UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Dipartimento di Scienze e Metodi dell'Ingegneria

Dipartimento di Scienze e Metodi dell'Ingegneria, Università degli Studi di Modena e Reggio Emilia, via Amendola 2, 42122, Reggio Emilia, Italy

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ENVIRONMENTAL PRODUCT DECLARATION

First Stage Tertiary Education System offered by the Department of Sciences and Methods for Engineering of the University of Modena and Reggio Emilia:

in compliance with ISO 14025

1. GENERAL INFORMATION

OWNER OF THE DECLARATION:	Università di Modena e Reggio Emilia – Via Università, 4 41121 Modena (MO)
DEPARTMENT INVOLVED IN THE EPD:	DISMI, Dipartimento di Scienze e Metodi dell'Ingegneria, viale Amendola 2, 42122 Reggio Emilia, Italy
PROGRAM OPERATOR:	EPDITALY (www.epditaly.it) Via Gaetano De Castillia, n° 10 - 20124 Milano, Italy
INDEPENDENT VERIFICATION:	This declaration has been developed in accordance with the EPDItaly Regulations; further information and the Regulations themselves are available on the website: www.epditaly.it. The PCR revision was carried out by ICMQ - info@epditaly.it. Independent verification of the declaration and data according to ISO 14025:2010. Internal ○ External ✓ Third party verification performed by: ICMQ S.p.A, Via Gaetano De Castillia, n°10 - 20124 Milan, Italy. Accredia.
CPC-BASED CODE:	92510 First stage tertiary education services
INSTITUTION CONTACT:	Prof. Anna Maria Ferrari, viale Amendola 2, 42122 Reggio Emilia, Italy annamaria.ferrari@unimore.it Prof. Roberto Rosa, viale Amendola 2, 42122 Reggio Emilia, Italy roberto.rosa@unimore.it
TECHNICAL SUPPORT:	Department of Sciences and Methods for Engineering LCA Working Group University of Modena and Reggio Emilia Via Amendola n°2, Pad. Morselli - 42122 Reggio Emilia, Italy
COMPARABILITY:	Environmental declarations of products belonging to the same category but belonging to different programs may not be comparable.
RESPONSIBILITY:	University of Modena and Reggio Emilia lifts EPDItaly from any non-compliance with environmental legislation self-declared by the manufacturer itself. The holder of the declaration will be responsible for the information and supporting evidence; EPDItaly declines all responsibility for the manufacturer's information, data and results of the life cycle assessment.
REFERENCE DOCUMENTS:	This declaration has been developed following the EPDItaly Programme Regulations Rev. 0, 2023/10/30, available on the website: www.epditaly.it.
PRODUCT CATEGORY RULES (PCR):	PCR EPDItaly030 (Education services), V. 0, 2022/12/22 PCR EPDItaly031 (First stage tertiary education services), V. 0, 2022/12/22

2. INSTITUTION PROFILE

Environmental Product Declaration – Dipartimento di Scienze e Metodi dell'Ingegneria, University of Modena and Reggio Emilia

The University of Modena dates back to 1175, a few decades after the founding of the University of Bologna, making it one of the oldest universities in Italy and the world. It was established by the city of Modena, which financed professors' contracts through local taxation. The first to be invited to teach was Pillio da Medicina from Bologna. The School of Law (*Studium iuris*) was subsequently formed around him and made up the nucleus of the University.

In the two centuries that followed, the *Studium* expanded from legal studies to include the training of notaries and the study of medicine as well. The subsequent history of the University was profoundly marked by the changing fortunes of the ruling Este family. Between the sixteenth and seventeenth centuries, when the Court of Este settled in Ferrara, academic titles were no longer awarded, and the activities of the *Studium* were greatly reduced.

Only after the Court moved to Modena in 1772 did the University regain its original splendour and academic prestige, receiving an imperial charter from Duke Francis II. The University offered multiple disciplines, including law, medicine and surgery, pharmacy, and mathematical, physical, and natural sciences.

The Department of Economics was established in 1968, followed by the Department of Engineering in 1989. The year 1998 was of fundamental importance in the history of the University when the Reggio Emilia site was instituted and the University of Modena and Reggio Emilia was founded, with the support of local institutions.

In fact, Reggio Emilia already had an ancient and noble tradition of university studies which ended in 1772 following the reform of Duke Francis II of Este. A School of Law, proposed by the city, is mentioned as early as 1188. In 1532, Emperor Charles V granted the College of Judges the privilege of awarding diplomas and degrees in Law. Duke Alfonso II of Este established a Medical College in 1561 and ten years later, Emperor Maximilian II authorized the conferral of degrees in medicine. In the seventeenth century, a School of Letters was opened at the Seminary and, in the following century, a chair of Scholastic Theology was established along with schools of grammar and rhetoric. In 1752, the University of Reggio was inaugurated in Palazzo Busetti and consisted of four faculties: Law, Theology, Medicine and Philosophy. However, its activities continued only until 1772 when, after the reform of Francis II, its right to grant degrees was taken away and given solely to the University of Modena.

The creation of the University of Modena and Reggio Emilia (UNIMORE) not only combined the ancient traditions of the two cities into one institution, but also gave a new and powerful boost to the development of the University, resulting in a substantial growth of scientific and academic activities, which still continues today.

The Department of Engineering and Agriculture was established in Reggio Emilia in 1998, followed in 1999, by the Department of Arts and Humanities in Modena. Subsequently, the University witnessed the birth of the Departments of Communication Studies and of Education Studies in Reggio Emilia, while growth continued in Modena with the institution of the Department of Biosciences and Biotechnologies.

Nowadays UNIMORE is considered one of the best universities in Italy for teaching and research. It is ranked among the top 10 large-sized Italian universities by the Censis University Ranking 2023. UNIMORE, which has just over 28,000 students including 3,500 postgraduates, is large enough to offer all the facilities one would expect from a major university (well-stocked libraries, computer rooms, free internet connection and study support services) but small enough to retain a personal and friendly learning environment.

UNIMORE is composed of 13 Departments, 1 School of Engineering and 1 Faculty of Medicine, offering a wide range of degree programmes at undergraduate level, right up to doctoral studies in most disciplinary areas, from the humanities and social sciences to engineering and technology, and from physical and natural sciences to medicine and life sciences.

UNIMORE is located in the heart of one of Europe's wealthiest and most dynamic regions, which is world-renowned for its production of mechanical parts, engines, sports cars (e.g. Ferrari and Maserati) as well as for its agro-food sector, ceramic tiles and manufacturing industries.
UNIMORE is located in two cities with the highest quality of living standards in Italy. Both Modena and Reggio Emilia are considered important cities of art and culture.
Furthermore, didactic activities take place also in Carpi (Modena) and Mantua (Lombardia).

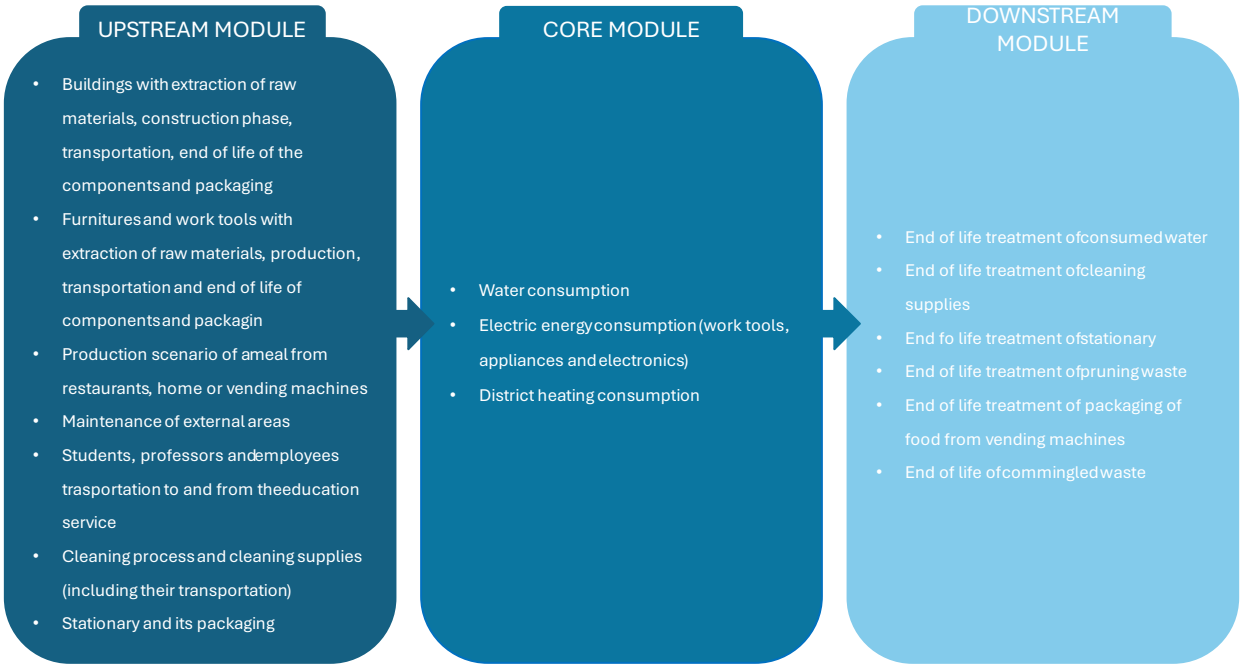
UNIMORE AND SUSTAINABILITY

Recently, the University of Modena and Reggio Emilia has launched the initiative "UNIMORE sostenibile" (*Sustainable UNIMORE*) that promotes numerous actions to improve the environmental, economic and social sustainability of the Institution both internally and externally (e.g., research projects, public engagement).
Moreover, according to its strategic development plan 2020-2025, UNIMORE is committed to monitoring and quantifying the outcomes of this initiative in terms of the potential environmental, economic and social impacts. This led to the realization of a Life Cycle Assessment (LCA) study aimed at quantifying the potential environmental impacts associated with the life cycle of the first stage tertiary educational service delivered by the Department of Sciences and Methods for Engineering.

3. SCOPE AND TYPE OF THE EPD

SYSTEM BOUNDARIES

The entire life cycle of the educational service is considered (cradle-to-grave) and the three modules described below are declared in this EPD.



Since the flows related to the buildings in which the education takes place and those related to the construction operations for such buildings are optional (according to the PCR of reference, i.e., EPDItaly031), the results are first given without considering those contributions in the UPSTREAM

MODULE. However, for the sake of completeness, the results are also given by considering those contributions in the UPSTREAM module.

TYPE OF EPD:

EPD related to the tertiary educational service delivered by the Department of Sciences and Methods for Engineering of the University of Modena and Reggio Emilia over the academic year September 2021- August 2022. The Department object of this EPD is located in Reggio Emilia. The education service is provided in three different buildings ("pavilions") and additional locations as detailed in the Service Description (Section 4).

GEOGRAPHICAL REPRESENTATIVENESS:

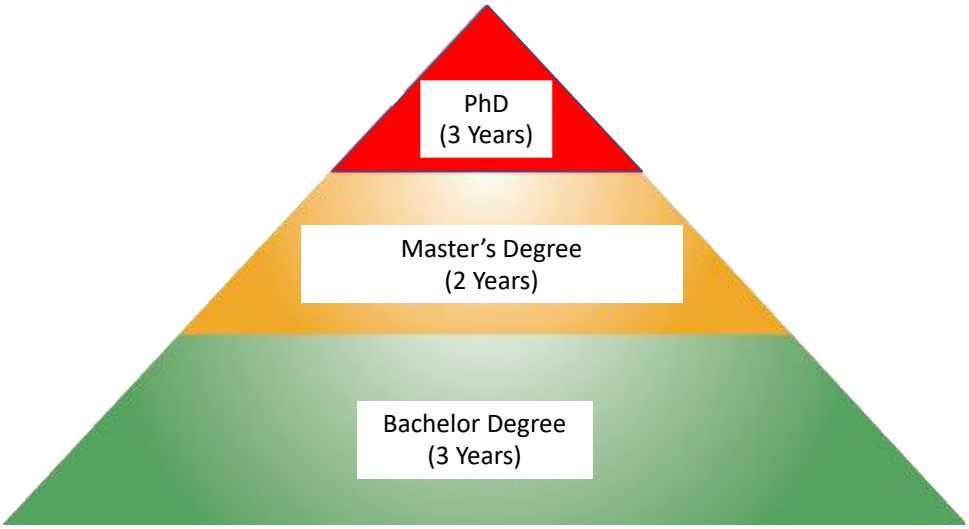
The environmental performance is calculated with reference to the Italian Scenario when available in the used database or to the European one, when specific data related to Italy could not be found.

SOFTWARE AND DATABASE:

SimaPro v. 9.6.0.1 software was used to carry out the LCA modelling with background LCI datasets taken from the Ecoinvent database v. 3.10.

4. SERVICE DESCRIPTION

The educational services offered by the Department of Sciences and Methods for Engineering of the University of Modena and Reggio Emilia are structured according to the following pyramid.



Since the object of the present EPD is the first stage tertiary educational service (c.p.c. 92510), the PhD is excluded.

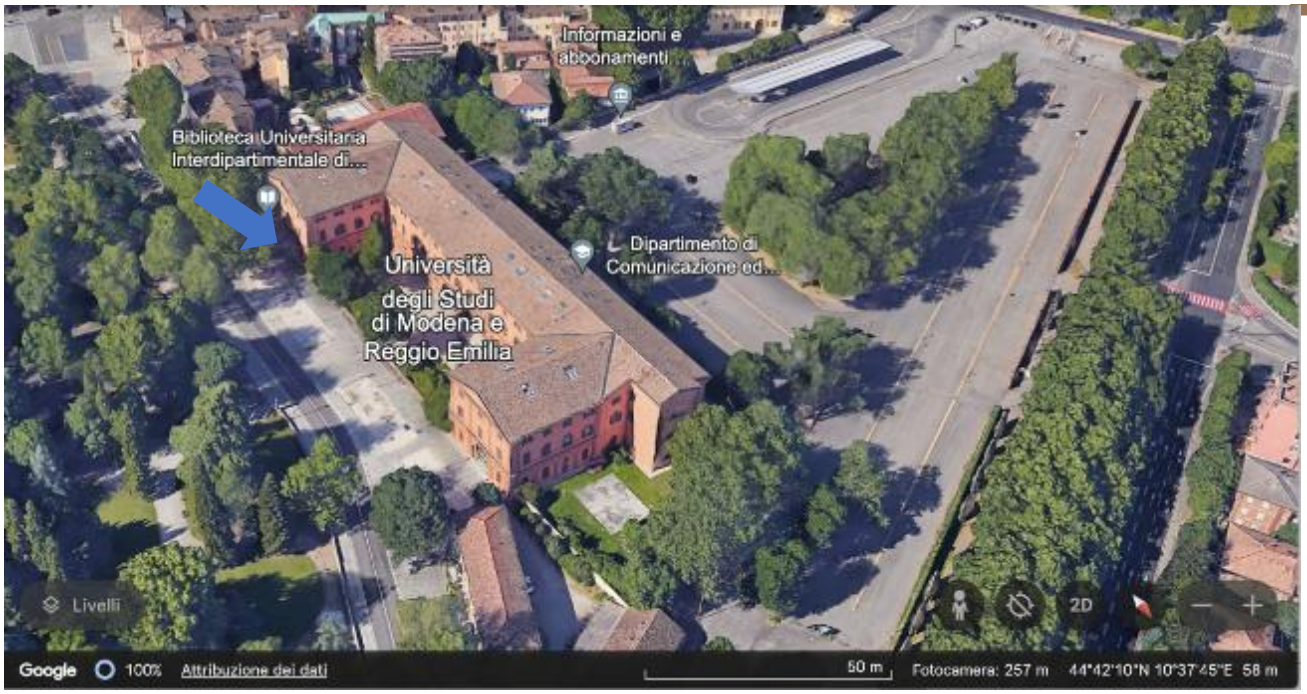
The peculiarity of the educational service offered by the Department of Sciences and Methods for Engineering of UNIMORE is the interdisciplinarity of its curricula, wherein a variety of disciplines like informatics, electronics, mechanics, economics and support to decision-making are integrated in an harmonized manner.

The bachelor's degrees require the students to acquire 180 CFU (i.e., Crediti Formativi Universitari) distributed homogeneously over the three years, with a maximum of 20 courses (and exams).

The CFU represents a measure of the amount of work required for the student to get ready for the examination of a given course. The CFU are acquired once the student has been successful on an examination (with the mark being not less than eighteen out of thirty).
The active bachelor's degrees at the Department of Sciences and Methods for Engineering of UNIMORE are Management Engineering (free access), Mechatronics Engineering (number of access limited to 199 students) and Technologies for Intelligent Industry (number of access limited to 50 students)
The master's degree requires the students to acquire 120 CFU homogeneously distributed over two years, with a maximum of 12 courses (and exams). In order to be admitted to a master's degree, the student must have a bachelor's degree. The minimum mark for admission is 80/100.
The active master's Degrees at the Department of Sciences and Methods for Engineering of UNIMORE are Management Engineering, Mechatronics Engineering and Digital Automation Engineering.
The Department of Sciences and Methods for Engineering is located in Reggio Emilia (Italy) at the Campus San Lazzaro, via Amendola 2. As previously mentioned, the Department comprises three Pavilions:

- Buccola-Bisi (RE-07)
- Morselli (RE-09)
- Tamburini (RE-08), which are indicated (from left to right respectively) by the blue arrows in the following image.

There is also an Interdepartmental University Library in Reggio Emilia (whose services are also available to DISMI students), located at Viale Allegri 9 (RE-04), indicated by the blue arrow in the following figure.



Moreover, during the academic year 2021-2022 (i.e., the one considered for the present EPD) the Department of Sciences and Methods for Engineering also utilized two additional rooms for educational activities:

- Centro Simonazzi (located in via Turri 55, Reggio Emilia, Italy)
- Sala A Teatro San Prospero (located in via Guidelli 5, Reggio Emilia, Italy). These are shown in the two photographs in the following figure (from left to right respectively).

FUNCTIONAL UNIT AND REFERENCE FLOW:

In accordance with PCR EPDItaly031 the functional unit is the total number of students regularly enrolled at the Department of Sciences and Methods for Engineering of UNIMORE in the academic year 2021-2022 (i.e., 1964 students), multiplied by the total number of education hours characterizing the education service of the same Department in the same academic year (i.e., 9037.3 hours), corresponding to 17749232.68 students*education hours.

The total number of hours refers to the three different bachelor's degrees (i.e., Management Engineering, Mechatronics Engineering and Technologies for Intelligent Industry) and to the three different master's degrees (i.e., Management Engineering, Mechatronics Engineering and Digital Automation Engineering).

REFERENCE SERVICE LIFE:

The reference service life in the EPD is 1 academic year, particularly the academic year 2021-2022.

5. LIFE CYCLE ASSESSMENT RESULTS

The following tables show the results of the LCA study for a functional unit of 17749232.68 students*education hours of the first stage tertiary educational service delivered by the Department of Sciences and Methods for Engineering in the academic year 2021-2022.
The calculation methods used for the analysis are reported hereafter:

- EN 15804+A2 v.1.01 (adapted), for environmental impact.
- CML-IA baseline v.3.10 used for some of the indicators (MRF e MER) related to waste production obtained through inventory counting.
- Cumulative Energy Demand (LHV) V1.01 for the indicators related to the consumption of resources.
- Selected LCI results, additional for the indicator “net use of fresh water”.
- EDIP 2003 V.1.07 for radioactive waste (RWD) and for other indicators related to waste production (HWD and NHWD).
- TRACI 2.1 v.1.09.

In the following paragraphs the results, that do not consider the buildings of the pavilions considered in the study, are reported.

5.1 ENVIRONMENTAL IMPACT

1 year of tertiary education services (17749232.68 students*education hours), EN15804+A2 (adapted)		MODULES		
Parameter	Unit	Upstream	Core	Downstream
AP	mol H+ eq	9,61E+03	4,28E+02	6,65E+02
GWP	kg CO2 eq	2,54E+06	2,10E+05	1,48E+05
GWP - Biogenic	kg CO2 eq	-1,28E+05	1,84E+04	3,82E+04
GWP - Fossil	kg CO2 eq	2,66E+06	1,91E+05	1,09E+05
GWP - Land use/Land use change	kg CO2 eq	5,52E+03	1,71E+02	3,70E+02
ETP - freshwater - part 1	CTUe	1,19E+07	2,92E+05	6,42E+05
ETP - freshwater - part 2	CTUe	5,23E+06	1,42E+05	5,57E+05
PM	disease inc.	1,27E-01	2,32E-03	5,32E-03
EP - marine	kg N eq	2,84E+03	9,58E+01	2,88E+02
EP - freshwater	kg P eq	4,01E+02	2,54E+01	5,86E+01
EP - terrestrial	mol N eq	2,65E+04	9,39E+02	1,87E+03
HTP - c	CTUh	1,91E-02	4,78E-04	5,03E-04
HTP - nc	CTUh	3,07E-02	6,68E-04	2,24E-03
IRP	kBq U-235 eq	9,67E+04	1,25E+04	3,04E+04
SQP	Pt	1,82E+07	5,83E+05	4,72E+06

ODP	kg CFC11 eq	2,06E-01	5,56E-03	3,30E-03
POCP	kg NMVOC eq	1,14E+04	4,58E+02	3,68E+02
ADP - fossil	MJ	3,55E+07	3,04E+06	1,69E+06
ADP - minerals & metals	kg Sb eq	3,34E+01	2,43E-01	4,80E-01

AP = Acidification potential of land and water; GWP = Global warming potential; ETP-fw = Potential Comparative Toxic Unit for ecosystems; PM = Potential incidence of disease due to PM emissions; EP = Eutrophication potential; HTP-c= Potential Comparative Toxic Unit for humans; HTP-nc= Potential Comparative Toxic Unit for humans; IRP = Potential Human exposure efficiency relative to U235; SQP= Potential Soil quality index; ODP = Depletion potential of the stratospheric ozone layer; ; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADP-fossil = Abiotic depletion potential for fossil resources; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ; WDP = Water (user) deprivation potential

5.2 RESOURCE USE

1 year of tertiary education services (17749232.68 students*education hours)		MODULES		
Parameter	Unit	Upstream	Core	Downstream
PERE	MJ	3,07E+06	5,59E+05	1,10E+06
PERM	MJ	9,89E+02	0,00E+00	0,00E+00
PERT	MJ	3,07E+06	5,59E+05	1,10E+06
PENRE	MJ	3,55E+07	3,04E+06	2,06E+06
PENRM	MJ	4,73E+00	0,00E+00	0,00E+00
PENRT	MJ	3,55E+07	3,04E+06	1,69E+06
SM	kg	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00
FW	m3	2,31E+04	7,35E+03	-1,90E+03

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water.

5.3 OUTPUT FLOWS AND WASTE CATEGORIES

1 year of tertiary education services (17749232.68 students*education hours)		MODULES		
Parameter	Unit	Upstream	Core	Downstream
HWD	kg	7,63E+03	3,45E+03	6,89E+03
NHWD	kg	8,65E+05	6,91E+03	2,33E+04
RWD	kg	2,43E+01	3,30E+00	7,79E+00
CRU	kg	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	1,36E+05
MER	kg	0,00E+00	0,00E+00	4,91E-03
EEE	MJ	0,00E+00	0,00E+00	0,00E+00
EET	MJ	0,00E+00	0,00E+00	0,00E+00

HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy.

5.4 TRACI INDICATORS

According to UL, USA program operator, TRACI indicators (version 2.1), from EPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts, are listed below:

1 year of tertiary education services (17749232.68 students*education hours)		MODULES		
Parameter	Unit	Upstream	Core	Downstream
Ozone depletion	kg CFC-11 eq	1,95E-01	5,81E-03	3,57E-03
Global warming	kg CO_2 eq	2,63E+06	1,89E+05	1,16E+05
Smog	kg O_3 eq	1,34E+05	5,04E+03	6,07E+03
Acidification	kg SO_2 eq	8,11E+03	3,55E+02	5,33E+02
Eutrophication	kg N eq	5,47E+03	2,53E+02	8,03E+02

5.5 INTERPRETATION OF THE RESULTS

The UPSTREAM module is responsible for the majority of the analysed impacts (90.29%). By analysing in detail the impacts associated with the UPSTREAM module, it can be noticed that the main contributions to the impact category Global Warming Potential (GWP) are related to the emissions in air of *carbon dioxide of fossil origin*, mainly associated with the datasets used to model the round-trip transportation of students and University staff at the Department of Sciences and Methods for Engineering.

In the ozone layer depletion (ODP) category the main impacts are due to atmospheric emissions of *methane, bromo-, and Halon 1001*, which primarily result from the synthesis of purified terephthalic acid, needed for the production of PET used in plastic bottles consumed daily by students, professors, and university staff.
Eutrophication potential (EP) -freshwater is mainly influenced by emissions in water of *phosphates*, originating from the treatment of coal waste used in the production of gasoline and diesel cars utilized for the transportation of staff and students.
In the category Eutrophication potential (EP) -marine the impact is mainly caused by atmospheric emissions of *nitrogen oxides* resulting from the diesel-based car transportation of students, professors, and university staff.
In the category Eutrophication potential (EP) -terrestrial, the environmental impact is mainly due to the atmospheric emissions of *nitrogen oxides* associated with the diesel-based round-trip transportation of students and University staff.
These emissions of *nitrogen oxides*, arising from the production of oil and natural gas, are also responsible for most of the impacts in the category Photochemical oxidation (POCP).
Sulfur dioxide emission in air is the main responsible for the impact in the category Acidification potential (AP). *Sulfur dioxide* emission is mainly associated with the production of crude oil and diesel necessary for the round-trip transportation of students and University staff.
The category Abiotic depletion potential for non-fossil resources (ADP- minerals & metals) is primarily affected by the consumption of Gold involved both in the production of integrated circuits necessary for building gasoline, methane, and diesel vehicles used by students, professors, and university staff, and to a lesser extent in the production of electrical connectors used in the electronic equipment of the Morselli Pavilion.
The consumption of *Oil, crude* is the main responsible for the value of the impact category Abiotic depletion potential for fossil resources (ADP-fossil). The consumption of this resource is mainly due to the production of the fuels necessary for the round-trip transportation by car of the students and University staff.

5.6 SCALED RESULTS

In order to make the results comparable among education services with a different number of students receiving a different number of education hours, the results of the impact assessment were being scaled down to be referred to a single student receiving one single education hour in a single year. The scaled results are reported hereafter.

1 student receiving 1 hour of education in a single year **EN 15804**		MODULES		
Parameter	Unit	Upstream	Core	Downstream
AP	mol H+ eq	5,42E-04	2,41E-05	3,75E-05
GWP	kg CO2 eq	1,43E-01	1,18E-02	8,33E-03
GWP - Biogenic	kg CO2 eq	-7,19E-03	1,04E-03	2,16E-03
GWP - Fossil	kg CO2 eq	1,50E-01	1,08E-02	6,16E-03
GWP - Land use/Land use change	kg CO2 eq	3,11E-04	9,66E-06	2,08E-05

ETP - freshwater - part 1	CTUe	6,70E-01	1,64E-02	3,62E-02
ETP - freshwater - part 2	CTUe	2,95E-01	8,02E-03	3,14E-02
PM	disease inc.	7,13E-09	1,31E-10	3,00E-10
EP - marine	kg N eq	1,60E-04	5,40E-06	1,62E-05
EP - freshwater	kg P eq	2,26E-05	1,43E-06	3,30E-06
EP - terrestrial	mol N eq	1,49E-03	5,29E-05	1,05E-04
HTP - c	CTUh	1,08E-09	2,69E-11	2,84E-11
HTP - nc	CTUh	1,73E-09	3,77E-11	1,26E-10
IRP	kBq U-235 eq	5,45E-03	7,04E-04	1,71E-03
SQP	Pt	1,02E+00	3,28E-02	2,66E-01
ODP	kg CFC11 eq	1,16E-08	3,13E-10	1,86E-10
POCP	kg NMVOC eq	6,43E-04	2,58E-05	2,07E-05
ADP - fossil	MJ	2,00E+00	1,71E-01	9,53E-02
ADP - minerals & metals	kg Sb eq	1,88E-06	1,37E-08	2,70E-08
WDP	m3 depriv.	4,11E-02	1,76E-02	-4,93E-03

AP = Acidification potential of land and water; GWP = Global warming potential; ETP-fw = Potential Comparative Toxic Unit for ecosystems; PM = Potential incidence of disease due to PM emissions; EP = Eutrophication potential; HTP-c= Potential Comparative Toxic Unit for humans; HTP-nc= Potential Comparative Toxic Unit for humans; IRP = Potential Human exposure efficiency relative to U235; SQP= Potential Soil quality index; ODP = Depletion potential of the stratospheric ozone layer; ; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADP-fossil = Abiotic depletion potential for fossil resources; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ; WDP = Water (user) deprivation potential.

1 student receiving 1 hour of education in a single year **CML-IA**		MODULES		
Parameter	Unit	Upstream	Core	Downstream
ADP	kg Sb eq	1,89E-06	1,38E-08	3,01E-08
ADP-fossil	MJ	1,91E+00	1,58E-01	6,46E-02
GWP	kg CO2 eq	1,49E-01	1,08E-02	6,65E-03
ODP	kg CFC-11 eq	8,20E-09	2,58E-10	1,65E-10
POCP	kg C2H4 eq	3,89E-05	1,39E-06	1,35E-06
AP	kg SO2 eq	4,23E-04	1,97E-05	2,78E-05
EP	kg PO4--- eq	1,66E-04	7,37E-06	2,19E-05

GWP = Global warming potential; ODP = Ozone depletion potential; AP = Acidification potential; EP = Eutrophication potential; POCP = Photochemical ozone creation potential; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion potential for fossil resources.

1 student receiving 1 hour of education in a single year **RESOURSE USE**		MODULES		
Parameter	Unit	Upstream	Core	Downstream
PERE	MJ	1,72E-01	3,15E-02	5,98E-02
PERM	MJ	1,07E-03	0,00E+00	0,00E+00
PERT	MJ	1,73E-01	3,15E-02	5,98E-02
PENRE	MJ	2,00E+00	1,71E-01	9,53E-02
PENRM	MJ	2,67E-07	0,00E+00	0,00E+00
PENRT	MJ	2,00E+00	1,71E-01	9,53E-02
SM	kg	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00
FW	m^3	1,30E-03	4,14E-04	-1,07E-04

PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water.

1 student receiving 1 hour of education in a single year **WASTE**		MODULES		
Parameter	Unit	Upstream	Core	Downstream
HWD	kg	4,30E-04	1,95E-04	3,88E-04
NHWD	kg	4,87E-02	3,89E-04	1,31E-03
RWD	kg	1,37E-06	1,86E-07	4,39E-07
CRU	kg	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	7,68E-03
MER	kg	0,00E+00	0,00E+00	2,77E-10
EEE	MJ	0,00E+00	0,00E+00	0,00E+00
EET	MJ	0,00E+00	0,00E+00	0,00E+00

HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy.

1 student receiving 1 hour of education in a single year **TRACI**		MODULES		
Parameter	Unit	Upstream	Core	Downstream
Ozone depletion	kg CFC-11 eq	1,10E-08	3,28E-10	2,01E-10
Global warming	kg CO_2 eq	1,48E-01	1,06E-02	6,53E-03
Smog	kg O_3 eq	7,54E-03	2,84E-04	3,42E-04
Acidification	kg SO_2 eq	4,57E-04	2,00E-05	3,00E-05
Eutrophication	kg N eq	3,08E-04	1,42E-05	4,53E-05

6.CALCULATION RULES

FUNCTIONAL UNIT:

NAME	AMOUNT	UNIT
Functional unit	17749232.68	Students*education hours
Conversion factor	5.63E-08	-

MAIN ASSUMPTIONS:

- The main assumptions regarding the different lifetime hypothesized in the Upstream module are hereafter reported:

Module	Reference process	Life time	Value	Description
UPSTREAM	Buccola pavilion	TvitaBuccolarist	300 years (2.63E6 h)	Lifetime of the renovated buildings (the same applies to all DISMI pavilions)
	Green area managment	Tvitasega	2500 h	Lifetime of chainsaw for tree pruning
		TvitaLGV	43800 h	Lifetime of forklift for tree pruning
	Equipment/Furniture	TvitaSedia	50 years	Lifetime chair
		TvitaArmadio	50 years	Lifetime wardrobe
		TvitaTavolo	50 years	Lifetime table
		TvitaComputer	8years	Lifetime of laptop, also used for: - Printers - Desktop computer - Tablet - Mouse - General electronic equipment (motorized screens, transmitter,

				splitter, speaker, camera, amplifier, DVD player, video lesson systems, switcher, RAM, video projector, adapter)
		TvitaMonitor	10 years	Lifetime of monitor for desktop computer
		TvitaFrigo	20 years	Lifetime of refrigerator
		Tvitarilegatrici	10 years	Lifetime of office binding machines
		Tvitabacheca	10 years	Lifetime of a bulletin board
		TvitaTV	20 years	Lifetime smart TV
		Tvitacell	4 years	Lifetime smartphone
		TvitaSedute	20 years	Lifetime of modular metal triple seats
		Tvitapostlav	20 years	Lifetime of office workstation (desk)
		Tvitalam	15 years	Lifetime lamp
		Tvitacassaforte	50 years	Lifetime of a safe
		Tvitascala	15 years	Lifetime of step ladder
		Tvitabachecasug	7 years	Lifetime of cork bulletin board
		Tvitaplast	5 years	Lifetime of plastic equipment (graphic tablet pen, phone case
		Tvitaclimatiz	10 years	Lifetime portable AC unit
		Tvitateloproiett	8 years	Lifetime of projector screens for lessons
		Tvitalavagna	10 years	Lifetime of blackboards
	Homemade lunch	Tvitacont	40000 h	Lifetime of plastic container for transporting food from home to DISMI
	Stationary	Tvitapile	2 years	Lifetime of AA batteries for microphones
		TvitaToner	1 year	Lifetime for printer
		Tvitacarta	7 years	Lifetime of paper (for envelopes, sheets, etc.)
		TvitaPlastica	10 years	Lifetime plastic materials
		Tvitacucitrice	10 years	Lifetime of metal stapler
		Tvitapuntina	8 years	Lifetime of a metal push pin
		Tvitalevapunti	10 years	Lifetime of an office staple remover
		Tvitagesso	2 years	Lifetime of blackboard chalk
		Tvitascotch	10 years	Lifetime scotch
		Tvitaforbici	50 years	Lifetime scissors
		Tvitapenna	5 years	Lifetime pen
		Tvitafermagli	10 years	Lifetime of galvanized paper clips for documents
		Tvitaracc	10 years	Lifetime of paper binder for documents

- For the transport scenario, the following distances were considered after completing a survey among students and University staff:

Origin	Means of transport	Distance one way (km)
Reggio Emilia province	car	20.03
Outside Reggio Emilia province (adjacent provinces)	car	35
Inside Reggio Emilia province	train	10
Outside Reggio Emilia province (adjacent provinces)	train	35
Outside Reggio Emilia province (non-adjacent provinces and outside Emilia Romagna)	train	75
Reggio Emilia (city)	bus	10
Outside Reggio Emilia province (adjacent provinces)	bus	35
Average distance from the survey (personnel)	motorcycle	35
Average distance from the survey (students)	motorcycle	12.44
Reggio Emilia (city)	Electric kick scooter	8
Reggio emilia (city)	bike	5

- As for the students' meals, since no survey had been made (conversely, this aspect had been included in the questionnaire directed to the University staff), it was hypothesized that 80% of students brought their lunch from home and the remaining 20% bought their lunch in the bar/restaurant near the Department.

-For coffee and drinking water, it was assumed that the consumption by each student and University staff member is 1 coffee/day and 1 l water/day.

-Regarding the composition of the meal, it was hypothesised to consider a balanced meal composed of cooked pasta, legumes (beans), vegetables (tomato) and fruit (apple), around 800kcals. This meal composition was considered both for the homemade lunch and for the bar/restaurant lunch. As for the vending machine products, chips and jam tarts were considered.

-Regarding the process related to green area management, it is assumed that grass mowing will be carried out on 90% of the total area (assuming that the remaining 10% consists of walkable pedestrian paths). It is also assumed that the grass waste, resulting from mowing, will be left on the ground. For tree pruning, it is assumed that only half of the total number of trees surrounding the three DISMI pavilions will be pruned using an electric chainsaw (1900W). The number of trees will be evenly split between young and adult trees, considering different pruning times for young and adult trees, respectively 3 and 18 minutes. Additionally, it is assumed that 1% of the tree crown will be pruned. The weight of the crown is calculated as 20% of the trunk's trees weight, with the latter estimated using the following measurements:

- adult trees: 10m height, 0.60m trunk diameter
- young trees: 4m height, 0.10m trunk diameter

The waste treatment considered for the pruning waste is a biowaste one.

-As for the end of life treatment, when possible, recycling processes were considered (like for plastic and paper waste); if that was not possible, landfill waste disposal were considered (as for waste originated from cleaning operations); mixed waste, generated from all the three pavilions, were disposed, for 30% through landfill and for 70% through incineration.
Mixed waste weight was determined starting from the TARI documents that reported the number of bins emptings during the academic year 2021-2022, then considering the volume of the bin in litres and an average density of mixed waste it was possible to determine their weight. The same calculation was applied for determining the weight of paper waste.

CUT OFF RULES:

All input and output processes were considered in the analysis and thus in the final results without any exclusion (cut-off: 0).

DATA QUALITY:

The data related to the number of enrolled students and their provenance were obtained from the Intranet page of the University of Modena and Reggio Emilia, in the section Statistics.
Data related to the academic calendar, staff and furniture of the Department, were obtained by the technical-administrative personnel of the same Department.
Data related to the books available in the Interdepartmental library were obtained by the technical-administrative personnel of the same library.
Data related to the waste generated by the Department as well as those related to the energy and water consumption were obtained from the Technical Direction of the University of Modena and Reggio Emilia.
Data related to the transportation and meals consumed by University staff members were obtained by ad -hoc surveys.

ALLOCATIONS:

For those processes in which materials and products are involved not only in the educational service but also in research and third-party activities, an allocation was made by considering the ratio between the (minimum) number of hours for teaching and student support that need to be guaranteed by each Assistant Professor, Associate Professor and Full Professor of the University of Modena and Reggio Emilia (i.e., 350 h) and the number of their total working hours (i.e., 1720), in the same academic year.

7. ADDITIONAL ENVIRONMENTAL INFORMATION

7.1 ENVIROMENTAL IMPACT USING CML-IA

To better understand the environmental impacts, another method, CML-IA baseline v.3.10, was used to determined them. In the table below some additional environmental impacts results are reported.

1 year of tertiary education services (17749232.68 students*education hours), CML-IA baseline		MODULES		
Parameter	Unit	Upstream	Core	Downstream
ADP	kg Sb eq	3,35E+01	2,45E-01	5,35E-01
ADP-fossil	MJ	3,39E+07	2,81E+06	1,15E+06
GWP	kg CO2 eq	2,65E+06	1,91E+05	1,18E+05
ODP	kg CFC-11 eq	1,46E-01	4,57E-03	2,92E-03
POCP	kg C2H4 eq	6,91E+02	2,46E+01	2,39E+01
AP	kg SO2 eq	7,50E+03	3,49E+02	4,93E+02
EP	kg PO4--- eq	2,94E+03	1,31E+02	3,90E+02

GWP = Global warming potential; ODP = Ozone depletion potential; AP = Acidification potential; EP = Eutrophication potential; POCP = Photochemical ozone creation potential; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion potential for fossil resources.

7.2 UNCERTANITY TROUGH MONTE CARLO ANALISYS

1 year of tertiary education services (17749232.68 students*education hours), EN15804+A2		MODULES			UNCERTANITY RESULTS						
Parameter	Unit	Upstream	Core	Downstream	mean	median	SD	CV	2.5%	97.5%	SEM
AP	mol H+ eq	9,61E+03	4,28E+02	6,65E+02	1,07E+04	1,07E+04	8,25E+02	769,58%	9,24E+03	1,25E+04	2,61E+01
GWP	kg CO2 eq	2,54E+06	2,10E+05	1,48E+05	2,89E+06	2,88E+06	2,29E+05	790,97%	2,50E+06	3,40E+06	7,23E+03
GWP - Biogenic	kg CO2 eq	-1,28E+05	1,84E+04	3,82E+04	-7,15E+04	-7,04E+04	1,86E+04	-2600,50%	-1,10E+05	-3,53E+04	5,88E+02
GWP - Fossil	kg CO2 eq	2,66E+06	1,91E+05	1,09E+05	2,96E+06	2,95E+06	2,27E+05	767,24%	2,57E+06	3,46E+06	7,18E+03
GWP - Land use/Land use change	kg CO2 eq	5,52E+03	1,71E+02	3,70E+02	6,02E+03	6,04E+03	1,16E+03	1928,03%	3,77E+03	8,28E+03	3,67E+01
ETP - freshwater - part 1	CTUe	1,19E+07	2,92E+05	6,42E+05	1,50E+07	1,37E+07	3,38E+07	22466,00%	-5,18E+07	8,35E+07	1,07E+06
ETP - freshwater - part 2	CTUe	5,23E+06	1,42E+05	5,57E+05	5,85E+06	5,77E+06	2,33E+06	3990,07%	1,32E+06	1,05E+07	7,38E+04
PM	disease inc.	1,27E-01	2,32E-03	5,32E-03	1,34E-01	1,31E-01	1,70E-02	1270,43%	1,08E-01	1,74E-01	5,37E-04
EP - marine	kg N eq	2,84E+03	9,58E+01	2,88E+02	3,24E+03	3,23E+03	1,87E+02	575,62%	2,88E+03	3,63E+03	5,90E+00
EP - freshwater	kg P eq	4,01E+02	2,54E+01	5,86E+01	4,78E+02	4,44E+02	1,66E+02	3481,37%	2,59E+02	9,01E+02	5,26E+00

EP - terrestrial	mol N eq	2,65E+04	9,39E+02	1,87E+03	2,94E+04	2,92E+04	1,83E+03	622,17%	2,59E+04	3,32E+04	5,78E+01
HTP - c	CTUh	1,91E-02	4,78E-04	5,03E-04	8,53E-03	1,54E-02	3,22E-01	377841,66%	-6,15E-01	6,72E-01	1,02E-02
HTP - nc	CTUh	3,07E-02	6,68E-04	2,24E-03	-1,27E+00	-1,04E+00	3,82E+01	-300716,66%	-7,47E+01	7,93E+01	1,21E+00
IRP	kBq U-235 eq	9,67E+04	1,25E+04	3,04E+04	1,41E+05	9,94E+04	1,27E+05	9026,78%	4,75E+04	5,23E+05	4,02E+03
SQP	Pt	1,82E+07	5,83E+05	4,72E+06	2,30E+07	2,20E+07	2,17E+07	9431,25%	-1,88E+07	6,68E+07	6,85E+05
ODP	kg CFC11 eq	2,06E-01	5,56E-03	3,30E-03	2,18E-01	2,07E-01	5,92E-02	2714,18%	1,33E-01	3,60E-01	1,87E-03
POCP	kg NMVOC eq	1,14E+04	4,58E+02	3,68E+02	1,23E+04	1,20E+04	1,60E+03	1301,95%	9,95E+03	1,62E+04	5,05E+01
ADP - fossil	MJ	3,55E+07	3,04E+06	1,69E+06	4,03E+07	3,94E+07	6,11E+06	1515,28%	3,16E+07	5,43E+07	1,93E+05
ADP - minerals & metals	kg Sb eq	3,34E+01	2,43E-01	4,80E-01	3,42E+01	3,35E+01	5,82E+00	1701,44%	2,46E+01	4,68E+01	1,84E-01

AP = Acidification potential of land and water; GWP = Global warming potential; ETP-fw = Potential Comparative Toxic Unit for ecosystems; PM = Potential incidence of disease due to PM emissions; EP = Eutrophication potential; HTP-c= Potential Comparative Toxic Unit for humans; HTP-nc= Potential Comparative Toxic Unit for humans; IRP = Potential Human exposure efficiency relative to U235; SQP= Potential Soil quality index; ODP = Depletion potential of the stratospheric ozone layer; ; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADP-fossil = Abiotic depletion potential for fossil resources; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ; WDP = Water (user) deprivation potential; SD =standard deviation; CV = variation coefficient; SEM =mean standard devation;

7.3 ENVIROMENTAL IMPACT CONSIDERING BUILDINGS AND CONSTRUCTION OPERATION

To better understand the role of buildings and their construction (which includes packaging, materials, and processing), the environmental impact was recalculated by introducing a new Upstream module, modified to include the buildings for each pavilion considered in the study. The following tables present the results obtained when including the buildings (only the Upstream module is shown, as it is the only one affected by changes in the results; the other two modules, Core and Downstream, remain unchanged from the scenario without buildings). Each table also includes the previously obtained results in order to calculate the percentage increase resulting from the inclusion of buildings.

EN 15804				
Impact category	Unit	Upstream (with buildings)	Upstream (no buildings)	% increase
AP	mol H+ eq	9,70E+03	9,61E+03	0,90
GWP	kg CO2 eq	2,55E+06	2,54E+06	0,43
GWP - Biogenic	kg CO2 eq	-1,29E+05	-1,28E+05	1,30
GWP - Fossil	kg CO2 eq	2,67E+06	2,66E+06	0,47
GWP - Land use/Land use change	kg CO2 eq	5,54E+03	5,52E+03	0,36
ETP - freshwater - part 1	CTUe	1,19E+07	1,19E+07	0,35
ETP - freshwater - part 2	CTUe	5,28E+06	5,23E+06	0,98
PM	disease inc.	1,28E-01	1,27E-01	1,21
EP - marine	kg N eq	2,86E+03	2,84E+03	0,41
EP - freshwater	kg P eq	4,06E+02	4,01E+02	1,18
EP - terrestrial	mol N eq	2,66E+04	2,65E+04	0,51
HTP - c	CTUh	1,92E-02	1,91E-02	0,59
HTP - nc	CTUh	3,12E-02	3,07E-02	1,34
IRP	kBq U-235 eq	9,74E+04	9,67E+04	0,78
SQP	Pt	1,83E+07	1,82E+07	0,85
ODP	kg CFC11 eq	2,07E-01	2,06E-01	0,09
POCP	kg NMVOC eq	1,15E+04	1,14E+04	0,44
ADP - fossil	MJ	3,57E+07	3,55E+07	0,44
ADP - minerals & metals	kg Sb eq	3,37E+01	3,34E+01	1,07
WDP	m3 depriv.	7,36E+05	7,30E+05	0,73

AP = Acidification potential of land and water; GWP = Global warming potential; ETP-fw = Potential Comparative Toxic Unit for ecosystems; PM = Potential incidence of disease due to PM emissions; EP = Eutrophication potential; HTP-c= Potential Comparative Toxic Unit for humans; HTP-nc= Potential Comparative Toxic Unit for humans; IRP = Potential Human exposure efficiency relative to U235; SQP= Potential Soil quality index; ODP = Depletion potential of the stratospheric ozone layer; ; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADP-fossil = Abiotic depletion potential for fossil resources; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ; WDP = Water (user) deprivation potential.

Average % increase = 0.72%

The average percentage increase is 0.72%, which is not a particularly significant increase, probably due to the fact that buildings, when considered, are allocated to just one year of their supposed lifetime, probably a period too short for them to have a significant impact on the results.

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UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Dipartimento di Scienze e Metodi dell'Ingegneria

Dipartimento di Scienze e Metodi dell'Ingegneria, Università degli Studi di Modena e Reggio Emilia, via Amendola 2, 42122, Reggio Emilia, Italy

www.dismi.unimore.it