Carbon Accounting

of Research Activities in the School of Life Sciences

Van der Goot Lab & Oates Lab

Written by:
Zero Emission Group,
Consulting division

Partners:
Quantis
Act4Change Lab
SV Sustainability
SKIL EPFL

September 2020

Foreword

In the summer of 2020 and in the midst of the COVID-19 crisis, Martin Vetterli, the President of EPFL, announced the creation of a new Vice-Presidency for the Responsible Transformation. In this context, the Zero Emission Group association has set itself the mission to achieve two goals:

- Accelerating the sustainable transformation of EPFL and of its partners
- Providing the community with essential skills to build a sustainable future

This report is the outcome of one of the most comprehensive projects of our association and contributes to reach both goals above. First, it provides EPFL's research entities with tools to improve their sustainable performance in a near future. Secondly, it has led a team of students from bachelor to PhD to gain valuable skills in the monitoring of greenhouse gas emissions, and to propose a roadmap for continuous improvement in the sustainable transformation of research activities.

This environmental assessment is the first public issue of our consulting division and it is focusing on two laboratories: van der Goot lab and Oates lab from the School of Life Sciences. It was a great honour to start with an engaged School from EPFL, where scientists are already aware of the pollution from single-use goods, packaging and professional flights. Although public awareness is necessary to the School's sustainable transformation, monitoring its climate impact is also key. Therefore, this report proposes a bottom-up approach to monitor direct and indirect emissions from laboratories.

In a process of continuous improvement, the report is providing the School with two sets of recommendations: the first one to reduce laboratories' carbon footprint based on the quantitative results, the second one to improve the monitoring methodology in the future.

While the COVID-19 pandemic has not stopped climate change, it has not stopped our hardworking team to develop this report either. On the contrary, past lockdowns have proven that ambitious social transformations can be deployed, and technical reports such as this one will be needed to ensure an efficient sustainable recovery of global activities.

This is the most thorough assessment our multidisciplinary group could compile; our recommendations are the most robust we can offer at this time. Our sincere thanks to the committed team who have contributed to reach these conclusions.

We encourage the laboratories from the School of Life Sciences to consider our advice carefully, and other EPFL Schools to replicate this process. We must now increase our ambition to tackle climate emergency, and collaborate between students, researchers and private partners to make carbon neutrality a reality at EPFL in the near future.

Adrien Legrain
Zero Emission Group Senior Advisor

Christopher Padovani
Zero Emission Group Consulting Officer

Acknowledgements

The Zero Emission Group's Committee would like to thank:

The team that prepared this report and the analysis: The team intended Jan Linder, Curdin Wüthrich, Damien Ronssin, Adrien Loretan, Thomas Dardano, Guilhem Sicard, Ana Tejonrodizza, Juliette Vincent and Nathan Greiner.

The team that contributed to the design of the report: Agatha Duranceau and Eric Bolliger

The financially supportive Act4Change Lab team:
Gianluca Paglia and Philippe Vollichard

The supportive Deanship of the School of Life Sciences:
Agnès Le Tiec and Prof. Gisou van der Goot

The supervising team from SKIL:
Samuel Cotture and Prof. Anders Meibom

The training team from Quantis:
Anna Kounina and Denis Bochatay

Other participating members from EPFL entities: Laurence Gouzi Abrami, Mathieu Grangé, David Gremaud, Chloé Jollivet and Prof. Andrew Oates

A wide range of stakeholders who participated in discussions, engaged with us or submitted evidence.

Executive Summary

Carbon Accounting of Research Activities in the School of Life Sciences (SV)

Context

In autumn 2019, **Zero Emission Group** has opened a new pole dedicated to carbon accounting. It expressed the will from students to learn engineering skills to face the climate issues of the coming decades.

In the same period, the **SV Sustainability** office expressed the need to monitor the environmental impact of the School's research activities.

Since data about EPFL consumable goods' climate impact were not available, it was the opportunity for Zero Emission Group to collaborate with SV and propose a first comprehensive carbon accounting study. For the sake of quality, **Quantis** supported the analysis with consulting hours, and **Act4Change Lab** financed it.

Two SV laboratories opened their door for the study: **Van der Goot and Oates Labs**

By

ZERO EMISSION GROUP

Partners

EPFL, Quantis, Act for Change Lab, SKIL, Sustainable Life Sciences

Methodology

System Boundaries

Scope 1	Scope 2	Scope 3
• Oil heating • Natural gaz heating	• Electrical heating • Electricity consumption	• Commuting • Travel • Consumer goods
Direct emissions	Indirect emissions from electricity	Other indirect emissions

Scopes 1 & 2:

Heating: The heating consumption in the AI building is given by EPFL. We apply an effective surface ratio to determine the lab consumption from the building's. Finally, the carbon intensity of heating is defined based on EPFL's heating primary energy mix.

Electricity: The method used consists in obtaining the inventory of electrical devices in both labs, visiting them to observe the power of each device and estimate the time of use for each. Lighting was added proportionally to the laboratories size.

Scope 3:

Commuting: EPFL Sustainability is providing the average commuting distance per person (15 km). They also give the proportion of transportation modes used in commuting at EPFL. Using Mobitool, we determined equivalent CO_2 (eq. CO_2) factors for each mode, and computed the impact proportionnally to the number of people in the lab.

Travel: Atmosfair provides an annual study to SV with the eq. CO_2 impact of flights in the faculty according to 4 different categories of people. We have multiplied the number of people from each category with its corresponding eq. CO_2 factor from flights.

Consumer Goods: We obtained two inventories from labs containing all the IT and non-IT purchases. The goods from the IT inventory were classified in sub-categories with attributed eq. CO_2 conversion factors. For the non-IT inventory, each item was labelled with a mass and a material having its own eq. CO_2 factor. The factors come from well established LCA databases such as Ecoinvent, Ademe or GHG reporting.

Challenges:

1. The animal facility and washing facility were not included into the study.
2. Lab visits weren't enough to monitor precisely the power and time of use of machines.
3. We didn't have access to business travel data from the precise laboratories but only from SV.
4. Inventories are very time consuming to analyse from scratch (mass and materials had to be investigated online for each item).

Outook and next steps:

1. We plan to realise an LCA of the animal facility by the end of 2020
2. EPFL should form green teams that would be rewarded for going into labs and monitoring the power consumption profiles with meters.
3. SV is currently obtaining rights to use these data strictly for research purpose.
4. SV has started to involve suppliers to obtain CO2 information in the inventory. Moreover, a calculator is being developed by the School to avoid time consuming data acquisition.

Results

Heating

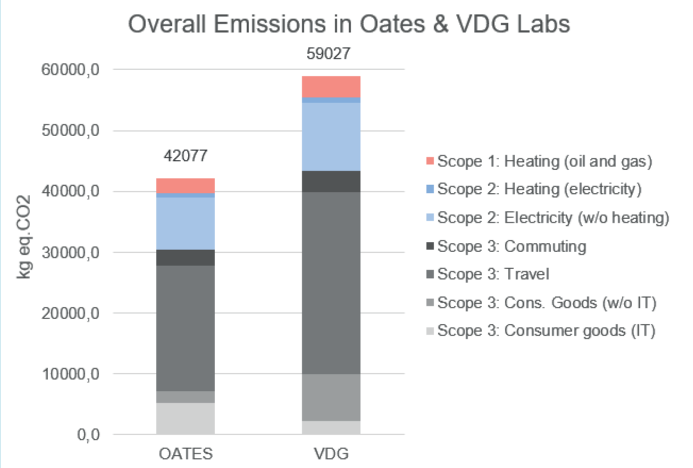
- eq. CO_2 from heating only represents **7 to 8%** of total emissions.
- Oil, gas and a heat pump were used for heating. The **heat pump remains the less polluting**.
- Only 3 months of **natural gas** heating accounted for almost **50%** of annual heating emissions.

Electricity:

- Electricity consumption generates around **20%** of overall emissions.
- **Refrigerators** and **incubators** are key emitters (up to 65% in VDG). **Lighting** contributes to 11 to 14%.
- In **OATES**, due to the **servers**, **IT** contributes to **18%.**
- In **VDG, centrifuges** contribute twice more than in OATES.

Commuting:

- Commuting is only responsible for **6%** of total emissions.
- Among commuting modes, **cars** emit **65%** of emissions for only 23% of total commuting distance.
- Achieving a similar distance (17% of commuting), **bikes emit ≈0 kg eq. CO_2**.



Travel:

- **Travelling** represents the **largest contribution** with up to to **50%** of total emissions.
- **Professors, MERs and scientific collaborators** are responsible for **84 to 88%** of these emissions.
- **PhDs** emit **8%**, constituting 20% of the staff members in the considered laboratories.

Consumer goods:

- Purchases are responsible for **16 to 17% of eq. CO_2**.
- In **OATES, IT goods** emit **75%** among all purchases, mostly due to the server, computers and screens.
- In **VDG,** more than 65% of eq. CO_2 comes from **chemicals** and **plastic goods**.

A climate-neutral society would emit 1 t eq.CO2 per person, while the studied labs lead to 4 t eq.CO2 per person for professional activities alone!

Recommendations to mitigate emissions in labs:

1. **Travel** represents 50% of total emissions, they should thus be the **first priority** to reduce a laboratory's footprint. Furthermore, **professors, MERs and scientific collaborators** have a better leverage than PhDs to reduce their professional flights. To this end, scientists should follow the *Travel Less Without Loss Guidelines* by reflecting about the necessity of the travel, giving preference to videoconferences and preferring train trips to avoid short-distance flights.
2. **Electricity consumption** emits 20% of emissions and are therefore significant. On the one hand, purchasing low-carbon electricity can have a direct impact on all the emissions from electricity, but it depends on Swiss energy policy and not on scientists. As **freezers** are big consumers, using them efficiently is key, and avoiding **space heaters** as well. **Daily** actions such as **shutting down equipment, closing hoods, keeping windows closed and saving light** whenever possible can reduce emissions as well if properly coordinnated.
3. **Consumable goods** account for 17% of emissions, and therefore should be seriously considered. Follow wisely the «Reduce, Reuse, Recycle». MIT's *Green Chemical Alternative Purchasing Wizard* allows to **avoid buying** a new product if an **alternative** one is already available. Encouraging labs to **share goods** or participate in **take back programs** can limit purchase. Many products can be recycled, such as **printer ink, toner cartridges, cell phones, portable electronics, and single-use plastic goods** should as well belong to a **circular supply chain**.
4. In general, **keeping inventories updated** is key to enable efficient lab management.
5. In terms of **commuting, biking** is the **best option**, and coming by **public transport** remains much less carbon intense than by individual car.
6. Although **data** were not included in the study, it is recommended to prefer **sharing workspace on clouds** than sending attachments by email. Collaborating with **climate-efficient data managers** for cloud services is beneficial as well.

Useful links:

Travel Less Without Loss Guidelines: https://www.epfl.ch/schools/sv/wp-content/uploads/2020/03/TLWL_recommandations_EN.pdf
MIT's Green Chemistry Webpage: https://greenlab.mit.edu/chemistry
LabConscious Green Lab Tips: https://www.labconscious.com/green-lab-tips
Guidelines for Green Labs at UPenn: https://www.sustainability.upenn.edu/sites/default/files/Green%20Labs%20Guide_UpdatedSummer2020_v2.pdf

Content Table

1. Introduction

In a context where EPFL students showed a will to gain competencies in carbon accounting on the one hand, and where the School of Life Sciences was keen to monitor the CO_2 emissions of its laboratories on the other hand, a collaboration started between the Zero Emission Group, the SV School, Act4Change Lab and Quantis. This report is the outcome of that collaboration, providing:

- a replicable methodology for carbon accounting in laboratories
- key findings on emission sources of two laboratories from SV
- recommendations for laboratories
- insights for future improvements of methodology

1.1. Who we are

Zero Emission Group is an association consisting of members of the Ecole polytechnique fédérale de Lausanne (EPFL) concerned by the consecutive scientific reports on global warming. We all share a strong willingness to mobilize our scientific expertise to address this issue. As students and scientists from different departments, we are convinced that interdisciplinarity is crucial in designing solutions for a carbon-neutral society. We are also keen to promote the high reputation and scientific excellence of EPFL so that it can bring its scientific credibility to the debate on the climate crisis. As future engineers, we want to use our technical and systems knowledge in a low carbon transition context and develop unique expertise in the global fight against greenhouse gas emissions.

1.2. Motivation

Each year, a campus carbon footprint is produced by the EPFL spin-off Quantis and takes into account various sources of greenhouse gas emissions such as food, commuting, professional air travel and energy (electricity, air conditioning, heating). However, one parameter is not taken into account: greenhouse gas emissions due to the purchase of consumable goods, such as in research laboratories. Given the scope of EPFL's research, the association has been wondering about the contribution of consumables in the global footprint of our institution's research. It seemed obvious that those emissions would represent a non-negligible part of the campus' carbon footprint. It was the opportunity to better understand where these emissions come from and how they should be computed.

In parallel to these internal thoughts, the School of Life Sciences (SV) has launched the sustainability project "Travel less without loss", which consists in reducing the CO_2 emissions due to the travel of its School's researchers. This project, led by Agnès Le Tiec and Kelly McClary, has opened the door to other initiatives. The SV Sustainability decided to extend the scope of its work to all of the School's activities, including research in laboratories. Thus, Zero Emission Group has volunteered to collaborate and establish a carbon footprint of the School's research activities.

As the SV School contains a very large number of laboratories, our ambition was to realize the carbon accounting of two laboratories that volunteered to collaborate in this project. These are the Oates Lab run by Andrew Oates and the van der Goot (VDG) Lab of SV Dean Gisou van der Goot. This work would enable us to develop a methodology that would then be replicable in all of the School's laboratories and potentially, in the long term, in all of EPFL's research laboratories.

1.3. Project conception

A team of 10 EPFL students, all members of the association, was built in September 2019 to constitute the consulting division of Zero Emission Group. The aim of this division is to advise the key players at EPFL with precise and reliable figures on environmental issues. We had the opportunity to exchange on the subject and to note that we are not all at the same level of knowledge about life cycle assessment (LCA) since we almost all come from different sections. We therefore decided that it was essential to be trained by an expert on the subject in order to have a precise methodology for the LCA of an entire laboratory (energy, transport, consumer goods). After several discussions with experts, no precise and replicable methodology to monitor overall emissions from research laboratories has been found and we have come to the conclusion that only experience and sufficient hindsight on the subject would allow us to have a complete and representative carbon footprint.

As our consulting division is exclusively composed of EPFL students from bachelor to PhD, we wanted to optimize our time and thus be trained by experts in carbon accounting and LCA. As the carbon balance of EPFL is already carried out by Quantis in general, we have decided to collaborate with the company, who gave us an initial training and proposed to supervise our work along the study.

After meeting with the managers of the Oates Lab and van der Goot Lab, we noticed that there was no lack of willingness to reduce their impact on the environment. However, they lacked numbers about these impacts which would enable them to put in place relevant measures to reduce their CO_2 footprint. There was therefore a real desire to collaborate with our association to determine their carbon footprint by the end of the spring semester 2020 so that they could take measures accordingly during the autumn semester and reduce their share of CO_2 emissions. Carrying out the carbon balance of two entities would allow us to deal with different cases and thus to have a complete methodology on the topic for the SV department.

1.4. Objectives

The main goal of this project is to get a result that would serve as a support for the SV School to extend the process to all laboratories and identify a series of measures to reduce the carbon impact of research activities.

The spin-offs of this project are expected not only to be beneficial for the SV Department but also for our association which, in the perspective of a development imperative to achieve its ambitions, would be able to use this work for communication purposes at EPFL and thus have greater visibility to develop its various poles.

The acquired knowledge could then be passed on to the next students joining the Zero Emission Group, knowing that the EPFL carbon accounting project fundamentally requires a long-term and sustainable vision.

In addition, enabling a group of students to acquire a technical background on carbon accounting will have a great added value in our future professional experiences as this training will be given in an extra-university setting.

1.5. Project team and partners

Table 1.1 Members of the team and partners

Name	Section / Institution	Function	Email
Gisou van der Goot	SV School	SV Dean / VDG Lab Director	gisou.vandergoot@epfl.ch
Andrew Oates	SV School	Oates Lab Director	andrew.oates@epfl.ch
Agnès Le Tiec	SV School	SV Sustainability Officer	agnes.letiec@epfl.ch
Anders Meibom	SKIL	Supervisor	anders.meibom@epfl.ch
Samuel Cotture	SKIL	Supervisor	samuel.cotture@epfl.ch
Anna Kounina	Quantis International EPFL Innovation Park	Instructor	anna.kounina@quantis-intl.com
Denis Bochatay	Quantis International EPFL Innovation Park	Instructor	denis.bochatay@quantis-intl.com
Adrien Legrain	Zero Emission Group / SV School	ZEG Senior Advisor /SV Sustainability Specialist	adrien.legrain@epfl.ch
Christopher Padovani	Zero Emission Group ENAC School MA2	Consulting division Officer	christopher.padovani@epfl.ch
Jan Linder	Zero Emission Group IC School BA4	Consulting division	jan.linder@epfl.ch
Curdin Wüthrich	Zero Emission Group SB School PHD	Consulting division	curdin.wuethrich@epfl.ch
Damien Ronssin	Zero Emission Group SB School MA4	Consulting division	damien.ronssin@epfl.ch
Ana Tejonrodizza	Zero Emission Group Future EPFL student	Consulting division	anatejonrodizza@gmail.com
Juliette Vincent	Zero Emission Group ENAC School MA2	Consulting division	juliette.vincent@epfl.ch
Guilhem Sicard	Zero Emission Group CDH Colledge MA2	Consulting division	guilhem.sicard@epfl.ch
Adrien Loretan	Zero Emission Group ENAC School MA2	Consulting division	adrien.loretan@epfl.ch
Thomas Dardano	Zero Emission Group SB School BA6	Consulting division	thomas.dardano@epfl.ch

1.6. Interdisciplinary aspects

Table 1.2 Combined aspects in the interdisciplinary project	
Innovation	• Development of a rigorous methodology for carbon accounting of laboratories on an international campus in collaboration with Quantis. Multidisciplinary project adaptable to all EPFL Department and UNIL.
Potential	• Extra-university training to develop students' knowledge and awaken their curiosity about environmental issues. • Capitalization of knowledge and transmission of this capital from year to year through training courses carried out by students to students. • May become a semester project for all departments so that more and more students will be trained to do carbon accounting in their respective settings (a necessary skill in the future).
Interest	• Essential communication tool in discussions with key EPFL stakeholders for decisions related to sustainability. • Communication tool to recruit and see the project replicate in order to have a detailed carbon accounting of ALL research activities on campus (long term). • Contributes new elements of analysis to the Research and Campus pillars of the Task Force for Sustainability recently launched by the EPFL presidency.
Environmental impact	• Life Cycle Assessment (LCA) of two EPFL laboratories in order to define actions to reduce their greenhouse gas emissions. • Essential methodology to reduce the carbon footprint of the campus.
Social Impact	• Unite students, doctoral students, collaborators and professors around sustainability issues by involving them jointly in current and soon-to-be-involved themes. • Approach based on the good will of the students as it is a voluntary project. • Communication at all levels to raise awareness.
Economic impact	• Project with a sustainable and long-term vision. • High financial sustainability as little funding will be needed in the future as knowledge capitalization will allow for gradual self-sufficiency. • Financing of the continuation of the project through foundcrowding of laboratories interested in our services.

	• Will reduce the carbon offsets that EPFL pays for by reducing CO_2 emissions from laboratories.
Characteristics of the project	• Multidisciplinary team sensitive to a common theme: sustainability. • Ambitious project carried by a team composed exclusively of students with one and only one will: a clean campus.

2. Methodology

We decided to assess the following categories: energy, mobility, data and consumer goods. Alimentation is not included as it's hardly influenced by the fact of where people work and hence not under the influence of the laboratories.

2.1. Functional Unit and System Boundaries

The purpose of this study is to monitor greenhouse gas (GHG) emissions emitted by 2 laboratories of the SV School over one typical year, respectively the labs of Prof. Oates and Prof. van der Goot. In compliance with the GHG Protocol[1], we have monitored both direct (scope 1) and indirect (scope 2 & 3) emissions to benefit from the most comprehensive overview of emission sources related to research activities.

Functional unit

The function of a laboratory is to provide an operational space to make scientific experiments, generate scientific results and share them internationally. For both laboratories in this study, the functional unit is defined as 1 year of research activities in the lab, including the administration, offices, commuting, professional travel, electricity consumption and purchase of consumable goods.

System boundaries

- **Scope 1** emissions are the ones directly emitted from EPFL's campus. In the case of our 2 laboratories, they only result from oil and gas combustion in EPFL's heating plant.
- **Scope 2** emissions are the indirect ones only related to electricity consumption, thus only encompassing electrical heating and appliances consumption.
- **Scope 3** emissions are the indirect ones not related to electricity consumption. In this study, we include commuting, travel and consumable goods which are the most important categories for this scope.

Table 2.1 System boundaries

Scope 1	Scope 2	Scope 3
• Heating from oil • Heating from natural gas	• Electrical heating • Electricity consumption in lab	• Commuting • Travel • Consumable Goods

2.2. Scope 1 - Direct emissions

Heating (Gas and Oil)

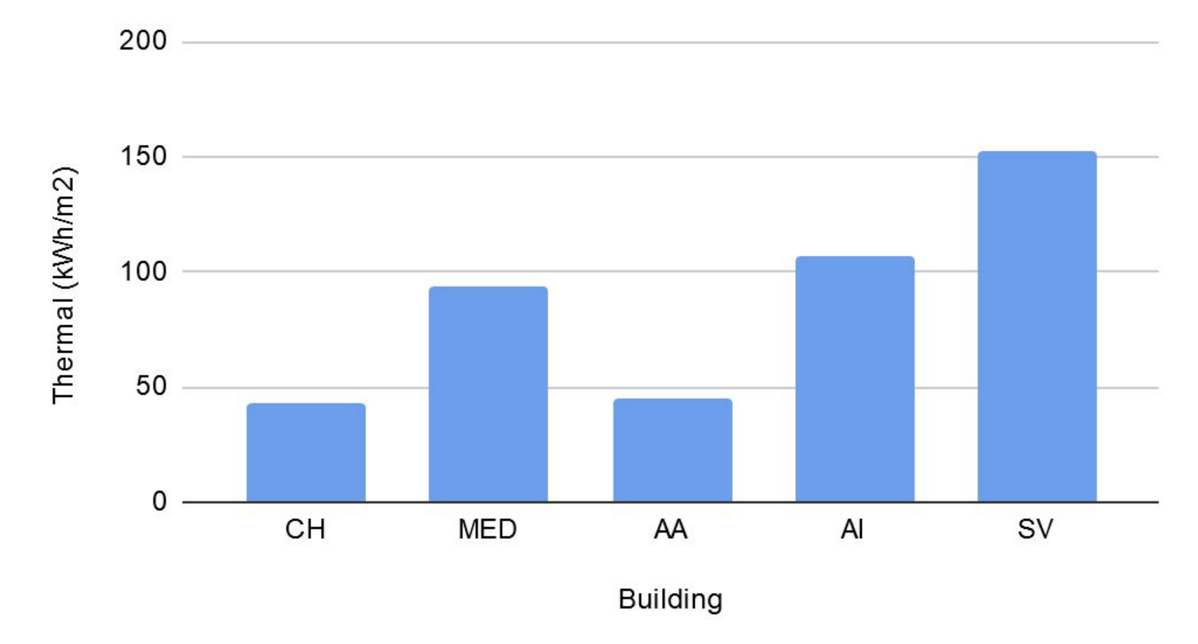
During the last years, the heating of EPFL's buildings was mainly done by two heat pumps, which only consume electricity and thus generate emissions that are linked to scope 2. However when those didn't produce enough heat, they were completed by **oil combustion**. Since October 2019, there are construction works on the heat system, that's why the heat

[1] https://ghgprotocol.org/

production was switched completely to **two gas turbines** during the work phase.[2] Therefore the heating emissions are splitted between scope 1 and 2.

From EPFL, we received the consumed thermal energy per building and the percentages of how much - in primary energy - each energy supplier delivered. For electricity, we simply applied the same global warming potential (GWP) as for the electricity consumption of the labs (see below). Note that this part of the heating is included in the Scope 2. For the gas and heat oil, we estimated the thermal efficiency of the gas boilers (92%, EPFL estimation) and the oil boilers (90%, our estimation). Then we used the ecoinvent database to find the corresponding GWP. (Wernet et al., 2016) The resulting GWP of the heating per building was broken down proportionally to the laboratory's surface.

Chart 2.1 Annual Heating Consumption per Building



2.3. Scope 2 - Indirect emissions from electricity

Heating (Electricity)

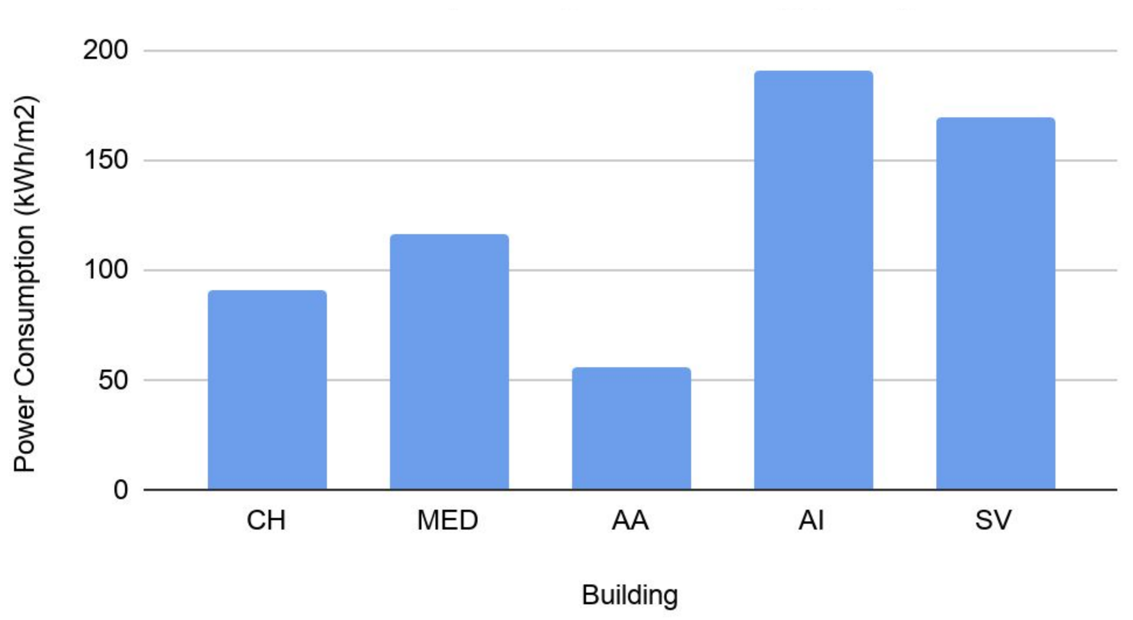
As mentioned above, part of the heating is done with electricity. The methodology is the same as explained under scope 1.

Electricity

EPFL measures the electricity use on its campus only by building, and only in three categories (Electricité force, Electricité force + service, Electricité lumière). We used this information to compute a rough estimate of the electricity use by assuming that electricity consumption is related linearly to the used surface of a building. For sure, this estimation is imprecise, as the big electricity consumers can be located in very little rooms.

[2] Information by Projet Energie EPFL

Chart 2.2 Annual Electricity Consumption per Building



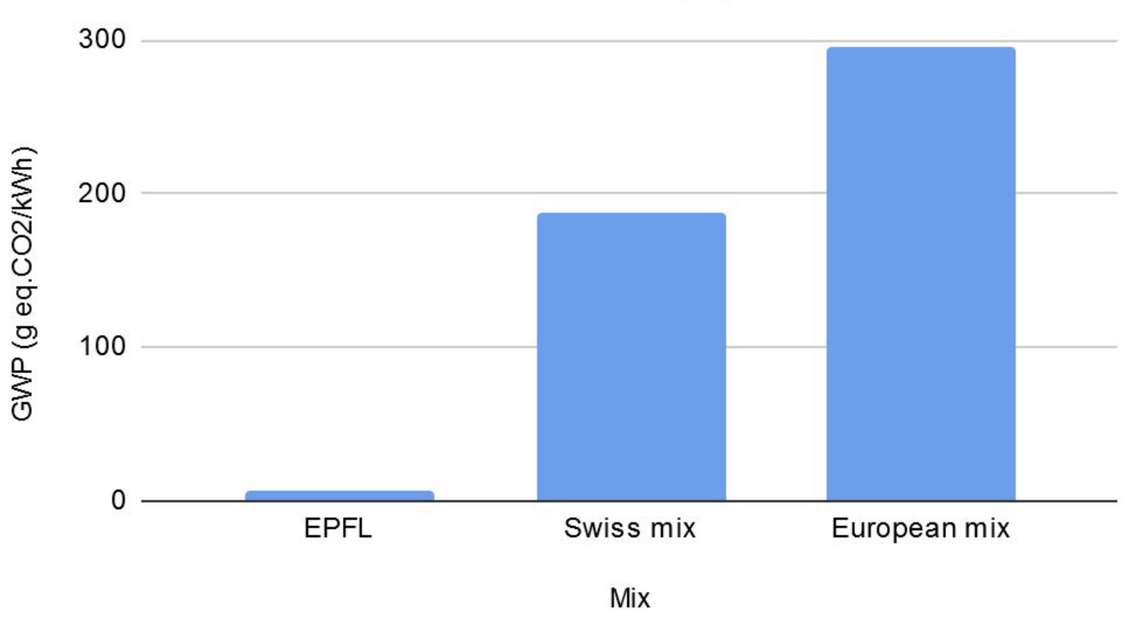
In a second step, we visited the laboratories to identify the biggest electricity consumers and estimate their use of electricity. During those visits, we tried to find the power of the used devices and asked a collaborator of the laboratory about the estimated average usage of the devices. This approach is very approximative, as it is often difficult to even find an exact information about the power of the device. The usage time is hard to estimate as well. For example for the fridges and freezers, which are of the biggest consumers in both laboratories, we looked for similar modern models and then took their power consumption claimed by the producer. This may lead to a lower consumption than they actually have, because modern models are probably more efficient. Another example are personal computers and laptops: because the power consumption varies from device to device and also depending on the intensity of usage, we chose very rough average estimations that seemed to be reasonable compared to the possible range. As these devices turned out to be not the most consuming in terms of power, we didn't refine these estimations for the final result.

The results of this second approach are hence not to be understood as exact. The method could fairly be improved by measuring the power consumption of the biggest devices for some time with electric meters. What we still added as a linear function of the laboratories surface was the lighting, as this is probably used equally distributed per building. The tables we used for the estimation during the lab visits can be found in the appendix.

The final results used for this report were the ones computed with the second approach, which was the estimation made within our laboratory visits.

After having determined the power consumptions of the laboratories, we needed to quantify the impact of the used energy. There exist many approaches to find the carbon footprint of electricity, Chart 2.3 compares three of them. A recent study by EPFL and the university of Geneva investigated the Swiss electricity mix (Vuarnoz & Moreno, 2020). Their data states as an average over the hourly result of the years 2016 and 2017 a GWP of 188 g eq.CO_2/kWh (1 g eq.CO_2 being the acronym for 1 gram CO_2 equivalent). Another approach could be to take the GWP of the European grid, which is 296 g eq.CO_2/kWh (ENTSO-E, 2019). Choosing this mix could make sense if you want to stress out the fact that there are hardly any borders in the electricity grid in Europe, especially not around Switzerland. Another possibility would be to consider the electricity mix EPFL is paying for, which consists of 97.5% hydroelectric power and 2.5% solar power. This mix gives a GWP of about 7.2 g eq.CO_2/kWh (Ademe). We decided not to take into account the mix that EPFL is paying for. Due to the fact that just paying more doesn't improve the Swiss mix in general and that the laboratories don't have a direct influence on EPFL's energy policies, we consider the Swiss mix to be the most accurate choice.

Chart 2.3 Global Warming Potential of the Power Grid



2.4. Scope 3 - Other indirect emissions

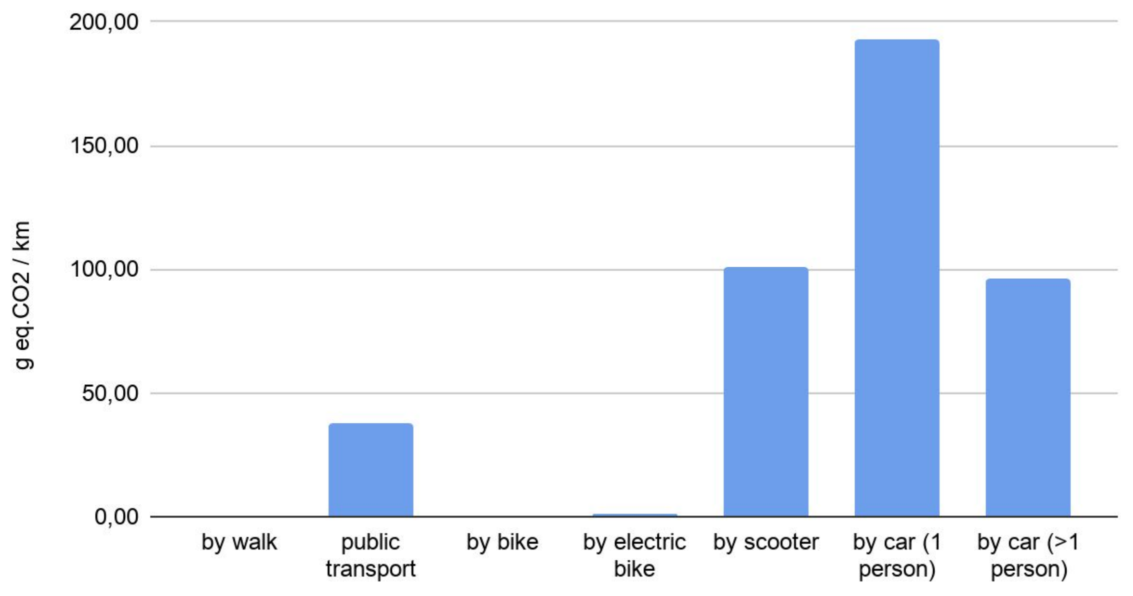
Commuting

Using the Mobility Survey EPFL 2019 *"Etude empirique sur les pratiques de mobilité des étudiant-e-s et du personnel de l'EPFL"*, a study on the mobility practices of EPFL students and staff, we got the general information concerning commuting for the whole university. Based on this document, we determined the average distance and percentage of use of each type of transport per worker. First, we found the rate of attendance per week (68% for professionals) and the average distance they do per day (15.1 km/day). From the websites of the laboratories, we obtained the numbers of persons that work per laboratory. Knowing this, we could calculate the kilometers per year per laboratory, pointing out that we did not consider vacation days.

Secondly, also based on the EPFL 2019 Mobility Survey, we found the percentages of use for each type of transport - by foot 7%, public transport 40%, bike 17%, electric bike 3%, car (1 person) 23%, car (>1 person) 7%, scooter 2%, and others 1%. We didn't include the 1% that represents "others" due to the lack of knowledge of what it includes.

To connect the distance travelled according to the means of transport with the eq.CO_2 emissions we used Mobitool.

Chart 2.4 CO_2 Intensity per Transportation Mode



Travel

For a precise analysis, the professional travel data from the laboratories under investigation should be considered. Due to a lack of this latter one, the study from Atmosfair on the business travels of the whole SV School in 2019 has been used. In this study, only trips by flight that were booked through the EPFL travel agency have been included. According to Durabilité EPFL, it is reasonable to assume that 20% of the trips are booked directly by the laboratories. Hence, this factor will be added in all factors of this category.

The CO_2 emission calculations in this work are according to VDR standards identical to the Atmosfair report. For the estimation of the total eq.CO_2 emissions, the CO_2+ RFI2.0 (radiative force index) coefficient has been used[3]. As an order of magnitude, one can take a reference value of 159 g eq.CO_2/km/pers even though precise emissions depend on the flight altitude, plane type and size. Note that this number corresponds to flights in economy class, higher classes also imply a much higher carbon footprint.

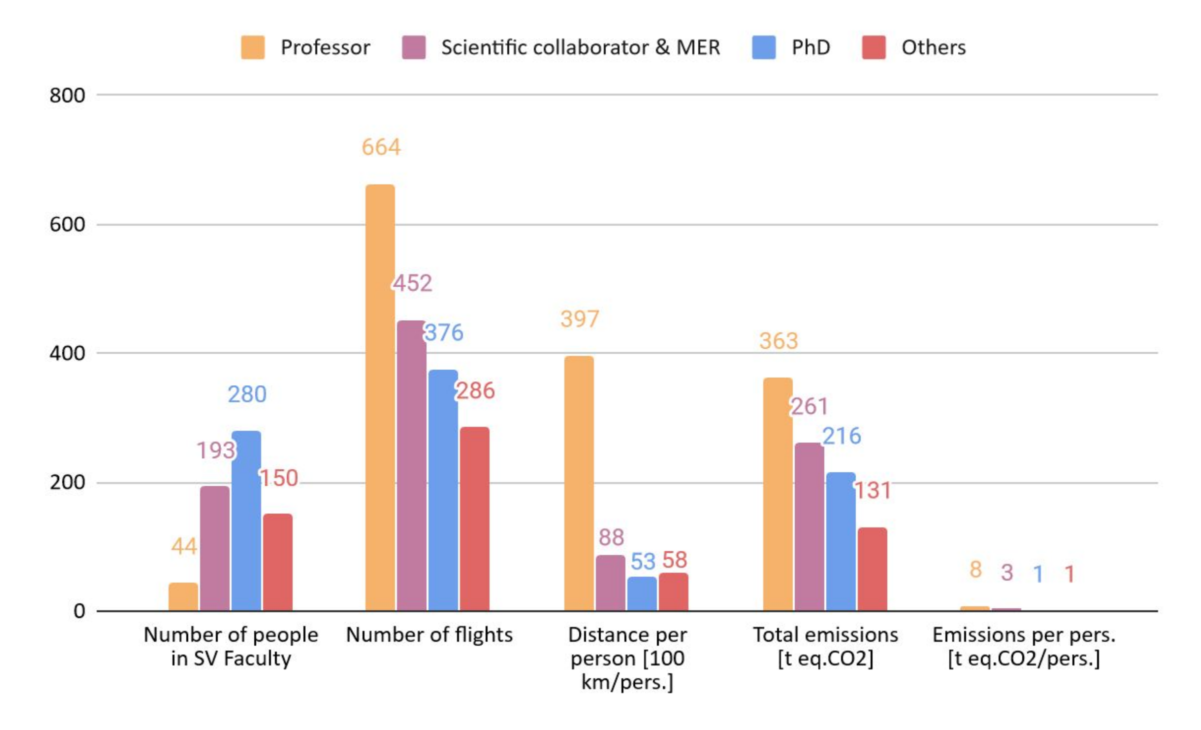
As a first impression of the impact linked to business trips, the SV School has travelled a total distance of 4.8 mio. km by plane in 2019. This is equivalent to approximately 165 trips from Switzerland to Australia and back or 125 times around the world. Considering the

[3] More information on the calculation protocols can be found under www.atmosfair.de/en/co2-bilanz_fuer_unternehmen and http://esu-services.ch/fileadmin/download/jungbluth-2018-RFI-best-practice.pdf

approx. 667 scientific employees of the School, each person travelled an equivalent of once to New York.

In order to estimate the emissions per laboratory, all flights have been categorised by 4 types of collaborators as employed by Atmosfair: professors, scientific collaborators + maître d'enseignement et de recherche (MER) and others. In the categories others are for example post-doctoral employees and scientific staff not categorised in the other three groups. Secretaries and technical staff have not been included, since their number of business flights is very small. The number of collaborators per category as well as their flight statistics are displayed in Chart 2.5. Professors clearly travel the largest distances per person and exhibit a ten times higher footprint than a doctoral assistant. Furthermore, professors and MER tend to occupy first and business class seats linked to a higher footprint per passenger.

Chart 2.5 Statistics of Flight-related Emissions in SV



Distances below 700 km are hereafter categorised as short distance segments. After studying the individual connections, one can see that 90% of the categorised destinations are very well connected by train. The School of SV has travelled a total of 431 such segments, representing 26% of all flights. For illustration, replacing all the segments to trips by train, the CO_2 emissions would be reduced by 26 t eq.CO_2 per year. The emissions from the train equivalent has been calculated using mobitoo (Mobitool, 2016) as an average between French (17 g eq.CO_2/km/pers.) and German (50 g eq.CO_2/km/pers.). Professors show to fly such distances about twice as much as all other employers categories as can be seen in Chart 2.6.

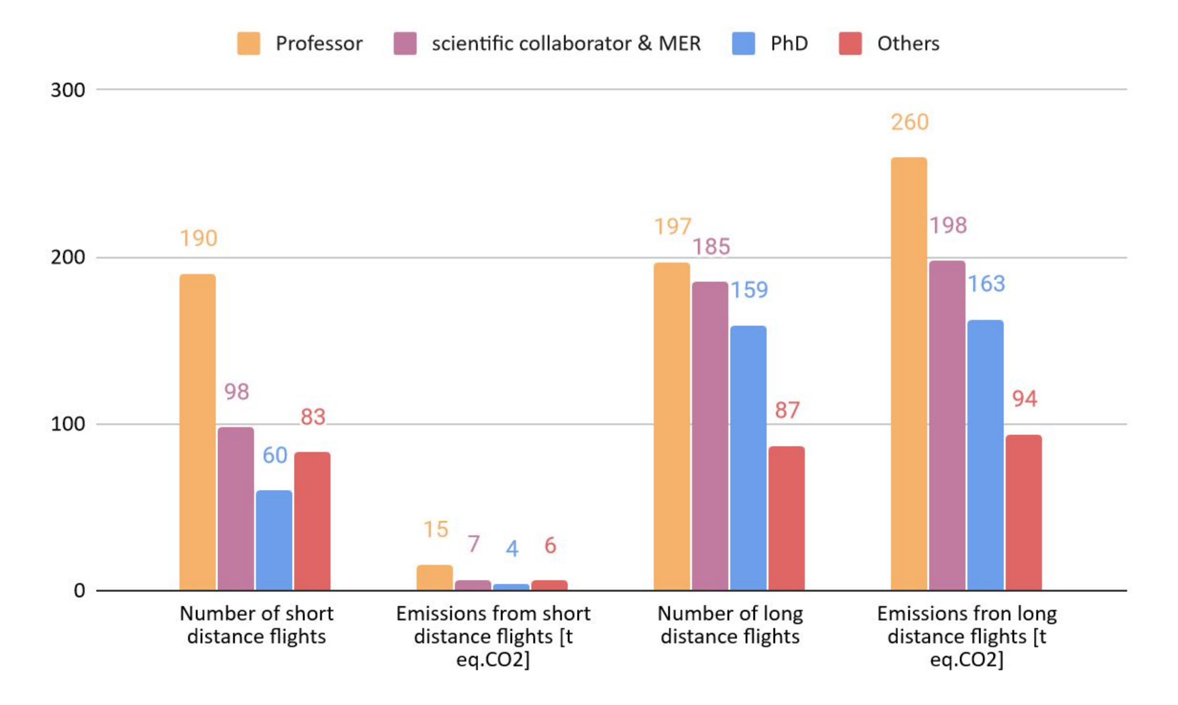
We mention that amongst the most frequented trips remain Geneva-Zürich, Geneva-Frankfurt and Geneva-Paris with a total of 220 trips, where all are very easily accessible by train with a low CO_2 footprint.

In terms of emissions, however, long distance segments of >1600 km represent more than 87% of the total CO_2 footprint. With a total of 714 t eq.CO_2, those trips have a huge impact and need to be reduced. Other transportation alternatives are limited and alternatives such as video participations and meetings need to be considered. All scientific employee levels show similar flight balances compared to the short distance case.

Atmosfair study estimates the reduction potential due to seat classes to about 10% mostly in long distance flights.

The emissions from the laboratories considered in this report, their number of employees per category has been taken from their website and in agreement with their most recent number.

Chart 2.6 Emissions according to Flight Distance



Data

The impact of digital activities is a field that was often not considered in the past, but gains in importance and awareness in the past years. Although we know that on a global perspective, the digital sector is a non-negligible greenhouse gas emitter, with a contribution of 4% to the worldwide CO_2 emissions in 2018 (The Shift Project, 2018), it is difficult to quantify the impact on a lower level.

The electricity consumption of digital devices is included in scope 2. As there are only very few reliable sources of how to quantify the impact of the internet and data transmission in general, we did not include any numbers on the digital impact in our analysis. Nevertheless, we mention some facts that we encountered and stress out the importance of future analysis of this topic.

Consumer goods

In this section, we will explain the methods that have been used to estimate the amount of greenhouse gas emissions due to goods consumption in the van der Goot and Oates laboratories. We mainly worked with the two inventories each laboratory provided us:

- an IT inventory containing essentially computers or screens purchases
- a regular inventory with all the non-IT consumables

For the regular inventories, we decided to focus only on the year 2019 considering that it was representative of a normal consumption year for both laboratories. Conversely, for the IT inventories, we decided to average the results of the past four years (2016 to 2019) as most of the items have a long lifetime (>1 year), and thus the consumption may vary significantly from one year to the next.

To estimate the total carbon footprint caused by the purchase of all the items in the different inventories, we used a bottom-up approach. It consisted in manually labelling each item with its mass and principal material to then compute the carbon footprint of its production and transport, using so-called conversion factors for each material. We will now describe separately the method applied to each inventory. The following explanations hold for both laboratories as the inventories had the same structure and have been processed similarly.

Regular inventories

In 2019, the numbers of purchases in the Oates and van der Goot lab inventories were respectively 354 and 650. By merging the different purchases of identical items, we finally had inventories with respectively 263 and 427 different items. First, we classified all the items in the following different general categories:

- Plastics: Mainly pipettes, tubes, syringes, cell culture plates ...
- Nitrile: Protective and examination single use gloves
- Chemicals: Wide variety of chemical or biological products such as antibodies, proteins, buffer solutions ...
- Electronics/IT: Electronics and IT elements (that have been classified in the regular inventory)
- Metals: Usually small lab equipments
- Organics: Mainly papers, cardboards
- Glass: Glass containers
- Textile: Lab coats

Note that some items could have been classified to multiple categories, however we chose to assign each item to a single category, the one we thought to be the most important in terms of GHG emissions for the particular item.

Chart 2.7 Number of Items per Category

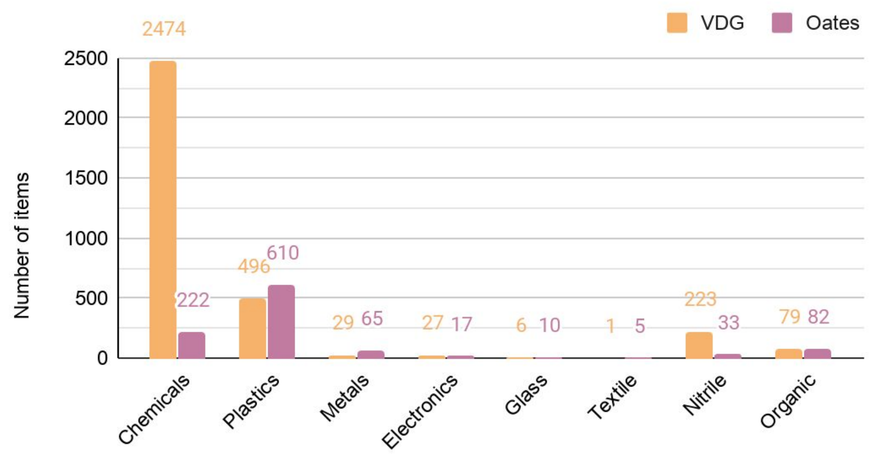
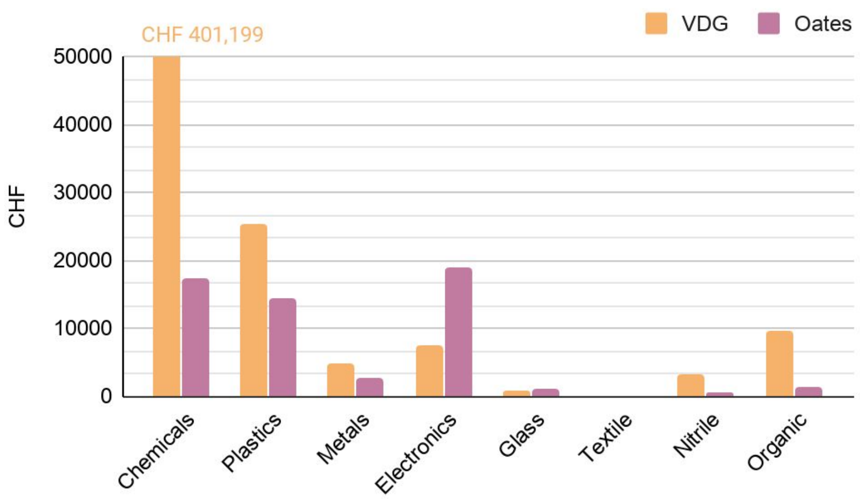


Chart 2.8 Expenses per Category



In Charts 2.7 and 2.8, we can see that the category Chemicals is very important both in terms of number of items and of price fraction. This category is wide and also very heterogeneous as it regroups very different products. We didn't manage to form more meaningful categories for those items for two reasons. First, our lack of knowledge in life science did not allow us to apprehend the items and to have a clear idea on how the products were made and what they were used for. Secondly, almost no data about the environmental impacts of the production of such specific and advanced biological or chemical products was available. This is why we decided to gather everything into this very general category and to use a single conversion factor. Concerning the specific case of antibodies, a life cycle assessment study concluded that producing 2000 L of monoclonal antibody at a concentration of 6g/L emits between 200 and 400 tons of eq.CO_2 throughout the whole process, depending on the production process (Pietrzykowski et al., 2011). However, the volume of purchased antibodies is so small that it resulted in a negligible impact, thus we decided to exclude antibodies from the study.

Let's now detail the method applied to the different categories in order to obtain their contribution to the overall carbon footprint.

Mass method

The mass method was applied to compute the carbon footprint of most of the items. It consists in finding the mass of each item and then to multiply it by the corresponding conversion factor. The different conversion factors used in this study are presented in Table 2.1 along with their source. Thus for each item, the mass and the material had to be found.

Table 2.1 CO_2 Conversion Factors per Raw Material

Material	Conversion factor (kg eq.CO_2/kg)	Source
Polypropylene (Plastic)	3.072	UK BEIS, 2019 - primary material production
Polystyrene (Plastic)	3.777	UK BEIS, 2019 - primary material production
Polyethylene (Plastic)	3.072	UK BEIS, 2019 - primary material production
Polycarbonate (Plastic)	7.870	Ecoinvent - Polycarbonate {GLO}
Average Plastics (Plastic)	3.116	UK BEIS, 2019 - primary material production
Electronics	1.759	UK BEIS, 2019 - WEEE small
Nitrile	2.5	Ecoinvent - Synthetic rubber
Aluminum (Metals)	7.803	Ademe - Aluminium - neuf
Steel	3	UK BEIS, 2019 - primary material production
Chemicals	3	Ecoinvent - Representative value chosen over different chemicals[4]
Paper	0.432	Ecoinvent - Paper newsprint {CH}

The main material composing a product can be found easily on suppliers' websites with the information provided in the inventory. The conversion factor is then chosen according to that main material.

[4] The different values used to build this indicator are the following and are taken from Ecoinvent database: Phenol (3.050 kg eq.CO2/kg), Acetic acid (1.630 kg eq.CO2/kg), Benzyl alcohol (4.080 kg eq.CO2/kg), Sodium (1.980 kg eq.CO2/kg). We finally chose the value of 3 kg eq.CO2/kg as it is an intermediate value. Consequently, the uncertainty about this conversion factor is really large, as numerous products in this category do not correspond to those used to build this indicator.

Concerning the mass, the information was harder to find or estimate. Some suppliers such as Fisher Scientific provide the mass for several products, but it corresponds to what is being sent and thus includes packaging. For numerous items, the mass couldn't be found on supplier's or manufacturer's websites. In this case, we either estimated the mass by taking that of a similar product with known mass, or by guessing it from pictures along with other information we had on the product. Having such limited information on the mass of the items leads to large uncertainties in the analysis.

Price method

Some types of conversion factors are based on the price. They allow you to obtain a result when no more data than the price and the type of item is available. However, these methods are often less precise as it is always better to base the analysis on a physical quantity such as the mass or the volume.

We decided to explore this possibility for the chemicals as it is the most problematic category. Indeed, the mass conversion factor presented in Table 2.1 above may not account for all the diversity of products present in this category. Moreover, estimating the mass of each item was not an easy task either. We decided to use those two price conversion factors[5] for this alternative analysis for the chemical category:

- Biological product (except diagnostic) manufacturing: 0.1464 kg eq.CO_2/ CHF
- Pharmaceutical preparation manufacturing: 0.1791 kg eq.CO_2/ CHF

As before, the antibodies are not taken into account in this alternative analysis.

The application of this method resulted in a significant increase of the carbon footprint of the chemical category compared to the mass method. This phenomenon is particularly important for the van der Goot lab that consumes a lot of expensive but yet small products that were classified in the chemical category. In the end, we decided to use the mass method for all the categories for consistency reasons. However, the results of the analysis using the price method for the chemical category are briefly presented in the appendix of this report.

Price extrapolation

Unfortunately, we were not able to manually label every item with its mass and material as this process was very time consuming. As said before, the mass information, if it existed, was hard to find and not always reliable. This is why we decided to extend the analysis via a price extrapolation. For each category, we have estimated the ratio between the aggregated price of all items within the category and the aggregated price of monitored items. This allowed us to extend the analysis from the studied subsets to the complete inventories. Note that each category was treated independently during the extrapolation, avoiding the introduction of a bias in the analysis that would have been caused by an unbalanced base subset in terms of category content. The amount of manually labelled items with the mass method is at least 75% for each category, also representing more than 60% in terms of price fraction. However, this manipulation still increases the uncertainty on the result.

To summarize, the regular inventories were processed by first classifying each item in one of the above presented categories. Then, a number of items have been manually labeled with their mass and sometimes assigned a more precise material than just the category. Having an item's mass and material conversion factor allows you to compute its carbon footprint by

[5] US input/output database, values provided by Quantis

a simple multiplication. Finally, a price extrapolation based on the labelled items was performed in order to obtain an estimation of the carbon footprint of the complete inventories.

IT inventories

As explained before, the IT inventories are mainly composed of items that last more than one year. Thus, 2019 may not be representative of a normal consumption year of IT products and this is why we decided to take into account the last four years of IT purchases and then to average the result. For this inventory, we did not use the mass method to compute the carbon footprint. Instead we used different categories such as laptops, screens, printers … and had a specific conversion factor for one unit of a given category. This methodology is pretty straight forward thanks to the available data concerning the carbon footprint of widely used IT products. The conversion factors are presented in Table 2.2.

Table 2.2 CO_2 Conversion Factors per IT Appliance

Product	Conversion factor (kg eq.CO_2 / unit)	Source
Office Computer	700	Apple Environmental Report (Mac Pro 2019 and iMac 2017, no consumer use)
Laptop	250	Apple Environmental Report (Macbook pro average on 13''/15'', no consumer use)
Screen 23''	248	Ademe - Screen 23.8"
TV Screen 30-40''	340	Ademe - Television 30-40"
Hive Servers (Oates)	2737	Apple Environmental report (count as three MacPro 2019 no consumer use)
Microscope	60	Ademe - Machine (5.5 kg eq.CO_2/kg) for approximately 11kg microscope
Laser printer	197	Ademe - Imprimante laser
Tablet	82.2	Ademe - Tablette-détachable

However, some important choices in the analysis have to be detailed. For the 2 Acquifer servers installed in the Oates laboratory, we used a conversion factor equal to three times the carbon footprint of a 2019 MacPro as computed by Apple and presented in their Environmental Report (without the consumer use). We think that this hypothesis is conservative, the actual impact could be way more important regarding the high price of the server. However, by taking the average over 4 years, we implicitly considered that those servers had a lifetime of 4 years, or equivalently that 2 of those servers are bought every 4 years. In the end, we considered that the 2 hypotheses on those servers compensate and that the final estimate for their carbon footprint for 1 year is reasonable. Also, for different products, we used an indicator called "Machines" in the Ademe carbon database. It is equal to 5.5 kg eq.CO_2/kg and this indicator is based on an average car production process, i.e. producing a one-ton car emits 5.5 tons of eq.CO_2. We used this indicator for different items for which we did not have more relevant information about their environmental impact. Especially, we used it to approximate the carbon footprint of microscopes. In the analysis, we applied for every microscope, no matter their particular specifications, a conversion factor of 60 kg eq.CO_2 / unit which roughly corresponds to 11 kg times the machine conversion factor of 5.5 kg eq.CO_2 / kg. Finally, we decided to remove from the analysis some IT items, as we had no information at all on the possible impact of those products and we did not want to risk ourselves in an uninformed guess. Those items are listed in the appendix.

Goods' transport

The emissions due to the transport of goods to EPFL have been incorporated in the analysis. They have been calculated by supposing an average travel distance from the supplier's warehouse to EPFL of 200 km, 70% of deliveries done by delivery vans (3.5 to 7.5 tons) and 30% by trucks (16 to 32 tons).

Table 2.3 CO_2 Conversion Factors per Transport Solution

Vehicle type	Emissions (g eq.CO_2/t/km)	Source
Delivery van (3.5 to 7.5 tons)	239	Ecoinvent 3.6
Truck (16 to 32 tons)	163	Ecoinvent 3.6

3. Results

In this section, we will present the results of the analysis, i.e. the GHG emissions induced by the activities of the Oates and VDG labs.
Emissions from Oates lab are first described following the three scopes and in a second part emissions from VDG lab are presented following the same scopes.

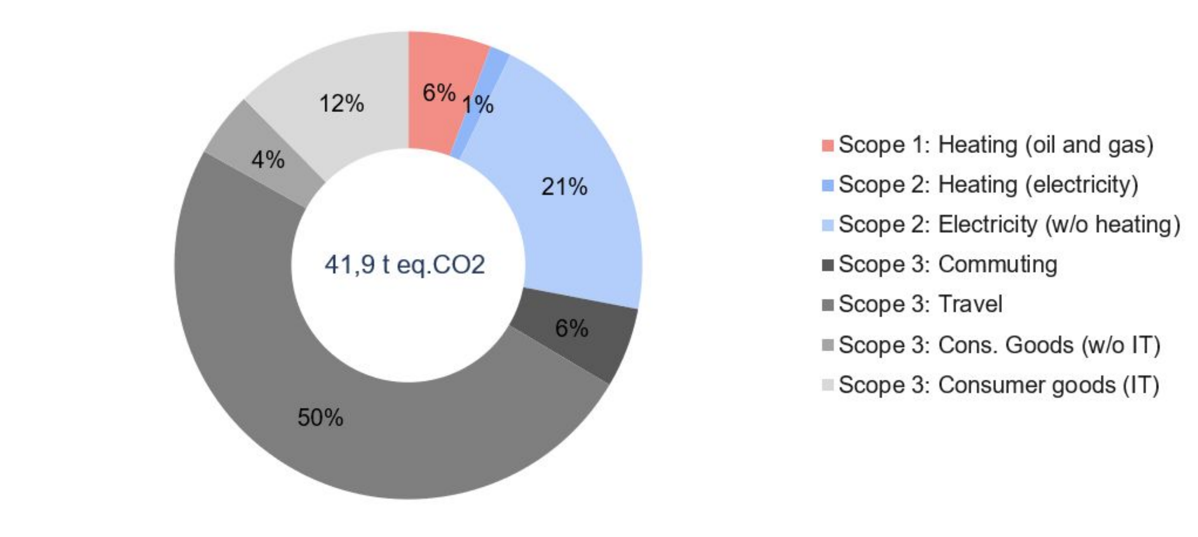
3.1. Oates lab

Overall emissions

Overall annual emissions in Oates lab represent **41,9 t eq.CO_2** (Chart 3.1).

- Scope 1 emissions account for 6% of the total
- Scope 2 emissions for 22%
- Scope 3 emissions for 72%

Chart 3.1 Oates Lab Overall Emissions

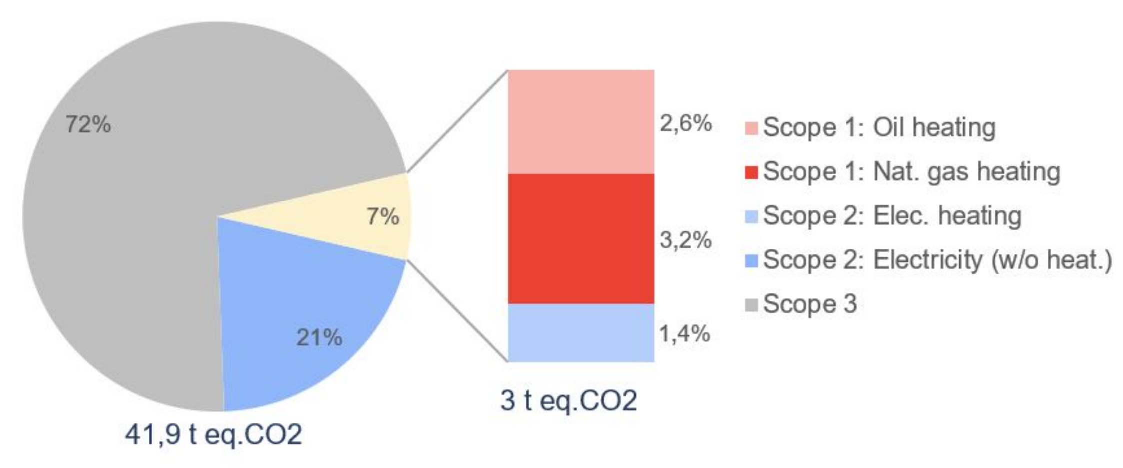


Heating (Scope 1 & 2)

Heating emits **3 t eq.CO_2/yr**, only 7% of total emissions of the Oates lab (Chart 3.2).

Note that even if the heating was done by gas only during three months in 2019, it was responsible for almost half of the emissions due to heating.

Chart 3.2 Oates Lab Emissions - Heating Focus



Electricity excluding heating (Scope 2)

The two estimates we made lead to pretty similar results in terms of energy consumptions, even if the **"in lab" approach turned out to bring rather higher results** (Chart 3.3).

Electricity related emissions excluding heating made out **21% of total emissions** (Chart 3.2), according to the "in lab" approach which will be kept as the reference in this section. The exact estimations we did in this approach can be found in the appendix.

Chart 3.3 Oates Lab Emissions - Electricity Following Two Approaches

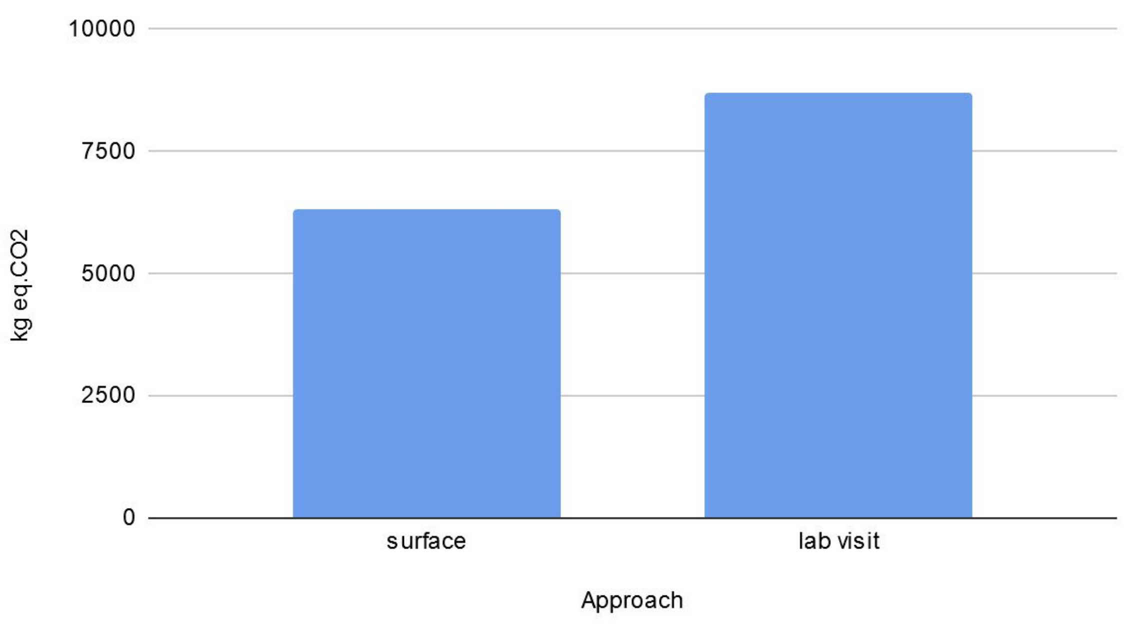
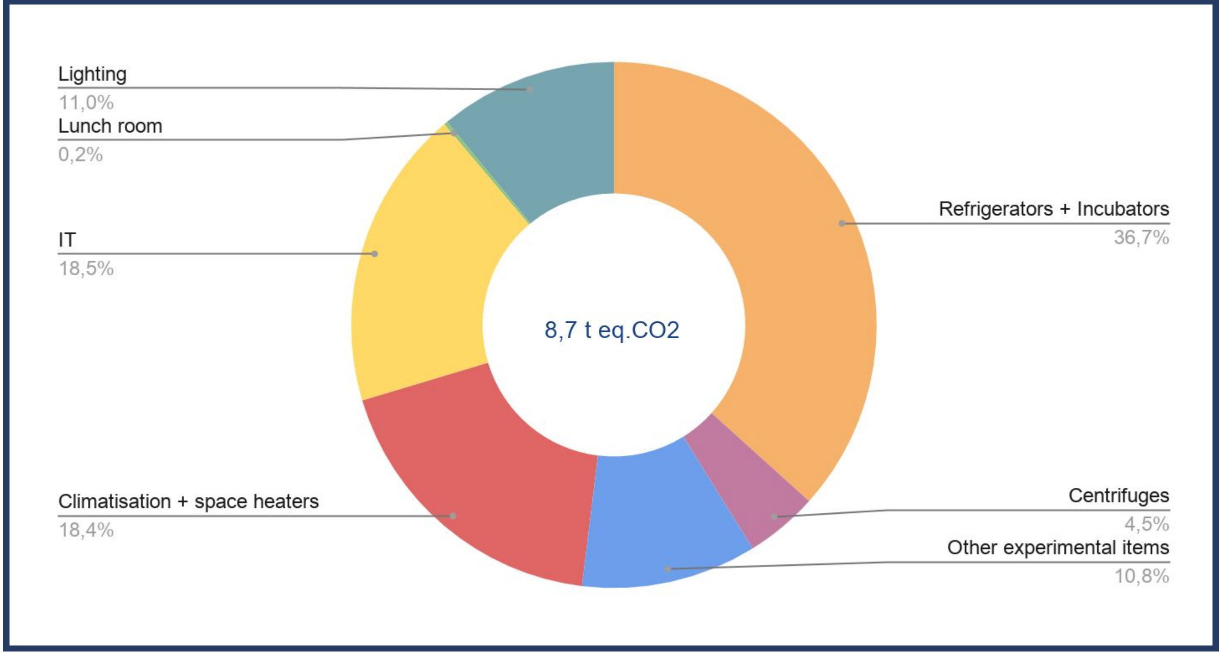


Chart 3.4 below shows the estimated power consumption of the Oates lab in one year distributed in 7 categories. Note that some machines that probably consume a lot of energy were hard to quantify in terms of power. This includes the two large climate control units in the rooms AI 3236 and AI 3235, the server in AI 3236, the microscopes and cameras in AI 3236. Some of them are now not even included in the results.

Note that the lab uses two oil-filled radiators for additional heating during winter, as the central heating control apparently is not doing well enough and it becomes very cold in the rooms. This leads to estimated 1200 kWh of additional power consumption.

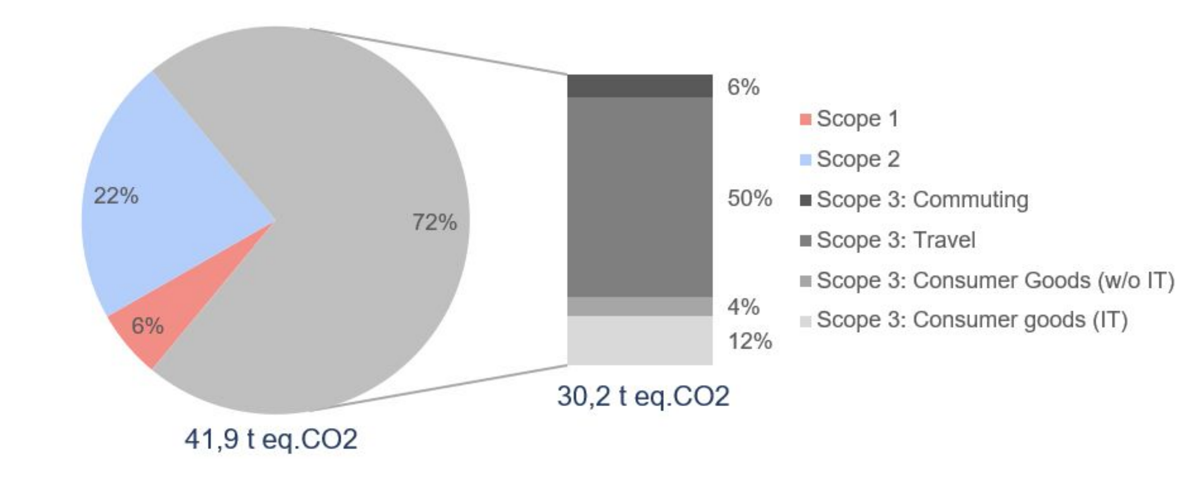
The most consuming items in the lab are the two servers in AI 3236. In 2019, there was only one active including the 2 NAS server systems which leads to an estimated power consumption of about 17 kWh per day. This estimation was done by the company Acquifer who is responsible for hosting the servers. Since December 2019, the second server was installed which now results in a total power consumption of about 24 kWh per day. So, the consumption of IT is even higher in the years after 2019.

Chart 3.4 Oates Lab Emissions - Electricity Consumption Detailed



Other indirect emissions (Scope 3)

Chart 3.5 Oates Lab Emissions - Scope 3 Focus



Scope 3 represents the most significant source of emissions in Oates laboratory, accounting for **30,2 tons eq.CO_2** and 72% of total emissions (Chart 3.5). This shows how crucial it is to integrate indirect emissions in the carbon accounting of research activities.

- Commuting accounts for 6% of total emissions
- Travel for 50%
- Consumer goods for 16%

Travel accounts for almost half of total emissions, consumer goods are another significant emitter although lower, and commuting is the less impactful category of indirect emissions.

Commuting

Due to the daily commuting of the Oates laboratory, **2.3 t eq.CO_2** are emitted per year, which makes 6% of its total emissions, with an estimated travel distance of 37638 km in one year. This result is computed as the average commuting emissions of 9 staff members.

According to the data in the EPFL mobility report, more than 23% of workers go to their jobs by car travelling alone. This represents more than 65% of the Oates laboratory's emissions due to commuting. Public transport is used by 40% of the university staff, almost twice as much as by car, and yet its emissions are a third of those emitted by a car with only one person (509 and 1512 kg eq.CO_2 respectively).

Chart 3.6 Annual Distance & Emissions per Transportation Mode

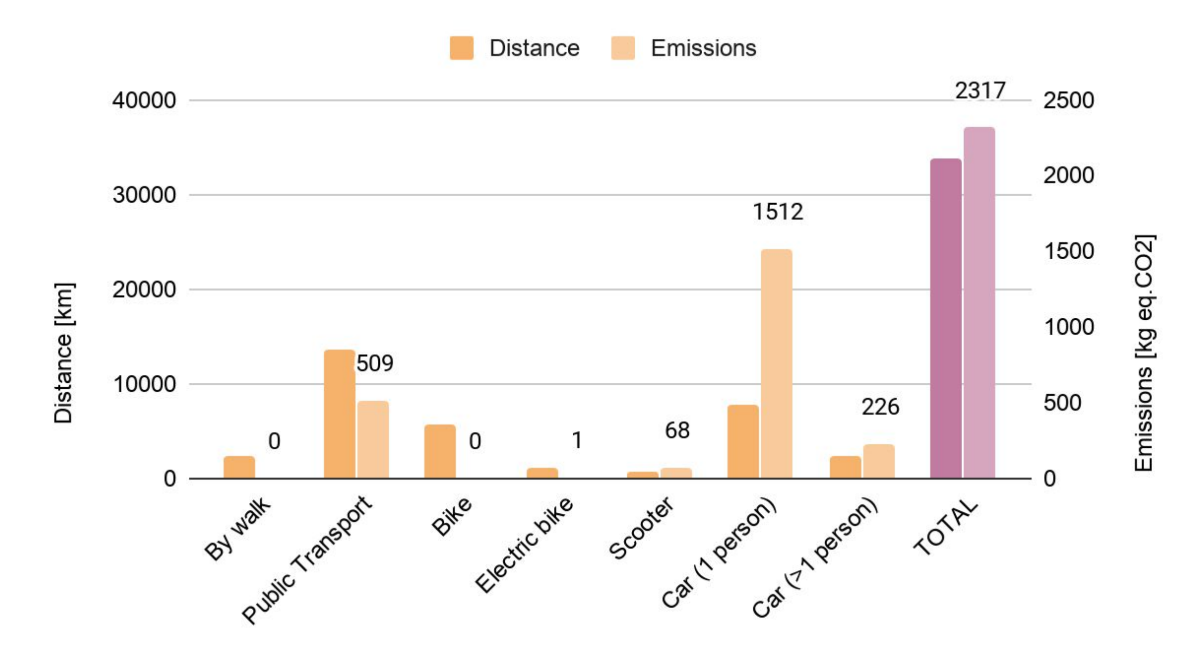
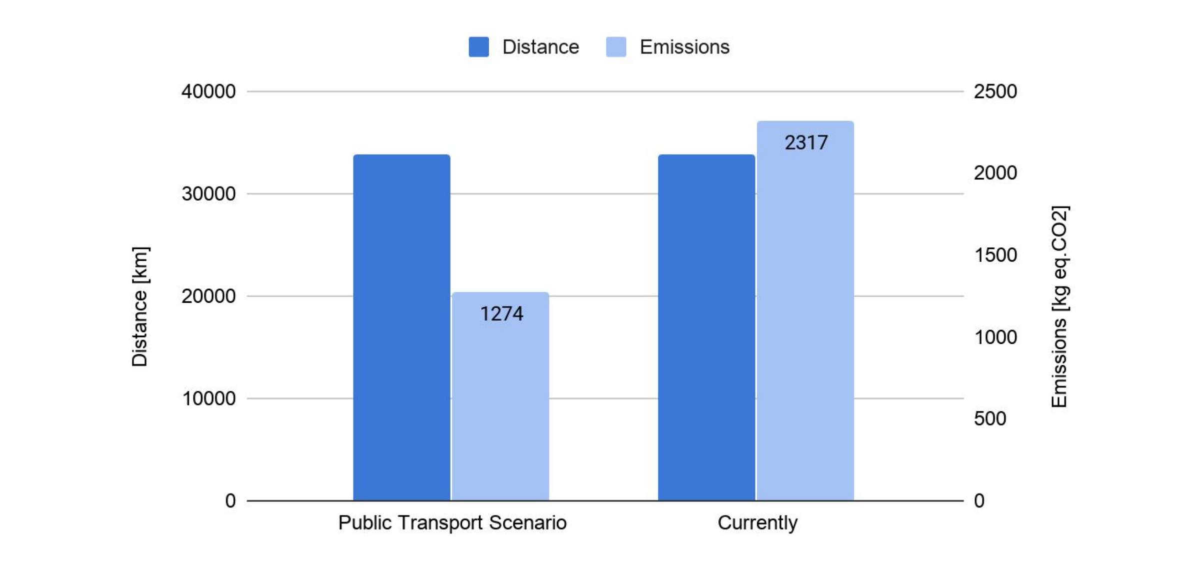


Chart 3.7 compares our estimation to a scenario where the whole commuting is only done by public transportation. This change of behavior could reduce the emissions linked to commuting by 45% without even reducing the days of presence on campus.

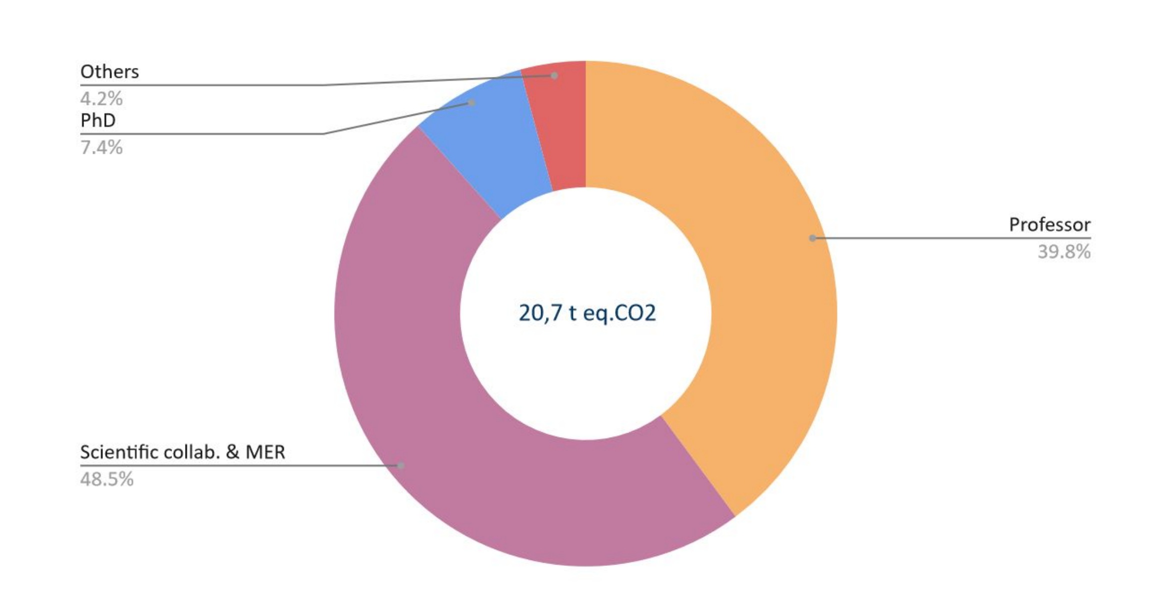
Chart 3.7 Oates Lab Emissions - 2 Commuting Scenarios



Travel

With emissions of **20,7 t eq.CO_2**, business travel is responsible for 50% of the Oates lab's carbon footprint. On average, professors have the most polluting travel behavior of a laboratory.

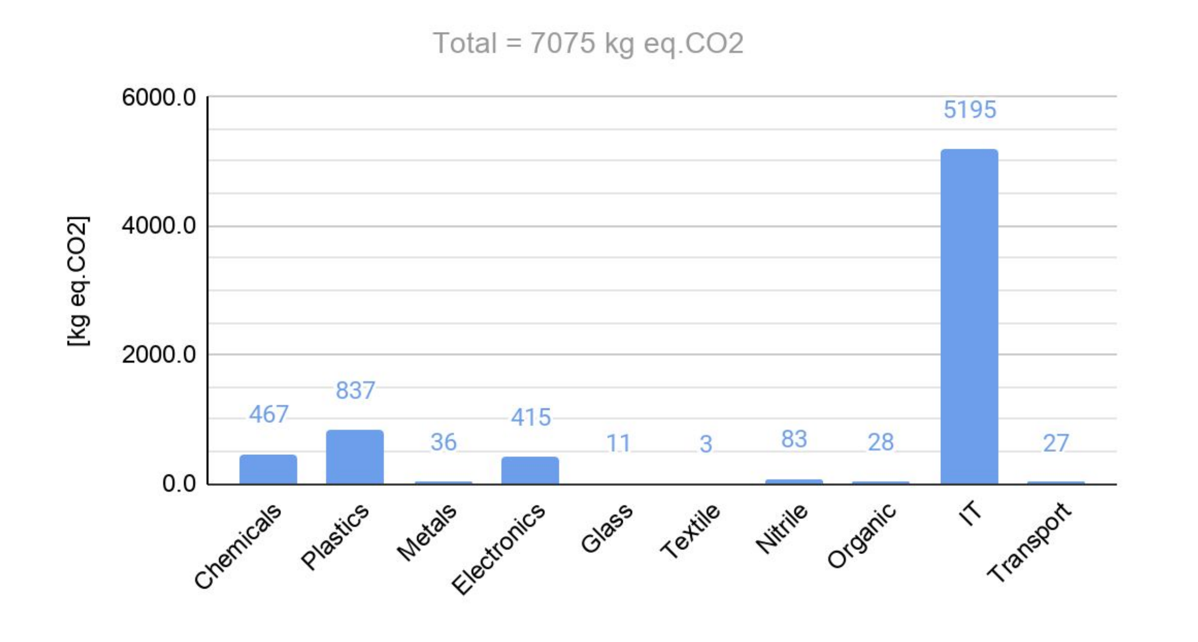
Chart 3.8 Oates Lab Plane Business Travel Emissions



Consumer goods

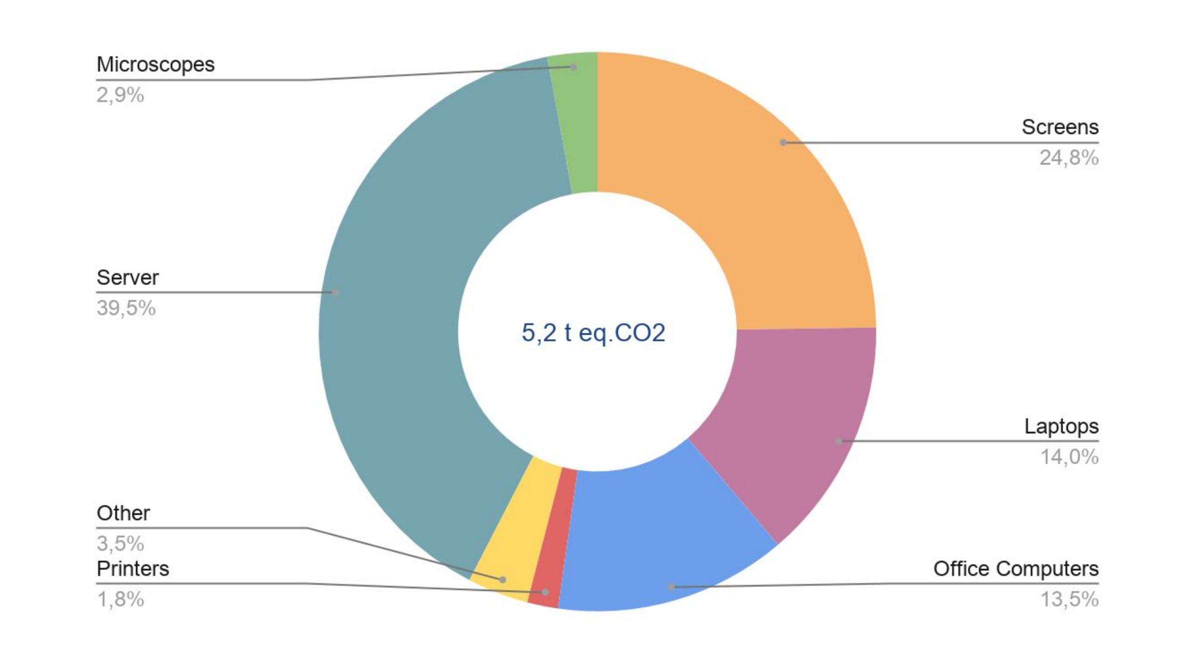
The global warming potential (GWP) caused by the goods consumptions needed for the research activities of the Oates lab is **7 t eq.CO_2** and represents approximately 16% of the lab's total emissions. The details about this contribution are presented in Chart 3.9. One can see that almost 75% of the carbon footprint of this category is caused by the purchase of IT products.

Chart 3.9 Oates Lab Emissions - Consumer Goods Emissions



The details about the IT items are presented in Chart 3.10. One can see that the two Acquifer servers account for 40% of the IT footprint while the rest mainly corresponds to computer and screen purchases. The fact that the servers belong to the lab allows to integrate their environmental impact in the analysis more easily. When data management is externalised as it is the case in the VDG lab, an estimate of the data's environmental impact is harder to build. The plastic consumption also accounts for a non-negligible part of the goods consumption carbon footprint.

Chart 3.10 Oates Lab Emissions - IT Goods Emissions



Data

The Oates lab stores about 100 TB of data on the servers of EPFL, as well as 197 TB on their own hive servers. We didn't determine the impact on the EPFL servers, as they are located in several buildings and thus hard to quantify. Their own servers are included in the electricity part (see above). As this result shows, storing and processing data needs a lot of electricity, which has a non-negligible effect on the carbon footprint. For the storage of the 197 TB on their own servers, taking an estimate of 450 W (which is the estimated power of server and 2 NAS during inactive phase) leads to a power consumption of almost 4 MWh per year and a GWP of 740.22 kg eq.CO_2 per year. This is equivalent to 3.76 kg eq.CO_2 per Terabyte. Hence, the other 100 TB on EPFL's probably lead to additional 300 - 400 kg eq.CO_2. Note that we didn't include this number into the report as the estimate is very hard to verify, but still it shows the order of impact of the digital.

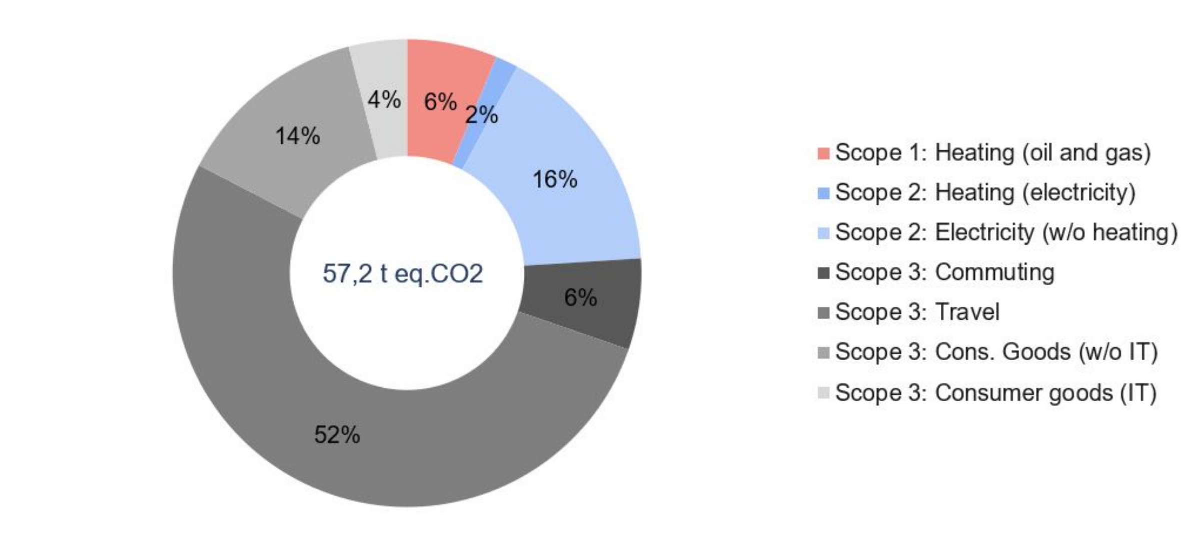
3.2. Van der Goot lab

Overall Emissions

Overall annual emissions in van der Goot lab represent **57,2 t eq.CO_2** (Chart 3.11).

- Scope 1 emissions account for 6% of the total
- Scope 2 emissions for 18%
- Scope 3 emissions for 76%

Chart 3.11 VDG Lab Overall Emissions

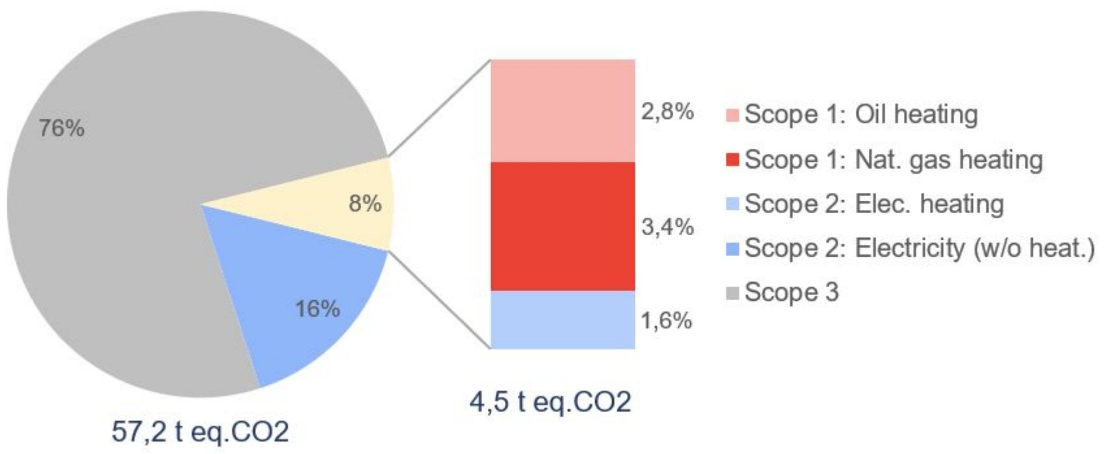


Heating (Scope 1 & 2)

Heating emits **4.5 t eq.CO_2/yr**, only 8% of total emissions of the VDG lab (Chart 3.12).

Note that even if the heating was done by gas only for three months in 2019, it was responsible for almost half of the emissions due to heating.

Chart 3.12 VDG Lab Emissions - Heating Focus



Electricity excluding heating (Scope 2)

For the VDG lab, the result of our two approaches to quantify the power consumption lead to pretty similar results (Chart 3.13). The power consumption without heating emits **9.3 t eq.CO_2/yr**, which makes 16% of the total emissions of the VDG lab. The exact estimations we did in the lab visit approach can be found in the appendix.

Chart 3.13 VDG Lab Emissions - Electricity Following Two Approaches

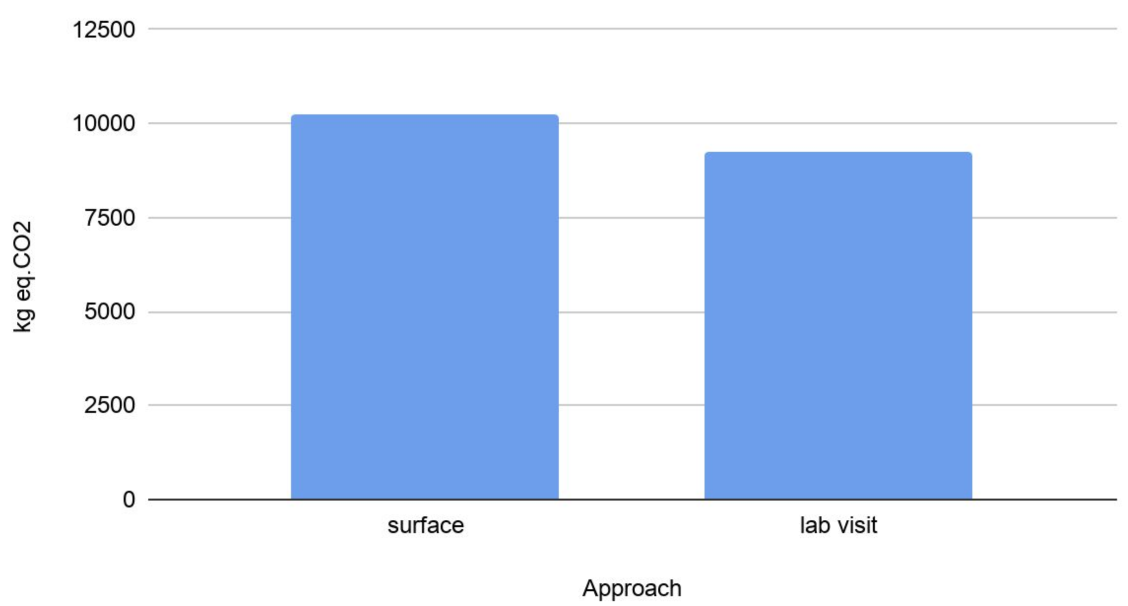
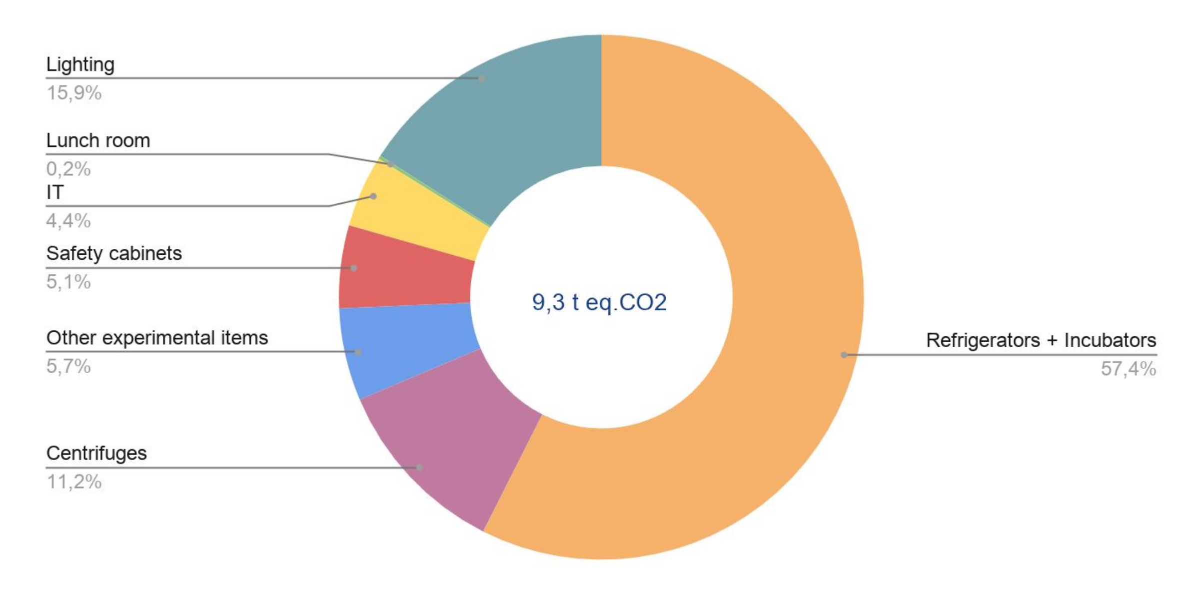


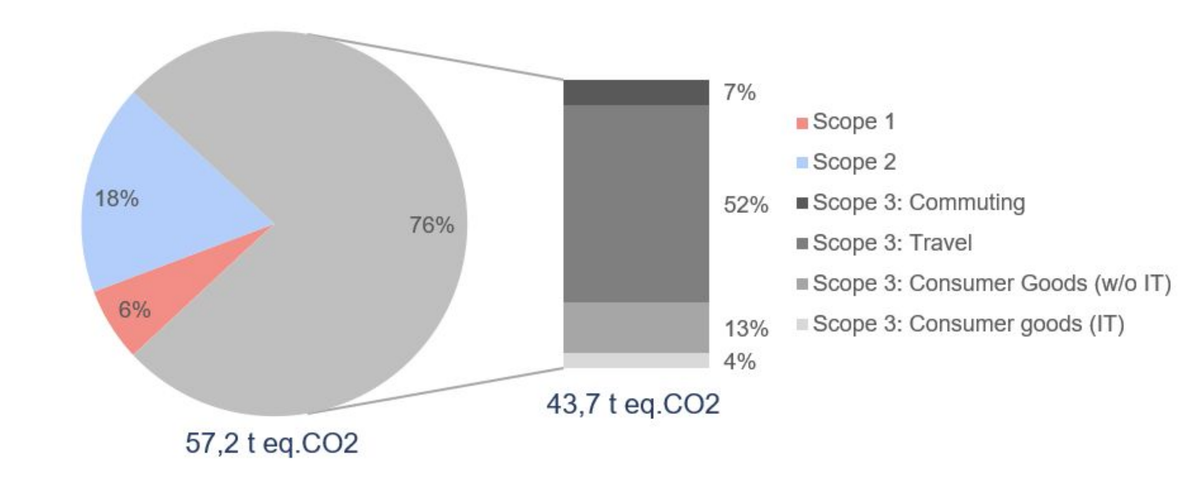
Chart 3.14 shows the electricity consumption divided into seven categories. By far the highest power consumers seem to be freezers, refrigerators and incubators, also because there are 34 items that fall into this category. Note that their consumption is probably even underestimated, as we used the impact of modern models as a reference for our estimation.

Chart 3.14 VDG Lab Emissions - Electricity Consumption Detailed



Other indirect emissions (Scope 3)

Chart 3.15 VDG Lab Emissions - Scope 3 Focus



Scope 3 are the most significant sources of emissions in the VDG laboratory, accounting for **43.7 tons eq.CO_2** and 76% of total emissions (Chart 3.15). This shows how crucial it is to integrate indirect emissions in the carbon accounting of research activities.

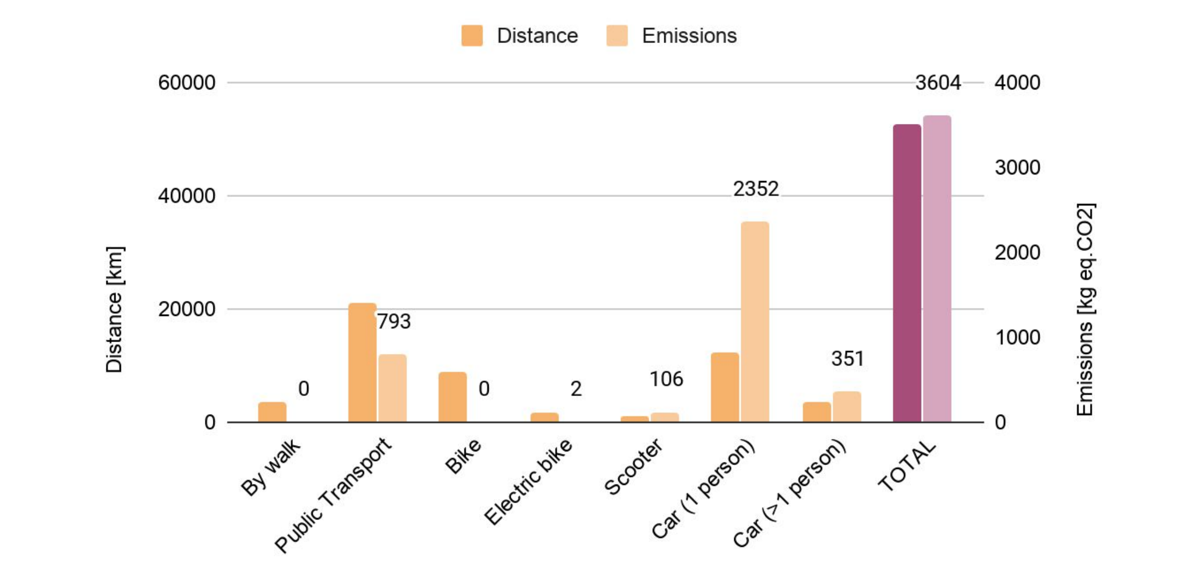
- Commuting accounts for 7% of total emissions
- Travel for 52%
- Consumer goods for 17%

Travel accounts for almost half of total emissions, consumer goods are another significant emitter although lower, and commuting is the least impactful category of indirect emissions.

Commuting

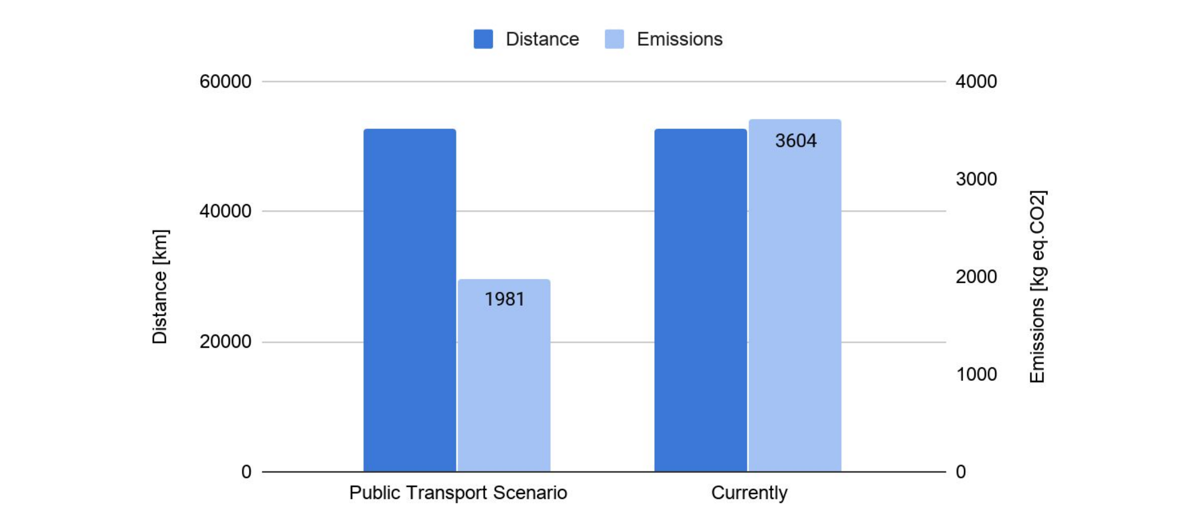
The everyday transportation of the VDG lab creates emissions of **3.6 t eq.CO_2**, which is 7% of the total emissions. This result we get in computing the average commuting emissions of 14 staff members. As shown in Chart 3.16, the transfers made by cars with only one person are those that emit the most emissions, reaching 65% of the emissions but only 23% of the kilometers traveled. On the contrary, public transport is the means of transport with the most kilometres, almost 40%, but it emits only 22% of the emissions linked to the VDG laboratory's commute.

Chart 3.16 Annual Distance & Emissions per Transportation Mode



As for the other laboratory, we have analysed the scenario in which all the workers of the VDG lab commute by public transport (Chart 3.17). We can see that by changing the means of transport to public transport we can reduce 1623 kg eq.CO_2 which represents a reduction of 45% of the emissions linked to the daily transport of the workers.

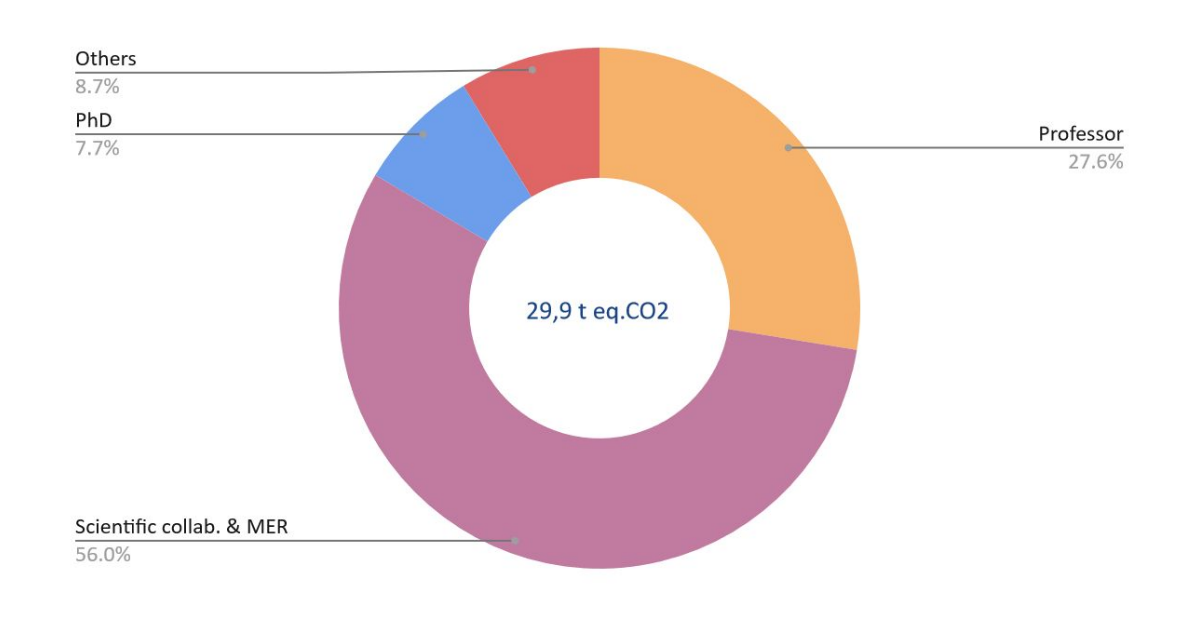
Chart 3.17 VDG Lab Emissions - 2 Commuting Scenarios



Travel

Being the most emitting category, business travel is responsible for **29.9 t eq.CO_2**, which is more than half of the total emissions. On average, professors emit clearly the most per person, the lower the position, the lower the emissions.

Chart 3.18 VDG Lab Travel Emissions



Consumer goods

The contribution of goods consumptions to the total carbon footprint of the van der Got lab is of approximately 10 t eq.CO_2 and corresponds to 17% of the total. One can see in Chart 3.19 that it is the chemical and plastic purchases that contribute the most to the carbon footprint with approximately 3 tons each of eq.CO_2. As explained before, the uncertainty about the environmental impact of the "Chemicals" category is large. IT products account for almost one fourth of the total emission of goods consumption. The IT impact is detailed in Chart 3.20 and one can see that the majority of the emissions comes from the computer, screens and laptops purchases. The “Other” category stands for different machines inside the IT inventory. The contribution of the gloves consumption (Nitrile) is also significant in terms of CO2 emissions. The impact of goods transport to EPFL appears to be negligible, but this result is largely determined by the assumptions made to get that number.

Chart 3.19 VDG Lab Emissions - Consumer Goods Emissions

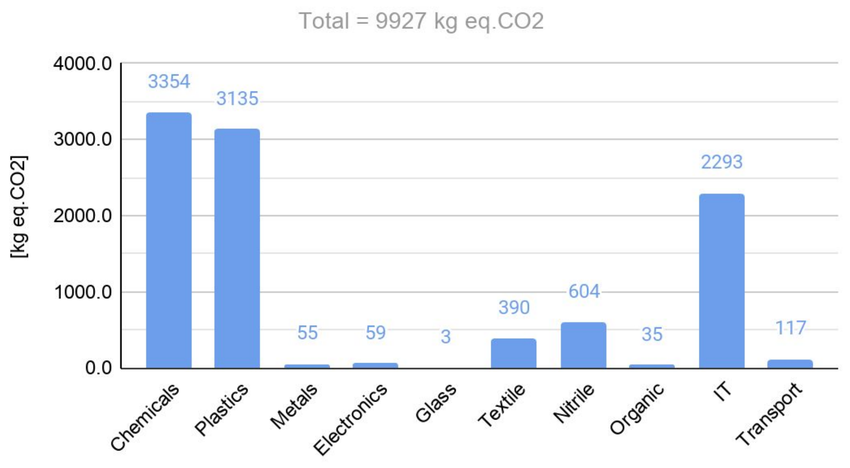
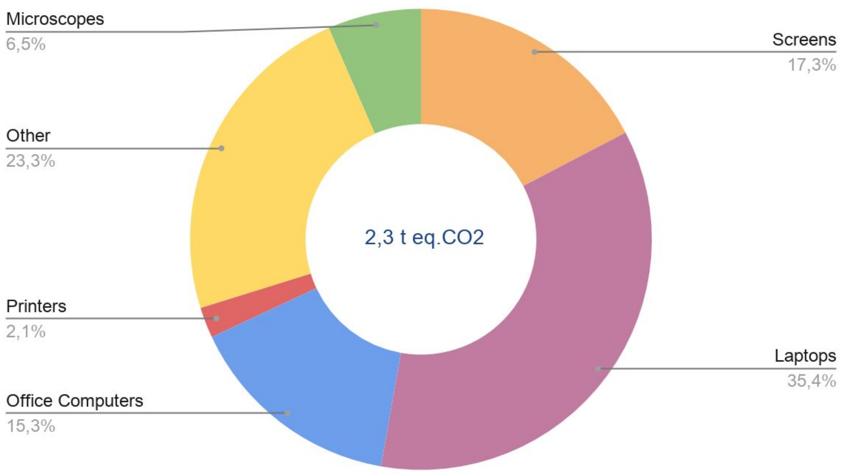


Chart 3.20 VDG Lab Emissions - IT Goods Emissions



Data

The lab stores 13 TB of data on the servers of EPFL. We didn’t determine the impact of the EPFL servers, as they are located in several buildings and thus hard to quantify. As the rough estimate we made in the section DATA result for the Oates lab implies (3.76 kg eq.CO_2 per stored TB per year), the impact of the stored data of the VDG lab may lay around 50 kg eq.CO_2 and thus be negligible compared to the rest of our results.

4. Discussion

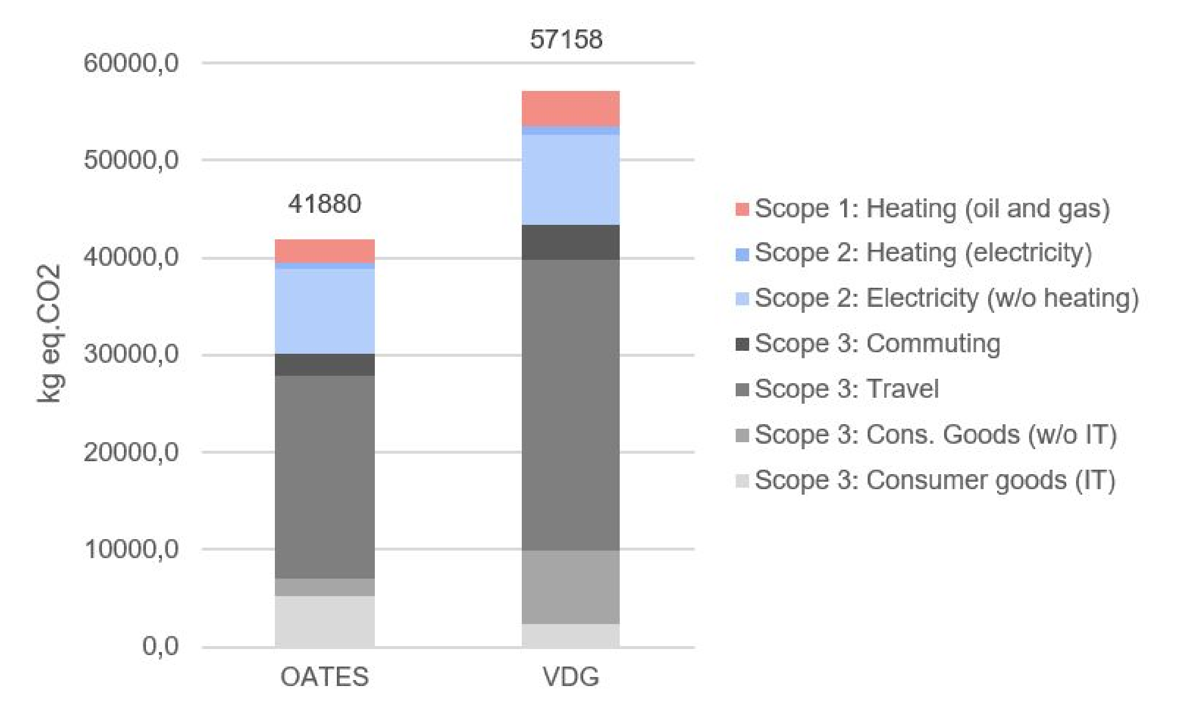
We would like to highlight four elements in the discussion:

- A comparison of results between both laboratories
- An analysis of results' compliance with global CO_2 emissions goals
- A set of recommendations to start mitigating emissions in laboratories
- Propositions for future methodology improvements

4.1. Comparison

Chart 4.1 compares the GHG emissions of the two investigated laboratories. Considering that in the Oates lab work 9 people and in the VDG lab 14, this results in a carbon footprint per person of 4.7 t eq.CO_2 and 4.1 t eq.CO_2 respectively. The differences we found are mainly explained by the fact that the Oates lab runs their own servers, which has a big impact on consumer goods (IT) and also the electricity consumption. But also other facts as the climatisation of two rooms in the Oates lab create a larger power consumption. Furthermore, as a main part of our analysis was based on simplifications depending on the number of employees, potential significant differences between the labs, for example in business travel, may have stayed undetected.

Chart 4.1 Overall emissions in Oates and VDG labs



4.2. Compliance with global goals

Our study has confirmed that the two investigated laboratories have a significant carbon footprint. Comparing our results to the average footprint per person in Switzerland which is 14 t eq.CO_2/year, the workers emit more than a fourth of their personal emission for the work in the laboratory. And even the average Swiss carbon footprint is really high, the global average per person is about 6 t eq.CO_2/year. Knowing that the planetary limit is below 1 t eq.CO_2 per capita and the goal of the Paris Agreement is net zero emissions, it is obvious that there is a big need for reduction in the laboratories as well[6]. For this reason we present some possibilities to reduce the impact of the labs in the following section, based on the findings of our study.

[6] https://www.bafu.admin.ch/bafu/en/home/topics/climate/in-brief.html

4.3. Recommendations

Scope 1 - Direct emissions

Direct emissions on site for the purpose of the two analyzed labs are only emitted by the heating system. As described in the methodology part of the report, EPFL is currently renewing this system such that by 2022 the heating will be done almost completely by heat pumps, hence electricity. This means that the emissions for this category will become even smaller, and scope 1 will almost entirely disappear without any change for the laboratories.

Scope 2 - Indirect emissions from electricity

For the **heating**, the laboratories have only little impact on the emissions. Good guidelines are not to use space heaters because they are very inefficient.

On the other hand, **electricity** is surprisingly more significant and responsible for about 20% of the laboratories' emissions. One first leverage to reduce the climate impact of electricity would be to improve the electricity mix, which depends mostly on the Swiss policy and therefore not on laboratories directly.

On the side of laboratories, reducing the power consumption is therefore playing a bigger role than one may think. It is thus important to buy the most efficient machines, share them between laboratories when possible, and maintain them carefully. A guide for efficient maintenance of freezers proposed by the University of Pennsylvania[7] could be a good starting reference for EPFL laboratories. Moreover, daily actions such as turning off the equipment that is currently not in use and closing windows are significantly beneficial, especially during nights and weekends.

Scope 3 - Other indirect emissions

Our study shows that the carbon footprint of both laboratories is dominated by the emissions of **business travel**. This means that there is the biggest potential and also need for reduction. Hence, only travel when necessary, and if train is an option, take it. If a flight is inevitable, book it in economy class preferably, and without multiple connections. More information and recommendations are provided by the project *Travel less without loss*[8] of the SV faculty.

Although compared to other fields, the **commuting** may seem a section of little weight or relevance, we must highlight the ease of acting on it. Considering the scenarios in Charts 3.7 and 3.17 assuming that the entire laboratory travels by public transport, we could reduce the emissions linked to commuting by 45% compared to EPFL's average. Obviously, this number can be reduced more if there are less presence days on campus.

Concerning the **goods consumption**, the main recommendation is to follow the "Reduce, Reuse, Recycle" principles.

---

[7] Green Labs Guide at UPenn: https://www.sustainability.upenn.edu/sites/default/files/Green%20Labs%20Guide_UpdatedSummer2020_v2.pdf

[8] Travel Less Without Loss guidelines: https://www.epfl.ch/schools/sv/wp-content/uploads/2020/03/TLWL_recommandations_EN.pdf

An example of reduction concerns IT products which contribute significantly to the carbon footprint of purchased goods. A solution would be to avoid buying new computers or screens too often and to try to keep older ones for a longer time. To reduce the purchase of chemical products, the MIT's Green Chemical Alternative Purchasing Wizard[9] enables researchers to identify which alternative chemical product could be easily found in close laboratories instead of buying a new one.

An interesting practice of reuse consists in organizing days during which laboratories can sell and purchase internally their equipment and tools no longer useful. This enables economical and ecological gains, and promotes exchange among the community.

Finally, if the faculty wants to reach climate-neutrality, a regenerative design of its supply chain should be developed through recycling. Recycling single-use products should be implemented. Star-Lab is proposing a solution in Switzerland to recycle pipette tip racks, but they don't recycle tips themselves. Moreover, solvents could be recycled as well, and we encourage the School to pursue its projects in that direction.

Even though we didn't include the storage and exchange of **data** into our carbon footprint analysis, it is important to be aware of this topic. The internet usage, especially with large amounts of data such as videos or high quality images, has a non-negligible impact as it consumes a big and growing amount of energy. Thus, it is reasonable to reduce the transfers of large data. This could possibly include deleting stale data that is not used anymore from servers or clouds and only sending such data across the internet when really necessary. Some companies provide sustainable web services such as Infomaniak, thus mandating data management to an efficient and low-carbon operator is recommended.

4.4. Future methodology improvements

Heating

The heating done by the system per building is rather simple to quantify and our results concerning this are probably quite precise as it is reasonable to assume that the whole building is heated to a similar temperature. A more sophisticated approach would not consider the room's surface but its volume. On the other hand, we did not include our estimations for special rooms that need a very stable temperature, as the ones in the Oates lab, into the heating part, but rather into the electricity part. This is due to the imprecision of the estimation which follows the same methodology as the electricity.

Electricity

Our estimation of the electricity consumption was based on a multiplication of the maximum power of each machine by its approximate time of use per week. To develop a more precise analysis of the consumption, it would be interesting to identify the real-time consumption profile of these devices. To do so, meters should be connected to all machines in the laboratories, especially those with an irregular use. This monitoring approach has proved to be efficient in other institutes where the consumption of hoods and lighting declined after installing meters with a real-time display. This could also show scientists the difference between a freezer well managed and one with ice frost inside. At a wider scale, meters should be installed permanently to understand which zone of the building consumes more.

[9] Link to MIT's green chemistry webpage: https://greenlab.mit.edu/chemistry

Business travel

Our results revealed that business travel is the category that emits the most greenhouse gases. But as we didn't have access to the actual traveling behaviour of the labs but only to the numbers of the whole faculty, our results are very imprecise and do not take into account if a laboratory makes an effort towards less business travel or not at all. It is thus crucial to collect the precise data and analyze it in a detailed manner, a task that can also be done by the labs themselves.

Commuting

Similar to the business travel part, we based our results of commuting on averages over the whole EPFL community. A small survey with the staff of the laboratories would help to get results that are more precise and more informative. But as commuting only produces a small share of the carbon footprint (around 6%) in both laboratories, it's not a category to prioritize in further studies.

Consumer goods

As said before, the uncertainties of our results for the consumer goods impact in terms of GHG emissions is large. One way to reduce this uncertainty would be to engage a dialogue with the suppliers so that they could provide reliable information about the environmental impact of their products in the future. In this way, the labs would be able to choose the products that fit their needs with the least environmental impact.

5. Conclusion

The first project of Zero Emission Group's consulting pole aimed to lay a foundation for laboratories to investigate their carbon footprint. Although EPFL already provides GHG emissions of the whole campus, we started bottom-up to look closer into research activities. The two laboratories Oates lab and van der Goot lab let us investigate their work and impact over the year 2019 to have a better knowledge of where to reduce GHG emissions.

We found the total emissions in 2019 of the Oates lab and the VDG lab to be 41,9 t eq.CO_2 and 57,2 t eq.CO_2 respectively. Per employee this makes 4.7 t eq.CO_2 and 4.1 t eq.CO_2 respectively. To face the climate crisis, the emissions per person for both their private and professional activities must go below 1 t eq.CO_2. This comparison with the global goal of carbon neutrality, as decided in the Paris Agreement in 2015, shows the huge effort needed in the years to come. For this reason, we propose some measures to reduce the carbon impact of research laboratories.

By far the biggest carbon footprint is the category of business travel, which we found to be responsible for about half of the emissions. Especially air travel has a huge impact and therefore represents the biggest potential for reduction. Following the guidelines of the project "Travel less without loss" by the SV faculty is highly encouraged and would be a great step towards a climate-friendly laboratory.

Electricity consumption emits 15 - 20% of the total emissions considering the GWP of the Swiss electricity grid. As a category that is often forgotten, our results show that reducing power consumption has an important impact on the carbon footprint. The third highly emitting category in both laboratories are consumable goods, an aspect that hasn't been analyzed at EPFL up to now. Even though the method provided in this study has certain significant uncertainties, it shows nevertheless that the consumption is responsible for over 15% of the total. We provide incentive to investigate this topic further in future studies.

To conclude, this analysis indicates a significantly high carbon footprint of research laboratories at EPFL. We encourage all EPFL's research entities to take a position, investigate their environmental impact furtherly and implement our recommendations towards climate-compatible research.

6. References

Ademe: Base Carbone. Available at: https://www.bilans-ges.ademe.fr/

Apple: [Environmental reports for several products]. Available at: https://www.apple.com/environment/

European Network of Transmission System Operators for Electricity (ENTSO-E) (2020): Powerfacts Europe, 2019. Available at: https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/Publications/ENTSO-E%20general%20publications/ENTSO-E_PowerFacts_2019.pdf

Mobitool (2016): Umweltdaten & Emissionsfaktoren von Mobitool: Treibhauspotential (v2.0.2). Available at: https://www.mobitool.ch/de/info/mobitool-faktoren_0-29.html

Pietrzykowski, M., et al. (2011): An environmental life cycle assessment comparing single-use and conventional process technology. BioPharm Int 24.S11 : 30-38.

The Shift Project (2018): Lean ICT - Pour une sobriété numérique. Available at: https://theshiftproject.org/wp-content/uploads/2018/11/Rapport-final-v8-WEB.pdf

UK Department for Business, Energy and Industrial Strategy (BEIS) (2019): UK Government GHG Conversion Factors for Company Reporting 2019 (v1.0). Available at: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

Vuarnoz, D., & Moreno, S.A. (2020): Dataset concerning the hourly conversion factors for the cumulative energy demand and its non-renewable part, and hourly GHG emission factors of the Swiss mix during a one-year period (2016 and 2017). doi:10.1016/j.dib.2020.105509

Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., & Weidema, B. (2016): The **ecoinvent** database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp.1218–1230. Available at: http://link.springer.com/10.1007/s11367-016-1087-8

7. Appendices

7.1. Electricity estimate, laboratory visit approach

Table 7.1 Oates Lab - Electricity Consumption by Item

Utility Type	Utility Type	Power [W]	Hours of use per day [h]	Days per week	Nb. of items	Energy consumption per year [kWh]
Refrigerants/Incubators						
	Liebherr small 5°C	80	2	7	3	985.5
	Liebherr small -25°	100	10	7	4	1351.96
	cooling chamber	140	14	7	5	3567.2
	Liebherr large 5°	130		7	1	492.75
	Kochkälte 33° and 19° incubators	275	14	7	2	2802.8
	Binder 28°	700	12	7	1	3057.6
	Liebherr large -25°	140			2	2489.3
	Julabo F25	130	24	7	2	2271.36
Centrifuges						
	Centrifuge eppendorf 5417R	700	1	5	2	364
	Biometra Tadvanced	580	1	5	8	1206.4
	Centrifuge eppendorf 5810R	1650	1	5	1	429
	Microcentrifuge	100	1	5	3	78
Other experimental items						
	Azure biosystems C200	60.65217391	10	7	2	441.5478261
	E-Gel Imager	40	1	5	1	10.4
	Leica microscope	100	1	5	1	26
	Thermomixer	100	1	5	3	78
	Fischer Scientific	240	1	5	2	124.8
	Model P-97	370	1	5	1	96.2
	Milli-Q Advantage A10	50	24	7	1	436.8
	Large microscope	100	1	5	2	52
	Viventis LS1 live	100	2	5	1	52
	Labgene	600	1	5	5	780
Safty cabinets						
	Nuaire Biological Safety cabinets Chapelle toxique	1600	5	7	1	2912
Climatisation and heating						
	2 large climatisers for 16.5 m2		24	7	2	7300
	2 small oil-filled radiators	1500	8	1	2	1248
IT						
	computers + screen A 24 zoll	120	8	5	5	1248
	screens	20	2	5	14	145.6
	laptops	50	8	5	10	1040
	printer small	7.53125	8	5	1	15.665
	CyberPower PR 1500W + Nas (below	700	24	7	1	6115.2
	Acquifer NAS storage 297TB					
Cafet						
	coffee machine	1000	1	5	0.1	26
	Micro wave	1100	1	5	0.1	28.6
	Fridge				0.100	49.275
Lighting						
	Lights				1	5085.69
			TOTAL		**75.30**	**46407.65**

Table 7.2 VDG Lab - Electricity Consumption by Item

Utility Type	Utility Type	Power [W]	Hours of use per day [h]	Days per week	Nb. of items	Energy consumption per year [kWh]
Refrigerants/Incubators	Thermo electron corporation	316	24	7	1	2760.576
	Cryocube FC660h	337.5	24	7	1	2948.4
	Liebherr profiline 4°C small	80		7	7	2299.5
	Liebherr profiline -20°C small	100		7	6	2027.94
	Liebherr profiline -5°	150	24	7	0	0
	cooling chamber	140	14	7	5	3567.2
	Liebherr ProfiLine -21° large	140		7	9	1244.65
	HERA cell 240 90°	640	12	7	3	8386.56
	HERA cell 150 90°	580	12	7	2	5066.88
Centrifugeuse						
	Centrifuge eppendorf 5417R	700	2	5	4	1456
	Eppendorf 5424 R	350	2	5	8	1456
	labofuge 400r heraeus	500	2	5	9	2340
	Labnet PrismR	500	2	5	1	260
Other experimental items						
	Thermo scientific Precision SWB 15	2200	2	5	2	2288
	Small rotators and other lab table items	100	2	5	10	520
Safty cabinets						
	Nuaire Biological Safety Cabinets Class II	1610	1.5	5	3	1883.7
	Safeflow 0.9	1610	1.5	5	1	627.9
IT						
computers	std laptop with mouse	50	8	5	15	1560
screen A 24 zoll	Screen	20	8	5	15	624
Cafet						
	coffee machine	1000	1	5	0.1	26
	Micro wave	1100	1	5	0.1	28.6
	Fridge				0.100	49.275
Lighting						
	Lights				1	7854.32
			TOTAL		**103.30**	**49275.50**

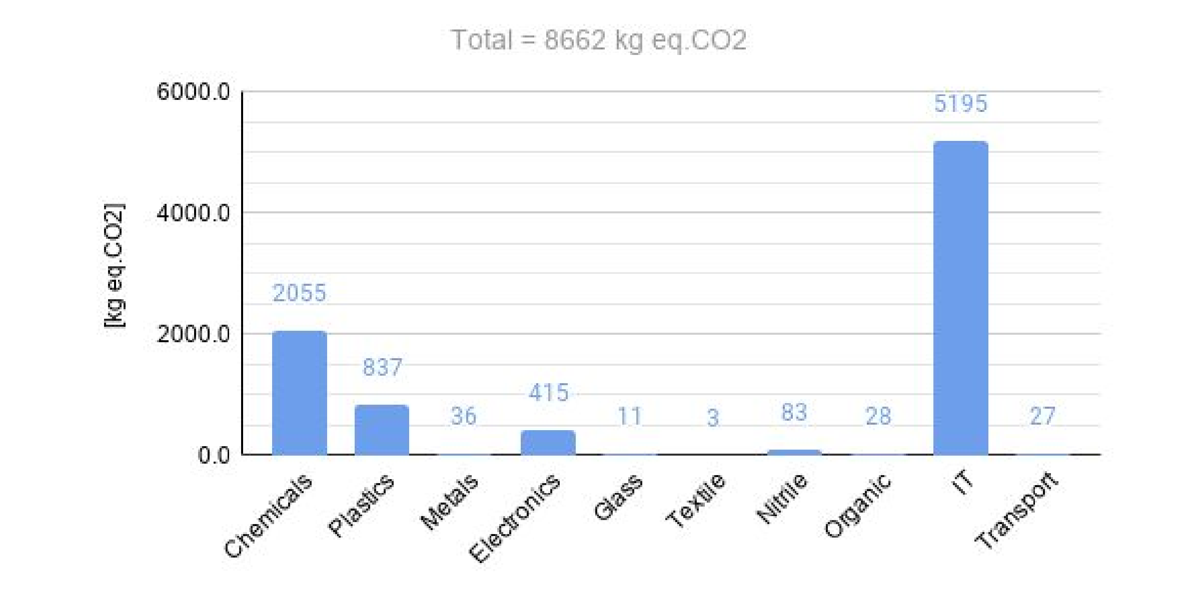
7.2. Consumer goods - Results using the price method for the "Chemicals" category

As explained in the consumer goods methodology part, different techniques were tried to analyse the "Chemical" category. Here we will present the results for both labs when using price conversion factors. We took the smaller of those two numbers.

- Biological product (except diagnostic) manufacturing: 0.1464 kg eq.CO2/ CHF
- Pharmaceutical preparation manufacturing: 0.1791 kg eq.CO2/ CHF

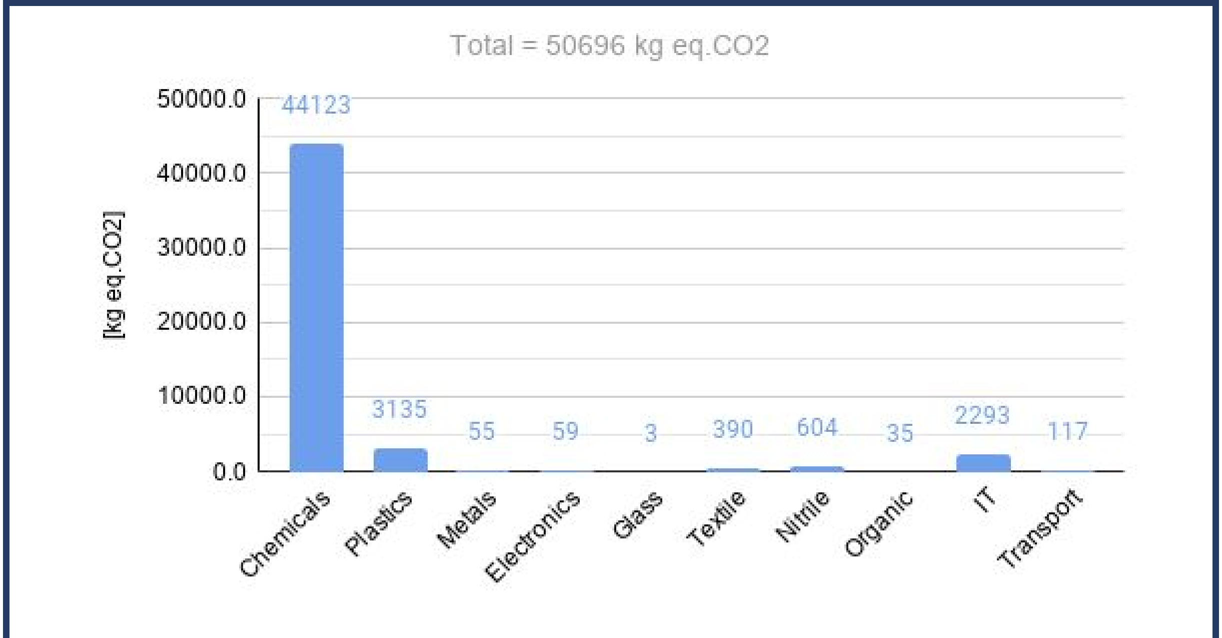
For the Oates lab, we observe that when using the price method, the chemical category has a larger contribution than with the mass method, but still significantly less than the IT contribution. The final result is of the same order of magnitude than with the mass method.

Chart 7.1 Oates Lab Emissions - Price Method - Goods Consumption



For the van der Goot lab, one can see that the "Chemicals" category which represented one third of the consumer goods emissions now represents almost 90% with the price method. This large change is due to the fact that the price of the chemical items are generally not correlated at all with their price.

Chart 7.2 VDG Lab Emissions - Price Method - Goods Consumption



7.3. List of IT items excluded from the analysis

As explained in the consumer goods methodology section of this report, some items were excluded from the analysis because of a lack of information allowing us to approximate their carbon footprint. These products are listed here (Inventory number + description), they all are from the Oates IT inventory:

- 20091932, Filter Wheel
- 20092595, Positioning system SmarAct
- 20092636, SOLE-6 Laser
- 20092771, Sutter P-97
- 25000407, PHD ULT REMOTE RS485 I/W, P/P
- 25001550, Laser