Interreg Sudoe

3SqAir

European Regional Development Fund

SUSTAINABLE SMART STRATEGY FOR AIR QUALITY ASSURANCE IN CLASSROOMS

Deliverable

Case Studies (3.2.1)

Demo-site 6 – Portugal FCTUC-DEM

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SUMMARY

The 3SqAir project is a multi-partner and cross-border project. Its main goal is to design a "Smart" and "Sustainable" action plan, to ensure, through a common quality approach, the indoor air quality of French, Spanish and Portuguese educational buildings.

1-OBJECTIVES:

The Deliverable 3.1.2-Best Practices guidelines and criteria indicators for better Indoor Air Quality in classrooms - was developed within the scope of the Activity 3.1of the project 3SqAir. The objective of this technical report is to define and present feedback on a remarkable indoor air quality (IAQ) management operation, through a reference framework of IAQ criteria in order to assess the inclusion of IAQ in school buildings.

This reference framework was established as part of the task 3.1.2 of the 3SQAIR project, the deliverable of which can be downloaded from the project website www.3SqAir.com

The approach has a dual objective:

- improve stakeholder knowledge on how to manage IAQ in their own buildings;
- propose a common methodology for comparative studies on "best practice" case studies.

1.1 – Methodology:

The objective of the 3SQAIR project is to define **RIS3**[1] strategies to improve indoor air quality IAQ in classrooms. One of the levers to achieve this objective is to share best practices (BP) with all stakeholders in order to enhance their knowledge, and consequently, their practices. To this end, we propose to identify the major action criteria to help stakeholders to improve IAQ in educational buildings.

Our work consisted in drawing up a first state of the art of methodologies for assessing the IAQ in educational buildings. This first analysis made it possible to identify a list of IAQ improvement levers considering technical and organizational. And, we propose a simplified methodology assessing a synthesis profile of the IAQ for feedback from operations.

In fact, the characterization of IAQ has many components, themselves linked to the complexity of the life cycle of a building. Such an analysis must be holistic because the IAQ of a classroom also depends on organizational aspects (maintenance and management of real estate), sociological (behavior and comfort of the occupants), economic (available resources) and even political considerations (exemplary public policies for contractors).

We propose a baseline to define common criteria for promoting best practices in IAQ in classrooms, which also lays down common guideline settings for smart, sustainable and energy efficient IAQ solutions.

[1] RIS3 = Research and Innovation Strategies for Smart Specialisation

Through a selective bibliographic study and an in-depth presentation of the modeling of IAQ pollutants, we have identified 10 major indicators for the inclusion of IAQ, classified into 2 areas:

1) BUILDING FACILITIES: "TECHNICAL SOLUTIONS ON IAQ AND VENTILATION"

A) POLLUTANT SOURCES
B) INTAKE AND EXHAUSTS
C) FILTRATION
D) AIR RENEWAL SYSTEMS
E) AIR PURIFICATION

2) STAKEHOLDERS ORGANIZATION: "MANAGEMENT"

F) COST
G) OCCUPANTS' COMFORT AND BEHAVIOR
H) COMMUNICATION AND QUALITY MANAGEMENT SYSTEMS
I) MAINTENANCE
J) SUSTAINABILITY (ENVIRONMENTAL IMPACT & ENERGY EFFICIENT STRATEGIES)

This report offers a common reference simplified methodology to establish comparative studies on IAQ in educational buildings. This methodology constitutes a basis for the practical resource (best practices experience feedback case studies) for stakeholders that have to be produced within the 3SqAir project, through the eponymous online platform website. It will be used to build an analysis framework for the 12 operations that are the subject of experience feedback as part of task 3.2.1 of the 3SQAIR project.

2-CASE STUDIES: Classroom 3.3 and 6.3 of the DEM of the FCTUC

2.1 – General Description

Demo-site 6 [Portugal, FCTUC-DEM]

Location	Coimbra (Portugal)
Year building / Renovation	1994
Number of building	4
Total occupancy	1100 students
Surface	total useful floor area (TUFA) – 7347 m^2 / TOTAL AREA = 8239 m^2
Educational stage	University

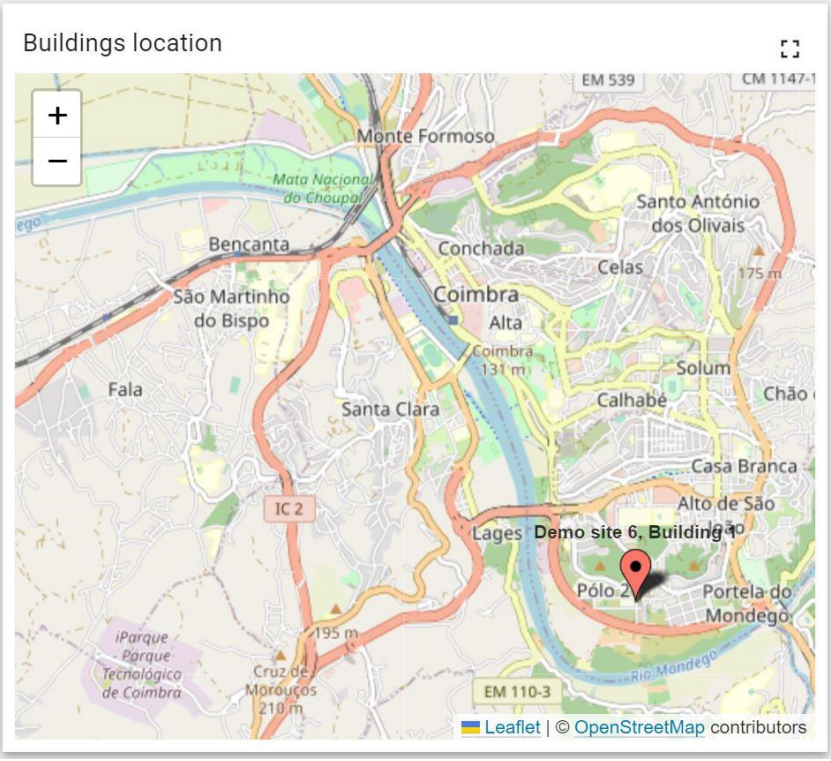
Site location:

Departamento de Engenharia Mecânica

Rua Luís Reis Santos, Pólo II da Universidade de Coimbra

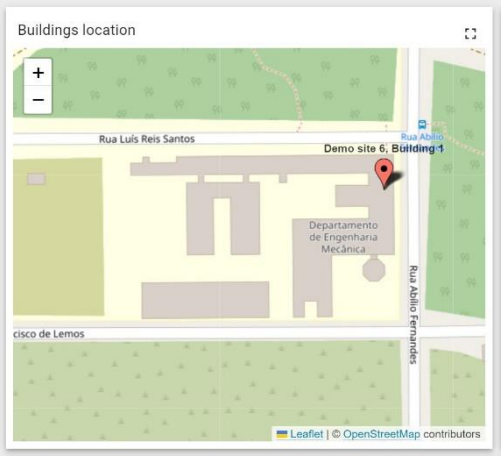
3030-788 Coimbra PORTUGAL

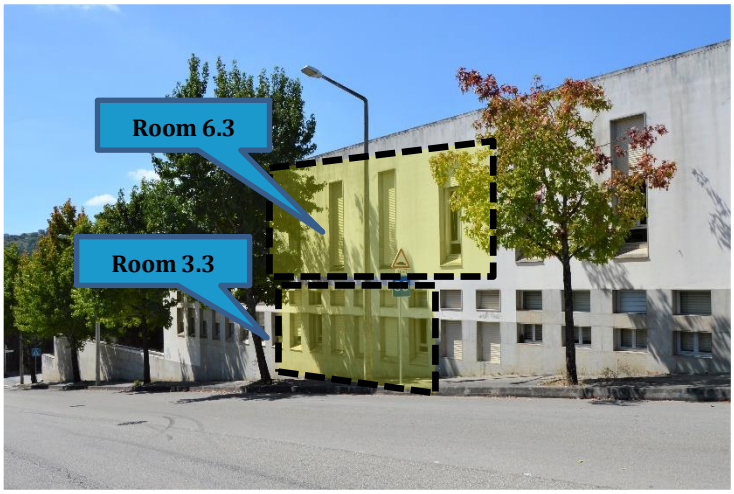
40º 11’ 10’’ N; 08º 25’ 06’’ W



Aerial view:

General Plan of the FCTUC-DEM building / East façade and classrooms identification:





2.1.1 – BUILDING FACILITIES: TECHNICAL SOLUTIONS ON IAQ AND VENTILATION

A) POLLUTANT SOURCES:

The Outdoor Environmental Zone			The Indoor Environmental Zone		
	Yes	No		Yes	No
Urban area	x		Maintenance products used for interior cleaning	x	
Rural area		x	Room's Activity	x	
Industrial area nearby		x	Wall and floor coverings		x
Nearest gas station (less than 1km)		x	Luminaire type		x
Commercial zone		x	Heating method *		x
Parking lot					
Presence of electromagnetic waves		x			
Other(s) – to be specified			Other(s) – to be specified		

B) INTAKE AND EXHAUSTS:

Intake and Exhausts Information's | Room 3.3 (*Mechanical Ventilation System and an All-Air HVAC System)*

Self-adjusting	No
MECHANICAL VENTILATION	
humidity-controlled air inlets	Yes
humidity-controlled air outlets	Yes
NATURAL VENTILATION	
Air entry/evaluation through openings	Windows surface: Room 3.3 | Five windows glazed surface of 9,45 m^2 *openable surface: 1.1 m^2*

Intake | Room 6.3 (*Natural Ventilation System, Total Recirculation HVAC Split System and a Heating System based on warm water radiators supplied by a central natural gas boiler*)

NATURAL VENTILATION	
Air entry/evaluation through openings	Room 6.3 |Four windows glazed surface of 10,8 m^2 *openable surface: 1.5 m^2*

C) FILTRATION:

Note: only applies to room 3.3 that has HVAC

Filtration Information's *(according to the PREVENTIVE MAINTENANCE PLAN of the new HVAC project of classroom 3.3)*

AIR CONDITING	
Type of maintenance / Frequency	**Chiller / Heat pumps / UE's VRV /EU's Split** Monthly - General operation should be checked - Check operation of compressor, fan, in all speeds, (pay attention to the vibrations, noise levels and state of bearings) **Chiller / Heat pumps** Quarterly - Cleaning the condensate tray and checking for correct evacuation. **Condenser cleaning** Every 6months
VENTILATION	
Type of maintenance / Frequency	Chiller / Heat pumps Monthly - Cleaning the air filters
HEATING	
Type of maintenance / Frequency	-

Note concerning air conditioning and air renewal grills: *outdoor Grills have inside an anti-bird grid in galvanized steel wire inside, and are also equipped with an anti-mosquito net.*

*According to the **PREVENTIVE MAINTENANCE PLAN**, grills and diffusers (intake, extraction and return) should be cleaned every 6M. The same periodicity is due to: check operation and adjust the control equipment of room temperature; measure and record air temperatures in ducts, the environment and correct if necessary.*

D) AIR RENEWAL SYSTEMS:

Air Renewal System Information's | Room 3.3 (*Mechanical Ventilation System and an All-Air HVAC System)*

Planned air change rates *(A = 51m² / V = 156 m³)*	5.13 (1.9 – 5.7) h^{-1}	
Possibility opening windows	[X] yes *	[ ] no
Windows operability	[ ] single-hung [ ] slinding [ ] pivot	[X] French window (casement) [ ] tilt and turn [ ]
Air renewal system	[ ] natural ventilation [ ] double-flow	[ ] single-flow [ ] over-ventilation at night
Air System **	[X] mechanical [X] automated	[X] programmed [ ]
Flowrate	800 (300-900) m^3/h **	
Ventilation protocol	9:00 am – 7:00 pm ** (	
HEATING AND COOLING MODE		
Summer	25ºC (air temperature reference value)	
Winter	20ºC (air temperature reference value)	
Air conditioning		

** Windows can be opened, but should not be opened unless the air conditioning and air renewal system is not running.*

*** The mechanical system can be fully automated and programmed remotely.*

Currently it is programmed to shut down daily (weekdays from Monday to Friday) but it is automated daily in the morning by a technician. The 9h00 kick-off relates to the classroom first scheduled class in the morning.

**** requisites relate to daily CO_2 average during occupancy period*

FCTUC-DEM (class)Room 3.3

- *New air conditioning and air renewal system replaced the heating system with conventional radiators (previously there was no mechanical ventilation, just NV through window and door opening)*
- *New fresh air intake through mechanical system according to national legislation (requisites relate to daily CO_2 average during occupancy period)*
- *The hot and chilled water are be routed, through a piping network of four properly insulated pipes, to the air conditioning terminal units, fan coils*
- *The fresh air for the occupied spaces will be ensured by the direct capture from the outside and its intake in the considered places by means of fan coils*

Other data relating the pilot-site

- *ROCA (boilers), Carrier (chillers), WOLF (AHUs)*
- *Nominal power: AHUs = 7.71 kW; Chillers = 69.2 kW (each); Boilers 348.8 kW (each)*

Air Renewal System Information's | Room 6.3 (Naturally ventilated)

On-site measured air change rates *(A = 103,5m² / V = 314 m³)*	Min = 0.21 h^{-1} (infiltration rate) Max = 9 h^{-1} (all windows open)
Possibility opening windows	[X] yes * [ ] no
Windows operability	[ ] single-hung [X] French window (casement) [ ] slinding [ ] tilt and turn [ ] pivot [ ]
Air renewal system	[ ] natural ventilation [ ] single-flow [ ] double-flow [ ] over-ventilation at night
Air System **	[X] mechanical [X] programmed [X] automated [ ]
Flowrate	65.9 - 2826 m^3/h
Ventilation protocol	N/A. Users preference dictates windows' opening
HEATING MODE	
Winter	20ºC (air temperature reference value)

2.1.2 ORGANIZATION OF STAKEHOLDERS – BUILDING MANAGEMENT:

Indicate the maintenance manager(s) of the site's various systems and the service providers. Explain their role and importance in the decision chain.

Building Management Information's *(serving solely room 3.3)*

Type of system	Building Management System
Model	TRANE VC1.0 – DFE 4P-341LX

HVAC system: Installer / Maintenance

Installer	
Electroclima	https://www.electroclima.pt/
Current Maintenance Contracted entity	
Sistclima	https://sistclima.com/

F) COST

Cost Information's *(general energy costs of FCTUC-DEM)*

Consumption (kWh)	
Surface building (m²)	total useful floor area (TUFA) – 7347m² TOTAL AREA = 8239 m²
Price (€)	Tariff type: *"tetra-horária"* (four different periods of consumption in the electricity plan) Averaged cost estimation: 0,15 €/kWh (calculation over the annual kWh consumption/energy cost)
Energy (Type of energy is the site using)	Energy and Natural Gas
Energy's consumption	Annual electric consumption: chillers = 33kW Annual thermal consumption: 87666 kgep/yr (heating) & 4843 kgep/yr (cooling) Annual global energy consumption: 628089 kWh/yr

Energy source Information's (for the entire Department)

Type	**Electricity**
Annual Electric consumption	443578 kWh (data from 2019)
Renewable energy power	100 kW (nominal installed power)
Annual electric generation	116159 kWh (data from 2022)
Type	**Gas**
Annual gas consumption	318042 kWh (data from 2019)

G) OCCUPANTS' COMFORT AND BEHAVIOR

Occupants' Confort Information | Room 3.3

Description of activities	Regular classroom	
Frequency of site occupancy	Daily occupancy	
Accommodation capacity	40 students	
Presence of vegetation	[ ] yes	[X] no
Ability for occupants to control:		
Ventilation equipment	[ ] yes	[X] no
windows	[X] yes *	[ ] no

* *Occupants may operate windows but they should not do it while the mechanical ventilation system is in operation.*

Occupants' Confort Information | Room 6.3

Description of activities	Regular classroom	
Frequency of site occupancy	Daily occupancy	
Accommodation capacity	60 students	
Presence of vegetation	[ ] yes	[X] no
Ability for occupants to control:		
Ventilation equipment	[X] yes	[ ] no
windows	[X] yes *	[ ] no

* *Occupants may operate windows as the room is Natural Ventilated.*

I) MAINTENANCE

Please consider the information on the tables below, extracted from the **PREVENTIVE MAINTENANCE PLAN** *(of the new HVAC project of classroom 3.3)*

Descrição dos trabalhos a efectuar	Periodicidade / FREQUENCY				
	Q	M	T	S	A
Chiller / Heat pumps ***Chillers*/Bombas de Calor**					
Verificar funcionamento geral		X			
Verificar funcionamento do compressor, ventilador, em todas as velocidades, (ter em atenção as vibrações, níveis de ruído e estado das chumaceiras)		X			
Limpeza dos filtros de ar		X			
Limpeza do tabuleiro de condensados e verificar a correcta evacuação destes.			X		
Verificar fugas de refrigerante e ajustar a carga, se necessário					
Limpeza do evaporador					X
Limpeza do condensador				X	
Lubrificação geral (motor, ventilador, etc.)			X		
Limpeza, verificação e aperto de todos os contactos eléctricos				X	
Verificação da actuação dos comutadores (termóstatos e ventilação) em todos os escalões e velocidades		X			
Verificar orientação das alhetas das grelhas de retorno e insuflação				X	

Q – Every 2 weeks**; M** – Monthl**y; T** – Quarterly (every 3 M); **S** – Every 6M; **A** – Annual.

Descrição dos trabalhos a efectuar	Periodicidade / FREQUENCY Q	M	T	S	A
UTAN's, VE's, VC's					
Registos: limpeza, afinação, lubrificação, apertos e controlo do bom funcionamento		X			
Verificar apertos das fixações do motor e ventilador			X		
Verificar alinhamento das polis (motor-ventilador)		X			
Verificar estado e ajustar tensão das correias de transmissão, se necessário		X			
Verificar estado dos rolamentos (ou casquilhos), vibrações e níveis de ruídos				X	
Substituir correias de transmissão	Quando necessário / when necessary				
Regulação dos aparelhos de controlo e segurança		X			
Limpeza e reajustamento dos *dampers* de ar novo		X			
Motor eléctrico: limpeza geral, testar esta do dos rolamentos, lubrificar e medir e registar corrente absorvida				X	
Medir o isolamento do motor em relação à massa					X
Tomadas de ar exterior					
Verificação do estado de deterioração, contaminação e corrosão					X
Filtros					
Verificação do estado de deterioração (fugas) e contaminação			X		
Verificação da pressão diferencial	X				
Mudança de filtros de 1º estágio				X	
Mudança de filtros de 2º estágio					X
Baterias					
Limpeza					X
Limpeza do tabuleiro de condensados				X	

Q – Every 2 weeks**; M** – Monthly**; T** – Quarterly (every 3 M); **S** – Every 6M; **A** – Annual.

J) SUSTAINABILITY (ENVIRONMENTAL IMPACT AND ENERGY EFFICIENCY STRATEGIES)

Sustainability refers to the ability to maintain or support a process continuously over time. Sustainability seeks to prevent the depletion of natural or physical resources, so that they remain available over time.

Sustainability Information's

CO2 emissions reduction 2023	2,486.905 kg
Material and equipment life cycle analysis	Photovoltaic (PV) panels are in silicon with 76% glass, 10% plastic, 8% aluminum, 5% silicon, and 1% metals. 25 to 30-year lifespan
Means implemented to ensure the sustainability of the facilities.	The DEM building facility energy supply has been equipped with the Solar energy systems (PV and inverter battery storage) as primary supply to augment grid supply. Mechanical Ventilation and Natural ventilation are also employed to ensure good Indoor climate as per seasonal requirements.
IDENTITY CARD	
Actions	Regular cleaning and annual inspections, however solar panels do not require much additional maintenance.
Resources	Nominal power 100 kW
Objectives	Energy saving by using PV panel.

Actions: *how to protect, how to restore and manage?*
Resources: *production and consumption mode*
Objectives: *ex: energy saving - use of solar panels*

3-CONCLUSION AND PERSPECTIVES

This work proposes a methodology for evaluating the IAQ in educational buildings. Through a deliberately simplified approach, we have defined a baseline based on two domains describing the building's facilities and the organization of the whole stakeholder chain actors.

A summary of the multi-criteria analysis for this operation is presented in the form of a radar made up of the 10 benchmark indicators, established in task 3.1.2 of the 3SqAir project.

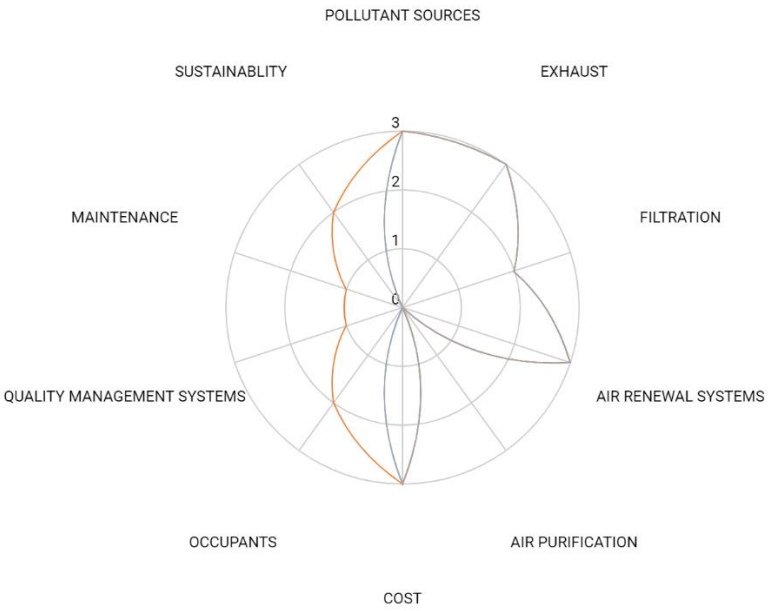
We have previously indicated that this type of analysis requires a transversal (holistic) approach, since all these criteria are interconnected and influence each other. In order to determine the relevance of taking into account the IAQ of a building, we propose to carry out a two-step approach:

1) First, an analytical approach: characterization of each of the 10 criteria separately, through a qualitative or quantitative approach;

2) Secondly, a global synthesis, through a graphic representation in the form of a "3SqAir profile", with a radar representation, according to the a “basic” or “thorough” rating scale (see below, an example of fictive radars on the basis of a 1-5 scale, with a representation mode).

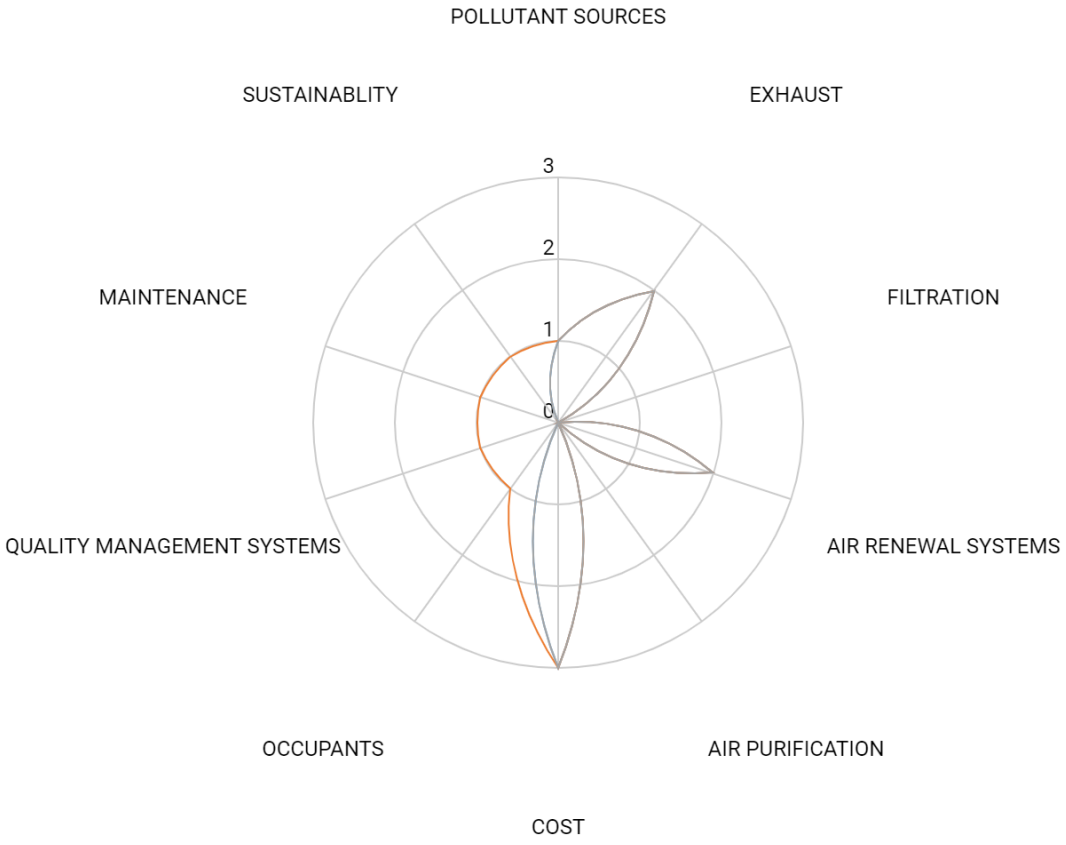
The result is as follows:

Classroom 3.3



Room 3.3 analysis - Building Facilities: "technical solutions on IAQ and ventilation" and Stakeholders organization: "management"

Classroom 6.3



Room 6.3 analysis - Building Facilities: "technical solutions on IAQ and ventilation" and Stakeholders organization: "management"

This result was established after a collective analysis of all operations, during the workshop held in Coimbra (Portugal) on 8-9/11/2022. During this workshop, the partners presented the 12 feedbacks and voted collectively to define the level of performance for each criterion and establish the corresponding radar profile.