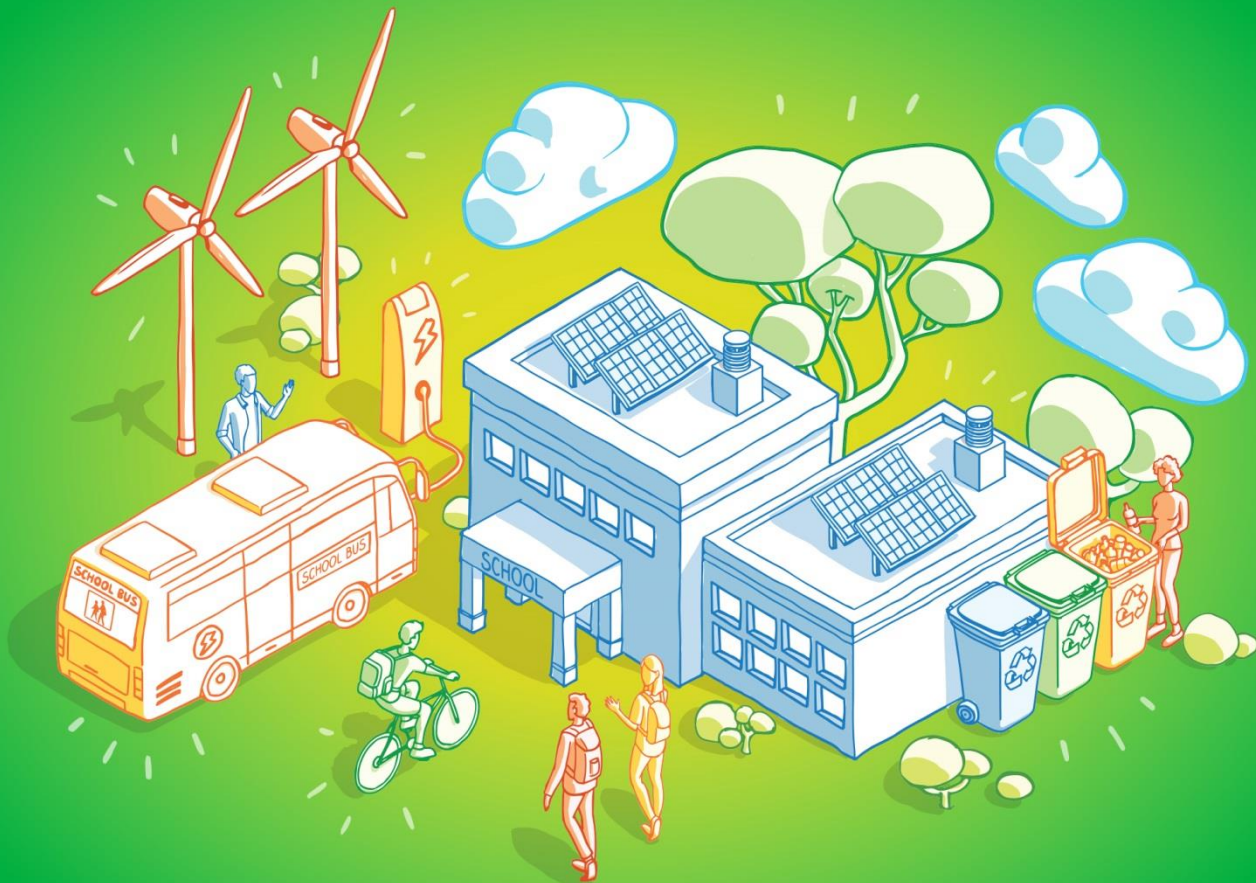




ClimACT



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

E2.6 Cost Benefit Analysis Module

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Executive Summary

This task titled “**Cost Benefit Module**” has been developed into the WP2, as a component of the ClimACT tool to support the decision-making process in schools on the path to an efficient low-carbon economy transition.

Considering a selection of proposed portfolio of most potential retrofit solutions for school buildings has been tailored an algorithm to provided schools with the benefit and cost, including the direct cost and savings, and external cost and benefits derived of the environmental improvement of the performance if measures were implemented.

1 Introduction

Cost-Benefit Analysis (CBA) is an analytical tool for judging the economic advantages or disadvantages of an investment decision by assessing its costs and benefits in order to assess the welfare change attributable to it. In other words, the purpose of CBA is to facilitate a more efficient allocation of resources, demonstrating the convenience for society of a particular intervention rather than possible alternatives (European Commission, 2014).

From an economic theory perspective, accurate cost-benefit analysis identifies choices that increase welfare from a utilitarian perspective. Assuming an accurate CBA, changing the status quo by implementing the alternative with the lowest cost-benefit ratio can improve Pareto efficiency.

1.1 Objective

The objective of applying the CBA methodology in the context of the ClimACT project is to evaluate in terms of the costs and benefits of the proposed improvements in schools in the framework of the ClimACT project.

The ClimACT project has identified a set of measures or “Best available actions and smart control strategies” that are included in the ClimACT decision tool. For each one of these measures, the CBA performed will quantify the net benefit of implementing the measure compared to the status quo situation and taking into account costs and benefits including the relevant externalities.

Any measure which reduces energy or material consumption or increase the use of renewable energies may produce important external benefits that should be accounted for. These benefits will in some way counteract the direct costs needed to implement the measures. Additionally, any energy efficiency measure adopted may have direct savings in energy bills. The CBA module developed in ClimACT includes costs and benefits to society including the relevant external costs and benefits.

1.2 Typologies of project

Considering the methodology presented in the previous chapter, the ClimACT CBA can be classified according to criteria of timing as an **Ex-ante CBA** since it will be performed before the measure is implemented, guiding the decision maker of the school towards choosing the best possible alternative project.

In spite of the initial goal of considering all potential impacts of the measures, the ClimACT CBA can be considered a **partial cost benefit analysis**, since only a set of the major cost and benefits will be considered.

According to the criteria related to the financial and economic CBA, the CBA module designed for the ClimACT tool is a social cost-benefit analysis, since it integrates environmental externalities as well as private (or financial) cost-benefit analysis.

1.3 Scenario determination

As a result of the implementation of the proposed measures several alternative systems could be found. Each one of those alternative systems presents a scenario in terms of costs and benefits.

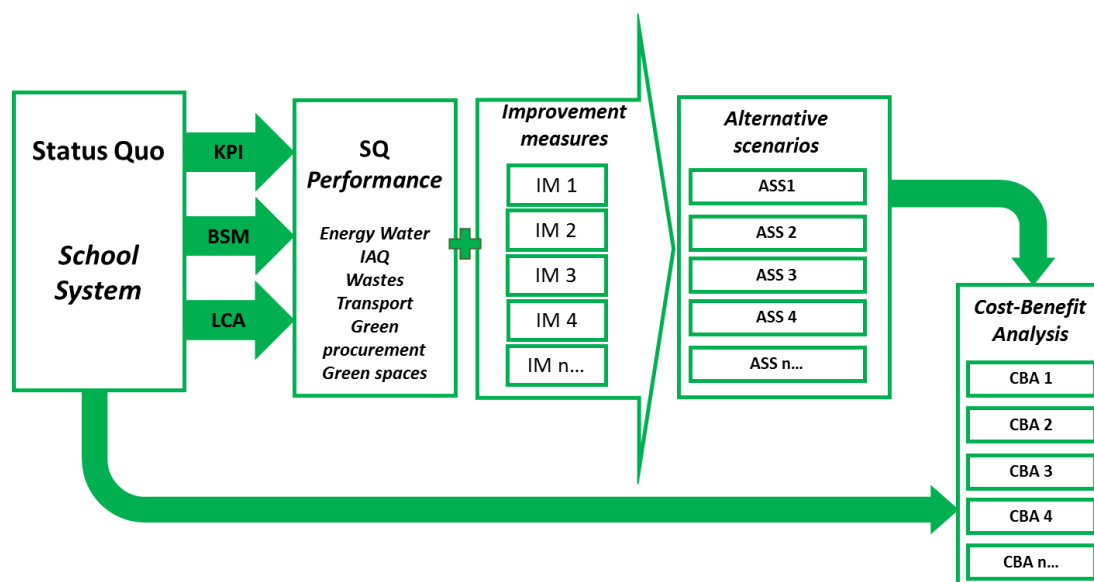


Figure 1. Diagram of scenarios determination.

In order to duly perform the cost-benefit analysis of the measures implementation, the scenarios are described with a focus on the differences, between alternative systems with and without the measure implementation. Impacts due to each measure (infrastructure, transport, wastes) have to be described in detail. To that end, for each one of the proposed measures, a cost-benefit determination table is built which includes the relevant information.

An example of this type of table of a measure is shown below.

Measure	Type of Impact	Cost/Benefit	Private/Social	Methodology to quantify the impacts	Methodology to give a monetary value	Accounted for?	Included in the CBA?
Change of windows	Financial cost	Cost	Private	Euro	Direct	Yes	Yes
	Infrastructure cost	Cost	Private	Euro	Direct	Yes	Yes
	Environmental cost	Cost	Social	Emissions from materials manufacturing	ExternE	Yes	Yes
	Environmental benefit	Benefit	Social	Emissions reduction	Extern.E	Yes	Yes
	Operation benefit	Benefit	Private	Fuel reduction	Direct	Yes	Yes
...

1.4 Analyzed costs and benefits

Social costs include both the private costs and any other external costs to society arising from the production or consumption of a good or service. In the case of the ClimACT project CBA, the cost-benefit analysis takes into account the following costs:

- Private costs and benefits considered:
 - Direct costs of production of the materials and equipment required for the measure (infrastructure)
 - Direct costs of the maintenance of the measure
 - Direct cost of the operation (fuel, energy, material).
 - Direct cost of financing (cost associated to interest rates if loan or other financial mechanism is used)
- Social costs and benefits considered are related to the emission to air and water, including the:
 - External cost of required materials/equipment manufacturing
 - External cost of the maintenance of the measure
 - External costs of the operation.
 - External cost of the wastes removal (if the case).

Consider for example that the school decision maker decides implementing the substitution of the Diesel Oil Boiler by a Biomass Boiler. The social costs of the measure include, on the one hand all private costs of a measure implementation (costs of the boiler equipment, installation, costs of materials and energy spent in maintenance-lubricants, etc. - and operation – fuel -, financial costs if a loan is required, etc.), and also the cost experienced by people because the increased emissions to the atmosphere, for example. On the other hand, there could be direct savings in terms of fuel costs. As for the external costs and benefits, biomass boiler will have lower CO₂ emissions than the natural gas boiler with the associated external benefit.

The final step in a CBA is the decision making process based on the obtained results carried a balance between costs and benefits in comparison with the status quo situation.

1.5 Limitations

There exist various limitations associated to CBA such as the difficulties associated to accounting, quantifying and monetizing for all possible costs and benefits. Trying to assign a monetary value to some non-market effects is always subject to some degree of subjectivity and the resulting value very much depends on the quality and data availability.

The net benefits of a project may incorporate cost savings or public willingness to pay compensation (implying the public has no legal right to the benefits of the policy) or willingness to accept compensation (implying the public has a right to the benefits of the policy) for the welfare change resulting from the policy. The actual compensation an individual would require to have their welfare unchanged by a policy is inexact at

best. Surveys (stated preference techniques) or market behavior (revealed preference techniques) are often used to estimate the compensation associated with a policy. Stated preference technique is a direct way of assessing willingness to pay. Because that, it involves asking people directly to indicate their willingness to pay for some environmental feature, or some outcome that is closely connected to the state of the environment. However, survey respondents often have strong incentives to misreport their true preferences and market behavior does not provide any information about important non-market welfare impacts. Revealed preference technique is an indirect approach to individual willingness to pay. People make market choices among certain items that have different characteristics related to the environment, they reveal the value they place on these environmental factors (European Commission, 2014)

1.6 Accounting for social costs and benefits

In order to take into account the external cost and benefits, there are several different estimation methodologies and economic valuation methodologies.

To calculate the external cost associated to each measure, an integration of two methodologies is made. First a life cycle assessment (LCA) of the proposed measures is performed to obtain the pollutants inventories. Second, using the ExternE methodology damage factors the external costs caused by the release of pollutant to the water or air environment due to measure implementation is calculated..

1.6.1 External cost estimation

The quantification of external costs is based on the 'impact pathway' methodology which has been developed in the series of ExternE projects, and is further improved within NEEDS (NEEDS, n.d.) and other related ongoing projects. The impact pathway analysis aims at modelling the causal chain of interactions from the emission of a pollutant through transport and chemical conversion in the atmosphere to the impacts on various receptors, such as human beings, crops, building materials or ecosystems. Welfare losses resulting from these impacts are transferred into monetary values using monetary valuation techniques.

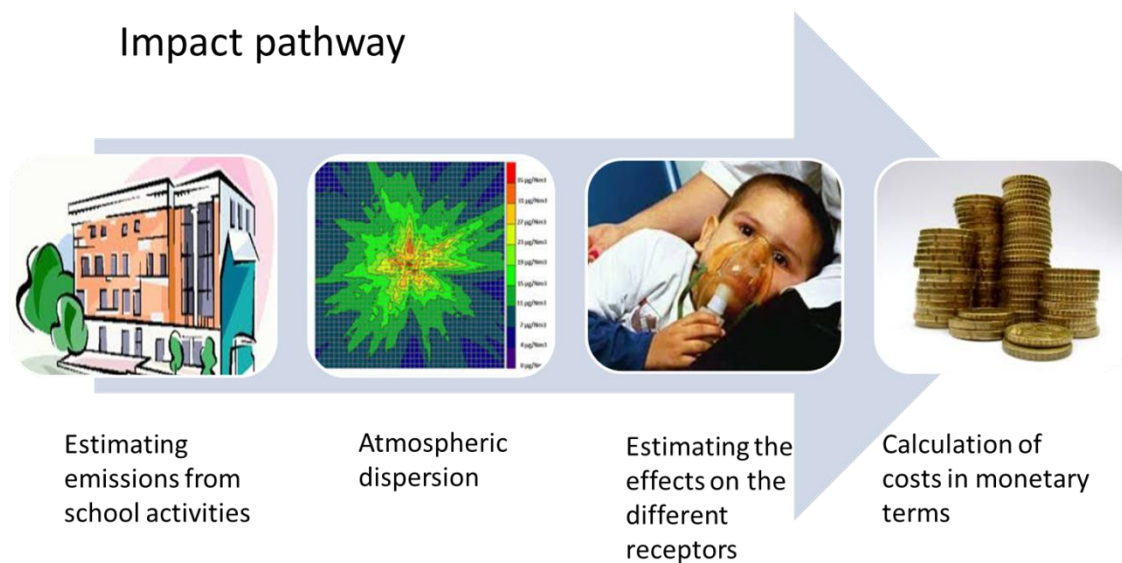


Figure 2. Impact pathway approach to estimate external costs using the ExternE methodology

The quantification of externalities in the ClimACT CBA module is made using a simplified approach based on the use of damage factors developed in the framework of the CASES (European Commission, 2008) project expressed in Euro/tonne of each relevant pollutant. To calculate the external cost of each measure, the marginal damage value for unit of emission is multiplied by the quantity of pollutants emitted in the whole value chain of the analysed measure.

Marginal damage factors for the considered air pollutants are calculated in CASES using the updated Eco- SenseWebV1.2 tool⁵. The approach used to quantify environmental impacts is the impact pathway above mentioned. In the EcoSenseWebV1.2 tool, the results of the industrial source complex model (ISC)—used for transport modelling of primary air pollutants (SO₂, NO_x, particulates)—and the source receptor (SR)-matrices for regional modelling are incorporated. The costs of these emissions are calculated with respect to the impact of pollutants on human health, crops, damage to materials, and loss of biodiversity caused by acidification and eutrophication.

The environmental burdens associated with each of these measures are obtained through Life Cycle Assessment (LCA), the standardized methodology that allows to evaluate the environmental impacts associated with a product, the process of the activity during the life cycle, from the extraction of raw material until end of life, through the identification of energy consumption and raw materials, as well as emissions and waste generated ((AENOR, 2006; International Organization for Standardization, 2006)).

Airborne pollutants

Life cycle impact assessment results usually offer a very large set of pollutants. In this study, a reduced list of the most relevant pollutants was extracted, including only the ones considered by the ExternE method. These pollutants are listed in Table 1.

Table 1 Airborne pollutants considered in the external costs analysis

Impact	Pollutants
Human health (HH) regional and North hemisphere model	Fine particles, NO _x , SO ₂ , NMVOC, NH ₃ , Cd, As, Ni, Pb, Hg, Cr, Formaldehyde, Dioxin, several radionuclides
Loss of biodiversity (LD)	NH ₃ , NMVOC, NO _x , SO ₂
Crops	SO ₂ , NO _x
Material Damage (MD)	SO ₂ , NO _x

Damage costs provided by CASE differ by the emission source country (all European countries, EU27 average), by release height (average release height, low release height, high release height), and by the year of the background emissions. In the ClimACT CBA module, the emission source countries are Spain (ES), Portugal (PT), and France (FR). In Gibraltar case, since the location is close to Spain, damage costs for Spain have been considered. For the release height, it is not possible to establish any value, so the average release height (*unknown*) have been chosen.

Damage costs of greenhouse gas emissions

The estimation of the damage costs of greenhouse gas emissions differs not only because the underlying integrated assessment models represent key climate and socio-economic relations differently, but also because there are a number of assumptions to be made to which these estimates are highly sensitive, which cannot easily be resolved. Examples include the choice of discount rate and the use of equity weighting. Discounting is related to the adequate representation of a preference order that fits a decision maker's intertemporal substitutability of consumption. Equity weighting takes into account the attitude towards inequality in average per capita income between different world regions.

The *NEEDS RS1b*¹ work provides estimates of marginal damage from an extra ton of greenhouse gas emissions (CO₂, CH₄, N₂O, SF₆) based on *FUND model*² runs. Key parameters affecting the greenhouse gas damage costs are discounting and equity weighting. In this report we have used a damage costs derived without equity weighting.

¹ More info: <http://www.needs-project.org/>

² More info: <http://www.fund-model.org/versions>

Damage costs

Damage costs are discounted to the year of emission using a discount rate of 3% (till 2030) and 2% (after 2030).

Damage costs from CASES are expressed in euros of the year 2000. These values have been updated to 2016 using the corresponding variation of the Harmonised Indices of Consumer Prices (HICP). The HICP measures the changes over time in the prices of consumer goods and services acquired by households. The HICP gives a comparable measure of inflation in the euro area, the EU, the European Economic Area and for other countries. Data has been obtained from Eurostat databases³, for year 2016 (the most updated available data for annual value).

Table A. 1 ANNEX II shows the damage costs factors considered in this study.

³ <http://ec.europa.eu/eurostat/web/hicp/data/database>

2 Cost Benefit Analysis of ClimACT Low Carbon retrofit solutions: Measures scenarios

2.1 Definition of the analyzed scenarios

The *impact* of a measure or retrofit solution is the difference between what the situation in the study area would be with and without the project. Thus, when a project is being evaluated the analysis must estimate not only what the situation would be with the project but also what it would be without the project. In other words, the alternative to the project must be explicitly specified and considered in the evaluation of the project. It must be noted that the with-and-without comparison is not the same as a before-and-after comparison.

Besides comparing the with-and-without comparison, it is also possible to consider other alternative projects. This is particularly relevant when considering an ex-ante CBA because the comparison of the net present value of the various alternatives will help decision makers in choosing the best possible alternative.




The costs and benefit are compound by direct costs and benefits, considering the lifespan of the retrofit solution, as well as external cost and benefit, the balance lets to clarify the annual profit of the alternative.

An alternative scenario is created for each measure which is possible to calculate the economical or environmental cost and benefit. Description and assumptions are specifying below the table. The Life cycle assessment of each alternative scenario of implementing retrofit solutions, lets to calculate the external cost of the required infrastructure EC1, the maintenance, EC2, and the external benefit (EB). Below a description of the scenarios considered in the Life cycle of the retrofit solutions

2.1.1 Wastes

Next table defines each selected low-carbon retrofit solutions of the proposed portfolio of measures to improve the Waste sector of schools. For each infrastructure, an alternative scenario is created. Description and assumptions are specifying the table below.

A. Low-carbon retrofit solutions for recycling

	DESCRIPTION	CHARACTERISATION	LIFETIME		TARGET
W1	Setting up containers for paper recycling 	Recycling bin of 30x30x50 for indoor spaces	15 years	⇒	Reduction of 20% of non-recycled waste
W2	Setting up containers for plastic recycling 	Recycling bin of 30x30x50 for indoor spaces	15 years	⇒	Reduction of 20% of non-recycled waste
W3	Setting up containers for glass recycling 	Recycling bin of 30x30x50 for indoor spaces	15 years	⇒	Reduction of 20% of non-recycled waste


There are 3 scenarios (W1, W2, and W3). The scenarios infrastructure includes the production of raw material and moulding of the plastic bin (Polypropylene, PP). The weight of the bin is 2.7 kg. The colouring and printing are excluded. The scenarios consider a lifetime of 15 year for containers, and a substitution of 5% of containers per year. A plastic bag per week is included (considering 36 weeks).

The expected benefit is the reduction of the mixed wasted, increasing the segregation of the treatment and recycling of each type of wastes (kg), being W1 increase the segregation of paper and cardboard, W2 increase the segregation of plastics and similar, and W3 promotes the segregation of glass. On the one hand the measure lets a reduction of the waste into the municipal mixed wasted, and on the other hand, required a treatment process itself to be sorted to next uses (classification in plant to recycling as cardboard, paper, incineration, landfill...). Density of the mixed municipal waste is considered 100 kg/m³.

The number of bins depends on the number of students, considering that the 20% of reduction is reached when the ratio is 1 bin per 30 students (best scenario).

Commercial info was used: <https://logismarketmx.cdnwm.com/ip/cointer-bote-con-pedal-hoja-tecnica-del-bote-con-pedal-1205065.pdf>

B. Low-carbon retrofit solutions for composting

DESCRIPTION	CHARACTERISATION	LIFETIME	TARGET
Compost production from organic waste produced in the canteen 	Compost bin of 74x84x74 for outdoor spaces, capacity for 400 l	15 years	Exploit organic waste to produce a profitable product

The scenario (W4) infrastructure includes the production of raw material and moulding of the plastic (Polypropylene, PP). The weight of the container is 12.5 kg. The colouring and printing are excluded. The selected compost bin is produce using a 90% of recycled PP, according with the source. Pieces for assembly are not included.

Commercial info was used: <https://www.crazysales.com.au/online-400l-compost-bin-73597.html>




The expected benefit is the reduction of the mixed wasted (kg) avoiding the emissions as consequence of the management of this amount wastes in the municipal treatment, disposal in landfill and incineration. Instead of that, could be used to organic material could be used to generate compost producing a profitable product.

The emissions of the compost process production are not included due to be highly different depending on the composition of the organic residue.

2.1.2 Transports

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the transport and mobility of schools.

A. Low-carbon retrofit solutions for parking

	DESCRIPTION	CHARACTERISATION	LIFETIME		TARGET
T1	Increase parking for disable 	Create parking places for disables	30 years	⇒	Increase parking for disable in 1 place per 100 students
T2	Increase parking for bicycles 	Create covered parking places for bicycles 5 places	30 years	⇒	Increase parking for bicycles in 1 place per 25 students
T3	Increase parking for electric cars 	Create parking places for electric cars	12 years	⇒	Increase parking for electric cars in 1 place per 200 students

- Create parking places for disables (T1): the measure is referred to the signalling of the booked place for disables. The scenario consists in the special paint production and application on the asphalt (ground).

The dimension of the parking places is 360x500 cm, and the wide of the line is 10 cm. as well as the pictogram in a central position of 1m2, being required 0.9 l/place.

Commercial info has been used:

<https://www.uni-her.com/suelos-garajes-locales-y-naves/339-pintura-marcaje-vial.html>
<http://www.pinturas-macy.com/productos-detalle.php?idP=188>

- Create parking places for bicycles (T2): the measure consists in the installation of the covered parking which includes 5 places for bicycles. The scenario considers a lifetime of 30 years, without maintenance. It is compounds of thro parts:
 - Bicycle holder (parking) installed on the ground. The scenario includes the material for production (tubes of galvanized steel, including the manufacturing, moulded and welding) as well as the materials for installation (nuts and bolts).
 - Canopy: Structure of anodized aluminium tubular profiles (2 mm d. ext, 1.6 mm d.int) to be assembled using aluminium casting fittings, blocking with self-tapping screws. There is also the option of electrogalvanized steel pipe. The cover is made of translucent polycarbonate of 10 mm thickness.

Commercial info has been used:

<http://www.alu-stock.es/es/aluminio-industria/perfiles-normalizados/tubos-redondos/>

<http://www.elaplas.es/wp-content/uploads/polycarbonato.pdf>

<https://www.parkingsymarquesinas.com/p/marquesinas-aparcabicicletas-para-zonas-urbanas/>

[https://www.tectake.es/soporte-de-bicicleta-](https://www.tectake.es/soporte-de-bicicleta-800399?gclid=EAlaIQobChMlrlC_4cvw2QIV0mYbCh3g5wypEAQYAYABEgIypvD_BwE#402379)

[800399?gclid=EAlaIQobChMlrlC_4cvw2QIV0mYbCh3g5wypEAQYAYABEgIypvD_BwE#402379](https://www.tectake.es/soporte-de-bicicleta-800399?gclid=EAlaIQobChMlrlC_4cvw2QIV0mYbCh3g5wypEAQYAYABEgIypvD_BwE#402379)

The expected benefit is the replacing of the 4% of mobility by car in the school, decreasing the emission by fossil-fuelled cars. That means that 4% of pkm⁴, which usually goes to school by car, would replace the car by bicycle.

- Create parking places for electric cars (T3). The retrofit solution includes the creation of a charging point, which consider the required infrastructure (charger and electronic components production) and the installation (electrical connexion and build of the place including construction materials). The scenario is based on bibliography (Bi, 2015; Lucas, Alexandra Silva, & Costa Neto, 2012; U.S. Department of Energy, 2015).

The power coming from the EVSE depends on the voltage from the electrical service and the EVSE amperage rating. A supply power of AC level 2 has been selected (240VAC/30A) based on U.S. Department of Energy (2015). According to bibliography a lifetime of 12 years is realistic. To calculate the cost In operation and maintenance is considered an annual consumption of 6600 kwh/year considering that each charging takes 4hrs/day, and 5 days/week.

Links to bibliography:

[https://ac.els-cdn.com/S0301421511008925/1-s2.0-S0301421511008925-](https://ac.els-cdn.com/S0301421511008925/1-s2.0-S0301421511008925-main.pdf?_tid=f4bdd344-f56b-4fb6-9a6e-1b57bd4f2de9&acdnat=1521029468_1122d14123fcbe4e85ba2a9a49505948)

[main.pdf?_tid=f4bdd344-f56b-4fb6-9a6e-](https://ac.els-cdn.com/S0301421511008925/1-s2.0-S0301421511008925-main.pdf?_tid=f4bdd344-f56b-4fb6-9a6e-1b57bd4f2de9&acdnat=1521029468_1122d14123fcbe4e85ba2a9a49505948)

[1b57bd4f2de9&acdnat=1521029468_1122d14123fcbe4e85ba2a9a49505948](https://ac.els-cdn.com/S0301421511008925/1-s2.0-S0301421511008925-main.pdf?_tid=f4bdd344-f56b-4fb6-9a6e-1b57bd4f2de9&acdnat=1521029468_1122d14123fcbe4e85ba2a9a49505948)

[https://deepblue.lib.umich.edu/bitstream/handle/2027.42/110984/Bi,%20Zicheng%20\(K](https://deepblue.lib.umich.edu/bitstream/handle/2027.42/110984/Bi,%20Zicheng%20(Kevin)%20-%20Thesis%20April%202015.pdf?sequence=1&isAllowed=y)



[evin\)%20-%20Thesis%20April%202015.pdf?sequence=1&isAllowed=y](https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf)

https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf

The expected benefit is the avoiding of the emission of the CO₂ considering the replacing of the 0.5% (1/200) of mobility by car in the school. That means that the 0.5% of pkm, which usually goes to school by car, would replace the car by bicycle.

⁴ Pkm: Personkilometre.

B. Low-carbon retrofit solutions for public transport






	DESCRIPTION	CHARACTERISATION	LIFETIME	TARGET
T4	Increase public transport 	Stakeholder's meetings for school public transport planning	-	 Increase options of public transport services



Stakeholder's meetings for school public transport planning (T4): the scenario consist in action developed by authorities and decision makers in relation with the public transport network with the goal of increase options of public transport services. No scenario of Life cycle assessment scenario is developed for the measure.

C. Low-carbon retrofit solutions for CO₂ emissions

The retrofit solutions scenarios included in the table below has not a developed of specific infrastructure, since they consist in behavioural and awareness actions (T5 to T24), but they have a high relevance in the transport and mobility performance potentially. The expected benefits of the solutions and measures implementation have consequence in the use of the means of transport to commute to school every day reducing the CO₂ equivalent emission, as well as a reduction in the direct costs of transport. That has been calculated using the average money spent in transport mobility (data from behavioural questionnaire).

The case of the action related to **Decrease car transport** (T22, T23 y T24, it also includes the avoided emissions of pollutant associated to car use per pkm.



	DESCRIPTION	CHARACTERISATION	LIFETIME	TARGET
T5	Increase walking 	Happy shoesday	-	 Reduction of CO ₂ emissions associated to transport higher than 20%
T6		Miles champion's board for walkers		
T7		Traffic snake game		
T8		Find walking friends platform		
T9		Safety route planner for walk		
T10		Walking safety for children guide with monitoring sheets		
T11	Increase bicycling 	Bike Clubs	-	 Reduction of CO ₂ emissions associated to transport higher than 20%
T12		Miles champion's board for bikers		
T13		Traffic snake game		
T14		Find bicycling friends platform		
T15		Safety route planner for bicycle		
T16		Cycling safety for children guide with monitoring sheets		
T17	Increase public transportation	Miles champion's board for public transport	-	 Reduction of CO ₂ emissions

T18		Traffic snake game			associated to transport higher than 20%
T19		Find public transport friends platform			
T20		Safety route planner for public transport			
T21		Public transport safety for children guide with monitoring sheets			
T22	<p>Decrease car transport</p> 	Parents awareness to the importance of reduce car traffic	-	⇒	Reduction of CO ₂ emissions associated to transport higher than 20%
T23		Parents car-sharing platform			
T24		Eco-driving awareness actions for parents			

2.1.3 Green spaces

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the green spaces of schools.

A. Low-carbon retrofits solutions for green areas





	DESCRIPTION	CHARACTERISATION	LIFETIME	TARGET
GS1		Rooftop (Aquaponic Greenhouse Lab)	-	 Increase green area of 5%
GS2		Wildlife Habitat (for shaded areas)		
GS3		Vertical gardens		
GS4		Farming our own veggies		
GS5		Feast of our veggies to students' motivation		

- Rooftop (GS1): the infrastructure scenario requires to implement the measure is based on bibliography (Gargari, Bibbiani, Fantozzi, & Campiotti, 2016; Li & Yeung, 2014) Materials has been adapted to area unit (m² of the garden in rooftop). It includes the infrastructure for cover shapes, sand, organic and the irrigation system.

The expected benefit is regarding increasing of carbon capture.


GS2 to GS5 are not analysed thought scenarios.

B. Low-carbon retrofit solutions for CO₂ sequestration

	DESCRIPTION	CHARACTERISATION	LIFETIME	TARGET
GS6		Planting trees with more sequestration level in related international days (Environment and Forest International Day)	-	 Increase CO ₂ sequestration of 5%
GS7		Informative placards of CO ₂ sequestration levels of each existing plants	-	
GS8		Planting grass in waterproof area	-	 Increase CO ₂ sequestration of 5%



- Planting trees (G6) with more sequestration level in related international days (Environment and Forest International Day). The scenario includes the tree seedling production ready to be plant in the garden. Sequestration rate used is the Pinus Radiata. Maintenance is not included. No need irrigation.
- Informative placards of CO₂ sequestration levels of each existent plant (GS7). *The measure is not analysed in the CBA module.*
- Maximize the green area per non-covered area to promote sequestration rate though planting grass in waterproof area (GS8). The scenario includes the transformation of the urban to grass soil, and the grass plant production seed production. Cultivation maintenance is considered (a rate of 1 kg/m²*year of grass removed). Include, irrigation, harvest and loading for transport. The benefit is the increase of the sequestration of CO₂ of turf grass is 0.78027 kg/m² and year.

C. Low-carbon retrofit solutions for use of chemists

GS9	Decrease chemical pesticides and fertilizers used for green space maintenance 	Use of organic instead pesticides and fertilizers	-	⇒	Reduction of 5% in the use of chemical compounds
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Use of organic pesticides and fertilizers instead of chemical phytosanitary treatments (GS9): Due to the variability in the production of organic substances, only can be calculated in the scenario the environmental benefit of the avoiding of production of chemical phytosanitary treatments as a reduction of 5% in the use of chemical compounds.

D. Low-carbon retrofit solutions for CO₂ emissions

GS10	Decrease tap water consumption for green	Rain water storage with implementation of drip irrigation systems	⇒	Reduction of 10% in CO ₂ emissions associated to green areas activities
GS11	space maintenance 	Improve the irrigation system efficiency (e.g. access water leaks and install timers)	⇒	Reduction of 10% in CO ₂ emissions associated to green areas activities
GS12	Decrease energy and petrol usage for green space maintenance 	Change to electric equipment charged with renewable energy	⇒	Reduction of 10% in CO ₂ emissions associated to green areas activities

GS13	Electric equipment charged with renewable energy	⇒	Reduction of 10% in CO ₂ emissions associated to green areas activities
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- Rain water storage with implementation of drip irrigation systems of hose (GS10). The scenario including a water storage tank production, the collected network, and the drip irrigation system (a pump plus dripped hose circuit). For operation, electricity consumption is included (electricity consumption). The scenario is calculated per volume of the tank (m³).
- Improve the irrigation system efficiency installing timers (GS11). The scenario is the equipment timer. Power is derived via time-tested internal photovoltaic module and microelectronic energy management system that is fuelled by the surrounding ambient light (solar). After being charged, this efficient energy system provides enough power for the timer to function at any time, night or day, and in any weather with no direct sunlight required. The expected benefit is a reduction of the emission due to overconsumption of water.

In order to complete the inventories, some commercial information has been used:

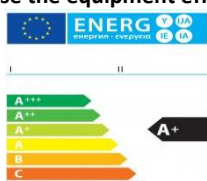
<https://www.digcorp.com/professional-irrigation-products/evo-100-waterproof-solar-powered-digital-hose-end-timer-tap-timer>

- Decrease energy and petrol usage for green space maintenance:
 - GS12, Change to electric equipment charged with renewable energy (solar) the infrastructure scenario consists in the production and manufacturing of new electrical machinery (kg), and the removing of the petrol machinery (kg). The operation consist is the power consumption of machinery from PV solar source and the avoiding of petrol consumption.
 - GS13, Electric equipment charged with renewable energy. The infrastructure scenario consists in the production and manufacturing of new electrical machinery (kg). The operation consist is the power consumption of machinery from PV solar source and the avoiding of petrol consumption.

2.1.4 Green procurement

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the green procurement of schools.

A. Low-carbon retrofit solutions for equipment efficiency


GP1	Increase the equipment efficiency 	Change equipment with efficiency lower than A+	20 years	⇒	Increase the energy efficiency in 10% of school equipment
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The scenario considers the change equipment with efficiency lower than A+, including the production of equipment and the treatment of the replaced electronic machinery and equipment. Due to the big range and diversity of appliances a general scenario of production of equipment is included using a media rate for grey, brown and white EEE.

The expected benefit is the saving energy due to the reduction of energy consumption per equipment and appliances. The measure proposes an increase of the energy efficiency in 10% of school equipment.

B. Low-carbon retrofit solutions for paper used

In order to increase the use of recycled paper the measures below are proposed:

GP2	increase the use of recycled paper 	Purchase recycled paper	years	⇒	Increase of 15% in recycled paper consumption
GP3		Awareness of staff for the importance of recycled paper		⇒	
GP4		Purchase new efficient printers		⇒	

- Purchase recycled paper (GP2). The scenario of the infrastructure consists in the production of the recycled paper. The expected environmental benefit is the avoiding of the production of non-recycled paper.
- Awareness of staff for the importance of recycled paper (GP3). Due to the measure has a behavioural perspective and does not have infrastructure, the scenario consider the benefit of avoiding of the production of non-recycled paper.
- Purchase new efficient printers (GP4). The infrastructures scenarios included the production of equipment. The performance scenario considers the replacing of the non-recycled printed printed (ink + non-recycled paper) by recycled printed printed (ink + non-recycled paper). It is suppose that the electricity consumption is also 15% less that the conventional printers.

C. Low-carbon retrofit solutions for training green procurement

INCREASE THE STAFF WITH TRAIN IN GREEN PROCUREMENT: The measure is not analysed in the CBA module since the evaluation of the cost and benefits in physical and/or monetary terms or environmental externalities of the intangible measures will require a high detail cases study beyond the period of the project. It is supposed that the training about green procurement for the staff would cost around 300-550€ / course, and could increase of 5% in staff qualification.

D. Low-carbon retrofit solutions for eco-driving

INCREASE STAFF ECO-DRIVING CERTIFICATION: The measure is not analysed in the CBA module since the evaluation of the cost and benefits in physical and/or monetary terms or environmental externalities of the intangible measures will require a high detail cases study beyond the period of the project. It is foreseen that training and certify staff in eco-driving cost could be around 150-250€ / course and reach and increasing of 5% in staff qualification.

E. Low-carbon retrofit solutions for biological food

INCREASE PURCHASES OF FOOD WITH BIOLOGICAL CERTIFICATE: The measure is not analysed in the CBA module since the evaluation of the cost and benefits in physical and/or monetary terms or environmental externalities of the measures will require a high detail cases study beyond the period of the project. Purchase biological food can reach costs around 120-140% of normal food cost , what would increase of 10% in biological food consumption.



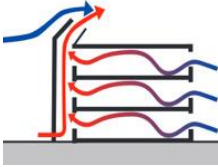

F. Low-carbon retrofit solutions for suppliers

Increase purchases from eco/local suppliers: : The measure is not analysed in the CBA module. The costs and benefit depends on a high level of the case, so it is difficult to include in the tool.

2.1.5 IAQ

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the IAQ of schools.

A. *Low-carbon retrofit solutions for interior air quality*

	DESCRIPTION	CHARACTERISATION	LIFETIME	TARGET
IAQ1	Checking of ventilation system 	Check the mechanical ventilation system: if the air change rate when the system operates was measured and is significantly below the mandatory air change rate	- ➡	Increase and/or ensure a constant ventilation rate to Improve IAQ performance over guideline reference of 20%.
IAQ2	Install a mechanical ventilation system 	Assign the mandatory air change rate in occupancy periods	15 years ➡	Improve IAQ performance over guideline reference of 20%.
IAQ3	Install a natural ventilation system 	Assign the a higher air change rate in occupancy periods	15 years ➡	Improve IAQ performance over guideline reference of 20%.
IAQ4	Open windows during morning, afternoon, and lunch breaks, as well as 5 % of the class time 	Increase in the time with high air change rates Assign the air change when windows are open to these periods	15 years ➡	Improve IAQ performance over guideline reference of 20%.

- Checking of ventilation system (IAQ1). Due to the measure does not require the in installation of infrastructure and does not info about the balance referred to the energy saving consumption any scenario is developed. Any case, in spite of the scenario has not been developed; the social benefit is expected, being the improving of the IAQ performance ensuring the constant ventilation rate.
- Install a mechanical ventilation system (IAQ2). The measure scenario includes the infrastructure for centralised system, the materials and equipment required to impulse and extract the air, and a network supply infrastructure in the building (conductions). The reference unit is the m2 of the surface of using area. Electricity consumption for operation is including. The measure consists of assigning the mandatory air change rate in occupancy periods. What would be achieved is the improvement of IAQ performance over guideline reference of 20%.
- Install a natural ventilation system (IAQ3). The scenario includes the materials production of a network supply infrastructure in the building (conductions). The reference unit is m2 of the surface of using area of the building. The measure consists of assigning higher air change rate in occupancy periods. What would be achieved is the improvement of IAQ performance over guideline reference of 20%.
- Open windows during morning, afternoon, and lunch breaks, as well as 5 % of the class time (IAQ4). Increase in the time with high air change rates. What would be achieved is the improvement of IAQ performance over guideline reference of 20%.

2.1.6 Thermal comfort

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

A. *Low-carbon retrofit solutions for thermal comfort*

- Smart control of existing rollable awnings (TC1). To ensure the best operating of rollable awnings. The infrastructure required is the equipment required to automatized awning and sensors. Furthermore, electricity consumption in operation. The lifetime of the infrastructure is 15 years.

The expected benefit is the reduction of solar gains in summer and increasing of solar gains in winter. Reduction of energy consumption associated to heating and cooling of 20%.

Based on commercial information:

http://www.tubacex.es/media_publicaciones/descargas/TM_BarraCromada_30.pdf

https://www.donpersiana.com/somfy-motor-lt-50-meteor-20nm-hasta-40kg.html?gclid=EAlalQobChMlz-6d2eX_2QIV5SnTCh3q6AKtEAQYAyABEgJVmfD_BwE

<http://www.gardenfurniturecentre.co.uk/downloads/awnings-instructions.pdf>

- Free-cooling at night along summer period (TC2)

Opening windows at night for free-cooling 0 € 0€ 15 years

Reduction of internal loads in summer, reducing indoor peak temperatures.
Reduction of energy consumption associated to heating and cooling of 5-10%.

- New rollable awnings (TC3). Ensure a best solar protection for summer periods SRF (%): 0.3. 100-200 €/m² 0€ 15 years Reduction of solar gains in summer and increasing of solar gains in winter. Reduction of energy consumption associated to heating and cooling of 10-15%.

Based on commercial information:

http://direct.tencate.com/emea/Images/LCA%20Digital%20Printed%20Sun%20Awning%20-%20pblc%20-%20150923_tcm28-40406.pdf Width 6.0m x Length 3.0m (Max Size) <http://www.solarprotect.de/en/automatically-retractable-awning/>

https://ovacen.com/wp-content/uploads/2014/06/guia_tecnica_ventanas.pdf

- New windows (TC4). Setting up new windows in schools. The scenario includes the production of material per m² of window. Installation requires is excluded. Remove of wastes of previous window is including.

The window is a double with low emissivity double glazing and thermal-break frames. Frames are made of aluminium. The lifetime is 30 years.

The expected benefit is the reduction of heating and cooling demand by improving thermal insulation in windows. Reduction of energy consumption associated to heating and cooling of 20-30%.

- Facade insulation (ETICS of EPS) (TC5)

The scenario of the infrastructure is based on literature. The defined functional unit is 1 m² of a wall. The study focused on fixed thermal transmittance (U) parameter to the value 0.27 W/m²K. It is considered 14 cm shape compound by EPS (expanded polystyrene), adhesive, render and a final coating (plaster).

https://ac.els-cdn.com/S1876610216307937/1-s2.0-S1876610216307937-main.pdf?_tid=2c9dfdb4-277e-4202-bee1-406884897951&acdnat=1522239678_7b03523491c65b499ccc6fd2218fea44

Achieving higher insulation of the envelope with a cost around 50-70€/m² 0€ 30years. Reduction of heating and cooling demand by improving the thermal insulation of façade. Reduction of energy consumption associated with heating and cooling of 30-40%.

- Roof insulation (TC6).

Higher insulation of the envelope 40-60 €/m² 0€ 30 years
Reduction of heating and cooling demand by improving thermal insulation of roof. Reduction of energy consumption associated to heating and cooling of 5-15%.

2.1.7 Energy

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

A. *Low-carbon retrofit solutions for energy systems*

- Efficient individual heat pumps (E1): 10 kW. The infrastructure scenario includes the materials, energy and water consumption in the production of the infrastructure. As well as the energy consumption in the production emission of the refrigerant is (R134a) during production and scrapping. The operation scenario includes the electricity consumption.

The expected benefit is the reduction of non-renewable energy consumption and energy cost of 10-15%. The lifetime is 15-20 years (17.5 years)

- Chiller (E2). The measure is consisting in setting up of new efficient chiller for cooling. Scenario reflects the absorption chiller with 100kW cooling capacity and air cooler for the waste heat. The unit include 40 m of pipping between chiller and air cooler. The module include the most important materials for production the infrastructure as well as transport of material to the plant production.

The expected benefit is the reduction of non-renewable energy consumption and energy cost of 10-15%. The lifetime is 15-20 years (17.5 years).

- Setting up of new efficient biomass boiler for SHW and Heating (Centralised biomass boiler) (E3): the scenario of the infrastructure is consist inn the most important material used for the fabrication of the furnace, the chimney, the storage silo, automatic system for supply of wood chips, as well as transport and energy requires for the disposal the previous furnace.

The expected benefit is the reduction of non-renewable energy consumption and energy cost of 5-10%. The lifetime is 15-20 years (17.5 years).

- Centralised condensing boiler (E4). The scenario of the infrastructure includes the material for the fabrication of the boiler, and the removing of recycling metal of the previous boiler. The expected benefit is the reduction of non-renewable energy consumption and energy cost of 10-15%. The lifetime is 20-40 years (17.5 years).

- Solar thermal energy: the infrastructure consists of the solar thermal energy units for SHW and Heating. The lifetime considered is 15-20 years. The benefit is supposed to be the reduction of non-renewable energy consumption and energy cost of 10-15%.

- Photovoltaic energy: the production of the 1 m² of photovoltaic panel is considered. Transport and installation of the infrastructure is included. The lifetime considered is 15-20 years. The benefit is supposed to be the reduction of non-renewable energy consumption and energy cost of 10-15%.







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

- Automatic sensors to regulate lighting in spaces not permanently occupied.. the measure consist of setting up an smart control for lighting. The direct cost is around 40-50 €/unit and the life time is 15 years . the benefit is the reduction of non-renewable energy consumption and energy cost of 10-15%.
- Photocells to regulate outdoor lighting. : *The measure is not analysed in the CBA module since the evaluation of the cost and benefits in physical and/or monetary terms or environmental externalities of the measures will require a high detail cases study beyond the period of the project.*
- LED lights: replacement of old lighting system by new lighting based on LED technology. The lifetime is 15 years. The benefit would be the reduction of non-renewable energy consumption and energy cost of 10-15%.

2.1.8 Water

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

C. A. Low-carbon retrofit solutions for water

WATER	DESCRIPTION	CHARACTERISATION	LIFETIME		TARGET
	Reducers of water flow for faucets 	Setting up of water reducers	15 years	⇒	Reduction of water consumption and water cost of 25-30%.
	Reducers of water flow for showers 	Setting up of water reducers	15 years	⇒	Reduction of water consumption and water cost of 25-30%.
	Self-timer for faucets 	Reducing the water flow period	15 years	⇒	Reduction of water consumption and water cost of 5-10%.
	Self-timer for shower 	Reducing the water flow period	15 years	⇒	Reduction of water consumption and water cost of 5-10%.
	Deposit to collect rain water 	Storing and providing rain water for specific uses	15 years	⇒	Reduction of water consumption and water cost of 10-30%.
	Flushing with double discharge 	Avoiding to flush the full discharge when it is not needed	15 years	⇒	Reduction of water consumption and water cost of 10-15%.
	Variable speed pumps (for water systems)	Reducing the water flow	15 years	⇒	Reduction of water consumption and water cost of 5-15%.

- Reducers of water flow for faucets (W1) and reducers of water flow for showers (W2): the scenarios of infrastructure consider the material production requires per each device including the chroming brass, rubber, POM, and copper grid (Table 2). The expected benefit is the reduction of water consumption and water cost of 25-30%, decreasing the direct costs of water consumption and the external cost.

- Self-timer for faucets (w3) and for shower (W4): the scenario infrastructure includes the material required per each self-timer faucet, being the main material the chromed brass and the NBR (rubber) (Table 2). The expected benefit is the reduction of water consumption and water cost of 5-10%, decreasing the direct costs of water consumption and the external cost.

Table 2. Reducers infrastructure inventory.

	Faucet reducer (W1)	Shower reducer (W2)	Self-timer for faucets (w3)	Self-timer for shower (W4)
Rubber (NBR)	2,50%	8%	0,176%	0,212%
Brass	92,50%	77%	99,824%	99,788%
Copper Grid	2,50%	8%	-	
POM (Polyoxymethylene)	2,50%	8%	-	
Total mass (kg)	0.040	0.013	0.569	0.470

Based on commercial information:

<http://www.ecologicbarna.com/productosficha15.html>

http://www.grifaru.es/fichas_tecnicas/1-prod-98-ref-82.pdf

<http://www.prestoiberica.com/producto/presto-27-eco/ficha-t%C3%A9cnica/>

- Deposit to collect rain water: the storing infrastructure scenario includes the material required to manufacturing the major components of benchmark commercial rainwater harvesting system and life cycle inventory based on literature (Ghimire, Johnston, Ingwersen, & Sojka, 2017) per m3 of storage.

The direct cost of the infrastructure is calculated depending on the storage volume. At once, the storage volume depends on the country (rainfall average per month) and the collecting area of rainfall water) available in the school (typically is the roof area), and the total consumption of water in the school per year.

The target is getting a saving of 20% implementing the measure. If the total average of monthly accumulated rainfall is bigger than the 20% of the average of monthly consumption, the storage is calculated considering the minimum storage to get the target.

If the area of collecting is small, savings are lower than 20% (the target is not possible to reach), so the storage system dimension is calculated depending on the maximum rainfall water which is possible to collect. A % of saving is provided to calculated the direct benefit and the external cost or benefit.

In the Table 3 the average values of rainfall water per year and country are presented (World Bank, 2018).

Table 3. Average precipitation in depth (mm per year).

Country	mm (l/m2)
Spain	636
France	867
Gibraltar	636
Portugal	854

Literature and data sources:

- Santosh R. Ghimire, John M. Johnston, Wesley W. Ingwersen, Sarah Sojka (2017). Life cycle assessment of a commercial rainwater harvesting system compared with a municipal water supply system. Journal of Cleaner Production, Volume 151, 2017, Pages 74-86, ISSN 0959-6526, <https://doi.org/10.1016/j.jclepro.2017.02.025>.
- World Bank (2018). Average precipitation is the long-term average in depth (over space and time) of annual precipitation in the country. Period 1962 – 2014 Precipitation is defined as any kind of water that falls from clouds as a liquid or a solid. Statics - Food and Agriculture Organization, electronic files and web site. <http://data.worldbank.org/indicator/AG.LND.PRCP.MM>
- Flushing with double discharge: the scenario includes the material production and the moulding of the device made of PVC. Some parts to installation have been excluded. The expected benefit is the reduction of water consumption and water cost depending of the area of collecting (typically is the area of roof), the country, and the volume of storage. The ratio of 20% is targeted in the plan obtaining a 20% decreasing the direct costs of water consumption and the external cost.

Based on commercial information:

<http://www.sodimac.cl/sodimac-cl/product/2020483/Valvula-Doble-Descarga-para-WC>

https://www.gustavsberg.com/fileadmin/user_upload/pdf_files/Product_Info_Twicoll_13.pdf

- Variable speed pumps (for water systems)

Infrastructures: pump dataset from the ecoinvent database was used

2.2 Determination of costs and benefits

In order to identify, quantify, monetize and include the various impacts in the CBA calculation, it is suggested that the analyst follows the following steps that are required to collect info and complete all items of the list below: (i) First, the full list of possible impacts that will affect the focused population as a result of the implementation of the project must be defined. (ii) second, the analyst must classify the impacts into cost and benefits depending on if such impacts will generate a burden or a positive effect on the affected population (iii) third, such costs and benefits must be classified into financial (also known as private) or economic (also known as social impacts or externalities), (iv) next, one must choose the methodology and/or underlying assumptions will be used to quantify such effects, (v) fifth, once the impacts have been quantified, if such impacts do not have a monetary value, the analyst must find the way to assign a monetary value to such impacts (thought contingent valuation methods, for example) in order to include them in the CBA. The information requires determining the cost – benefit analysis of each impact identified in project is:

- Type of Impact
- Cost or Benefit
- Private or Social
- Methodology to quantify the impacts
- Methodology to monetarization
- Accounted for?
- Included in the CBA?

It has to be taking into account that some retrofit solutions are not developed in the frame of the install or build an infrastructure but is connected with the behaviour. Also, the implementation of other measures has consequences which are valuable, but it is difficult to measure or calculate the direct benefit, private or social, or monetarization is not possible to be done by LCA and ExternE methodologies. In both cases, the scenario of the measure has not been developed because are no determinate, identified as ND when the scenario is highly specified to external factors (place, authorities, etc.) and is about of the system, or insufficient information, when it is not possible to create the scenario because of the info is insufficient (I.I.).

The creation of scenarios has been supported by the use of SimaPro, ecoinvent database, bibliography and commercial information.

A. Low-carbon retrofit solutions for recycling

	DESCRIPTION		COST				BENEFIT	
		INVESTMENT		MAINTENANCE				
W1	Setting up containers for paper recycling	Private/ Economic	15€/bin	Direct Market price Bin	5% replaced	Direct Market price	-	I.I.
		Social/ External	Yes (EC1)	LCA Bin	5% replaced (EC2)	LCA infrastructure replacement and bags	Reduction of non- recycled waste (EB)	LCA mixed municipal waste avoided and recycling paper increased +ExternE
W2	Setting up containers for plastic recycling	Private/ Economic	15€/bin	Direct Market price Bin	5% replaced	Direct Market price	-	I.I.
		Social/ External	Yes (EC1)	LCA Bin	5% replaced (EC2)	LCA infrastructure replacement and bags	Reduction of non- recycled waste (EB)	LCA mixed municipal waste avoided and recycling plastic increased +ExternE
W3	Setting up containers for glass recycling	Private/ Economic	15€/bin	Direct Market price Bin	5% replaced	Direct Market price	-	I.I.
		Social/ External	Yes (EC1)	LCA Bin	5% replaced (EC2)	LCA infrastructure replacement and bags	Reduction of non- recycled waste (EB)	LCA mixed municipal waste avoided and recycling glass increased +ExternE

B. Low-carbon retrofit solutions for composting

	DESCRIPTION		COST				BENEFIT		
	INVESTMENT			MAINTENANCE					
W4	Compost production from organic waste produced in the canteen	Private/ Economic	55€/bin	Direct Market price Bin	5% replaced	Direct Market price	Exploit organic waste to produce a profitable product		I.I.
		Social/ External	Yes (EC1)	LCA Bin	5% replaced (EC2)	LCA infrastructure replacement and bags	Reduction of non-recycled waste		LCA mixed municipal waste avoided + ExternE

2.2.1 Transports

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the transport and mobility of schools.

A. Low-carbon retrofit solutions for parking

	DESCRIPTION		COST				BENEFIT	
		INVESTMENT		MAINTENANCE				
T1	Increase parking for disables	Private/ Economic	10.26 €	Direct Market price paint	10% repair paint	Direct Market price	-	I.I.
		Social/ External	Yes (EC1)	LCA paint and COVs emission on application	10% replaced (EC1)	LCA paint and COVs emission on application	Increase parking for disable in 1 place per 100 students improving the accessibility	-
T2	Increase parking for bicylces	Private/ Economic	45 €	Direct Market price parking 5 places	0€	I.I.	II	I.I.
		Social/ External	Yes (EC1)	LCA infrastructure	0€ (EC1)	-	Increase parking for disable in 1 place per 25 students	-
T3	Increase parking for electric cars	Private/ Economic	840 €	Direct Market price	Electricity consumption cost	Direct Market price	II	- I.I.
		Social/ External	Yes (EC1)	LCA infrastructure and installation	Yes (EC1)	LCA electricity consumption	Increase parking for electric cars in 1 place per 200 students, replacing fossil-fuelled car use for electric car in 4% (EB)	LCA +ExternE

<https://www.lugenergy.com/instalacion-punto-recarga-coche-electrico/>

http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics

B. Low-carbon retrofit solutions for public transport

	DESCRIPTION		COST				BENEFIT	
			INVESTMENT		MAINTENANCE			
T4	Increase public transport. Stakeholder’s meetings for school public transport planning	Private/ Economic	0€	N.D.	0€	N.D.	-	N.D.
		Social/ External	0€	N.D.	0€	N.D.	-	N.D.

C. Low-carbon retrofit solutions for CO₂ emissions

	DESCRIPTION		COST				BENEFIT	
			INVESTMENT		MAINTENANCE			
T5	Increase walking Happy shoesday	Private/ Economic	0€€	I.I.	0€	I.I.	-	I.I.
		Social/ External	0€	I.I.	0€	I.I.	Yes (EB)	Avoided kg Co2 eq + ExternE
T6	Increase walking Miles champion’s board for walkers	Private/ Economic	0€	I.I.	0€	I.I.		I.I.
		Social/ External	0€	I.I.	0€	I.I.	Yes (EB)	Avoided kg Co2 eq + ExternE
T7	Increase walking Traffic snake game	Private/ Economic	0€	I.I.	0€	I.I.		I.I.
		Social/ External	0€	I.I.	0€	I.I.	Yes (EB)	Avoided kg Co2 eq + ExternE
T8	Increase walking Find walking friends platform	Private/ Economic	0€	I.I.	0€	I.I.		I.I.
		Social/ External	0€	I.I.	0€	I.I.	Yes (EB)	Avoided kg Co2 eq + ExternE
T9	Increase walking Safety route planner for walk	Private/ Economic	0€	I.I.	0€	I.I.		I.I.
		Social/ External	0€	I.I.	0€	I.I.	Yes (EB)	Avoided kg Co2 eq + ExternE
T10€	Increase walking Walking safety for children guide with monitoring sheets	Private/ Economic	0€	I.I.	0€	I.I.		I.I.
		Social/ External	0€	I.I.	0€	I.I.	Yes (EB)	Avoided kg Co2 eq + ExternE

	DESCRIPTION	COST				BENEFIT	
		INVESTMENT		MAINTENANCE			
T11	Increase bicycling Bike Clubs	Private/Economic	0€	I.I.	0€	I.I.	
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T12	Increase bicycling Miles champion's board for bikers	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T13	Increase bicycling Traffic snake game	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T14	Increase bicycling Find bicycling friends platform	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T15	Increase bicycling Safety route planner for bicycle	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T16	Increase bicycling Cycling safety for children guide with monitoring sheets	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T17	Increase public transportation Miles champion's board for public transport	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T18	Increase public transportation Traffic snake game	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T19	Increase public transportation Find public transport friends platform	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T20€	Increase public transportation Safety route planner for public transport	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Avoided kg Co2 eq + ExternE
T21	Increase public transportation Public transport safety for children guide with monitoring sheets	Private/Economic	0€	I.I.	0€	I.I.	I.I.
		Social/External	0€	I.I.	0€	I.I.	Yes (EB) Decrease of kg Co2 eq + ExternE

	DESCRIPTION		COST				BENEFIT	
			INVESTMENT		MAINTENANCE			
T22	Decrease car transport Parents awareness to the importance of reduce car traffic	Private/Economic	0€	I.I.	0€	I.I.		I.I.
		Social/External	0€	I.I.	0€	I.I.	Decreasing fossil-fuelled car use in 20€% (EB)	LCA of avoided pkm which use car to commute + ExternE
T23	Decrease car transport Parents car-sharing platform	Private/ Economic	0€	I.I.	0€	I.I.		I.I.
		Social/ External	0€	I.I.	0€	I.I.	Decreasing fossil-fuelled car use (EB)	LCA of avoided pkm which use car to commute + ExternE
T24	Decrease car transport Eco-driving awareness actions for parents	Private/ Economic	0€	I.I.	0€	I.I.	0€	I.I.
		Social/ External	0€	I.I.	0€	I.I.	Decreasing fossil-fuelled car use (EB)	LCA of avoided pkm which use car to commute + ExternE

2.2.2 Green spaces

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the green spaces of schools.

A. Low-carbon retrofits solutions for green areas

	DESCRIPTION	COST				BENEFIT		
		INVESTMENT		MAINTENANCE				
GS1	Increase green area per non-covered area Rooftop	Private/ Economic	82 €/m2	Market/ Commercial Price	5% of inversion cost in repairing and maintenance	Market/ Commercial Price	Potential of isolation of the roof (thermal/other)	<i>I.I.</i>
		Social/ External	Yes (EC1) Building of a garden rooftop (required materials for infrastructure and installation)	<i>LCA + ExternE</i> Emission due to the conversion of a conventional rooftop to a garden rooftop	Yes (EC2) Associated emission to a repairing (5%) in repairing and maintenance	<i>LCA + ExternE</i>	Intangible, benefit as educational, awareness	<i>I.I.</i>
GS2	Increase green area per non-covered area Wildlife Habitat	Private/ Economic	-	<i>I.I.</i>	-	<i>I.I.</i>	-	<i>I.I.</i>
		Social/ External	-	<i>I.I.</i>	-	<i>I.I.</i>	Intangible, benefit as educational, awareness	<i>I.I.</i>
GS3	Increase green area per non-covered area Vertical gardens	Private/ Economic	173 €/m2	<i>I.I.</i>	-	<i>I.I.</i>	-	<i>I.I.</i>
		Social/ External	-	<i>I.I.</i>	-	<i>I.I.</i>	Intangible, benefit as educational, awareness	<i>I.I.</i>
GS4	Increase green area per non-covered area Vertical gardens Farming our own veggies	Private/ Economic	-	<i>I.I.</i>	-	<i>I.I.</i>	-	<i>I.I.</i>
		Social/ External	-	<i>I.I.</i>	-	<i>I.I.</i>	Intangible, benefit as educational, awareness	<i>I.I.</i>
GS5	Increase green area per non-covered area Feast of our veggies to Student's motivation	Private/ Economic	-	<i>I.I.</i>	-	<i>I.I.</i>	-	<i>I.I.</i>
		Social/External	-	<i>I.I.</i>	-	<i>I.I.</i>	Intangible, benefit as educational, awareness	<i>I.I.</i>

B. Low-carbon retrofit solutions for CO2 sequestration

	DESCRIPTION	COST				BENEFIT		
		INVESTMENT		MAINTENANCE				
GS6	Increase the number of trees to maximize the no. of trees per student and the sequestration rate Planting trees with more sequestration level, maximize the no. of trees per student and the sequestration rate	Private/ Economic	50€/tree	Average of market price	0€	-	0€	-
		Social/ External	Emissions associated to materials and consumption related to planting a tree including the sapling production (EC1)	LCA+ExternE	0€	-	Sequestration of CO2 according with target (5%)	ExternE CO2 sequestration
GS7	Increase the number of trees to maximize the no. of trees per student and the sequestration rate Informative placards of CO2 sequestration levels of each existent plants	Private/ Economic	62.5 €/placard	I.I.	0€	I.I.	0€	I.I.
		Social/ External	-	I.I.	0€	I.I.	0€	I.I.
GS8	Increase the number of trees to maximize the no. of trees per student and the sequestration rate Transform the waterproof area into grass area to maximize the green area per non-covered area and promote sequestration rate Planting grass in waterproof area	Private/ Economic	9.46 €/m2	Average of market price	2.46 €/m2	Average of market price	-	I.I.
		Social/ External	Emissions associated to materials and consumption related to remove the covered (debris removing and planting grass) (EC1)	LCA + ExternE	Emissions associated to materials and consumptions (EC2)	LCA + ExternE	Potential sequestration of CO2 according with target (5%)	ExternE CO2 sequestration

C. Low-carbon retrofit solutions for use of chemists

	DESCRIPTION	COST				BENEFIT	
		INVESTMENT		MAINTENANCE			
GS9	Decrease chemical pesticides and fertilizers used for green space O&M	Private/ Economic	6 €/kg	Commercial /market price	-	-	Cost of fertilizer
		Social/ External	-	I:I	-	Reduction of emission due to the chemical fertilizer	LCA + ExternE

D. Low-carbon retrofit solutions for CO2 emissions

	DESCRIPTION	COST				BENEFIT	
		INVESTMENT		MAINTENANCE			
GS10	Decrease tap water consumption for green space maintenance Rain water storage with implementation of drip irrigation systems	Private/ Economic	166 €/m3	Direct Market/commercial price	5% of invest cost in repairing + electricity consumption per pump	Direct Market/commercial price	Direct reduction of water billing
		Social/ External	Yes (EC1) Water tank for storage of 2500 L + drip irrigation 25 m	LCA +externE	5% of repairing	LCA +externE	Potential sequestration of CO2 according with target (10%)
GS11	Decrease tap water consumption for green space maintenance Improve the irrigation system efficiency TIMER	Private/ Economic	6 €/ timer	Direct Market/commercialprice	0€	Direct Market/commercialprice	Direct reduction of water billing
		Social/ External	Yes (EC1) Component materials (electronics)	LCA +ExternE	5% of invest cost in maintenance	LCA +externE	Potential sequestration of CO2 according with target (10%)
GS12	Decrease energy and petrol usage for green space maintenance Change to electric equipment charged with renewable energy	Private/ Economic	10 €/kg machinery	Direct Market price paint	2%	Direct Market price paint	Direct reduction of petrol expenditure
		Social/ External	Yes (EC1) Component materials (electronics)	LCA +externE	2% investment + petrol consumption costs	LCA +externE	Reduction in 100% the use of petrol for gardening
GS13	Decrease energy and petrol usage for green space maintenance Electric equipment charged with		20 €/kg machinery	Direct Marke/commercialt price	5% of invest cost in repairing + electricity consumption per pump	Direct Marke/commercialt price	-

	renewable energy	-	Yes (EC1) Water tank for storage Component materials (electronics)	<i>LCA +externE</i>	5% of repairing + (EC2)	<i>LCA +externE</i>	<i>Reduction in 100% the use of petrol for gardening</i>	<i>LCA + ExternE avoiding emissions of petrol production and use</i>
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2.2.3 Green procurement

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the green procurement of schools.

A. Low-carbon retrofit solutions for equipment efficiency

	DESCRIPTION	COST				BENEFIT		
		INVESTMENT		MAINTENANCE				
GP1	Increase the equipment efficiency Change equipment with efficiency lower than A+	Private/ Economic	Production of equipment	Average of market price	5% of cost of investment + electricity consumption	5% of price market price	Default value, depends on country ⁵	Increase the energy efficiency in 10% of school equipment, so electricity costs due to appliances decrease
		Social/ External	Production of equipment (EC1)	LCA	5% of cost of investment + electricity consumption (EC2)	LCA	Avoided emission related to electricity consumption (EB)	LCA

⁵ Electricity price of kWh from country grids: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics

B. Low-carbon retrofit solutions for paper used

	DESCRIPTION		COST				BENEFIT	
			INVESTMENT		MAINTENANCE			
GP2	Increase the use of recycled paper Purchase recycled paper	Private/ Economic	Acquisition of recycled paper ⁶ Default value	Average of market price	0€	-	Acquisition of recycled paper ⁷ Default value	Average of market price
		Social/ External	YES (EC1) Production of recycled paper	LCA	0€	-	Avoided emission of the production of non-recycled paper (EB)	LCA
GP3	Increase the use of recycled paper Awareness of staff for the importance of recycled paper	Private/ Economic	200-300	Average of market price	0€	-	Acquisition of recycled paper Default value	Average of market price
		Social/ External	0€	0€	0€	-	Avoided emission of the production of non-recycled paper (EB)	LCA
GP4	Increase the use of recycled paper Purchase new efficient printers	Private/ Economic	Acquisition of equipment ⁸ Default value	Average of market price	5% of cost of investment + electricity consumption (EC2)	5% of market price	Acquisition of recycled paper Default value	Average of market price
		Social/ External	Production of equipment (EC1)	LCA	5% of cost of investment + electricity consumption (EC2)	LCA	Avoided emission of the production of non-recycled paper + Avoided emission related to electricity consumption (EB)	LCA

⁶ Recycled paper direct cost (€/kg) obtained from: <https://ofiterra.es/Pape-A4-Reciclado-Barato>

⁷ Recycled paper direct cost (€/kg) obtained from:

https://ofiterra.es/epages/con0580263.sf/es_ES/?ObjectPath=/Shops/con0580263/Products/%22Papel%20A4%20Pioneer%22

⁸ Recycled paper direct cost (€/kg) obtained from: <https://ofiterra.es/Pape-A4-Reciclado-Barato>

2.2.4 IAQ

Next table defines each selected low-carbon retrofit solutions measures and developed scenarios of the proposed portfolio of measures to improve the IAQ of schools.

A. Low-carbon retrofit solutions for interior air quality

	DESCRIPTION		COST			BENEFIT		
		INVESTMENT		MAINTENANCE				
IAQ1	Checking of ventilation system	Private/ Economic	800€	Commercial/Market price	0€	-	0€	Average of market price
		Social/ External	0€	LCA	0€	-	0€	External benefits due to Reduction of potential mobility and mortality due to reduction of exposure of students to pollutants (PM10 and PM2.5)
IAQ2	Install a mechanical ventilation system	Private/ Economic	Users complete info €/m2	Commercial/Market price	5% of cost of investment + electricity consumption (EC2)	5% of market price	0€	Average of market price
		Social/ External	Production of equipment (EC1)	LCA	5% of cost of investment + electricity consumption (EC2)	5% of market price	0€	External benefits due to Reduction of potential mobility and mortality due to reduction of exposure of students to pollutants (PM10 and PM2.5)
IAQ3	Install a natural ventilation system	Private/ Economic	YES (EC1) Users complete info €/m2	Commercial/Market price	5% of cost of investment + electricity consumption (EC2)	5% of market price	0€	Average of market price
		Social/ External	Production of equipment (EC1)	LCA	5% of cost of investment + electricity consumption (EC2)	5% of market price	0€	External benefits due to Reduction of potential mobility and mortality due to reduction of exposure of students to pollutants (PM10 and PM2.5)

IAQ4	Open windows during morning, afternoon, and lunch breaks, as well as 5 % of the class time	Private/ Economic	0€	Commercial/Market price	0€	-	0€	Average of market price
		Social/ External	0€	LCA	0€	-	0€	External benefits due to Reduction of potential mobility and mortality due to reduction of exposure of students to pollutants (PM10 and PM2.5)

2.2.5 Thermal comfort

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

A. Low-carbon retrofit solutions for thermal comfort

	DESCRIPTION	COST				BENEFIT		
		INVESTMENT		MAINTENANCE				
TC1	Smart control of existing rollable awnings	Private/ Economic	50 €/unit	Commercial/Market price	5% of cost of investment + electricity consumption	-	Reduction of cost associated to energy consumption around 20,0%	Average of market price
		Social/ External	Production of equipment (EC1)	LCA+ExternE	5% of external cost of investment + electricity consumption (EC2)	LCA+ExternE	Reduction of emissions from energy consumption around 20,0%	LCA+ExternE
TC2	Free-cooling at night along summer period	Private/ Economic	Users complete the info	Commercial/Market price	0€	-	Reduction of cost associated to energy consumption around 7.5%	Average of market price
		Social/ External	Production of equipment (EC1)	LCA+ExternE	0€	LCA+ExternE	Reduction of emissions from energy consumption around 7.5%	LCA+ExternE
TC3	New rollable awnings	Private/ Economic	Users complete the info	Commercial/Market price	5% of cost of investment	-	Reduction of cost associated to energy consumption around 12.5%	Average of market price
		Social/ External	Production of equipment (EC1)	LCA+ExternE	5% of external cost of investment	LCA+ExternE	Reduction of emissions from energy consumption around 12.5%	LCA+ExternE
TC4	New windows	Private/ Economic	Users complete the info	Commercial/Market price	0€	-	Reduction of cost associated to energy consumption around 25%	Average of market price
		Social/ External	Production of equipment (EC1)	LCA+ExternE	0€	LCA+ExternE	Reduction of emissions from energy consumption around 25%	LCA+ExternE
TC5	Facade insulation (ETICS of EPS)	Private/ Economic	Users complete the info	Commercial/Market price	0€	-	Reduction of cost associated to energy consumption around 35%	Average of market price

TC6	Roof insulation	Social/ External	Production of equipment (EC1)	LCA	0€	LCA+ExternE	Reduction of emissions from energy consumption around 35%	LCA+ExternE
		Private/ Economic	Users complete the info	Commercial/Market price	0€	-	Reduction of cost associated to energy consumption around 35%	Average of market price
		Social/ External	Production of materials required (EC1)	LCA	0€	LCA+ExternE	Reduction of emissions from energy consumption around 20,0%	LCA+ExternE

2.2.6 Energy

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

A. Low-carbon retrofit solutions for energy systems

	DESCRIPTION	COST				BENEFIT		
		INVESTMENT		MAINTENANCE				
E1	Efficient individual heat pumps ¹	Private/ Economic	Users complete the info	Commercial/Market price	5% of cost of investment + electricity consumption	Average of market price	Reduction of cost associated to energy consumption around 12,50%	Average of market price
		Social/ External	Production of equipment and Consumption of electricity (EC1)	LCA	5% of external cost of investment + electricity consumption (EC2)	LCA+ExternE	Reduction of emissions from energy consumption around 12,5%	LCA+ExternE
E2	Chiller	Private/ Economic	Users complete the info	Commercial/Market price	5% of cost of investment + electricity consumption	Average of market price	Reduction of cost associated to energy consumption around 12,50%	Average of market price
		Social/ External	Production of equipment (EC1)	LCA	5% of external cost of investment + fuel consumption (EC2)	LCA+ExternE	Reduction of emissions from energy consumption around 12,5%	LCA+ExternE
E3	Centralised biomass boiler	Private/ Economic	Users complete the info	Commercial/Market price	5% of cost of investment + fuel consumption	Average of market price	Reduction of cost associated to energy consumption around 7,50%	Average of market price
		Social/ External	Production of equipment (EC1)	LCA	5% of external cost of investment + fuel consumption (EC2)	LCA+ExternE	Reduction of emissions from energy consumption around 7,5%	LCA+ExternE
E4	Centralised condensing boiler	Private/ Economic	Users complete the info	Commercial/Market price	5% of cost of investment + electricity consumption	Average of market price	Reduction of cost associated to energy consumption around 30%	Average of market price
		Social/ External	Production of equipment (EC1)	LCA	5% of external cost of investment + fuel consumption (EC2)	LCA+ExternE	Reduction of emissions from energy consumption around 30%	LCA+ExternE

E5	Solar thermal energy	Private/ Economic	Users complete the info	<i>Commercial/Market price</i>	5% of cost of investment + electricity consumption	<i>Average of market price</i>	Reduction of cost associated to energy consumption around 12,50%	<i>Average of market price</i>
		Social/ External	Production of equipment (EC1)	<i>LCA</i>	5% of external cost of investment + electricity consumption (EC2)	<i>LCA+ExternE</i>	Reduction of emissions from energy consumption around 12,5%	<i>LCA+ExternE</i>
E6	Photovoltaic energy	Private/ Economic	Users complete the info	<i>Commercial/Market price</i>	5% of cost of investment (EC2)	<i>Average of market price</i>	Reduction of cost associated to energy consumption around 12,50%	<i>Average of market price</i>
		Social/ External	Production of equipment (EC1)	<i>LCA</i>	5% of external cost of investment (EC2)	<i>LCA+ExternE</i>	Reduction of emissions from energy consumption around 12,5%	<i>LCA+ExternE</i>

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

DESCRIPTION			COST			BENEFIT		
			INVESTMENT		MAINTENANCE			
E9	LED lights	Private/ Economic	Users complete the info	<i>Commercial/Market price</i>	5% of cost of investment (EC2)	<i>Average of market price</i>	Reduction of cost associated to energy consumption around 7.5%	<i>Average of market price</i>
		Social/ External	Production of equipment and electricity consumption (EC1)	<i>LCA</i>	5% of external cost of investment (EC2)	<i>LCA+ExternE</i>	Reduction of emissions from energy consumption around 7.5%	<i>LCA+ExternE</i>

2.2.7 Water

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

A. Low-carbon retrofit solutions for water

	DESCRIPTION	COST				BENEFIT		
		INVESTMENT		MAINTENANCE AND OPERATION				
W1	Reducers of water flow for faucets	Private/ Economic	1,50-3€/unit	Commercial/Market price	5% (substitution and material repairing)	Commercial/Market price	Decrease the expenditure in water	Commercial/Market price
		Social/ External	Material production for infrastructure (EC1)	LCA	Water use (EC2)	LCA	Decrease the amount of consumed water	LCA + ExternE Avoided emissions due to supply of tap water
W2	Reducers of water flow for showers	Private/ Economic	3-5€/unit	Commercial/Market price	5% (substitution and material repairing)	Commercial/Market price	Decrease the expenditure in water	Commercial/Market price
		Social/ External	Material production for infrastructure (EC1)	LCA	Water use (EC2)	LCA	Decrease the amount of consumed water	LCA + ExternE Avoided emissions due to supply of tap water
W3	Self-timer for faucets	Private/ Economic	From 55€/unit	Commercial/Market price	5% (substitution and material repairing)	Commercial/Market price	Decrease the expenditure in water	Commercial/Market price
		Social/ External	Material production for infrastructure (EC1)	LCA	Water use (EC2)	LCA	Decrease the amount of consumed water	LCA + ExternE Avoided emissions due to supply of tap water
W4	Self-timer for shower	Private/ Economic	10-15€	Commercial/Market price	5% (substitution and material repairing)	Commercial/Market price	Decrease the expenditure in water	Commercial/Market price
		Social/ External	Material production for infrastructure (EC1)	LCA	Water use (EC2)	LCA	Decrease the amount of consumed water	LCA + ExternE Avoided emissions due to supply of tap water

W5	Deposit to collect rain water	Private/ Economic	2900 € + 150 €/m3 additional ⁹	Commercial/Market price	5% (substitution and material repairing) Energy consumption (electricity consumption of pump)	Commercial/Market price	Decrease the expenditure in water	Commercial/Market price
		Social/ External	Material production for infrastructure (EC1)	LCA	5% (substitution and material repairing) Energy consumption (electricity consumption of pump) Water consumption EC2	LCA	Decrease the amount of consumed water	LCA + ExterneE Avoided emissions due to supply of tap water
W6	Flushing with double discharge	Private/ Economic	20-30€/unit	Average of market price	5% (substitution and material repairing)	Commercial/Market price	Decrease the expenditure in water	Commercial/Market price
		Social/ External	Material production for infrastructure (EC1)	LCA	Water use (EC2)	LCA	Decrease the amount of consumed water	LCA + ExterneE Avoided emissions due to supply of tap water
W7	Variable speed pumps (for water systems)	Private/ Economic	-	-	-	-	Decrease the expenditure in water	Commercial/Market price
		Social/ External	-	-	-	-	Decrease the amount of consumed water	LCA + ExterneE Avoided emissions due to supply of tap water

⁹ <https://www.renewableenergyhub.co.uk/rainwater-harvesting-information/rainwater-collection-cost.html>

ANEXO I

Table A. 1 Damage costs per tonne of each pollutant in eur 2016, for the different countries

		Eur2016/tonne of pollutants			
		Spain	France	Gibraltar	Portugal
HH, LB, crops, MD	NH ₃	5,31E+03	1,45E+04	1,57E+04	3,58E+03
	NMVOC	8,69E+02	1,20E+03	1,30E+03	9,59E+02
	NOX	5,60E+03	1,65E+04	1,78E+04	2,68E+03
	PPMco	1,54E+03	2,18E+03	2,36E+03	1,68E+03
	PPM ₂₅	2,55E+04	4,78E+04	5,16E+04	3,08E+04
	SO ₂	8,79E+03	1,65E+04	1,79E+04	6,85E+03
	Cd	1,49E+05	1,45E+05	1,57E+05	1,48E+05
	As	9,44E+05	9,27E+05	1,00E+06	9,36E+05
	Ni	2,11E+03	4,04E+03	4,36E+03	2,43E+03
	Pb	5,07E+05	4,80E+05	5,18E+05	4,99E+05
	Hg	1,52E+07	1,39E+07	1,50E+07	1,49E+07
	Cr	1,26E+04	2,21E+04	2,39E+04	1,33E+04
	Cr-VI	6,29E+04	1,11E+05	1,20E+05	6,64E+04
	Formaldehyde	3,79E+02	3,47E+02	3,75E+02	3,73E+02
	Dioxin	7,01E+10	6,43E+10	6,94E+10	6,89E+10
GWP	CO ₂	1,41E+01	1,29E+01	1,39E+01	1,38E+01
	CH ₄	5,18E+02	4,74E+02	5,13E+02	5,09E+02
	N ₂ O	2,29E+04	2,10E+04	2,26E+04	2,25E+04
	SF ₆	1,09E+03	1,00E+03	1,08E+03	1,07E+03
	Aerosols, radioactive, unspecified	4,88E-04	4,47E-04	4,83E-04	4,80E-04
Radionucleidos	Carbon-14 (air)	2,65E-03	2,43E-03	2,62E-03	2,60E-03
	Carbon-14 (water)	1,78E-05	1,63E-05	1,76E-05	1,75E-05
	Cesium-137 (air)	1,81E-03	1,65E-03	1,79E-03	1,77E-03
	Cesium-137	2,39E-05	2,19E-05	2,37E-05	2,35E-05
	Hydrogen-3, Tritium (air)	9,67E-07	8,86E-07	9,57E-07	9,50E-07
	Hydrogen-3, Tritium (water)	2,07E-07	1,90E-07	2,05E-07	2,04E-07
	Iodine-129	1,56E-02	1,43E-02	1,55E-02	1,53E-02
	Iodine-131 (air)	4,95E-03	4,54E-03	4,90E-03	4,87E-03
	Iodine-131 (water)	1,55E-02	1,42E-02	1,53E-02	1,52E-02
	Iodine-133	7,13E-07	6,53E-07	7,05E-07	7,00E-07
	Krypton-85	5,22E-08	4,78E-08	5,17E-08	5,13E-08
	Noble gases, radioactive, unspecified	1,05E-07	9,61E-08	1,04E-07	1,03E-07
	Radon-222	2,74E-08	2,52E-08	2,72E-08	2,70E-08
	Thorium-230	7,32E-03	6,71E-03	7,25E-03	7,19E-03
	Uranium-234 (air)	1,95E-03	1,79E-03	1,93E-03	1,92E-03
	Uranium-234	4,83E-05	4,43E-05	4,78E-05	4,75E-05
	Uranium-235 (air)	1,59E-03	1,46E-03	1,58E-03	1,56E-03
	Uranium-235	1,74E-04	1,60E-04	1,73E-04	1,71E-04
	Uranium-238 (water)	1,71E-03	1,56E-03	1,69E-03	1,68E-03
	Uranium-238	4,79E-04	4,39E-04	4,74E-04	4,71E-04
	Strontium-90	1,15E-06	1,05E-06	1,14E-06	1,13E-06
	Rubidium-106	8,05E-07	7,38E-07	7,97E-07	7,91E-07
	Lead-210	2,44E-04	2,24E-04	2,42E-04	2,40E-04
	Polonium-210	2,44E-04	2,24E-04	2,42E-04	2,40E-04
	Radium-226	1,46E-04	1,34E-04	1,45E-04	1,44E-04

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