THE CARBON FOOTPRINT OF THE VUB

2018

ecolife

VRIJE UNIVERSITEIT BRUSSEL

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

In 2017, the VUB (Vrije Universiteit Brussel) performed a baseline measurement of its carbon footprint for the year 2016. Together with an internal working group at the VUB, Ecolife calculated the carbon footprint of the university as well as the reduction potential of possible climate actions. The total carbon footprint of VUB teaching and research activities at campuses Etterbeek and Jette was 34.869 ton CO_2e or 2,3 ton CO_2e per student, with 55% of emissions related to mobility (see the Ecolife 2017 report[1]). The results and potential climate actions were discussed with the VUB community in November 2017.

To keep track of the emission reductions and CO_2-compensation requirements for carbon neutrality, the carbon footprint of the VUB is reevaluated for the year 2018. This report presents the results of the evolution of the VUB carbon footprint for the years 2016-2018 per activity or impact category. As in the 2016 baseline study, the carbon footprint of the VUB was carried out according to the same Bilan Carbone® methodology of the French Association Bilan Carbone, with CO_2 emission values adapted to a Belgian context.

For a general description of carbon footprinting, climate targets, CO_2-reduction simulations and CO_2-compensation measures for the VUB, as well as detailed data collection and calculation methodologies and comparisons with other universities and colleges, we refer to the Ecolife 2017 report.

1 The Carbon Footprint of the VUB (2016), Ecolife, Leuven, August 2017
Te downloaden op https://www.vub.be/duurzaamheid/carbon-footprint

2. ADMINISTRATIVE INFORMATION

Client

Name:	Vrije Universiteit Brussel (VUB)
Address:	Pleinlaan 2, 1050 Elsene
Contact person:	Rebecca Lefevere
Mail:	Rebecca.Lefevere@vub.be
Tel:	+32 (0)2 629 14 76
Examined sites:	Campus Etterbeek & Campus Jette
Data year:	2018

Executor

Auditor:	Stijn Bruers
Organisation:	Ecolife vzw
Address:	Valkerijgang 26, 3000 Leuven
Mail:	stijn.bruers@ecolife.be
Tel:	+32 (0)16 22 21 03

Date first draft report:	September 2019
Date publication final report:	November 2019

3. THE CARBON FOOTPRINT

The carbon footprint measures the anthropogenic emissions of Kyoto greenhouse gases.[2] These are the gases included in the Kyoto-protocol (1997):

- *Carbon dioxide* CO_2 (sources: burning of fossil fuels, production of cement, deforestation, change in land use);
- *Methane* CH_4 (sources: agriculture, production processes, natural gas leaks);
- *Nitrous oxide* N_2O (sources: agriculture);
- *Fluorinated gases and halocarbons* SF_6, HFCs, PFCs (sources: cooling systems).

Adding up the global warming potentials of these gases, the carbon footprint is measured in tons of CO_2-equivalents.

For organizations and companies, the carbon footprint has been standardized in ISO Standards 14064-1. The Bilan Carbone® methodology (www.associationbilancarbone.fr) is in accordance with the ISO standards and the Greenhouse Gas Protocol and is used in this study.

According to ISO standards, the carbon footprint consists of three scopes

Scope 1 (direct GHG emissions) consists of all the direct greenhouse gas emissions on the site or by the cars owned by the organization or company. This involves the own fuel consumption for heating, machinery and mobility, as well as possible leaks of cooling gases from cooling installations.

Scope 2 (electricity indirect GHG emissions) consists of the indirect greenhouse gas emissions as a result of the direct consumption of purchased electricity on the site. These indirect emissions are the emissions at the electricity power plants.

Scope 3 (other indirect GHG emissions) contains all other indirect emissions, related to the production of purchased products (goods and services), the processing of waste, commuting, transport and business travel (excluding from own company cars, which are included in scope 1). Scope 3 GHG is often the largest component of most organizations' carbon footprint.

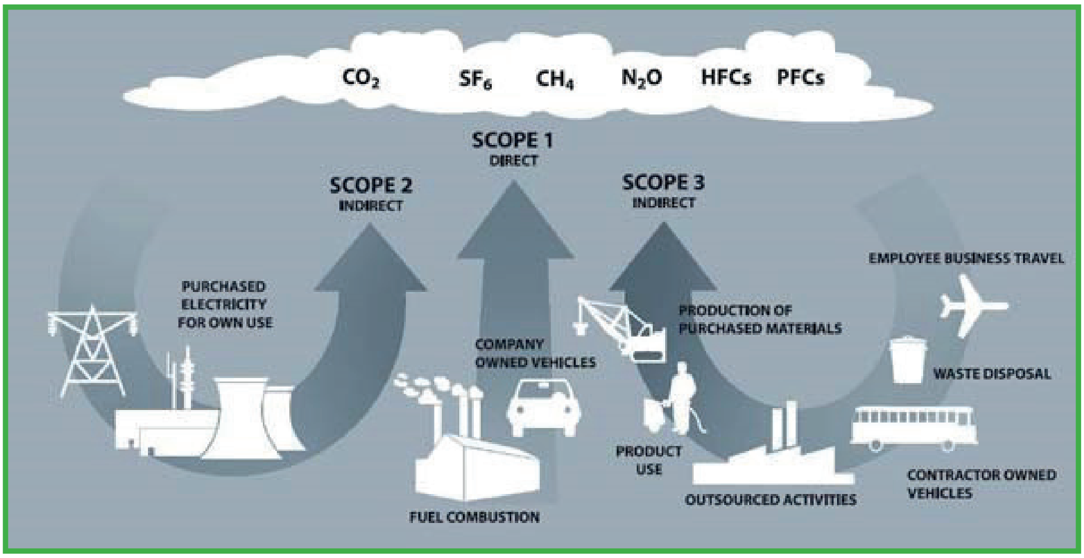

Figure 1: ISO scopes

2 Biological short-cycle emissions from e.g. human respiration or wood combustion do not contribute to the carbon footprint, provided that CO2 is captured by planting new trees or crops for human consumption. Emissions of changes in land use (for example, burning forests if the forests are not re-planted) are included in the carbon footprint.

4. METHODOLOGY

4.1. Definition of the scope

The carbon footprint of the VUB has the following scope.

Sites:

- the campuses at Etterbeek and Jette,
- administrative, research and education buildings, including sporting facilities on Etterbeek (see next section for the list of included buildings),
- student homes owned by VUB,
- the student restaurants located at the campuses.

Activities:

- activities related to administration and academic research: research equipment, waste generation, business travel, employee commuting,
- activities related to education: educational equipment (IT, furniture), student mobility (including airplane travel for foreign students studying at the VUB), student courses paper use, energy use and general waste generated at the student homes on the campuses,
- food consumption (meals) at the student restaurants.

Not included in the carbon footprint (due to lack of data) are:

- private student homes not owned by the VUB (due to lack of data about their energy use and waste generated);
- food consumption at places other than the student restaurants at the campuses;
- equipment and furniture of the student homes owned by the VUB (including the student homes on the campuses);
- logistics and transport of goods other than the transport of waste collection;
- mobility (airplane, car, train) from non-student visitors (e.g. guest lecturers);
- spin-offs of the VUB;
- water consumption (not included due to expected negligible share to the total footprint).

4.2. Impact categories

According to the Bilan Carbone® methodology, the carbon footprint of the VUB consists of 7 relevant impact categories.

1. Energy: emissions related to direct energy use (natural gas, electricity used on the campuses);
2. Non-energy: leaks of halocarbons from cooling installations;
3. Inputs: emissions from the production of purchased materials and services, including meals at student restaurant, purchase of paper and small office equipment;
4. Direct waste: emissions from the transport and treatment of waste collected at the VUB;
5. End-of-life: emissions from the transport and treatment of waste generated for the VUB related activities but not collected at VUB (e.g. paper for student courses);
6. Transporting people: emissions from employee commuting, business travel and student mobility, including direct emissions and indirect emissions from the production of the fuels

and vehicles;

7. Capital goods: embodied energy related emissions from the production, construction and renovation of infrastructure, equipment (ICT), furniture and vehicles owned by the VUB.

4.3. Data collection and processing

The footprint of an activity is always the product of the consumption amount per year (e.g. kWh energy used, kg material consumed, km distance travelled, m^2 infrastructure used or euros purchased) and the footprint intensity of the activity (kg CO_2e per kWh, kg, km, m^2 or euro). Hence, there are two types of data: emission factors or footprint intensities (kg CO_2e per unit of activity) and activity data (including consumption and infrastructure data).

The footprint intensities are data based on LCA-studies (life cycle analysis) and used in the Bilan Carbone® V7.4 Excel file, except for recycled paper, where the value of EcoInvent 2.0 LCA-database is used. These are the same as in the 2016 VUB carbon footprint study.

The activity data for campuses Etterbeek and Jette, presented in the tables below, are data collected by the VUB (Rebecca Lefevere and Maarten Ipers) and processed by Ecolife (Stijn Bruers) to become suitable for the Bilan Carbone® method. Activity data uncertainty values were estimated using the following rules (conform with the ULB carbon footprint):

- 5% uncertainty on internal data from own direct measurements with local meters (e.g. kWh electricity) or accurately counted (e.g. number of meals, m^2 surface area);
- 10% uncertainty on internal data with conversion factor (e.g. kg paper based on number of sheets);
- 20% uncertainty on data extrapolated with assumptions (e.g. leaks of cooling gases, km travel based on surveys);
- 50% uncertainty on data with very uncertain extrapolations (e.g. international train travel).

Impact category	Campus: Etterbeek	2016	2018	Unit	Uncer-tainty
	number of students	13 918	14 204		
	number of employees	2 693	2 556		
Energy	natural gas (LHV)	24 272 869	24 045 999	kWh	5%
	purchased electricity	15 520 866	14 871 582	kWh	5%
	avoided grey electricity production from own produced electricity (from PV and CHP)			kWh	5%
Non-energy direct emis-sions of Kyoto halocarbons	leaks cooling installationsn during use, R134a	0,008	0,011	tonnes	20%
	leaks cooling installationsn during use, R404a	0,005	0,003	tonnes	20%
	leaks cooling installationsn during use, R407c	0,017	0,013	tonnes	20%
	leaks cooling installationsn during use, R410a	0,017	0,019	tonnes	20%
	leaks cooling installationsn during use, R507	0,001	0,001	tonnes	20%
Inputs	common metals	5,3	38,6	tonnes	20%
	plastics (PET)	1,2	7,2	tonnes	20%
	paper (student courses) from new material	36	32	tonnes	10%
	paper from recycled material	5,7	6,2	tonnes	10%
	paper from new material	75	82,6	tonnes	10%
	cardboard	0,4	2,4	tonnes	20%
	medical products	4,7	7,1	tonnes	10%
	industrial products	12,3	16,8	tonnes	10%
	small office equipment	464 121	561 991	euros	5%

Agricultural products (food)	typical meal (with beef)	18 865	20 611	no of meals	5%
	typical meal (with porc)	57 465	55 003	no of meals	5%
	typical meal (with chicken)	52 587	52 765	no of meals	5%
	seafood meal (with fish)	30 443	36 061	no of meals	5%
	seafood meal (with shrimp)	3 593	3 458	no of meals	5%
	vegetarian meal (with cheese)	21 066	20 125	no of meals	5%
	vegan meal	18 803	23 606	no of meals	5%
Direct waste	average household waste - incineration	396	388	tonnes	5%
	steel or tinplate - recycling	5,3	38,6	tonnes	20%
	plastic (PET) - recycling	1,2	7,2	tonnes	20%
	paper - recycling	81	89	tonnes	5%
	cardboard - recycling	0,4	2,4	tonnes	20%
	SIW (Special Industrial Waste) - stabilisation and storage	6,1	8,4	tonnes	5%
	SIW (Special Industrial Waste) - incineration	6,1	8,4	tonnes	5%
	DMW (Dangerous Medical Waste) - incineration	4,7	7,1	tonnes	5%
End of life	paper (student courses) from recycled material	36	32	tonnes	10%
	leaks cooling installations, R134a	0,041	0,053	tonnes	20%
	leaks cooling installations, R404a	0,023	0,015	tonnes	20%
	leaks cooling installations, R407c	0,086	0,067	tonnes	20%
	leaks cooling installations, R410a	0,083	0,093	tonnes	20%
	leaks cooling installations, R507	0,007	0,007	tonnes	20%

Impact category	Campus: Etterbeek	2016	2018	Unit	Uncer-tainty
Transport-ing people - employee commuting	average passenger car	4 467 248	3 534 292	vehicle.km	20%
	bus & coach (urban networks)	557 285	487 577	passenger.km	20%
	train in Belgium	14 131 435	18 122 462	passenger.km	20%
	subway / tram / trolley	1 232 027	1 313 855	passenger.km	20%
Transporting people - employee business travel	average passenger car	922 898	982 883	vehicle.km	20%
	train in Belgium	1 447 135	1 486 901	passenger.km	50%
	train in Germany	23 407	178 068	passenger.km	50%
	train in Netherlands	29 956	227 889	passenger.km	50%
	train in United-Kingdom	27 801	211 497	passenger.km	50%
	train in France, TGV	46 730	355 494	passenger.km	50%
	plane, 100-180 seats, 0-1000 km	99 665	101 776	passenger.km	20%
	plane, 180-250 seats, 1000-2000 km	1 139 307	1 458 520	passenger.km	20%
	plane, 180-250 seats, 2000-3000 km	992 910	1 130 802	passenger.km	20%
	plane, 180-250 seats, 3000-4000 km	527 875	828 304	passenger.km	20%
	plane, 180-250 seats, 4000-5000 km	206 250	450 967	passenger.km	20%
	plane, > 250 seats, 5000-6000 km	102 457	182 805	passenger.km	20%
	plane, > 250 seats, 6000-7000 km	443 623	276 021	passenger.km	20%
	plane, > 250 seats, 7000-8000 km	0	413 245	passenger.km	20%
	plane, > 250 seats, 8000-9000 km	26 609	60 089	passenger.km	20%
	plane, > 250 seats, 9000-10000 km	0	225 604	passenger.km	20%
	plane, > 250 seats, 10000-11000 km	91 172	175 067	passenger.km	20%
	plane, > 250 seats, > 11000 km	14 299 071	15 090 575	passenger.km	20%
Transporting people - students' travels	average passenger car, Belgian students	13 374 248	13 649 228	vehicle.km	20%
	average passenger car, foreign students	987 115	877 435	vehicle.km	20%
	bus & coach (urban networks)	6 166 591	6 293 379	passenger.km	20%
	train in Belgium	45 024 982	45 950 713	passenger.km	20%
	train abroad	2 303 267	2 047 349	passenger.km	20%
	subway / tram / trolley	4 690 284	4 786 718	passenger.km	20%
	plane, 180-250 seats, 1000-2000 km	1 890 830	1 680 737	passenger.km	20%
	plane, 180-250 seats, 5000-6000 km	12 004 267	15 563 672	passenger.km	20%

Capital goods	buildings (dwellings, concrete)	32 588	55 272	m^2 floor area	5%
	buildings (education, concrete)	197 471	206 315	m^2 floor area	5%
	depreciation period buildings	40	40	years	
	TC2 or "normal" parking areas (bitumen)	27 272	27 272	m^2 surface area	20%
	depreciation period parking areas	40	40	years	
	vehicles	18	18	tonnes	20%
	depreciation period vehicles	10	10	years	
	furniture	7 873 913	8 662 983	euros	5%
	depreciation period furniture	20	20	years	
	IT	4 033 167	4 504 778	euros	5%
	depreciation period IT	5	5	years	

Table 1: Consumption and infrastructure data Etterbeek

Impact category	Campus: Jette	2016	2018	Unit	Uncer-tainty
	number of students	1 500	1 531		
	number of employees	484	465		
Energy	natural gas (LHV)	10 265 521	9 941 973	kWh	5%
	purchased electricity	6 402 261	7 073 204	kWh	5%
	avoided grey electricity production from own produced electricity (from PV and CHP)	-628 544	-1 273 619	kWh	5%
Non-energy direct emis-sions of Kyoto halocarbons	leaks cooling installationsn during use, R134a	0,007	0,007	tonnes	20%
	leaks cooling installationsn during use, R404a	0,0002	0,0002	tonnes	20%
	leaks cooling installationsn during use, R407c	0,019	0,019	tonnes	20%
	leaks cooling installationsn during use, R410a	0,007	0,015	tonnes	20%
	leaks cooling installationsn during use, R507	0,0001	0,0001	tonnes	20%
Inputs	common metals	0,0	1,7	tonnes	20%
	plastics (PET)	0,0	0,0	tonnes	20%
	paper (student courses) from new material	3,9	3,4	tonnes	10%
	paper from recycled material	0,7	1,6	tonnes	10%
	paper from new material	8,8	21,0	tonnes	10%
	cardboard	0,0	0,0	tonnes	20%
	medical products	13,8	16,1	tonnes	10%
	industrial products	4,5	6,0	tonnes	10%
	small office equipment	83 731	101 388	euros	5%
Agricultural products (food)	typical meal (with beef)	2 472	2 221	no of meals	5%
	typical meal (with porc)	7 529	5 928	no of meals	5%
	typical meal (with chicken)	6 890	5 687	no of meals	5%
	seafood meal (with fish)	3 989	3 886	no of meals	5%
	seafood meal (with shrimp)	471	373	no of meals	5%
	vegetarian meal (with cheese)	2 760	2 169	no of meals	5%
	vegan meal	2 464	2 544	no of meals	5%
Direct waste	average household waste - incineration	182	185	tonnes	5%
	steel or tinplate - recycling	0,0	1,7	tonnes	20%
	plastic (PET) - recycling	0,00	0,03	tonnes	20%
	paper - recycling	10	23	tonnes	5%
	cardboard - recycling	0,00	0,02	tonnes	20%
	SIW (Special Industrial Waste) - stabilisation and storage	2,2	3,0	tonnes	5%
	SIW (Special Industrial Waste) - incineration	2,2	3,0	tonnes	5%
	DMW (Dangerous Medical Waste) - incineration	13,8	16,1	tonnes	5%

End of life	paper (student courses) from recycled material	3,9	3,4	tonnes	10%
	leaks cooling installations, R134a	0,033	0,033	tonnes	20%
	leaks cooling installations, R404a	0,001	0,001	tonnes	20%
	leaks cooling installations, R407c	0,097	0,097	tonnes	20%
	leaks cooling installations, R410a	0,035	0,077	tonnes	20%
	leaks cooling installations, R507	0,0005	0,0005	tonnes	20%
Impact category	**Campus: Jette**	**2016**	**2018**	**Unit**	**Uncer-tainty**
Transport-ing people - employee commuting	average passenger car	2 133 339	2 526 321	vehicle.km	20%
	bus & coach (urban networks)	70 287	143 788	passenger.km	20%
	train in Belgium	1 110 557	1 263 367	passenger.km	20%
	subway / tram / trolley	187 735	404 383	passenger.km	20%
Transporting people - employee business travel	average passenger car	316 169	329 402	vehicle.km	20%
	train in Belgium	119 518	98 464	passenger.km	50%
	train in Germany	4 293	32 658	passenger.km	50%
	train in Netherlands	5 494	41 795	passenger.km	50%
	train in United-Kingdom	5 099	38 789	passenger.km	50%
	train in France, TGV	8 570	65 199	passenger.km	50%
	plane, 100-180 seats, 0-1000 km	18 279	18 516	passenger.km	20%
	plane, 180-250 seats, 1000-2000 km	208 952	265 341	passenger.km	20%
	plane, 180-250 seats, 2000-3000 km	182 102	205 721	passenger.km	20%
	plane, 180-250 seats, 3000-4000 km	96 814	150 689	passenger.km	20%
	plane, 180-250 seats, 4000-5000 km	37 827	82 042	passenger.km	20%
	plane, > 250 seats, 5000-6000 km	18 791	33 257	passenger.km	20%
	plane, > 250 seats, 6000-7000 km	81 362	50 215	passenger.km	20%
	plane, > 250 seats, 7000-8000 km	0	75 180	passenger.km	20%
	plane, > 250 seats, 8000-9000 km	4 880	10 932	passenger.km	20%
	plane, > 250 seats, 9000-10000 km	0	41 043	passenger.km	20%
	plane, > 250 seats, 10000-11000 km	16 721	31 849	passenger.km	20%
	plane, > 250 seats, > 11000 km	2 622 490	2 745 351	passenger.km	20%
Transporting people - students' travels	average passenger car, Belgian students	2 310 262	2 357 762	vehicle.km	20%
	average passenger car, foreign students	106 385	94 565	vehicle.km	20%
	bus & coach (urban networks)	698 331	712 689	passenger.km	20%
	train in Belgium	1 943 383	1 983 339	passenger.km	20%
	train abroad	248 233	220 651	passenger.km	20%
	subway / tram / trolley	291 742	297 740	passenger.km	20%
	plane, 180-250 seats, 1000-2000 km	203 782	181 140	passenger.km	20%
	plane, 180-250 seats, 5000-6000 km	1 293 749	1 677 361	passenger.km	20%
Capital goods	buildings (dwellings, concrete)	7 383	7 383	m^2 floor area	5%
	buildings (education, concrete)	40 649	41 209	m^2 floor area	5%
	depreciation period buildings	40	40	years	
	TC2 or "normal" parking areas (bitumen)	5 694	5 694	m^2 surface area	20%
	depreciation period parking areas	40	40	years	
	vehicles	0	0	tonnes	20%
	depreciation period vehicles	10	10	years	
	furniture	2 313 488	933 645	euros	5%
	depreciation period furniture	20	20	years	
	IT	826 052	485 498	euros	5%
	depreciation period IT	5	5	years	

Table 2: Consumption and infrastructure data Jette

Impact category	Campus: Etterbeek and Jette	2016	2018	Unit	Uncer-tainty
	number of students	15 418	15 735		
	number of employees	3 177	3 021		
Energy	natural gas (LHV)	34 538 390	33 987 972	kWh	5%
	purchased electricity	21 923 127	21 944 786	kWh	5%
	avoided grey electricity production from own produced electricity (from PV and CHP)	-628 544	-1 273 619	kWh	5%
Non-energy direct emis-sions of Kyoto halocarbons	leaks cooling installations during use, R134a	0,015	0,017	tonnes	20%
	leaks cooling installations during use, R404a	0,005	0,003	tonnes	20%
	leaks cooling installations during use, R407c	0,037	0,033	tonnes	20%
	leaks cooling installations during use, R410a	0,024	0,034	tonnes	20%
	leaks cooling installations during use, R507	0,002	0,002	tonnes	20%
Inputs	common metals	5,3	40,3	tonnes	20%
	plastics (PET)	1,2	7,2	tonnes	20%
	paper (student courses) from new material	40	35,2	tonnes	10%
	paper from recycled material	6,3	7,8	tonnes	10%
	paper from new material	84	103,6	tonnes	10%
	cardboard	0,4	2,4	tonnes	20%
	medical products	18,5	23,1	tonnes	10%
	industrial products	16,8	22,8	tonnes	10%
	small office equipment	547 852	663 379	euros	5%
Agricultural products (food)	typical meal (with beef)	21 337	22 832	no of meals	5%
	typical meal (with porc)	64 994	60 931	no of meals	5%
	typical meal (with chicken)	59 477	58 452	no of meals	5%
	seafood meal (with fish)	34 432	39 947	no of meals	5%
	seafood meal (with shrimp)	4 064	3 831	no of meals	5%
	vegetarian meal (with cheese)	23 826	22 294	no of meals	5%
	vegan meal	21 267	26 150	no of meals	5%
Direct waste	average household waste - incineration	578	572	tonnes	5%
	steel or tinplate - recycling	5,3	40,3	tonnes	20%
	plastic (PET) - recycling	1,2	7,2	tonnes	20%
	paper - recycling	91	111	tonnes	5%
	cardboard - recycling	0,4	2,4	tonnes	20%
	SIW (Special Industrial Waste) - stabilisation and storage	8,4	11,4	tonnes	5%
	SIW (Special Industrial Waste) - incineration	8,4	11,4	tonnes	5%
	DMW (Dangerous Medical Waste) - incineration	18,5	23,1	tonnes	5%
End of life	paper (student courses) from recycled material	40	35,2	tonnes	10%
	leaks cooling installations, R134a	0,074	0,086	tonnes	20%
	leaks cooling installations, R404a	0,024	0,016	tonnes	20%
	leaks cooling installations, R407c	0,183	0,164	tonnes	20%
	leaks cooling installations, R410a	0,118	0,170	tonnes	20%
	leaks cooling installations, R507	0,008	0,008	tonnes	20%

Impact category	Campus: Etterbeek and Jette	2016	2018	Unit	Uncer-tainty
Transport-ing people - employee commuting	average passenger car	6 600 587	6 060 612	vehicle.km	20%
	bus & coach (urban networks)	627 573	631 365	passenger.km	20%
	train in Belgium	15 241 991	19 385 829	passenger.km	20%
	subway / tram / trolley	1 419 762	1 718 237	passenger.km	20%

Transporting people - employee business travel	average passenger car	1 239 067	1 312 285	vehicle.km	20%
	train in Belgium	1 566 652	1 585 365	passenger.km	50%
	train in Germany	27 700	210 727	passenger.km	50%
	train in Netherlands	35 450	269 685	passenger.km	50%
	train in United-Kingdom	32 900	250 286	passenger.km	50%
	train in France, TGV	55 300	420 693	passenger.km	50%
	plane, 100-180 seats, 0-1000 km	117 944	120 291	passenger.km	20%
	plane, 180-250 seats, 1000-2000 km	1 348 259	1 723 861	passenger.km	20%
	plane, 180-250 seats, 2000-3000 km	1 175 012	1 336 523	passenger.km	20%
	plane, 180-250 seats, 3000-4000 km	624 689	978 993	passenger.km	20%
	plane, 180-250 seats, 4000-5000 km	244 077	533 009	passenger.km	20%
	plane, > 250 seats, 5000-6000 km	121 248	216 061	passenger.km	20%
	plane, > 250 seats, 6000-7000 km	524 985	326 236	passenger.km	20%
	plane, > 250 seats, 7000-8000 km	0	488 425	passenger.km	20%
	plane, > 250 seats, 8000-9000 km	31 489	71 020	passenger.km	20%
	plane, > 250 seats, 9000-10000 km	0	266 647	passenger.km	20%
	plane, > 250 seats, 10000-11000 km	107 893	206 916	passenger.km	20%
	plane, > 250 seats, > 11000 km	16 921 561	17 835 926	passenger.km	20%
Transporting people - students' travels	average passenger car, Belgian students	15 684 511	16 006 990	vehicle.km	20%
	average passenger car, foreign students	1 093 500	972 000	vehicle.km	20%
	bus & coach (urban networks)	6 864 922	7 006 068	passenger.km	20%
	train in Belgium	46 968 365	47 934 052	passenger.km	20%
	train abroad	2 551 500	2 268 000	passenger.km	20%
	subway / tram / trolley	4 982 026	5 084 458	passenger.km	20%
	plane, 180-250 seats, 1000-2000 km	2 094 612	1 861 877	passenger.km	20%
	plane, 180-250 seats, 5000-6000 km	13 298 016	17 241 032	passenger.km	20%
Capital goods	buildings (dwellings, concrete)	39 971	62 655	m² floor area	5%
	buildings (education, concrete)	238 120	247 524	m² floor area	5%
	depreciation period buildings	40	40	years	
	TC2 or "normal" parking areas (bitumen)	32 966	32 966	m² surface area	20%
	depreciation period parking areas	40	40	years	
	vehicles	18	18	tonnes	20%
	depreciation period vehicles	10	10	years	
	furniture	10 187 401	9 596 628	euros	5%
	depreciation period furniture	20	20	years	
	IT	4 859 219	4 990 276	euros	5%
	depreciation period IT	5	5	years	

Table 3: Consumption and infrastructure data total (Etterbeek and Jette)

4.3.1. Energy

Energy: natural gas

Description	The direct energy emissions from natural gas (ISO scope 1) result from the use of natural gas (kWh) for heating and appliances.
Scope	• Etterbeek: Pleinlaan 2, 5 & 9, student homes, Schoofslaan, Triomflaan and Nieuwelaan. • Jette: campus, student homes and student restaurant. Including heat supply to 'Kring 4' and heat withdrawal. Excluding Basic Fit and Red Cross.

Assumptions	For the local CHP-installation (Combined Heat and Power cogeneration), we assume an efficiency of 50% (meaning that 1 kWh thermal heat corresponds with 2 kWh primary energy). For Pleinlaan 2, 77% of gas use is allocated to VUB, 23% is allocated to ULB. For Pleinlaan 5 and 9 gas and electricity, we assume resp. 59% and 46% of the buildings are in use by the VUB.

Energy: electricity

Description	The direct energy emissions from electricity (ISO scope 2) consist of the emissions at the power plants and result from the use of electricity (kWh).
Scope	• Etterbeek: Pleinlaan 2, 5 & 9, student homes, Schoofslaan, Triomflaan and Nieuwelaan. • Jette: campus, student homes and student restaurant.
Assumptions	In 2016, electricity was from biomass (with an emission factor of 0,05 kg CO2e/kWh). For 2018, the electricity consists of a mix of nuclear (51%), fossil fuels (36%) and coal (13%), resulting in an estimated emission factor of 0,26 kg CO2e/kWh (roughly equal to the average Belgian electricity mix). When PV (photovoltaic) and CHP (Combined Heat – Power) electricity is locally produced and sold to the grid, we can assume that this replaces average electricity production. Hence, the generation of average Belgian (grey) electricity is avoided. This means that selling green electricity counts as carbon credits and has a negative carbon footprint.

4.3.2. Non-energy

Description	The direct, non-energy emissions (ISO scope 1) consist of the leaks of green-house gases (Kyoto halocarbons) of cooling installations during operation.
Scope	• List of 300 cooling installations for air conditioning. • Etterbeek: Pleinlaan 2, 5 & 9, Triomflaan. • Jette: whole campus.
Assumptions	Five Kyoto halocarbon cooling gases: R134a, R404a, R407c, R410a en R507. Cooling capacity (kW) multiplied by cooling fluid amount (kg/kW) and leakage percentage (10% yearly leakage during operation).

4.3.3. Inputs

Inputs: materials and products

Description	The indirect emissions (ISO scope 3) for inputs are the emissions from the production of all materials that end up in the direct waste.
Scope	• Volume of metals, plastics, cardboard, medical products, industrial products are based on waste data (kg) for Etterbeek and Jette. • Volume of paper is based on waste data (kg) for Etterbeek and Jette plus student courses.
Assumptions	All materials are assumed new, except cardboard and 7% of other paper, which are assumed to be from recycled material.

Inputs: meals

Description	The indirect emissions (ISO scope 3) for meals are the emissions from the production of agricultural products (food) consumed at the student restaurants.
Scope	Student restaurants Etterbeek and Jette.
Assumptions	There are seven types of meal: with beef, pork, chicken, fish, shrimp, vegetarian with cheese and vegan.

Inputs: small office equipment

Description	The indirect emissions (ISO scope 3) for office equipment are the emissions from the production of purchased small office equipment (e.g. small electronics, ink cartridges, toners, batteries, writing material, memory sticks, small computer equipment, maps, stamps, lamps, staplers, glue, magnets, writing paper, envelopes. . .).
Scope	Purchases of small equipment for offices ('kleine kantoorbenodigdheden') Etterbeek and Jette.
Assumptions	The list of small office equipment contains some small printers, small amounts of writing paper, electronics and other materials that are probably included in other inputs (that are based on waste data, such as industrial products) and capital goods (larger IT-equipment). We assume that resulting double counting is negligible. Total purchases (euros) allocated between Etterbeek and Jette according to 2016 distribution.

4.3.4. Direct waste

Description	The indirect emissions (ISO scope 3) for direct waste are the emissions from the waste treatment of the collected waste at the VUB.
Scope	The volumes of metals, plastics, paper/cardboard, medical products, industrial products and average household waste are based on waste data (kg) for Etterbeek and Jette.
Assumptions	• Emissions can be avoided with recycling (avoiding the production of new materials) and incineration with energy recuperation (avoiding production of electricity from non-waste sources). • Metals, plastics, paper and cardboard are 100% recycled. Household waste and dangerous medical waste is 100% incinerated. Special industrial waste is 50% stabilisation and storage and 50% incineration. Paper waste consists of 7% from recycled material. • PMD-waste contains 1/3 metals, ½ plastics, 1/6 cardboard • Chemical waste counts as special industrial waste • 'Restafval' (residual waste) and 'groot vuil' are counted as household waste

4.3.5. End-of-life

End-of-life: paper

Description	The indirect emissions (ISO scope 3) for end-of-life of paper are the emissions from the waste treatment of the paper courses used by the students and collected at the student homes.
Scope	Paper waste from student courses.
Assumptions	The paper waste treatment is a mix of recycling and incineration according to the average Belgian treatment of paper waste. Paper comes from courses from student shops (Overkoepelende Studentendienst and Cursusdienst VUB). The number of pages is multiplied by the weight per page (0,005 gram). The negative footprint of avoided emissions of waste treatment equals the avoided production of new materials (kg) and electricity (kWh) due to recycling of paper and electricity production from paper waste incineration, times the footprint intensities of production (kg CO2/kWh for average Belgian electricity mix, kg CO2/kg material for production of new paper).

End-of-life: cooling gases

Description	The indirect emissions (ISO scope 3) for end-of-life of cooling gases are the leaks of Kyoto halocarbon greenhouse gases of cooling installations during end-of-life treatment.
Scope	• List of 300 cooling installations. • Etterbeek: Pleinlaan 2, 5 & 9, Triomflaan. • Jette: whole campus.
Assumptions	Five Kyoto halocarbon cooling gases: R134a, R404a, R407c, R410a en R507. Cooling capacity (kW) multiplied by cooling fluid amount (kg/kW) and leakage percentage (50% leakage during end of life treatment of discarded installations).

4.3.6. Transporting people

Transporting people: employee commuting

Description	The emissions (ISO scope 3) for employee commuting are the direct emissions of the vehicles and the indirect emissions of the production of fuels, vehicles and transport infrastructure.
Scope	Vehiclekilometres with cars, passengerkilometres with bus, train and tram/subway.

Assumptions	An employee mobility survey in 2017 is used to calculate the modal split: the percentages of distances travelled by car, train, bus, subway/trolley, motorbike and unmotorized (bike, foot). Based on the postal codes of the survey respondents, distances are calculated. The distance travelled by carpooling is allocated to 50% car and 50% unmotorized. As the survey does not include data of employment rate, the modal split calculation assumes that all survey respondents have the same employment rate (the employment rates of employees are only used to calculate the total distance travelled, see below). The modal split percentages are corrected for pre and post trajectories (e.g. travel to and from the train station), using data of a 2014 mobility survey.[3] The modal split percentages are multiplied by the total distance travelled of all active employees in 2018, excluding employees with a lower than 40% employment rate. The total distance travelled per employee per working day on site (at the campus) is based on the postal codes of home address and campus site of all employees active at 31st December 2018. The average number of on-site working days per year per employee is the employment rate times 5 working days per week times 44 working weeks per year times the fraction of on-site working days. This fraction is assumed to be 80% for Etterbeek employees (i.e. a full time employee is assumed to work 4 days per week at the VUB and one day elsewhere, at home or at another site such as conferences) and 90% for Jette employees.[4]

3 The 2016 carbon footprint used a mobility survey from the year 2014 to calculate the shares (percentages) of distances travelled by transportation mode. This survey included pre and post trajectories. Including the pre and post trajectories decreases the relative distance travelled by train compared to the other modes of transportation, and increases the use of the other modes of transportation, because these other modes are used in the pre and post trajectories, for example to travel to and from the train station. Using the 2014 mobility survey, we can compare the shares of the transportation modes according to two calculation methods: one estimating the distances including the pre, main and post trajectories, and one only including the main mode of transportation. For each mode of transportation we can use the 2014 ratios of those two methods and apply them to the data from the 2017 survey. For the 2018 carbon footprint, we use the 2017 shares of transportation modes, corrected for the pre and post trajectories, see table below.

Site	Etterbeek				Jette			
Survey year	2017	2017	2014	2014	2017	2017	2014	2014
Method	Only main mode of transport	Corrected for pre- and post-trajectory	Only main mode of transport	Including pre- and post-trajectory	Only main mode of transport	Corrected for pre- and post-trajectory	Only main mode of transport	Including pre- and post-trajectory
Car (incl. 50% of carpool)	12,4%	13,9%	18,5%	20,3%	54,7%	54,2%	56,2%	57,3%
Bus	0,9%	1,9%	1,2%	2,5%	2,0%	3,1%	1,2%	1,9%
Train	79,2%	71,4%	72,7%	64,2%	33,2%	27,1%	35,5%	29,8%
Subway/trolley	4,1%	5,2%	4,5%	5,6%	4,6%	8,7%	2,6%	5,0%
Motorbike	0,9%	0,9%	0,5%	0,5%	1,8%	1,8%	1,3%	1,3%
Unmotorized (bike, foot, incl. 50% of carpool)	2,5%	6,8%	2,6%	6,9%	3,7%	5,1%	3,3%	4,6%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

4 The 2016 carbon footprint calculation assumed a fraction of 80% for Jette, just like Etterbeek. However, the average employment rate of Jette and Etterbeek are very similar (around 90%), but a 2014 mobility survey shows that Jette employees have to work more on site (at campus Jette) than Etterbeek employees. 70% of Etterbeek survey respondents indicate that they work almost every working day on site, compared to 80% for Jette respondents. This is the reason why we assume a 10 percentage point difference in the fraction of on-site working days.

Transporting people: employee business travel

Description	The emissions (ISO scope 3) for employee business travel are the direct emissions of the vehicles and the indirect emissions of the production of fuels, vehicles and transport infrastructure.
Scope	Domestic and international travel with cars, trains and airplanes.
Assumptions	• Domestic business travel includes travel by private car, company car and taxi. Travel by private and company cars is based on the 2018 expense notes. Mileage allowance is 0,352 euro/km (average of 0,346 euro/km for Jan-June 2018 and 0,3573 euro/km for July-Dec 2018), fuel price is 1,26 euro/liter and average fuel use is 0,07 liter/km. The taxi rides are estimated using the 2014 mobility survey (used for the 2016 calculation), multiplied by the 2017/2014 ratios of the number of employees, the number of daily business travels per employer and the percentage share of taxi rides in total business travel according to the 2017 and 2014 mobility surveys. • Allocation to Etterbeek and Jette of distance travelled by car is based on the number of travels with private cars and service cars for Etterbeek and Jette. • The distance with trains for domestic business travels (in Belgium) is based on the 2016 data, which was calculated as the distance travelled with cars, multiplied by the ratio of the number of travels with trains and cars for Etterbeek and Jette staff members, according to the mobility survey 2014 (number of travels and percentages by car and train for surveyed staff members). The 2016 data is then extrapolated by the number of employees, the number of daily business travels per employer and the percentage share of public transport in total business travel according to the 2017 mobility survey relative to the 2014 survey. • The distance by train for international travels only includes travels from Belgium (Brussels) to a neighbouring country (Germany, Netherlands, United-Kingdom and France) and not domestic travels abroad (e.g. train travels to the local airport). The calculation is based on the expense notes, extrapolated from the 2016 data. The 2016 calculation only included 238 international travels with known destination. The 2018 list of expense notes contains 5690 items for all train business travel in Belgium, internationally, abroad and unknown. A random sample of 10% of the total size is used to estimate a number of 1811 international travels. Hence 1811/238=7,6 times more international travels are included in the 2018 calculation than the 2016 calculation. The distance travelled in 2018 is the distance travelled in 2016 multiplied by 7,6. The allocation of the total distances travelled to campus sites is based on the number of staff members of Etterbeek and Jette. • The distances of flights are calculated using the transportation expense notes: the distances from local airport to destinations are calculated for all travels with known destination (this includes roughly 70% of all airplane travels). Total distances are extrapolated using the ratio of expenditures of all flights to expenditures of flights with known destination. Total distances are divided in 12 categories, from flights of 0-1000 km to flights of more than 11000 km. • The footprint intensity of a flight also contains emissions not covered by the Kyoto protocol, in particular water vapour at high altitudes (stratospheric greenhouse effect).

Transporting people: student mobility

Description	The emissions (ISO scope 3) for student mobility are the direct emissions of the vehicles and the indirect emissions of the production of fuels, vehicles and transport infrastructure.
Scope	• For Belgian students studying at the VUB: vehiclekilometres with cars, passengerkilometres with bus, train and tram/subway. Including daily and weekly home-campus, home-student room and student room-campus trips. • For international students, registered at the VUB: distances with car, train and airplane.
Assumptions	• For Belgian students: car, bus and train are the same data as in 2016 study (based on a student mobility survey), extrapolated to 2018 based on the total number of students 2018/2016. • For foreign students: car, train abroad and small distance flights are the same data as in 2016 study, extrapolated to 2018 based on the number of guest students 2018/2016. Large distance flights are extrapolated to 2018 based on the number of non-EU students 2018/2016. • Distance per travel per student of a commuter student is calculated based on postal codes of home address of a commuter student in the student mobility survey (Dutch and English). • The distance from home to student room of a residential student is calculated based on postal codes of home address of all residential students. • The footprint of outgoing students (VUB-students who study at another university and travel to another country) are not included in the VUB-footprint.

4.3.7. Capital goods

Capital goods: buildings

Description	The indirect emissions (ISO scope 3) for buildings are the emissions from the construction and renovation of buildings.
Scope	• Buildings Etterbeek: B, B1, C, D, E, F, G, I', K, KB, Ke, L1, L3, L4, M, N1, NL, P, Q, S, V, W, Z, Restaurant (R), extension restaurant, Sportopolis, Pleinlaan 5, Pleinlaan 9, daycare 5GJ, student homes Schoofslaan, Triomflaan, U-residence, building X and Blok 5. • Buildings Jette: A, B, C, D, E, F, G, H, K, restaurant (R), student homes, MEBO (I, II & III) and KRO. Not included: cyclotron and oncology.
Assumptions	There are two types of buildings: offices and education buildings. The buildings are assumed to be made of concrete. The footprint is divided by the depreciation period of 40 years.

Capital goods: roads and car parks

Description	The indirect emissions (ISO scope 3) for parking area are the emissions from the construction and renovation of the area.
Scope	• Parking area Etterbeek: impermeable surfaces. • Parking area Jette: extrapolated from parking area Etterbeek using ratio of building area of Jette and Etterbeek.
Assumptions	Same surface area as used in 2016. The roads and parking area are assumed to be made of bitumen. The depreciation period is 40 years.

Capital goods: vehicles

Description	The indirect emissions (ISO scope 3) for vehicles are the emissions from the production of cars.
Scope	All service vehicles
Assumptions	Same as in 2016 (12 cars). The depreciation period of cars is 10 years. A car weights on average 1,5 tonnes.

Capital goods: furniture

Description	The indirect emissions (ISO scope 3) for furniture are the emissions from the production of furniture.
Scope	Purchasing value of all furniture classrooms plus tables and chairs in PC-rooms plus tables, chairs and cabinets staff members.
Assumptions	Same as in 2016: purchase value (euro) of furniture for units / departments, staff members and PC rooms). Total is allocated according to student numbers Etterbeek / Jette: The depreciation period of furniture is 20 years.

Capital goods: IT

Description	The indirect emissions (ISO scope 3) for IT are the emissions from the production of IT-equipment.
Scope	Purchasing value of all audiovisual equipment of classrooms plus audiovisual equipment, computers and printers in PC-rooms plus computers and printers for staff members.
Assumptions	Same as in 2016: purchase value (euro) of installed equipment (projector, audiovisual equipment, smartboard) in classrooms, IT equipment (PC, printer) for staff and PC classrooms, allocated according to student numbers Etterbeek / Jette. The depreciation period of IT-equipment is 5 years.

5. RESULTS

This chapter contains the results of the carbon footprint calculation of the VUB for data year 2018. First, the total carbon footprint will be compared with other references, such as emissions related to car travel or CO_2 absorbed by trees. Next, the footprint results per impact category are discussed. The total footprint can also be expressed per person (per employee or student), to be used as a benchmark for comparisons with other universities or future recalculations of the VUB footprint. In the next chapter, the VUB footprint per student in 2018 will be compared with the footprint in 2016.

5.1. Total carbon footprint

The carbon footprint of the VUB in 2018 is **41.909 ton CO_2e**. As a comparison, this is the equivalent of driving 170 million kilometres with a car. It also corresponds with the total yearly carbon footprint of almost 2600 average people in Belgium (0,026% of the total Belgian carbon footprint). It requires 1,7 million trees to absorb this amount of CO_2 within one year.

CO_2e Overview	Emissions Etterbeek	Emissions Jette	Emissions total		Uncertainties	
	t CO_2e	t CO_2e	t CO_2e	Relatives	t CO_2e	%
Energy	9 988	4 031	14 019	33,5%	2 920	21%
Non-energy	91	73	164	0,4%	33	20%
Inputs	1 223	233	1 456	3,5%	354	24%
Direct waste	159	86	245	0,6%	85	35%
End-of-Life	462	367	829	2,0%	164	20%
Transporting people	17 822	2 928	20 750	49,5%	2 327	11%
Capital goods	3 807	639	4 446	10,6%	1 484	33%
Total	**33 552**	**8 357**	**41 909**	**100,0%**	**4 037**	**10%**

Table 4: Total carbon footprint results

The total uncertainty (i.e. the combination of the uncertainties of the Bilan Carbone® emission factors and the VUB consumption and infrastructure data) on the total carbon footprint is 8%. Waste and capital goods have the highest uncertainties (due to high uncertainties in emission factors).

The three major contributors to the carbon footprint of the VUB are:

- Energy use (natural gas and electricity use on the campuses): **14.019 ton CO_2e** (33%)
- Transporting people (car, public transport and airplane for employee commuting, business travel and student travel including foreign students): **20.750 ton CO_2e** (50%)
- Capital goods (embedded energy for construction of infrastructure and equipment): **4.446 ton CO_2e** (11%)

We see that more than half of the carbon footprint is related to transporting people and one third is related to direct energy use. Therefore, future footprint reduction measures should focus on these two impact categories. The next section describes the carbon footprint for all the impact categories in more detail.

5.2. Carbon footprint per impact category

Figure 2 presents the contributions of the seven impact categories to the total carbon footprint. The categories inputs (materials and services, including food at the student restaurants), direct waste, end-of-life (including paper from student courses) and non-energy related emissions (cooling gases) all have relatively small contributions, less than 5 percent.

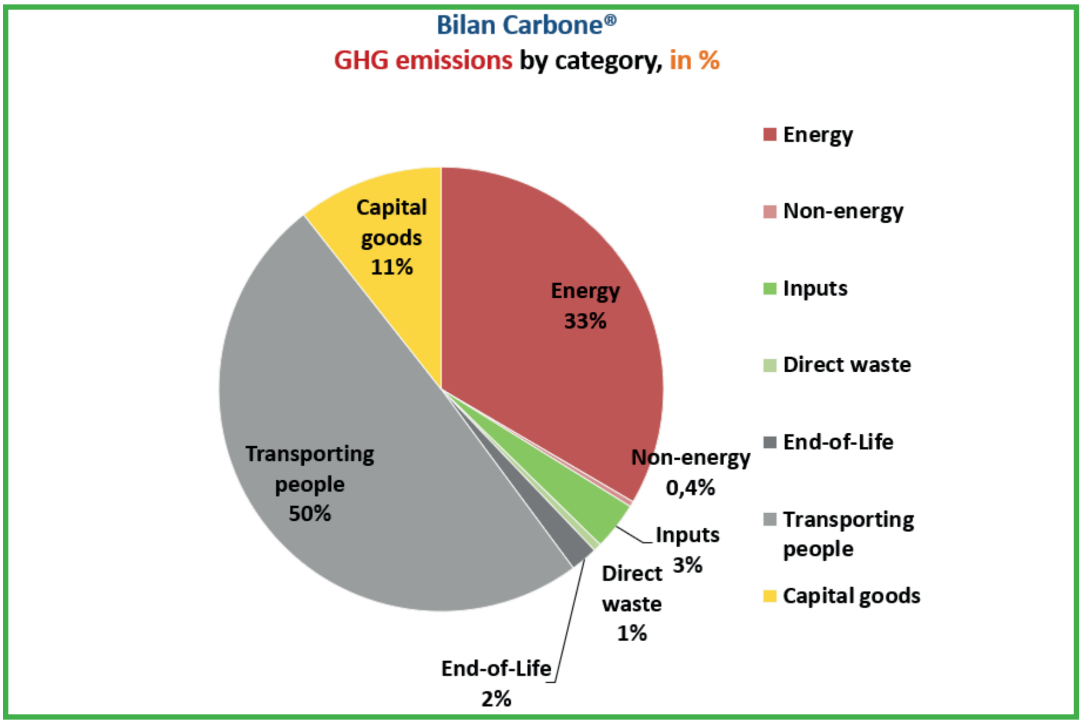

Figure 2: Contributions of impact categories to the total carbon footprint

The footprint values including the total uncertainties are given in Figure 3. These uncertainties are the combination of the uncertainties of the Bilan Carbone emission factors (footprint intensities) and the VUB consumption and infrastructure data.

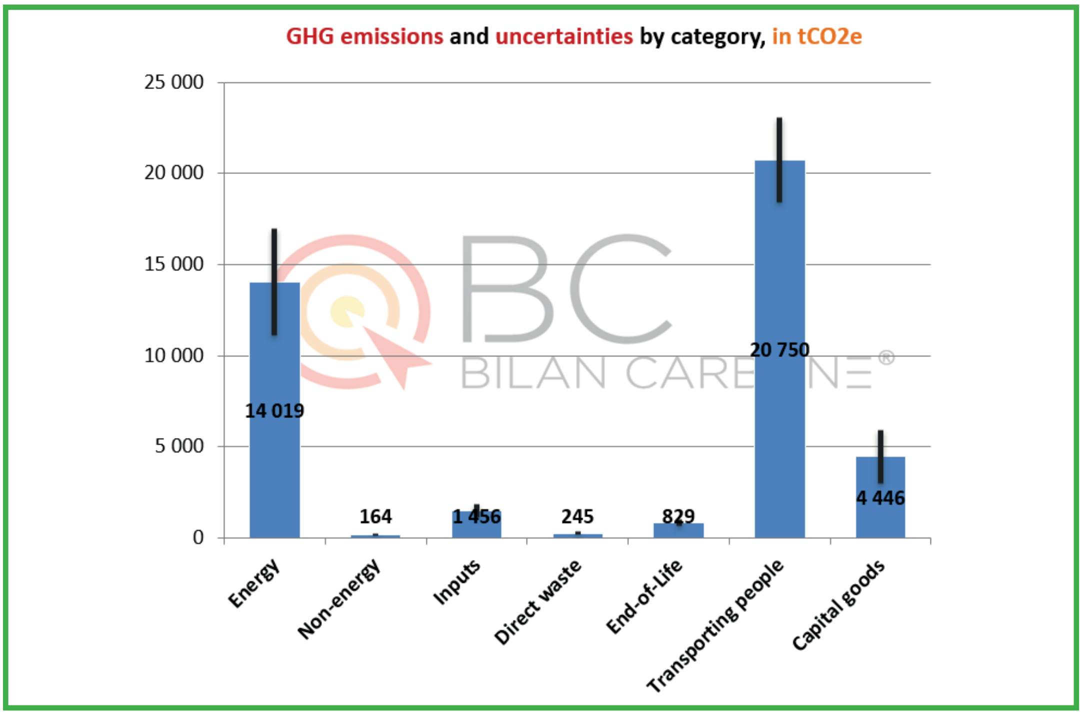

Figure 3: Carbon footprint per impact category

The footprint values and uncertainty values for all impact categories and subcategories and for the two campuses Etterbeek and Jette are summarized in Table 5.

	Emissions Etterbeek	Emissions Jette	Emissions total		Uncertainties	
	kg CO_2e	kg CO_2e	kg CO_2e	Relatives	kg CO_2e	%
Energy	**9 987 505**	**4 031 353**	**14 018 858**	**33,5%**	**2 919 701**	**21%**
Fuels, direct accounting	5 811 565	2 402 829	8 214 394	19,6%	500 684	6%
Electricity purchased	4 175 940	1 628 523	5 804 464	13,9%	2 876 450	50%
Non-energy	**90 867**	**73 209**	**164 076**	**0,4%**	**32 692**	**20%**
Kyoto halocarbons	90 867	73 209	164 076	0,4%	32 692	20%
Inputs	**1 223 286**	**232 762**	**1 456 048**	**3,5%**	**354 003**	**24%**
Metals	141 546	6 081	147 627	0,4%	121 737	82%
Plastics	23 396	90	23 485	0,1%	6 643	28%
Papers & cardboard	159 519	33 777	193 296	0,5%	31 513	16%
Chemical products	71 673	66 237	137 910	0,3%	97 641	71%
Agricultural products	311 806	33 605	345 410	0,8%	80 558	23%
Small office equipment	515 346	92 973	608 319	1,5%	305 676	50%
Direct waste	**158 985**	**85 614**	**244 600**	**0,6%**	**84 555**	**35%**
Incineration	140 663	66 966	207 630	0,5%	83 698	40%
Recycled or reused waste	4 521	801	5 322	0,0%	1 986	37%
Hazardous waste	13 801	17 847	31 648	0,1%	11 842	37%
End-of-Life	**461 790**	**366 848**	**828 637**	**2,0%**	**163 511**	**20%**
Papers, cardboards	7 454	803	8 258	0,0%	4 149	50%
Leaks and non-energy	454 336	366 044	820 380	2,0%	163 458	20%
Transporting people	**17 822 162**	**2 928 230**	**20 750 392**	**49,5%**	**2 326 725**	**11%**
Employees commuting, car	894 367	639 296	1 533 664	3,7%	308 841	20%
Employees commuting, public transport	961 659	86 073	1 047 733	2,5%	270 471	26%
Employees business, car	248 723	83 357	332 079	0,8%	66 872	20%
Employees business, public transport	118 466	13 289	131 756	0,3%	44 647	34%
Employees business, plane	4 558 256	829 260	5 387 516	12,9%	1 399 102	26%
Belgian students, car	3 493 620	603 486	4 097 106	9,8%	774 514	19%
Belgian students, public transport	3 229 094	208 102	3 437 196	8,2%	866 193	25%
Foreign students, car	224 586	24 205	248 791	0,6%	47 031	19%
Foreign students, public transport	156 260	16 841	173 101	0,4%	48 960	28%
Foreign students, plane	3 937 130	424 321	4 361 451	10,4%	1 387 944	32%
Capital goods	**3 807 400**	**638 553**	**4 445 954**	**10,6%**	**1 483 974**	**33%**
Buildings	2 871 930	533 774	3 405 704	8,1%	1 410 554	41%
Infrastructures excluding buildings	49 771	10 391	60 163	0,1%	15 041	25%
Vehicles, machines, furniture	59 523	5 348	64 871	0,2%	28 132	43%
IT	826 176	89 040	915 217	2,2%	459 891	50%

Table 5: Carbon footprint per impact category

5.2.1. Energy

Most of the footprint of direct energy use comes from the burning of natural gas on site. Electricity has a smaller contribution but is still high due to the presence of coal in the electricity mix. Electricity has a relatively large uncertainty value due to the uncertainty of its emission factor.

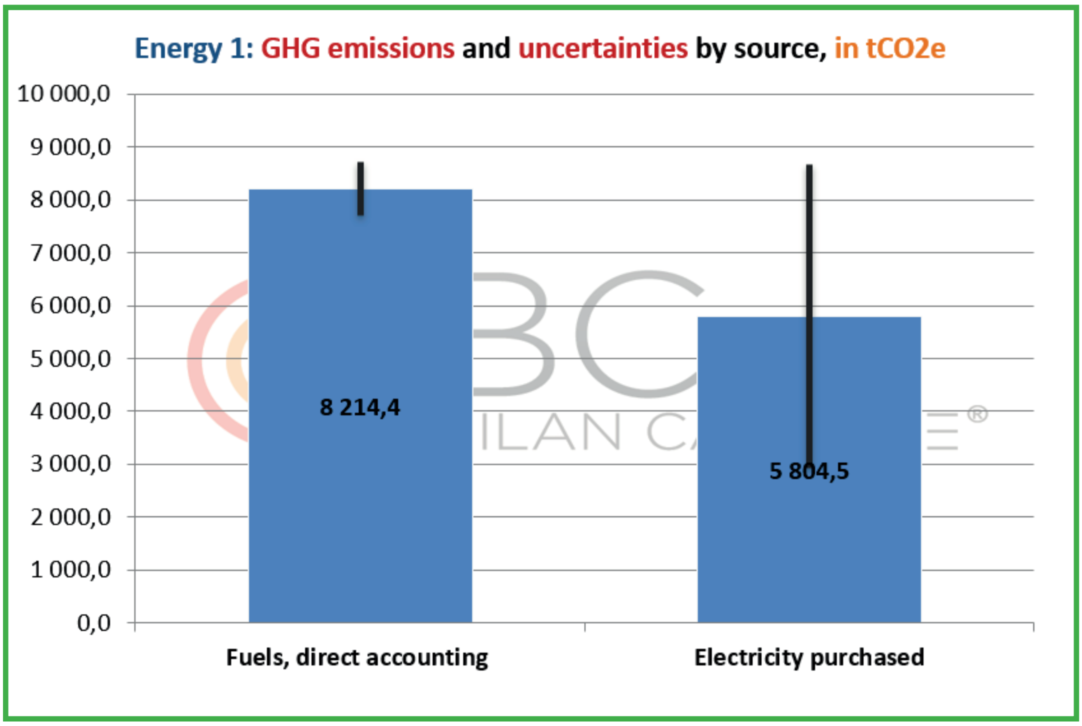

Figure 4: Carbon footprint of energy use

5.2.2. Non-energy

The non-energy related emissions of halocarbon from cooling installations is the smallest impact category which contributes less than 1% to the total footprint.

5.2.3. Inputs

The footprint of inputs corresponds with the indirect emissions (ISO Scope 3) for the production of materials. With a share of less than 4% it has a small contribution to the total footprint. Most of the footprint of inputs (1,7%) comes from the purchase of computer and office equipment (according to monetary ratios).

The footprint of agricultural products consists of the meals consumed at the student restaurants. It has a share of 1% of the total footprint. Note that if all the meals of the students (including meals consumed at home, at other local restaurants or at the student homes) would be included, the agricultural footprint would be roughly 10 times higher. For example, the footprint calculation of the KUL (Futureproofed, 2013) includes all student meals consumed in Leuven, which has a share of 9% of the total carbon footprint of the KUL.

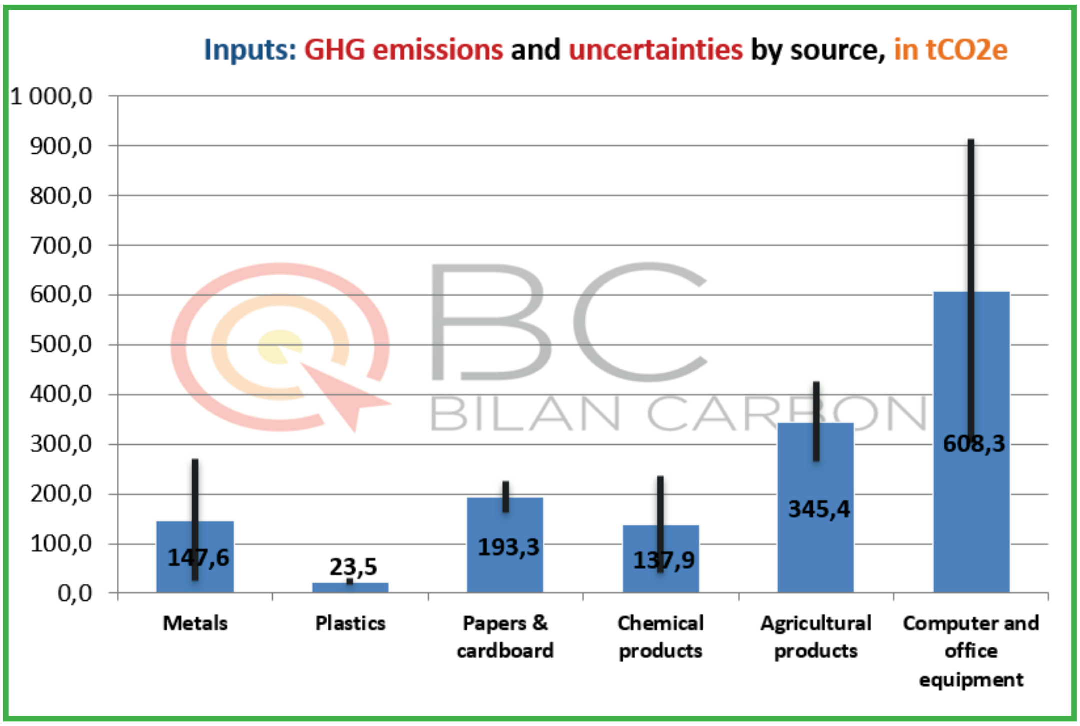

Figure 5: Carbon footprint of inputs

5.2.4. Direct waste

Most of the footprint of direct waste is from the incineration of residual waste, which in weight accounts for 80% of the total waste collected on the campuses.

5.2.5. End-of-Life

The end-of-life footprint consists of the waste generated from VUB activities but not collected on the campuses. This consists of the paper for the student courses and the leakages from dismissed cooling installations. The waste treatment of the student courses has a negligible footprint because the paper can be recycled, and even if incinerated the CO_2 emissions are biogenic. The dismissed cooling installations contribute 2% to the total footprint of the VUB. Even if the amount of emitted cooling gases is low, these cooling gases have a high global warming potential. That explains why the footprint of these leaks are not negligible.

5.2.6. Transporting people

Because mobility (transporting people) accounts for 50% of the global footprint, it is worthwhile to study this impact category more in detail. Figure 6 shows the footprint values (and uncertainty ranges) for the different subcategories of mobility.

60% of the mobility footprint is related to student mobility. Student travel by car and airplane (of foreign students studying at the VUB) have the highest shares, closely followed by public transport. The average emission factor (footprint values in terms of emissions per km travelled) of public transport is less than one quarter of the emission factor for average cars. But public transport accounts for more than 80% of the total distance travelled for daily student travel. This explains the fact that for student mobility the footprint of public transport is almost as high as for cars.

Airplane travel by foreign students accounts for 4361 ton CO_2e, which is 10% of the total footprint. However, due to rough estimations of flight distances and number of flights, this footprint has a high uncertainty of 32%.

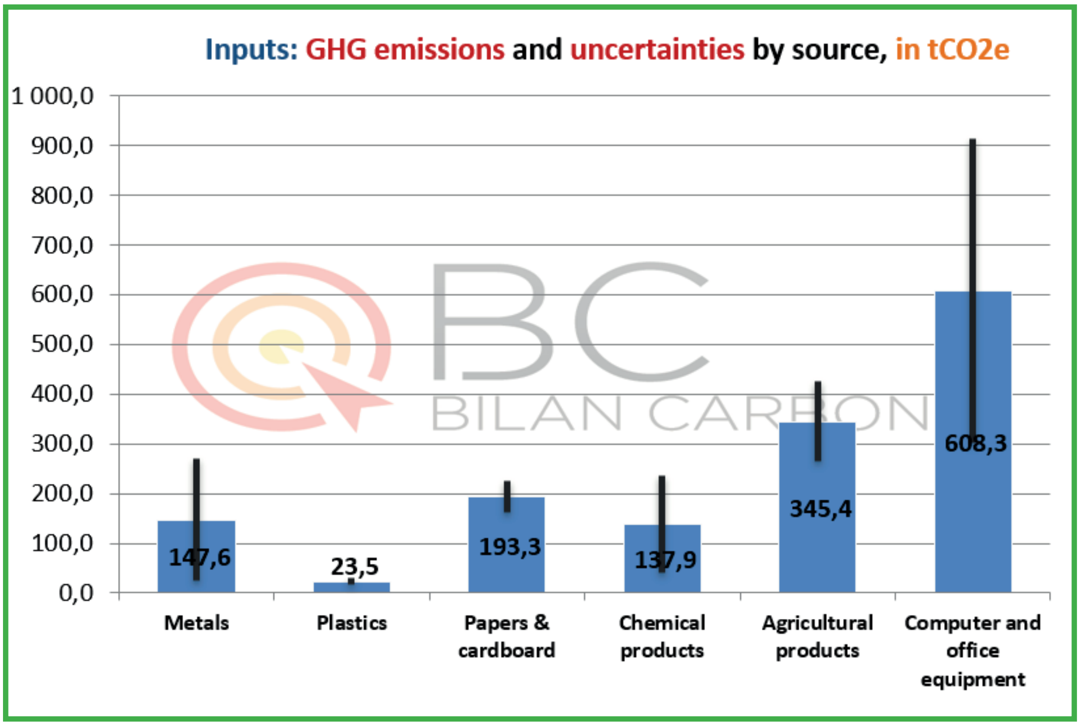

Figure 6: Carbon footprint of mobility

Concerning employee mobility, two thirds of its footprint is due to airplane business travel.

In terms of modal split (percentage of car versus public transport), we see a big difference between Etterbeek and Jette, where Etterbeek has a relatively much higher share of public transport and Jette has a higher share of car use. In Jette, 47% of the carbon footprint of all domestic travel (commuting, business and student travel) is from car travel, compared to 28% in Etterbeek.

Figure 7 below shows the carbon footprint of transport by type and by mode of transport for Etterbeek and Jette in more detail.

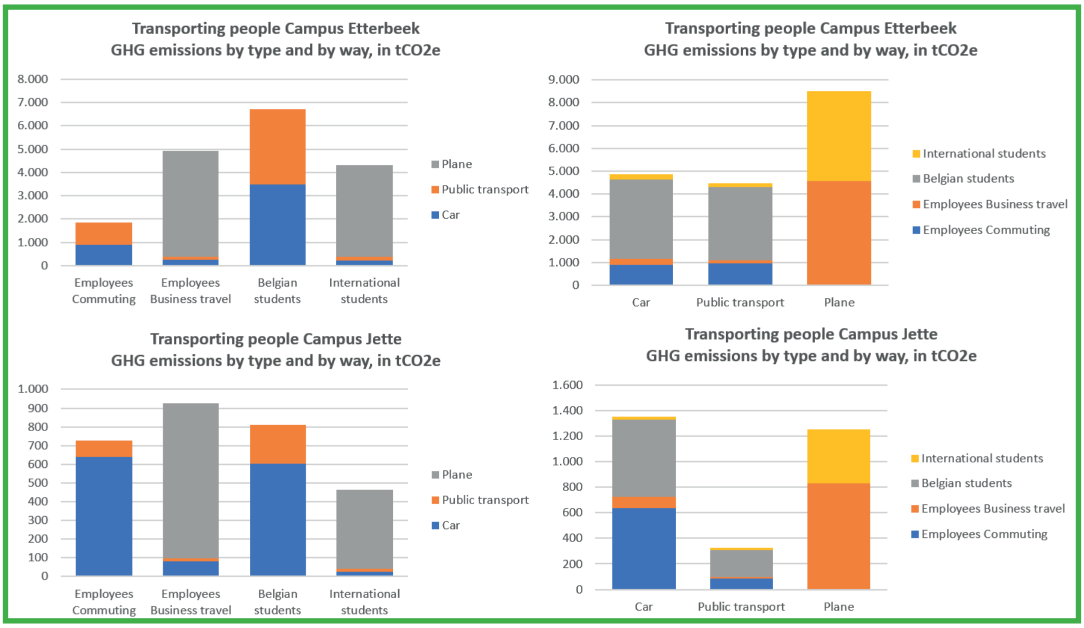

Figure 7: Transporting people by type and by way, Etterbeek and Jette

5.2.7. Capital goods

The final impact category is capital goods, which accounts for 11% of the total footprint. 8% of the total footprint is from the embedded energy of infrastructure (i.e. emissions related to construction and renovation of buildings and paved surfaces). 2% is from IT (production of equipment). The production of furniture and cars owned by the VUB each accounts for 0,2% of the total footprint.

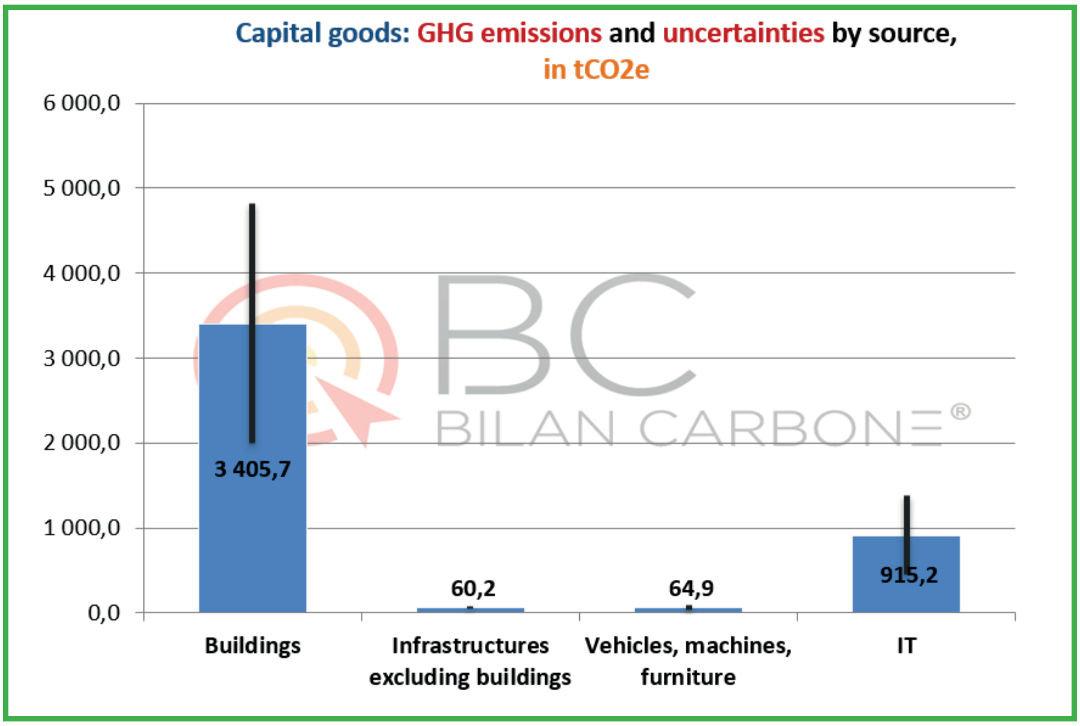

Figure 8: Carbon footprint of capital goods

5.2.8. Carbon footprint per employee and per student

The total footprint of the VUB can be divided by the number of people (employees and students) to obtain an interesting metric for benchmarking with other universities and future recalculations of the VUB footprint. The table below presents the footprints per employee and per student. An average student has a footprint of 2,7 ton CO_2e for all VUB-related activities in 2018.

Summary	kg CO_2e per employee	kg CO_2e per student
Energy	4 640	891
Non-energy	54	10
Inputs	482	93
Direct waste	81	16
End-of-Life	274	53
Transporting people	6 869	1 319
Capital goods	1 472	283
Total	**13 872**	**2 663**

Table 6: Total emissions per employee and student

6. COMPARISON BETWEEN 2016 AND 2018

In 2017, the VUB calculated its footprint for data year 2016. This first footprint calculation can be used as a reference or baseline measurement that allows for comparisons with subsequent carbon footprint measurements in future years. In this chapter we will compare the 2018 footprint with the 2016 baseline measurement. To allow for correct comparisons, keeping in mind the growth of VUB activities, we apply a benchmark by expressing the total footprint per unit of activity or service provided. Also footprint reduction targets can best be expressed in terms of footprint per unit of activity. A crucial service provided by the VUB, is education, so a suitable benchmark for the VUB is its footprint per student. This is summarized in the table below.

	Etterbeek 2016 kg CO2e	Etterbeek 2018 kg CO2e	Jette 2016 kg CO2e	Jette 2018 kg CO2e	Total 2016 kg CO2e	Total 2018 kg CO2e
Energy	**488**	**703**	**1 790**	**2 633**	**614,4**	**890,9**
Fuels, direct accounting	421	409	1 654	1 570	541,4	522,0
Electricity purchased	66	294	136	1 064	73,0	368,9
Non-energy	**7**	**6**	**38**	**48**	**9,9**	**10,4**
Kyoto halocarbons	7	6	38	48	9,9	10,4
Inputs	**68**	**86**	**125**	**152**	**73,1**	**92,5**
Metals	1	10	0	4	1,3	9,4
Plastics	0	2	0	0	0,2	1,5
Papers & cardboard	10	11	11	22	10,1	12,3
Chemical products	4	5	37	43	6,9	8,8
Agricultural products	22	22	26	22	22,0	22,0
Small office equipment	31	36	51	61	32,6	38,7
Direct waste	**11**	**11**	**54**	**56**	**15,4**	**15,5**
Incineration	10	10	44	44	13,6	13,2
Recycled or reused waste	0	0	0	1	0,2	0,3
Hazardous waste	1	1	10	12	1,6	2,0
End-of-Life	**35**	**33**	**189**	**240**	**49,9**	**52,7**
Papers, cardboards	1	1	1	1	0,6	0,5
Leaks and non-energy	34	32	188	239	49,3	52,1
Transporting people	**1 178**	**1 255**	**1 739**	**1 913**	**1 232,4**	**1 318,7**
Employees commuting, car	81	63	360	418	108,3	97,5
Employees commuting, public transport	56	68	44	56	54,8	66,6
Employees business, car	17	18	53	54	20,3	21,1
Employees business, public transport	5	8	5	9	5,4	8,4
Employees business, plane	287	321	488	542	306,6	342,4
Belgian students, car	246	246	394	394	260,4	260,4
Belgian students, public transport	227	227	136	136	218,4	218,4
Foreign students, car	18	16	18	16	18,2	15,8
Foreign students, public transport	13	11	13	11	12,6	11,0
Foreign students, plane	227	277	227	277	227,4	277,2
Capital goods	**242**	**268**	**469**	**417**	**266,4**	**282,6**
Buildings	182	202	352	349	200,3	216,4
Infrastructures excluding buildings	4	4	7	7	3,9	3,8
Vehicles, machines, furniture	4	4	9	3	4,4	4,1
IT	53	58	101	58	57,8	58,2

	Etterbeek 2016 kg CO2e	Etterbeek 2018 kg CO2e	Jette 2016 kg CO2e	Jette 2018 kg CO2e	Total 2016 kg CO2e	Total 2018 kg CO2e
Total	2 029	2 362	4 402	5 459	2 261,6	2 663,4

Table 7: Comparison footprint per student results 2016-2018

6.1. Comparison of the total carbon footprint

The total carbon footprint increased from 2.262 to 2.663 kg CO_2e per student. This is an increase of 18% in 2 years, or 9% per year. The Etterbeek and Jette footprints increased with respectively 8% and 12% per year. The reason for these increases in 2018 is fivefold, as will be discussed in the next sections:

1. real increases in consumption/activity levels per person (e.g. more foreign students that travel by airplane, more international business flights, higher purchases of office equipment),
2. increases in emission factors (e.g. grey instead of green electricity, new instead of recycled paper for student courses)
3. more accurate data (e.g. more destinations known for airplane travel),
4. larger scope (e.g. more student homes owned by the VUB[5], and probably more employee business travel by train taken into account), and
5. new assumptions (e.g. a higher fraction of on-campus working days for Jette employees).

Note that the latter three explanations can be considered as 'virtual' increases, because they are methodological and do not reflect real increases of greenhouse gas emissions in the world. In contrast, the VUB also realised some real decreases in its emissions, in particular due to a modal shift of employee commuting (from car to train) and a dietary shift of student restaurant meals (from meat to vegan). However, these real decreases are three times smaller than the real increases from airplane travel.

6.2. Comparison per impact category

6.2.1. Energy

2018 was a warmer year than 2016 (with 2091 degree days below 16,5°C in 2018, compared to 2330 degree days in 2016). This can (partly) explain why natural gas use for heating decreased. Note that even in Etterbeek, natural gas and electricity use decreased, even though newly build student rooms are taken into account. In 2016, more students rented private student rooms not owned by the VUB, and those heating emissions were not included in the 2016 VUB footprint. In 2018, more students rented the new VUB-owned student homes, which are included in the VUB carbon footprint scope.

5 The footprinting scope includes student rooms owned by the VUB and excludes privately rented student rooms in Brussels. The building of new student homes on campus can have two effects: students switch from private student rooms to VUB-owned student rooms, and more students decide to rent a student room (instead of commuting from home). The former effect is merely a switch from room to room and hence does not influence global carbon emissions. The resulting increase in the VUB carbon footprint is hence a virtual increase (it is a reallocation of the footprint from private student room owners to the VUB). The latter effect could mean a real reduction in global emissions, because it will decrease student mobility. However, due to a lack of a recent student mobility survey, we were not able to update the student mobility footprint for Belgian students: the 2018 student mobility footprint per student is the same as in 2016 (e.g. 260 kg CO2 per student for car travel). As we are not able to see a decrease in mobility footprint, the increase in footprint from the renting of extra student rooms should also be considered as virtual.

In Jette, we also see a decrease of natural gas use (with 3%). Although electricity consumption increased with 10% (see Table 2), the electricity footprint decreased due to a higher production and selling of electricity (from solar panels and CHP-installations on site).

Although electricity consumption (purchased electricity) decreased slightly from 1422 kWh/student in 2016 to 1395 kWh/student in 2018, and avoided grey electricity from own produced green electricity doubled, the footprint of electricity increased from 73 to 369 kg CO_2e/student. This is due to the fact that purchased electricity in 2016 was from biomass whereas in 2018 it was grey electricity from Luminus (a mix of fossil fuels, coal and nuclear) with a 5 times higher emission factor than biomass. Switching to green electricity (solar and wind) would reduce the electricity footprint with a factor 10.

6.2.2. Non-energy

The direct emissions of Kyoto halocarbons from cooling installations is very small and roughly the same between 2016 and 2018.

6.2.3. Inputs and direct waste

The footprint of inputs and waste increased, especially due to a higher collection of heavy materials (metals) and chemical products, and a higher purchase of electronic office equipment. These categories have a small contribution in the total carbon footprint, and they have very high uncertainty ranges (from 50% for office equipment purchases to 82% for metal use, see Table 5). Furthermore, the collection of heavy waste is highly variable, fluctuating a lot from year to year. Therefore, these footprint increases are rather virtual instead of real.

The footprint of purchase of student courses increased, because the courses are printed on new paper in 2018, instead of recycled paper in 2016. If courses were printed again on recycled paper in 2018, it would save 34 ton CO_2 (17% of the total paper and cardboard input footprint).

The footprint of agricultural products (for student meals) remains constant, because there are two opposing trends: an increase in meal consumption at the student restaurants and a dietary shift. The number of meals increased with 2,2% (and 4% in Etterbeek), which is a little bit more than the 2% increase in student numbers. This means an average student eats a little bit more at the VUB in 2018, resulting in a virtual increase in the VUB footprint due to a larger scope (meals not consumed at the VUB restaurant are not included in the VUB footprint). This virtual increase is offset by a real decrease in footprint due to a dietary shift towards plant-based meals. The percentage of vegan meals increased from 9,3% to 11,2%, the percentage of meals with meat decreased from 63,6% to 60,7%.

6.2.4. End-of-Life

The footprint of waste treatment of student courses (end-of-life paper waste) and leakage of halocarbons from discarded cooling installations remained roughly the same, the leakage of halocarbons

6.2.5. Transporting people

The footprint of employee commuting remained roughly the same, due to two offsetting mechanisms.

1. An increase in the total distance travelled. This increase is mostly virtual, because it is due to a new, more accurate estimate of the number of working days on site for Jette employees.

In the 2016 carbon footprint calculation, it was assumed that a full-time employee of Jette worked 80% of the working days at the campus, but based on an employee mobility survey, this is now estimated to be 90%. Next to this virtual increase, there is also a real increase in distance travelled: for Etterbeek, the average home-work distance travelled by employees with a 40% or higher employment rate, increased with 15%.

2. A modal shift towards public transport, especially in Etterbeek. In 2016 (based on a 2014 mobility survey), an estimated 20% of kilometers travelled was by car and 64% by train (see table in footnote 3). In 2018 (based in a 2017 mobility survey), these percentages were resp. 14% and 71%. For Jette, the percentage of car travel decreased from 57% to 54%, train decreased from 30% to 27%, but bus, tram and subway increased from 7% to 12%.

The footprint of employee business travel increased due to two causes.

3. A largely virtual increase in distance travelled by train. In 2018, a more extensive list of international train travels was used, with eight times more travels. However, international train travel is a bit less than 10% of total train travel for business, so the overall effect of train travel is small.
4. An increase of airplane travel. In 2018, there were 22% more flights and the total distance travelled was 14% higher than in 2016. This means that the distance of an average flight decreased a bit. This decrease is compensated by an increased number of flights. However, the decrease in average distance of flights could largely be virtual, because the 2018 data are more accurate: in 2018, 70% of the destinations of international flights was known, in 2016 a bit less than 30% was known.

The footprint of Belgian student mobility per student remained the same, because we used the 2016 results, extrapolated by the number of students. The footprint of foreign students increased, mostly due to a large increase of non-EU students by 30% (from 1200 in academic year 2015-2016 to 1560 students in 2017-2018).

6.2.6. Capital goods

The footprint of capital goods increased, especially for Etterbeek, because more and larger buildings (especially extra student rooms) were included.

7. SUMMARY

This report describes the calculation of the carbon footprint of the VUB for the year 2018, following the Bilan Carbone® method. The carbon footprint measures the direct and indirect emissions of greenhouse gases included in the Kyoto-protocol (in particular carbon dioxide, methane, nitrous oxide and halocarbons), for VUB activities and infrastructure. The impact categories that generate emissions are: direct energy use (electricity and heating), leaks of halocarbons from airconditioning systems, purchased equipment and services, meals at student restaurants, waste, employee commuting, business travel, student mobility, and capital goods (infrastructure, furniture, vehicles, ICT-equipment).

Included in the carbon footprint calculation are activities related to administration and academic research (research equipment, waste generation, international business travel, employee commuting) and activities related to education (educational equipment, student mobility including airplane travel for foreign students studying at the VUB, paper use for student courses, meals consumed at the student restaurants, and energy use and general waste generated at the student homes on the campuses of Jette and Etterbeek). The buildings include administrative, research and education buildings, and student homes and student restaurants located at the campuses.

Not included in the carbon footprint calculation are energy use and general waste generated at student homes other than the student homes at the campuses, food consumption at places other than the student restaurants at the campuses, equipment and furniture of the student homes (including the student homes on the campuses), water consumption, transport of goods other than the transport of waste collection, mobility (airplane, car, train) from non-student visitors (e.g. guest lecturers), and spin-offs of the VUB.

The total carbon footprint of the VUB for the year 2018 is 41.909 ton CO_2e, which corresponds with 2,7 ton CO_2e per student. Of this total footprint, 50% is due to transporting people (especially student travel by car, airplane and public transport), 33% comes from direct energy use (especially heating) and 11% from capital goods (especially construction of buildings).

Compared with the baseline measurement of the carbon footprint of 2016, the total carbon footprint in 2018 is 18% higher, which means a 9% increase per year. Most of this increase can be explained by more airplane travel (of both employees and foreign students) and a switch in 2017 from green electricity to grey electricity that includes fossil fuels and coal.

A smaller part of the increase is 'virtual' due to methodological choices: a larger scope (e.g. more new buildings and student homes, more student meals at the VUB restaurant and more employee business travel by train taken into account), new assumptions (e.g. a higher fraction of on-campus working days for Jette employees) and more accurate data (e.g. more destinations known for airplane travel). In contrast, the VUB realised some real decreases in its emissions, in particular due to a modal shift of employee commuting (from car to train) and a dietary shift of student restaurant meals (from meat to vegan). Also natural gas use decreased, but this can (partially) be due to 2018 being a warmer year than 2016. The footprint of electricity decreased due to more selling of own electricity (from solar panels). In total, these real decreases in footprint are smaller than the real increases from airplane travel and the virtual increases.

For further climate action plan recommendations, including simulations and CO_2-reduction and compensation measures, we refer to the report 'The Carbon Footprint of the VUB (2016)' (Ecolife, 2017). As a new important measure, a switch back to green electricity is recommended.

COLOFON

Ecolife vzw

Ecolife is a centre of expertise for footprinting and ecological behavioural change. Ecolife supports governments, organisations and companies in achieving their ecological objectives.

Valkerijgang 26
3000 Leuven
016 22 21 03
www.ecolife.be
info@ecolife.be

Contact

Bruno Verbeeck
bruno.verbeeck@ecolife.be
016 22 21 03