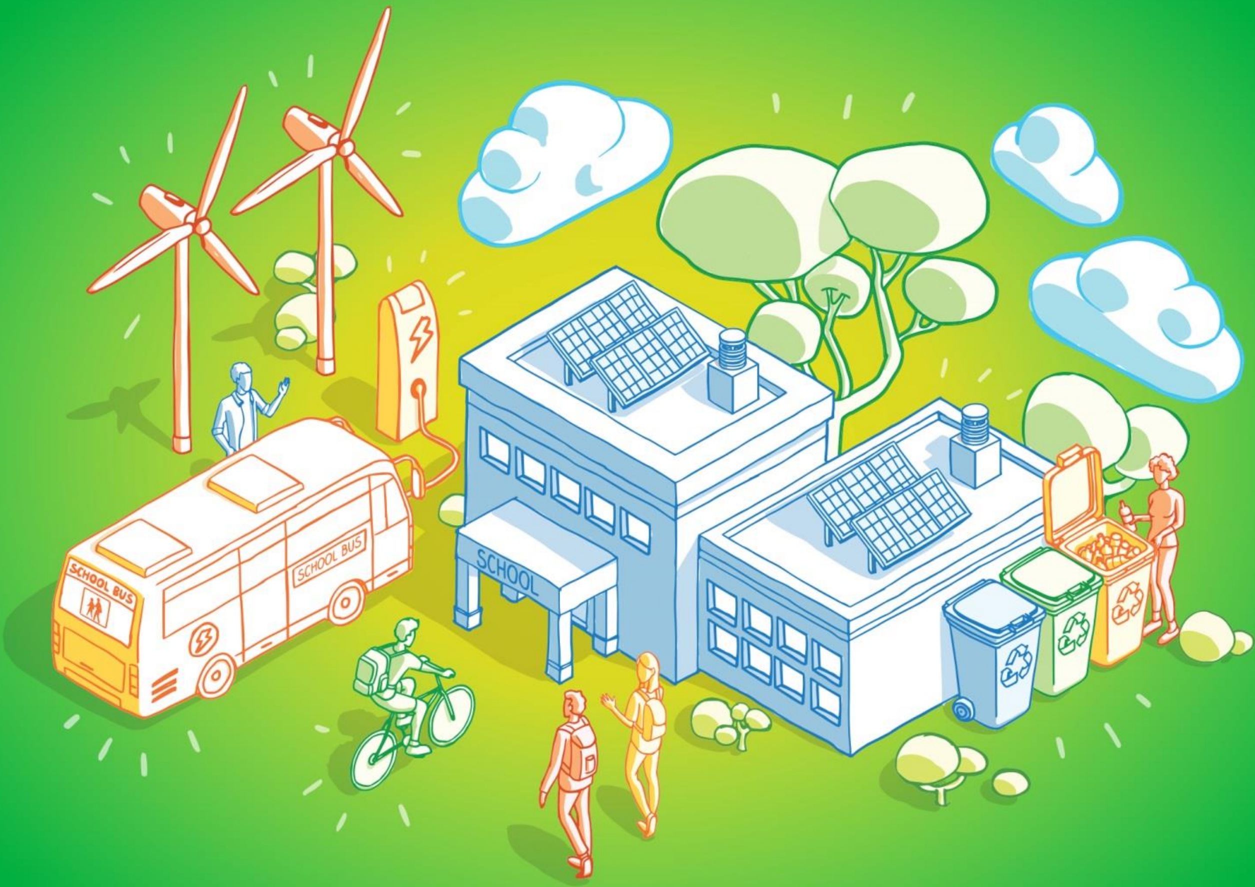
ClimACT



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

Life Cycle Assessment Module

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WWW.CLIMACT.NET

Author

Ana R. Gamarra
Yolanda Lechón
Ciemat

Executive Summary

The Report describes the work developed by CIEMAT Team in the frame of ClimACT Project. CIEMAT has designed a module for ClimACT tool to calculate the Life Cycle impacts of a student in a school from the four regions of the project scope using the Life Cycle Assessment methodology. This deliverable 2.5.1 is the result of the Activity 2.5 – LCA Module, and it contributes towards the objectives of the products of the WP2 - Development of tools to support the transition to a low-carbon economy in schools.

1 Life Cycle Assessment Tool

The aims of WP2 is the development of tools to support the transition to a low-carbon economy in schools by monitoring and benchmarking environment and energy performance, identifying sustainable and cost efficient solutions, based on procurement related and behavioral-related measures, and identifying mechanisms to economically enable the application of these solutions.

Within WP2, task 2.5 aims at creating a tool that enables the schools to carry out a Life Cycle Assessment of the school activities and installations in a very user friendly way.

The development of the LCA module has been preceded by the realization of LCA studies in 3 schools. The results of these studies have provided useful insights into the most important environmental impacts generated by schools and have allowed the selection of the main and most frequent hotspots and environmental distresses.

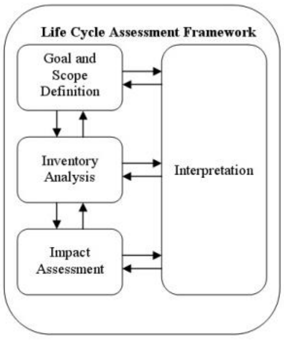
Aspects such as amount and type of fuel consumed for heating purposes, electricity consumption for different purposes, water consumption, paper and other materials consumption are included in the tool in its current version. Based on these results, the environmental impact of the status quo-situation of the schools can be estimated.

In a future version of the module, the different energy retrofitting and smart management strategies and a selection of measures proposed in the tool such a BSM retrofitting measures will be assessed in terms of energy demand, CO2 emissions and other environmental impacts, using LCA. The benefits of different strategies will be calculated based on a comparison with the status-quo situation.

The tool has been designed in excel format but it will be programmed to be part of the ClimACT tool.

2 Methodology

The work carried out makes use of the multi-criteria and holistic approach offered by LCA following the guidelines of ISO 14040 and ISO 14044 standards. LCA is a methodology that allows the evaluation of the environmental impacts associated to all the stages of a product's life cycle and encompasses extracting raw materials, processing, manufacturing, transportation and distribution, use, reuse and recycle and final disposal.



ISO 14040:2006

Figure 1. LCA Methodology Framework

The framework of the analysis includes four phases: i) Definition of objective and scope; ii) Inventory Analysis; iii) Impact Assessment and iv) Interpretation of results.

<u>LCA module plan according to LCA methodology</u>

The development of the LCA module started with realization of a LCA in 3 schools. The first step was the design of a template to collect info from schools establishing the goal and key aspects of the system (preliminary template). After that, that template was applied to collect information from the schools, considering the information easily available in schools to get the first approach to the inventory data collection. The analysis results have been used in order to characterize the environmental impacts generated by schools and have allowed the selection of the main and most frequent hotspots and environmental distresses.

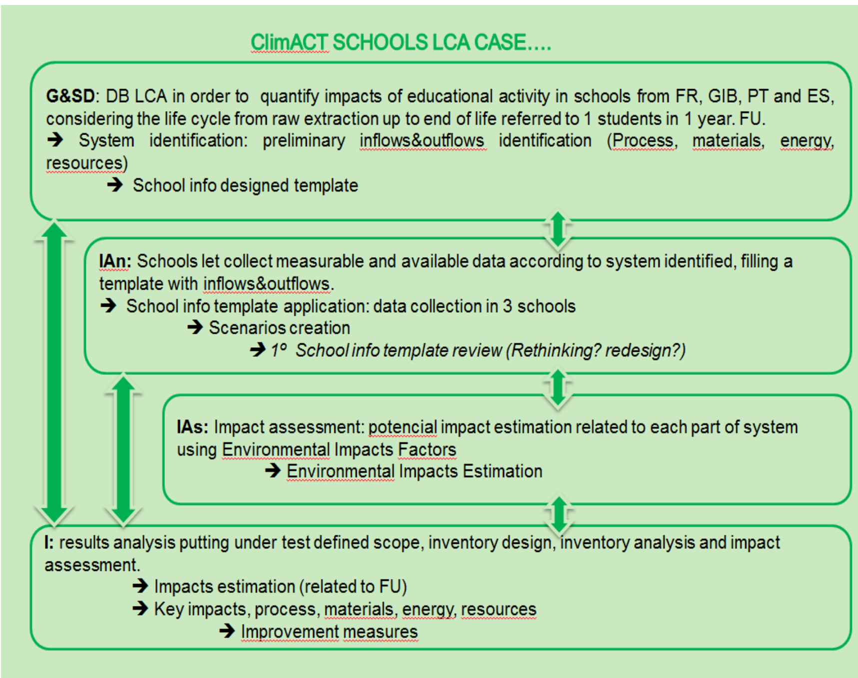


Figure 2. LCA framework adaptation to Climact LCA Module plan.

Goal and scope definition

The goal of this LCA is the quantification of the environmental impacts associated to the consumption of energy, materials and water of educational centers located in the regions of Spain, France, Gibraltar and Portugal.

Functional unit. The function considered in this LCA is a student activity for a course. The inventory of the whole energy, materials and water consumption will be referred to this period and will be calculated per school. Results will be the expressed per year and per student and for information also per m2.

Scope and system boundaries. The work is focused on the quantification of the environmental impacts for educational activities per student.

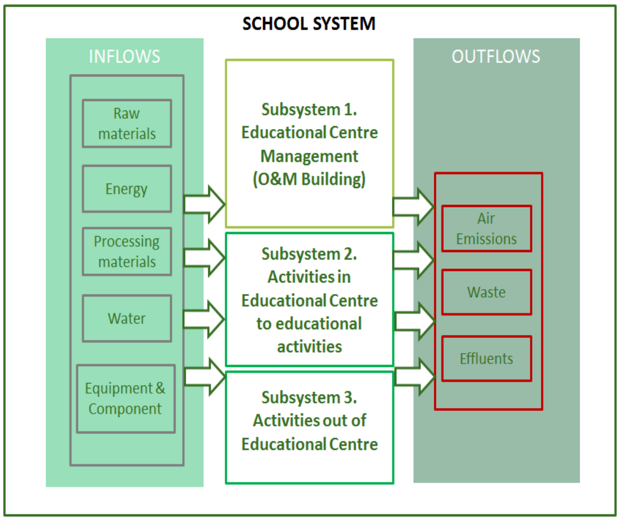


Figure 3. School system.

Figure 3. **School system**.depicts the total system boundaries considered and the activities considered. Important sources of information and consulted databases have been selected. Processes whose contribution to mass and energy flows are known to be important and whose emissions are relevant to the environment were selected and investigated. Ecoinvent database has been used for the most common processes such as transport, fuels and basic materials and chemicals. The LCA software used has been SIMAPRO™.

3 Environmental Impact Assessment

LCA module is oriented to obtain impact results referred to different impact categories. ILCD[1] handbook proposed methods have been used to analyze the impacts. As a result, the impact factors included in the LCA module correspond to the assortment of impact methodologies and impact categories which ILCD includes. Information was developed by the Institute for Environment and Sustainability in the European Commission Joint Research Centre (JRC), in co-operation with the Environment DG. It is part of the Commission's promotion of sustainable consumption and production patterns.

Table 1. Impact Categories included in ILCD Method.

Impact category	Recommended method	Indicator
Climate change	Baseline model of 100 years of the IPCC	**kg CO2 eq**
Ozone depletion	Steady-state ODPs 1999 as in WMO assessment	**kg CFC-11 eq**
Human toxicity, non-cancer effects	USEtox model (Rosenbaum et al, 2008)	**CTUh**
Human toxicity, cancer effects	USEtox model (Rosenbaum et al, 2008)	**CTUh**
Particulate matter	RiskPoll model (Rabl and Spadaro, 2004) and Greco et al 2007	**kg PM2.5 eq**
Ionizing radiation HH	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	**kBq U235 eq**
Photochemical ozone formation	LOTOS-EUROS (Van Zelm et al, 2008) as applied in ReCiPe	**kg NMVOC eq**
Acidification	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	**molc H+ eq**
Terrestrial eutrophication	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	**molc N eq**
Freshwater eutrophication	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	**kg P eq**
Marine eutrophication	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	**kg N eq**
Freshwater ecotoxicity	USEtox model, (Rosenbaum et al, 2008)	**CTUe**
Land use	Model based on Soil Organic Matter (SOM) (Milà i Canals et al, 2007)	**kg C deficit**
Water resource depletion	Model for water consumption as in Swiss Ecoscarcity (Frischknecht et al, 2008)	**m3 water eq**
Mineral, fossil & renewable resource depletion	CML 2002 (Guinée et al., 2002)	**kg Sb eq**

Method was developed by the Institute for Environment and Sustainability in the European Commission Joint Research Centre (JRC), in co-operation with the Environment DG. It is part of the Commission's promotion of sustainable consumption and production patterns.

References:

[1] International Reference Life Cycle Data System

- European Commission - Joint Research Centre. 2011. International Reference Life Cycle Data System (ILCD) Handbook Recommendations for Life Cycle Impact Assessment in the European context. First edition November 2011. EUR 24571 EN. Luxemburg. Publications Office of the European Union; 2011
- Frischknecht, R., Braunschweig, A., Hofstetter P., Suter P. (2000). Modelling human health effects of radioactive releases in Life Cycle Impact Assessment. Environmental Impact Assessment Review, 20 (2) pp. 159-189.
- Greco, S.L., Wilson, A.M., Spengler J.D., and Levy J.I. (2007). Spatial patterns of mobile source particulate matter emissions-to-exposure relationships across the United States. Atmospheric Environment (41), 1011-1025.
- Guinée, J.B. (Ed.), Gorrée, M., Heijungs, R., Huppes, G., Kleijn, R., de Koning, A., Van Oers, L., Wegener Sleeswijk, A., Suh, S.,. Udo de Haes, H.A, De Bruijn, J.A., Van Duin R., Huijbregts, M.A.J. (2002). Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards. Series: Eco-efficiency in industry and science. Kluwer Academic Publishers. Dordrecht (Hardbound, ISBN 1-4020-0228-9; Paperback, ISBN 1-4020-0557-1).
- IPCC (2007). IPCC Climate Change Fourth Assessment Report: Climate Change 2007. http://www.ipcc.ch/ipccreports/assessments-reports.htm
- Milà i Canals L, Romanyà J, Cowell SJ (2007b). Method for assessing impacts on life support functions (LSF) related to the use of 'fertile land' in Life Cycle Assessment (LCA). J Clean Prod 15 1426-1440
- Rabl, A. and Spadaro, J.V. (2004). The RiskPoll software, version is 1.051 (dated August 2004). www.arirabl.com
- Rosenbaum, R.K., Bachmann, T.M., Gold, L.S., Huijbregts, M.A.J., Jolliet, O., Juraske, R., Köhler, A., Larsen, H.F., MacLeod, M., Margni, M., McKone, T.E., Payet, J., Schuhmacher, M., van de Meent, D., Hauschild, M.Z. (2008): USEtox - The UNEP-SETAC toxicity model: recommended characterisation factors for human toxicity and freshwater ecotoxicity in Life Cycle Impact Assessment. International Journal of Life Cycle Assessment, 13(7): 532-546, 2008
- Seppälä, J., Posch, M., Johansson, M., Hettelingh, J.P. (2006). Country-dependent Characterisation Factors for Acidification and Terrestrial Eutrophication Based on Accumulated Exceedance as an Impact Category Indicator. International Journal of Life Cycle Assessment 11(6): 403-416.
- Struijs, J., Beusen, A., van Jaarsveld, H. and Huijbregts, M.A.J. (2009). Aquatic Eutrophication. Chapter 6 in: Goedkoop, M., Heijungs, R., Huijbregts, M.A.J., De Schryver, A., Struijs, J., Van Zelm, R. (2009). ReCiPe 2008 A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. Report I: Characterisation factors, first edition.

- Van Zelm, R., Huijbregts, M.A.J., Den Hollander, H.A., Van Jaarsveld, H.A., Sauter, F.J., Struijs, J., Van Wijnen, H.J., Van de Meent, D. (2008). European characterization factors for human health damage of PM10 and ozone in life cycle impact assessment. Atmospheric Environment 42, 441-453.

4 Module Structure

The module structure has been divided in two databases:

- Inflows and Outflows Database (flows data base, FDB): it contains flows calculations and relationship between inputs and outputs, and between process of different activities, connecting inflows and outflows, in suitable units to be connected with Impact Factors DB.
- Impact factors database (IFDB): contains the factors calculated per unit processes to be related with impact factors.

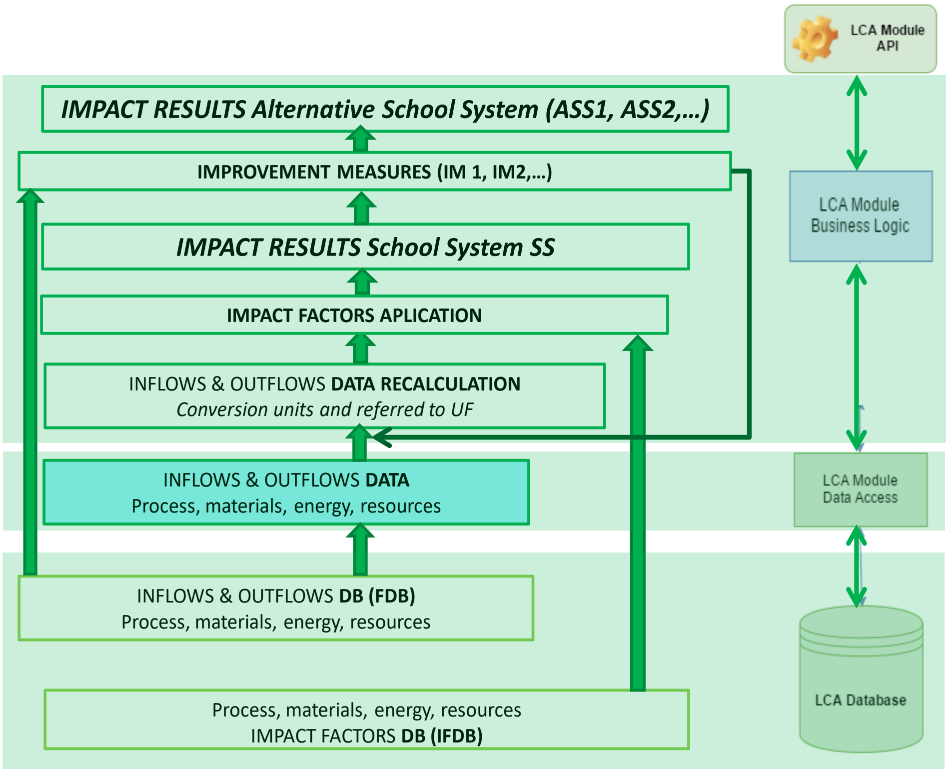


Figure 4. LCA Module Structure.

Flows have been designed according to the inventory analysis, and individual processes and scenarios for each process have been calculated (FDB). Finally, scenarios per process included are analyzed by ILCD Method to create IFDB. That means that IFDB contains impact factors per each process, and these factors are connected with the flows of FDB. Both parts have been integrated in the LCA Module.

FDB is feed with results of data inventory analysis. The schools have to be characterized and quantified according to a collection survey designed to gather information as inputs to elaborate the inventory. Module data access is structured in order to ask about goods and services consumptions to achieve an adequate characterization, and allow calculations. The design of the inputs data access collection has been adapted to the system scheme questionnaire format in order to provide a logical structure, providing a tool appearance (design by tabs). According to the school system scheme, input collection and calculations are divided in 3 subsystems and each one is subdivided by activities groups (tab = activity). Three tabs more collect general info from: General data, electricity consumption and water consumption.

5 Inventory: required inputs, FDB and IFDB

The inventory describes the inputs and information analysis which is needed to obtain flows of the system, as well as how the impact factors are calculated. In other words, it describes required inputs, FDB and IFDB per activity in the system.

Table 2. Activities included in the System, per subsystem.

Subsystem	Activity (Tab)
	General data Electricity Water
1 EC/School Management	Heating
	Hot water
	Cooling
	Ventilation
	Lighting
	Gardening
	Cleaning & Maintenance
	Food Service
	Wastes
2 Educational Activities in the EC/School	Students activities - classroom
	Laboratory activities
	Gym activities
	Library
	Administrative and support activities
3 Transport and Mobility	Outings/excursions transport
	Mobility

Each tab in the LCA module excel file (Annex I .xls format) corresponds to each activity referred in the **Error! Reference source not found.** where inputs can be completed. As a result the LCA module calculates impact per school, per student, and per m2 of usable area.

General data

This part collects info about school (name, country, days of curricular activity, courses, and number of student and staff, etc.) which is needed to the rest of calculations.

Electricity

Electricity is one of the main factors to take into account. Electricity is used as input in a multitude of activities and processes developed in schools. The potential environmental emissions linked to electricity consumption are strongly dependent on the electricity sources used in each country.

Two types of sources have been considered, electricity from the national grid, produced out of the school, which comes from outside the school (info from invoices), and electricity production *in site* (Photovoltaics Solar Panels, Wind energy, *Generators (engine)).*

Electricity grid impact factor

The diversity of technologies and the contribution from each one to the "mix" in each country is a determinant factor which must be characterized in order to create an updated scenario of electricity which schools use to supply their requirements. Table 3 shows the electricity grid considered per each country/region.

Table 3. Electricity mix percentages per Country/Region grid and technology.

Technology	Spain	France	Portugal	Gibraltar
Nuclear	18,9%	74,0%	0,0%	0,0%
Hydro	10,6%	10,4%	16,4%	0,0%
Hydro Pumped	1,1%	0,9%	1,9%	0,0%
Geothermal	0,0%	0,0%	0,3%	0,0%
Solar PV	2,8%	1,3%	1,3%	0,0%
Solar Thermal	1,8%	0,0%	0,0%	0,0%
Wind	16,6%	3,8%	19,4%	0,0%
Gas CC	10,0%	2,1%	9,6%	0,0%
Oil Products	4,4%	0,3%	0,0%	100,0%
Carbon	17,6%	1,9%	25,3%	0,0%
Biomass	1,3%	0,4%	2,1%	0,0%
Gas CHP	8,5%	1,9%	7,7%	0,0%
Oil Products CHP	0,8%	0,0%	0,0%	0,0%
Coal CHP	0,1%	0,1%	0,0%	0,0%
Biomass CHP	0,3%	1,0%	2,3%	0,0%
Imports	5,2%	1,8%	13,6%	0,0%

The scenarios of electricity were created using information of electricity generation per each country/region, and adding transport and distribution process of electricity until "low tension grid electricity distribution",. The results are impact factors per kWh of electricity consumed in the school.

Data of electricity mixes have been obtained from:

- Eurostat, 2017. http://ec.europa.eu/eurostat/web/energy/data/database
- REN, Dados Técnicos, 2016 https://www.ren.pt/files/2017-03/2017-03-24140032_7a820a40-3b49-417f-a962-6c4d7f037353$$7319a1b4-3b92-4c81-98d7-fea4bfefafcd$$912d7292-4d3c-4faa-8a0b-2f750e707e15$$File$$pt$$1.pdf
- REE, Informe eléctrico 2015, 2016. http://www.ree.es/sites/default/files/downloadable/inf_sis_elec_ree_2015.pdf
- Minetur, Libro de la energía 2015, 2016. http://www.minetad.gob.es/energia/balances/Balances/LibrosEnergia/Energia_2015.pdf

- RTE, Annual Electricity Report 2015, 2016. http://www.rte-france.com/sites/default/files/2015_annual_electricity_report.pdf
- Gibraltar data has been taken from the web of the Gibraltar government (Government of Gibraltar, 2014) and reports from the energy and environment department (Department of the Environment of the Ministry for Health, Environment, Energy & Climate Change of Her Majesty's Government of Gibraltar, Febrero 2015)

References:

- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230.

In site electricity flows and impact factors

Photovoltaic (PV) solar panels and wind energies are real renewable options to produce power in buildings. To simplify the scenario, standard ratios of production have been used to calculated electricity production using bibliography and commercial information.

PV solar panel electricity production has been calculated considered LCA inventories of the active panel area with different types of solar cells and efficiencies provided by the Ecoinvent database (Table 4). PV electricity impact results have been calculated considering the surface of panels with different capacity rate by type, and one extra (no data, ND) as an average of all types in order to be applied in case users do not know the type.

Table 4. Types of PV Solar Panel.

Type of PV cells	**Panel capacity rate (w/m2)**
Singlecrystalline silicon cells (single-Si)	140
Multicrystalline silicon cells (multi-Si)	136
Ribbon silicon cells (ribbon-Si)	125
Amorphous silicon cells (a-Si)	65
CIS cells - copper , indium and selenium (CIS)	108
Cadmium telluride cells (CdTe)	117

In the case of energy produced by wind, calculation of production has been carried out using a commercial simulator provided by ENAIR[2]. Wind power depends on technology, but it is highly determined by wind speed. Wind speed is once influenced by the presence of obstacles (local effect associated to buildings high, for example) and the wind regime in the specific location (regional effects related to cost proximity, mountains range, valleys, plane areas, etc.). The simulator presents an aerogenerator model, with different capacity (3, 5, 10 and 20 kW). Simulator lets choose the parameters according to the school location: city, village in mountainous location, village in plane location and cost location (<5 km to the cost). Four locations in each country were chosen as reference (except for Gibraltar, which is strongly characterized by coastal wind), taking into account bibliography about the variability of wind (Bett et al, 2012). Impact factor of generation of kWh by wind energy have also been obtained from Ecoinvent database.

In addition, schools could have power generator (engines) as an auxiliary source of energy for activities or special uses, so the tool includes scenarios to generate electricity using fuels for combustion (Diesel, gasoline, naphtha and LPG). Inputs required are fuel consumption per year.

If fuel consumption is unknown, power and operation time are used to estimate an electricity production, in order to quantify primary fuel consumption (Diesel, gasoline, naphtha or LPG).

Combustion process in the generator scenario (engine) to produce electricity has been calculated using LHV of IDEA and air pollutant emission inventories of EEA to calculate impact factors.

References:

- Niels Jungbluth, Matthias Stucki, Karin Flury, Rolf Frischknecht, Sybille Büsser ESU-services Ltd., Life Cycle Inventories of Photovoltaics, 2012, Uster

  http://treeze.ch/fileadmin/user_upload/downloads/PublicLCI/jungbluth-2012-LCI-Photovoltaics.pdf
- P. E. Bett, H. E. Thornton, and R. T. Clark. European wind variability over 140 yr (2012). Advances in Science & Research 12th EMS Annual Meeting and 9th European Conference on Applied Climatology (ECAC) Met Office Hadley Centre, Exeter, UK http://www.adv-sci-res.net/10/51/2013/asr-10-51-2013.pdf
- IDAE, poderes caloríficos http://www.idae.es/uploads/documentos/documentos_PCI_Combustibles_Carburantes_final_valores_Update_2014_0830376a.xlsx

[2] ENAIR Wind Energy Simulator (http://www.enair.es/es/aerogeneradores/E70PRO9)

- EMEP/EEA air pollutant emission inventory guidebook 2016. www.eea.europa.eu/publications/...eea...combustion/1-a-4-small-combustion-2016
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230.

On one hand, with the results of calculation of country/regional electricity grid scenario (generation, transport and distribution), a factor per country and impact category has been calculated. On the other hand, the results of the scenarios of the *in site* electricity production depending on data from schools are used bythe tool to calculate a specific factor. Finally, the tool calculates a global electricity impact factor in terms of the impact per kWh (for each impact). Electricity global factor is used as a factor to the electricity which is associated in each activity in the different activities (tabs).

The LCA module questionnaire ask the user for data about technical characteristics (machinery, appliances, etc.) used to develop the different activities (tabs in the tool), to calculate the electricity consumption by process (included in the activities), since one objective of the LCA module is to be able to allocate environmental impact to activities. To guarantee that whole electricity which schools consume is included in calculation to obtain global environmental LCA results each part of consumption by activities is subtracted from the invoice total consumption, and the difference represents the electricity from "other non-specific activities", being considered in life cycle assessment of the system.

Electricity Credit

The module includes the possibility of the school supplies electricity to the grid if the school produces electricity in site but school does not consume all the production. In this case, the electricity which is provided by the school facilities is considered as avoided electricity to be produced by the national grid. Consequently, this fact has a positive environmental impact, decreasing the impact due to the electricity consumption.

Water

Usually, tap water quantities are obtained from invoices (monthly or annual), being a unique total consumption value for all school. As the same as electricity, water is also a factor data consumption which is part of a several range of activities or process such as toilet use, drinking, gardening, etc. A *priori*, main consumption could be toilet use, but the designed system do not consider toilet activity as separated activity , due to the strong influence of behavior of students and users in general what makes difficult the estimation. In the case of gardening, it would be possible to estimate the amount of water by school staff *(see gardening)*.

Water resources constitute an environmental asset of growing importance in the SUDOE space. These resources have a dual component both in the generation of clean energy and in the need for guaranteeing supplies for humans, animals, and plants and the maintenance and improvement, if appropriate, of the quality of the water. The transnational space holds large water reserves especially in France. Most of the territory of the SUDOE space is characterized by a scarcity of water and cyclical difficulties in guaranteeing supply to the population, agriculture, or industry. This situation is becoming more and more frequent in the southern area of the cooperation space, where problems of desertification and soil erosion are increasing, as Spain and Portugal. Water resources thus constitute one of the major challenges as to how to act regarding natural risks within the SUDOE space. Because that, impact factor for amount of water consumption have been characterized per country, since the scarcity state and reservoirs are different. In addition, Gibraltar main source of water is salty water, which is produce through Reverse Osmosis (AquaGib, 2017).

Furthermore, the process of extraction and distribution of water uses electricity from the grids, what makes more specific the impact factor dependent on the impact electricity factor too.

With that information, impact factors per m3 of consumed tap water from water supply network is calculated for each country.

References:

- Aqua Gib. Access in March 2017. https://www.aquagib.gi/

- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230.

Subsystem 1. School Management

This subsystem is referred to activities in the building use phase, operation and maintenance.

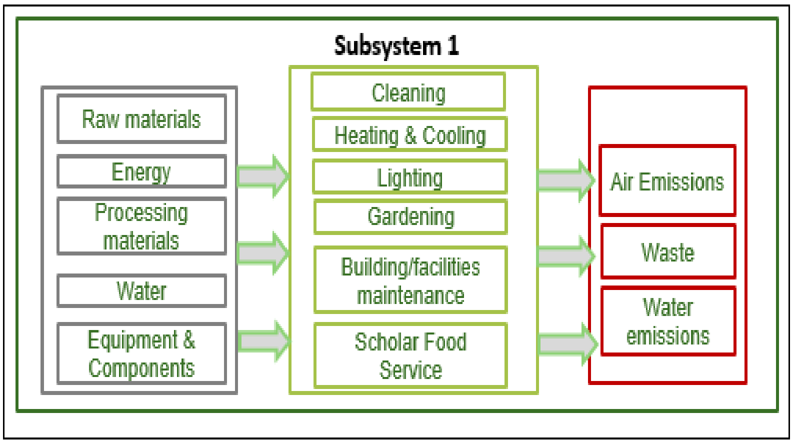


Figure 5. Subsysistem 1.

Heating

Heating of the school building requires the use of fuels and electricity. The manufacturing of the heating and cooling system itself is excluded from the analysis. Consumption was evaluated by considering the type of heating system (or systems), fuel and the technical characteristics of the equipment (power and yield). Twelve systems have been selected:

- Solar heating
- Electric resistance
- Portable heater
- Heat pump
- Geothermal heat pump
- Boiler (>100 kW) which use:
  - Natural Gas
  - Fuel oil
  - Diesel
  - Coal
  - Biomass (pellets)
  - Biofuel

Solar heating: due to the variability of influential factors the user must know the power and yield of the system in the location. And the production is obtained using the information about time utilization per year. The factor provided calculates the impact to produce heat, in terms of kWh by a solar heating system.

Electric resistance: power and utilization time is considered to calculate the electricity consumption.

Portable heater: power and utilization time are the required data. The scenario is referred to a little appliance which provides hot air, and consumes electricity.

Heat pump and geothermal heat pump: depends on COP[3], power and utilization time.

The boilers use fuel in a combustion process. The scenario has been calculated using a standard process for a "heat produced in a more than 100 kW boiler". To conversion and factor calculations LHV of IDAE and emission rates from IPCC and EEA have been used.

References:

- IDAE, poderes caloríficos http://www.idae.es/uploads/documentos/documentos_PCI_Combustibles_Carburantes_final_valores_Update_2014_0830376a.xlsx
- IPCC
- EMEP/EEA air pollutant emission inventory guidebook 2016. www.eea.europa.eu/publications/...eea...combustion/1-a-4-small-combustion-2016

Hot Water System

It is possible that hot water was produced apart from the heating system, allowing the estimation of the energy and resources consumption associated to the hot water system to supply the hot water demand. Estimated demand per student have been calculated using standard consumption criteria for design of hot water demand in different type of buildings using a technical guide of IDAE. The following assumptions have been taken:

- School without shower: 3 l/day*student, which corresponds with 57 kWh/year*student
- School with shower:15 l/day*student, which corresponds with 285 kWh/year*student

The created scenarios have been the following:

- Hot water produced with a heat pump: EER[4] is a necessary data to electricity demand calculation.
- Electric water heater: power, yield and operation time are the data to electricity demand calculation.
- Boiler which use:
    - Natural gas
    - Fuel oil
    - Diesel
    - Coal
    - Biomass
    - Biofuel

[3] Coefficient of performance of the equipment.
[4] EER: Energy Efficiency Ratio

- Solar Water Heating, can be combined with different options to support the hot water demand:
    - o SWH + electricity
    - o SWH + natural gas
    - o SWH + biomass

Boiler is referred to a combustion process in a boiler, and the impact factor has been calculated using LHV of IDAE and using emission rates of IPCC and EEA. Thermosolar energy contribution for solar water heating has been calculated with a factor of heating value of 899 kW/m2, provided as reference value similar to a LHV for fuels by IDAE.

. The scenario used to calculate impacts is referred to a heat from thermal solar energy. Auxiliary system could be electricity or natural gas and biomass.

References:

- IDAE. Guía Técnica Agua Caliente Sanitaria Central (2010) http://www.idae.es/uploads/documentos/documentos_08_Guia_tecnica_agua_caliente_sanitaria_central_906c75b2.pdf
- IDAE. Poderes caloríficos http://www.idae.es/uploads/documentos/documentos_PCI_Combustibles_Carburantes_final_valores_Update_2014_0830376a.xlsx

Cooling

Cooling system and appliance to alleviate warm temperatures requires energy consumption, and there are several types. The most common ones have been created:

- Chiller (central equipment per buildings, long lifetime): scenario considered the electricity consumption, thought EER.
- Splits appliances (with different refrigerant: fluorinated compounds, CO2 and water). Refrigerant presents leakages, more number of loads, etc.
- Fun: power
- Heat/cool pump: EER
- Geothermal heat/cool pump: EER

The calculated consumptions and emissions are the emissions from equipment electricity consumption and refrigerant leakages. For splits, inventories are based in the report from AC-Sun , a commercial study of cooling appliances, which analyses the carbon footprint of provision of cooling equipment during one year in Spain through LCA methodology. This work provides data about annual refrigerant leakages ratios for most common refrigerants. An average of these values was used, resulting a 13.2% of total refrigerant per year. The operation time corresponds to the hours per day and months in which the cooling system is used. The assumption is that the equipment works 80% of the operation time in active mode, 20% stand-by, and 10% in off-mode.

Ventilation

Ventilation moves outdoor air into a building or a room, and distributes the air within the building or room. The general purpose of ventilation in buildings is to provide healthy air for breathing by both diluting the pollutants originating in the building and removing the pollutants from it. There are different methods that may be used to ventilate a building: natural and mechanical. Building ventilation has a main ratio to calculate the electricity consumption – the ventilation rate- which is the amount of outdoor air that is provided into the space.

According to the requirements to keep a good quality air (offices, residences, reading rooms, museums, courtrooms, teaching and assailable classrooms and swimming pools) minimum values per flow (in case the school has mechanical ventilation) have been considered depending on the country:

m^3/h*student	COUNTRY
45	Spain
15[5]	France
18	Gibraltar
24	Portugal

Taking the number of students, the required flow is calculated. Two scenarios of mechanical ventilation have been created in order to calculate electricity consumption, using mean value for specific ventilators power (SPF): Only ventilation and not only ventilation (is used in cooling/heating). With flow, SPF and operation time, electricity consumption is calculated depending on the number of students.

References:

- RITE: Reglamento de Instalaciones Térmicas de Edificios. Spanish Thermal Building Regulations (Royal Decree 1027/2007 and updated in the Royal Decree 238/2013)
- Guía técnica. Instalaciones de climatización con equipos autónomos. IDAE, 2012. http://www.idae.es/uploads/documentos/documentos_17_Guia_tecnica_instalaciones_de_climatizacion_con_equipos_autonomos_5bd3407b.pdf
- Guidance Building Bulletin 101: ventilation for school buildings. March, 2014 https://www.gov.uk/government/publications/building-bulletin-101-ventilation-for-school-buildings
- Dias Pereira, L. M. Modernised Portuguese Schools - From IAQ and Thermal Comfort towards Energy Efficiency Plans. PhD Thesis in Sustainable Energy Systems. Department of Mechanical Engineering, FCTUC. February/2016 https://estudogeral.sib.uc.pt/bitstream/10316/29419/1/Modernised%20Portuguese%20Schools.pdf

[5] Requirement for nursery, primary and secondary schools.

- Reglement Sanitaire Departemental. Titre Iii Dispositions Applicables Aux Batiments Autres Que Ceux A Usage D'habitation Et Assimiles http://www.lot.gouv.fr/IMG/pdf/04_RSDtitreIII46.pdf
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20/03/2017]

Lighting

Lighting involves the use of electricity but also the yearly replacement of spent lamps. The waste stage of the lamps is considered as a waste activity (*see wastes*).

Electricity consumption is estimated taking to account a previous info collected by school (manager, LCC, LCB...), choosing 2 space per type (classroom, toilet, corridors, labs, etc) as sample, which characteristics are representative of the diversity of classrooms in the Centre. For example, the user can select one big classroom, and one little using the size as a criteria; or one class where the predominant lamp is 55 w fluorescent tube lamp and other where the predominant lamp type was 36 fluorescent tube lamp using the power as a criteria. Selecting the predominant type of lighting system, and completing the power, the number of lamps in the room and the number of room similar to the each one, a simplified calculation of the electricity consumption is made.

Five scenarios have been presented to calculate the impact of replaced lamp:

- Fluorescent tube lamp
- Compact fluorescent lamps
- Conventional tungsten lamps
- Halogen lamps
- LEDs

The required inventories for calculate life cycle of lighting fluorescent lamps production to consider the impact of replaced lamps was obtained from Tähkämo et al. (2013), Tähkämo et al. (2015). The inventory data of manufacturing, package, transport and end-of-life of LED panel luminaire was adapted to Spanish case according to U.S. Department of Energy (2012). One additional case of a conventional tungsten bulb was identified in the database in order to complete the variety of lighting types in the studied buildings. Electricity consumption was calculated considering the estimated occupancy hours per room type (offices, Classrooms, Toilets, Corridors, Laboratories, Library, gym and others), the power of lighting type and the number of luminaires.

References:

- Tähkämö, L. Life cycle assessment of light sources - Case studies and review of the analyses. Aalto University publications series - Doctoral Dissertations 111/2013, 2013.
- Life cycle assessment of road lighting luminaires - Comparison of light-emitting diode and high-pressure sodium technologies. Journal of Cleaner Production. Tähkämö, L. y Halonen, L. 2015, Journal of Cleaner Production, págs. 234-242.
- A Comparative Analysis between Fluorescent and LED illumination for Improve Energy Efficiency at IPBEN Building. . Avella, J. M., Souza, T., & Silveira, J. L. (2015). The Xi Latin-American Congress Electricity Generation And Transmission - Clagtee.
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20 03 2017].

Gardening

Gardening activities are those related to green areas care. As well as carbon sequestration, it includes machinery and equipment's use, watering, pesticides treatment and fertilization.

Carbon dioxide sequestration by vegetation

Required inputs to characterize green area are the surface of turf grass (m2), trees species and number of each one. Users have to complete info about predominant species (a maximum of three) choosing between 136 species.

Terrestrial vegetation can be a carbon dioxide sink. Vegetation captures CO_2 from the air by photosynthesis process during the growth of the plant. This CO_2 is stored in the structure of plants and soil and therefore it is removed from the atmosphere. However, at the same time losses of CO_2 can occur by mineralization of organic matter by autotrophic respiration of plants and when vegetation is removed. The sequestration and storage of carbon depends on several factors: type and age of species, climatic conditions and management of vegetation, among others. The factor considers that the existing vegetation in school is not going to be cut, but remains during the life cycle of the specie.

Data of CO_2 absorption by forest species values has been taken from Spanish National Forest Inventory, since many forest species are also planted in urban gardens and schools. This national level information is a very valuable date, due to the fact that it is updated periodically, collecting the variability of the carbon sequestration in different climates existing at Iberian Peninsula.

For species planted in the schools' gardens which do not grow naturally in the territory, the study on urban vegetation in the city of Barcelona has been applied. When data on CO_2 fixation rate is available in the National Forest Inventory this is the figure used in the tool. Otherwise, have to be considered data from Barcelona study is applied. It has been considered data for both types of vegetation (natural and urban) can be extrapolated to the other regions included in the ClimACT project: Portugal, France and Gibraltar.

Carbon dioxide sequestered by vegetation is subtracted for the global emissions of CO2 in the gardening activities.

References:

- Ex ante Carbon Dioxide Absorption Calculator. MAPAMA. 2015. http://www.mapama.gob.es/es/cambio-climatico/temas/mitigacion-politicas-y-medidas/proyectos-absorcion-co2.aspx
- Chaparro. l. & Terradas. j. Serveis Ecològics del Verd Urbà a Barcelona. Centre de Recerca Ecològica i Aplicacions Forestals. Universitat Autònoma de Barcelona.Bellaterra.Desembre2009. https://www.diba.cat/c/document_library/get_file?uuid=59c01a6c-09c5-45e1-9651-aabf4bed34d8&groupId=7294824
- Quian Y, Follet R.F. and Kimble J.M. Soil Organic Carbon Input from Urban Turfgrasses. Soil Carbon Sequestration & Greenhouse Gas Mitigation. Volume 74:Number2•March–April2010. http://www.carboncalculator.ncsu.edu/TurfGrass.aspx

- Selhorst A. and Lal R. Net carbon sequestration potential and emissions in home lawn turf grasses of the United States. Environ Manage. 2013 Jan;51(1):198-208. doi: 10.1007/s00267-012-9967-6. Epub 2012 Nov 4. https://www.ncbi.nlm.nih.gov/pubmed/23124590
  Hamido S. A, Guertal E.A., Wood C.W. Carbon Sequestration under Warm Season Turfgrasses in Home Lawns Journal of Geoscience and Environment Protection, 2016, 4, 53-63 http://file.scirp.org/pdf/GEP_2016091915581709.pdf
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20 03 2017].

Gardening machinery/equipment's use

The nature and scope of school green spaces varies strongly. Schools could have recreational lawn areas, gardens and some trees, different types of flora and scholar orchard. The area dedicated to "green spaces" is also highly variable.

The scenario considered supposes that not heavy machinery is needed. The tool asks about petrol consumption, and emissions are calculated according to that consumption. Equipment selected to be used in "green areas" of the schools is categorized as non- road equipment. Machinery commonly used in gardening is mainly fueled by petrol. The type of gardening equipment selected includes garden trimmers, lawn mowers, chain saws, garden shredders, wood cutters, suction machines and shrub clearers among others.

Relevant emissions from gasoline combustion in 2 or 4 stroke engines from 1 to 3 kW are CH_4, CO_2, N_2O, SO_2, NO_X, NMVOC, CO and NH_3 (Winter. 2012). Data from hydrocarbons (HC) and small particles (PM) have been collected from EPA-420 (2010).

References:

- EPA-420-R-10-019. Exhaust Emission Factors for Nonroad. Engine Modeling. Spark-Ignition. NR-010f. July 2010. U.S. Environmental Protection Agency. http://www.trpa.org/wp-content/uploads/2010-EPA-Non-road-spark-ignition-emissions.pdf
- Winther. M. 2012: Danish emission inventories for road transport and other mobile sources. Inventories until the year 2010. National Environmental Research Institute. University of Aarhus. 283 pp. – DCE Scientific Report No. 24. http://www.dmu.dk/Pub/SR24.pdf
- Winther. M. & Nielsen. O.K. 2006. National Environmental Research Institute. Denmark Fuel use and emissions from non-road machinery in Denmark from 1985-2004 - and projections from 2005-2030. National Environmental Research Institute. Denmark. Environmental Protection Agency. Danish Ministry of Environment. http://www2.mst.dk/udgiv/publications/2006/87-7052-085-2/html/helepubl_eng.htm#5.4
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20 03 2017].

Watering

As have been explained before, water consumption is a critical factor in the SUDOE region due to the existence of water scarcity areas. Therefore, the impact on water scarcity produced by irrigation of green areas can be relevant. However, in order to be able to assess water consumption in watering, school must to know the amount of water which is spent in watering and differentiate it from other water uses.

Three options are presented as source of water per origin:

- Tap water: only if that consumption is apart from the amount of water considered in water consumption (different invoices, for example).
- Rain water: if school collect water from rain in covers, or store tanks. It is not consider electricity to impulse water.
- Well water: depends on the country. Well is not included for Gibraltar, since water in Gibraltar is mainly desalinated water. Electricity consumption for pump the water is also considered.

Pesticides

Pesticides have great variability in composition, characteristics and function. There are three main categories of pesticides: herbicides, insecticides and fungicides. It has been selected two of them for each class to be included in the tool.

Two steps have been followed to select them. First, the Community List of Approved and Excluded Active Substances has been consulted to ensure included pesticides are approved by the European Union. And second, products included in the “Parks and Gardens" scope of the Register of Phytosanitary Products of the Ministry of Agriculture and Fisheries, Food and Environment of Spain (MAPAMA) have been consulted. is a summary of options presented in the tool, with main characteristic of the pesticide, and which is the pesticide of each type (herbicide, insecticide and fungicide) used as representative of the group.

Technical data of representative pesticide have been collected from Pesticide Properties DataBase (PPDB) from the University of Hertfordshire. However, in the absence of several parameters, the data have been supplemented by other sources (AP-42 (1995) Hazardous Substances Data Bank (HSDB) and Nageswara Rao (2016)).

Table 5 is a summary of options presented in the tool, with main characteristic of the pesticide, and which is the pesticide of each type (herbicide, insecticide and fungicide) used as representative of the group.

Technical data of representative pesticide have been collected from Pesticide Properties DataBase (PPDB) from the University of Hertfordshire. However, in the absence of several parameters, the data have been supplemented by other sources (AP-42 (1995) Hazardous Substances Data Bank (HSDB) and Nageswara Rao (2016)).

Table 5. Pesticides scenarios summary.

Type of pesticide	Option in the TOOL	Main characteristic	Representative pesticide
Herbicide	**Herbicide 1**	Preventive herbicide	Diflufenican 50%
Herbicide	**Herbicide 2**	Pre and post - emergence herbicide	Oxyfluorfen 48%
Insecticide	**insectcide 1**	Pyrethroide family	Cypermethrin 10%
Insecticide	**insectcide 2**	Other	Dimethoate 40%
Fungicide	**Fungicide 1**	Foliar and soil	80% Fosetil-AL
Fungicide	**Fungicide 2**	Foliar and soil Cu based	Cu 50% oxychloride

Application of pesticides in the field releases emissions to the different environmental compartments. A part of the applied pesticide is volatilized to air, both the active component of pesticide and the associated inert part (which that does not act against the pest but facilitates its dosage and application). These losses can be very important in some pesticides. Another part is spread on the soil. For the calculation of these emissions the EPA AP-42 methodology has been used.

Pesticides can also be incorporated into water by two ways, through runoff water or by leaching into groundwater. Surface water runoff calculations have been made following methodology by Wauchoupe (1978), which provides the transfer factors to the surface waters according to the type of pesticide and the type of formulation. Transfer factors for the selected pesticides fluctuate between 1% of the applied pesticide dose for copper Oxychloride and 0.5% for the rest of them. Potential groundwater contamination has been evaluated using Groundwater Ubiquity Score (GUS) combined with Organic Carbon-Water partition coefficient (Koc). Results show low leaching potential for the six selected pesticides.

References:

- AP-42 Fifth Edition (1995). Compilation of Air Pollutant Emission Factors. Volume I. Stationary Point and Area Sources. Chapter 9. Food and Agricultural Industries. 9.2.2. Pesticide Application. Office of Air Quality and Standards. Office of Air Radiation. U.S. Environmental Protection Agency.
- MAPAMA 2017a. Accessed April, 2017. http://www.mapama.gob.es/es/agricultura/temas/sanidad-vegetal/productos-fitosanitarios/registro/menu.asp
- MAPAMA. 2017 b. Registro Productos Sanitarios. Accessed April, 2017. http://www.mapama.gob.es/es/agricultura/temas/sanidad-vegetal/productos-fitosanitarios/registro/productos/conambuti.asp

- Nageswara Rao. T., Patrudu. T.B., Krishna Rao. N., Kumar. G., Basaveswara Rao. M.V. (2016). Dissipation kinetics of copper oxychloride and kasugamycin fungicide residues in different pH waters. Analytical CHEMISTRY. Volume 16 Issue 10.
- Hazardous Substances Data Bank (HSDB). Accessed April, 2017. https://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB
- PPBD (2017) http://sitem.herts.ac.uk/aeru/footprint/es/index.htm
- Wauchope, R.D. (1978). The pesticide content of surface water draining from agricultural fields - A review. J. Environ. Qual. 7(4):459-478.
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20 03 2017].

Fertilizers application

Gardening activities could include fertilizers application in order to improve soil characteristic of the school green areas. Extended commercial used fertilizers have been selected as input to gardening activities. The user will be able to choose and insert the amount per year which is applied. In case of NPK or PK compounds the user must provide info about % on Nitrogen, Phosphorous and Potassium.

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Table 6. Inorganic fertilizers.

Ammonium nitrate
Ammonium sulphate
Calcium ammonium nitrate (CAN)
Di ammonium phosphate (DAP)
Liquid urea-ammonium nitrate solution
NPK compound (Insert %N,%P,%K)
PK compound (Insert %N,%P,%K)

Triple superphosphate
Potassium sulfate

In case of organic fertilization, scenarios of production of compost have been obtained from bibliography, depending on the origin of organic material to produce compost, and each one is characterized by N content.

Table 7. Organic fertilization scenarios.

Organic fertilization 2: Organic materials of residues of municipal waste	**N**	**1,015%**
Organic fertilization1: Organic materials of residues of foods with green waste	**N**	**1,230%**

Fertilizers application on green areas results in emissions to air, water and soil. Direct and indirect emissions have been included both for nitrogen and phosphate fertilization. Emissions to the air are produced by NH3 volatilization, NOx and N2O emissions, which have been calculated following Nemecek and Kägi (2007) methodology. . Organic fertilization data is provided by grass cultivation scenario.

Outputs to water, in form of NO3 (nitrogen fertilization) and phosphorous (phosphate fertilization) are produced by three different ways: leaching, surface runoff and soil erosion with water participating as erosive factor. Nemecek & Kägi (2007) and Ausley (1999) have been applied to calculate them.

References:

- Miguel Ayuso , Jose Antonio Pascual , Carlos García & Teresa Hernández (1996) Evaluation of urban wastes for agricultural use, Soil Science and Plant Nutrition, 42:1, 105-111, DOI: 10.1080/00380768.1996.10414693
- Manios, T. (2004) The composting potential of different organic solid wastes: experience from the island of Crete. Environment International, 29, 1079- 1089
- E Audsley (Coordinator) (1997). Harmonisation of environmental life cycle assessment for agriculture. Final Report. Concerted Action AIR3-CT94-2028. European Commission. DG VI Agriculture. pp 139.
- Nemececk & Kägi. 2007. Life Cycle Inventories of Swiss and European Agriculture Production Systems. ART. Ecoinvent Report No 15a. https://db.ecoinvent.org/reports/15_Agriculture.pdf
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at:

<http://link.springer.com/10.1007/s11367-016-1087-8>
[Accessed 20 03 2017].

Cleaning and maintenance

Cleaning activities refer to the daily cleaning of classrooms, offices, corridors and other dependencies of the school building. Maintenance activities include the annual painting, repairing and other required maintenance of the building elements. They involve the use of cleaning, substances, chemical products, stuff and machines.

Several selected stuff has been presented in the tool. Some consumption is expressed as number of units of objects (gloves, keys, etc.), for which scenarios have been created, considering the amount of the main materials which it is made, basing on commercial information. Furthermore, there are also common materials such as plastics HPDE, PE, PP, ABS, PVC, PS, steel, wood, aluminum, etc., for which the user has to input the amount used in mass units. Electricity consumption of appliances and machinery are calculated with power and operation time per year.

Table 8. Consumptions of materials in cleaning (a) and maintenance activities considered (inputs per activity).

a) Cleaning material consumption

INPUT (MATERIAL/STUFF)	UNIT
Cotton	kg
Cotton cloth	units
Polyester	kg
Cleaning paper	kg
Cleaning paper - Toilet paper (roll)	units
Cleaning paper (big roll)	units
Ammonia	l
Detergent	l
Bleach	l
Wax	l
Soap	l
Plastic bags	units
Plastic HPDE	kg
Plastic PE	kg
Plastic PP	kg
Plastic ABS	kg
Plastic PVC	kg
Plastic PS	kg
Plastic PET	kg
Latex gloves	units

b) Maintenance material consumption.

INPUT (MATERIAL/STUFF)	UNIT	INPUT (MATERIAL/STUFF)	UNIT
Adhesive	kg	Key	units
Sealant	cm^3	Metal ns	kg
Paint (Water solvent)	l	Lubricant	kg
Paint (Acrylic solvent)	l	Cement Portland	kg
Barnes	l	Gravel	kg
Wood	m^3	Plaster	kg
Glass (flat)	m^2	Sand	kg
Glass	kg	Rubber	kg
Iron (kg)	kg	Leather	kg
Iron (m^3)	m^3	HPDE	kg
Aluminum (kg)	kg	PE	kg
Aluminum (m^3)	cm^3	ABS	kg
Aluminum doorknob/handle	units	PVC	kg
Steel sheet	kg	Plastic PS	kg
Steel (kg)	kg	Pipe PVC	m
Steel fence	m	Ceiling Panel (PS)	cm^2
Steel locked	units		

Data sources to commercial products:

- http://www.reactiva.com.ar/php/producto.php?action=info_product&id=196
- http://limpiezaycelulosa.com/Papel-higienico
- http://www.ecosmep.com/cabecera/upload/fichas/7182.pdf
- http://www.heraproject.com/files/7-f-04-hera%20sodium%20perborate%20full%20web%20wd.pdf
- http://corponor.gov.co/corponor/sigescor2010/Hojas%20de%20Seguridad/HS%20Jabon%20liquido%20manos%202015.pdf
- http://www.dimerc.pe/files/pdf/PR08265.pdf
- file:///C:/Users/acvase/Downloads/descargas-catalogos-Catalogo%20PVC%20(baja%20resolucion).pdf
- http://www.farmaceuticosmundi.org/farmamundi/descargas/pdf/Guante_latex_examen.pdf
- http://www.quimivisa.com/productos/fichas/SELL-SILICONA%20NEUTRA.pdf
- http://www.danco.es/F_tecnicas/Fichas%20Tecnicas%20Valentine/MONOCAPA.pdf
- http://www.visever.com/descargas/ficha_horizontal.pdf
- http://www.duracero.com/Catalogo_DURACERO_2014.pdf
- https://www.interempresas.net/FeriaVirtual/Catalogos_y_documentos/188785/Cerraduras-y-empun--771-aduras.pdf

Food Services

Scholar food service considers the equipment and operation time. The electricity consumption was calculated considering a working period in hours per day for discontinuous working appliances (Dishwasher, oven, kitchen/plate, microwave., coffeemaker) and the whole day for continuous working appliances (freezer and fridge) in the scholar period.

Wastes

Schools produce waste which is a mix between typical waste from offices activities and houses. Two groups of wastes have been presented depending on the subsystem which they are produced from. All wastes have been allocated as an activity into subsystem 1, school management. Some wastes have been characterized in unit values, considering commercial information, but most of the wastes are asked in the tool in mass value, due to heterogeneity of wastes. Impact factor per wastes have been calculated with general processes of waste treatment and end of life scenarios obtained from Ecoinvent. For some materials two possibilities are included: disposal and recycling. Wastewater treatment has been estimated considering a 75% ratio between water consumption and wastewater production based on bibliography (Marín Galvín, R. (2015)).

References:

- Marín Galvín, R. (2015) El ciclo integral del agua en Córdoba. Flujos de materia implicados y huella de carbono. IV Jornadas de Ingeniería del Agua. La precipitación y los procesos erosivos. Córdoba, 21 y 22 de Octubre 2015. http://www.uco.es/jia2015/ponencias/c/c008.pdf
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218-1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20 03 2017].

Table 9.Wastes produced in the system, divided in a) from subsystem 1, and b) from subsystem .

a) Wastes from subsystem 1

Input (Material/staff)	Unit
WEEE[6]	kg
Fluorescent tube	Units
Compact fluorescent lamps	Units
Incandescent bulbs	units
Halogen lamps	units
LEDs	units
Waste oil	Kg
Dirty cleaning paper	Kg
Dirty cleaning textile	Kg
Plastics mixed	kg
Iron disposed off	kg
aluminum disposed off	kg
Metal ns disposed off	kg
Glass disposed off	kg
Wasted mixed	kg

b) Wastes from subsystem 2

Input (Material/staff)	Unit
Disposal cardboard	Kg
Disposal glass	Kg
Disposal mixed plastics	Kg
Disposal metal	Kg
Recycling textiles	Kg
Recycling cardboard	Kg
Recycling glass	Kg
Recycling mixed plastics	Kg
Recycling steel and iron	Kg
Recycling textiles	Kg
Used toner module, laser printer	Kg
Computers disposed off to WEEE treatment	Kg
Laptop disposed off to WEEE treatment	Kg
CRT flat screen to WEEE treatment	Kg
LCD flat screen to WEEE treatment	Kg
WEEE different to computers,	Kg

[6] WEEE: waste electrical and electronic equipment.

Paint disposed off	kg
Wood disposed off	kg
Debris mixed	kg
Water treatment	m3

scanners,…to treatment

Subsystem 2. Activities in the School to educational activities.

Other activities strictly linked to the education performance in the schools such as the resources related to teaching such as pens, books, paper and other several materials and staff, and the use of computers and other electronic equipment are included within the scope of this subsystem. The subsystem is divided according to Figure 6.

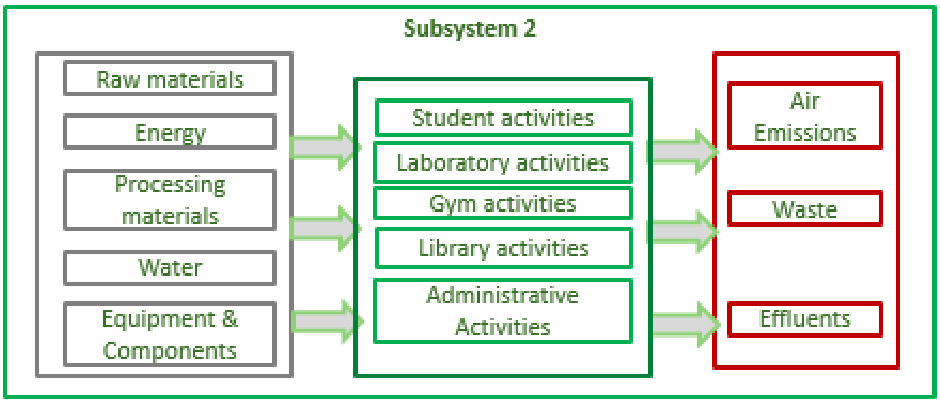

Figure 6. subsystem 2. Activities in the Schoolto Educational Activities

Student activities

Student activities are referred to learning activities, considering consumption of the student, when students support own education buying some resources to use in class. Previous work is required per school, since for this part an average of consumption of materials and products per student is needed. For example, school could collect data of a survey of materials and products which are spent by each student in a sample class or group of classes.

In addition, student activities could include other non-specific materials, such as paint, wood, plastic, rubber, ….). Therefore, a section dedicated to insert other consumption in material terms have been included. To calculate impact factor of the products, commercial information has been consulted, considering the production of material which makes up each product.

Other relevant consumption in this activity takes into account the average of number of books per course (book which student have to supply), to calculate a weighted average of total supplied books per student. Book could be bought or be reused (cero emissions considered in production of product). A percentage of secondhand book is obtained from Behavior Questionnaire. To calculate impact factor an average of literature have been used as to calculate weight per unit (Arberola Lopez et al, 2010).

Finally, student activity includes the student utilization of appliances and equipment. Educational centers are starting to use technological package as alternative to books, providing contents in electronical format. Electricity consumption determines the impact factor, so impact it is calculated thought the time of use of own laptops or tablets in class. Other electricity spent by "other appliances/equipment" has been covered, and it is calculated using power and operation time.

Table 10. List of student activity material consumptions.

Material/Product	**Unit**
Paper (kg)	kg
Recycled paper (kg)	kg
Paper (sheets, A4)	unit
Recycled paper (sheets, A4)	unit
Notebooks (little size)	unit
Notebooks (big size)	unit
Recycled paper notebook (little)	unit
Recycled paper notebook (big size)	unit
Cardboard folder	unit
Plastic folder	unit
Eraser	unit
Pen	unit
Marker pen	unit
Pencils	unit
Colour pencil	unit
CDs	unit
DVDs	unit
Glue stick	unit
Paperboard	kg
Corrector	unit
Scissors	unit
Rule (30 cm)	unit
Compass	unit

Laboratory Activities

Most typical substances in basic laboratory activities are include, and some stuff (gloves, glasses, etc.) as well.

Microscopes and Autoclave have been identified as typical laboratory appliances in schools in order to calculate electricity consumption. Other lab devices could be considered if school knows operation time and power.

Two options of typical lab waste, separated of the common "Waste activity" (Subsystem 1 included a part for Wastes), could be completed in that activity information. Lab activity could produce hazardous liquid effluents and hazardous solid effluents, considering the type of waste that will be managed. Density of the liquid hazardous wasted is based on density conversion factors developed by the UK Environment Agency for the commercial and industrial waste survey in UK. There is a factor for each of the European Wastes Codes in the List of Wastes. An average of density has been used.

In addition, lab activities could include other non-specific materials, as paint, wood, plastic, rubber,….), so a section to insert other consumption in material terms have been included. To calculate impact factors of the products commercial information of densities has been consulted, considering the production of simple material which makes up the product or substance.

Table 11. Laboratory consumptions.

Substance	Unit
Alcohol 96°.	l
Hcl	l
Nitric Acid	l
Acetic Acid	l
Hydrogen Peroxide	l
Formic Aldehyde	l
Potassium Hydroxide	kg
Eter Petroleum	kg
Potassium Permanganate	kg
Iron(Iii) Sulfate, Without Water, In 12.5% Iron Solution State	kg
Calcium Chloride, Cacl2	kg
Chemicals Organic	kg
Chemicals Inorganic	kg
Gloves	unit
Gloves Latex	unit
Security Glasses	unit

Gym activities

Due to the diversity of stuff used in gym activities a short list of consumptions has been proposed: Balls, Mats, Hurdles, Frisbi, Lockers, Foam/mattress). Additionally, gym activities could be include other non-specific products different to the proposed stuff, including a section where the user can insert products, by simple material composition in weight (plastic, rubber, etc.). To calculate impact factors of the products commercial information of weight has been considered.

Library Activities

Library activities consider the books bought by the school per year, as well as multimedia resources (CD/DVD). Moreover, library activities could include other non-specific materials, so a section to insert other consumption in material terms has been included. To calculate impact factors of the products commercial information of densities has been consulted.

Administrative Activities

Administrative activities include all consumption of materials, products and energy, necessary to develop the educational activity and that has been purchased by school. Consumptions are divided in three groups: material/products, devices used and new devices (**Table 12. Administrative activity consumptions.**Table 12).

Impact factor of materials/products have been calculated using commercial info about weight, and considering the production of materials which compound each product. For "devices used" the impact is referred to electricity consumption, so depends on operational time. As in other activities, other section have been included in which the user can be complete information about non-specific materials, as paint, wood, plastic, rubber, etc. To calculate impact factors of the products commercial information of densities has been consulted.

Table 12. Administrative activity consumptions.

Material/ products				**Devices used**		**New devices**	
Toner Cartridge (Black)	Units	Pencils	Units	Computer Desktop+CRT Screen	Units	Desktop Computer, Without Screen	Units
Ink Cartridges (Colour)	Units	Colour Pencils	Units	Computer Desktop+LCD Screen	Units	Laptop Computer	Units
Printed Paper A4	Units	CD	Units	Laptop	Units	LCD Flat Screen	Units
Printed Paper A3	Units	DVD	Units	Notebook	Units	CRT Screen	Units
Paper	Kg	Glue Stick	Units	Printer - Inject	Units	Printer, Laser Jet, B/W	Units
Cardboard Folder	Units	Pins	Units	Photocopier	Units	Printer, Laser Jet, Colour	Units
Plastic Folder	Units	Art Paper	Units	Printer Multifunction	Units	Keyboard	Units
Pen	Units	Art Paint	Units	3d Printer	Units	Mouse Device, Optical, With Cable, At Plant/GLO U CLIMACT	Units
Marker Pen	Units	Desk Teacher	Units	Speakers (10 W, Aux Desktop Computer)	Units	Tablet	Units
Tape	Units	Chairs	Units	Tablet	Units	Other Office Machinery (New)	Kg
Paper Envelope	Units	Bookcase	Units	Speakers (Big System)	Units		
Plastic Sleeve PP	Units	Desk Kid	Units	Overhead Projector	Units		
Clamp	Units	Chairs Kid	Units	Multimedia Projector	Units		
Elastic Rubber	Units	Cell Ion Li (Rechargeable)	Units	Scanner	Units		
Eraser	Unit	Cell Ion	Units	Plasticiser	Units		

	s	Li		Machine	
Chalk handle	Units	Cell Nimh (Rechargeable)	Units	E-Boards	Units
Clips	Units	Cell Nicd (1300mah)	Units	Cd Player	Units
Pad (Mouse)	Units	Cell Nicd (2000mah)	Units	DVD/VCR	Units
Chalks	Units			Network Access	Hours

References and sources:

- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20 03 2017].
- https://www.bicworld.com/es/
- http://www.esselte.com/es-es/
- http://www.papeleriaelcano.es/
- https://www.materialescolar.es/
- http://www.didatecnia.com/
- http://www.apli.es/
- https://www.deskidea.com/
- http://www.imedio.es/es-es/productos/1057-adhesivos/2/
- https://www.distrimar.es/
- http://cdn-docs.av-iq.com/dataSheet//DVD%2BR_Series_Datasheet.pdf
- http://cdn-docs.av-iq.com/dataSheet/CD-R_Series_Datasheet.pdf
- Alberola Lopez, S. et al (2010).Mochilas escolares y dolor de espalda en la poblaciÃ³n infantil. Rev Pediatr Aten Primaria [online]. vol.12, n.47, pp.385-397.

-http://redwoodbark.org/2016/09/12/text-heavy-hidden-eightpapertextbook-use/

- http://www.ibdciencia.com/es/reactivos-quimicos-c-95
- https://liderpapel.com/
- http://www.monfel.com/images/alcohol%20etilico%2096%20-%20hds.pdf
- http://www.lco.cl/operations/safety-and-health/technical-info/safety-data-sheets/Ficha%20seguridad%20Acido%20Cloridrico.pdf
- http://www.elksport.com/producto/accesorios-deportes-equipo/vallas-obstaculos/valla-retornable-multialtura.html
- http://downloads.smarttech.com/media/sitecore/es/support/product/smartboards-fpd/m600series/specs/sbm685specifications19jul13.pdf

https://energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use

http://www.samsung.com/

http://www.mypowerconsumption.com/

A.C. Menezes, R.A. Buswell. J. Wright. D. Bouchlaghem. Estimating the energy consumption and power demand of small power equipment in office buildings. Energy and Buildings, Volume 75, June 2014, Pages 199-209. https://doi.org/10.1016/j.enbuild.2014.02.011

https://ultimaker.com/en/products/ultimaker-2-go/specifications

Subsystem 3. Activities out of the school: Transport and mobility

Subsystem 3 is related to activities outside the center. Figure 7 present the subsystem 3 scheme, where two types of activities could be defined: transport of the students and school staff to official outings, and the mobility of the whole educational community to the center.

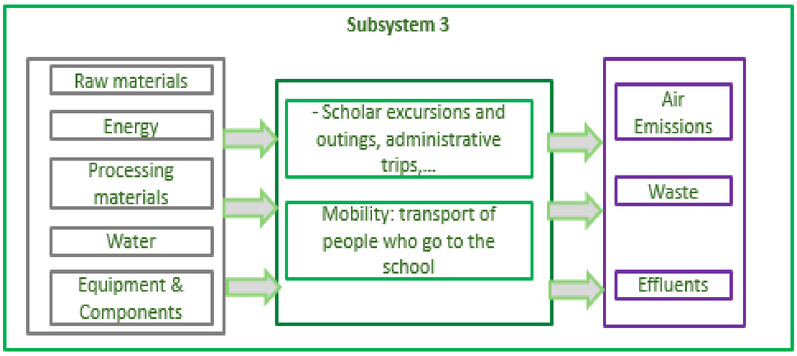

Figure 7. Subsystem 3. Activities out of the school. Transport and mobility.

Transport

Required data is number of passengers, type of vehicle and distance of trip (km). The impact factor depends on the vehicle and it has been calculated in terms of personaskm.

Possible vehicles included in LCA module: Bus, van, public bus, metro, tram, car, train, bicycle, plane and boat. Non vehicle (On foot, walking)

Mobility

Mobility could be a complex activity due to variability of scenarios considering the big range of territories, cities, village, etc. LCA module included 2 options:

- Private collective route: special route mobility to pick students up. It used to be hired by Parents Association, City Hall or School. Vehicle can be a private bus or a van. The LCA tool allows the introduction of up to 5 routes.
- Independent mobility: each person of the community provides his/her mobility. Means of transport can be: Walking, bicycle, public bus, metro, train, tram, boat, car and motorbike.

The calculations are made using the results of Behavior questionnaire:

- Info about means of transports: using Behavior Questionnaire results school must calculate a % of use of each meansof transport by community people to go to school.

% mobility by X= $((1*a+0.8\cdot a_1+0.4\cdot a_2)/ b) \cdot 100$

Where,

X: mean of transport

a_x: % of surveyed who answered "always" in question "Do you travel to the school by X?"

a_{x1}: % of surveyed who answered "almost always" in question "Do you travel to the school by X?"

a_{x2}: % of surveyed who answered "sometimes" in question "Do you travel to the school by X?"

b: 2.2 (weight of 100% of answers).

- Info about data of number of trips per day: direct result of the questionnaire, % Community people who come back to home per vehicle (4 trips to school per day).

- Info about people who share the car: direct result of the questionnaire, % community people who share car

- Info about passengers in sharing cars:

Average of the number of passengers in sharing cars= g/ h

Where,

g: sum of all answers (numerical values) to question to the question "how many passengers go to your school with you?"

h: number of answers.

Note that, it is need sum the passenger who has fill the answer, because that the total of passengers, needed to calculate transports in personkm, corresponds to *g* (rest of passengers) plus *h* (people how answer the questionnaire).

- Info about distance between home and to school

Average of the distance between home and to school = i/ j

Where:

i: sum of all answers (numerical values) to the question "What is the distance between your home and school?"

j: number of answers.

The impact factor depends on the vehicle and it has been calculated in terms of personkm. Percentages are assumed as a representative sample of the whole school, since they are multiplied by whole school people (total number of students plus teachers and staff who work in the school) and by the average of distance, to get a result in personkm per type of vehicle.

Regarding to calculations of the allocation of weight of impact in case of sharing car, a factor of relationship has been calculated to decrease the weight of impact per student when car is shared with more people. That means, the impact is distributed between people who travel in the car.

References:

- Annika Messmer, A.;Friscknech, R. tLife Cycle Inventories of Water Transport Services. Treeze Ltd., fair life cycle thinking Kanzleistr. 4, CH-8610 Uster. http://treeze.ch/fileadmin/user_upload/downloads/Publications/Case_Studies/Mobility/544-LCI-Water-Transport-Services-v2.0.pdf
- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., and Weidema, B., 2016. The ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218-1230. Available at: <http://link.springer.com/10.1007/s11367-016-1087-8> [Accessed 20 03 2017].

6 Results presentation

The module presents the results per impact category in terms total of the school, per student and per usable m^2 considering the contribution of different elements of the system to compare the influence of subsystems in the impact of the total system impact, and the activities in each subsystem impact. Electricity consumption of activities and process which has not been identified specifically, and general water consumption have been included in the "Subsystem 1 School Management Activities" to present results. So, 12 tables and 4 charts with percentages contributions to impacts per activity show the results.

Table 13. Summary of result presentation

	Tables	Charts
Results by subsystem: values and contribution per subsystem	- Impacts per school - Impacts per student - Impacts per usable m^2	Contribution per subsystem
Subsystem 1 School Management Activities: values per activity and graphical activities comparison **+ Other consumptions of electricity** **+ Water**	- Impacts per school - Impacts per student - Impacts per usable m^2	Contribution per activity
Subsystem 2 Educational Activities: values per activity and graphical activities comparison	- Impacts per school - Impacts per student - Impacts per usable m^2	Contribution per activity
Subsystem 3. Activities out of the school - Transport and mobility: values per activity and graphical activity comparison	- Impacts per school - Impacts per student - Impacts per usable m^2	Contribution per activity

Figure 8, Figure **9**, Figure 10 and Figure 11 below show examples of LCA module impact results presentation.

Results per student																
	Climate change kg CO2 eq	Ozone depletion kg CFC-11 eq	Human toxicity, non-cancer effects CTUh	Human toxicity, cancer effects CTUh	Particulate matter kg PM2.5 eq	Ionizing radiation HH kBq U235 eq	Ionizing radiation E (interim) CTUe	Photochemical ozone formation kg NMVOC eq	Acidification molc H+ eq	Terrestrial eutrophication molc N eq	Freshwater eutrophication kg P eq	Marine eutrophication kg N eq	Freshwater ecotoxicity CTUe	Land use kg C deficit	Water resource depletion m3 water eq	Mineral, fossil & ren resource depletion kg Sb eq
School Management Activities	9,66E+01	1,06E-04	1,08E-05	2,91E-06	3,23E-02	3,83E+01	1,19E-04	3,43E-01	5,45E-01	8,43E-01	1,61E-02	1,99E-01	1,85E+02	8,90E+00	3,90E+00	3,22E-03
Educational Activities	5,15E+01	3,64E-06	3,89E-05	6,15E-06	5,96E-02	1,20E+01	4,14E-05	1,82E-01	3,48E-01	5,93E-01	3,59E-02	7,43E-02	1,04E+03	2,24E+02	6,47E-01	1,75E-01
Activities out of the centre - Transport an	1,77E+02	2,43E-05	1,18E-05	1,32E-06	6,90E-02	8,66E+01	2,68E-04	4,21E+00	8,25E-01	3,15E+00	1,32E-02	2,88E-01	1,73E+02	3,91E-01	2,18E-01	3,68E-04
Total	3,25E+02	1,34E-04	6,14E-05	1,04E-05	1,61E-01	1,37E+02	4,28E-04	4,74E+00	1,72E+00	4,59E+00	6,52E-02	5,61E-01	1,39E+03	2,33E+02	4,76E+00	1,79E-01

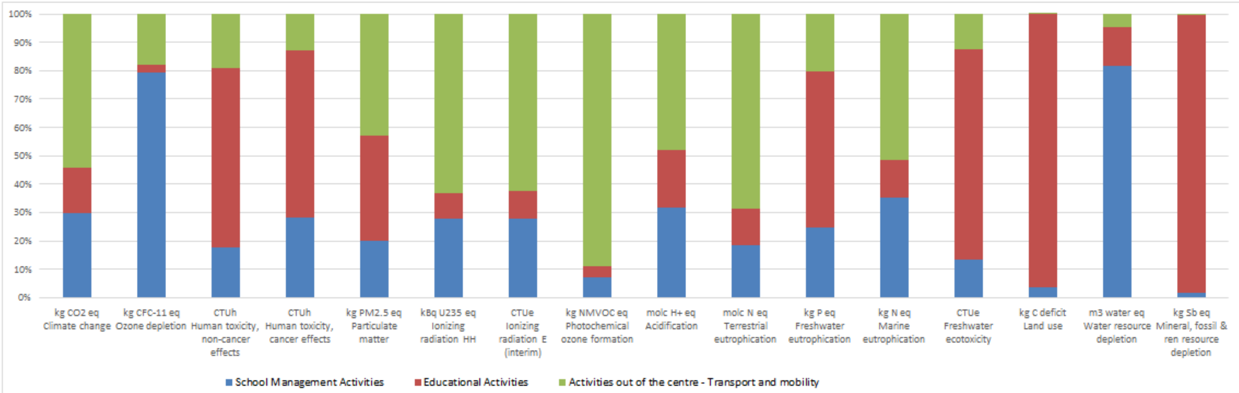

Figure 8. Example of presentation of impact results per student (Total system).

Results per m2

	Climate change	Ozone depletion	Human toxicity, non-cancer effects	Human toxicity, cancer effects	Particulat e matter	Ionizing radiation HH	Ionizing radiation E (interim)	Photoche mical ozone formation	Acidificati on	Terrestria l eutrophic ation	Freshwat er eutrophic ation	Marine eutrophic ation	Freshwat er ecotoxicit y	Land use	Water resource depletion	Mineral, fossil & ren resource depletion
	kg CO2 eq	kg CFC-11 eq	CTUh	CTUh	kg PM2.5 eq	kBq U235 eq	CTUe	kg NMVOC eq	molc H+ eq	molc N eq	kg P eq	kg N eq	CTUe	kg C deficit	m3 water eq	kg Sb eq
Other electricity consumption	3,78E+00	2,55E-07	5,86E-07	1,34E-07	1,92E-03	3,02E+00	9,15E-06	2,06E-02	3,43E-02	5,29E-02	1,10E-03	5,04E-03	1,15E+01	5,16E-01	2,51E-02	1,22E-05
Water	4,92E-02	3,31E-09	9,00E-09	2,63E-09	2,59E-05	3,96E-02	1,20E-07	2,52E-04	4,38E-04	6,47E-04	2,06E-05	6,32E-05	2,07E-01	1,88E-02	5,64E-01	1,64E-07
Heating	8,53E+00	1,26E-06	1,39E-07	1,44E-08	1,37E-03	2,27E-01	6,92E-07	1,26E-02	2,06E-02	3,04E-02	1,26E-04	2,81E-03	1,65E+00	9,28E-03	3,67E-03	1,90E-06
HW	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Cooling	2,38E-01	1,68E-05	5,21E-08	1,24E-08	6,53E-05	5,22E-02	1,59E-07	4,32E-04	8,21E-04	1,18E-03	4,29E-05	1,12E-04	1,15E+00	1,29E-02	4,36E-04	1,86E-05
Ventilation	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Lighting	2,48E+00	1,67E-07	3,84E-07	8,75E-08	1,26E-03	1,98E+00	6,00E-06	1,35E-02	2,25E-02	3,46E-02	7,23E-04	3,30E-03	7,56E+00	3,38E-01	1,64E-02	8,01E-06
Gardening	-5,85E-02	6,60E-09	2,95E-09	1,04E-10	9,89E-06	5,72E-04	1,83E-09	1,53E-03	9,81E-05	1,91E-04	1,48E-06	1,94E-05	5,50E-02	4,38E-04	9,65E-06	2,00E-07
Cleaning and Maintenance	3,72E-01	4,24E-08	1,15E-07	1,80E-07	2,60E-04	1,63E-01	1,10E-06	3,16E-03	2,75E-03	5,24E-03	1,63E-04	1,68E-02	4,03E+00	4,86E-01	6,25E-02	5,17E-04
Wastes	3,85E-02	3,59E-09	3,63E-07	2,66E-08	-1,63E-05	3,86E-02	1,16E-07	9,43E-05	5,16E-04	1,69E-03	2,11E-04	4,62E-03	1,63E+00	-2,47E-02	1,34E-04	1,47E-08
Food services	1,47E+00	9,92E-08	2,28E-07	5,21E-08	7,50E-04	1,18E+00	3,57E-06	8,01E-03	1,34E-02	2,06E-02	4,30E-04	1,96E-03	4,50E+00	2,01E-01	9,78E-03	4,76E-06
Total	1,69E+01	1,86E-05	1,88E-06	5,09E-07	5,65E-03	6,71E+00	2,09E-05	6,01E-02	9,54E-02	1,47E-01	2,82E-03	3,47E-02	3,23E+01	1,56E+00	6,82E-01	5,63E-04

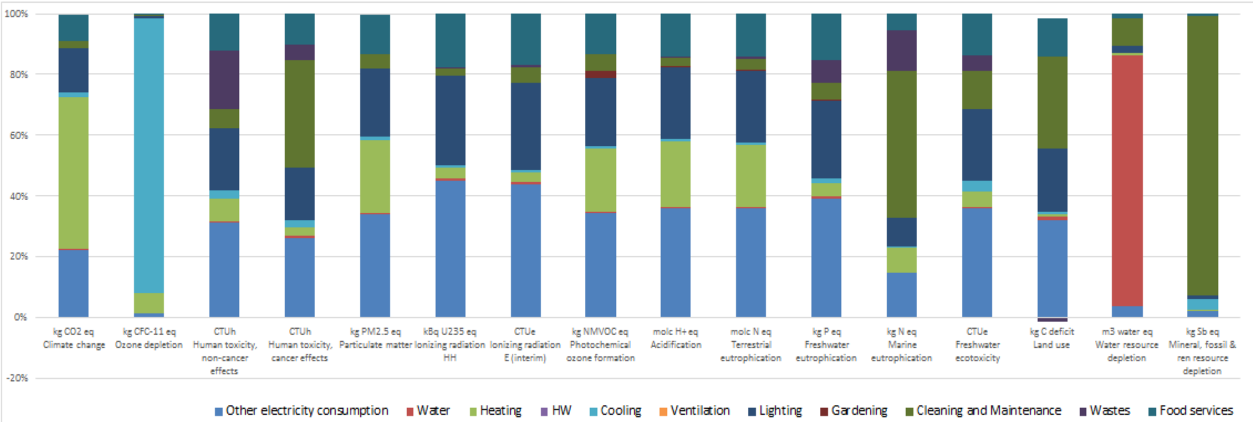

Figure 9. Example of presentation of impact results of Subsystem 1 (School Management), per student.

Results per student

	Climate change	Ozone depletion	Human toxicity, non-cancer effects	Human toxicity, cancer effects	Particulat e matter	Ionizing radiation HH	Ionizing radiation E (interim)	Photoche mical ozone formation	Acidificati on	Terrestria l eutrophic ation	Freshwat er eutrophic ation	Marine eutrophic ation	Freshwat er ecotoxicit y	Land use	Water resource depletion	Mineral, fossil & ren resource depletion
	kg CO2 eq	kg CFC-11 eq	CTUh	CTUh	kg PM2.5 eq	kBq U235 eq	CTUe	kg NMVOC eq	molc H+ eq	molc N eq	kg P eq	kg N eq	CTUe	kg C deficit	m3 water eq	kg Sb eq
Students activity - class	2,59E+01	1,64E-06	7,97E-06	1,81E-06	3,69E-02	2,75E+00	8,70E-06	8,43E-02	1,67E-01	2,71E-01	1,08E-02	2,84E-02	2,01E+02	8,68E+01	3,61E-01	1,60E-03
Laboratory activity	1,51E-02	2,56E-09	2,14E-09	5,11E-10	1,08E-05	7,47E-03	2,28E-08	6,67E-05	1,02E-04	1,61E-04	4,57E-06	1,54E-05	4,98E-02	1,91E-03	1,07E-04	1,38E-05
Gym activity	1,66E-01	1,74E-08	4,71E-08	3,97E-08	1,03E-04	4,06E-02	1,22E-07	3,98E-04	8,46E-04	1,19E-03	6,59E-05	1,18E-04	1,65E+00	1,60E-02	7,81E-04	6,59E-05
Library activity	7,44E-01	4,85E-08	2,49E-07	5,10E-08	1,15E-03	8,30E-02	1,74E-07	2,31E-03	5,03E-03	7,87E-03	3,38E-04	8,23E-04	6,22E+00	1,28E+00	1,06E-02	4,78E-05
Administrative and school	2,46E+01	1,94E-06	3,06E-05	4,25E-06	2,15E-02	9,08E+00	3,24E-05	9,51E-02	1,75E-01	3,13E-01	2,47E-02	4,49E-02	8,27E+02	1,36E+02	2,74E-01	1,73E-01
Total	5,15E+01	3,64E-06	3,89E-05	6,15E-06	5,96E-02	1,20E+01	4,14E-05	1,82E-01	3,48E-01	5,93E-01	3,59E-02	7,43E-02	1,04E+03	2,24E+02	6,47E-01	1,75E-01

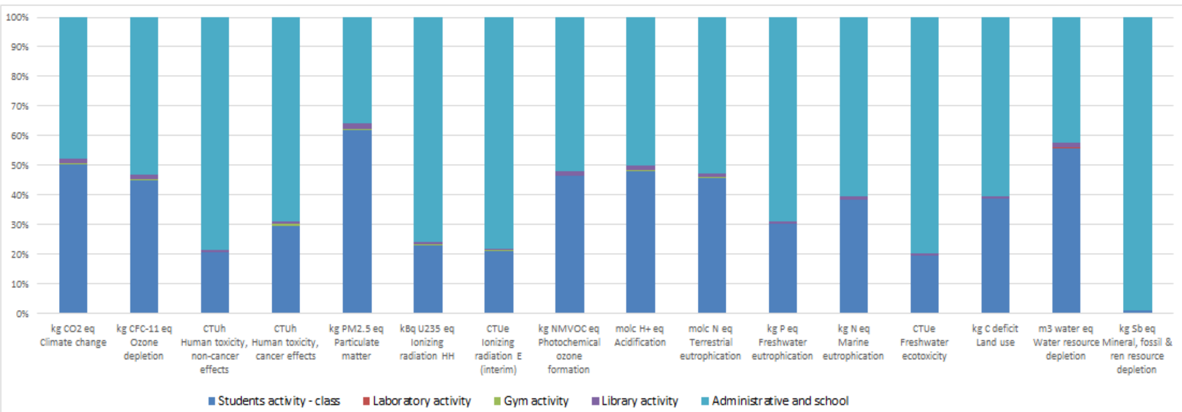

Figure 10. Example of presentation of impact results of Subsystem 2 (Educational Activities), per student.

Results per student																
	Climate change	Ozone depletion	Human toxicity, non-cancer effects	Human toxicity, cancer effects	Particulate matter	Ionizing radiation HH	Ionizing radiation E (interim)	Photochemical ozone formation	Acidification	Terrestrial eutrophication	Freshwater eutrophication	Marine eutrophication	Freshwater ecotoxicity	Land use	Water resource depletion	Mineral, fossil & ren resource depletion
	kg CO2 eq	kg CFC-11 eq	CTUh	CTUh	kg PM2.5 eq	kBq U235 eq	CTUe	kg NMVOC eq	molc H+ eq	molc N eq	kg P eq	kg N eq	CTUe	kg C deficit	m3 water eq	kg Sb eq
Transport - school activities outing	1,63E+02	2,25E-05	6,04E-06	3,93E-07	6,05E-02	5,14E+00	1,70E-05	4,18E+00	7,53E-01	3,04E+00	2,59E-03	2,75E-01	7,31E+01	2,46E-01	7,16E-02	7,09E-05
Transport mobility	1,33E+01	1,81E-06	5,74E-06	9,30E-07	8,49E-03	8,15E+01	2,51E-04	3,37E-02	7,22E-02	1,18E-01	1,07E-02	1,31E-02	9,96E+01	1,45E-01	1,46E-01	2,97E-04
Total	1,77E+02	2,43E-05	1,18E-05	1,32E-06	6,90E-02	8,66E+01	2,68E-04	4,21E+00	8,25E-01	3,15E+00	1,32E-02	2,88E-01	1,73E+02	3,91E-01	2,18E-01	3,68E-04

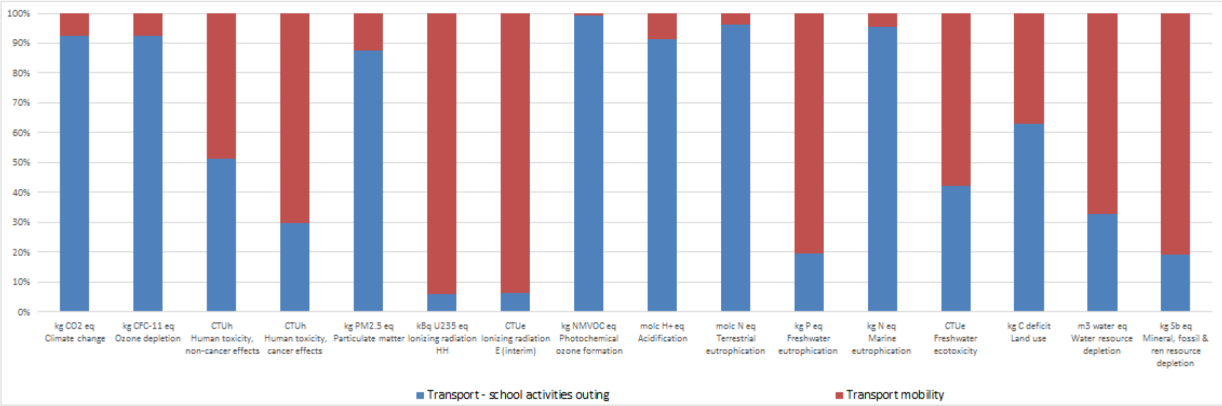

Figure 11. Example of presentation of impact results of Subsystem 3 (Activities out of the school - Transport and mobility), per student.