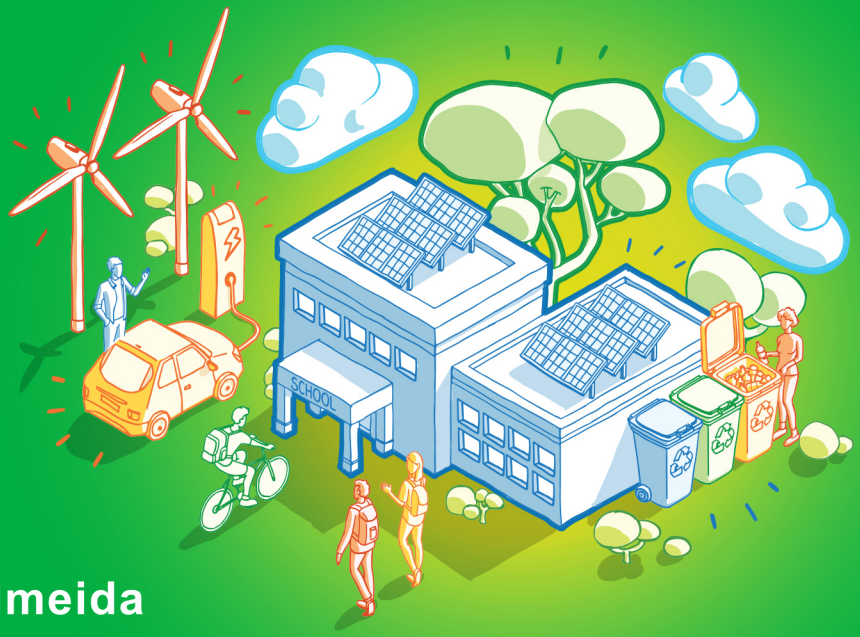
The Pathway Towards Low Carbon Schools

Criteria, Targets and Solutions

39 Pilot schools
Portugal, Spain, France and Gibraltar

>50 Activities and solutions
In transport, green procurement, green spaces, indoor air quality energy, water and waste



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Editors

NOVA

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Contents

Preface

This book presents the research work carried out in the European project ClimACT within the Interreg SUDOE Programme. The book collects the main research activities and findings to promote a low-carbon economy in schools, where we developed a special collaboration and awareness between authorities, researchers, companies, non-governmental organizations (NGOs), and school communities on the road to sustainable school buildings. The project brings together partners and associated entities with complementary functions from SUDOE countries (Spain, France, Portugal, United Kingdom, and Andorra) that coordinate the exchange of good practices and applications of joint solutions to common challenges that affect sustainability and the effective management of energy and the environment in schools. The project involved 39 pilot schools and had a budget of 1.3 million euros, 72% obtained as a part of the European territorial cooperation objective known as Interreg, which is financed by one of the European structural funds: the European Regional Development Fund (ERDF).

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This publication is part of the ClimACT project within the Interreg SUDOE Programme.

ClimACT - Acting for the Transition to a Low-Carbon Economy in Schools

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ClimACT Team

ClimACT Awards

Winner at EU Sustainable Energy Awards 2019 – Youth Category

2nd place at the Interreg Talks: 6 projects, 1 slam!

Finalists in RegioStars Awards 2018

Abbreviations

COP21	The Paris Climate Conference 2015
ESCO	energy service company
GHG	greenhouse gas
IAGV	indoor air guideline value
IAQ	indoor air quality
KPI	key performance indicator
LC	low-carbon coordinator
LCB	low-carbon brigades
LCC	low-carbon committee
LCE	low-carbon economy
NGO	Non-governmental organisation
PM	Particulate matter
PV	photovoltaic
TVOC	total volatile organic compound
VOC	volatile organic compound

Chapter 1
Introduction

1.1. **Low-Carbon Economy**

Climate change is one of the most critical threats that affect planet Earth and its environment, mainly caused by excessive resource consumption and reliance on fossil fuels, leading to CO_2 emissions. Massive reductions should be made in these emissions to limit the catastrophic impacts of climate change.

The targets proposed to reduce and manage the climate risks involve reducing greenhouse gas emissions (GHG) to at least 55% below 1990 levels by 2030 and from 80 to 95% by 2050.

Implementing a Low-Carbon Economy (LCE) by incorporating complementary approaches, such as energy efficiency, smart growth initiatives, transportation control measures, energy-efficient product procurement, and resource conservation, would create significant environmental, economic, and social benefits. It would reduce private and external costs and contribute to the accomplishment of carbon-related targets and the 3rd priority objective defined by the 7th Environment Action Program: 'to safeguard the Union's citizens from environment-related pressures and risk to health and well-being.'

1.2. **Role of Schools in Sustainability**

The educational sector's buildings consume a significant amount of energy and resources. They represent more than 12% of the tertiary building sector consumption, with energy bills typically the second-largest expenditure. It is imperative for schools to reduce energy and resource consumption and its associated environmental impacts, without affecting educational operations, by applying procurement-related and behavioural-related measures.

Many energy efficiency investments pay for themselves quickly. However, most of them are not realized in the educational sector due to short knowledge about energy and environment performance, tight budget to make investments, the lack of information about regional or national financial support mechanisms, and regulatory barriers.

The educational sector also has an enormous awareness-raising potential. With the proper support, education can empower pupils with knowledge about climate change and sustainability. Schools can ensure students grow up knowing how to protect the environment with robust behaviour that can pave the way towards a sustainable future.

1.3. **Welcome to ClimACT**

ClimACT project promotes the transition to a low-carbon economy in schools through the experience of the teaching community, researchers and management administrations. Universities, research institutions, companies, authorities, NGOs, and schools from France, Portugal, Gibraltar, and Spain, participated in the project to define, characterise and analyse solutions to support the transition to a low-carbon future. ClimACT has two main purposes: quantifying school sustainability through measurable indicators; and promoting and supporting school communities to adopt more environmentally friendly habits toward a low-carbon economy. Raising awareness in school communities (students, teachers and families) towards an energy-efficient and low-carbon pathway is key to empowering citizens toward a sustainable, low-carbon future.

1.4. About this Publication

This publication concludes and summarises a long period of study and research on the environmental performance of schools that covers from 2016 to 2019. The ClimACT book is structured in seven chapters and contains the main achievements of the ClimACT project concerning the environmental performance and activities developed in pilot schools. Chapter 1 introduces the framework of this project. In chapter 2, ClimACT project is summarised, describing objectives, partners, advisory boards, project structure and pilot school. Chapter 3 describes the ClimACT methodology for evaluating the schools' performance through measurable indicators divided into seven environmental areas: transport, green procurement, green spaces, indoor air quality, energy, water and waste. In chapter 4, the overall performance of 39 pilot schools obtained through technical audits and school surveys is presented to set a reference baseline in the SUDOE area. Chapter 5 defines short and long-term objectives for each environmental sector of schools, considering the average initial performance of pilot schools. It helps provide criteria for selecting the best available LCE retrofit solutions. In chapter 6, a portfolio of low-carbon retrofit activities and solutions for schools toward an LCE is provided, describing the pilot experiences in the 39 pilot schools. Finally, in chapter 7, the follow-up evaluation results of pilot schools after implementing the defined solutions are discussed, highlighting the main findings of this approach toward a sustainable, low-carbon future.

Chapter 2
ClimACT Project

2.1. **What is ClimACT?**

ClimACT project was drawn up under the priority axis “Low-Carbon Economy” from the Interreg SUDOE programme and involves the collaboration of universities, research institutions, companies, authorities, NGOs and schools from France, Portugal, Gibraltar, and Spain to support the transition to an LCE in schools.

2.2. **Objectives**

The main objective of this project is to support the transition to an LCE in schools. The aim is to develop and implement tools and methodologies to help school managers, teachers, and students identify intelligent solutions for the environmental management of schools and their communities. It involves the consideration of energy conservation, renewable energy use, respect for the environment, private and external costs, financial support mechanisms and human behaviours.

MAIN ACTIONS

Decision support tools

Decision support tools to assess and identify sustainable solutions for schools, based on intelligent resource management, renewable energy and behaviour change

New business models

Development of new business models and new management strategies for schools, some of them supported by Energy Service Companies (ESCOs), on the road to more efficient use of resources.

Educational tools

Education tools to raise awareness of low-carbon, assisted by information and communication technologies

A thematic network

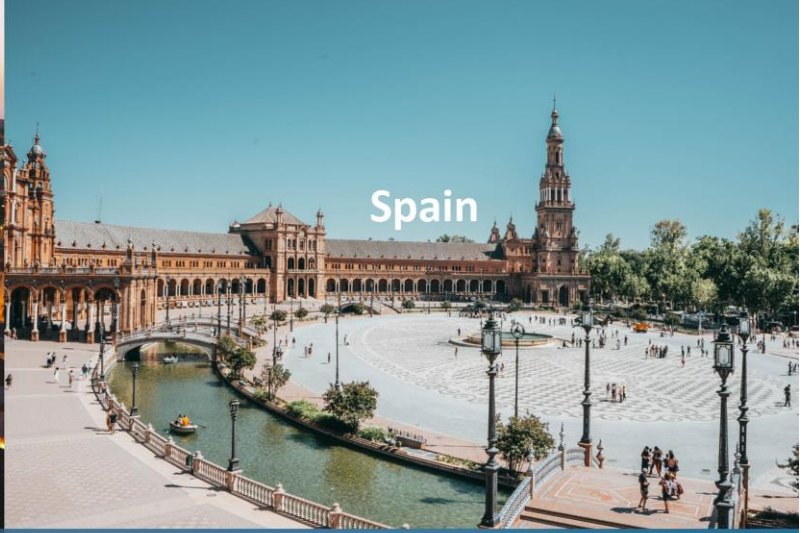
A thematic network in the SUDOE region, driven by a Living Lab methodology, which raises awareness and training, and fosters a communication framework between end-users and stakeholders

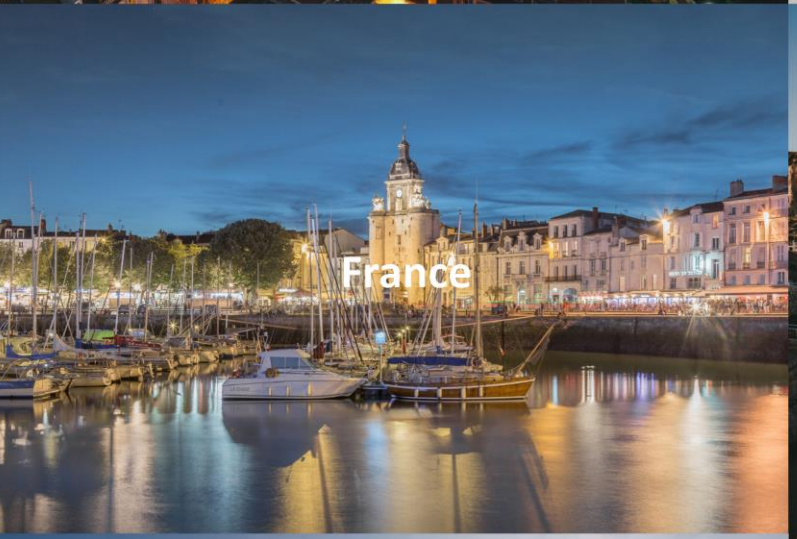
2.3. **Partners**

The project gathers partners with complementary roles from all SUDOE countries that coordinate the sharing of good practices and the implementation of joint solutions to common challenges affecting adequate energy and environment management in schools. The roles of the partners are based on multidisciplinarity, contributing to increasing the impact due to the expertise heterogeneity.

Instituto Superior Técnico	
Instituto de Soldadura e Qualidade	
Edigreen	
Associação Bandeira Azul da Europa	
Centro de Investigaciones Energéticas Medioambientales y Tecnológicas	
Universidad de Sevilla	
Université de La Rochelle	
Ville de La Rochelle	
University of Gibraltar	


Portugal


Spain


France


United Kingdom | Gibraltar


Andorra


Cooperation depends on you

2.4. **Advisory Boards**

An external advisory board composed of key stakeholders from Portugal, Spain, France, Gibraltar and Andorra guided the project in order to customise tools according to end-users needs and to guarantee that they were used during and after the end of the project:

Câmara Municipal de Loures
Câmara Municipal de Matosinhos
Câmara Municipal de Vila Nova de Gaia
Agência Portuguesa do Ambiente - Ministério do Ambiente
Direção Geral da Educação - Ministério da Educação
Agência de Energia do Porto
Associação das Agências de Energia e Ambiente
Associação Pólo de Competitividade e Tecnologia da Energia
Associação Portuguesa das Empresas de Serviços de Energia

Ayuntamiento de Alcalá de Hernares
Municipality of Seville
Ministry of Agriculture, Food and Environment. Spanish Office of Climate Change
Ministry of Education, Culture and Sports. Instituto Nacional de Tecnologías Educativas y Formación
Agencia Pública Andaluza de Educación (Consejería de Educación, Junta de Andalucía)
Agencia Andaluza de la Energía
Asociación de Educación Ambiental y del Consumidor
Argos. Proyectos educativos S.L.

Agence pour la Défense de l'Environnement et la Maîtrise de l'Energie

Her Majesty's Government of Gibraltar's Department of the Environment and Climate Change
Her Majesty's Government of Gibraltar's Department of Education

Departament d'Escola Andorrana i Formació Andorrana, Ministeri d'Educació i Ensenyament Superior


ClimACT
Saúde Ambiental
Saúde Ambiental

2.5. Project Structure and Work Packages

The ClimACT project was divided into three work packages, illustrated in Figure 2.1.

WP1. Development of thematic networking in SUDOE

WP1 developed a Thematic Network in the SUDOE region to promote the transition to an LCE in schools during the project period and built a solid foundation for implementing project outcomes after the term. The creation of this Thematic Network was driven by the Living Lab methodology that increased awareness and capacity building, and fostered a communication framework between end-users and stakeholders.

WP2. Development of tools to support the transition to a low-carbon economy in schools

WP2 developed tools to support the transition to an LCE in schools by monitoring and benchmarking environment and energy performance, identifying sustainable and cost-efficient solutions based on procurement- and behavioural-related measures, and identifying mechanisms to enable their application economically.

WP3. Implementation of a methodology conducting to a low-carbon economy in schools

In WP3, a systematic methodology was implemented, leading to an LCE in 39 pilot schools, in order to demonstrate that ClimACT tools allow an efficient transition and consequently guarantee an improvement in environmental performance, energy savings and significant cost reductions around the SUDOE region.

Additionally, three transversal work packages supported the research activities.

Transversal WP1. Project Management

WPT1 ensured coordination and project management to guarantee that all defined objectives were achieved.

Transversal WP2. Project Communication

WPT2 disclosed the main activities, events and products carried out under the ClimACT project.

Transversal WP3. Project Monitoring and Evaluation

WPT3 monitored and evaluated the progress of the actions.

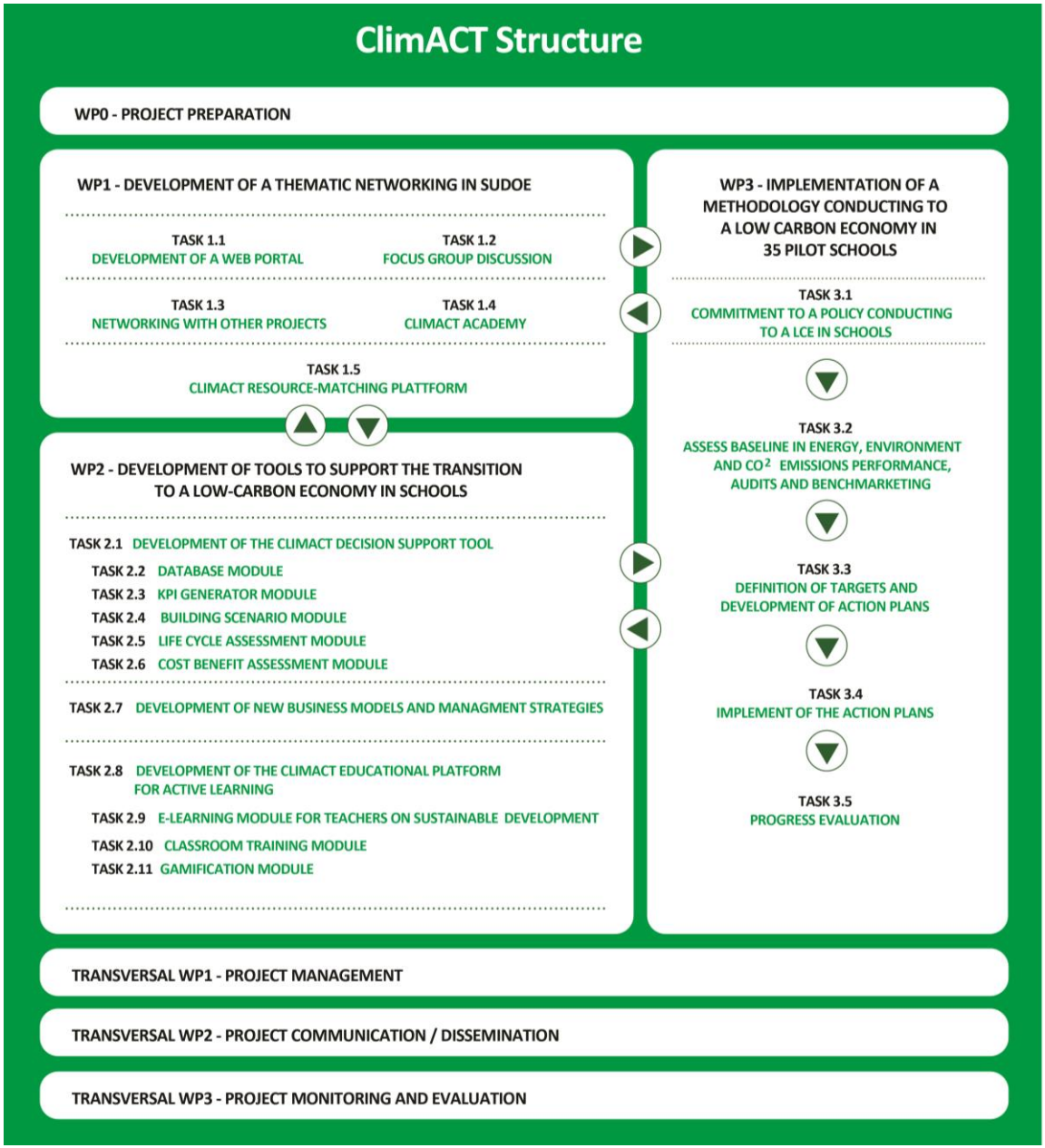


Figure 2.1 | ClimACT Project structure

2.6. **Pilot Schools and Regions**

The 39 schools from the SUDOE region selected as pilot case studies are illustrated in Figure 2.2. They comprise 9 schools from Portugal, of which 6 are located in Lisbon's district (5 in the municipality of Loures and 1 in the municipality of Lisbon) and 3 in Oporto's district (2 in the municipality of Matosinhos and 1 in the municipality of Vila Nova de Gaia); 13 schools from Spain, from which 8 are located in Seville, 1 in Málaga, 2 in Madrid and 2 in Alcalá de Henares; 9 schools from France located in La Rochelle; and 8 schools from Gibraltar. Schools' academic levels consist of 13 primary schools, 7 middle schools, 12 secondary schools and 3 universities and higher levels of education.

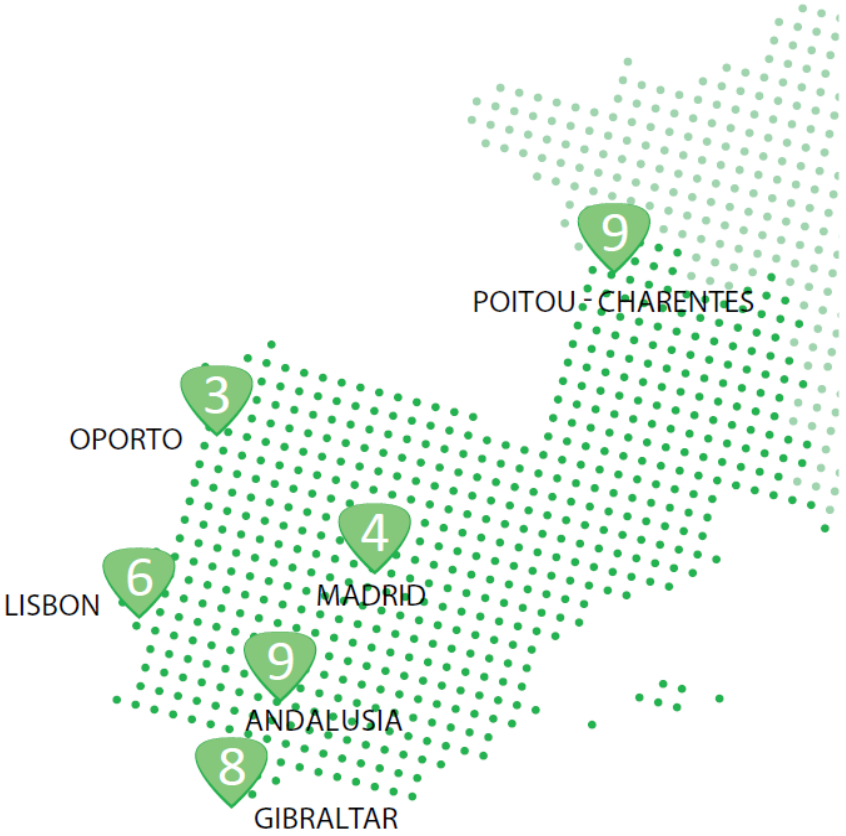


Figure 2.2 | Location of the ClimACT schools

A breakdown of ClimACT pilot schools per country is listed below.

PORTUGAL

Escola Básica de Camarate, Loures
Escola Básica de Prior Velho, Loures
Escola Básica General Humberto Delgado, Loures
Escola Básica Maria Veleda, Loures
Escola Básica Padre Manuel de Castro, Matosinhos
Escola Básica Júlio Dinis, Vila Nova de Gaia

Escola Secundária José Cardoso Pires, Loures
Escola Secundária Abel Salazar, Matosinhos

Escola Superior de Tecnologia da Saúde de Lisboa, Lisboa

SPAIN

CEIP Cardenal Cisneros, Alcalá de Henares
CEIP La Unión, La Rinconada
CEIP Maestro Pepe Gonzalez, La Rinconada
CEIP Nuestra Señora del Patrocinio, La Rinconada
CEIP Lope de Rueda, Seville

IES Cardenal Cisneros, Alcalá de Henares
IES Juan Ciudad Duarte, Bormujos
IES Gabriel García Márquez, Madrid
IES Ortega y Gasset, Madrid
IES Chaves Nogales, Seville
IES ITACA, Tomares
IES Nervión, Seville
IES Martín Rivero, Ronda

FRANCE

Ecole Barthélémy Profit, La Rochelle
Ecole Bongraine, La Rochelle
Ecole Marie Marvingt, La Rochelle
Ecole Grandes Varennes, La Rochelle
Ecole Jean Bart, La Rochelle
Ecole Marcelin Berthelot, La Rochelle

Lycée Dautet, La Rochelle
Lycée de Rompsay, La Rochelle

Institut Universitaire de Technologie, La Rochelle

GIBRALTAR

St Bernard's First School, Gibraltar
St Joseph's First School, Gibraltar

St Anne's Middle School, Gibraltar
St Joseph's Middle School, Gibraltar
St Bernard's Middle School, Gibraltar

Bayside Comprehensive School, Gibraltar
Gibraltar College, Gibraltar

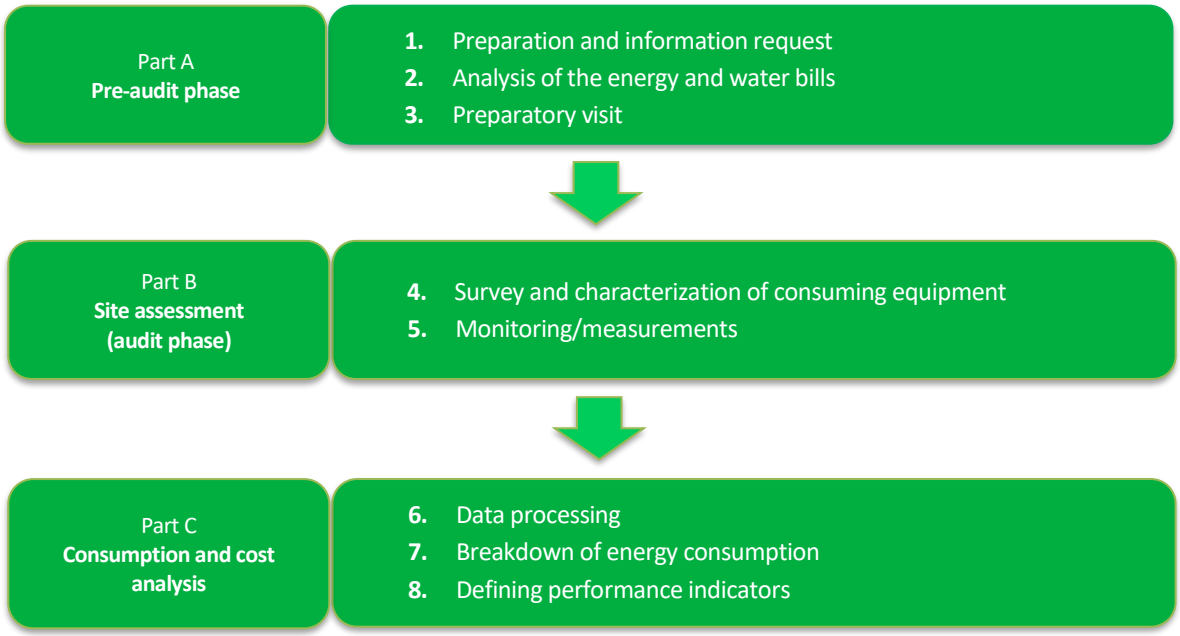
University of Gibraltar, Gibraltar

Chapter 3
ClimACT Methodology

3.1. **A Global Assessment**

ClimACT was based on a systematic methodology conducted for an LCE in 39 pilot schools to demonstrate that the tools developed in the framework of the project lead to an effective transition to an LCE, significant cost reduction, and quantifiable resources savings around the SUDOE region.

The environmental performance of schools was assessed through audits and behaviour questionnaires. The objective was to characterize the environmental baseline of each school. The audits were divided into three major parts: (A) pre-audit, (B) site assessment (audit), and (C) consumption and cost analysis.



3.2. **Environmental Sectors**

Environmental and energy performance was assessed through audits and surveys in schools in order to identify the schools' performance with regard to resource consumption and associated CO_2 emissions and costs. Seven environmental sectors were considered: Transports, Green Procurement, Green Spaces, Indoor Air Quality, Energy, Water and Waste. The characterisation process of environmental sectors is summarised in further detail in the following sections.

Summary of environmental sectors characterisation

TRANSPORTS 	Transport sector analyses the user's behaviour based on the transport mode used in the home-school path, quantifying CO_2 emissions. Moreover, it quantifies the different available parking spaces for low-carbon transport modes and the public transport network near schools.
GREEN PROCUREMENT 	Green procurement sector assesses the school behaviour concerning the electric and electronic equipment labelling, the consumption of recycled paper, the training in green procurement and eco-driving, the preference for food with a biological certificate and the existing local suppliers.
GREEN SPACES 	Green space quantifies green areas in schools, the use of chemicals and resource consumption associated with the green areas' maintenance, and the CO_2 emissions and sequestration of green spaces.
INDOOR AIR QUALITY 	Indoor air quality (IAQ) analyses thermal comfort, ventilation and indoor air pollutants in representative classrooms per school in terms of size, number of occupants and activities, furnishings or equipment that can release pollutants into the indoor air.
ENERGY 	Energy sector assesses the energy consumption from the last three years (i.e., 2014, 2015, and 2016) and the associated CO_2 emissions.
WATER 	Water sector audits the water consumption from the last three years (i.e., 2014, 2015, and 2016).
WASTE 	Waste sector quantifies the volume of waste produced divided into categories: waste produced (non-recycled), waste recycled, and reused.

3.2.1. Transport

The transports sector assesses the different parking spaces for low-carbon transport modes in schools, such as electric vehicles or bicycles; evaluates the available public transport networks in the school surroundings; and quantifies the user's behaviour with regard to the transport mode used in the home-school path and associated CO_2 emissions.

The transport sector assessment is divided into the four sub-areas defined below:

Parking characteristics

This sub-area evaluates existing parking areas for electric vehicles and bicycles, quantifying the number of spaces. It involves two key performance indicators (KPIs):

KPI-T1. Parking spaces for bicycles per student (up to a 100m radius)

KPI-T2. Parking spaces for electric cars per school (up to a 100m radius)

Public transports network

This sub-area assesses existing public transport networks for bus, subway, train, tram and boat, evaluating the number of public transports passing near the schools per hour. It involves one KPI:

KPI-T3. Public transport passing daily per hour (1000m radius)

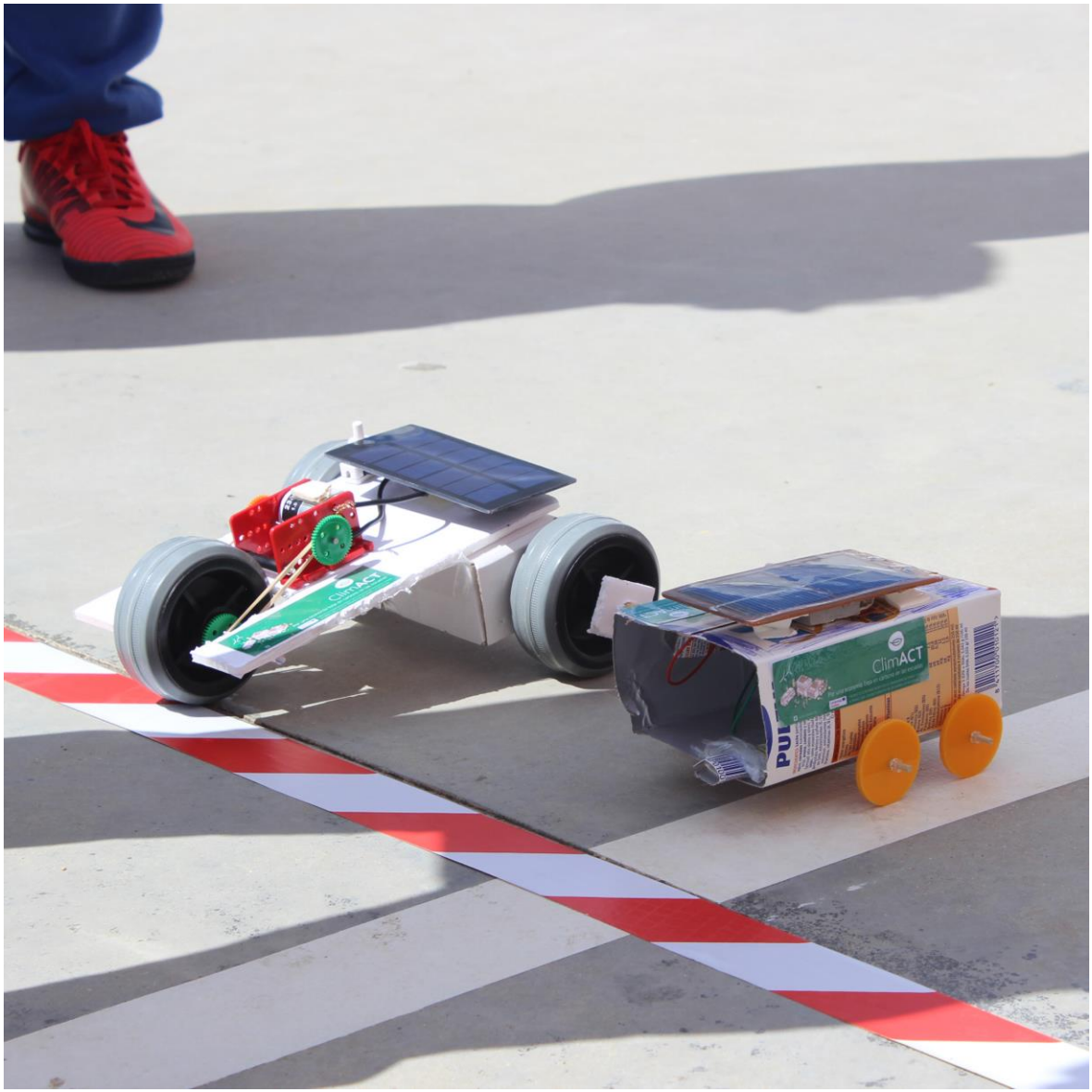
School community behaviour

This sub-area characterises the transport mode used by the school community in the daily commuting to school. It is evaluated through an online survey of the whole school community, ensuring a percentage of participation higher than 25%.

CO_2 emissions from daily commuting to school

This sub-area evaluates the annual CO_2 emissions associated with the school community's transport mode in the daily commute to school. It uses the data obtained from the online survey. It involves one KPI:

KPI-T4. Annual CO_2 emissions per student ($kgCO_2$/student yr)


ClimACT
ClimACT

3.2.2. Green procurement

The green procurement sector analyses electric and electronic equipment labelling, consumption of recycled paper, training in green procurement and eco-driving, and preference for food with a biological certificate and from local suppliers.

The green procurement sector is divided into the six sub-areas defined below:

Equipment efficiency

This sub-area evaluates the percentage of electronic equipment with labelling A+ or higher, considering all school devices. It involves one KPI:

KPI-GP1. Equipment A+ or higher EU energy label per total number of equipment

Paper used

Assessment of the amount of paper and recycled paper used. It involves two KPIs:

KPI-GP2. Annual paper used in school (kg/student yr)

KPI-GP3. Annual recycled paper used in school (kg recycled/kg paper yr)

Training in green procurement

Evaluation of staff with training in green procurement. It involves one KPI:

KPI-GP4. Staff with training in green procurement (No. staff with training/ total no. staff)

Eco-driving certification

Evaluation of the number of staff with training in eco-driving. It involves one KPI:

KPI-GP5. Staff with training in eco-driving (No. staff with training/ total no. staff)

Biological food

Assessment of the amount of food consumed with a biological certificate as a ratio of the total amount of food consumed. It involves one KPI:

KPI-GP6. Food with biological certificate (kg food with biological certificate/kg total food)

Suppliers

Evaluation of the number of local suppliers of school services. It involves one KPI:

KPI-GP7. Local suppliers (No. local suppliers/total suppliers)

3.2.3. Green spaces

Green spaces are assessed through audits that analyse and quantify the green areas, CO_2 sequestration, chemicals and consumption of resources associated with the green area's maintenance, and CO_2 emissions.

Green spaces sector assessment is divided into the four sub-areas defined below:

Green areas

Evaluation of number of trees and green area per non-covered area (m^2) and per student. It involves four KPIs:

KPI-GS1. Trees per non-covered area (No. trees/m^2)

KPI-GS2. Trees per student (No. trees/student)

KPI-GS3. Green area per non-covered area (%)

KPI-GS4. Green area per student (m^2/ student)

CO_2 sequestration

Evaluation of annual CO_2 sequestrated per non-covered area. This value is calculated considering the number of trees, the estimated sequestration rate per tree, the grass area and the estimated sequestration rate per grass area. It involves one KPI:

KPI-GS5 - Annual CO_2 sank per non-covered area ($kgCO_2/m^2$ yr)

Use of chemists

Evaluation of total kg of chemicals used for green area maintenance activities. It involves one KPI:

KPI-GS6. Annual kg of chemists used for green area maintenance (kg/m^2 yr)

CO_2 emissions

Assessment of annual CO_2 emitted for the maintenance activities of green spaces. It involves one KPI:

KPI-GS7 - Annual CO_2 emissions associated with space maintenance per non-covered area ($kgCO_2/m^2$ yr)

3.2.4. Indoor air quality

Indoor Air Quality is assessed through on-site measurements in two classrooms in all schools, together with the occupancy pattern of the rooms, window openings, and outdoor concentrations (when available). Classrooms are representative of the school building in terms of size, number of occupants and activities, furnishings or equipment that can release pollutants into the indoor air. Main indoor and outdoor pollutants are identified and analysed.

Indoor air quality sector assessment is divided into the three sub-areas defined below:

Air pollutants concentration

The pollutants evaluated in this sub-area are a group of specific aldehydes:

Formaldehyde (mg/m^3), Acetaldehyde (mg/m^3) and Acrolein (mg/m^3)

A group of specific volatile organic compounds (VOCs):

Benzene (mg/m^3), Toluene (mg/m^3), Styrene (mg/m^3), Tetrachloroethylene (mg/m^3), Trichloroethylene (mg/m^3), m+p+o-xylene (mg/m^3), Ethylbenzene (mg/m^3), 1,4-dichlorobenzene (mg/m^3), Alpha-pinene (mg/m^3) and TVOC (mg/m^3)

And other air pollutants:

PM10 (mg/m^3), PM2.5 (mg/m^3), CO_2 (ppm) and CO (ppm)

Ventilation

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

KPI-IAQ1. CO_2 concentrations between 1000 and 1700 ppm during occupancy (%)

KPI-IAQ2. CO_2 concentrations over 1700 ppm during the occupancy (%)

Thermal comfort

Assessment of the time percentage of temperature between 20°C and 26°C during occupancy (%).

KPI-IAQ3. Temperature between 20° and 26° during occupancy (%)

3.2.5. Energy

The energy sector evaluates the energy consumption of the schools over the last three years and the CO_2 emissions associated.

The energy sector assessment is divided into the four sub-areas defined below:

Energy consumption

Assessment of final energy consumption of school (electricity, diesel, LPG, biomass pellets and natural gas). It involves two KPIs:

KPI-E1. Annual final energy consumption per m^2 (kWh/m^2)

KPI-E2. Annual final energy consumption per student (kWh/student)

Use of renewable energy

Evaluation of on-site renewable energy production in school. It implies renewable energy is consumed and sold to the grid. It involves one KPI:

KPI-E3. Renewables energy production (%)

Energy cost

Assessment of annual energy cost of school. It involves two KPIs:

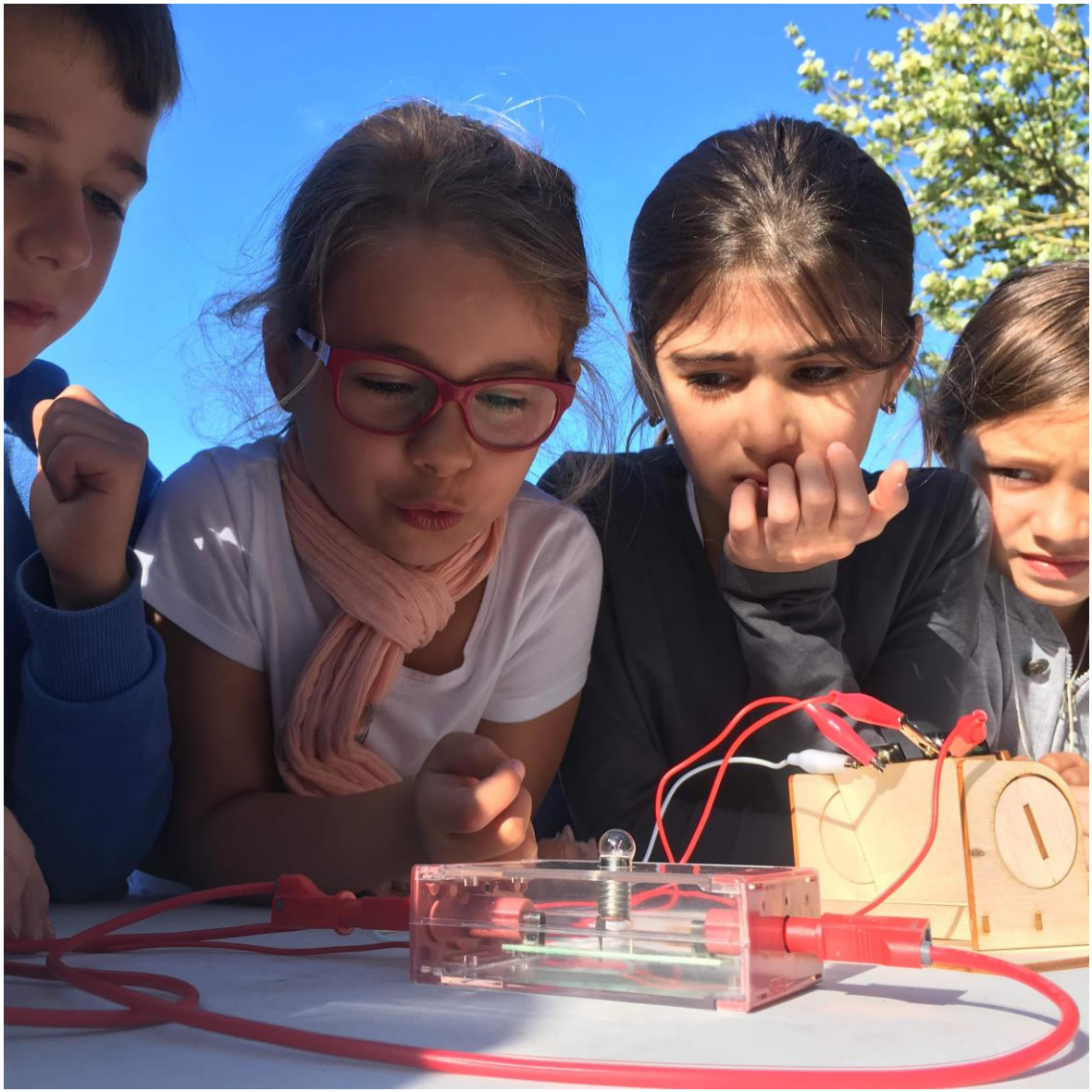
KPI-E4. Annual energy cost per m^2 (€/m^2)

KPI-E5. Annual energy cost per student (€/student)

CO_2 emissions

Assessment of CO_2 emissions related to the annual energy consumption of school. It involves one KPI:

KPI-E6. Annual associated CO_2 emissions per student ($kgCO_2$/student)



3.2.6. Water

The water sector evaluates the water consumption of the school during the last three years and its associated cost.

The environmental sector of water is divided into two sub-areas defined below:

Water consumption

Assessment of annual water consumption in school. It involves two KPIs:

- KPI-H_2O1. Annual water consumption (m^3/m^2)
- KPI-H_2O2. Annual water consumption (m^3/student)

Water cost

Assessment of annual water costs in school. It involves two KPIs:

- KPI-H_2O3. Annual water cost (€/m^2)
- KPI-H_2O4. Annual water cost (€/student)

3.2.7. Waste

Waste is quantified according to the volume of waste produced, recycled and reused in schools.

The waste sector assessment is divided into three sub-areas defined below:

Waste produced

Accounting the volume of waste produced in schools, with the aim of implementing strategies for waste reduction. It involves one KPI:

KPI-W1. Weekly waste production per student (m^3/student)

Waste recycled

Accounting for the type and volume of waste recycled in schools, compared to the amount of waste produced. It involves one KPI:

KPI-W2. Weekly waste recycled per student (m^3/student)

Waste reused

Accounting for the amount of waste reused for further life cycle in schools. It involves one KPI:

KPI-W3. Weekly waste reused per student (m^3/student)

3.3. **Low-Carbon Rating**

The “low-carbon rating” of schools was obtained through different KPIs calculated using the following input data:

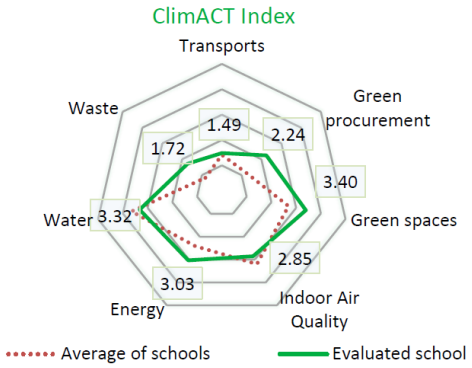
- Information and inputs collected in pre-audits through the pre-audit checklist (building characteristics, location, equipment, activities, behaviours, occupation profiles, etc.);
- Information obtained in audits, through on-site measurement campaigns;
- And information collected through a behaviour questionnaire for students, teachers and administrative staff.

The key performance indicators (KPIs) were divided into the following environmental areas: transport, green procurement, green spaces, IAQ, energy, water, and waste. These KPI were then used to calculate a score per environmental area based on an environmental ranking from 0 to 5, which is obtained by comparing each KPI against the performance of all evaluated schools. Further details of the mathematical procedure are provided in Lizana et al. (2021).

The summary of the environmental performance per school and the breakdown of indicators per environmental sector are provided following the next structure. It compares each school's performance with the average scores obtained for the whole school sample.

SUMMARY OF SCHOOL ENVIRONMENTAL PERFORMANCE

ClimACT



Final score:	2.58 /5

Sector	Results	Average
Transports	1.49	*1.42*
Green procurement	2.24	*1.19*
Green spaces	3.40	*2.70*
Indoor Air Quality	2.85	*3.20*
Energy	3.03	*2.41*
Water	3.32	*3.65*
Waste	1.72	*0.83*

The breakdown of indicators (0-5) per environmental sector is the following:

Transports	*Results*	*Average*
Parking	0.0	*0.4*
Public transports	0.4	*0.6*
CO_2 emissions	3.5	*2.9*
Total	1.5	*1.4*

Energy	*Results*	*Average*
Energy consumption	4.6	*3.4*
Energy cost	4.2	*3.8*
Renewable energy	0.0	*0.0*
CO_2 emissions	3.3	2.4
Total	3.0	2.4

Green procurement	*Results*	*Average*
Equipment	3.6	*0.9*
Paper	2.2	*1.8*
Training	0.0	*0.0*
Eco-driving	0.0	*0.0*
Food	0.0	*0.2*
Suppliers	3.8	*0.9*
Total	2.2	*1.2*

Water	*Results*	*Average*
Water consumption/m^2	3.2	*3.4*
Water consumption/student	3.8	*4.0*
Water cost/m^2	3.5	*3.7*
Water cost/student	2.8	*3.6*
Total	3.3	3.6

Green spaces	*Results*	*Average*
Green areas	1.3	*1.0*
Usage of chemicals	5.0	*4.6*
CO_2 sequestration	2.3	*0.7*
CO_2 emissions	5.0	*4.5*
Total	3.4	*2.7*

Waste	*Results*	*Average*
Waste produced	2.3	*1.1*
Waste recycled	2.3	*0.8*
Waste reused	0.0	*0.3*
Total	1.72	0.8

Indoor Air Quality	*Results*	*Average*
Air pollutants	4.2	*4.0*
Ventilation	4.3	*3.2*
Thermal comfort	0.0	*2.4*
Total	2.9	3.2

Figure 3.1 | Example of environmental performance per school.

Chapter 4
Schools' Performance

4.1. **Introduction**

Initial audits were performed following the previously defined methodology for assessing schools' environmental performance to set a reference baseline. These values supported the definition of short- and long-term objectives for each environmental sector per school to provide criteria for selecting the best available LCE retrofit solution.

In this chapter, the overall results of schools' performance are presented, taking into account the low-carbon rating, as well as the specific results of KPIs per environmental sector.

4.2. **Global Score**

The audits performed in the 39 ClimACT schools gave the first status of these schools' performance. The initial scores of all sectors per school are presented in Fig. 4.1, along with the average scores calculated considering the whole school sample. This first evaluation provided a mean score among all the schools of 2.20 out of 5.

The transport sector showed an average score of 1.42. French schools had the best performance (average score of 1.98), followed by the Portuguese schools (average score of 1.54) and Spanish schools (average score of 1.37).

The green procurement sector provided an average score of 1.19. I, French schools had the best performance (average score of 1.90), followed by the Portuguese schools (average score of 1.74) and Spanish schools (average score of 1.04).

The green spaces sector showed an average score of 2.70. Portuguese schools had better performance (average score of 3.17), followed by French schools (average score of 2.64), Spanish schools (average score of 2.53) and Gibraltar schools (average score of 2.50).

The Indoor air quality sector resulted in an average score of 3.20. The average score in the sub-sector "air pollutants" was 4.0 out of 5, which indicates that, despite some guideline exceedances in air pollutant concentrations, IAQ is quite good in all schools studied. Regarding CO_2 concentrations and ventilation scores, they vary in a wide range, and they can be significantly different in the classrooms of the same school, while the building characteristics and operation parameters are similar.

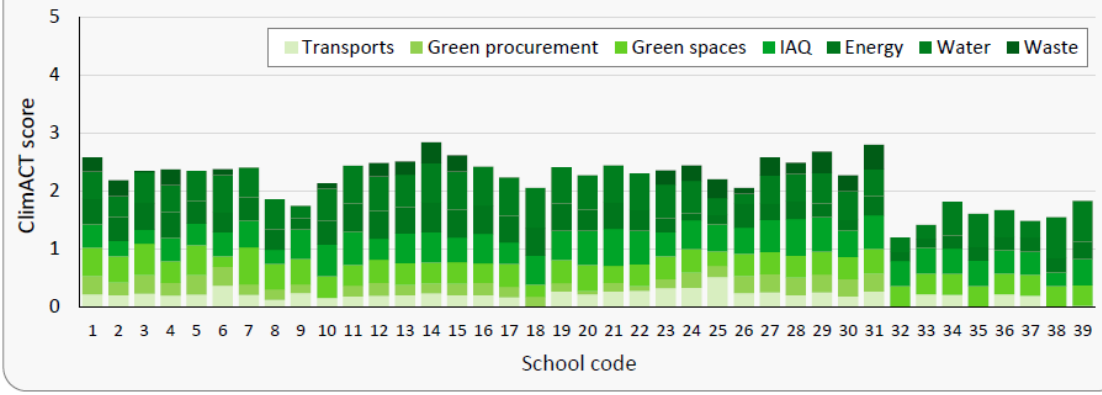
The energy sector showed an average score of 2.41. Gibraltar and French schools had the lowest scores, while Spain schools had the highest scores (average score of 3.18). The higher space heating needs in France resulted in a slightly lower score for French schools compared to the rest. Additionally, the electricity energy mix of Gibraltar resulted in higher CO_2 emissions associated with the energy consumption, which reduced the final energy score of schools.

The water sector achieved an average score of 3.65. Spanish schools had excellent scores (average score of 4.43), mainly associated with low water consumption per student and the low water cost rate compared to other regions. French schools had the lowest result in this sector, influenced by the higher water cost ratio.

Finally, **the waste sector** showed an average score of 0.83. France schools had the highest score (average score of 1.94), followed by Portuguese schools (average score of 0.71). The waste sector was the most potential sector for improvement in all regions.

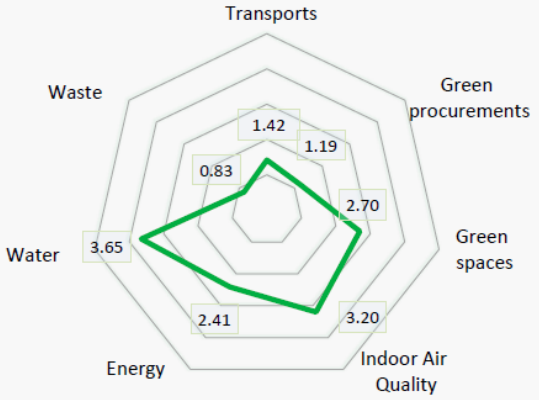
INITIAL CLIMACT SCORE OF PILOT SCHOOLS

Figure 4.1. Initial ClimACT score of pilot schools



AVERAGE PERFORMANCE

Figure 4.2. ClimACT Index



Average score: **2.20**/5

Sector	*Average*
Transports	*1.42*
Green procurement	*1.19*
Green spaces	*2.70*
Indoor Air Quality	*3.20*
Energy	*2.41*
Water	*3.65*
Waste	*0.83*

Figure 4.1 | ClimACT Index.

4.3. **Transport**

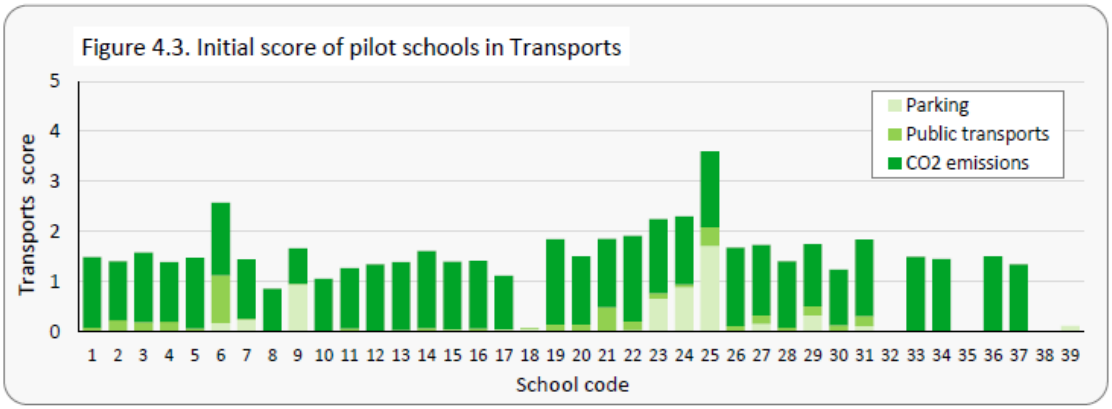
The parameters assessed in the transport sector are summarised in Table 4.1. The maximum and minimum final transport scores obtained (from 0 to 5) were 3.60 and 0.00, with a **final average score in the transport sector of 1.42**.

Table 4.1 | Transport sub-areas and KPIs.

TRANSPORT SUB-AREAS	QUANTIFICATION of KPIs	AVERAGE KPI VALUE	AVERAGE SCORES (0-5)
PARKING CHARACTERISTICS	KPI-T1. Parking spaces for bicycles per student (up to a 100m radius)	0.0003	0.35
	KPI-T2. Parking spaces for electric cars per school (up to a 100m radius)	0.02	
PUBLIC TRANSPORTS NETWORK	KPI-T3. Number of Public Transports passing daily per hour (1000m radius)	14.26	0.56
CO_2 EMISSIONS	KPI-T4. Annual CO_2 Emissions per student ($kgCO_2$/student)	*104.34*	*2.91*
		Final score	*1.42*

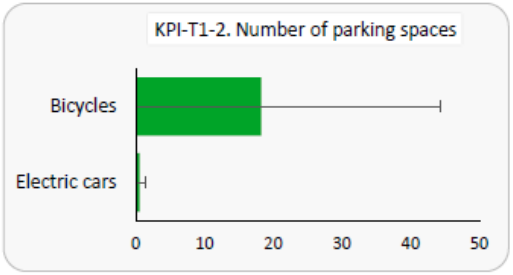
Among the 39 ClimACT schools, only 3 (1 in Portugal and 2 in France) had charging stations for electric cars. Parking places for bicycles were only equipped in 44% of schools, having the highest number of parking places for bikes in the French schools. Bus stops within a radius of 1000m were available in 82% of cases (32 schools), 21% (8 schools) had a train stop, and 5% (2 schools) had a subway stop. Trams and boats were not available in pilot schools. On average, the number of bus stops was 24 in Portugal, 11 in Spain and France, and 1 in Gibraltar. Most of the students go to school on foot (41%), followed by car (30%) and bus (15%). The use of the different transports depends on the region and the school level. The schools from Portugal presented the highest annual average CO_2 emissions associated with transport (113.91 $kgCO_2 \cdot student^{-1}$), followed by Spanish schools (103.65 $kgCO_2 \cdot student^{-1}$), French schools (96.23 $kgCO_2 \cdot student^{-1}$) and Gibraltar schools (15.86 $kgCO_2 \cdot student^{-1}$).

TRANSPORT SCORE

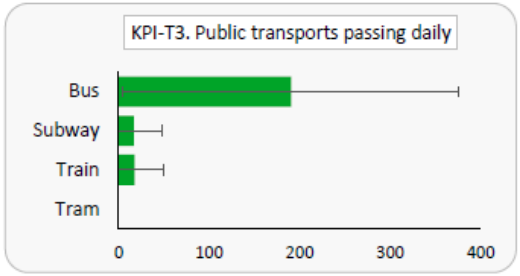


AVERAGE PERFORMANCE OF ASSESSED PARAMETERS

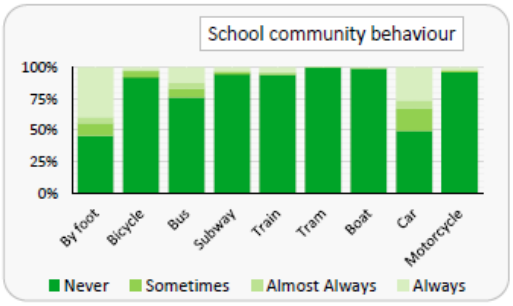
Parking characteristics



Public transports network



School community behaviour in transports



CO_2 emissions from daily commuting to school

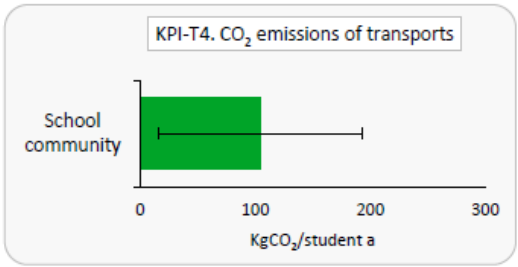


Figure 4.2 | Initial score of pilot schools in Transports.

4.4. Green Procurement

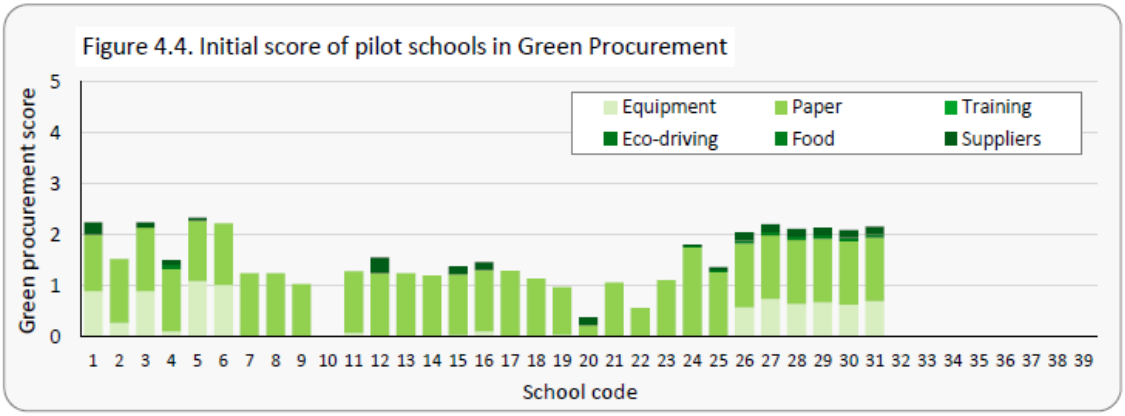
The parameters assessed in green procurement are shown in Table 4.2. The maximum and minimum final green procurement scores obtained (from 0 to 5) were 2.34 and 0.00, with a **final average score in the green procurement sector of 1.19.**

Table 4.2 |Green procurement sub-areas and KPIs

GREEN PROCUREMENT SUB-AREAS	QUANTIFICATION of KPIs	AVERAGE KPI VALUE	AVERAGE SCORES (0-5)
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)	0.18	0.88
PAPER	**KPI-GP2. Annual paper used in school** (kg/student yr)	9.79	1.79
	KPI-GP3. Annual recycled paper used in school (Kg recycled/Kg paper)	0.02	
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)	0.04	0.22
SUPPLIERS	**KPI-GP7. Local suppliers** (No. local suppliers/total suppliers)	0.19	0.95
		Final score	1.19

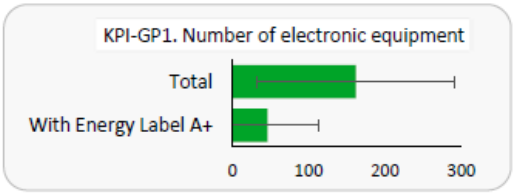
Results show a weak investment in training on green procurement and eco-driving. The consumption of paper was higher in Spanish schools (7.6 kg·student^{-1} yr), followed by Portuguese schools (1.5 kg·student^{-1} yr) and French schools (1.2 kg·student^{-1} yr). It was verified that only a few schools use recycled paper at a low amount. The schools from Portugal and France presented the electric equipment with better efficiency (average KPI-GP1 of 0.38 and 0.36, respectively), followed by Spanish schools (0.02). The French schools presented the highest values for KPI-GP7, related to local suppliers, with an average value of 0.37, followed by the Spanish and Portuguese schools with 0.19 and 0.18, respectively.

GREEN PROCUREMENT SCORE

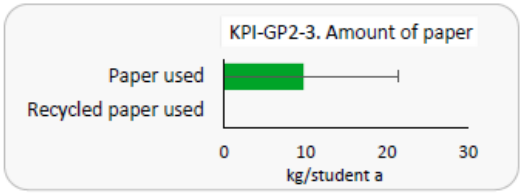


AVERAGE PERFORMANCE OF ASSESSED PARAMETERS

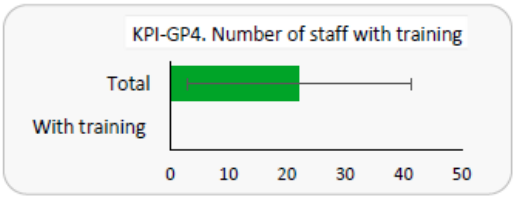
Equipment



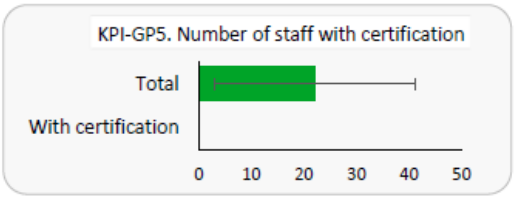
Paper



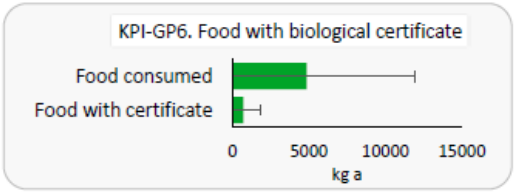
Training in green procurement



Certification in Eco-driving



Food



Suppliers

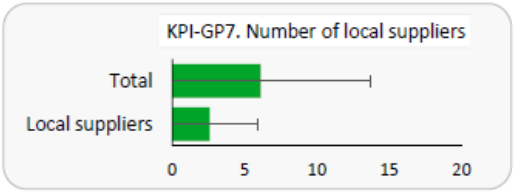


Figure 4.3 | Initial score of pilot schools in Green Procurement.

4.5. Green Spaces

Parameters assessed in green spaces are shown in Table 4.3. The maximum and minimum final green space scores obtained (from 0 to 5) were 4.49 and 1.29, with a **final average score in the green spaces sector of 2.70**.

Table 4.3 | Green spaces sub-areas and KPIs

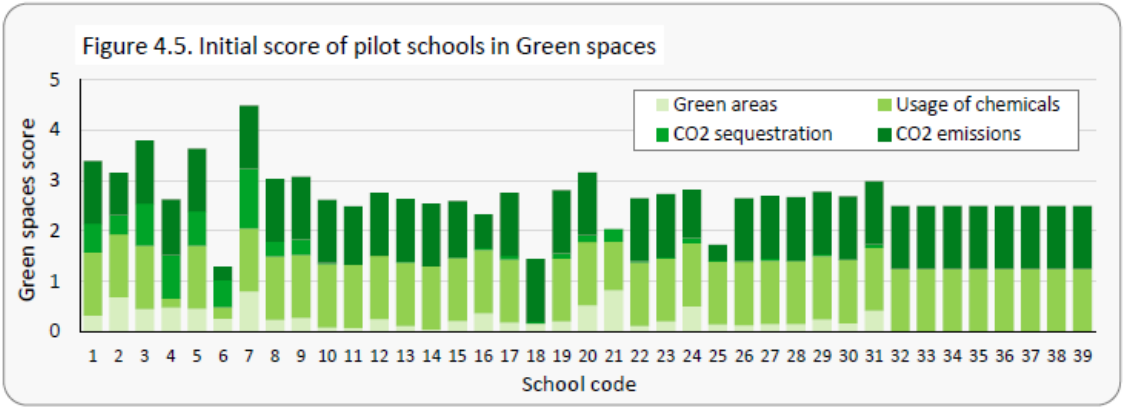
GREEN SPACES SUB-AREAS	QUANTIFICATION of KPIs	AVERAGE KPI VALUE	AVERAGE SCORES (0-5)
GREEN AREAS	KPI-GS1. Number of trees per non-covered area (trees/m^2)	0.01	0.96
	KPI-GS2. Number of trees per student (trees/student)	0.11	
	KPI-GS3. Green area per non-covered area (%)	24.61	
	KPI-GS4. Green area per student (m^2/ student)	5.35	
CO_2 SEQUESTRATION	KPI-GS5. Annual CO_2 sank per non-covered area ($kgCO_2/m^2$ yr)	0.12	0.70
USE OF CHEMISTS	KPI-GS6. Annual kg of chemists used for green area maintenance (kg/m^2 yr)	0.0001	4.63
CO_2 EMISSIONS	KPI-GS7. Annual CO_2 emissions associated with space maintenance per non-covered area ($kgCO_2/m^2$ yr)	*0.01*	*4.51*
		Final score	*2.70*

The Portuguese schools showed the best results concerning the number of trees per student, and the green areas per student, achieving the highest score of 1.78, followed by Spanish schools (0.99) and French schools (0.95).

The Portuguese schools had the best performance related to the annual CO_2 sequestration per non-covered area, showing a value of 0.43 $kgCO_2 \cdot m^{-2}$ yr, followed by Spanish schools (0.04 $kgCO_2 \cdot m^{-2}$ yr) and French schools (0.03 $kgCO_2 \cdot m^{-2}$ yr). The variability of the results is due to the difference in the predominant tree species and, consequently, the sequestration ratio.

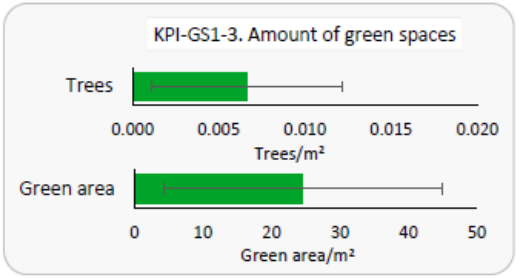
The use of chemists and resource consumption during maintenance is non-existent in most schools.

GREEN SPACES SCORE

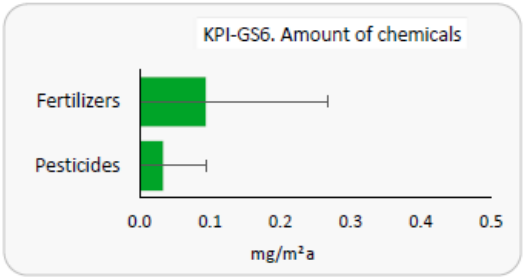


AVERAGE PERFORMANCE OF ASSESSED PARAMETERS

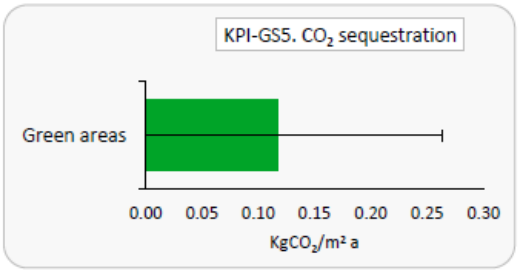
Green areas



Use of chemists



CO_2 sequestration



CO_2 emissions

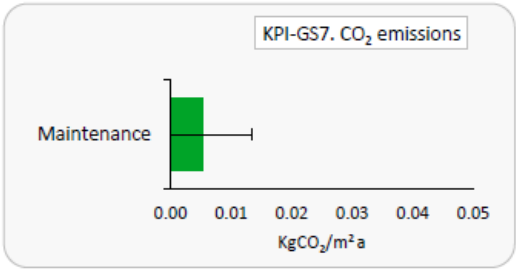


Figure 4.4 | The initial score of pilot schools in Green spaces.

4.6. Indoor Air Quality

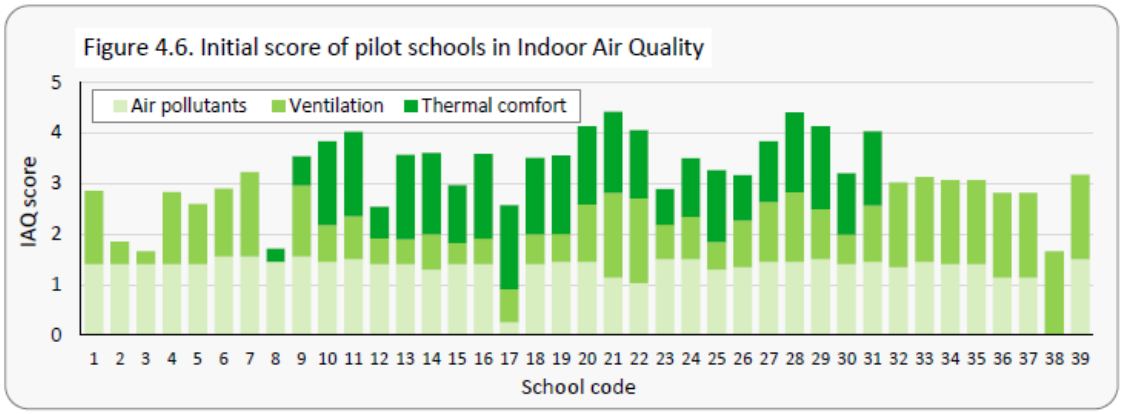
Parameters assessed in IAQ are shown in Table 4.4. The maximum and minimum final IAQ scores obtained (from 0 to 5) were 4.43 and 1.66, respectively, with a **final average score in the IAQ sector of 3.20**.

Table 4.4 | IAQ sub-areas and KPIs

IAQ SUB-AREAS	QUANTIFICATION of KPIs	AVERAGE KPI VALUE	AVERAGE SCORES (0-5)
AIR POLLUTANTS CONCENTRATION	PM_{10} (mg/m^3)	33.7	4.02
	$PM_{2.5}$ (mg/m^3)	11.6	
	CO_2 (ppm)	1196.6	
	CO (ppm)	0.6	
	TVOC (mg/m^3)	394.4	
	Group of specific aldehydes (mg/m^3)	-	
	Group of specific VOCs (mg/m^3)	-	
VENTILATION	KPI-IAQ1. CO_2 concentrations between 1000 and 1700 ppm (%)	26%	3.17
	KPI-IAQ2. CO_2 concentrations over 1700 ppm during the occupancy (%)	21%	
THERMAL COMFORT	KPI-IAQ3. Temperature between 20º and 26º during occupancy (%)	78%	2.42
		Final score	3.20

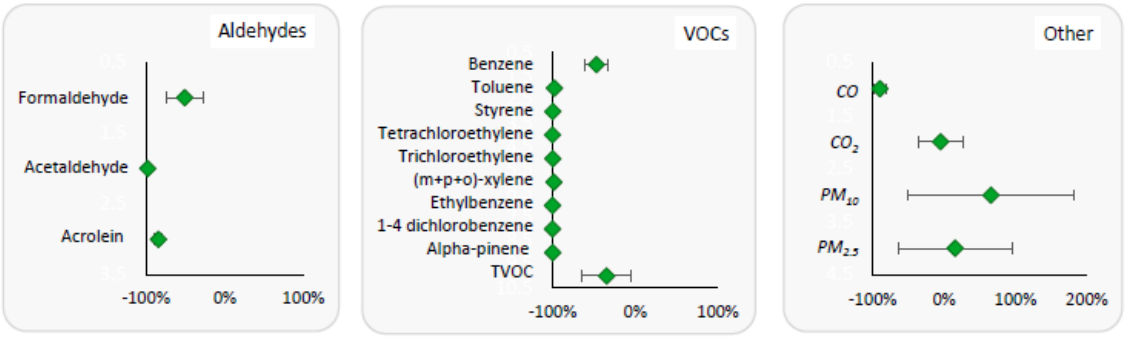
Main high priority pollutants in school environments were evaluated and compared with recommended indoor air guideline values (IAGVs) reported by different regulations and health organisations. The results showed that school occupancy had a direct effect on indoor CO_2 concentration levels; particle suspension was mainly associated with dirty areas; and blackboard chalk was the main indoor source origin affecting air particulate matter concentrations. Additionally, a wide range of construction and furnishing materials, cleaning products, rubbish or other specific products affected TVOC, VOC and aldehyde levels during teaching hours. The pilot schools showed concentrations over the guidelines in more than 50% of the classrooms for $PM_{2.5}$, PM_{10}, and CO_2, more than 20% for Total Volatile Organic Compounds (TVOCs), and more than 9% for formaldehyde. The results showed that PM concentrations were lower in Spanish schools than in Portuguese and French schools. The mean TVOC concentration was lower in Spain (295 $\mu g/m^3$) in comparison with Portugal (361 $\mu g/m^3$) and France (459 $\mu g/m^3$).

INDOOR AIR QUALITY SCORE

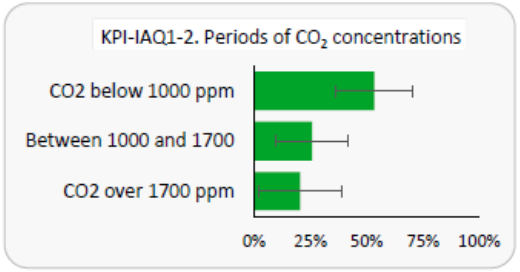


AVERAGE PERFORMANCE OF ASSESSED PARAMETERS

Air pollutants concentration (percentage of air pollution exceedance over the guideline)



Ventilation



Thermal comfort

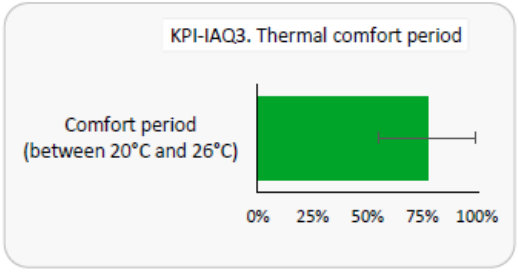


Figure 4.5 | Initial score of pilot schools in Indoor Air Quality.

4.7. Energy

Parameters assessed in energy are shown in Table 4.5. The maximum and minimum final energy scores obtained (from 0 to 5) were 3.60 and 0.88, with a **final average score in the energy sector of 2.41**.

Table 4.5 | Energy sub-areas and KPIs

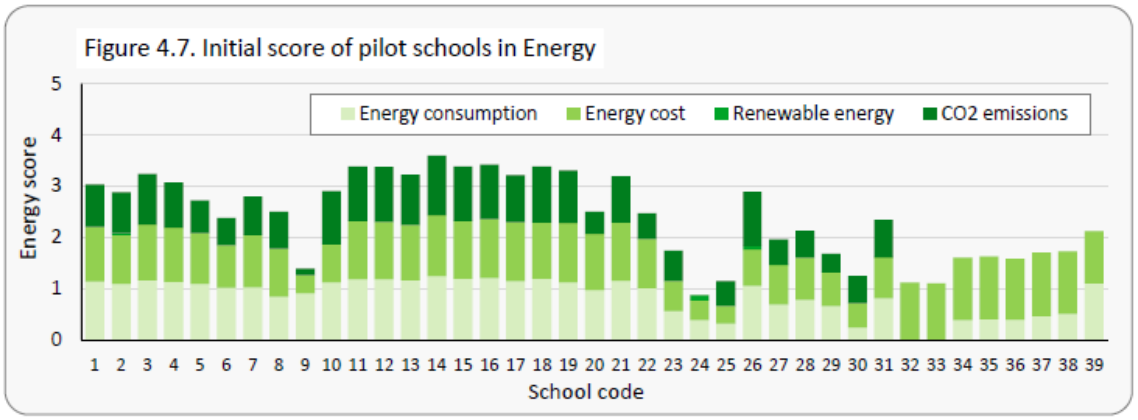
ENERGY SUB-AREAS	QUANTIFICATION of KPIs	AVERAGE KPI VALUE	AVERAGE SCORES (0-5)
ENERGY CONSUMPTION	KPI-E1. Annual final energy consumption per m² (kWh/m²)	79.7	3.40
	KPI-E2. Annual final energy consumption per student (kWh/student)	911.9	
RENEWABLE ENERGY	KPI-E3. Renewables energy production (%)	0.5%	0.02
ENERGY COST	KPI-E4. Annual energy cost per m² (€/m²)	5.5	3.82
	KPI-E5. Annual energy cost per student (€/student)	53.6	
CO_2 EMISSIONS	KPI-E6. Annual associated CO_2 emissions per student ($kgCO_2$/student)	431.7	2.40
		Final score	2.41

Portugal and Spain had similar scores across all energy KPIs, but there is a significant discrepancy with values in France. The most obvious reason for the lower scores in France is the higher necessity of space heating due to lower winter temperatures. This is why energy consumption and cost scores have higher values in France than in Portugal and Spain.

Renewable energy production was insignificant in all pilot schools. It was highlighted that only one French school had high renewable energy production, which obtained the highest score (0.43). Additionally, a few cases had solar collectors for hot water.

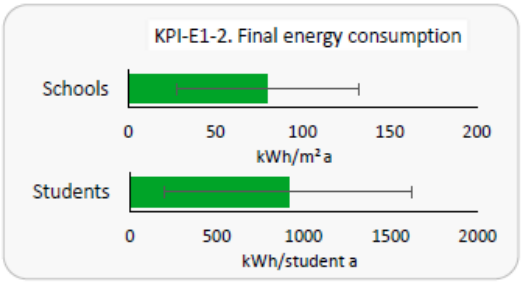
CO_2 emissions associated with energy consumption were mainly influenced by the energy mix per school, and the electricity generation technologies per region. Spanish and Portuguese electricity grids were mainly based on thermal plants using fossil fuels, around 40-50%. French electric mix was mainly based on nuclear energy. And renewable energy, mainly wind, was responsible for 36% in Spain, 17% in France and 49% in Portugal. ON the other hand, for the specific case of Gibraltar, the total electricity mix was based on oil.

ENERGY SCORE

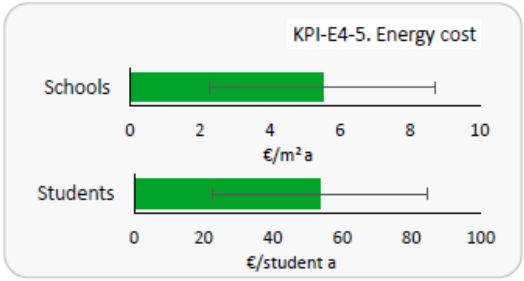


AVERAGE PERFORMANCE OF ASSESSED PARAMETERS

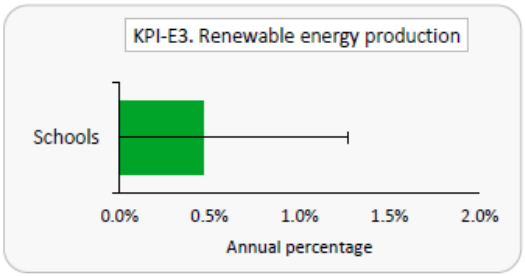
Energy consumption



Energy cost



Renewable energy



CO_2 emissions

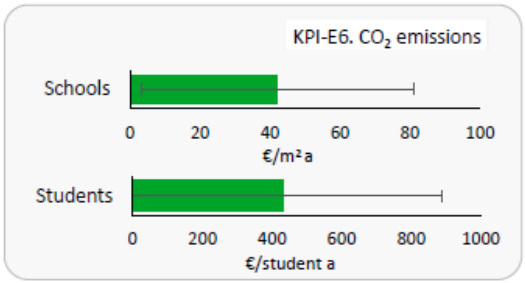


Figure 4.6 | Initial score of pilot schools in Energy.

4.8. **Water**

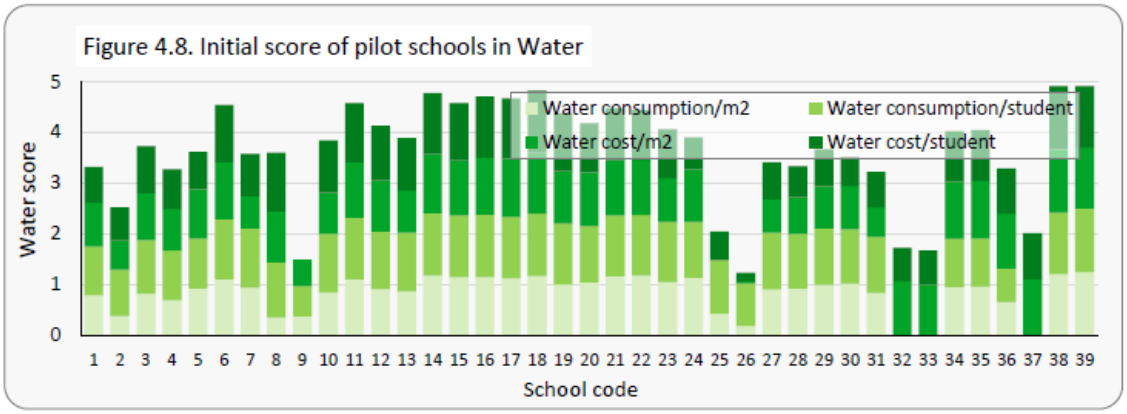
Parameters assessed in water are shown in Table 4.6. The maximum and minimum final water scores obtained (from 0 to 5) were 4.92 and 1.23, respectively, with a **final average score in the water sector of 3.65**.

Table 4.6 |Water sub-areas and KPIs

WATER SUB-AREAS	QUANTIFICATION of KPIs	*AVERAGE KPI VALUE*	*AVERAGE SCORES (0-5)*
WATER CONSUMPTION	**KPI-H_2O1. Annual water consumption** (m^3/m^2)	**0.49**	**4.00**
	KPI-H_2O2. Annual water consumption (m^3/student)	**5.28**	
WATER COST	**KPI-H_2O3. Annual water cost** (€/m^2)	**1.01**	**3.55**
	KPI-H_2O4. Annual water cost (€/student)	**10.11**	
		Final score	**3.65**

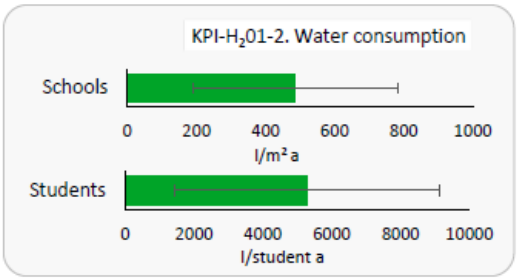
The Spanish schools had the highest scores in the water sector due to their low water consumption and low cost. The Portuguese schools had the highest water consumption on average, even considering the water consumption per student or school area. French schools had the final scores raised due to their high-water cost. This was something out of control for the schools that negatively impacted their economic resources.

WATER SCORE



AVERAGE PERFORMANCE OF ASSESSED PARAMETERS

Water consumption



Water cost

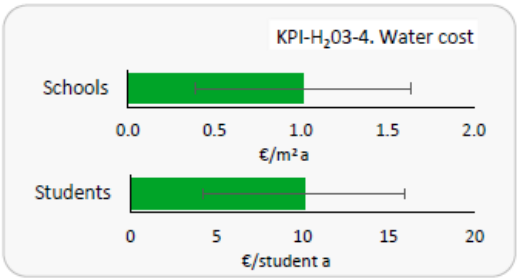


Figure 4.7 | Initial score of pilot schools in Water.

4.9. **Waste**

Parameters assessed in waste are shown in table 4.7. The maximum and minimum final waste scores obtained (from 0 to 5) were 2.96 and 0.00, with a **final average score in the waste sector of 0.83**.

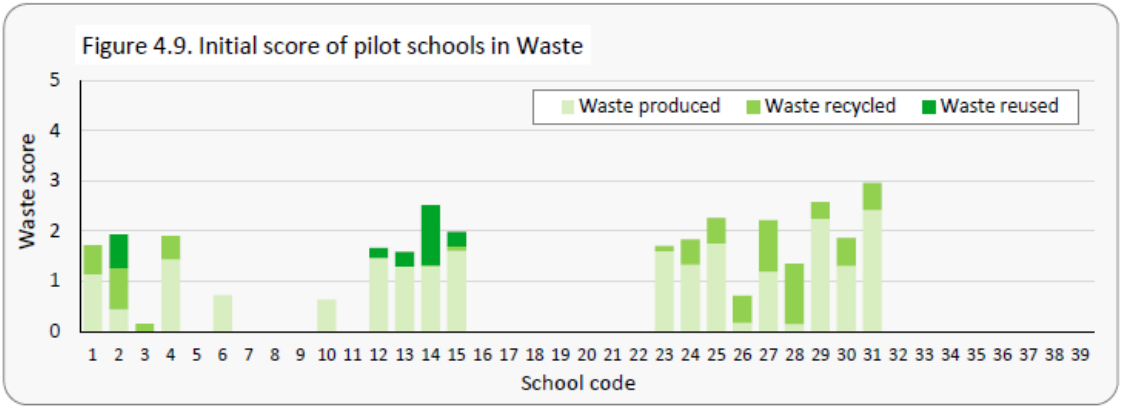
Table 4.7 | Waste sub-areas and KPIs

WASTE SUB-AREAS	QUANTIFICATION of KPIs	*AVERAGE KPI VALUE*	*AVERAGE SCORES (0-5)*
WASTE PRODUCED (non- recycled)	**KPI-W1. Weekly waste production per student** (m^3/student)	**6.31**	**1.14**
WASTE RECYCLED	**KPI-W2. Weekly waste recycled per student** (m^3/student)	**4.86**	**0.76**
WASTE REUSED	**KPI-W3. Weekly waste reused per student** (m^3/student)	**0.04**	**0.27**
		Final score	***0.83***

The average waste produced by all the schools is almost 10 litres per student every week. It was complicated to compare and extract reliable information about the waste sector, but the fact is that French schools had a higher percentage of recycled waste.

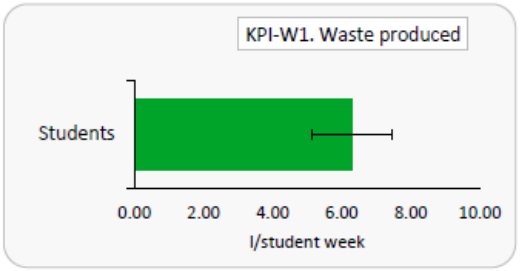
The reused waste for most schools assessed was zero, meaning that there was no reuse of waste products in pilot schools.

WASTE SCORE

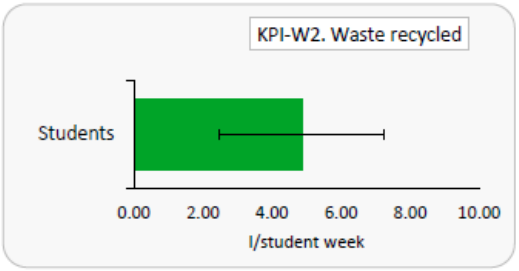


AVERAGE PERFORMANCE OF ASSESSED PARAMETERS

Waste produced (non recyclabes and reusables)



Waste recycled



Waste reused

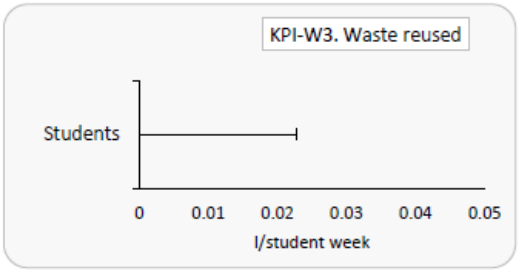


Figure 4.8 | Initial score of pilot schools in Waste.

Chapter 5
Towards a Low-Carbon School

5.1. The Role of Teachers and Students

The pathway toward a low-carbon school should engage and encourage the whole school community. Schools have a major social responsibility considering their educational purpose. The retrofitting activities and solutions in schools toward an LCE represent a learning opportunity to upgrade the environmental performance of school communities for their ongoing life. Raising awareness and involving school communities (students, teachers and families) towards an energy-efficient and LCE pathway through the wide deployment of the best available solutions can lead to an efficient LCE transition in the whole region.

The ClimACT structure to involve all school communities in an LCE is summarised in Table 5.1. It involves three school profiles: Low-Carbon Coordinator (LC), Low-Carbon Committee (LCC) and Low-Carbon Brigades (LCB).

Table 5.1 | The ClimACT engagement. The role of teachers and students

ClimACT Structure	Decisions	Coordination	Implementation
School profiles	Low-Carbon Coordinator (LC)	Low-Carbon Committee (LCC)	Low-Carbon Brigades (LCB)
Role	Project leader in the school	Representatives of the whole school community: students, teachers, staff, parents, municipalities and other relevant entities	Group of students to deploy the ClimACT activities
Tasks	Global management of the LCE project	Livelong internal structure for planning and evaluation	Coordination of students

The Low-Carbon Coordinator (LC) is the project leader in the school, responsible for ClimACT management and implementation and meeting organisation.

The Low-Carbon Committee (LCC) is a lifelong internal structure inside the school, composed of students, teachers, staff, parents, municipalities and other relevant entities. This committee is responsible for planning the LCE actions, selecting the best available strategies, and implementing them involving the entire school community. Also, they should monitor the school performance and evaluate the school process to support the transition to an LCE.

The Low-Carbon Brigades (LCB) are responsible for the coordination of students for the successful implementation of activities and solutions that will conduct for an LCE. They should carry out the working plan defined by the LCC.

All school profiles (LC, LCC, and LCB) should work together to deploy a low-carbon pathway by identifying and deploying the best available low-carbon solutions and activities.

These activities involve modifications to existing infrastructures, operating conditions, daily routines and habits, which may reduce the associated carbon emissions, improve energy efficiency and decrease the global environmental impact. Moreover, retrofitting actions are an opportunity to develop new solutions that can reduce operational costs, particularly in older buildings, and help attract new students and gain social impact.

5.2. **Short and Long-Term Targets**

The targets for a low-carbon school are divided into short and long-term objectives. They are deployed in schools taking the initial baseline reported per environmental sectors from surveys and technical audits as a reference. The targets aim to define potential improvement scenarios through short- and long-term goals in all environmental sectors at different levels, ranging from a single classroom to the whole school community. Taking as a reference initial baseline, potential environmental improvements can be easily identified, and the best practices leading to fulfilling the reported objectives can be further defined and characterised. This evaluation of baseline data would allow schools to define two potential targets:

- **A relative target value (%)** as a short-term objective. It is based on a percentage of improvement according to the school performance compared to the average achieved across all schools. It can be defined by each environmental KPI and score, according to Table 5.2.
- **An absolute target value** as a long-term objective. It can be based on an absolute indicator value of improvement according to the school performance compared to the average achieved across all schools. It can be defined by each environmental KPI and score, according to Table 5.2.

Table 5.2 | Steps that schools should follow toward a low-carbon economy

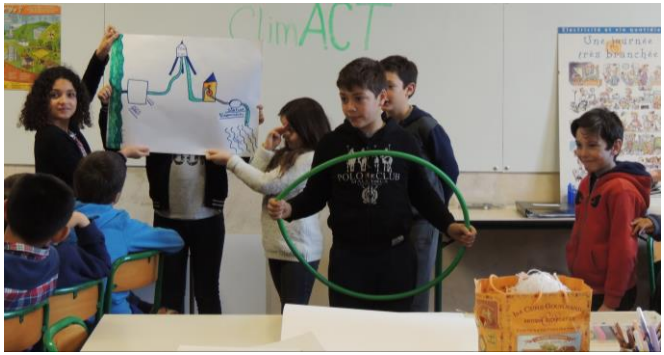
Sector	Step 1: Initial school performance	Step 2: Comparison	Step 3: Short-term targets	Step 4: Long-term targets
Energy Water Waste Transport IAQ Green Space Green Procurement	Assessment of initial school performance through surveys and technical audits (KPIs and scores)	Comparison with average performance identifying strengths and weakness	Definition of potential relative targets (%)	Definition of absolute targets

The procedure for evaluation, comparison and definition of targets ensures that the LCE deployment is progressive and constant over time due to the consideration of the average performance of all schools as a reference value.

5.3. **Definition of Action Plans**

Once short- and long-term targets are defined per environmental sectors, action plans for implementing low-carbon activities and solutions should be defined. The action plan should include the definition of work stages, work dates, activities and solutions to improve the school performance and raise awareness in the whole school community, and the methodology for the follow-up evaluation.

The priority in implementing low-carbon retrofit solutions and activities should be based on the initial baseline of the school according to the achieved results in comparison to the rest of the schools. All solutions and activities should involve students, professors, staff and school managers. Moreover, the results should be shown to the school community through online media, posters or alternative diffusive activities. The aim is to involve and increase awareness of the whole school community towards an LCE pathway.



The following section defines a portfolio of low-carbon retrofit solutions and activities for each environmental sector, which can be taken as a reference to involving the whole school community in an LCE pathway.

Chapter 6

Portfolio of Low-Carbon Activities and Solutions

6.1. **Objectives and Scope**

This portfolio of low-carbon retrofit activities and solutions supports the targets towards an LCE in schools. Selected solutions and alternatives should be implemented according to the short- and long-term objectives defined per school and taken as a reference to the initial school performance. The implementation priority should be based on the recommendations provided by the audits and the initial baseline in comparison to the other schools. Following these strategies, schools can define a set of measures to be implemented in the short- and long-term.

The LCE solutions and activities can be classified into different groups:

Minor low-carbon solutions are low-cost or no-cost measures that are easy and inexpensive to carry out, but they can make a considerable difference in the environmental performance of the school. Changing the habits of end-users, 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 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. Major retrofit strategies can reduce the environmental impact of schools in a very efficient way, achieving social, economic and environmental benefits in almost all cases.

Deep 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 low-carbon alternatives can lead to substantial environmental and economic savings that make the added cost of such options extremely cost-effective within a reasonable timeframe.

This portfolio of low-carbon retrofit solutions defines and characterises most of the tested solutions in the ClimACT project for all environmental sectors.

6.2. **Transport**

Transport activities and solutions are divided into three areas listed below. They can be implemented in schools to enable parking spaces for low-carbon transport modes (electric vehicles and bicycles), promote public transport and its availability near schools, and improve the user's behaviour in the home-school path.

T1) Solutions for parking spaces

Increase parking spaces for bicycles

T1-a Promotion of cycling as a transport mode

Create parking places for low-carbon vehicles

T1-b Workshop on parking for low-carbon vehicles

T2) Solutions to promote public transport

Promote and improve public transport services

T2-a. Leave the car at home!

T3) Solutions to reduce CO_2 emissions

Increase walking and bicycling

T3-a. Cycling tour "Eco-bike"

Decrease transport by car

T3-b. "Swap the car for an electric… bike?"

T1-a Promotion of cycling as a transport mode

Low-carbon economy solution

Name	Incitation of students to bike
Description	Initiatives to raise awareness among students and promote cycling.
Objective	Raise awareness in students about the advantages of biking.
Characterisation	Activities can involve the construction of new spaces for bikes, the design of a wooden bike shed, a photo campaign showing students and staff promoting cycling as a daily transport mode to the school, or the distribution to all new students and staff of a welcome bike pack including a bell and a notebook.
Cost	Bells and notebooks can be provided by sponsors or with the municipality's support. The construction of the bike shed can be designed and supported by students.

IUT La Rochelle
Like to Bike

Performance - Benefits

Environmental	More extensive use of cycling decreases air pollution.
Economic	Reduction of monthly cost in transport.
Social	Cycling improves health and quality of life.

Experiences in pilot schools

Pilot school A

Name	Institut Universitaire de Technologie
Location	La Rochelle (France)
Results	Raising awareness about cycling and the construction of new parking spaces for bikes increased the number of school users that go biking to school from 13.8% to 21.5%. Additionally, a 38 m^2 wooden bike shed was built.

T1-b Workshop on parking for low-carbon vehicles

Low-carbon economy solution

Name	Design and construction of parking places for low-carbon vehicles in the school
Description	Initiatives to promote the use of low-carbon transport modes, such as bikes or electric vehicles.
Objective	Raise awareness in students about low-carbon transport.
Characterisation	Design and construction of new parking spaces for bikes or electric vehicles.
Cost	The use of reused materials can reduce the investment cost.

Performance - Benefits

Environmental	The use of low-carbon transport decreases air pollution.
Economic	Reduction of monthly cost in transport.
Social	Working in groups increases collaboration and productivity. Activities in groups are better for solving problems, finishing off difficult tasks and increasing creativity.

T2-a Leave the car at home!

Low-carbon economy solution

Name Raising awareness in the school community about low-carbon transport modes

Description Few-day actions can be taken to demonstrate the advantages of using low-carbon transport modes to travel from home to the school.

Objective Raise awareness in the school community, especially parents, to use public transport, walking or biking to go to school. Another important objective is to increase the children's skills in biking.

Characterisation The school street should be closed to the traffic during school hours through mobile fences. Then, the children are invited to participate in various workshops with their bikes.

Performance - Benefits

Environmental Larger use of cycling/walking decreases air pollution.

Economic Reduction of monthly cost in transport.

Social Cycling and walking improve health and the quality of life. The school area is safer and more quiet and pleasant.

Experiences in pilot schools

Pilot school A

Name Ecole Marie Marvingt

Location La Rochelle (France)

Results The event was a success, but few users answered the survey to evaluate the activity.

Pilot school B

Name Ecole Bongraine

Location La Rochelle (France)

Results The event was a success, but few users answered the final survey to evaluate the activity.

T3-a Cycling tour "Eco-Bike"

Low-carbon economy solution

Name	Cycling tour through the closest neighbourhoods
Description	Organisation by the school of a cycling tour through the closest neighbourhoods, allowing the students to create their own path to school, with no traffic and without pollution under the slogan: "Less CO_2 more O_2".
Objective	Raising awareness of sustainable modes of transport for schools.
Characterisation	In order to reduce the carbon footprint, this activity is suggested to learn alternative ways to go to school. With the support of the Municipality and the Police Department, students and their families can take a cycling tour.

Performance - Benefits

Environmental	Improving air quality due to transport modes with no air pollutants
Economic	Students can change their behaviours and go to school by bicycle, reducing public/private transport expenses.
Social	Cycling improves health and quality of life.

Experiences in pilot schools

Pilot school A

Name	Escola Básica de Prior Velho
Location	Loures (Portugal)
Results	The event was a success and very well received by the whole community.

T3-b "Swap the car for an electric… bike?"

Low-carbon economy solution

Name	Training courses and driving lessons for electric bicycles
Description	One–day or few-day actions were undertaken in two schools to demonstrate the advantages of using low-carbon transport modes.
Objective	Raise awareness of alternative and sustainable modes of transport for schools.
Characterisation	Training courses and driving lessons were given to whoever wanted to participate in order to raise motivation in the school community to swap their cars for (electric) bicycles, explaining the importance of reducing the carbon footprint.

Performance - Benefits

Environmental	Improving air quality due to transport modes with no air pollutants.
Economic	People can change their behaviours and go to school by bicycle, reducing public/ private transport expenses.
Social	Cycling and walking improve health and quality of life.

Experiences in pilot schools

Pilot school A

Name	Escola Superior de Tecnologia da Saúde de Lisboa
Location	Lisbon (Portugal)
Results	The event was a success, with many students, staff and professors involved.

6.3. **Green Procurement**

Green procurement activities and solutions are divided into six areas listed below. They can be implemented to improve the negative environmental impact of products and services acquired by the schools. Solutions can improve electric and electronic equipment labelling, consumption of recycled paper, training in green procurement and eco-driving, preference for food with a biological certificate, and the use of local suppliers.

GP1) Solutions for equipment efficiency

Increase the rating of the energy label

GP1-a. Energy savings through A+++ labelling

GP2) Solutions for recycled paper use

Increase usage of recycled paper

GP2-a. Paper use reduction

GP3) Teacher training in green procurement

Increase the staff with training in green procurement

GP3-a. Increase the staff certification

Eco Drivers

GP4) Solutions for biological food

Increase purchases of food with a biological certificate

GP4-a. Food Balance Wheel

GP5) Solutions toward local suppliers

Increase purchases from eco/local suppliers

GP5-a. Celebrating the “World Food Day”

GP5-b. Distribution of carrots on sticks

GP1-a Energy savings through A+++ labelling

Low-carbon economy solution

Name	Evaluation of potential energy savings with the use of equipment with A+++ labelling
Description	Development of a student workshop to compare the energy consumption of different electronic devices, such as fridges, televisions, air-conditioners, lights, clothes washers, dishwashers, etc., with different energy labelling.
Objective	Increase awareness of potential energy savings by the use of energy rating labelling
Characterisation	Students are divided into several groups. Each group selects an electronic product and compares the energy consumption of different brands with different energy rating labels.

Performance - Benefits

Environmental	Students learn the importance of energy rating labelling.
Economic	Potential reduction in energy bill by the implementation of more efficient equipment in school and at home.
Social	Awareness about energy consumption and efficiency of electronic equipment.

Experiences in pilot schools

Pilot school A

Name	IES Martín Rivero
Location	Ronda (Spain)
Results	The energy consumption of different lighting types was measured, and potential energy savings were calculated. The results showed energy savings of 24% by implementing more efficient technologies and the better use of the equipment.

GP2-a Paper use reduction

Low-carbon economy solution

Name	Optimization of the paper use
Description	Awareness about the use of the unused side of old papers and printing using both sides.
Objective	Awareness to promote the better use of paper.
Characterisation	Save the papers that are only used on one side, and then use them as draft papers. Students are involved in collecting sheets used one-sided and making these draft papers available to the entire school community. Another way to save on paper is to print on both sides of the sheet. Alert for printing on both sides of the sheet of paper.

Performance - Benefits

Environmental	Students learn the importance of reducing paper consumption, alerting them about the life-cycle of the paper and the urgency to reduce its consumption.
Economic	Reduction of paper investment.
Social	This measure can increase awareness in the whole school community about paper savings.

Experiences in pilot schools

Pilot schools

Name	Escola Básica Maria Veleda
Location	Loures (Portugal)
Results	There were non-measurable results. Students became more alert and aware of the importance of paper consumption reduction.

GP4-a Food Balance Wheel

Low-carbon economy solution

Name	Food Balance Wheel Workshop
Description	Workshop about healthy food and the importance of the Food Balance Wheel.
Objective	To promote a sustainable diet without food waste.
Characterisation	Students learn about the importance of the Food Balance Wheel, giving prominence to healthier foods, which should be eaten more frequently to have a more balanced consumption of food. The workshop ends with the preparation of easy and healthy desserts by the students. The students also learn about the importance of local farmers' food and food certification. At the end, they eat a healthy and balanced meal.
Cost	This activity can have the collaboration of the whole school community with the support of a local bakery to have no significant costs associated.

Performance - Benefits

Environmental	Students learn the importance of a sustainable diet without food waste, and to be aware of the environmental implications related to the type of diet and food origin.
Economic	-
Social	This measure can increase awareness in the whole school community about the importance of supplying food from local certified suppliers and its implications in CO_2 emissions.

Experiences in pilot schools

Pilot school

Name	Escola Básica Padre Manuel de Castro and Escola Básica de Prior Velho
Location	Matosinhos and Loures (Portugal)
Results	There were non-measurable results. Students became more alert and aware of the importance of a sustainable diet.

GP5-a Celebrating the "World Food Day"

Low-carbon economy solution

Name	The Bread Cycle
Description	To celebrate the "World Food Day", students can participate in an activity about the evolution of the Bread Cycle over time. This learning is enriched with the opportunity of making their own bread in a local bakery.
Objective	Promote a sustainable diet through local suppliers.
Characterisation	Explanation to students about the history of bread over time, based on visual materials, such as posters. Then, it allows them to make their own bread, which they can take home after being cooked. This activity can have the collaboration of a local bakery to promote local suppliers.
Cost	With the support of local bakeries, there are no significant costs associated.

Performance - Benefits

Environmental	Students learn the importance of a sustainable diet without food waste and to be aware of the environmental implications related to the type of diet.
Economic	-
Social	This measure can increase awareness in the whole school community about the importance of supplying food from local certified suppliers and its implications in CO_2 emissions.

Experiences in pilot schools

Pilot school

Name	Escola Básica Padre Manuel de Castro
Location	Matosinhos (Portugal)
Results	There were non-measurable results. Students became more alert and aware of the importance of a sustainable diet.

GP5-b Distribution of carrots on sticks

Low-carbon economy solution

Name	Sustainable diet from local suppliers without food waste
Description	Students can perform an awareness campaign, "Distribution of carrots on sticks", where they prepare and distribute carrot skewers in school.
Objective	Promote a sustainable diet without food waste and from local suppliers.
Characterisation	Students prepare and distribute biological carrots, raising awareness for the preference of food with a biological certificate and from local suppliers.
Cost	With support from local suppliers, there are no significant costs associated.

Performance - Benefits

Environmental	Importance of a diet without food waste and awareness about how local food implies low CO_2 emissions.
Economic	-
Social	Increase awareness about the importance of local suppliers of food.

Experiences in pilot schools

Pilot schools

Name	Escola Básica Maria Veleda
Location	Loures (Portugal)
Results	Students became more aware of the importance of a sustainable diet.

6.4. **Green Spaces**

Activities and solutions in green spaces are divided into four areas listed below. They can be implemented to improve the quality of green areas and their CO_2 sequestration rate, reduce the use of chemicals, and decrease the energy consumption associated with the maintenance of green areas and their associated CO_2 emissions.

GS1) Green areas

Increase green area per non-covered area

GP1-a. Pedagogic garden

GP1-b. A pond on the school plot

GP1-c. Promoting biodiversity on the school plot

GS2) CO_2 sequestration

Increase the number of trees to increase the CO_2 sequestration rate

GP2-a. From CO_2 to O_2

GP2-b. Planting Trees

GS3) Use of chemicals

Decrease pesticides and fertilizers used in green spaces

GP3-a. Shared permaculture garden

GS4) CO_2 emissions

Decrease the use of fossil fuels in maintenance

GS1-a Pedagogic garden

Low-carbon economy solution

Name	Construction of a biological and pedagogical garden by students.
Description	Students build their fruit and vegetable garden based on strawberries, lettuces and aromatic flowers.
Objective	Awareness of the importance and maintenance of green spaces.
Characterisation	Growing and maintenance of a pedagogic vegetable garden by the students. Germination of several seeds in transparent gloves with moistened cotton.
Cost	5 €/m^2

Performance - Benefits

Environmental	Increasing the green space area of the school and contributing to the increase of local CO_2 sequestration.
Economic	-
Social	Students can share the learnings acquired through this activity with impact on the global environment.

Experiences in pilot schools

Pilot school A

Name	Escola Básica Maria Veleda
Location	Loures (Portugal)
Results	Students showed a considerable interest in contributing themselves to improving the number and type of species planted.

GS1-b A pond on the school plot

Low-carbon economy solution

Name	Creation of an open natural pond on the school plot
Description	Creation of a pond with two water tanks to collect the rain water coming from the school roofs. Additional facilities designed by students (birdhouse or hedgehog) help make the pond a pleasant place and develop biodiversity.
Objective	Develop biodiversity in the neighbourhood of the school. Create a link between nature and the school users (students, adults, activity leaders, etc.).
Characterisation	The municipality, parents and students can be involved in pond construction. The pond space can also be used to grow vegetables, aromatic plants and fruit trees.
Cost	2000 € for the equipment + work time.

Performance - Benefits

Environmental	The pond promotes biodiversity in the city area by creating connected spaces favourable to its development.
Economic	Raise interest in growing fruits and vegetables in a bio-responsible way.
Social	The pond helps students understand the requirements to maintain and develop biodiversity. The pond also helps to create a social link between the students and the school neighbours involved in its construction.

Experiences in pilot schools

Pilot school A

Name	Ecole Marcelin Berthelot
Location	La Rochelle (France)
Results	The pond project was a success, involving the whole school community.

GS1-c Promoting biodiversity on the school plot

Low-carbon economy solution

Name	Equipment and good practices to promote biodiversity on the school plot
Description	Installation of two bee hives and birdhouses on the campus. Late mowing of the lawn.
Objective	Preserve and develop biodiversity in order to maintain green spaces.
Characterisation	Installation of equipment. Information and explanations about their use and objectives are provided to the school community with posters.
Cost	Less than 100 €.

Performance - Benefits

Environmental	The measure helps to preserve and develop the biodiversity inside the city.
Economic	Reduction of chemicals in green spaces.
Social	The posters help raise the students' awareness of biodiversity and the means to preserve it.

Experiences in pilot schools

Pilot school A

Name	Institut Universitaire de Technologie
Location	La Rochelle (France)
Results	A large number of bees and birds flying around showed the positive impact of the equipment on biodiversity.

GS2-a From CO_2 to O_2

Low-carbon economy solution

Name AgroBio

Description Cultivation of a biological vegetable garden with growth accompanied by the students.

Objective Exchange of ideas/actions in order to encourage students towards a more sustainable way of life focused on the importance of green spaces.

Characterisation Growing and maintenance of a biological vegetable garden. Collection of plastic bottles to use as vessels. Support from the Municipality can be provided for the soil and planting acquisitions.

Cost <5€/m^2

Performance - Benefits

Environmental Extending the greenspace area of the school and contributing to increasing the local CO_2 sequestration.

Economic -

Social Students can share the learnings obtained through this activity, with an positive impact on the global environment.

Experiences in pilot schools

Pilot school A

Name Escola Básica General Humberto Delgado

Location Loures (Portugal)

Results The activity was carried out for the Global Action Days. It was an excellent opportunity for the school to show the many actions that students can take to promote the environment.

GS2-b Planting Trees

Low-carbon economy solution

Name Planting trees for the International Day of the Forests and Arbour Day

Description Celebration of the International Day of the Forests and Arbour Day with the plantation of trees by students.

Objective Awareness of the importance of conservation and use of green spaces.

Characterisation Tree planting by students with the help of the entire school community. A focus on autochthonous trees should be given.

Cost <5€/m^2 (Soil and plants can be obtained from local environment organizations).

Performance - Benefits

Environmental Increasing the greenspace area of the school and contributing to the increase of local CO_2 sequestration.

Economic -

Social Students can share the learnings obtained through this activity, with an positive impact on the global environment.

Experiences in pilot schools

Pilot school A

Name Escola Básica General Humberto Delgado and Escola Básica Padre Manuel de Castro

Location Loures and Matosinhos (Portugal)

Results -

GS3-a Shared permaculture garden

Low-carbon economy solution

Name	Permaculture garden created and maintained by students
Description	Creation of a shared permaculture garden with communication campaigns to promote healthy food without chemicals.
Objective	Raise awareness in students on alternative production modes.
Characterisation	Creation of an organization for permaculture. The school administration, school community and the Municipality can provide some support. The students fully operate the garden, from soil preparation to planting and maintenance.
Cost	<5€/$m^{2,}$ and if necessary, the cost of a water tank is approximately 100 €.

Performance - Benefits

Environmental	Promotion of local agricultural activity without chemicals.
Economic	The students can share the vegetable and fruit production**.**
Social	This activity allows providing information on how to maintain gardens.

Experiences in pilot schools

Pilot school A

Name	Institut Universitaire de Technologie
Location	La Rochelle (France)
Results	A large number of fruits and vegetables were produced throughout the year, and students received a regional award for their initiative.

6.5. Indoor Air Quality

IAQ solutions and activities are divided into three categories listed below. They can be implemented to reduce the concentration of air pollutants, increase ventilation rate, and improve thermal comfort.

IAQ1) Solutions for air pollutants

Improve indoor air quality

IAQ1-a. IAQ assessment by students

IAQ1-b. Mechanical ventilation in classrooms

IAQ2) Solutions for ventilation

Improve indoor air quality

IAQ2-a. Natural ventilation through window openings

IAQ2-b. Open the windows when the light turns red!

IAQ2-c. Magic ball for a good air quality

IAQ2-d. Smart window opening

IAQ3) Solutions for thermal comfort

Reduce heating and cooling demand

IAQ3-a. Free-cooling through night ventilation

IAQ3-b. Smart use of solar protection awnings

IAQ1-a IAQ assessment by students

Low-carbon economy solution

Name	Indoor air quality assessment by students
Description	Assessment of the indoor air quality in representative school spaces (classrooms, laboratory areas, offices and common areas). This evaluation should be performed by the students.
Objective	Know and communicate data on indoor air quality of schools.
Characterisation	Along one semester, the students should assess the IAQ in the representative spaces of the school using air quality equipment.
Cost	-

Performance - Benefits

Environmental	Scientific studies have demonstrated the impact of indoor air quality on the health and learning performance of students.
Economic	-
Social	Students can be aware of the importance of good indoor air quality and what should be done to improve it.

Experiences in pilot schools

Pilot school A

Name	Escola Superior de Tecnologia da Saúde de Lisboa
Location	Lisbon (Portugal)
Results	-

IAQ1-b Mechanical ventilation in classrooms

Low-carbon economy solution

Name	Improving indoor air quality by mechanical ventilation.
Description	Installation of a mechanical ventilation system in one school building.
Objective	Improve indoor air quality and comfort.
Characterisation	The installation of a mechanical ventilation system in the school building aimed to promote indoor air quality by establishing fixed ventilation rates in classrooms (18 m^3/h/person) during class hours.
Cost	No information is available.

Performance - Benefits

Environmental	Scientific studies have demonstrated the impact of indoor air quality on the health and learning performance of students.
Economic	-
Social	-

Experiences in pilot schools

Pilot school A

Name	Lycée Dautet
Location	La Rochelle (France)
Results	On-site measurements showed that the mechanical ventilation system was not working correctly. Therefore, no indoor air quality improvement could be observed after installing the system. However, implementing air change rates of 18 m^3/h/person in the classrooms should keep CO_2 concentrations under 1000 ppm, significantly decreasing indoor air pollutant concentrations.

IAQ2-a Natural ventilation through window openings

Low-carbon economy solution

Name Improving natural ventilation rate through window openings

Description This action consists of improving the IAQ of classrooms by implementing natural ventilation strategies based on different window opening periods, such as between subjects and during the school break. The aim is to increase the ventilation rate to avoid high CO_2 concentration.

Objective Improve the IAQ of classrooms avoiding high concentrations of air pollutants.

Characterisation -

Cost -

Performance - Benefits

Environmental IAQ improvement with better management of window opening periods. After the implementation of different operating strategies, the percentage of the time with CO_2 concentration over 1700 ppm was reduced to 0-5%.

Economic -

Social An awareness campaign of results can promote better windows management to reduce air pollutant concentration in the school environment.

Experiences in pilot schools

Pilot school A

Name IES ITACA

Location Seville (Spain)

Results The IAQ measurements carried out by a student, with the support of ClimACT research members, identified a reduction in the percentage of CO_2 concentrations over 1700 ppm during occupancy (%) from 61-68% to 42-2% along different days.

IAQ2-b Open the windows when the light turns red!

Low-carbon economy solution

Name CO_2 sensors to promote windows openings during the class hours

Description Use of CO_2 sensors with red, orange and red lights in the classrooms to indicate when more ventilation is needed.

Objective Improve indoor air quality and comfort.

Characterisation Class air sensors should be provided to voluntary teachers. The sensors monitor the CO_2 concentrations every 1 minute. If the concentration exceeds 1250 ppm, the light turns from green to orange. If the concentration is over 2500 ppm, the light turns red. The students attending the class are in charge of opening the windows to promote natural ventilation and keep the CO_2 levels below the limits. After some time, teachers and students should get familiar with the dynamics of CO_2 concentrations in their classroom and anticipate the window openings without the help of the sensor.

Cost 350 €/sensor

Performance - Benefits

Environmental Better indoor air quality through proper ventilation positively impacts student health and learning performance.

Economic -

Social Experiments conducted with 6-year-old students revealed that children were very keen on the system since they had to read big numbers (4 digits) on the instruments as they were starting to learn.

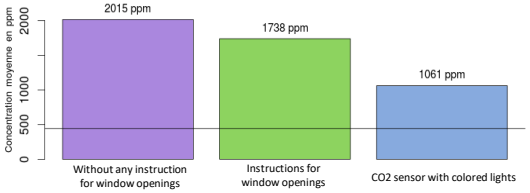
Experiences in pilot schools

Pilot school A

Name Ecole Grandes Varennes

Location La Rochelle (France)

Results Experiments were carried out with and without a CO_2 sensor for one full week. They showed that CO_2 concentrations during the occupancy period with a CO_2 sensor were decreased by almost 50%.



IAQ2-c Magic ball for a good air quality

Low-carbon economy solution

Name	A magic ball with a CO_2 sensor to promote window openings during the class
Description	Use of CO_2 sensors with green, yellow and red lights in the classrooms to indicate when more ventilation is needed.
Objective	Improve indoor air quality and comfort.
Characterisation	The magic ball should be located in any visible place. The light turns from green to yellow if the CO_2 concentration exceeds 1000 ppm. If the concentration is over 1500 ppm, the light turns red. The students are in charge of opening the windows to promote natural ventilation and keep a low CO_2 level. The students in technical courses can produce the magic ball.
Cost	350 €/sensor

Performance - Benefits

Environmental	Students realise that adequate ventilation improves indoor air quality.
Economic	-
Social	Promote student collaboration to ensure a good environment in the classroom.

Experiences in pilot schools

Pilot school A

Name	Action performed in all Portuguese ClimACT schools
Location	Loures, Lisbon, Matosinhos and Vila Nova de Gaia (Portugal)
Results	The magic ball improved IAQ in all classrooms. After some time, teachers and students anticipate the window openings without the help of the lights.

IAQ2-d Smart window opening

Low-carbon economy solution

Name	Smart and automatic natural ventilation system to guarantee IAQ conditions
Description	Installation of an automatic window opening system when CO_2 concentration is above 1500 ppm.
Objective	Improve indoor air quality through better management of natural ventilation.
Characterisation	Windows with an automatic opening linked to a CO_2 sensor.
Cost	It should be evaluated per each specific building.

Performance - Benefits

Environmental	Periods with CO_2 concentrations over 1500 ppm are eliminated.
Economic	-
Social	-

Experiences in pilot schools

Pilot school A

Name	CEIP Malala
Location	Seville (Spain)
Results	The results showed that CO_2 concentration levels were consistently below the indoor air guideline values. CO_2 was always below 1500ppm due to the natural ventilation promoted by the window opening.

IAQ3-a Free-cooling through night ventilation

Low-carbon economy solution

Name	Free-cooling through night ventilation in summer
Description	Free-cooling through natural ventilation when the exterior temperature is lower.
Objective	Decrease the indoor building temperature and provide thermal inertia to the building to reduce thermal discomfort during summer days.
Characterisation	Leave windows open during the night.
Cost	-

Performance - Benefits

Environmental	Improve the thermal comfort reducing the need for air-conditioning.
Economic	Reduce energy bills associated with the energy consumption of air conditioning systems.
Social	-

Experiences in pilot schools

Pilot school A

Name	IES Chaves Nogales
Location	Seville (Spain)
Results	The solution was well implemented by students and professors. However, there was no evaluation of the benefits.

IAQ3-b Optimal use of solar protection awnings

Low-carbon economy solution

Name	Optimal use of solar protection awnings
Description	Appropriate use of solar protection awnings to reduce cooling energy demand.
Objective	Reduce direct solar gains during summer days.
Characterisation	Avoid direct solar gains through the correct use of solar protection awnings. Solar protection awnings should be closed during periods with high solar radiation to reduce solar gains and mitigate cooling needs.
Cost	-

Performance - Benefits

Environmental	Improve the thermal comfort by reducing the need for air conditioning.
Economic	Reduce energy bills associated with the energy consumption of air conditioning systems.
Social	-

Experiences in pilot schools

Pilot school A

Name	CEIP Nuestra Señora del Patrocinio
Location	La Rinconada (Spain)
Results	The solution was well addressed by students and teachers. There was no evaluation of benefits. However, previous studies show that energy demand can be reduced by 10% through the better use of solar awnings.

6.6. **Energy**

Energy retrofit solutions and activities are divided into three categories listed below. They should be implemented to reduce the energy consumption of the schools, increase the use of renewable energy, reduce the energy costs and mitigate the associated CO_2 emissions.

E1) Solutions to reduce energy consumption

Reduce energy consumption and costs

E1-a. Low-energy lighting systems in schools

E1-b. Keep the heat inside

E1-c. Let's build sustainable and low-energy houses

E2) Solutions of renewable energy

Increase the use of renewable energy

E2-a. Assembly of solar cars

E2-b. Construction of solar ovens

E2-c. Solar energy is welcome on the school roofs

E3) Solutions for energy management, automation and monitoring

Reduce energy consumption costs

E3-a. Energy savings awareness

E3-b. Energy day at school

E3-c. Reduction of operating hours of lighting

E1-a Low-energy lighting systems in schools

Low-carbon economy solution

Name	Installation of low-energy lighting systems in schools
Description	Led lights in the schools have replaced fluorescent lighting systems.
Objective	Saving electricity. Lighting can represent up to 50% of the total electricity consumption of schools.
Characterisation	Substitution of fluorescent lights with led lights in some spaces of the school. In addition, a smart lighting control system based on occupancy and light sensors can be installed.
Cost	Each project and light typology should be specifically evaluated.

Performance - Benefits

Environmental	Saving electricity reduces CO_2 emissions.
Economic	Saving electricity also leads to substantial money savings due to less energy consumed. The possibility of contracting a cheaper subscription for electricity supply should also be considered.
Social	The dissemination of these activities, with posters or social networks, can make students aware of the ease of saving energy and money in their day to day life through the control and efficiency of lighting.

Experiences in pilot schools

Pilot school A	
Name	Ecole Grandes Varennes
Location	La Rochelle (France)
Results	The yearly electricity consumption dropped from 52 050 kWh (mean of years 2014, 2015, 2016) to 36 830 kWh in 2018. The lights have been changed in only 1/3 of the school buildings (all lights will be changed by 2020).
Pilot school B	
Name	Ecole Bongraine
Location	La Rochelle (France)
Results	The yearly electricity consumption was slightly lower after the lights had been changed in the kindergarten playroom. More savings are expected when all classrooms are equipped with led lights.
Pilot school C	
Name	Lycée de Rompsay
Location	La Rochelle (France)
Results	Electricity consumption was slightly higher in 2018 than in 2014, 2015 and 2016, showing that the switch to low-energy lighting did not offset the increase in other consumption sectors.

E1-b Keep the heat inside

Low-carbon economy solution

Name	Insulation of the school building
Description	Improving the thermal insulation of the building to reduce heat losses and mitigate heating and cooling demand
Objective	Reduce energy demand and improve occupants' comfort.
Characterisation	Single glazing windows were replaced by double glazing windows in one school building.
Cost	No information is available.

Performance - Benefits

Environmental	Saving energy reduces CO_2 emissions.
Economic	Reduction of the energy bill due to the reduction of heating and cooling demand
Social	-

Experiences in pilot schools

Pilot school A

Name	Lycée Dautet
Location	La Rochelle (France)
Results	The school did not provide the energy consumption data after the work. Therefore, the information on the energy savings resulting from this action is not available.

E1-c Let's build sustainable and low-energy houses

Low-carbon economy solution

Name Initiation of students on sustainable construction and energy savings

Description Construction of an ecological house at a scale of 1/10 and measurement of heat consumption with and without thermal insulation.

Objective Raise awareness of students about energy savings in buildings.

Characterisation Construction of an ecological house with the participation of students and teachers from universities or higher schools. The pupils monitor the heat consumption of the house before and after installing a thin insulating material on the inner side of the walls and ceiling. The pupils create graphs showing the heating loads as a function of time to demonstrate the impact of insulating. They also can see thermal losses by watching the housing prototype through an infrared camera.

Cost The university or higher school could provide all materials needed to build the housing prototype. The cost of the insulating materials and instruments to monitor heat consumption is about 1100 €.

Performance – Benefits

Environmental Show strategies to reduce the energy demand and associated environmental impacts of buildings.

Economic Well-insulated houses require less energy demand, reducing operational costs.

Social Raise awareness about sustainable construction and energy savings that can be achieved with the insulation of buildings.

Experiences in pilot schools

Pilot school A

Name Ecole Bongraine

Location La Rochelle (France)

Results The students were very proud of the model house they built. Furthermore, they were very interested in quantifying the energy saved through numbers and visualizing improvements through infrared images.

E2-a Assembly of solar cars

Low-carbon economy solution

Name Creation of solar cars using recycled materials

Description Assembling of a solar car by the students. Recyclable materials and a lot of imagination allow the construction of several types of vehicles.

Objective Awareness about the importance of using solar energy.

Characterisation Schools should prepare a kit with the basic material for the assembly of the solar cars (engine, PV panel and instructions). Students bring recycled materials to embellish the structures of their cars. The assembly and subsequent decoration of the solar cars are in accord with the originality of the students.

Cost -

Performance - Benefits

Environmental The importance of clean energies and their applications can be learned by this activity, with a huge impact on the environment.

Economic -

Social Students learn about energy alternatives, in this case, solar energy.

Experiences in pilot schools

Pilot schools in Portugal

Name Action performed in all Portuguese ClimACT schools

Location Loures, Lisbon, Matosinhos and Vila Nova de Gaia (Portugal)

Results The experience was a success. Students were involved in the car construction in a very enthusiastic way, improving their knowledge of solar energy potential.

Pilot school A

Name IES Chaves Nogales

Location Seville (Spain)

Results The experience was a success, with all students involved in designing the lightest and more beautiful solar car. At the end of the event, there was a final solar car race to evaluate the fastest car.

Pilot school B

Name CEIP Cardenal Cisneros

Location Madrid (Spain)

Results The experience was a success. Different prototypes were built with all students involved in the activity.

E2-b Construction of solar ovens

Low-carbon economy solution

Name	Construction of solar ovens
Description	Construction of solar ovens by students with reused or recycled materials.
Objective	Awareness of the importance of using solar energy.
Characterisation	Students are divided into groups. They receive instructions about possible designs and materials. All of them defined and built different alternatives to solar ovens with the help of teachers.
Cost	-

Performance - Benefits

Environmental	The importance of clean energies and their applications can be learned by this activity.
Economic	-
Social	Promotion of the importance and usefulness of renewable energies.

Experiences in pilot schools

Pilot schools in Portugal

Name	Action performed in all Portuguese ClimACT schools.
Location	Loures, Lisbon, Matosinhos and Vila Nova de Gaia (Portugal)
Results	-

Pilot school A

Name	IES Chaves Nogales
Location	Seville (Spain)
Results	The students collaborated in the construction of a solar oven. They were left outside to see if they could boil water.

Pilot school B

Name	IES Martín Rivero
Location	Ronda (Spain)
Results	Two solar oven prototypes were built. One was based on a carton box, being able to boil water up to 60ºC. Another one was built by using a reused satellite dish. This was able to boil water up to 65ºC.

E2-c Solar energy is welcome on the school roofs

Low-carbon economy solution

Name	Solar collectors and PV panels on the school roofs
Description	Installation of solar collectors and photovoltaic panels on the school roofs.
Objective	Saving energy and earning money by renting the school roofs to private renewable energy producers.
Characterisation	Solar collectors and PV panels can be installed on the roof of schools as a way to cover a significant part of the hot water and electricity needs.
Cost	Each case should be evaluated separately.

Performance - Benefits

Environmental	Energy consumption based on renewable energy sources reduces CO_2 emissions
Economic	Renting the school roofs to private companies that produce solar electricity and sell it to the grid is an easy way to earn money while implementing renewable energy. Moreover, producing hot water from solar collectors showed an average payback period of 10 years.
Social	The benefits of on-site renewable energy are tested in the real environment of the school, sharing knowledge and advantages with all the school community.

Experiences in pilot schools

Pilot school A	
Name	Ecole Varennes
Location	La Rochelle (France)
Results	In 2018, 25 000 kWh of photovoltaic electricity was produced and 7277 kWh of hot water.
Pilot school B	
Name	Ecole Jean Bart
Location	La Rochelle (France)
Results	In 2018, approximately 86250 kWh of renewable electricity was produced and 2186 kWh of hot water.
Pilot school C	
Name	Ecole Marie Marvingt
Location	La Rochelle (France)
Results	1108 kWh of hot water was produced in 2018.

E3-a Energy savings awareness

Low-carbon economy solution

Name	Awareness campaigns about energy savings
Description	Implementation of actions to reinforce the creation of eco-friendlier habits regarding energy consumption practices.
Objective	Awareness of the importance of saving energy.
Characterisation	Mobilize students to save energy in their daily routine, showing them that little actions can greatly impact the environment.
Cost	-

Performance - Benefits

Environmental	Saving energy reduces CO_2 emissions and other environmental impacts.
Economic	Schools can improve their energy consumption and energy costs.
Social	Students can apply the acquired knowledge about energy savings in their lives (future and present), impacting the environment and sharing this knowledge with others.

Experiences in pilot schools

Pilot schools

Name	Action performed in all Portuguese ClimACT schools
Location	Loures, Lisbon, Matosinhos and Vila Nova de Gaia (Portugal)
Results	-

E3-c Energy day at school

Low-carbon economy solution

Name The city's commitment to renewable energies

Description Development of dissemination and communication materials, such as posters and activities to inform the users about the distribution of energy consumption in the school buildings.

Objective Provide information about the energy consumption of the school, and the program of the city/municipality for renewable energies, to the school community.

Characterisation Use of posters to show the details of the energy consumption of the school buildings, which can be displayed at the school entrance. In addition, an Energy or Science Day can be organized with the support of universities, high schools or energy professionals. Various energy-related activities can be proposed to students. The company that provides energy to the city/municipality can also be involved in the organisation of this Energy or Science Day. At the end of the day, parents and families are invited to join the event to discuss actions for energy savings at home.

Cost -

Performance – Benefits

Environmental -

Economic -

Social The posters, communication materials, and events, such as the Energy or Science Day, can help raise students' and parents' awareness about behaviours that lead to energy savings and reduce CO2 emissions in their daily lives.

Experiences in pilot schools

Pilot school A

Name Ecole Marie Marvingt

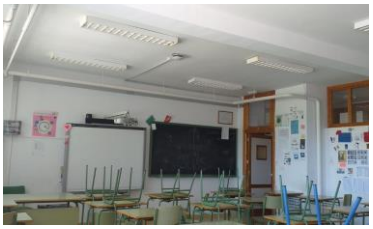
Location La Rochelle (France)

Results -

E3-c Reduction of operating hours of lighting

Low-carbon economy solution

Name	Reduction of operating hours of lighting in the classroom
Description	Evaluate the energy consumption and associated cost of lighting in the classroom.
Objective	Increasing awareness about the consumption of lighting.
Characterisation	Calculation of the operating hours of lighting in a common classroom per day and quantification of energy and economic savings due to the reduction in operating hours. It requires the characterisation of the lighting power installed per classroom and the lighting typology.
Cost	-



Performance - Benefits

Environmental	Energy consumption and associated environmental impact can be reduced by improving the habits of lighting.
Economic	High economic savings can be obtained.
Social	A collaborative activity to learn in groups. The results can also be extrapolated at home to increase awareness in all school communities.

Experiences in pilot schools

Pilot school A

Name	IES ITACA
Location	Seville (Spain)
Results	Monthly energy consumption in the classroom was reduced by 16% by reducing lighting operating hours. This energy saving measure reduces the energy bill by 1.50€ per classroom.

Pilot school B

Name	IES Martín Rivero
Location	Seville (Spain)
Results	Monthly energy consumption in the classroom was reduced by 24% by reducing lighting operating hours. This energy saving measure reduces the energy bill by 5€ per classroom.

6.7. **Water**

Water solutions and activities are listed below. They should be implemented to reduce water consumption in schools and its associated cost.

WR1) Solutions for water

Reduce water consumption and costs

- WR1-a. Awareness campaigns
- WR1-b. Educational Games
- WR1-c. New toilet facilities for water savings
- WR1-d. We water the garden with rainwaters
- WR1-e. Reducers of water flow

WR1-a Awareness campaigns

Low-carbon economy solution

Name	Awareness campaigns about water savings.
Description	Several actions can create awareness concerning water resources and create new "eco-habits." Students can acquire several skills to use in everyday life through awareness campaigns targeting: "How much water do you spend?". Dissemination activities can be based on posters and other media.
Objective	Awareness of the importance of conservation and use of water.
Characterisation	Awareness campaigns to alert students to the importance of water.
Cost	-

Performance - Benefits

Environmental	Students learn the importance of water savings in order to protect and save this natural resource. The lower the consumption of water, the lower the CO_2 emission.
Economic	Water saving leads to fewer financial expenses concerning water bills for schools.
Social	This measure can increase awareness in the whole school community about water saving since it includes dissemination activities, highlighting the potential of water savings for the whole school community.

Experiences in pilot schools

Pilot schools

Name	Escola Básica General Humberto Delgado, Escola Básica Maria Veleda, Escola Básica de Prior Velho and Escola Básica Padre Manuel de Castro.
Location	Loures and Matosinhos (Portugal)
Results	There were non-measurable results. Students became more alert and aware of the importance of saving water.

WR1-b Educational Games

Low-carbon economy solution

Name	Development of educational games to protect water resources
Description	Development of a game called "Fishing the trash in the ocean" that - as the name implies – consists of "fishing" the garbage from the ocean, protecting the marine species.
Objective	Awareness about the conservation of this natural resource
Characterisation	Using recycled materials, the students can create a game consisting of "fishing" garbage from the ocean. They can use magnets to build fishing rods and insert metal in marine animals and polluting packages.
Cost	-

Performance - Benefits

Environmental	Students learn the importance of water savings in order to protect and save water, a natural resource.
Economic	Water saving leads to lower financial expenses concerning water bills for schools.
Social	This measure can increase awareness in the whole school community about water protection. It includes oral and printed communication materials, highlighting the potential of water protection for the whole school community.

Experiences in pilot schools

Pilot schools

Name	Escola Básica Maria Veleda
Location	Loures (Portugal)
Results	There were non-measurable results. Students became more alert and aware of the importance of saving water.

WR1-c New toilet facilities for water savings

Low-carbon economy solution

Name	Change of the toilet facilities
Description	Replacement of the toilet facilities in one of the school buildings.
Objective	Save water and decrease the water bill.
Characterisation	Toilets can be a very significant part of the water consumption in schools. The existing facilities can be changed for low water consumption facilities in the toilets. The water savings can be assessed by using an ultrasonic water flowmeter connected to a data logger.
Cost	1200 €, including taxes to change the facilities in the building (8 WC and 4 sinks).

Performance - Benefits

Environmental	Water savings mean less energy and CO_2 emission to treat the water.
Economic	Water savings are also money savings.
Social	-

Experiences in pilot schools

Pilot school A

Name	Institut Universitaire de Technologie
Location	La Rochelle (France)
Results	Before and after changing the facilities, measurements were carried out with an ultrasonic flow meter. The results showed water savings of about 20%, representing 35 m^3/year for the specific building assessed.

WR1-d We water the garden with rain waters

Low-carbon economy solution

Name	Water tanks to water the garden
Description	Installation of rainwater tanks to collect the rainwater.
Objective	Save water and decrease the water bill.
Characterisation	Installation of rainwater tanks to collect the water coming from the building roof. The initiative can be part of a larger school project which aims to raise the awareness of students about the need to preserve water and learn about the wastewater cycle. Various educational activities can be initiated on this topic, including a visit to a wastewater plant.
Cost	109 €/tank

Performance - Benefits

Environmental	Water savings also mean less energy and CO_2 emission to treat the water.
Economic	-
Social	Collaborative tasks to work in a group with the aim of fostering creativity and learning. Creativity thrives when people work together on a team.

Experiences in pilot schools

Pilot school A

Name	Ecole Marie Marvingt
Location	La Rochelle (France)
Results	The mean water consumption of School Marie Marvingt was 1010 m^3 as on average for 2014, 2015 and 2016. It was only 769 and 777 m^3 for the years 2017 and 2018, respectively. Therefore, the water savings are more than 20%.

WR1-e Reducers of water flow

Low-carbon economy solution

Name Reducers of water flow for faucets, showers or toilet bowl

Description Evaluation of the amount of water that the school can reduce through the installation of water reducers.

Objective Increase awareness about water consumption and the potential for water consumption reduction through new water flow reduction devices and small routines.

Characterisation Firstly, students should evaluate the water consumption each time they use a faucet, a shower or a toilet bowl. They can calculate the monthly water consumption of the classroom according to the number of students. Then, they evaluate how much water consumption they can reduce through the implementation of water reducers and small routines.

Cost 1,50-3€/unit

Performance - Benefits

Environmental Water savings also mean less energy and CO_2 emission to treat the water and wastewater.

Economic Water savings are also money savings.

Social

Experiences in pilot schools

Pilot school A

Name IES ITACA

Location Tomares (Spain)

Results The evaluation of the potential for water reduction in school showed that water consumption and water cost could be decreased by 25-30% by reducing water flow in faucets and toilet bowls.

6.8. **Waste**

Waste solutions and activities are divided into three categories listed below. They should be implemented to reduce the volume of waste produced and increase the amount of recycled and reused materials in schools.

W1) Solutions to reduce waste produced

Reduce waste production

W1-a. Environmental educational programs

W1-b. Cleaning the school

W1-c. Cleaning the school surroundings

W1-d. Food waste reduction program

W2) Solutions for waste recycled

Increase waste recycling

W2-a. Recyclable waste in the yellow bins

W2-b. Potential of paper recycling

W2-c. Select the right recycling bin for your waste

W2-d. Shared composting

W2-e. Composting and farm animals to reduce waste

W3) Solutions for waste reused

Increase waste reuse

W3-a. Recycling of roller shutter slats

W3-b. Market of reused materials

W3-c. Christmas decoration

W3-d. Carnival parade reusing materials

W1-a Environmental educational programs

Low-carbon economy solution

Name	Participation in environmental educational programs
Description	This activity involves the school community collecting paper, plastic, metal, batteries, and electrical and electronic waste used in their school to promote recycling and good environmental practices. All the participants have access to awareness actions. The school that gathers more material wins a money prize.
Objective	Increasing the good recycling practices in the whole school community.
Characterisation	Encourage the participation of the entire school community in collecting recycling goods, with the bonus of getting a prize.
Cost	-

Performance - Benefits

Environmental	The reduction of waste in schools.
Economic	Schools can win a money prize to use in their school's activities or infrastructures.
Social	Students and teachers are involved in this action, raising awareness about waste sorting and recycling.

Experiences in pilot schools

Pilot school A

Name	Actions performed in all Portuguese ClimACT schools
Location	Loures, Lisbon, Matosinhos and Vila Nova de Gaia (Portugal)
Results	-

W1-b Cleaning the school

Low-carbon economy solution

Name	Let's clean the school
Description	Cleaning some areas of the school by the students.
Objective	Awareness of the importance of having good habits and manners in the environment.
Characterisation	Organization of a timetable with students shifts. Cleaning of a different area of the school each week by a class of students. Awareness of students about good environmental practices (throwing the garbage in the specific bin). All students were organized to maintain the school cleaner.
Cost	-

Performance - Benefits

Environmental	The waste collection improves the quality of life and the school environment.
Economic	-
Social	The activity raises the students' awareness of the problem of waste and its impacts on the environment.

Experiences in pilot schools

Pilot school A

Name	Escola Básica General Humberto Delgado
Location	Loures (Portugal)
Results	-

W1-c Cleaning the school surroundings

Low-carbon economy solution

Name	Waste collection in and around the school
Description	A waste collection activity for students.
Objective	Raise awareness of students about the need to throw their personal waste in dedicated bins.
Characterisation	The activity consists of waste collection and then the weighing and sorting of the collected waste. It should be organized for each first-year class of the school. Expected time: 1h30m.
Cost	The gloves (3€/person), bags and vests can be provided by, for example, the supermarket sponsoring the activity.

Performance - Benefits

Environmental	The waste collection improves the quality of life and reduces soil and sea pollution.
Economic	-
Social	Raise awareness of students and improve the relationship between the school community and the people living around the school.

Experiences in pilot schools

Pilot school A

Name	Lycée de Rompsay
Location	La Rochelle (France)
Results	From November 2018 to March 2019, 141 kg of waste were collected and sorted by 13 classes.

W1-d Food waste reduction program

Low-carbon economy solution

Name Reducing the food waste from the school restaurant

Description Creation of a working group with the participation of the cook, children, parents, teachers, and the municipal staff operating the canteen and in charge of taking after of the kids after lunch. Implementation of actions to reduce the food waste.

Objective Reduce food waste and raise the curiosity of students about all kinds of food

Characterisation Several actions can be undertaken in primary schools, among which:
A theatre game related to food waste in the school for all the students;
Training for the adults in charge of students during lunchtime to learn about how to develop the children's curiosity about food;
New recipes containing vegetables that kids do not really appreciate;
Systematic sorting of food waste after lunch in 4 bins (bread, first course, main course, dessert) and weighing.
Students design posters in plastic art classes as a way to illustrate their costs.

Cost -

Performance - Benefits

Environmental The measure leads to a decrease in the amounts of waste to be treated or incinerated.

Economic -

Social The activity raises the students' awareness of the problem of waste treatment in general. It also helps them enjoy a wider range of foods, which is a health benefit.

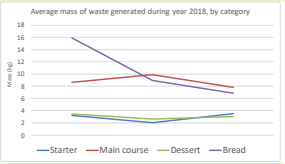
Experiences in pilot schools

Pilot school A

Name Ecole Marcellin Berthelot.

Location La Rochelle (France)

Results On average, the restaurant waste coming from the main course, dessert, and bread decreased by 10%, 11% and 57%, respectively, between the beginning and the end of 2018. On the other hand, the waste generated by the starter was increased by 9%.

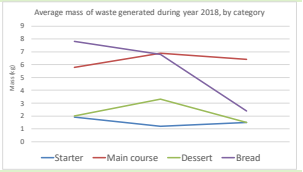


Pilot school B

Name Ecole Bongraine

Location La Rochelle (France)

Results On average, the restaurant waste coming from the starter, desserts, and bread decreased by 21%, 25% and 69%, respectively, between the beginning and the end of 2018. On the other hand, the waste generated by the main course was increased by 10%.



Pilot school C

Name Lycée de Rompsay

Location La Rochelle (France)

Results The food waste weighting showed that 16 tons of food and 34 000 small breads are thrown into the trash each school year, representing costs of 31 000 € and 2700 €, respectively.

W2-a Recyclable plastic waste in the yellow bins

Low-carbon economy solution

Name	Specific bins in classrooms to promote waste sorting
Description	Installation of specific bins in order to collect the recyclable paper and plastic waste in classrooms.
Objective	Make students aware of the need to dispose of waste in specific bins
Characterisation	Installation of yellow bins in all classrooms available for plastic wastes generated by students. The cleaning and maintenance staff must collaborate on collecting the waste and throwing it in the outdoor recycling bins.
Cost	17 € /bin

Performance - Benefits

Environmental	The measure contributes to improving waste sorting and recycling.
Economic	-
Social	The presence of highly visible bins for recycling draws the students' attention and promotes waste sorting. They can ask the teacher which bin they should throw away the garbage, which also improves the quality of their waste sorting at home.

Experiences in pilot schools

Pilot school A

Name	Ecole Bongraine
Location	La Rochelle (France)
Results	About two full bins were collected in each classroom per week.

W2-b Potential of paper recycling

Low-carbon economy solution

Name	Installation of bins for paper recycling
Description	Setting up bins for paper recycling in classrooms, involving students and the school community in recycling.
Objective	Increase the paper recycling in whole school building and community. Awareness campaign on paper recycling by carrying out a poster with the campaign results.
Characterisation	Paper recycling bin of 30x30x50 for indoor spaces.
Cost	15€/bin

Performance - Benefits

Environmental	Potential for paper recycling of 2-3 kg/month per classroom. This result can be extrapolated to whatever school building.
Economic	-
Social	This measure can increase awareness in the whole school community about paper recycling by carrying out a communication campaign (for example, a poster) with the amount of recycled paper in a classroom along a month, highlighting the potential of paper recycling for the whole school community.

Experiences in pilot schools

Pilot school A

Name	IES ITACA
Location	Seville (Spain)
Results	The amount of paper recycled was 2.3 kg/month per classroom. The school has a potential for paper recycling of 610 kg/year. These results were presented through a poster to the whole school community with the aim of increasing awareness of recycling.

W2-c Select the right recycling bin for your waste

Low-carbon economy solution

Name Colour code for waste sorting

Description Posters can be designed and spread all over the school to inform students and staff about where to throw different types of waste produced in the school area (related to personal waste, restaurant or school activities). Sorting can be made according to a colour code. This colour code and the principles of waste sorting and recycling can be integrated into the lessons. Collected paper and cardboard can be sold to a recycling company that manufactures sneakers, bags, etc.

Objective Make students aware of the need to classify waste as a way to promote recycling efficiency and the circular economy.

Characterisation Posters informing on the waste sorting are displayed throughout the school. Coloured recycling bins or containers are highly visible.

Cost Recycling bins can be provided by the municipality or companies dedicated to collecting and/or recycling each kind of waste.

Performance - Benefits

Environmental The measure contributes to improving waste sorting and, therefore, increasing the amount of recycled waste.

Economic -

Social The presence of highly visible bins for recycling draws the students' attention and promotes waste sorting. It also raises their awareness of waste sorting and recycling in their everyday lives.

Experiences in pilot schools

Pilot school A

Name Lycée de Rompsay

Location La Rochelle (France)

Results 11.43 tons of electric and electronic waste, 30 m^3 of common industrial waste, 3 m^3 of solid toxic waste, 546 kg of liquid toxic waste, 1.4 tons of green waste, 10 m^3 of metals, 150 m^3 of paper/cardboard, and 3 kg of batteries were sorted and collected by recycling companies in 2016.

W2-d Shared composting

Low-carbon economy solution

Name	Composting of green waste onsite
Description	Installation of shared composting bins to collect organic waste.
Objective	Decrease the waste generated by the school and produce compost to maintain the permaculture garden operated by students.
Characterisation	Use of composting bins.
Cost	100 €/bin + work cost of the representatives of an NGO appointed by the municipality to supervise the operation.

Performance - Benefits

Environmental	The expected reduction of waste depends strongly on the green surface area of the school and the activity of the school cafeteria or canteen.
Economic	The amount of compost produced is used onsite to maintain the permaculture garden. This reduces the cost of maintaining the garden.
Social	This measure potentially involves all students and staff since anybody can freely access the bins and throw organic waste. It contributes to raising awareness about waste sorting and recycling.

Experiences in pilot schools

Pilot school A

Name	Institut Universitaire de Technologie
Location	La Rochelle (France)
Results	Around 600 l of compost is produced each year

W2-e Composting and farm animals to reduce the waste

Low-carbon economy solution

Name
Composting and feeding the school animals to reduce the waste coming from the school cafeteria

Description
Children help reduce food waste by sorting, composting and feeding the school animals.

Objective
Raise awareness of students about the possibility of reducing waste and associated CO_2 emissions by recycling onsite.

Characterisation
If the school has a garden and a chicken house that hosts other domestic animals, the peels and other waste can be used to feed those animals. The rest of the organic waste and the green waste coming from the garden can be composted. The soil coming from the composting helps to maintain the garden. A non-governmental organisation, or the municipality, can collaborate to turn over the compost. Each day the children bring buckets of waste to the compost bins based on a specific order decided by the school council.

Cost
100 €/bin + cost of the representatives of an NGO appointed by the municipality to supervise the operation.

Performance – Benefits

Environmental
The measure helps reduce the school's waste produced and the associated CO_2 emissions.

Economic
-

Social
Children like to grow fruits and vegetables in their school garden. They can learn how organic waste can help do that, as well as all the positive impacts of recycling.

Experiences in pilot schools

Pilot school A

Name
Ecole Marie Marvingt

Location
La Rochelle (France)

Results
Each week, about 75 kg of waste from the cafeteria and from the fruits provided by the students were collected and recycled by feeding the animals or composting.

W3-a Recycling of roller shutter slats

Low-carbon economy solution

Name Recycling of roller shutter slats for the construction of geodesic structures with students

Description Development of a workshop on recycling roller shutter slats for the construction of geodesic structures, such as parking for bikes, spheres or gardening items.

Objective Raise awareness in students about the potential of recycling.

Characterisation Different structure ideas should be provided along with construction procedures that students should follow for the correct use of elements. Then, students should be divided into teams and collaborate to construct the geodesic structure. The activities should be supported by teachers or external agents.

Cost -

Performance - Benefits

Environmental Raise awareness of students about the potential of recycling.

Economic -

Social Encourages creativity and learning. Creativity thrives when people work together in a team.

Experiences in pilot schools

Pilot school A

Name IES Chaves Nogales

Location Seville (Spain)

Results A company was contracted to support the construction process of the geodesic structure. The students were divided into different groups with different tasks. The company and ClimACT research members explained the procedure for construction. Then, students carry out the construction process. There was a nice playtime with the geodesic structure. The event was a success.

W3-b Market of reused materials

Low-carbon economy solution

Name	Give a second life to recyclable materials
Description	Design and assemble several school supplies and toys by students, using recycled materials, to sell them to parents after parent-teacher conferences.
Objective	Promote consciousness for the collection and reuse of waste.
Characterisation	Students and teachers gather recyclable materials, manufacture school supplies and toys using the materials collected, and sell these new recycled products in a small market after a school event.
Cost	-

Performance - Benefits

Environmental	The waste collection and their reuse reduce pollution and CO_2 emissions.
Economic	Schools can receive money in order to improve their infrastructures or promote additional activities.
Social	This measure can increase awareness in the whole school community about reusable materials and the potential of recycling.

Experiences in pilot schools

Pilot school A

Name	Escola Básica Maria Veleda.
Location	Loures (Portugal)
Results	

W3-c Christmas decoration

Low-carbon economy solution

Name	Reuse of materials to build Christmas decoration
Description	Students reuse materials for the construction of Christmas decorations with the collaboration of the whole school community.
Objective	Promotion of recycling and good environmental practices between students.
Characterisation	Students can collect and reuse daily items such as egg cartons, caps, yoghurt bottles, or coffee capsules to celebrate the holiday season, giving them a second life as Christmas decorations. This decoration can be used to adorn the school.
Cost	-

Performance – Benefits

Environmental	The waste collection contributes to the reduction of pollution and CO_2 emissions.
Economic	-
Social	The activity raises awareness among the students and families about the problem of waste and its impacts on the environment.

Experiences in pilot schools

Pilot school A

Name	Actions performed in all Portuguese ClimACT schools
Location	Lisbon, Loures, Matosinhos and Vila Nova de Gaia (Portugal)
Results	-

W3-d Carnival parade

Low-carbon economy solution

Name	Carnival parade reusing materials
Description	Students design and make costumes to celebrate Carnival, reusing materials.
Objective	Promotion of recycling and good environmental practices between students.
Characterisation	Reuse of materials to create costumes that would be used in the parade. Materials are collected with the contribution of the students' families. Costumes are produced by the students with the help of the teachers. The Carnival Parade goes through the streets around the school.
Cost	-

Performance - Benefits

Environmental	The waste collection contributes to the reduction of pollution and CO_2 emissions.
Economic	-
Social	The activity raises awareness among the students and families about the problem of waste and its impacts on the environment.

Experiences in pilot schools

Pilot school A

Name	Escola Básica de Prior Velho
Location	Loures (Portugal)
Results	-

Chapter 7
Conclusions

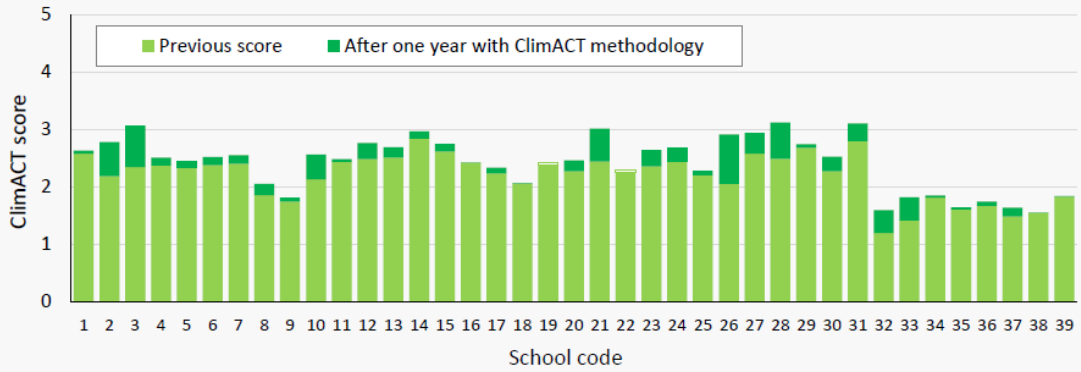
7.1. **Progress Evaluation of Schools**

The implementation of a methodology toward a low-carbon economy (LCE) conducted in 39 pilot schools began to yield its first results after a year. This section evaluates the work progress and quantifies the success achieved in the pilot schools. After implementing LCE action plans, new technical audits and surveys were deployed along all SUDOE regions to assess the ClimACT benefits and validate the developed methodology and tools.

The results were promising and encouraging. The average ClimACT score across 39 pilot schools improved from 2.20 to 2.42 after the first year. Most pilot schools achieved a percentage of improvement higher than 10% in the ClimACT score. The **waste** area resulted in a significant improvement of +0.64 out of 5. It was the environmental sector with the lowest average score at the beginning of the project. However, at the end of the project, the action plans addressed by pilot schools were able to promote awareness about waste and the importance of recycling, being one of the most successful low-carbon solutions. **Indoor air quality** showed an average improvement of +0.34 out of 5. The results showed how indoor air pollutant concentrations could be effectively controlled during teaching hours by using natural ventilation during the breaks through opening windows and doors. **Water** and **green procurement** areas also achieved a mean improvement of +0.31 and +0.10 out of 5. The activities carried out by students and the awareness campaign allowed significant improvements in the schools' behaviour in these areas. Other environmental sectors remained almost constant because they require major improvement actions and big infrastructure changes, such as **transport**, **green spaces**, or the **energy** sector. However, some schools started to deploy major retrofitting actions, which are expected to improve these sectors throughout the following years significantly.

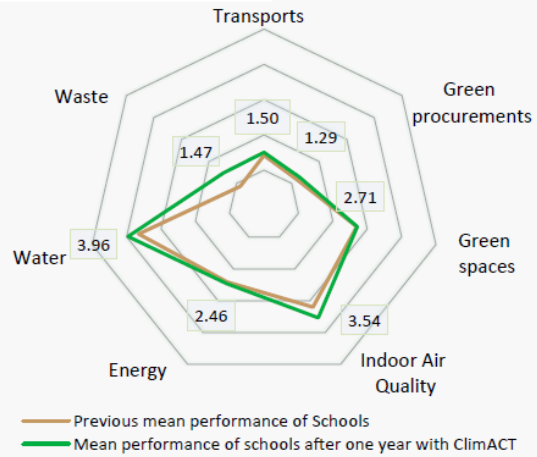
CLIMACT SCORE OF PILOT SCHOOLS AFTER ONE YEAR WITH CLIMACT METHODOLOGY

Figure A. Final ClimACT score of pilot schools



AVERAGE PERFORMANCE

Figure B1. ClimACT Index



Final average score:

2.42/5

Sector	*Average*
Transports	*1.50*
Green procurement	*1.29*
Green spaces	*2.71*
Indoor Air Quality	*3.54*
Energy	*2.46*
Water	*3.96*
Waste	*1.47*

7.2. **Final Remarks**

This book summarises the research activities conducted inside the European project ClimACT within the Interreg SUDOE Programme from 2016 to 2019. A methodology to measure and promote sustainability in schools has been proposed, tested and validated, aiming at showing the environmental performance and informing of potential environmental savings. The aim was to support schools' managers, teachers, staff and students in identifying the best available low-carbon economy activities and solutions that can improve the environmental performance of schools concerning energy efficiency, renewable energy use, consumption of resources and respect for the environment. Over three years, a special collaboration and awareness to develop, shape and test the methodology was developed, involving academic institutions, researchers, students, teachers, and the whole school community.

The results achieved highlight the success of the approach and the potential of schools for environmental empowerment to control resource consumption and environmental impacts. All pilot schools deployed the ClimACT methodology successfully, achieving high environmental benefits after one year. The ClimACT methodology, validated as a powerful tool to encourage and support the transition towards an LCE, is now ready to support the environmentally friendly pathway of schools.

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This publication summarizes a long period of research on the environmental performance of schools inside the framework of the ClimACT project (2016-2019). It proposes a methodological approach towards a low-carbon economy based on two main actions for environmental education in schools: measuring the environmental performance of school communities through a school sustainability index based on measurable indicators in the areas of transport, procurement, green spaces, indoor air quality, energy, water and waste; and encouraging students, teachers, and families towards an energy-efficient and low-carbon pathway through a structural procedure based on roles, activities and progress evaluation. The book includes the results of 39 pilot schools in Europe before and after implementing the methodology and the catalog of low-carbon activities and solutions proposed and implemented to empower school communities towards a low-carbon economy.

ClimACT

A holistic approach to support the transition to a low carbon economy in schools

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