indicators

Table 17 presents the KPIs that should be assessed to identify the baseline situation of the school, and then compare to the final situation (after EE measures applied). These KPIs can also be used to compare different schools regarding their use of energy. They should be assessed in monthly absolute values of energy (toe and kWh) and of cost, and also relative values per student and per useful area of the school.

Table 17 – Energy KPIs to assess.

KPI level 1	Breakdown	KPI level 2
Primary energy (toe)	Electricity	Electricity
	Thermal	Natural gas
		Propane
		Diesel
Energy generated on-site (kWh)	Electricity	Photovoltaic
		Wind
	Thermal	Solar
		Biomass
Final energy (kWh)	By use	HVAC
		DHW
		Lighting
		Other

5.2 Water

5.2.1 Data processing

The measurements of water flow in faucets should be presented in table format as follows.

Table 18 – Water flow measurements.

Location	Water flow (l/min)
Bathroom 1	
Bathroom 2	
Bathroom 3	
Bathroom 4	

5.2.2 Breakdown of water consumption

As referred in section 4.2.1 regarding water it is more difficult to characterize exactly how much water is being consumed in the school for each use or sector. So this assessment will not be done during the audit. However, it is possible to breakdown water consumption between the different DHW producing equipment (section 4.1.1.3) measured. This allows to identify how much DHW is consumed in the areas that have a dedicated boiler (by sector) and the amount of water that is consumed as DHW (by use).

For example, if there are two boilers in the school, being one dedicated to the kitchen and other dedicated to a sports pavilion, then DHW consumption can be disaggregated between these two sectors.

This way the monthly water consumption (m^3) presented in the water bill could be disaggregated between:

- DHW consumed in the kitchen;
- DHW consumed in the sports pavilion;
- Water consumed cold.

5.2.3 Defining the Key Water Performance Indicators

Table 19 presents the KPIs that should be assessed to identify the baseline situation of the school, and then compare to the final situation (after water savings measures applied). These KPIs can also be used to compare different schools regarding their water consumption. They should be assessed in monthly absolute values of volume (m^3) and cost (€), and also relative values per student and per useful area of the school.

Table 19 – Water KPIs to assess.

KPI level 1	Breakdown	KPI level 2
Water consumption (m^3)	Cold water	Cold water
	DHW	Kitchen
		Sports pavilion

5.3 Waste

5.3.1 Data processing

The results obtained during the two weeks of site assessment should be extrapolated to monthly and annual values.

5.3.2 Breakdown of waste production

The breakdown of waste production should be done by type of end for the waste:

- Disposed
- Composted
- Reused
- Recycled

Within each of these categories, breakdown can be performed by level 2 KPIs as presented in the next section.

5.3.3 Defining the Key Waste Performance Indicators

Table 20 presents the KPIs that should be assessed to identify the baseline situation of the school, and then compare to the final situation. These KPIs can also be used to compare different schools regarding their waste production.

Table 20 – Waste KPIs to assess.

KPI level 1	Breakdown	KPI level 2
Waste production (m3)	Disposed	Organic
		WEEE
		Undifferentiated
	Composted	Organic
	Reused	Paper
		Plastic
		Glass
		Other
	Recycled	Paper
		Plastic
		Glass
		Other

5.4 Comfort and Indoor Air Quality

5.4.1 Data Processing

5.4.1.1 Thermal and visual comfort

Data from temperature and relative humidity measurements should be presented in the tables and graphs provided in the excel file "***5 - Measurements - T and RH.xls***". Table 21 and Figure 14 present temperature measurements data.

Table 21 – Temperature measurements: minimum, maximum and average values.

	TEMP. (ºC)	06-07-16 (Wed)	07-07-16 (Thu)	08-07-16 (Fri)	09-07-16 (Sat)	10-07-16 (Sun)	11-07-16 (Mon)	12-07-16 (Tue)
Room A	**MIN.**	26,7	26,8	26,8	26,8	26,7	26,6	26,4
	MAX.	29,2	29,9	28,3	29,5	28,9	28,5	32,1
	AVE.	27,8	27,8	27,3	27,7	27,4	27,4	27,5

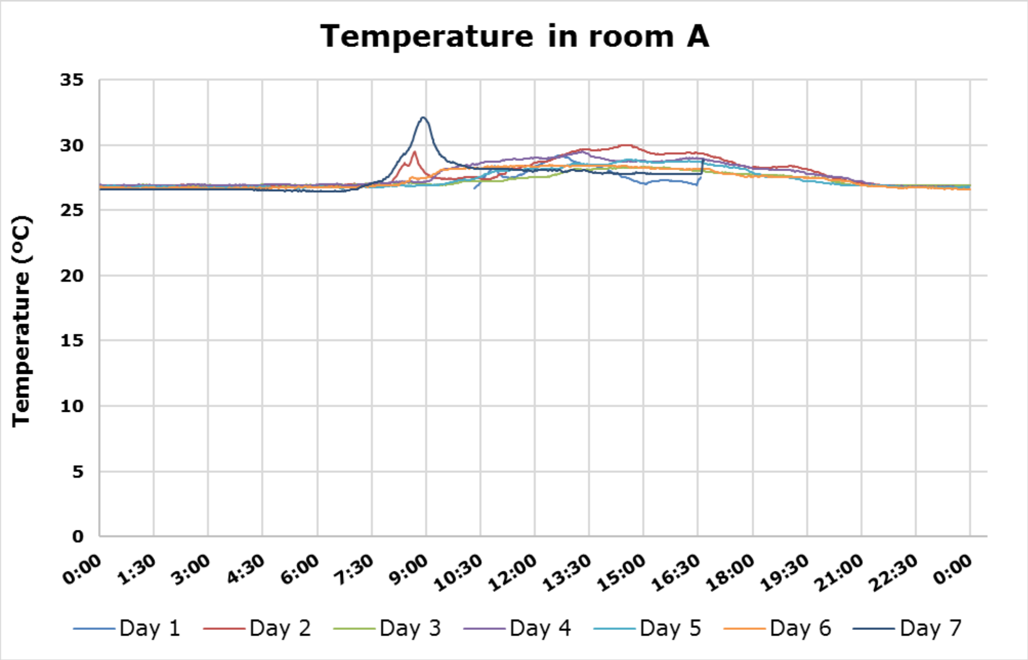

Figure 14 – Temperature measurements: daily variations.

Table 22 and Figure 15 present relative humidity measurements data.

Table 22 – Relative humidity measurements: minimum, maximum and average values.

	RH (%)	06-07-16 (Wed)	07-07-16 (Thu)	08-07-16 (Fri)	09-07-16 (Sat)	10-07-16 (Sun)	11-07-16 (Mon)	12-07-16 (Tue)
Room A	MIN.	52,0	60,1	62,9	60,0	61,8	62,6	46,3
	MAX.	68,0	76,1	75,3	72,6	75,6	75,3	74,0
	AVE.	62,2	70,2	69,7	66,3	70,3	68,9	66,5

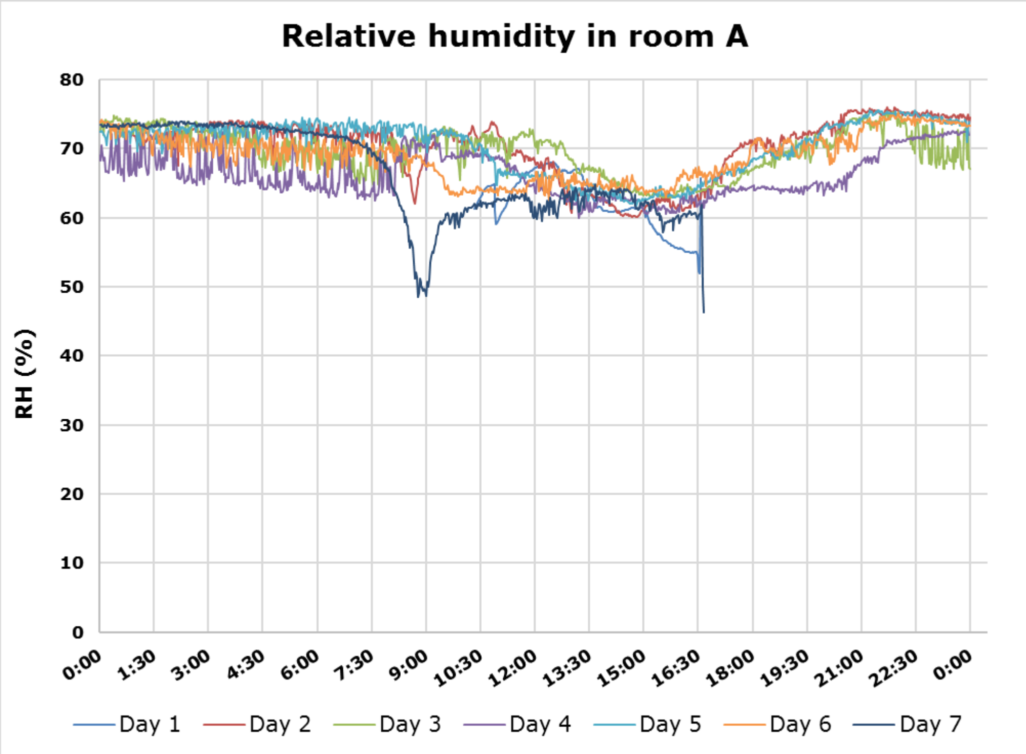

Figure 15 – Relative humidity measurements: daily variations.

Regarding visual comfort, the measurements of illuminance should be presented in table format as follows.

Table 23 – Illuminance measurements.

Location	Desk	Illuminance measured (lux)	Illuminance recommended (lux)	Difference (%)
Room A	1			
	2			
	3			
	4			

5.4.1.2 Indoor Air Quality- radar charts of measured pollutant levels

As a way to have an overview of IAQ in each school investigated, an individual IAQ index will first be computed for each target pollutant *p* listed in Table 24. These individual IAQ indices are defined by:

$$I_p = \frac{C_p - TLV_p}{TLV_p},$$

Where C_p is the pollutant concentration in the school, taken as the average of the concentrations measured in the two classrooms, and TLV_p the corresponding threshold limit value (guideline) of the contaminant (see Table 24 hereafter).

Then the results will be displayed as radar charts displaying all I_p values with contaminants belonging to a same category being next one each other, *i.e.* suspended particles (PM_{10} and $PM_{2.5}$), CO, aldehydes (formaldehyde and acetaldehyde), and VOCs (including TVOC).

Based on the above equation, I_p is dimensionless and ranges from -1 (C_p = 0, *i.e.* best air quality) to infinity in theory. For practical reasons (representation of diagram charts), an upper limit of 2 will nevertheless be considered. An excel file template will be developed to represent the IAQ results accordingly. That way the radar chart will be displayed in a standard format based on the concentrations input by the auditor.

It must be noted that other aldehydes than the ones listed in Table 24 will be analyzed from passive samplers. These are propanal, butanal, pentanal, isopentanal, hexanal and benzaldehyde. No guidelines exist for those chemicals. Therefore, they will not be figured out on the radar chart. The concentration data of these contaminants should nevertheless be stored in the database and considered for an expert analysis of IAQ.

5.4.2 Key Performance Index for IAQ

The key performance index for indoor air quality, I_{IAQ}, is defined by the number of occurrences where the concentration of a target pollutant exceed the TLV in a classroom, divided by 30:

$$I_{IAQ} = \frac{\sum_p \delta_p}{30},$$

with δ_p =1 if $C_p > TLV_p$ and δ_p =0 otherwise.

Unlike the combination of I_p values, this summing method is consistent with the fundamentals of health risk assessment (due to averaging effects, the combination of I_p values could lead to the conclusion that the IAQ is good while some concentrations exceed the guidelines and therefore there's a risk).

30 is the total number of measurements, corresponding to the 15 target pollutants having a TLV (Table 24) times 2 classrooms investigated in the school. Dividing by 30 normalizes the index, which then ranges on a scale from 0 (best score) to 1 (worst performance = all concentrations exceed the guidelines in the two classrooms).

Table 24 –Threshold limit values of target pollutants

Pollutant	Measurement method	Relevant concentration C	Threshold Limit Value	Unit	Comment
PM_{10}	Online	Mean during occupancy period	20	µg/m³	This is the long-term exposure health-based guideline set by the WHO. The Portuguese TLV of 50 µg/m³ is a management guideline
$PM_{2.5}$	Online	Mean during occupancy period	10	µg/m³	This is the long-term exposure health-based guideline set by the WHO. The Portuguese TLV of 20 µg/m³ is a management guideline
CO	Online	Mean during occupancy period	6	ppm	10 µg/m³ (8.7 ppm) is the guideline set by EU (Index project) for an 8h-exposure repeated each day of the week. The Portuguese value is lower and is therefore expected to be a long term guideline
TVOC	Online	Mean during occupancy period	600	µg/m³	There are no health-based guidelines associated to TVOC since TVOC cannot figure out the health impact of VOCs. The Portuguese management guideline of 600 µg/m³ is proposed but all the IAQ audits should be performed using the Portuguese instruments in order to ensure that the same thing is measured in all schools (especially the question with TVOC is to know which chemical equivalent is this concentration measured)
Formaldehyde	Passive sampler	Weekly average	30	µg/m³	The Portuguese and French upper limits of 100 µg/m³ for mandatory IAQ audits in schools are not health-based. 100 µg/m³ is an extremely high concentration. On the other hand, the French health-based guideline of 10 µg/m³ is extremely difficult to reach. As a way to be able to distinguish between schools regarding formaldehyde concentrations it is suggested to consider a TLV of 30 µg/m³ which is management guideline set by the French Public Health Council for IAQ audits.
Acetaldehyde	Passive sampler	Weekly average	200	µg/m³	200 µg/m³ is the long-term exposure set by EU (Index project) for acetaldehyde. The French health-based guideline is 160 µg/m³, also for a long term exposure
Acrolein	Passive sampler	Weekly average	0.8	µg/m³	0.8 µg/m³ is the French guideline for a long-term exposure. The Californian one is 0.35 µg/m³
Benzene	Passive	Weekly average	2	µg/m³	The Portuguese management guideline of 5 is quite high. It is suggested

	sampler				to consider the French health- based guideline of 2 µg/m^3, which corresponds to an ERU of 1 x 10^{-5}. Measurements made in French schools show that most concentrations are below this guideline.
Toluene	Passive sampler	Weekly average	250	µg/m^3	The Portuguese guideline. No guideline were set by the WHO or EU
Xylenes (m+o+p)	Passive sampler	Weekly average	200	µg/m^3	EU guideline (Index project) for a long-term exposure. LCI are 500 µg/m^3 for each type
Trichloroethylene	Passive sampler	Weekly average	20	µg/m^3	The Portuguese guideline is 25 µg/m^3 but it is proposed to take the French one, which is of 20 µg/m^3. It is health-based and corresponds to an URE of 1 x 10^{-5}
Tetrachloroethylene	Passive sampler	Weekly average	250	µg/m^3	Portuguese, French and WHO guideline for a long-term exposure
Styrene	Passive sampler	Weekly average	250	µg/m^3	This is the EU health-based guideline (Index and LCI), which is very close to the Portuguese one (260 µg/m^3)
1,4-dichlorobenzene	Passive sampler	Weekly average	150	µg/m^3	150 µg/m^3 is the LCI set by EU-JRC. the Japanese guideline is 240 µg/m^3 for a long-term exposure.
α-pinene	Passive sampler	Weekly average	200	µg/m^3	200 µg/m^3 is the German guideline for a long-term exposure. No European or SUDOE country guideline exists, except the JRC LCI of 2500 µg/m^3.

<u>NB1</u>: In a general way, it is more relevant to consider health-based guidelines than management guidelines since here there will have no mandatory actions to undertake if measured concentrations exceed the guideline. In a similar way, long-term exposure guidelines should be considered first considering that children spend long times in their classrooms.

NB2: No relevant guideline for schools could be found for propanal, isopentanal and benzaldehyde. Therefore those aldehydes will be measured (they are included in the list of 9 aldehydes which are analyzed by ICSM from cartridges ref 165), but their concentrations will not be included in the definition of KPI and assessment of IAQ in schools. On the other hand, only Lower Concentrations of Interest (LCI) set by the EU Joint Research Centre were found for butanal (650 µg/m^3), pentanal (800 µg/m^3) and hexanal (µg/m^3). These LCI are health-based threshold limit values that aim at the harmonization of mandatory labelling of material emissions in Europe. The LCI are nevertheless so high that neither it is relevant to consider these chemicals in the definition of KPI. Finally, only 3 aldehydes will be included in the definition of IAQ KPI, that is formaldehyde, acetaldehyde and acrolein

5.4.3 Key Performance Index for ventilation efficiency

The indoor air quality data must be analyzed considering the classrooms ventilation. In the context of the study, ventilation efficiency must be regarded as the fresh airflow rate which is provided to the classrooms by reference to the number of occupants. Therefore, whatever the ventilation system, ventilation efficiency can be assessed from measured CO_2 concentrations.

A ventilation efficiency index I_{vent} can be defined as the percentage of measurements where the CO_2 concentration in the two classrooms exceeds the guideline during the occupancy period, that is:

$$I_{vent} = \frac{\sum_i \delta_i}{N_i},$$

With δ_i =1 if $C_{CO2,i}$ > 1250 ppm and δ_i =0 otherwise, and N_i is the total number of measurements in the 2 classrooms during the occupancy period. 1250 ppm (2250 mg/m^3) is the Portuguese guideline for CO_2.

Based on the above equation, one can see that I_{vent} lies in the range from 0 (best situation) to 1 (worst situation), as I_{IAQ} does.

5.5 Transports

5.5.1 Data processing

The following table concerning parking characteristics, public transport network and users' behaviour should be filled in the excel file.

Table 25 – Parking characteristics

	School 1	School 2	…
No. students			
No. of parking spaces at school or periphery (up to a 100m radius)			
No. of parking spaces for disabled at school or periphery (up to a 100m radius)			
No. of parking spaces for electric cars at school or periphery (up to a 100m radius)			
No. of parking spaces for bicycles at school or periphery (up to a 100m radius)			

Table 26 – Public Transport network

	School 1	School 2	…
Bus stops on a 1000m radius (Y/N)			
Subway stops on a 1000m radius (Y/N)			
Train stops on a 1000m radius (Y/N)			
Tram stops on a 1000m radius (Y/N)			
Boat stops on a 1000m radius (Y/N)			

Bus Analysis			
	School 1	School 2	…
Number of stops in a 500m radius			
Number of stops in a 1000m radius			
Number of Bus passing daily (1000m radius)			
Total number of hours analyzed			
Number of Bus passing daily per hour (1000m radius)			
Number of Bus passing daily during rushing hour (1000m radius)			
Total number of rushing hours analyzed			
Number of Bus passing daily during rushing hour per hour (1000m radius)			
Distance between the nearest stop and school (m)			

Subway Analysis			
	School 1	School 2	…
Number of stops in a 500m radius			
Number of stops in a 1000m radius			
Number of Subway passing daily (1000m radius)			

Total number of hours analyzed			
Number of Subway passing daily per hour (1000m radius)			
Number of Subway passing daily during rushing hour (1000m radius)			
Total number of rushing hours analyzed			
Number of Subway passing daily during rushing hour per hour (1000m radius)			
Distance between the nearest stop and school (m)			

Etc for the other transport means

Table 27 – Users' behaviours

	School 1	School 2	...
Users praticing car sharing			
Average number of passengers on car sharing			
Users that use public transport when they go out with their families on the weekends			
Average distance between user's school and home			
Average time spent during the trip from home to school			
Average money spent on home-school trips monthly			

School 1								
	Never		Sometimes		Almost Always		Always	
	No.	%	No.	%	No.	%	No.	%
Foot								
Bicycle								
Bus								
Subway								
Train								
Tram								
Boat								
Car								
Motorcycle								
Public Transports (Bus+Subway+Train+Tram+Boat)								
Private Transports (Car+Motorcycle)								
Users that If there was a bike path they would use it								
Users that go back home and and return to school more than once per day								

5.5.2 Defining the Key Performance Indicators

Table 20 presents the KPIs that should be assessed to identify the baseline situation of the school for transports, and then compare to the final situation. These KPIs can also be used to compare different schools.

Table 28 – Transports KPI

KPI	Description	Units
KPI-T1	No. of parking spaces for disabled at school or periphery (up to a 100m radius)/student	$Student^{-1}$
KPI-T2	No. of parking spaces for electric cars at school or periphery (up to a 100m radius)/student	$Student^{-1}$
KPI-T3	No. of parking spaces for bicycles at school or periphery (up to a 100m radius)/student	$Student^{-1}$
KPI-T4	No. of public transports passing daily per hour per student (1000 m radius)	$h^{-1}student^{-1}$
KPI-T5	CO_2 emitted per km	gCO_2km^{-1}

5.6 Green spaces

5.6.1 Data processing

The following table concerning greenspaces should be filled in the excel file.

Table 29 – Green spaces

	School 1	School 2	...
Total school area			
Covered area			
Total garden area			
Total grassland area			
Type of fuel used in gardening activities			
Annual diesel consumption in gardening activities (l/year)			
Annual gasoline consumption in gardening activities (l/year)			
Annual heavy fuel oil consumption in gardening activities (l/year)			
Annual electricity consumption in gardening activities (kWh/year)			
Chain saw power (kW)			
Mower Power (kW)			
Operation hours chainsaw			
Operation hours mower			
Type of irrigation system			
Origin of irrigation water			
Water consumption in irrigation (m3/year)			
Name of pesticide used #1			
Name of pesticide used #2			

Name of pesticide used #3			
Name of pesticide used #4			
Name of pesticide used #5			
Amount of each pesticed used (Kg/year) #1			
Amount of each pesticed used (Kg/year) #2			
Amount of each pesticed used (Kg/year) #3			
Amount of each pesticed used (Kg/year) #4			
Amount of each pesticed used (Kg/year) #5			
% of active ingredient of each pesticide #1			
% of active ingredient of each pesticide #2			
% of active ingredient of each pesticide #3			
% of active ingredient of each pesticide #4			
% of active ingredient of each pesticide #5			
Name of each fertilizer used #1			
Name of each fertilizer used #2			
Name of each fertilizer used #3			
Name of each fertilizer used #4			
Name of each fertilizer used #5			
Amount of each fertilizer used (Kg/year) #1			
Amount of each fertilizer used (Kg/year) #2			
Amount of each fertilizer used (Kg/year) #3			
Amount of each fertilizer used (Kg/year) #4			
Amount of each fertilizer used (Kg/year) #5			
% of N of each fertilizer #1			
% of N of each fertilizer #2			
% of N of each fertilizer #3			
% of N of each fertilizer #4			
% of N of each fertilizer #5			
% of P_2O_5 of each fertilizer #1			
% of P_2O_5 of each fertilizer #2			
% of P_2O_5 of each fertilizer #3			
% of P_2O_5 of each fertilizer #4			
% of P_2O_5 of each fertilizer #5			
% of K_2O of fertilizer #1			
% of K_2O of fertilizer #2			
% of K_2O of fertilizer #3			
% of K_2O of fertilizer #4			
% of K_2O of fertilizer #5			
Type of compost used			
Amount of each compost used			
Number of trees			
Predominant tree specie			
Average age of trees			

5.6.2 Defining the Key Performance Indicators

Table 20 presents the KPIs that should be assessed to identify the baseline situation of the school for green spaces, and then compare to the final situation. These KPIs can also be used to compare different schools.

Table 30 – KPIs for green spaces

KPI	Description	Units
KPI-GS1	Number of trees per non-covered area	m^{-2}
KPI-GS2	Number of trees per student	$student^{-1}$
KPI-GS3	Green area per non-covered area	%
KPI-GS4	Green area per student	m^2/ $student^{-1}$
KPI-GS5	CO_2 sinked per non-covered area per year	$tonCO_2/m^2.year$
KPI-GS6	Quantity of chemists used for the space maintenance	$kg_{chemists}/m^2_{green\ area}$
KPI-GS7	Quantity of CO_2 emitted for the space maintenance (equipment + energy + water)	$kgCO_2/m^2_{green\ area}$

5.7 Green procurement

5.7.1 Data processing

The following table concerning green procurement should be filled in the excel file.

Table 31 – Green procurement

	School 1	School 2	…
Policies, objectives or a target for conserving the environment			
No. of individuals in school with training in green procurement			
No. of individuals with eco-driving certificate			
No. of equipments with A+++			
No. of equipments with A++			
No. of equipments with A+			
No. of equipments with A			
No. of equipments with B			
No. of equipments with C			
No. of equipments with D			
No. of equipments without star level of efficiency			
No. of printers			
No. of printers with optimum consumption			
Amount of used paper (Kg/Month)			
Amount of paper purchased directly to National producers (Kg/Month)			

Amount of recycled paper used (Kg/Month)			
Use of chlorine-free paper (Yes/No)			
Concern about chemical information in the labels of detergents (Yes/No)			
Concern about chemical information in the labels of Lab. Chemical products (Yes/No)			
Total amount of purchased food per month (Kg/Month)			
Total amount of purchased food with biological certificate per month (Kg/Month)			
No. of county providers			
No. of district providers			
No. of country providers			
No. of international providers			

5.7.2 Defining the Key Performance Indicators

Table 20 presents the KPIs that should be assessed to identify the baseline situation of the school for green procurement, and then compare to the final situation. These KPIs can also be used to compare different schools.

Table 32 – KPIs for green spaces

KPI	Description	Units
KPI-GP1	Quantity of electric and electronic equipment with A+ or higher EU Energy Label used in school	No. equip A+ or higher EU Energy Label /total no. equipment.
KPI-GP2	Quantity of recycled paper used in school	Kg recycled paper/Kg consumed paper
KPI-GP3	Training in green procurement	No. staff with training in green procurement / Total no. staff
KPI-GP4	Eco-driving certificate	No. staff with eco-driving certificates / Total no. staff
KPI-GP5	Food with biological certificate	Kg food with biological certificate/Kg total food
KPI-GP6	Local suppliers	No. local suppliers /total suppliers

6 Repor on baseline energy and environment performance

The environmental audit report presents all the relevant information collected during the environmental audit and shall contain all the information collected, the analysis of the building's current situation (baseline), the identification of anomalies/wastes and it must propose measures considered more convenient to prevent or reduce energy waste (within ClimACT framework, the measures proposal will be developed in Activity 3.3 - Definition of targets and development of action plans).

Activity 3.2 of ClimACT comprises the development of a *Report on baseline energy and environment performance* (E3.2.2) for each school. The structure of this report is necessarily affected by the specific characteristics of the school audited. Following an example of an energy audit report contents is presented based on the structure of the pre-audit checklist (Annex 1) and on the present document.

Example of an environment audit report index:

EXECUTIVE SUMMARY

SCHOOL GENERAL CHARACTERIZATION

1. Administrative data
2. Physical characteristics
3. Use of the building

ENERGY

1. Energy usage description
    1.1. Energy consumption/energy bills analysis
        1.1.1. Electricity
        1.1.2. Natural gas
        1.1.3. Other fuels
        1.1.4. Global energy consumption
    1.2. Energy production on site
    1.3. Primary energy consumption
2. Main energy systems analysis
    2.1. Electrical installation
    2.2. HVAC system
    2.3. DHW production system
    2.4. Lighting
    2.5. Other equipment
3. Building envelope characteristics
5. Results of energy measurements
    5.1. Loads/consumption
        5.1.1. Electrical energy
        5.1.2. Thermal energy
    5.2. Equipment performance
        5.2.1. Analysis of boiler combustion conditions
        5.2.2. Analysis of chiller EER
6. Breakdown of consumption
7. Key performance indicators

8. Conclusions

WATER

1. Water usage description
    1.1. Water consumption/water bills analysis
2. Main water systems analysis
    2.1. Water saving measures already used
    2.2. Identification of water losses and leakages
3. Results of water measurements
4. Breakdown of water consumption
5. Key performance indicators
6. Conclusions

WASTE

1. Waste production description
2. Results of waste measurements
3. Breakdown of waste production
4. Key performance indicators
5. Conclusions

COMFORT AND INDOOR AIR QUALITY

1. Results of measurements
2. Key performance indicators
3. Conclusions

TRANSPORTS

1. Results of the assessment
2. Key performance indicators
3. Conclusions

GREEN SPACES

1. Results of the assessment
2. Key performance indicators
3. Conclusions

GREEN PROCUREMENT

1. Results of the assessment
2. Key performance indicators
3. Conclusions

GENERAL CONCLUSIONS

The body of the report should summarize the current building status and the main findings, while more technical data should be presented as annex.

A template for the *Report on baseline energy and environment performance* (E3.2.2) will be developed and shared with the partners in order to standardize data presentation

7. References

Pereira (2016) – Pereira L., Modernised Portuguese Schools - From IAQ and Thermal Comfort towards Energy Efficiency Plan, PhD thesis in Sustainable Energy Systems, Faculdade de Pereira (2016) – Pereira L., Modernised Portuguese Schools - From IAQ and Thermal Comfort towards Energy Efficiency Plan, PhD thesis in Sustainable Energy Systems, Faculdade de Ciências e Tecnologia da Universidade de Coimbra.

Silvonen et al (2006) – Silvonen S., Markovitch J., Naumov G., *Guidelines and Models for Energy Auditing*, 2006.

Thumann & Younger (2007) - Thumann A., Younger W., *Handbook of Energy Audits*, 7th edition, 2007.

8. Annexos

Annexe 1 – Pre-audit checklist

Interreg Sudoe ClimACT
European Regional Development Fund
EUROPEAN UNION

Action B3.2
PRE-AUDIT CHECKLIST

A) Administrative data	
A1. Name of the school	
A2. Type of school	
A3. Age-range of students	
A4. Country	
A5. City	
A6. Address	
A7. Low Carbon Coordinator	
A8. Name/role of the persons that provide information for this questionnaire	
General Foto of the School	

B) Physical characteristics		Data to request
B1. Year of construction		**1 - Architecture project (blueprints of the building)**
B2. Area of the school (m2)		
B3. Gross floor area (m2)		
B4. Usable floor area (m2)		
B5. Indoor conditioned area (m2)		
B6. Number of floors		
B7. Number of classrooms		
B8. Area of the classrooms (m2)		
B9. Canteen (Y/N)		
B10. Gymnasium (Y/N)		
B11. Description and year of any refurbishment process or upgrading of heating, ventilation and air conditioned & refrigeration (HVAC&R) systems		
B12. Definition of national/regional technical codes of school design (e.g.: Andalusian school design code: http://www.juntadeandalucia.es/boja/2003/43/3)		

C) Use of the building	
C1. Number of occupants	
C1.1. Students	
C1.2. Teachers	
C1.3. Administrative Staff	
C1.4. Auxiliar Staff	
C2. Number of occupants per classroom	
C3. Number of canteen users/day	
C4. Number of the gymnasium users/day	
C5. Building utilization period (open and close time)	
C5.1. Week	
C5.2. Weekend	
C6. Yearly closure periods	
C6.1. Which energy-using equipment are in operation during this period?	
Observations/comments on the use of the building (e.g. definition of extra-curricular school activities)	

D) Energy consumption		Data to request
D1. Is eletricity consumed? (Y/N)		2 - Monthly bills of 3 years (2014, 2015 and 2016) for all the types of energy consumed
D1.1. Annual average bill (kWh, €)		
D1.2. What are the main uses of electricity (eg: air conditioning, ventilation, lighting,...)?		
D2. Is natural gas consumed? (Y/N)		
D2.1. Annual average bill (kWh, m3, €)		
D2.2. What are the main uses of natural gas (eg: hot water, heating,...)?		
D3. Is propane/LPG consumed? (Y/N)		
D3.1. Annual average billl (kg, €)		
D3.2. What are the main uses of propane/LPG (eg: hot water, heating,...)?		
D4. Is oil/diesel consumed? (Y/N)		
D4.1. Annual average billl (kg, €)		
D4.2. What are the main uses of oil/diesel (eg: hot water, heating,...)?		
D5. Are other fuels or other energies consumed? (Y/N) Which? (eg: biomass,...)		
D5.1. Annual average bill (energy units, €)		
D5.2. What are the main uses of other fuels or other energies (eg: hot water, heating, ...)?		
Observations/comments on energy consumption		

E) Energy production	
E1. Is there energy production (eg: photovoltaic panels)?	
E1.1. What portion of this energy is consumed in the building?	
Observations/comments on energy production	

F) Lighting		Data to request
Fi) Interior Lighting		3 - Lighting project
Fi1. What type of lighting is predominantly used in the building (eg: fluorescent, incandescent, halogen, LED,...)?		
Fi1.1. Definition of available technical data. Characterization (eg.: power (W), luminous flux (lumen),...)		
Fi1.2. Approximate year of the system installation		
Fi1.3. Brand and model of the system (most common system)		
Fi2. What is the lighting schedule?		
Fi3. Are there systems for automatic control (eg: motion sensor, time clock, photocell,...)? Which and where?		
Fe) Exterior Lighting		
Fe1. What type of lighting is predominantly used in the exterior (eg: fluorescent, incandescent, halogen, LED, metal halide...)?		
Fe1.1. Definition of available technical data. Characterization (eg.: power (W), luminous flux (lumen),..)		
Fe1.2. Approximate year of the system installation		
Fe1.3. Brand and model of the system (most common system)		
Fe2. What is the lighting schedule?		
Fe3. Are there systems for automatic control (eg: motion sensor, time clock, photocell,...)? Which and where?		
Observations/comments on lighting		

G) Heating		Data to request
G1. Are there heating systems in the building?		4 - HVAC project and HVAC descriptive documents
G2. Equipment used for heating in the building:		
G2.1. Type of system (centralized system, single units,...)?		
G2.2. Which is the temperature setpoint for heating?		
G2.3. Type of equipment (eg: heat pump, boiler, radiators...)		
G2.4. Type of energy/fuel consumed (eg: eletricity, natural gas, propane,...)		
G2.5. Definition of available technical data. Characterization (eg: power, yield, EER, COP,..)		
G2.6. Approximate year of the system installation		
G2.7. Brand and model of the system (most common system)		
G3. Utilisation schedules		
G3.1. The heating is used in which months of the year?		
G3.2. How many hours a day is the heating on during those months?		
G4. Is there regular maintenance work?		
G4.1. Definition of maintenance frequency		
G4.2. Definition of annual maintenance cost		
Observations/comments on heating		

H) Cooling		Data to request
H1. Are there cooling systems in the building?		4 - HVAC project and HVAC descriptive documents
H2. Equipament used for cooling in the building:		
H2.1. Type of system (centralized system, single units,...)?		
H2.2. Which is the temperature setpoint for cooling?		
H2.3. Type of equipment (eg: chiller, monosplits,...)?		
H2.4. Type of energy/fuel consumed (eg: eletricity, natural gas,		
H2.5. Definition of available technical data. Characterization (eg: power, yield, EER, COP,..)		
H2.6. Approximate year of the system installation		
H2.7. Brand and model of the system (most common system)		
H3. Utilisation schedules		
H3.1. In which months of the year is the cooling used ?		
H3.2. How many hours a day is the cooling on during those months?		
H4. Is there regular maintenance work?		
H4.1. Definition of maintenance frequency		
H4.2. Definition of annual maintenance cost		
Observations/comments on cooling		

I) Ventilation		Data to request
I1. Is there mechanical ventilation in classrooms?		4 - HVAC project and HVAC descriptive documents
I1.1. Type of system/equipment of ventilation		
I1.2. Approximate year of the system installation		
I1.3. Definition of available technical data. Characterization (eg.: ventilation rate, electric power,...)		
I1.4. How many hours per day is the mechanical ventilation in classroom on?		
I2. Is there natural ventilation in classrooms?		
I2.1. Type of system/equipment of natural ventilation (eg: windows, free-cooling system,...)		
I2.2. Is ventilation operating at night?		
I2.3. Does the teachers open the windows during the classes?		
I2.4 Does the teachers open the windows during the intervals?		
I3. Is there mechanical ventilation in other zones? Where? (eg: kitchen, toilets, parking, ,...)		
I3.1. Type of system/equipment of ventilation		
I3.2. Approximate year of the system installation		
I3.3 Definition of available technical data. Characterization (eg.: ventilation rate, electric power,...)		
I3.4. How many hours a day is the ventilation on?		
I4. Is there natural ventilation in other zones (eg: kitchen, toilets,...)? Where?		
I5. Is there regular maintenance work of mechanical ventilation systems?		
I5.1. Definition of maintenance frequency per system		
I5.2. Definition of annual maintenance cost per system		
Observations/comments on ventilation		

J) Other equipments	
J1. Are there digital blackboards in classrooms?	
J1.1. Are shading devices and lighting used when the digital blackboard is on?	
J2. Are there digital projectors in classrooms?	
J2.1. Are shading devices and lighting used when the digital projector is on?	

K) Energy metering		Data to request
K1. Electricity metering (Y/N and where)		5 - Electric installations project
K1.1. General distribution board?		
K1.2. Partial distribution boards?		
K2. Natural gas metering (Y/N and where)		6 - Gas installations project
K2.1. General meter?		
K2.2. Partial meters?		
K3. Propane/LPG metering (Y/N and where)		
K3.1. General meter?		
K3.2. Partial meters?		
Observations/comments on energy metering		

L) Energy management	
L1. Identification of the entity/person responsible for the Energy Management	
L1.1. Function, tasks and main responsabilities?	
L1.2. Heating, cooling and ventilation systems are manually or	
L2. Is there an energy management system?	
Observations/comments on energy management	

M) Energy audits	
M1. Was it previously held any energy audit in the building?	
M1.1. Date of the audit	
Observations/comments on energy audits	

N) Building envelope		Data to request
N1. How do you rate the quality of the facade and roof of the building (good/acceptable/bad)? *Good: high insulation* *Acceptable: moderate insulation* *Bad: without insulation*		8 - Construction details of the building envelope 9 - Map of glazed areas 10 - Characteristics of glasses and window frames
N1.1. Definition of facade and roof layers (if data is available)		
N1.2. Average thickness of facade and roof		
N1.3. Are there infiltrations in the building facade? Where?		
N2. How do you rate the quality of the building's windows		
N2.1 Definition of windows (e.g: sliding or hinged)		
N2.2. Are there infiltrations through the windows? Where?		
N2.3. Characterization of the glazing and window frames		
N3. Shading devices		
N3.1. Are there outdoor shading elements (eg: blinds, shutters,...)?		
N3.2. Are there indoor shading elements (eg: blinds, curtains,...)?		
N3.3. Are there natural shading elements or from the building		
Observations/comments on the building envelope		

O) Comfort	
O1. How do you rate the thermal comfort felt in the building (good/acceptable/bad)?	
O1.1. Is there any particular aspect that should be improved (eg: there are building zones very cold in the winter or too hot in the	
O2. How do you rate the visual comfort felt in the building (good/acceptable/bad)?	
O2.1. Is there any particular aspect that should be improved (eg: there are building zones with poor lighting or too bright)?	
O3. How do you rate the noise from outdoor in the building (good/acceptable/bad)?	
O3.1. Is there any particular aspect that should be improved?	
Observations/comments on comfort	

P) Indoor Air Quality		
P1. How do you rate the air quality in the building (good/acceptable/bad)?		
P2. Is there any particular aspect that should be improved (eg: there are building zones with poor ventilation)?		
P3. Did the users complain about headaches, dry nose or other symptoms related with poor Indoor Air Quality?		
P4. Are there noticiable odours in the spaces (example transpiration, combustion exhaust, humidity, chemicals, perfumes, solvents, paints, weat cement or calcarium)? Where?		
P5. Is it visible the deposition of particles in the surfaces?		
P6. Is it visible the existence of fungy in the halls and ceilings?		
P7. Are there any spaces with presence of chemicals (e.g. printers' rooms, labs, etc)?		
P8. Where are the printers located?		
P9. Considereing the insuflation and extraction of air in the rooms, is it expected to exist by-pass?		
P10. Are the hygenic condition of the spaces acceptable? (from 1-5)		
P11. Are the hygenic condition of the HVAC system acceptable? (from 1-5)		
P12. Is the school located near a busy road?		
P13. Is the air admitance influenced by the soil?		
P14. Is the air admitance influenced by the building exhausts?		
P15. Is there any space in the school where it is allowed to smoke? Where?		
P16. Are there blackboards in classrooms/ chalk?		
P17. Select 2 class rooms where the IAQ will be developed and characterize them	**Classroom 1**	**Classroom 2**
P17.1. Localization		
P17.2. Number of the classroom		
P17.3. Area (m2)		
P17.4. Height (m)		
P17.5. Number of students in the classroom		
P17.6. Blackboard, white board or digital board		
P17.7. Type of flooring		
P17.8. Type of windows		
P17.9. Energy power available (Y/N). Number and location of the electric plugs.		
Foto of the classrooms		
Observations/comments on IAQ		

Q) Waste management	
Q1. Is there any accounting for the amount of waste produced?	
Q2. Is there separation of waste for recycling?	
Q2.1. What types of waste are recycled?	
Q2.2. Is there any accounting for the amount of waste sent for recycling?	
Q2.2.1 How this accounting is done (global value, type,...)?	
Q3. Is there re-use of paper?	
Observations/comments on waste management	

R) Water		Data to request
R1. Monthly average bill (R3, €)		7 - Monthly water bills of 3 years (2014, 2015 and 2016)
R2. Water metering (Y/N and where)		
R2.1. General meter?		
R2.2. Partial meters?		
R3. Are there any devices for water saving (eg: flow controller taps, dual system of sanitary discharge,...)? Which?		
R4. Is there consumption of hot water in the building? (Y/N)		
R4.1. What kind of equipment is used for hot water production (e.g. heat pump, boiler, water heater,...)?		
R4.2. Which is the temperature setpoint for hot water (eg: in the storage tank)?		
R4.3. Type of energy/fuel consumed (eletricity, natural gas, propane,...)?		
R4.4 Definition of available technical data. Characterization (eg: power, yield, EER, COP,..)		
R4.5. Approximate year of the system installation		
R4.6. Brand and model of the system (most common system)		
R4.7. Are there solar thermal collectors installed and in operation? How many collectors?		
R4.8. Definition of available technical data. Characterization of solar collectors		
R5. Utilisation schedules of hot water		
R5.1. Hot water is used in which months of the year?		
R5.2. Where is hot water used (kitchen, toilets, baths,...)?		
R6. Sources of water available		
Observations/comments on the use of water		

S) Transports	
S1. Parking area	
S1.1. No. of parking spaces at school or periphery (up to a 100m radius)	
S1.2. No. of parking spaces for disabled at school or periphery (up to a 100m radius)	
S1.3. No. of parking spaces for electric cars at school or periphery (up to a 100m radius)	
S1.4. No. of parking spaces for bicycles at school or periphery (up to a 100m radius)	
S1.5 Foto of the Parking Area	
S2. Characterization of the transport network	
S2.1 Bus	
S2.1.1 No. of stops in a 100m radius	
S2.1.2 No. of stops in a 250m radius	
S2.1.3 No. of stops in a 500m radius	
S2.1.4 Daily average frequency passing per hour	
S2.1.5 Daily average frequency passing per rush hour	
S2.1.6 Distance between the nearest stop and school	
S2.2 Subway	
S2.2.1 No. of stops in a 100m radius	
S2.2.2 No. of stops in a 250m radius	
S2.2.3 No. of stops in a 500m radius	
S2.2.4 Daily average frequency passing per hour	
S2.2.5 Daily average frequency passing per rush hour	
S2.2.6 Distance between the nearest stop and school	
S2.3 Train	
S2.3.1 No. of stops in a 100m radius	
S2.3.2 No. of stops in a 250m radius	
S2.3.3 No. of stops in a 500m radius	
S2.3.4 Daily average frequency passing per hour	
S2.3.5 Daily average frequency passing per rush hour	
S2.3.6 Distance between the nearest stop and school	
S2.4 Boat	
S2.4.1 No. of stops in a 100m radius	
S2.4.2 No. of stops in a 250m radius	
S2.4.3 No. of stops in a 500m radius	
S2.4.4 Daily average frequency passing per hour	
S2.4.5 Daily average frequency passing per rush hour	
S2.4.6 Distance between the nearest stop and school	
Observations/comments on transports	

T) Green Spaces	
T1. General Information	
T1.1 Type of green spaces (garden/kitchen garden/trees)	
T1.2 Area of green space (m2)	
T1.3 Year of construction	
T1.4 Existence of amusement equipment (Y/N)	
T1.5 No. of seats	
T1.6 Photo of the green spaces	
T2. Energy	
T2.1 Amount of energy consumed by the green space	
T3. Water	
T3.1 Total water consumption of the green space per month	
T3.2 Sources of water consumed by the green space	
T3.3 Existence of lakes, streams, fountains	
T4. Maintenance	
T4.1 Entity in charge of the maintenance	
T4.2 Maintenance cost of the green space	
T4.3 Maintenance frequency of the green space	
T5. Biome information	
T5.1 Fauna species	
T5.2 Flora species	
T5.3 Native fauna species	
T5.4 Native flora species	
T5.5 Number of trees	
Comments on green spaces	

U) Green Procurement	
U1. Certifications Information	
U1.1 Existence of certificate ISO 14001: 2004 - Environmental Management Systems, taking into consideration environmental protection, pollution prevention, legal compliance and socio-economic needs (Y/N)	
U1.2 Existence of certificate ISO 9001 -International Standard for Quality Management Systems (Y/N)	
U1.3 No. of individuals in school with training in green procurement	
U1.4 No. of individuals with eco-driving certificate	
U2. Electronic equipment information	
U2.1 Energy star level of efficiency	
U2.1.1 No. of equipments with A+++	
U2.1.2 No. of equipments with A++	
U2.1.3 No. of equipments with A+	
U2.1.4 No. of equipments with A	
U2.1.5 No. of equipments with B	
U2.1.6 No. of equipments with C	
U2.1.7 No. of equipments with D	
U2.1.8 No. of equipments without star level of efficiency	
U2.2 Printers	
U2.2.1 No. of printers	
U2.2.2 No. of printers with optimum consumption	
U2.2.3 Amount of used paper (Kg/Month)	
U2.2.4 Amount of paper purchased directly to National producers (Kg/Month)	
U2.2.5 Amount of recycled paper used (Kg/Month)	
U2.2.6 Use of chlorine-free paper (Y/N)	
U3. Food products Information	
U3.1 Total amount of purchased food per month (Kg/Month)	
U3.2 Total amount of purchased food with biological certificate per month (Kg/Month)	
U3.3 Amount of produced edible oil per month (L/month)	
U3.4 Amount of produced edible oil delivered to the competent authority per month (L/month)	
U3.5 Quantity of separate food waste according to good food waste management practices per month (Kg/Month)	
U3.6 Quantity of food waste which are reused as fertilizer per month (Kg/Month)	
U3.7 Purchase site of products	
U3.7.1 No. of county providers	
U3.7.2 No. of district providers	
U3.7.3 No. of country providers	
U3.7.4 No. of international providers	
Comments on green procurement	

General Comments

Annexe 2 – Supporting excel files index

- 2a - Energy accountancy – Electricity.xls
- 2b - Energy accountancy - Natural Gas.xls
- 2c - Energy accountancy - Other fuels.xls
- 2d - Water accountancy.xls
- 4 – Surveys.xls
- 5 - Measurements – Electricity.xls
- 5 - Measurements - T and RH.xls
- ClimACT_3.2.1_excel files (Transports GreenSpaces Green Procurement)_V_2.xlsx
- IAQ measurements (template).xlsx