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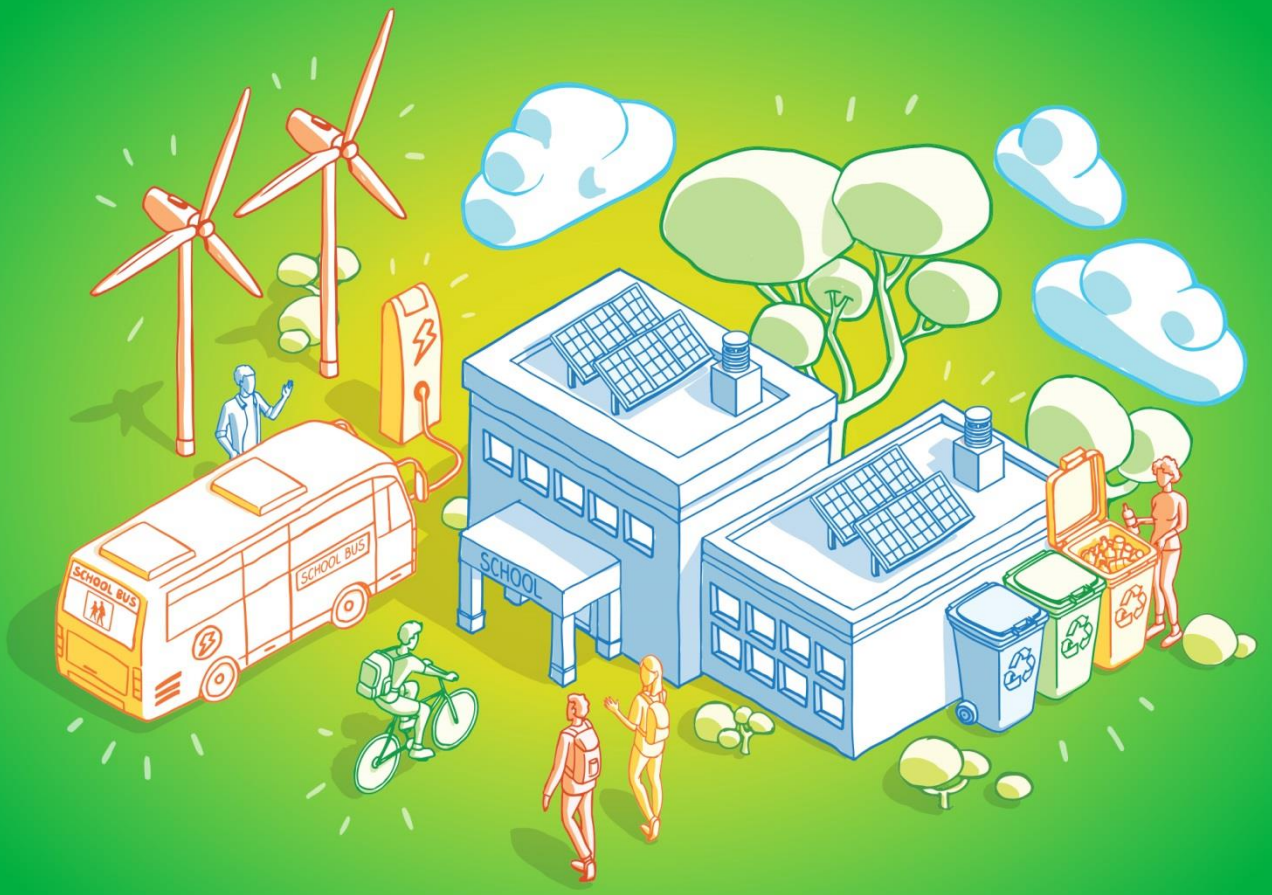

CLIMACT - ACTING FOR THE TRANSITION TO A LOW CARBON ECONOMY IN SCHOOLS – DEVELOPMENT OF SUPPORT TOOLS

KPI Performance Indicators

June 2017

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CONTENTS

Executive Summary

The ClimACT KPI performance indicators is an internal document of the ClimACT project, in the context of WP2 – Development of tools to support the transition to a low-carbon economy in schools. One of the objectives of WP2 is to develop an integrated tool able to support decision making with respect to the transition to a LCE (Low Carbon Economy) in schools. This tool will incorporate 5 modules that will be developed in the framework of Act. 2.2-2.6 while providing a user-friendly interface suitable for schools managers and other stakeholders.

The goal of this document is to state clearly what are those KPIs, the metrics they depend on, as well as how these metrics will be obtained. Therefore, the present document is essential to bring all the participants together on a common vision of what are the most important indicators.

The KPIs here presented will also be used as a basis to the Building Scenario module, being the benchmark of how well the tested scenario would work and its real impact on the school energetic behavior.

This document is not intended to be a final static version, but instead it will be maintained and updated as needed by the project participants.

1 Introduction

1.1 Introduction

The key performance indicators (KPI) are a group of measurable values demonstrating how well the schools behaving in therms of reducing their carbon footprint. This KPIs are a powerful tool that give school administration easy-to-read values showing both their evolution and their relative position to other similar schools.

The goal of this document is to state clearly what are those KPIs, the metrics they depend on, as well as how these metrics will be obtained. Therefore, the present document is essential to bring all the participants together on a common vision of what are the most important indicators.

The KPIs here presented will also be used as a basis to the Building Scenario module, being the benchmark of how well the tested scenario would work and its real impact on the school energetic behavior.

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2 KPI List

For each environmental sector (energy, water, waste, Indoor Air Quality (IAQ), transport, green spaces and green procurement) KPIs have been defined by the leaders and participants of each sector, according to table 1.

Table 1 - Environmental sectors, leaders and participants.

SECTOR	LEADER	PARTICIPANTS
Energy	ISQ	Edigreen, USE
Water	ISQ	IST
Waste	ISQ	IST
Mobility	IST	UniGib
Indoor Air Quality (IAQ)	ULR	IST
Green spaces	IST	VLR
Green procurement	IST	UniGib

2.1 Energy

The energy consumption can be divided as presented on figure 1. The KPI and score energy measured are presented on table 2 and table 3.

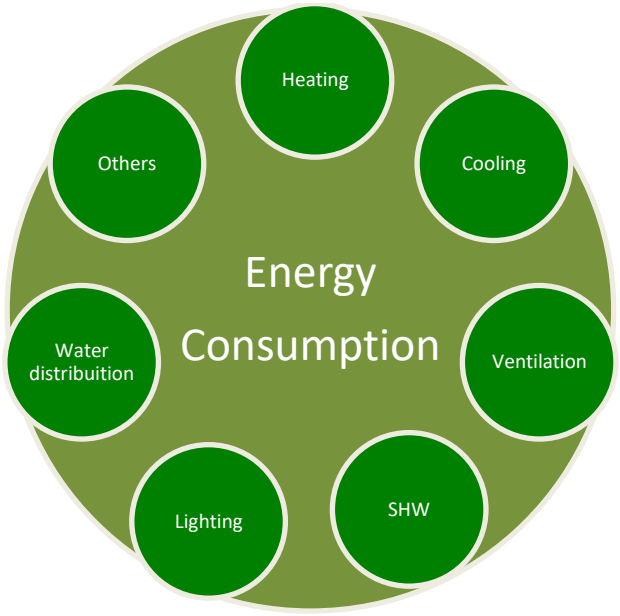

Figure 1 – Different uses for the energy in the school sector.

Table 2 - List of Energy KPI.

KPI designation	KPI calculation
Energy consumption per useful area	$\mathrm{KPI}_{E1} = \frac{\sum_i \text{annual consumption of eletricidade}_i + \sum_j (\text{annual consumption of fuel}_j \times \text{density}_j \times \mathrm{FC}_j)}{\text{useful area}}$ Where: *i* = type of electricity (provide by the grid; onsite produced); *j* = type of fuel (diesel; LPG; natural gas);

KPI designation	KPI calculation
	FC_j = conversion factor to kWh of fuel *j*
Energy consumption per student	$KPI_{E2} = \frac{\sum_i \text{annual consumption of eletricidade}_i + \sum_j (\text{annual consumption of fuel}_j \times \text{density}_j \times FC_j)}{\text{student}}$ Where: *i* = type of electricity (provide by the grid; onsite produced); *j* = type of fuel (diesel; LPG; natural gas); FC_j = conversion factor to kWh of fuel *j*
Percentage of renewable energy production	$KPI_{E3} = \frac{\text{Renewable energy produced for onsite comsumption} + \text{renewable energy production sold to grid}}{\sum_i \text{annual consumption of eletricidade}_i + \sum_j (\text{annual consumption of fuel}_j \times \text{density}_j \times FC_j)}$ Where: *i* = type of electricity (provide by the grid; onsite produced); *j* = type of fuel (diesel; LPG; natural gas); FC_j = conversion factor to kWh of fuel *j*
Energy costs per useful area	$KPI_{E4} = \frac{\text{energy annual costs}}{\text{useful area}}$
Energy costs per student	$KPI_{E5} = \frac{\text{energy annual costs}}{\text{nr of studentss}}$
CO_2 annual emissions	$KPI_{E6} = \frac{(\text{electricity consumption} - REP \times GL) \times FE_e + \sum_i (\text{consumption of fuel }_i \times \text{density}_i \times FC_i) \times FE_i)}{\text{nr of students}}$ Where: *i* = type of fuel (diesel; LPG; natural gas); FC_i = conversion factor to kWh of fuel i FE_e = emission factor associated to electrical energy consumption. FE_i = emission factor associated to fuel. REP = Renewable electrical production GL = Grid losses

Table 3 - List of energy scores.

Score designation	Score calculation	Less favourable scenario	More favourable scenario	Weighting for final score
Energy consumption per useful area	$S_{E1} = \frac{(\max(KPI_{E1}) - KPI_{E1}) \times 5}{\max(KPI_{E1}) - \min(KPI_{E1}) \times 0.95}$	Highest KPI_{E1} found	Lowest KPI_{E1} found less 5%	$\frac{1}{2}$
Energy consumption per student	$S_{E2} = \frac{(\max(KPI_{E1}) - KPI_{E1}) \times 5}{\max(KPI_{E1}) - \min(KPI_{E1}) \times 0.95}$	Highest KPI_{E2} found	Lowest KPI_{E2} found less 5%	$\frac{1}{2}$
Percentage of renewable energy production	$S_{E3} = KPI_{E3} \times 5$	0% renewable energy	100% renewable energy	1
Energy costs per useful area	$S_{E4} = \frac{(\max(KPI_{E5}) - KPI_{E5}) \times 5}{\max(KPI_{E5}) - \min(KPI_{E5}) \times 0.95}$	Highest KPI_{E4} found	Lowest KPI_{E4} found less 5%	$\frac{1}{2}$

Energy costs per student	$S_{E5} = \frac{(\max(KPI_{E6}) - KPI_{E6}) \times 5}{\max(KPI_{E6}) - \min(KPI_{E6}) \times 0.95}$	Highest KPI_{E5} found	Lowest KPI_{E5} found less 5%	$\frac{1}{2}$
CO_2 annual emissions	$S_{E6} = \frac{(\max(KPI_{E7}) - KPI_{E7}) \times 5}{\max(KPI_{E7}) - \min(KPI_{E7}) \times 0.95}$	Highest KPI_{E6} found	Lowest KPI_{E6} found less 5%	1

2.2 Water

The water consumption can be divided as presented on figure 2. Once again, the first approach is to determine the water used in each distinct area. In addition, for each water use the KPI listed on table 4 will be measured, as well the score presented on table 5

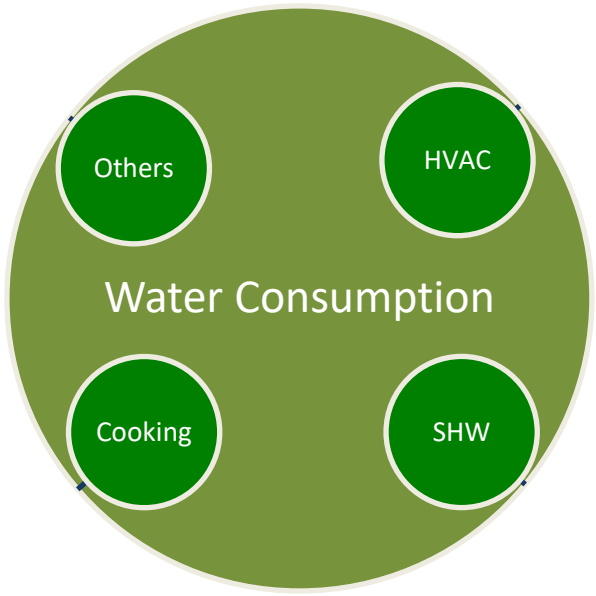

Figure 2 - Different uses for the water in the school sector.

Table 4 - List of water KPI

KPI designation	KPI calculation
Water consumption per useful area	$KPI_{W1} = \frac{\text{annual water consumption}}{\text{useful area}}$
Water consumption per student	$KPI_{W2} = \frac{\text{annual water consumption}}{\text{nr of students}}$
Water costs per useful area	$KPI_{W3} = \frac{\text{annual water costs}}{\text{useful area}}$
Water costs per student	$KPI_{W4} = \frac{\text{annual water costs}}{\text{nr of students}}$

Table 5 - List of variables needs for water consumption evaluation.

Score designation	Score calculation	Less favourable scenario	More favourable scenario	Weighting for final score
Water consumption per useful area	$S_{w1} = \frac{(\max(KPI_{w1}) - KPI_{w1}) \times 5}{\max(KPI_{w1}) - \min(KPI_{w1}) \times 0.95}$	Highest KPI_{w1} found	Lowest KPI_{w1} found less 5%	$\frac{1}{2}$
Water consumption per student	$S_{w2} = \frac{(\max(KPI_{w2}) - KPI_{w2}) \times 5}{\max(KPI_{w2}) - \min(KPI_{w2}) \times 0.95}$	Highest KPI_{w2} found	Lowest KPI_{w2} found less 5%	$\frac{1}{2}$
Water costs per useful area	$S_{w3} = \frac{(\max(KPI_{w3}) - KPI_{w3}) \times 5}{\max(KPI_{w3}) - \min(KPI_{w3}) \times 0.95}$	Highest KPI_{w3} found	Lowest KPI_{w3} found less 5%	$\frac{1}{2}$
Water costs per student	$S_{w4} = \frac{(\max(KPI_{w4}) - KPI_{w4}) \times 5}{\max(KPI_{w4}) - \min(KPI_{w4}) \times 0.95}$	Highest KPI_{w4} found	Lowest KPI_{w4} found less 5%	$\frac{1}{2}$

2.3 Waste

The typical school waste is presented on figure 3, to the analysis is important to know the different quantities of each type of waste (plastic, metals, paper, food, glass and others). In table 6 presents the possible KPI to assess the waste production in schools and the table 7the waste scores.

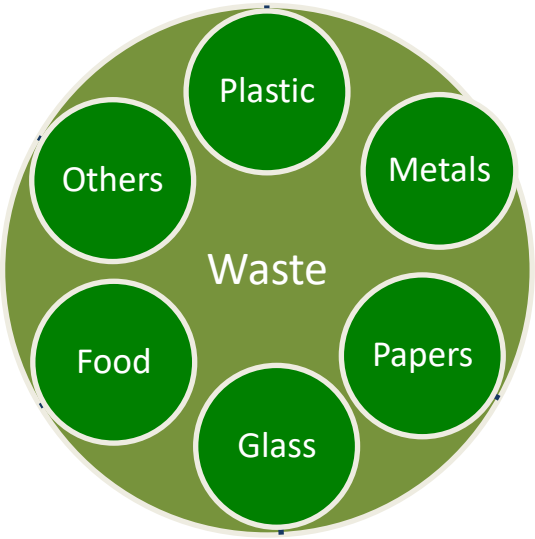

Figure 3 - Different types of waste in the school sector.

Table 6 - List of waste KPI.

KPI designation	KPI calculation
Annual production of urban solid waste (USW) per student	$\mathbf{KPI_{R1}} = \frac{\mathbf{weekly\ production\ of\ USW}}{\mathbf{nr\ of\ students}}$
Annual production of recyclables per student	$\mathbf{KPI_{R2}} = \frac{\mathbf{weekly\ production\ of\ recyclable\ waste}}{\mathbf{nr\ of\ students}}$
Annual production of reusables per student	$\mathbf{KPI_{R3}} = \frac{\mathbf{weekly\ production\ of\ reusable\ waste}}{\mathbf{nr\ of\ students}}$

Table 7 - List of waste scores.

Score designation	Score calculation	Less favourable scenario	More favourable scenario	Weighting for final score
Annual production of urban solid waste (USW)	$S_{R1} = \frac{(\max(KPI_{R1}) - KPI_{R1}) \times 5}{\max(KPI_{R1}) - \min(KPI_{R1}) \times 0.95}$	Highest KPI_{R1} found	Lowest KPI_{R1} found less 5%	2
Annual production of recyclables	$S_{R2} = \frac{KPI_{R2} \times 5}{\max(KPI_{R2}) \times 1.05}$	Without recyclable waste	Highest KPI_{R2} found plus 5%	1

Annual production of reusables	$S_{R3} = \frac{KPI_{R3} \times 5}{\max(KPI_{R3}) \times 1.05}$	Without reusable waste	Highest KPI_{R3} found plus 5%	1

2.4 IAQ – Indoor Air Quality

The IAQ analysis requires a measure of different pollutants in the classroom, these ones are listed on Annex I. In Table 8 is presented the possible KPI to assess the IAQ in schools.

Table 8 - List of IAQ, ventilation and comfort KPI

Description	Formulation	Units
Indoor Air Quality Index	$I_{IAQ} = \frac{\sum_p \delta_p}{30}$	%
Ventilation effectiveness Index	$I_{vent} = \frac{\sum_v \delta_v}{N_v}$	%
Thermal Comfort Index	$I_{comfort} = \frac{\sum_i \delta_i}{N_i}$	%

- with δ_p =1 if $C_p > TLV_p$ and δ_p =0 otherwise;
- δ_v =1 if $C_{CO2,v} > 1250$ ppm and δ_v =0 otherwise
- with δ_i =1 if $T_{op,i} > T_{op,max}$ or $T_{op,i} < T_{op,min}$, and δ_i =0 otherwise.

The Database should contemplate the variables listed on Table 9 for the presented analysis.

Table 9 - List of variables needs for IAQ, ventilation and comfort evaluation.

Variable	Information source
Pollutants quantity	Data logger over time
Classroom surrounding information (highway, green space, city, village, others)	Audits
Ventilation rate (outside air)	Audits
Classroom volume	Audits

2.5 Transport

The transport sector analyzes the parking conditions, the public transport network and the users' behavior. figure 4 shows the points focused to perform the analysis and table 10 and table 11 presents the KPIs defined for the transport sector and the scores.

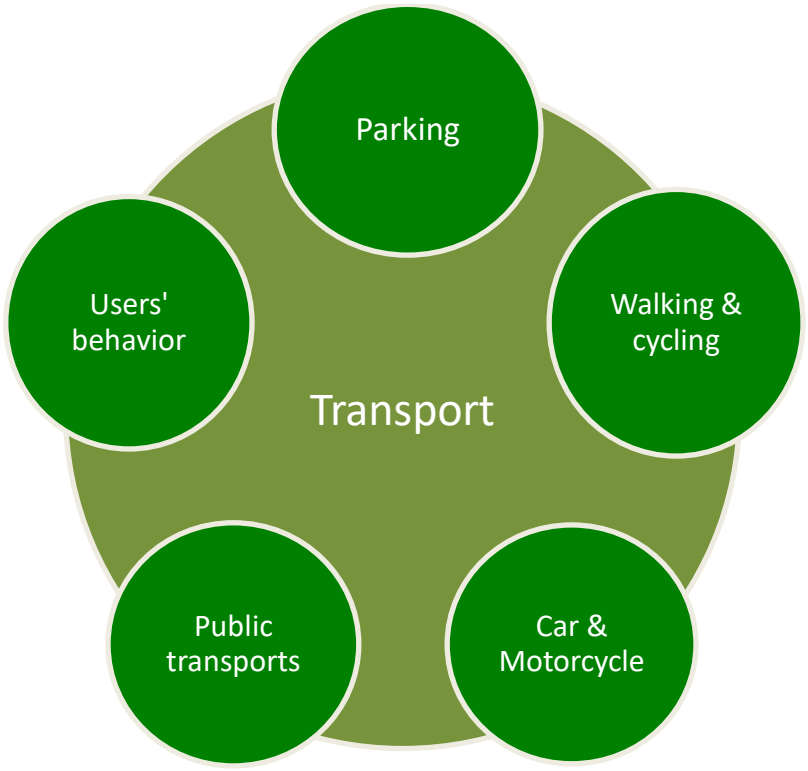

Figure 4 – Parameters analyzed in the transport sector.

Table 10 - List of transport KPIs

KPI designation	KPI calculation
Charging stations for electric cars per student	$\mathrm{KPI}_{T1} = \frac{\text{nr of charging stations for eletric cars}}{\text{nr of students}}$
Parking places for bicycle per student	$\mathrm{KPI}_{T2} = \frac{\text{nr of parking places for bicycle}}{\text{nr of students}}$
Public Transports per hour per student	$\mathrm{KPI}_{T3} = \frac{\text{nr of public transports per hour within a 1000m radius}}{\text{nr of students}}$
CO_2 annual emissions per student	$\mathbf{PE}_i = \frac{\left(\#_{\mathbf{never}} \times \mathbf{0} + \#_{\mathbf{almost\ never}} \times \mathbf{1/3} + \#_{\mathbf{almost\ always}} \times \mathbf{2/3} + \#_{\mathbf{always}} \times \right.}{\mathbf{nr\ of\ persons\ that\ answered\ to\ the\ ques}}$ Where: *i* = transport mean (motorbike; car; boat; tram; train; subway; bus; bicycle; on foot); PE_i = person equivalent of the transport mean *i*.

KPI designation	KPI calculation
	$\mathbf{CO_{2\,i}\,Emissions} = \sum_i (\mathbf{FE_i} \times \mathbf{PE_i}) \times \mathbf{daily\ average\ distance} \times \mathbf{22} \times \mathbf{10}$ Where: $CO_{2\,i}$ Emissions = Annual emissions associated to the transport mean *i*. **FE_i = emission factor of the transport mean *i* [1].** $KPI_{T4} = \frac{\sum_i CO_{2\,i}\ \text{Emissions}}{\text{nr of students}}$

Table 11 - List of transport scores

Score designation	Score calculation	Less favourable scenario	More favourable scenario	Weighting for final score
Charging stations for electric cars	$S_{T1} = \frac{KPI_{T1} \times 5}{1.05 \times \max(KPI_{T1})}$	Without charging stations	Highest KPI_{T2} found plus 5%	1
Parking places for bicycle	$S_{T2} = \frac{KPI_{T2} \times 5}{1.05 \times \max(KPI_{T2})}$	Without parking places	Highest KPI_{T3} found plus 5%	1
Public Transports	$S_{T3} = \frac{KPI_{T3} \times 5}{1.05 \times \max(KPI_{T3})}$	Without public transports	Highest KPI_{T4} found plus 5%	1
CO_2 annual emissions	$S_{T4} = 5 - \frac{\text{school emissions} \times 5}{\text{emissions of 100\% of students going by car}}$	100% of the students go by car	100% of the students go on foot or by bicycle	2

2.6 Green Spaces

In the green space sector the following parameters are assessed: biodiversity in the school, the green spaces, the impacts associated with the maintenance of the spaces and the CO_2 sinked. figure 5 shows the parameters focused to perform the green spaces analysis, figure 6 presents the areas definition, table 12 shows the KPIs defined to assess the impact of the green space on the school and the table 13 the green spaces score.

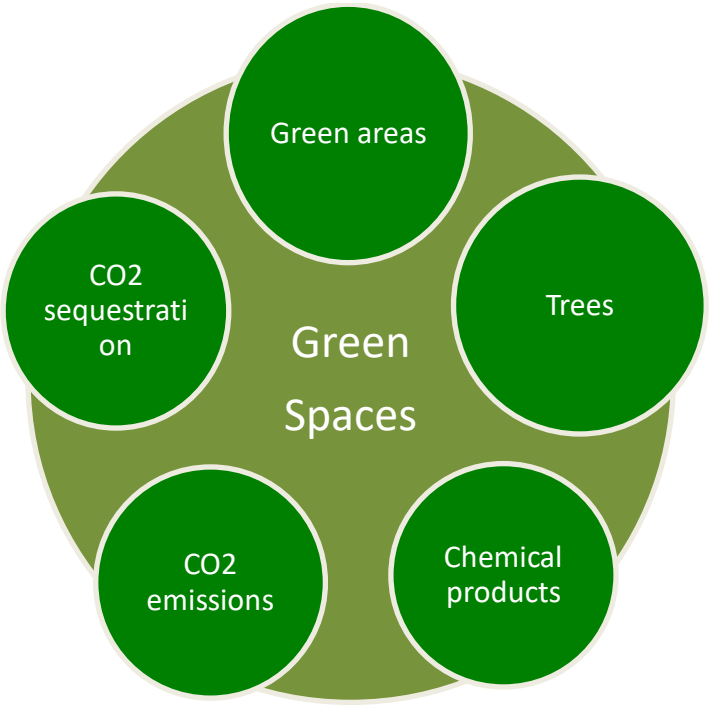

Figure 5 - Parameters analyzed in the green spaces sector.

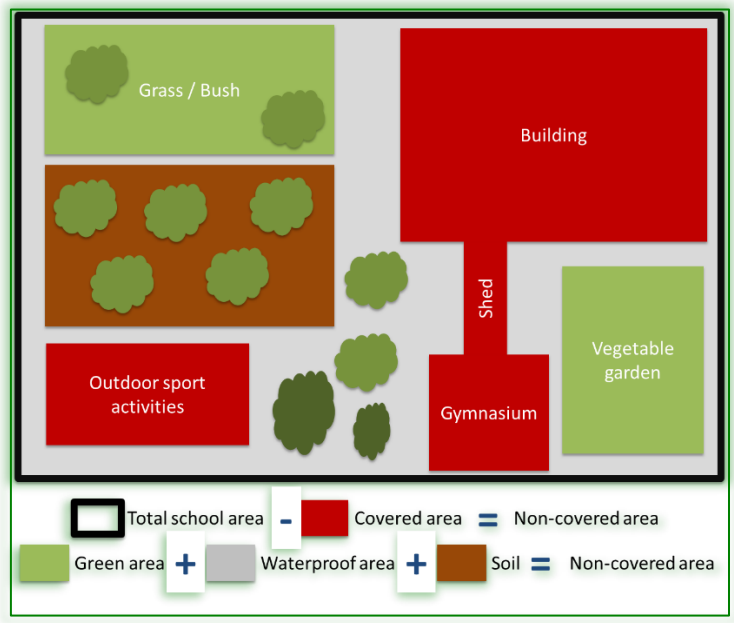

Figure 6 – Areas definition in school for the calculation of green spaces KPIs.

Table 12 - List of green spaces KPI.

KPI designation	KPI calculation
Trees per non-covered area	$\mathrm{KPI}_{\mathrm{GS1}} = \frac{\text{nr of trees}}{\text{non} - \text{covered area}}$
Trees per student	$\mathrm{KPI}_{\mathrm{GS2}} = \frac{\text{nr of trees}}{\text{nr of students}}$
Green area per non-covered area	$\mathrm{KPI}_{\mathrm{GS3}} = \frac{\text{green area}}{\text{non} - \text{covered area}}$ x 100
Green area per student	$\mathrm{KPI}_{\mathrm{GS4}} = \frac{\text{green area}}{\text{nr of students}}$
Annual usage of chemicals per green area	$\mathrm{KPI}_{\mathrm{GS5}} = \frac{\text{quantity of fertilizers and pesticides}}{\text{green area}}$
Annual CO_2 sequestration per non-covered area	$\mathrm{KPI}_{\mathrm{GS6}} = \frac{\text{nr of trees} \times \mathrm{SR}_{\text{dominant species}} + \text{lawn area} \times \mathrm{SR}_{\text{lawn}}}{\text{non} - \text{covered area}}$ Where: SR = sequestration rate [2].
Annual CO_2 emissions per non-covered area	$\mathrm{KPI}_{\mathrm{GS7}} = \frac{\text{Combustível} \times \mathrm{FE}_{\text{fuel}} + \text{water} \times \mathrm{FE}_{\text{water}} + \text{electicity} \times \mathrm{FE}_{\text{electricity}}}{\text{non} - \text{covered area}}$ Where: FE = factor emission [1].

Table 13 - List of green spaces scores.

Score designation	Score calculation	Less favourable scenario	More favourable scenario	Weighting for final score
Trees per non-covered area	$\mathrm{S}_{\mathrm{GS1}} = \frac{\mathrm{KPI}_{GS1} \times 5}{1.05 \times \max(\mathrm{KPI}_{GS1})}$	Without trees	Highest $\mathrm{KPI}_{\mathrm{GS1}}$ found plus 5%	0.5
Green area per non-covered area	$\mathrm{S}_{\mathrm{GS2}} = \frac{\mathrm{KPI}_{GS3} \times 5}{1.05 \times \max(\mathrm{KPI}_{GS3})}$	Without green area	Highest $\mathrm{KPI}_{\mathrm{GS3}}$ found plus 5%	0.5
Annual usage of chemicals per green area	$\mathrm{S}_{\mathrm{GS3}} = 5 - \frac{\mathrm{KPI}_{GS4} \times 5}{\max(\mathrm{KPI}_{GS4})}$	Highest $\mathrm{KPI}_{\mathrm{GS4}}$ found	Without chemicals	1
Annual CO_2 sequestration per non-covered area	$\mathrm{S}_{\mathrm{GS4}} = \frac{\mathrm{KPI}_{GS5} \times 5}{1.05 \times \max(\mathrm{KPI}_{GS5})}$	Without sequestration	Highest $\mathrm{KPI}_{\mathrm{GS5}}$ found plus 5%	1

Annual CO_2 emissions per green area	$S_{GS5} = 5 - \frac{KPI_{GS6} \times 5}{\max(KPI_{GS6})}$	Highest KPI_{EV7} found	Without emissions	1

2.7 Green procurement

The green procurement evaluates the environmental impact associated with the purchase of products and services by the school. figure 7 shows the parameters focused to perform the green procurement analysis. table 14 shows the green procurement KPIs and table 15 the green procurement scores.

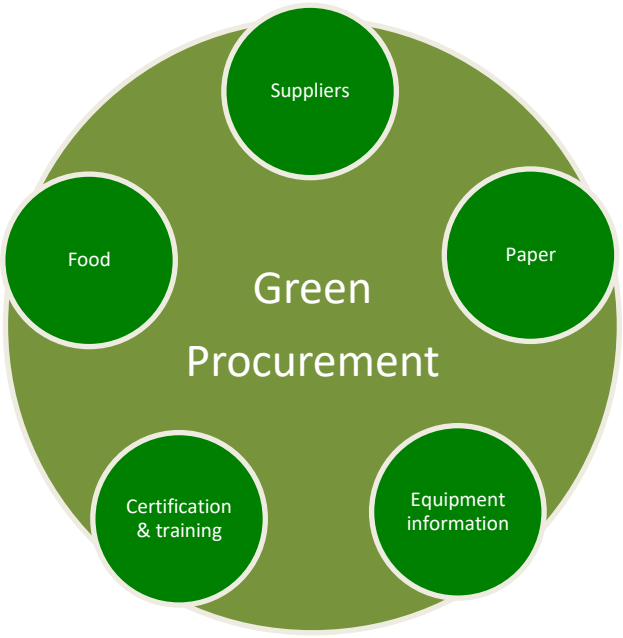

Figure 7 - Different variables that impact on green procurement.

Table 14 - List of green procurement KPI

KPI designation	KPI calculation
Equipment efficiency	$\mathrm{KPI}_{\mathrm{GP1}} = \frac{\text{nr of equipment A + or higher EU energy label}}{\text{total nr of equipments}}$
Recycled paper	$\mathrm{KPI}_{\mathrm{GP2}} = \frac{\text{quantity of recycled paper}}{\text{total quantity of paper}}$
Biological food	$\mathrm{KPI}_{\mathrm{GP3}} = \frac{\text{quantity of food with biological certificate}}{\text{total quantity of food}}$
Eco driving certification	$\mathrm{KPI}_{\mathrm{GP4}} = \frac{\text{nr of employees with eco - driving certificates}}{\text{total nr of employees}}$
Training in green procurement	$\mathrm{KPI}_{\mathrm{GP5}} = \frac{\text{nr of employees with training in green procurement}}{\text{total nr of employees}}$
Local suppliers	$\mathbf{KPI_{GP6} = \frac{nr\ of\ local\ suppliers}{total\ nr\ of\ suppliers}}$

Table 15 - List of variables needed for green procurement evaluation.

Score designation	Score calculation	Less favourable scenario	More favourable scenario	Weighting for final score
Equipment efficiency	$S_{GP1} = KPI_{GP1} \times 5$	Without certified equipment	100% of certified equipment	1
Recycled paper	$S_{GP2} = KPI_{GP2} \times 5$	Without recycled paper	100% recycled paper	0.75
Biological food	$S_{GP3} = KPI_{GP3} \times 5$	Without training	100% trained employees	1
Eco-driving certification	$S_{GP4} = KPI_{GP4} \times 5$	Without certified employees	100% certified employees	0.5
Training in green procurement	$S_{GP5} = KPI_{GP5} \times 5$	Without certified employees	100% certified employees	0.75
Local suppliers	$S_{GP6} = KPI_{GP6} \times 5$	Without local suppliers	100% local suppliers	1

2.8 Annex 1 – List of selected pollutants for analysis

Pollutant	Measurement method	Relevant concentration C	Threshold Limit Value [µg/m^3]	Comment
PM_{10}	Online	Mean during occupancy period	20	This is the long-term exposure health-based guideline set by the WHO. The portuguese TLV of 50 µg/m^3 is a management guideline
$PM_{2.5}$	Online	Mean during occupancy period	10	This is the long-term exposure health-based guideline set by the WHO. The Portuguese TLV of 20 µg/m^3 is a management guideline
CO	Online	Mean during occupancy period	6	10 µg/m^3 (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	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/m^3 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	The Portuguese and French upper limits of 100 µg/m^3 for mandatory IAQ audits in schools are not health-based. 100 µg/m^3 is an extremely high concentration. On the other hand, the French health-based guideline of 10 µg/m^3 is extremely difficult to reach. To be able to distinguish between schools regarding formaldehyde concentrations it is suggested to consider a TLV of 30 µg/m^3 which is management guideline set by the French Public Health Council for IAQ audits.
Acetaldehyde	Passive sampler	Weekly average	200	200 µg/m^3 is the long-term exposure set by EU (Index project) for acetaldehyde. The French health-based guideline is 160 µg/m^3, also for a long-term exposure
Benzene	Passive sampler	Weekly average	2	The Portuguese management guideline of 5 is high. It is suggested to consider the French health- based guideline of 2 µg/m^3, which

Pollutant	Measurement method	Relevant concentration C	Threshold Limit Value [µg/m^3]	Comment
				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	The Portuguese guideline. No guideline was set by the WHO or EU
Xylenes	Passive sampler	Weekly average	200	EU guideline (Index project) for a long-term exposure
Trichloroethylene	Passive sampler	Weekly average	20	The Portuguese guideline is 25 µg/m^3 but it is suggested to take the French one which is of 20 µg/m^3. It is health-based and corresponds to an ERU of 1 x 10^{-5}
Tetrachloroethylene	Passive sampler	Weekly average	250	Portuguese, French and WHO guideline for a long-term exposure
Styrene	Passive sampler	Weekly average	250	This is the EU health-based guideline, which is very close from the Portuguese one (260 µg/m^3)

NB: 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.

3 Variable list

This chapter resumes in table 16 and table 17 the list of variables needs to perform the KPI evaluation.

Table 16 - List of all the variables read by sensors.

Variable
Energy consumption by end use
Energy consumption by source
Energy consumption over time
Water consumption by end use
Water consumption over time
Pollutants quantity

Table 17 - List of all the variables known by pre-audits, audits and questioners.

Variable
Useful floor area
Number of students
Energy bills
Water bills
Biodiversity
Quantity of CO_2 absorbed by the green space
Waste quantity by type
Waste sent for recycling
Ventilation rate (outside air)
Typical energy source of the region / country
Transportation used by student / staff
Daily traveled distance home-school by student / staff
Equipment transported to the school and distance traveled
Food transported for the school and distance traveled
Tons of chemists used on green space maintenance
CO_2 used for the green space maintenance
Quantity of electric and electronic equipment with A+ or higher EU Energy Label used in school
Recycled paper used in school per time
Training in green procurement per staff
Eco-driving certificate per staff
Food with biological certificate
Local suppliers