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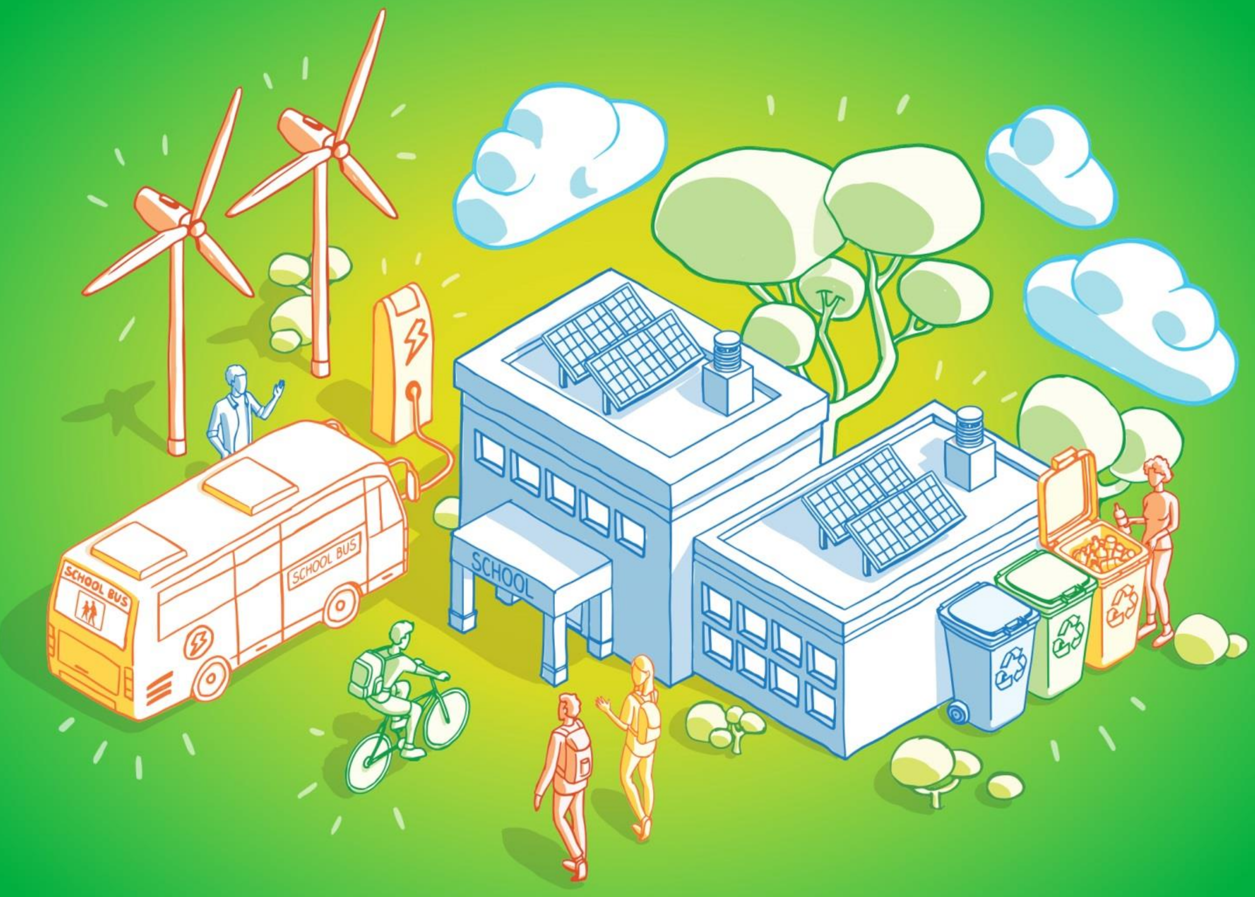

CLIMACT - ACTING FOR THE TRANSITION TO A LOW CARBON ECONOMY IN SCHOOLS – DEVELOPMENT OF SUPPORT TOOLS

E3.3.2 Best available actions and smart control strategies

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WWW.CLIMACT.NET

Executive Summary

This deliverable **3.3.2, titled "Best available actions and smart control strategies",** is part of the Activity 3.3 – Definition of targets and development of action plans, and it contributes towards the objectives of the products of the **WP3 - Implementation of a methodology conducting to a low carbon economy in 35 pilot schools.**

The aim of this document is to support the decision-making process in schools on the road to an efficient low-carbon economy transition. Best available actions and smart control strategies consists of a portfolio of most potential retrofit solutions for school buildings. They have been selected according to the results obtained from pre-audits, technical inspection and monitoring audits carried out in 35 pilot schools within the Task 3.2 (WP2).

This deliverable will support the development of a specific action plans for each pilot school. Action plan reports will be compiled through the ClimACT tool, and will be uploaded in the ClimACT gateway.

Glossary

Acronym	Full name
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
DH	Percentage of discomfort hours (%)
DHW	Domestic Hot Water
ED	Annual energy demand (kWh/m^2 a)
EER	Energy Efficiency Ratio
FEC	Final energy consumption (kWh/m^2 a)
HVAC&R	Heating, Ventilation, Air Conditioning and Refrigeration
IAQ	Indoor Air Quality
KPI	Key Performance Indicator
LCE	Low Carbon Economy
PEC	Primary energy consumption (kWh/m^2 a)
T	Temperature
O&M	Operation and Maintenance

Introduction

Acting for the transition to a low-carbon economy in schools, the objective of the present document is to define a portfolio of best available actions and smart control strategies towards a low-carbon economy retrofitting of schools. The portfolio has been divided into two groups as follows: overview of low-carbon retrofitting objectives for each environmental sector, and breakdown of low-carbon retrofit solutions for all environmental sectors. The environmental sectors, in which the Interreg SUDOE ClimACT project works, are reported in Table 1.

Table 1 – Environmental sectors, leaders and participants

Sector	Leader	Participants
Energy	ISQ	EDGR, USE
Water	ISQ	IST
Waste	ISQ	IST
Transport	IST	UniGib
IAQ	ULR	IST
Green Space	IST	VLR
Green Procurement	IST	UniGib

Taking into account the results of technical inspections and audits carried out in task 3.2 (WP3), leader and participans of all environmental sectors worked in the definition of objectives at short and long-term and a selection of best available retrofit solutions for pilots schools. Proposed solutions are widely common for all schools, derived from boundary conditions, modular basis, common building configuration and type of uses of school building spaces. They have been structured according to the environmental sector of affection, and have been characterised from the economical and technical point of view.

This portfolio should be considered for the selection of low-carbon retrofit solutions for the specific action plan generation. According to the initial performance results of the school, its specific needs and requirements, and existing facilities and systems, most potential solutions with higher environmental, economic and social benefits should be selected as priority.

1 Low-carbon economy retrofitting. Aim

1.1 Strategies of low-carbon economy retrofitting

Low-carbon retrofitting of existing schools represents an opportunity to upgrade the environmental performance of school communities for their ongoing life. Retrofit involves modifications to existing infrastructures, operating conditions, daily routines and habits, that may improve carbon performance, energy efficiency or decrease global environmental impact. In addition, retrofits are often used as opportune time to install new solutions and devices which can reduce the operational costs, particularly in older buildings, as well as help to attract new students and gain social impact. Taking into account their educational activity, schools have a major social responsibility. Raising awareness and involving school communities (students, teachers and families) towards an energy efficient and low-carbon pathway through the wide deployment of best available solutions and measures can lead to a low-carbon economy in the whole building sector.

The most beneficial low-carbon retrofit actions and smart control strategies will be identified through the environmental and economic assessment by means of the ClimACT assessments. The development of strategies can be classified into different groups:

- **Minor low-carbon retrofits** are low-cost or no cost measures that are easy and inexpensive to carry out but can make a considerable difference in the environmental performance of school. Changing end-users' habits, improving operating conditions and modifying operational schedules following new management strategies are easy solutions to be implemented by schools, and can reduce the environmental impact in all environmental sectors. It can be deployed by awareness campaigns to all school communities and by more appropriate use of facilities and systems through training to school managers.
- **Major energy retrofits** are more holistic, and typically involve several low-carbon retrofit measures across multiple building systems. These measures should typically be staged to maximize the environmental performance and benefits. A major energy retrofit project can lead to savings of up to 40 percent. Replacing building infrastructures (such as windows or heating and cooling systems) and adding new equipment (such as new green areas or renewable energy) can reduce the environmental impact of schools in a very efficient way, achieving social, economic and environmental benefits in almost all cases.
- **Deep energy retrofits** involve significant overhauls to major building systems. Due to their disruptive and cost-intensive nature, they are usually triggered by non-environmental-related factors, such as the end of the service life of a major component of the envelope or a significant change in building occupancy. However, taking the opportunity to replace these components with energy-efficient options can lead to substantial environmental and economic savings that make the added cost of such options extremely cost effective within a reasonable timeframe. Examples are upgrading building envelope (windows, adding an air barrier or insulation as part of an update of the exterior façade) or installing an efficient and renewable heating/cooling systems (like a condensing boiler, ground-source heat pump or solar technologies).

ClimACT Resource-Matching Platform will provide the external financing support, which could facilitate the financing steps in retrofitting processes. Action plans for the implementation of low-carbon strategies will include the definition of work stage, work dates, actions for awareness-raising of users, and progress monitoring.

1.2 Waste

Waste retrofit solutions should be implemented to improve the volume of waste produced, recycled and reused in schools. Waste assessment is divided into three sub-areas: waste disposed, waste reused and waste recycled, and solutions should improve the KPIs and score performance in all indicators. The aim in each sub-area consists of:

- Waste produced: volume of waste produced in schools, with the aim of implementing strategies for waste reduction.
- Waste recycled: type and volume of was recycled in schools, compared to the amount of waste produced.
- Waste reused: amount of waste reused for further life cycle in schools.

Parameters to improve through the implementation of low-carbon waste measures in sub-waste areas are showed in table 2.

Table 2 – Waste sub-areas and average performance

WASTE SUB-AREAS	KPIs	*AVERAGE KPI VALUE [a]*	*AVERAGE SCORES (0-5)[b]*
WASTE PRODUCED (non- recycled)	**KPI-W1. Total waste per student (m^3/student)**	**10.16**	**2.38**
WASTE RECYCLED	**KPI-W2. Total recycled waste per student (m^3/student)**	**5.86**	**2.38**
WASTE REUSED	***KPI-W3. Total amount of reused waste per student (m^3/student)***	***0.00***	***0.00***
		Final score	***1.44***

[a] Average KPI value refers to the total average considering the results of all ClimACT pilot schools.

[b] Average scores refers to the average indexes considering the results of all ClimACT pilot schools.

As ranging values, the maximum and minimum final waste score obtained (from 0 up to 5) are 2.88 and 0.00, being the ***average waste score in all ClimACT schools of 1.44***.

1.3 Transports

Transport retrofit solutions should be implemented to improve the user's behaviour in the home-school path, the CO_2 emissions associated, the quantification of different parking spaces (disable, electric and bicycle) in schools, and the transports access and availability nearby schools. Transport sector assessment is divided into 4 sub-areas: parking characteristics, public transports network, school community behaviour and CO_2 emissions from daily commuting to school, and solutions should improve the KPIs and score performance in all indicators. The aim in each sub-area consists of:

- Parking characteristics: existing parking spaces for disabled, electric cars, bicycles and number of parking spaces.
- Public transports network: existing public transport network for bus, subway, train, tram and boat, distance nearest to schools, nº transport passing per hour and no. transport passing per rush hour are evaluated.
- School community behaviour: transports used by the school community in the daily commuting to school. It was evaluated through an online survey to all school community, with a percentage of participation higher than 25% in almost all cases. The results of this evaluation affect to associated CO_2 emissions in school community transport.
- CO_2 emissions from daily commuting to school: annual CO_2 emissions associated to school community transports ($kgCO_2$), according to the results of surveys.

Parameters to improve through the implementation of low-carbon transport measures in sub-waste areas are showed in table 3.

Table 3 – Transport sub-areas and average performance

WASTE SUB-AREAS	QUANTIFICATION of KPIs	*AVERAGE KPI VALUE* [a]	*AVERAGE SCORES (0-5)* [b]
PARKING CHARACTERISTICS	**KPI-T1. Parking spaces for bicycles per student** (up to a 100m radius)	**0.004**	**2.14**
	KPI-T2. Parking spaces for electric cars per school (up to a 100m radius)	**0.1**	
PUBLIC TRANSPORTS NETWORK	**KPI-T3. Number of Public Transports passing daily per hour** (1000m radius)	**60.15**	**2.38**
CO_2 EMISSIONS	**KPI-T4. Annual CO2 Emissions per student** ($kgCO_2$/student)	***234.38***	***1.89***
		Final score	***1.68***

[a] Average KPI value refers to the total average considering the results of all ClimACT pilot schools.

[b] Average scores refers to the average indexes considering the results of all ClimACT pilot schools.

As ranging values, the maximum and minimum final transport score obtained (from 0 up to 5) are 3.35 and 0.00, being the ***average transport score in all ClimACT schools of 1.68***.

1.4 Green spaces

Green areas retrofit solutions should be implemented to improve the green areas, the CO_2 sequestration rate, the use of chemists and resources consumption associated to the green areas maintenance, and the CO_2 emissions. Green spaces assessment is divided into 4 sub-areas: green areas, use of chemists, CO_2 sequestration, and CO_2 emissions, and solutions should improve the KPIs and score performance in all indicators. The aim in each sub-area consists of:

- Green areas: number of trees and green area per non-covered area (m^2) and per student.
- CO_2 sequestration: annual CO_2 sequestrated per non-covered area. This value is calculated considering the number of trees and the estimated sequestration rate per tree, along with the grass area and the estimated sequestration rate per grass area.
- Use of chemists: total kg of chemists used for green area maintenance activities.
- CO_2 emissions: annual CO_2 emitted for the space maintenance activities.

Parameters to improve through the implementation of low-carbon green spaces measures in green spaces sub-areas are showed in 4.

Table 4 – Green spaces sub-areas and average performance

GREEN SPACES SUB-AREAS	KPIs	*AVERAGE KPI VALUE* [a]	*AVERAGE SCORES (0-5)* [b]
GREEN AREAS	**KPI-GS1. Number of trees per non-covered area (trees/m^2)**	**0.02**	**1.65**
	KPI-GS2. Number of trees per student (trees/student)	**0.30**	
	KPI-GS3. Green area per non-covered area (%)	**51.86**	
	KPI-GS4. Green area per student (m_2/ student)	**13.64**	
CO_2 SEQUESTRATION	**KPI-GS5 - Annual CO_2 sinked per non-covered area ($kgCO_2/m^2$ a)**	**3.54**	**2.38**
USE OF CHEMISTS	**KPI-GS6. Annual kg of chemists used for green area maintenance (kg/m^2 a)**	**0.001**	**2.50**
CO_2 EMISSIONS	**KPI-GS7 - Annual CO_2 emissions associated to space maintenance per non-covered area ($kgCO_2/m^2$ a)**	***0.03***	***2.50***
		Final score	***1.72***

[a] Average KPI value refers to the total average considering the results of all ClimACT pilot schools.

[b] Average scores refers to the average indexes considering the results of all ClimACT pilot schools.

As ranging values, the maximum and minimum final green spaces score obtained (from 0 up to 5) are 3.44 and 0.00, being the ***average green spaces score in all ClimACT schools of 1.72***.

1.5 Green procurement

Green procurement retrofit solutions should be implemented to improve the negative environmental impact of products and services acquired by the school. Solutions should improve electric and electronic equipment labelling, consumption of recycled paper, training in green procurement and eco-driving, and preference for food with biological certificate and from local suppliers. Green procurement assessment is divided into 6 sub-areas: equipment efficiency, paper used, training in green procurement, eco-driving certification, biological food and suppliers, and solutions should improve the KPIs and score performance in all indicators. The aim in each sub-area consists of:

- Equipment efficiency: number of electronic equipment with and without EU Energy Label A^+ or higher.
- Paper used: amount of paper and recycled paper used.
- Training in green procurement: number of staff with training in green procurement.
- Eco-driving certification: number of staff with training in eco-driving.
- Biological food: amount of food consumed with biological certificate as a ratio of total amount of food consumed.
- Suppliers: number of local suppliers of school services.

Parameters to improve through the implementation of low-carbon green procurement measures are showed in table 5.

Table 5 – Green procurement sub-areas and average performance

GREEN SPACES SUB-AREAS	KPIs	*AVERAGE KPI VALUE [a]*	*AVERAGE SCORES (0-5)[b]*
EQUIPMENT EFFICIENCY	**KPI-GP1. Quantity of electric and electronic equipment with A+ or higher EU Energy Label used in school (Nº A+ or higher/total)**	**0.44**	**2.19**
PAPER	**KPI-GP2. Annual paper used in school (kg/student a)**	**16.17**	**1.29**
	KPI-GP3. Annual recycled paper used in school (Kg recycled/Kg paper)	**0.04**	
TRAINING IN GREEN PROCUREMENT	**KPI-GP4. Staff with training in green procurement (Nº staff with training/ total nº staff)**	**0.00**	**0.00**
ECO-DRIVING CERTIFICATION	**KPI-GP5. Staff with training in eco-driving (Nº staff with training/ total nº staff)**	**0.00**	**0.00**
BIOLOGICAL FOOD	**KPI-GP6 - Food with biological certificate (Kg food with biological certificate/Kg total food)**	**1.13**	**0.67**
SUPPLIERS	**KPI-GP7. Local suppliers (Nº local suppliers/total suppliers)**	**0.50**	**2.50**
		Final score	**1.17**

[a] Average KPI value refers to the total average considering the results of all ClimACT pilot schools.
[b] Average scores refers to the average indexes considering the results of all ClimACT pilot schools.

As ranging values, the maximum and minimum final green procurement score obtained (from 0 up to 5) are 2.34 and 0.00, being the ***average green spaces score in all ClimACT schools of 1.17***.

1.6 IAQ

IAQ retrofit solutions should be implemented to improve the on-site measurements in two assessed classrooms. Solutions should improve main indoor concentration pollutants. IAQ assessment is divided into 3 sub-areas: air pollutants concentration, ventilation and thermal comfort. The aim in each sub-area consists of:

- Air pollutants concentration: the pollutants evaluated in this sub-area are: PM_{10} (mg/m^3), $PM_{2.5}$ (mg/m^3), CO_2 (ppm), CO (ppm), TVOC (mg/m^3), Formaldehyde (mg/m^3), Acetaldehyde (mg/m^3), Acrolein (mg/m^3), Benzene (mg/m^3), Toluene (mg/m^3), m+p-xylene (mg/m^3), o-xylene (mg/m^3), Ethylbenzene (mg/m^3), Trichloroethylene (mg/m^3), Tetrachloroethylene (mg/m^3), Styrene (mg/m^3), 1,4-dichlorobenzene (mg/m^3), Alpha-pinene (mg/m^3), Propanal (mg/m^3), Butanal (mg/m^3), Pentanal (mg/m^3), Isopentanal (mg/m^3), Hexanal (mg/m^3), Benzaldehyde (mg/m^3).

- Ventilation: evaluated through the percentage of CO_2 concentrations between 1000 and 1700 ppm, and over 1700 ppm, during occupancy (%).

- Thermal comfort: percentage of temperature between 20 ºC and 26 ºC during occupancy (%).

Parameters to improve through the implementation of low-carbon IAQ measures are showed in table 6.

Table 6 – IAQ sub-areas and average performance

IAQ SUB-AREAS	KPIs	*AVERAGE KPI VALUE [a]*	*AVERAGE SCORES (0-5)[b]*
AIR POLLUTANTS CONCENTRATION	PM10 (mg/m^3)	49.52	4.45
	PM2.5 (mg/m^3)	20.53	
	CO2 (ppm)	1462.36	
	CO (ppm)	508.00	
	TVOC (mg/m^3)	426.93	
	Group of specific aldehydes (mg/m^3)	-	
	Group of specific VOCs (mg/m^3)	-	
VENTILATION	CO_2 concentrations between 1000 and 1700 ppm during occupancy (%)	34%	2.50
	CO_2 concentrations over 1700 ppm during the occupancy (%)	40%	
THERMAL COMFORT	Temperature between 20º and 26º during occupancy (%)	50%	2.50
		Final score	4.45

[a] Average KPI value refers to the total average considering the results of all ClimACT pilot schools.

[b] Average scores refers to the average indexes considering the results of all ClimACT pilot schools.

As ranging values, the maximum and minimum final IAQ score obtained (from 0 up to 5) are 5.00 and 0.00, being the ***average IAQ score in all ClimACT schools of 4.45***.

1.7 Energy

Energy retrofit solutions should be implemented to improve energy consumption of the schools, and its CO_2 emissions associated. Environmental sector of energy area is divided into 4 sub-areas: energy consumption, renewable energy, energy cost and CO_2 emissions, and solutions should improve the KPIs and score performance in all indicators. The aim in each sub-area consists of:

- Energy consumption: final energy consumption (FEC) of school.
- Use of renewable energy: on-site renewable energy production in school. It implies renewable energy consumed and sold to the grid.
- Energy cost: annual energy cost of school.
- CO_2 emissions: CO_2 emissions related to annual energy consumption of school.

Parameters to improve through the implementation of low-carbon energy measures are showed in table 7.

Table 7 – Energy sub-areas and average performance

ENERGY SUB-AREAS	KPIs	*AVERAGE KPI VALUE [a]*	*AVERAGE SCORES (0-5)[b]*
ENERGY CONSUMPTION	KPI-E1. Annual final Energy consumption per m^2 (kWh/m^2)	129.11	2.50
	KPI-E2. Annual final Energy consumption per student (kWh/student)	1272.14	
RENEWABLE ENERGY	KPI-E3. Renewables energy production (%)	4.5%	2.49
ENERGY COST	KPI-E4. Annual energy cost per m^2 (€/m^2)	10.66	0.22
	KPI-E5. Annual energy cost per student (€/student)	104.57	
CO_2 EMISSIONS	KPI-E6. Annual associated CO2 emissions per student ($kgCO_2$/student)	359.37	2.50
		Final score	2.21

[a] Average KPI value refers to the total average considering the results of all ClimACT pilot schools.
[b] Average scores refers to the average indexes considering the results of all ClimACT pilot schools.

As ranging values, the maximum and minimum final Energy score obtained (from 0 up to 5) are 3.74 and 0.67, being the ***average Energy score in all ClimACT schools of 2.21***.

1.8 Water

Water retrofit solutions should be implemented to improve water consumption in schools and its associated cost. Water assessment is divided into 2 sub-areas: water consumption and water cost, and solutions should improve the KPIs and score performance in all indicators. The aim in each sub-area consists of:

- Water consumption: annual water consumption in school.
- Water cost: annual water cost in school.

Parameters to improve through the implementation of low-carbon water measures in water sub-areas are showed in table 8.

Table 8 – Water sub-areas and average performance

WATER SUB-AREAS	KPIs	*AVERAGE KPI VALUE* [a]	*AVERAGE SCORES (0-5)* [b]
WATER CONSUMPTION	**KPI-H_2O1. Annual water consumption (m^3/m^2)**	**0.75**	**2.50**
	KPI-H_2O2. Annual water consumption (m^3/student)	**8.65**	
WATER COST	**KPI-H_2O3. Annual water cost (€/m^2)**	**1.95**	**2.50**
	KPI-H_2O4. Annual Water cost (€/student)	**16.50**	
		Final score	**2.43**

[a] Average KPI value refers to the total average considering the results of all ClimACT pilot schools.

[b] Average scores refers to the average indexes considering the results of all ClimACT pilot schools.

As ranging values, the maximum and minimum final water score obtained (from 0 up to 5) are 4.86 and 0.00, being the ***average water score in all ClimACT schools of 2.43***

2 Portfolio of low-carbon actions and strategies

2.1 Low-carbon retrofit solutions

The portfolio of low-carbon retrofit solutions defined in this section would allow schools to achieve the targets towards a low-carbon economy schools defined in report E3.3.1. Solutions should be deployed according to short and long-term objectives and taking as a reference the initial baseline reported after technical audits.

The priority in the implementation of low-carbon retrofit solutions should be based on the recommendations provided in the initial baseline reports, according to the achieved results in comparison to the rest of schools.

Following these recommendations, schools have to define a set of measures to be implemented at short and long-term in schools:

- **Short-term measures must be implemented to fulfil the relative or absolute target defined per each KPI**. All schools should improve their performance in at least 2 environmental sectors per year according to the fixed short-term aims. After 3 years, schools should fulfil the fixed percentage of improvement in all environmental sectors.

- **Long-term actions must be implemented to fulfil the absolute target in all scores per schools**. All schools should improve their performance fulfilling after 6 years the obsolete target defined, taking as a reference the initial baseline report.

As the targets are defined taking as a reference the average initial performance of pilot schools, short and long-term objectives, which are based on relative and absolute targets, will be updated after 8 years. This procedure ensures that a low-carbon economy deployment will be progressive and constant over time, improving as much as possible in all cases.

The portfolio of low-carbon retrofit solutions for all environmental sectors are defined and characterised in following sections.

2.2 Waste

Next table defines the portfolio of low-carbon retrofit solutions to improve the Waste sector of schools:

A. Low-carbon retrofit solutions for recycling

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
RECYCLING	**Setting up containers for paper recycling** 	Recycling bin of 30x30x50 for indoor spaces	15€/bin	0€	15 years	⇨	Reduction of 20% of non-recycled waste
	Setting up containers for plastic recycling 	Recycling bin of 30x30x50 for indoor spaces	15€/bin	0€	15 years	⇨	Reduction of 20% of non-recycled waste
	Setting up containers for glass recycling 	Recycling bin of 30x30x50 for indoor spaces	15€/bin	0€	15 years	⇨	Reduction of 20% of non-recycled waste

B. Low-carbon retrofit solutions for composting

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
COMPOSTING	**Compost production from organic waste produced in the canteen** 	Compost bin of 74x84x74 for outdoor spaces, capacity for 400 l	55€/bin	0€	15 years	⇨	Exploit organic waste to produce a profitable product

2.3 Transports

Next table defines the portfolio of low-carbon retrofit solutions to improve the Transport sector of schools:

A. Low-carbon retrofit solutions for parking

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
PARKING	**Increase parking for disable** 	Create parking places for disables	10-50€/ud	0€	-	⇨	Increase parking for disable: at least 2 parking spaces for disables per school
	Increase parking for bicycles 	Create parking places for bicycles	15€/ud + rain protection	0€	30 years	⇨	Increase parking for bicycles: at least 1 place per 25 students
	Increase parking for electric cars 	Create parking places for electric cars	1000€/ud	0€	25 years	⇨	Increase parking for electric cars in at least 1 place per school

B. Low-carbon retrofit solutions for public transport

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
PUBLIC TRANSPORT	**Increase public transport services** 	Stakeholder's meetings for school public transport planning	0€	0€	-	⇨	Increase options of public transport services

C. Low-carbon retrofit solutions for CO_2 emissions

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
CO_2 EMISSIONS	**Increase walking** 	Happy shoesday Miles champion's board for walkers Traffic snake game Find walking friends platform Safety route planner for walk Walking safety for children guide with monitoring sheets	0€	0€	-	⇨	Reduction of CO_2 emissions associated to transport higher than 15%
	Increase bicycling 	Bike Clubs Miles champion's board for bikers Traffic snake game Find bicycling friends platform Safety route planner for bicycle Cycling safety for children guide with monitoring sheets	0€	0€	-	⇨	Reduction of CO_2 emissions associated to transport higher than 15%
	Increase public transport usage 	Miles champion's board for public transport Traffic snake game Find public transport friends platform Safety route planner for public transport Public transport safety for children guide with monitoring sheets	0€	0€	-	⇨	Reduction of CO_2 emissions associated to transport higher than 15%
	Decrease transport by car 	Parents awareness to the importance of reduce car traffic Parents car-sharing platform Eco-driving awareness actions for parents	0€	0€	-	⇨	Reduction of CO_2 emissions associated to transport higher than 15%

2.4 Green spaces

Next table defines the portfolio of low-carbon retrofit solutions to improve the Green spaces sector of schools:

A. Low-carbon retrofit solutions for green areas

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
GREEN AREAS	**Increase green area per non-covered area** 	Rooftop (Aquaponic Greenhouse Lab)	82,00 €/m^2	Implies LCC	-	Increase green area of 5%
		Wildlife Habitat (for shaded areas)	-	Implies LCC		
		Vertical gardens	173 €/m^2	Implies LCC		
		Farming our own veggies	5 €/m^2	Implies LCC		
		Feast of our veggies to students' motivation	-	0,00€		

B. Low-carbon retrofit solutions for CO_2 sequestration

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
CO_2 SEQUESTRATION	**Increase the number of trees to maximize the no. of trees per student and the sequestration rate** 	Planting trees with more sequestration level in related international days (Environment and Forest International Day)	50 €/tree	Implies LCC	-	Increase CO_2 sequestration of 5%
		Informative placards of CO_2 sequestration levels of each existent plants	50-75€ / placard	-	-	Increase CO_2 sequestration of 5%
	Maximize the green area per non-covered area to promote sequestration rate 	Planting grass in waterproof area	9,46 €/m^2	2,46 €/m^2.year	-	Increase CO_2 sequestration of 5%

C. Low-carbon retrofit solutions for use of chemists

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
USE OF CHEMISTS	**Decrease chemical pesticides and fertilizers used for green space maintenance**	Use of organic pesticides and fertilizers	6 €/un	-	-	Reduction of 5% in the use of chemical compounds

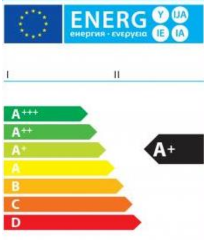
D. Low-carbon retrofit solutions for CO_2 emissions

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
CO_2 EMISSIONS	**Decrease tap water consumption for green space maintenance** 	Rain water storage with implementation of drip irrigation systems	50 (used) - 400 (new) €/container + 5,99 €/25m of hose	-	15 years	Reduction of 5% in CO_2 emissions associated to green areas activities
CO_2 EMISSIONS		Improve the irrigation system efficiency (e.g. access water leaks and install timers)	6 €/timer	-	15 years	Reduction of 5% in CO_2 emissions associated to green areas activities
CO_2 EMISSIONS	**Decrease energy and petrol usage for green space maintenance** 	Change to electric equipment charged with renewable energy	-	-	15 years	Reduction of 5% in CO_2 emissions associated to green areas activities

2.5 Green procurement

Next table defines the portfolio of low-carbon retrofit solutions to improve the Green procurement sector of schools:

A. Low-carbon retrofit solutions for equipment efficiency

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
EQUIPMENT EFFICIENCY	**Increase the equipment efficiency** 	Change equipment with efficiency lower than A+	The initial investment is amortized after 5 years	-	20 years	⇨	Reduce energy consumption of school equipment > 10%

B. Low-carbon retrofit solutions for paper used

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
PAPER USED	**Increase usage of recycled paper**	Purchase recycled paper	= normal cost	-	-	⇨	Increase of 15% in recycled paper consumption
		Awareness of staff for the importance of recycled paper	0,00€	-	-		
		Purchase new efficient printers	-	-	-		

C. Low-carbon retrofit solutions for training green procurement

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
TRAINING GREEN	**Increase the staff with train in green procurement** 	Trainning staff in green procurement	300-550€ / course	-	-	⇨	Increase of 5% in staff qualification

D. Low-carbon retrofit solutions for eco-driving

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
ECO-DRIVING	**Increase the staff eco-driving certification** Eco Drivers	Trainning and certify staff in eco-driving	150-250€ / course	-	-	⇨	Increase of 5% in staff qualification

E. Low-carbon retrofit solutions for biological food

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
BIOLOGICAL FOOD	**Increase purchases of food with bioligical certificate** 	Purchase biological food	120-140% of normal food cost	-	-	⇨	Increase of 10% in biological food consumption

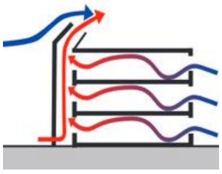
F. Low-carbon retrofit solutions for suppliers

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
SUPPLIERS	**Increase purchases from eco/local suppliers** 	Sustainability score matrix for supplier's selection	-	-	-	⇨	Increase of 10% in local suppliers
		Purchase from local suppliers	-	-			
		Schools partnerships to increase the bargaining power of schools	-	-			
		Students proposals contest on school's green procurement policy	-	-			

2.6 IAQ

Next table defines the portfolio of low-carbon retrofit solutions to improve the IAQ sector of schools:

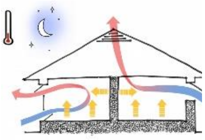
A. Low-carbon retrofit solutions for interior air quality

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
INDOOR AIR QUALITY	**Checking of ventilation system** 	Check the mechanical ventilation system: if the air change rate when the system operates was measured and is significantly below the mandatory air change rate	-	-	-	Increase and/or ensure a constant ventilation rate to Improve IAQ performance over guideline reference of 20%.
	Install a mechanical ventilation system 	Assign the mandatory air change rate in occupancy periods	-	-	15 years	Improve IAQ performance over guideline reference of 20%.
	Install a natural ventilation system 	Assign the a higher air change rate in occupancy periods	-	-	15 years	Improve IAQ performance over guideline reference of 20%.
	Improve operating behaviour by window opening routines 	Open windows during morning, afternoon, and lunch breaks, as well as 5 % of the class time. The aim is to Increase in the time with high air change rates.	-	-	15 years	Improve IAQ performance over guideline reference of 20%.

2.7 Thermal comfort

Next table defines the portfolio of low-carbon retrofit solutions to improve the thermal comfort sector of schools:

A. Low-carbon retrofit solutions for thermal comfort

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
THERMAL COMFORT	**Smart control of existing rollable awnings** 	Ensure the best operating of rollable awnings SRF (%): 0.4	-	0€	15 years	Reduction of solar gains in summer and increasing of solar gains in winter. Reduction of energy consumption associated to heating and cooling of 20%.
	Free-cooling at night along summer period 	Opening windows at night for free-cooling	0 €	0€	15 years	Reduction of internal loads in summer, reducing indoor peak temperatures. Reduction of energy consumption associated to heating and cooling of 5-10%.
	New rollable awnings 	Ensure a best solar protection for summer periods SRF (%): 0.3	100-200 €/m^2	0€	15 years	Reduction of solar gains in summer and increasing of solar gains in winter. Reduction of energy consumption associated to heating and cooling of 10-15%.
	New windows 	Setting up new windows in schools -value: 2.3 W/m^{2}ºC g⊥-value:0.63	200-300€/m^2	0€	30 years	Reduction of heating and cooling demand by improving thermal insulation in windows with low emissivity double glazing and thermal-break frames. Reduction of energy consumption associated to heating and cooling of 20-30%.
	Facade insulation (ETICS of EPS) 	Higher insulation of the envelope	50-70€/m^2	0€	30 years	Reduction of heating and cooling demand by improving thermal insulation of façade. Reduction of energy consumption associated to heating and cooling of 30-40%.
	Roof insulation 	Higher insulation of the envelope	40-60 €/m^2	0€	30 years	Reduction of heating and cooling demand by improving thermal insulation of roof. Reduction of energy consumption associated to heating and cooling of 5-15%.

2.8 Energy

Next table defines the portfolio of low-carbon retrofit solutions to improve the energy sector of schools:

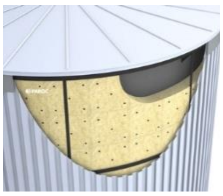
A. Low-carbon retrofit solutions for energy systems

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME		TARGET
ENERGY SYSTEMS	**Efficient individual heat pumps**[1] 	Setting up of new efficient HPs for Heating and Cooling	1700€/unit	100€	15-20 years	⇨	Reduction of non-renewable energy consumption and energy cost of 10-15%.
	Chiller 	Setting up of new efficient chiller for cooling	-	-	15-20 years	⇨	Reduction of non-renewable energy consumption and energy cost of 10-15%.
	Centralised biomass boiler 	Setting up of new efficient biomass boiler for SHW and Heating	-	-	15-20 years	⇨	Reduction of non-renewable energy consumption and energy cost of 5-10%.
	Centralised condensing boiler 	Setting up of new efficient condensing boiler for SHW and Heating	-	-	15-20 years	⇨	Reduction of non-renewable energy consumption and energy cost of 20-40%.
	Solar thermal energy 	Setting up of solar thermal energy for SHW and Heating	-	-	15-20 years	⇨	Reduction of non-renewable energy consumption and energy cost of 10-15%.
	Photovoltaic energy (support system) 	Setting up of solar panels for in-site electricity production	-	-	15-20 years	⇨	Reduction of non-renewable energy consumption and energy cost of 10-15%.

[1] Sources: IEA Heat Pump Programme; Navigant Consulting, 2007; IEA, 2010a.

B. Low-carbon retrofit solutions for energy automation and monitoring

ENERGY AUTOMATION AND MONITORING

DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
Automatic sensors to regulate lighting in spaces not permanently occupied 	Setting up an smart control for lighting	40-50 €/unit	-	15 years	Reduction of non-renewable energy consumption and energy cost of 10-15%.
Photocells to regulate outdoor lighting 	Setting up an smart control for lighting	-	-	15 years	Reduction of non-renewable energy consumption and energy cost of 5%.
LED lights 	New lighting based on LED technology	-	-	15 years	Reduction of non-renewable energy consumption and energy cost of 10-15%.
Automatic system to turn off air conditioning when windows are open 	Setting up an smart control for air-conditioning	-	-	15 years	Reduction of non-renewable energy consumption and energy cost of 10%.
Insulation of the DHW storage tank 	Increase the efficiency of storage tank with higher insulation	-	-	15 years	Reduction of non-renewable energy consumption and energy cost of 2-3%.
Variable speed pumps (for DHW production, DHW circulation and pumps)	Increase the efficiency of energy systems with a more efficient operating range	-	-	15 years	Reduction of non-renewable energy consumption and energy cost of 5%.

2.9 Water

Next table defines the portfolio of low-carbon retrofit solutions to improve the Water sector of schools:

A. Low-carbon retrofit solutions for water

	DESCRIPTION	CHARACTERISATION	INVESTMENT COST	MAINTENANCE COST	LIFETIME	TARGET
WATER	**Reducers of water flow for faucets** 	Setting up of water reducers	1,50-3€/unit	0€	15 years	Reduction of water consumption and water cost of 25-30%.
	Reducers of water flow for showers 	Setting up of water reducers	3-5€/unit	0€	15 years	Reduction of water consumption and water cost of 25-30%.
	Self-timer for faucets 	Reducing the water flow period	From 55€/unit	0€	15 years	Reduction of water consumption and water cost of 5-10%.
	Self-timer for shower 	Reducing the water flow period	10-15€	0€	15 years	Reduction of water consumption and water cost of 5-10%.
	Deposit to collect rain water 	Storing and providing rain water for specific uses	-	0€	15 years	Reduction of water consumption and water cost of 10-30%.
	Flushing with double discharge 	Avoiding to flush the full discharge when it is not needed	20-30€/unit	0€	15 years	Reduction of water consumption and water cost of 10-15%.
	Variable speed pumps (for water systems)	Reducing the water flow	-	0€	15 years	Reduction of water consumption and water cost of 5-15%.

3 References

3.1 References

ClimACT webpage: http://www.climact.net/