



EMISSION FREE EUROPEAN UNIVERSITIES
Strategic Development of Students' Sustainability Competencies
in Engineering Sciences

Work Package #2

State-of-the-art analysis for universities
on their way to emission neutrality

The EFEU Carbon Footprint Calculator

Authors

Mehran Attar, Jorma Säteri

Contributors

Dominique Deneux, El-Hadj Dogeche, Christian Götz, Klaus Homann, Yannik Knau,
Rui B. Ruben, Abeo Trotter

PUBLISHED

January 2024

Contact:

For any inquiries or questions about the unrestricted use of the project results, please get in touch with the project coordinator: klaus.homann@dhw-stuttgart.de

COPYRIGHT

The EFEU Consortium January 2024

REGISTRATION DATA

This work is licensed under the Creative Commons Attribution-Noncommercial-Share Alike 2.0 Belgium License.
To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-sa/2.0/b>

Disclaimer

EFEU is funded by Erasmus+ and DAAD to expand the exchange of best practices and enable strategic partnerships among European universities and companies. This project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Table of Contents

Table of Contents	III
Figures.....	V
Tables.....	V
List of Abbreviations	VI
Definitions.....	VII
About this Publication	IX
1 Introduction.....	1
1.1 Background: challenges, opportunities and critical activities	1
1.2 Project partners	2
1.3 Project Roadmap	3
2 Methodology	7
2.1 EFEU Methodology	7
2.2 General proceedings of the EFEU Team	8
2.3 Methodology of EFEU Work Package #2	10
2.4 Aim and Methodology of EFEU Work Package #2	11
2.4.1 Aim of EFEU Work Package #2	11
2.4.2 Methodology of Development of the EFEU Carbon Footprint Calculator	12
3. State of the Art Review: Carbon Footprint Calculation in Universities	13
3.1 Background	13
3.2 CF Calculation Tools and Frameworks	14
3.2.1 Organisational CF Frameworks	14
3.2.2 University-specific CF Frameworks	15
3.2.3 CF Calculation Tools	16
3.2.4 In Practice	18
3.3 Towards a Framework for University CF Calculation	19
3.3.1 Scopes of Emission.....	19
3.3.2 Defining Boundaries	21
3.3.3 Geographical Boundary: Campus, Building or the whole university?	22

3.3.4	Operational Boundary: Which emission sources should be included?	23
3.3.5	Commonly Reported Emissions	24
3.3.6	Emission Sources with Largest Impact	25
3.3.7	Emission Sources with Highest Reduction Potential.....	27
3.3.8	Ease of access to reliable data.....	29
4	An EFEU Tool For Carbon Footprint Measurement.....	31
4.1	Behind the Calculator - Approach	31
4.2	Structure of the Calculator	33
5	Results from the piloting of the tool	36
5.1	Case studies	36
5.2	Data collection	37
5.3	Carbon Footprint (CF) Results	39
6	Discussion and Recommendations on Data Management.....	43
7	Conclusion.....	44
	References	X
	ANNEXES	XIII

Figures

Figure 1: Project Overview EFEU – Work Packages	3
Figure 2: Online delivery via MS Teams	Error! Bookmark not defined.
Figure 3: Distribution of adopted frameworks among reviewed universities.	19
Figure 4: Scope of Emissions (WRI and WBCSD, 2011).....	20
Figure 5: Reporting rate of emission sources by the assessed universities	25
Figure 6: Contribution of emission sources to overall CF of universities	26
Figure 7: Overview of an input spreadsheet	34
Figure 8: Carbon Footprint results of the piloting phase (t Co2e)	39
Figure 9: Carbon intensity results of the piloting phase (t CO2e)	40
Figure 10: Carbon footprint results of Metropolia Myllypuro Campus	40
Figure 11: Carbon footprint results of DHBW Stuttgart’s Technical Faculty.....	41
Figure 12: Carbon footprint results of UPHF Le Mont Houy	42
Figure 13: Carbon footprint results of Polytechnic of Leiria	42

Tables

Table 1: Analysis of existing carbon footprint calculators	17
Table 2: Overview of the analysed CF reports.....	24
Table 3: Emission mitigation measures identified in the literature	28
Table 4: Identified data management strategies for each emission category to enhance accessibility	30

List of Abbreviations

CCC	Campus Carbon Calculator
CF	Carbon Footprint
CO ₂	Carbon Dioxide
CO ₂ e	Carbon Dioxide Equivalent
Defra	Department for Environment, Food & Rural Affairs
EAUC	Environmental Association for Universities and Colleges
EF	Emission Factor
EFEU	Emission Free European Universities
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
SME	Small and medium-sized enterprises
KWh	Kilowatt hours
SDG	Sustainable Development Goals

Definitions

Several words and phrases are used in this report that some readers might be unfamiliar with. Therefore, a list of definitions is listed here to make the report more accessible to a wide variety of readers. The definitions are mainly from the GHG Protocol (2004) and Defra's Guidance (2009).

Activity data is the quantified activity level multiplied by an emission factor to achieve GHG emissions for that activity. Examples of activity data include distance travelled, floor area of a building, amount of fuel consumed, and kWh electricity used.

Boundaries determine which emission sources are included in an organisation's GHG inventory. They also determine the geographical area, gases, and timeframe to be considered for the GHG inventory of an organisation.

Carbon dioxide equivalent (CO₂e) is a standard unit for comparing emissions caused by different greenhouse gases based on their global warming potential. For example, the global warming potential for methane over 100 years is 21. Therefore, 1 tCH₄ is equivalent to 21 tCO₂ over this period.

Carbon neutrality is the net zero balance between all GHG emissions produced and removed in a certain system.

Direct emissions are those emissions that are either owned or controlled by the organisation.

Downstream emissions are the emissions caused by selling goods and services. They include distribution, processing, use, and end-of-life treatment of the sold products and the investments an organisation makes.

Emission factor, also known as conversion or emission coefficient, is a conversion unit that is multiplied by activity data to produce GHG emissions data. For example, kg CO₂e/km travelled, or kg CO₂e/€ purchased.

Indirect emissions are emissions that occur off-site but are the consequences of the activities of the reporting organisation.

Global warming Potential (GWP) is a metric used to express the relative impact of different greenhouse gases on global warming, indicating how much heat a particular gas can trap in the atmosphere compared to carbon dioxide over a designated period.

Scopes define the operational boundaries concerning indirect and direct GHG emissions. Emission sources are categorised into three distinct Scopes. All the existing frameworks agree on the definition of these three Scopes.

Scope 1: All direct emissions that occur on-site originate from sources owned or controlled by the organisation.

Scope 2 Indirect emissions generated off the site, resulting from the purchase of electricity, heating, and steam.

Scope 3 All the other indirect emissions that occur off-site but result from activities that take place on-site.

A supply chain is a network of organisations involved in different stages of a product's sale from when it is manufactured until it reaches the customer. These include retailers, manufacturers, and distributors.

Upstream emissions are all the emissions that are caused by the purchase of goods and services. GHG Protocol defines eight categories of upstream emissions: purchased goods, services and capital, waste, business travel, and commuting.

About this Publication

This publication presents the first of two reports from the second work package of the Erasmus+ Strategic Partnership project, "Emission Free European Universities" (EFEU).

The first step in identifying suitable approaches to achieving emission-free status was to determine the carbon footprint on the campuses of contributing partners. The goal is to pinpoint the most significant sources of greenhouse gas emissions and develop strategies to reduce them. Recognising the unique characteristics of universities across different countries, we decided that a tailored and comprehensive approach was necessary.

The EFEU Carbon Footprint Calculator (EFEU CFC) was distributed to project partners to measure their carbon footprints. This report contains the results obtained from using the EFEU CFC, along with insights and a list of recommendations based on the experiences of the participating partners.

The EFEU CFC can be requested through the project website at:

<https://www.dhbw-stuttgart.de/forschung-transfer/technik/projekte/efeu/project-outcomes/>

1 Introduction

The transition to a low-carbon, low-energy, and resilient economy and society must mobilise all sectors of society more than ever. In higher education, students must be trained in socio-ecological issues and, a fortiori, in energy and climate issues. The engineer of the 21st century must be the driving force behind this ecological and energy transition. Whether they are decision-makers or technicians, they must and will have to integrate environmental issues into their choices and decisions, which are already impacting society. Therefore, students must be confronted with these issues from the time of their training.

The project aims to compare the points of view of 4 polytechnic universities covering Europe, from north to south and from east to west, to bring out a set of European best practices in terms of awareness-raising of various publics, training of HEI students, development of research, implementation of international cooperation, transfer of knowledge. Sustainable development and social responsibility will be at the heart of both the substance of the subjects dealt with and the form given to our actions. Efforts will focus on comparing practices, identifying and sharing the most successful ones, developing new practices, their joint experimentation, optimisation, and international dissemination, particularly to the benefit of other European universities.

1.1 Background: challenges, opportunities and critical activities

Many HEIs have adopted policies, educational programs, modules, and practices to promote sustainability. Nevertheless, university campuses still have significant carbon footprints and bear other substantial adverse environmental impacts. Staff and student commuting, administrative, learning, and laboratory activities, as well as cleaning, transportation, restaurant and other ancillary undertakings, contribute to the poor environmental performance of universities.

Through the implementation of the project, the partners address the following needs: The Need to implement the requirements of the European Climate Law (2021) at the national and federal levels. (i.e., the German Bundes-Klimaschutzgesetz and the Klimaschutzgesetz of the State of Baden Württemberg), setting the goal to achieve

climate neutrality by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990. To achieve this target, measures must be taken in a specific form. The implementation takes place at the national level, which makes the public educational institutions responsible for acting. By saving Co2 emissions in teaching and other fields of action, solving a global/international problem is supported locally. This includes the reduction of energy consumption, which helps achieve the national greenhouse gas reduction targets. The energy efficiency increase is linked to doubling the annual energy-saving commitment at the national level.

1.2 Project partners

The project consortium is made up of four universities:

- the Baden-Württemberg Cooperative State University in Stuttgart (DHBW Stuttgart, Germany) as project coordinator and represented by the Department of Industrial Engineering & Management and the Department of Electrical Engineering
- the Instituto Politécnico de Leiria (IPL, Portugal), represented by the Departments of Mechanical Engineering and Environmental Engineering
- the Metropolia Ammattikorkeakoulu Oy (Metropolia UAS, Finland), represented by the Department of Real Estate and Building Services
- the Université Polytechnique Hauts-de-France (UPHF, France), represented by the Institute of Electronic Microelectronic Nanotechnology CNRS and the Institut National des Sciences Appliquées Hauts-de-France (INSA)

From December 31st, 2022, to May 30th, 2025, the Erasmus + Strategic Partnership, under the direction of the German Academic Exchange Service, will commit €250, 000.00 to ensure the successful execution of the project's activities.

1.3 Project Roadmap

Logical Framework - EFEU Emission free European universities

- **Priorities applying to all Erasmus+ sectors (Horizontal):**
- Inclusion and diversity in all fields of education, training, youth and sport
- **Environment and fight against climate change**
- Addressing digital transformation through development of digital readiness, resilience and capacity
- Common values, civic engagement and participation

- **Sector specific priorities in higher education:**
- Promoting inter-connected higher education systems
- **Stimulating innovative learning and teaching practices**
- Developing STEM/STEAM in higher education, in particular women participation in STEM
- Rewarding excellence in learning, teaching and skills development
- Building inclusive higher education systems
- **Supporting digital and green capabilities of the higher education sector**

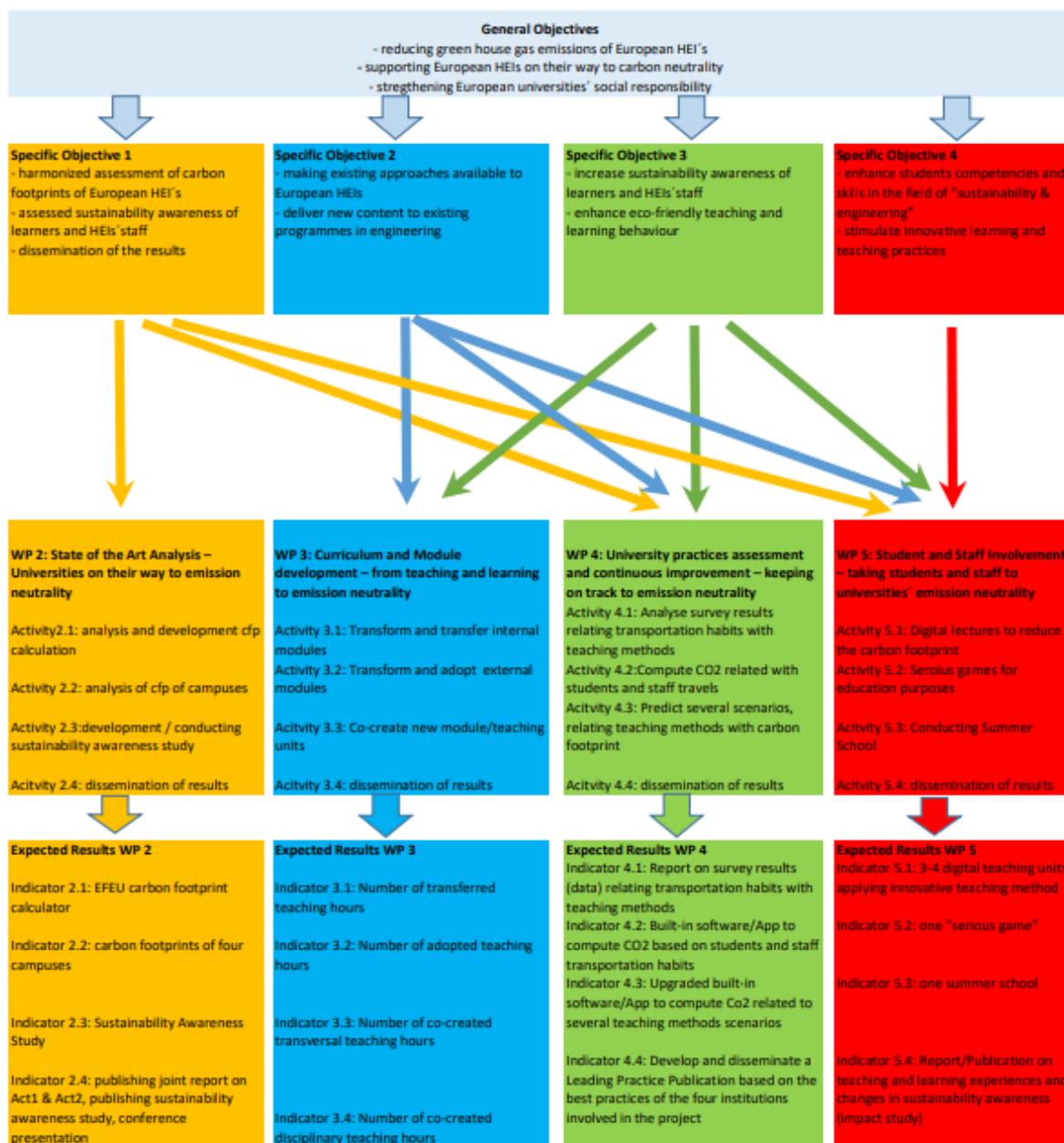


Figure 1: Project Overview EFEU – Work Packages

The project is structured into five work packages (Figure 1). WP1 focuses on the project management activities. The leader of this WP is the DHBW, whom the project partners will strongly support. The objective of this WP is to ensure the utmost success of the project's implementation through the hosting of project meetings, project tracking, documentation, quality supervision, budget control, time management, risk mitigation, communication and coordination, as well as ensuring inclusion and green practices are being promoted. Support from project partners is expected to provide the timely and accurate submission of information related to project activities, results and progress, as well as financial matters.

WP2 is to gather information about the four partner universities' carbon footprint and assess the sustainability awareness of students and staff. The WP will begin with the research and revision of existing tools and end with the development of the EFEU Carbon Footprint Calculator. This tool, intended to be open source, will be used by partner universities and eventually by universities outside of the project consortium (dissemination and replication) to determine their carbon footprint during the use phase.

Accompanying the EFEU CFC will be a description of the methodology to support the utilisation of the calculator. This document will define the system's boundaries, the means of collecting and processing data, and the necessary input values. Once the tool and the methodology are completed, partners will gather data about their university campuses and determine the carbon footprint of at least one university campus. The calculation tool should be seen as a tracker, through which each university can monitor their levels of carbon emissions, the progress in the implementation of sustainability strategies, and climate targets and strategies. Results from the carbon footprint assessment will be used to develop the subsequent WPs' content.

The four partner universities will develop and administer a sustainability awareness survey. The results from the sustainability awareness assessment will be used to develop the content of WP3, WP4, and WP5 and, therefore, curricula, teaching methods, and teaching activities. The results of the carbon footprint and sustainability awareness survey will be presented in an open webinar at each partner university and at one international conference.

The objectives of WP3 are to target, select, plan, and develop one of the core actions of the EFEU project – develop critical competencies and skills of future mechanical, electrical, industrial and business engineers in the field of sustainability and results used to support planned activities of Work package 5. In the development of new teaching material (adoption of external examples or co-creation of brand-new content), two kinds of modules may be considered:

1. Transversal modules that do not necessarily belong to a given program but can optionally be attended by any bachelor student, irrespective of the student's discipline (including humanities). This should be the primary target for co-developing a 3 to 5 ECTS module.
2. Disciplinary modules that belong to existing programs. Generally, it will not be possible to create an additional one because programs have a fixed amount of teaching hours. In that case, it would rather be a retrofit of an existing disciplinary module in which the Sustainable Development Social Responsibility (SDSR) aspect is inadequately covered.

The outcome might be a short-time emphasis on SDRS aspects in various disciplinary modules, representing 20 % of the module contents. The hope is that this approach is practical enough to allow for implementation beyond the four partners.

The maturity of each partner in the many themes covered by the project will be assessed. A partner can be qualified as "uninformed", "aware", "beginner", "qualified", or "expert". WP3 will create the conditions to improve the SDRS maturity of every partner individually and of the EFEU consortium as a whole, employing:

- Combined actions (serial, parallel asynchronous, parallel synchronous);
- Transversal modules transfer, optimisation, adoption or creation from scratch;
- Representative disciplinary modules creation in different domains (mechanical engineering, electrical engineering, industrial engineering and business engineering) and
- Consolidation of best practices applied internally and disseminated externally.

The main objectives of WP4 are to develop and apply built-in software to compute Co2 based on the students' and staff's mobility habits. To achieve these objectives, the following activities are planned:

- Consider and design relevant questions for the mobility survey to be integrated with the sustainability awareness survey.
- Analyze and compare how the teaching methods influence the carbon footprint, considering students' and staff's mobility habits.
- Create a digital platform that relates mobility choices with the carbon footprint. This platform will have built-in software to compute CO₂e based on mobility habits.
- Motivate students and staff to use bicycles, public transportation, or walking, based on information available on the platform, with some awards for the best practices.
- Motivate city councils to improve public transport access (improving the interconnection network), thus reducing transport fuel and promoting the transition to electric mobility.
- Develop and disseminate a Leading Practice Publication based on the best practices of the four institutions involved in this project.

The focus of work package 5 is to determine the best means of reducing the carbon footprint of teaching activities. Therefore, the objectives are as follows:

- Developing and conducting teaching concepts focused on reducing the carbon footprint,
- Using new digital formats so that virtual classes are more beneficial to students,
- Creating opportunities for student exchange within Europe that have a minimal carbon footprint and
- Making experiences of this work package available to other stakeholders and universities.

2 Methodology

This chapter covers the general methodologies and proceedings approved by the EFEU team for the development of the project activities and the execution of duties. It also provides more specific details on the approaches implemented for work package 2 and the development of this report.

2.1 EFEU Methodology

The Erasmus+ EFEU project adopts an exploratory approach to research and employs an action research methodology. The project consortium has devised a structured five-step process for implementation by utilising a mixed-method approach, resulting in five comprehensive reports and various implementations. Methodologies employed include literature review, qualitative and quantitative surveys, expert interviews, co-creation workshops, and piloting of teaching and learning events.

The initial phase entails an in-depth literature review to examine prevailing trends in carbon footprint calculators, sustainable awareness, educational practices, and mobility behaviours. Additionally, it encompasses the exploration of serious games addressing climate change, sustainability competence frameworks, curriculum analysis tools, Co2 computation and prediction software, and the examination of module catalogues from partner universities.

An online survey will be developed to assess sustainability awareness and mobility practices among students, lecturers, and administrative staff. Subsequently, the survey will be distributed and disseminated in the second phase. During this phase, the EFEU Carbon Footprint Calculator, along with the implementation methodology and set of pertinent indicators, will be created and piloted by the partner universities.

In the third phase, data collected from the survey will inform initiatives to foster sustainable learning. This will be complemented by a curriculum analysis to identify learning gaps and best practices, alongside co-creation workshops involving teachers, academic and industry experts, and practitioners to determine the requisite knowledge and skills for integrating sustainable practices into student curricula. In this phase, best practices identified in teaching and learning events will be transferred to the project partners.

In the fourth phase, data from the mobility survey will guide decision-making processes in enhancing and promoting sustainable mobility practices at individual campuses. Co2 prediction software will also be used to simulate future scenarios that analyse and compare teaching methods and carbon footprint. During the fifth phase, the EFEU serious game and EFEU digital modules will be developed and piloted during the EFEU summer school, and their impact will be evaluated through the implementation of an impact study.

Throughout the project, the transfer of learning activities will be encouraged to facilitate closer collaboration with project partners and nurture capacity-building among students and staff. Additionally, emphasis will be placed on dissemination activities to publicise the project outcomes and promote their potential use in academia and industry.

2.2 General proceedings of the EFEU Team

DHBW acts as Project Coordinator (PC), supervising the overall progress of the project. Its responsibilities include chairing the Steering Committee and consortium meetings; taking all actions to enable proper decision-making; supervising the consortium's activities concerning administrative, financial, legal, and contractual aspects; monitoring the project planning and the delivery of project results; and submitting all required progress reports, deliverables and financial statements.

A DHBW research assistant will support Project Management (PM). This individual will manage the Consortium activity concerning administrative, financial, legal, and contractual aspects; ensure the effective operation of the project, the project website, and project communication mechanisms; coordinate the organisation of the Steering Committee and Consortium meetings; manage the repository of project documentation (deliverables, task reports, minutes of meetings, publication, etc.); and upload relevant documents and information to the project platform. On a local basis, the other partners will also set up coordinated PM processes.

The consortium intends to use MS Teams, which will be hosted by DHBW. An exclusive Team, "EFEU", has been set up and will be used for regular meetings of the project core team and other planned or ad hoc meetings. DHBW will also provide a

secured project SharePoint. From the experience of former projects, social media—e.g., WhatsApp—has proven valuable as an informal and ad hoc communication tool between project members. Therefore, it will be utilised throughout the project duration.

A leader (s) has been designated for each WP. All project partners will support the WP leader and collaborate on each of the four content-related WPs

- Work Package 1; Work Package Leader: DHBW
- Work Package 2; Work Package Leader: Metropolia
- Work Package 3; Work Package Leader: UPHF
- Work Package 4; Work Package Leader: IPL
- Work Package 5; Work Package Leader: DHBW AND UPHF

The partners are aiming to distribute content-related workloads equally. Right from the beginning, all partners nominated/assigned sufficient staff, ensuring appropriate coverage of the expected workload. During implementation, the Project Core Team may vary from activity to activity, depending on individual expertise and the interest of the partners' staff. Each partner is responsible for organising communication with local stakeholders and hosting or organising one physical transnational meeting and one multiplier event.

Figure 2 shows the format of regular team meeting.

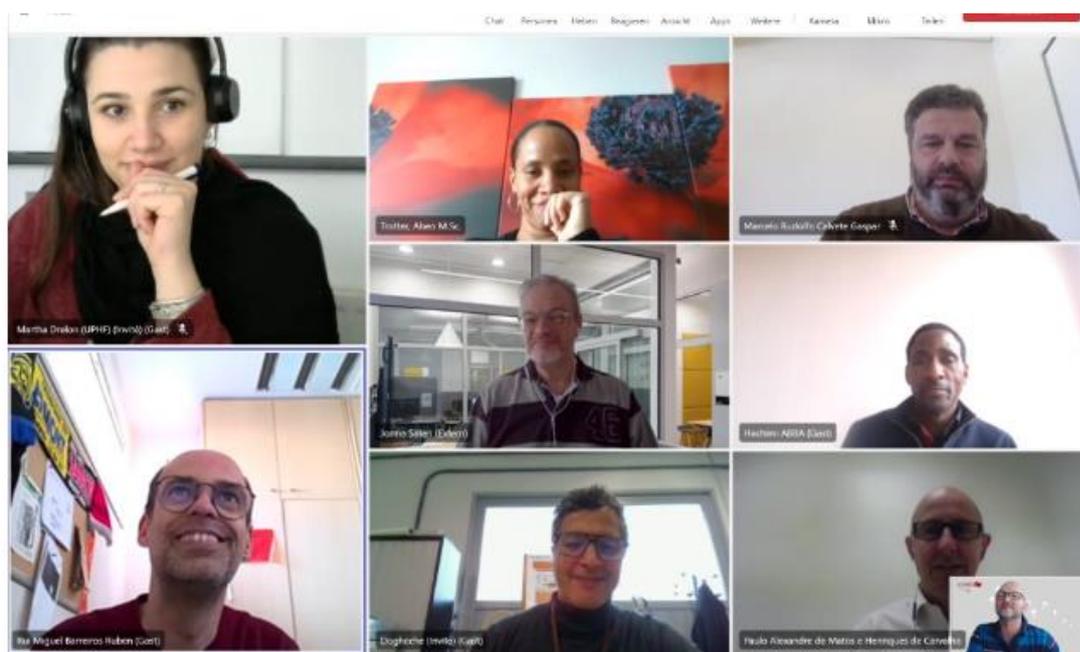


Figure 2: Online delivery via MS Teams

2.3 Methodology of EFEU Work Package #2

WP2's main objectives are to gather information about the actual carbon footprint of the university campuses and to assess staff and student awareness of sustainability themes. The results of these assessments will be used internally and disseminated externally.

University campuses are complex systems that encompass a large number of educational and management activities. The EFEU project will focus on developing a carbon footprint calculation tool that meets the needs for the assessment of university campuses. Evaluating the carbon footprint is vital for universities committed to carbon emission reduction targets or carbon neutrality targets. The tool can be used to track changes in the carbon footprint of universities, and having such a tool in use is indispensable to reaching those targets. Information about which activities are responsible for elevated greenhouse gas emissions will supplement efforts for the other WPs.

The EFEU survey aims to collectively evaluate sustainability awareness among students and staff. We seek not only to gauge awareness levels but also to engage students and staff in conceptualising and planning actionable steps to enhance campus sustainability, particularly in reducing carbon footprint.

The survey results will serve as a foundation for subsequent Work Packages (WPs), guiding the planning and implementation of activities involving students and staff. By incorporating their input and participation, we aim to foster a sense of ownership and commitment towards sustainability initiatives across the campus community.

2.4 Aim and Methodology of EFEU Work Package #2

2.4.1 Aim of EFEU Work Package #2

The main objectives of WP are to gather information about the actual carbon footprint of the university campuses and to assess awareness of sustainability issues among staff and students. The results of these assessments will be used internally and disseminated externally. University campuses are complex systems that encompass a large number of educational and management activities.

The EFEU project will focus on developing a carbon footprint calculation tool that meets the needs for the assessment of university campuses. Evaluating the carbon footprint is vital for universities committed to carbon emission reduction targets or carbon neutrality targets. The tool can be used to track changes in the carbon footprint of universities, and having such a tool in use is indispensable to reaching those targets. Information about which activities are responsible for more Green House Gases emissions will be used in the other WPs.

EFEUs survey aims to assess the awareness of sustainability among student and staff in a co-operative way: we are interested not just in the awareness level, we want to involve students and staff in conceiving and planning actions, which can be implemented and used to improve the Carbon Footprint of the Campuses. Results of the Survey will be used in the following WPs, as a base to plan and implement activities with students and staff.

2.4.2 Methodology of Development of the EFEU Carbon Footprint Calculator

WP2 begins with a review of the existing tools for calculating the carbon footprint, which are suitable for university campuses. The aim is to select and develop one standard tool for all project partners. The chosen tool should preferably be open-source and can be used by other universities outside the project consortium (Dissemination and replication). Together with the tool, a methodology to define the system's boundaries will be established, and the collection and processing of data will provide carbon emission factors and reference values for the Countries/ Regions represented by the partners. Once the tool and the methodology are ready, partners will gather data about their University Campuses, ultimately aiming to calculate the carbon footprint of at least one Campus of each University. The calculation tool should be seen as a tracker through which each university can follow the development of carbon emissions in the future years, compare them with historical and reference values, and monitor the implementation of sustainability strategies and the progress of their climate targets and strategies. Results from the Carbon Footprint Assessment will be used to develop the content of the following WPs.

The Carbon Footprint assessment tool will be tailored for university campuses, ensuring all relevant activities and processes are included and omitting information that is not important or non-critical. Sufficient knowledge of the current state of the carbon footprint of campuses and the ability to track changes in time is essential to implement carbon reduction policy and fulfil carbon neutrality targets successfully. Combining information about the carbon footprint of the Campuses with the outcomes of the sustainability awareness survey of staff and students will enable the choice of the most effective actions to improve the Carbon Footprint. It will also affect the design of the training programs in the following WPs.

3. State of the Art Review: Carbon Footprint Calculation in Universities

3.1 Background

Universities are the primary driver of knowledge creation and its dissemination in society, and thus, have a significant climate responsibility to educate the future generation and become the forerunners in transitioning to sustainable practices (Jain et al., 2017). More than one thousand universities worldwide have committed to the UN's Race to Zero initiative to become carbon-neutral by 2050 (UNEP, 2021). Many higher education institutions in Europe, including the universities in Finland, have even more ambitious goals and aim to achieve net zero by 2030 (UNIFI, 2020). These commitments are essential as they can significantly impact other organisations and governments (Gomez et al., 2016). Furthermore, research and education-based organisations can act independently of national policies and mandates by implementing new technologies based on their research and encouraging climate-friendly actions through education (Kiehle et al., 2023).

Given the substantial number of students, staff, and infrastructure, universities are prominent in emitting greenhouse gases. So, to identify and implement emission reduction strategies, universities must first assess their current emissions. Carbon footprinting as an emissions accounting tool is gaining popularity. This is evident by the recent emergence of tools and frameworks developed to assist the calculation process of universities' carbon footprints and the increasing number of universities that voluntarily publish their carbon footprint reports. Not only does carbon footprint assessment allow for the implementation of effective reduction strategies, but it also provides a baseline for monitoring the reduction progress and evaluating the success rate of the adopted strategies (Kiehle et al., 2023).

Carbon footprint calculation tools and guidelines specific to universities are still in the early stages of their development. GHG Protocol is universities' most popular carbon footprint framework (Valls-Val and Bovea, 2021). However, the protocol, like many other adopted frameworks, is not tailored to the needs and requirements of higher education institutions. The unsuitability of adopted frameworks, the absence of a standardised university-specific framework and the diversity of calculation tools and

methodologies have made carbon accounting at universities quite challenging. This emphasises the need for tools and frameworks to standardise and operationalise the process of carbon footprint measurement at universities.

This report aims to provide the basis for developing a standard carbon footprint calculation tool that meets the needs for assessing university campuses and reaching carbon neutrality. To achieve this, the applicability of existing tools and frameworks is assessed, and essential criteria for establishing boundaries and the critical determinants of the universities' carbon footprint are evaluated. This report also identifies emission sources specific to the context of universities and analyses the extent to which they impact a university's carbon footprint. Finally, the report identifies universities' best practices to help address the gaps in collecting and measuring the carbon footprint of universities.

3.2 CF Calculation Tools and Frameworks

3.2.1 Organisational CF Frameworks

Green House Gas (GHG) Protocol and ISO 14064 are the most notable frameworks for measuring an organisation's CF. These guidelines have established the groundwork for quantifying organisations' GHG impact and formed the basis for developing other carbon accounting guidelines.

The GHG Protocol Corporate Standard, developed in 2004 by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), offers a standardised approach to carbon accounting and reporting. It categorises emissions into three main categories. Scope 1 comprises direct emissions from sources owned or controlled by the organisation. Scope 2 emissions involve indirect emissions from the purchase of energy, and Scope 3 covers all other indirect emissions that occur in an organisation's value chain. Later, the GHG Protocol Value Chain Standard (2011) was released as an extension to the original standard to provide additional guidance to companies seeking to include their complete Scope of three emissions in their reports.

ISO 14064 was released in 2006 as part of the ISO series of environmental management standards. It guides organisations on the principles and requirements for

assessing their GHG emissions. The standard offers further guidance on verification, data validation and external dissemination of the final results to ensure consistent external communication (ISO, 2006). It aims to guide governments and companies in measuring and controlling their emissions.

The GHG Protocol and ISO 14064 are widely used by organisations worldwide to measure their carbon footprint. They both focus on the six GHGs outlined in the Kyoto Protocol and share similar approaches to boundary definition and emission quantification methodologies (Gao et al., 2014). However, because of the availability of several supplementary guidelines, the GHG Protocol offers a more transparent and operational method for selecting and collecting activity data and emission factors. As a result, it is the preferred approach for larger and more complex organisations (Gao et al., 2014).

The GHG Protocol and, to some degree, ISO 14064 have laid the groundwork for developing and implementing other carbon accounting frameworks. The main reason for creating these guidelines is to address the limitations of the GHG protocol, particularly the absence of country and sector-specific emission sources and emission factors. Some examples of country-specific guidelines include DEFRA's Guidance (2009), used across the UK, and its French counterpart, Bilan Carbone.

3.2.2 University-specific CF Frameworks

There are currently no international frameworks for universities to assess their carbon footprint (Kiehle et al., 2023). This has resulted in a lack of clear guidance for universities on what to report and which methods to employ. However, in recent years, guidelines and methodologies specific to universities' needs and requirements for assessing their carbon emissions have emerged.

The Standardised Carbon Emissions Framework (SCEF), aimed at universities and colleges in the UK, was published in late 2022 by The Alliance for Sustainability Leadership in Education. SCEF is currently the only standardised method for measuring university GHG emissions. The framework is based on the GHG Protocol, provides universities with guidance on setting boundaries, and offers detailed instructions on collecting data and calculating each emission. In addition, SCEF

interprets each emission category according to the GHG Protocol's definitions, which are sometimes difficult to understand and may not apply to a university setting. However, the framework has not yet been adopted by many universities. The UK's Department of Education expects all higher education institutions to embrace it starting from the 2024-25 academic year.

Cool Campus is a guide to help universities create climate action plans (Simpson, 2009). It also provides some insights into how to calculate their carbon footprint. EUSTEP Guideline (Pires et al., 2022) offers a series of recommendations to universities on assessing and mitigating their ecological footprint. The guideline is based on the ecological footprint method and the UN's Sustainable Development Goals (SDGs). In addition, it provides a series of recommendations on how to collect activity data for each emissions category. The guideline also offers mitigation measures and ranks them according to emission reduction potential and cost-effectiveness.

Finally, NTU's Carbon Footprint Framework (Evers et al., 2022), published by Nanyang Technological University, presents a methodology that is also based on the GHG Protocol for measuring and reporting the carbon footprint of universities. The framework discourages spending-based data, arguing that it leads to less accurate results. Furthermore, the NTU framework provides a list of university-specific emission sources. In addition, to encourage the comprehensive inclusion of Scope three emissions, it suggests a transparency score that weighs how open and transparent universities are in reporting their emission data.

3.2.3 CF Calculation Tools

Over the past few years, several tools have been developed for calculating the carbon footprint of organisations (Valls-Val and Bovea, 2022). Carbon Fund Calculator, Carbon Footprint Calculator, Cool Climate Calculator, Simple Carbon Calculator, myclimate, and Terrapass Calculator are some notable tools that are specifically aimed at organisations. However, most of these tools are aimed at organisations and lack the capability to incorporate emission factors and emission sources that are specific to universities (Evers et al., 2022). At the time of writing this report, three university-specific calculation tools exist. However, only two of them - Campus Carbon Calculator

and EUSTEPS' University Footprint Calculator - are available to the public. This section of the report looks into these three calculators in more detail.

Campus Carbon Calculator (CCC) was developed by the Clean Air-Cool Planet organisation in collaboration with the University of New Hampshire. The tool was an Excel-based spreadsheet and was available for free. CCC accounted for all three emission Scopes as it was based on the GHG Protocol. By 2017, more than 90% of universities and colleges in the US were using CCC to measure their GHG emissions (Santovito and Abiko, 2017). In 2018, however, CCC was discontinued and replaced by the subscription-based SIMAP tool. Both Campus Carbon Calculator and SIMAP can only be used by universities in the US as they only include emission factors specific to the region. Since 2020, SIMAP has also provided a version of the tool to Canadian universities, including Canada-based emission factors.

Tool	Country application	Sector	Methodology	Scope 3 emission sources			Tracks changes	Free	Platform
				Procurement	Transport	Other			
CCC	Canada, USA	Universities	GHG Protocol	Paper, Fertiliser	business travel, commuting	Waste, Wastewater	yes	yes	excel
SIMAP	Canada, USA	Universities	GHG Protocol	Paper, Fertiliser	business travel, commuting	Waste, Wastewater	yes	no	online tool
CO2UNV	Spain	Universities	GHG Protocol	paper, electronic devices, lab chemicals	business travel, commuting	waste, water	yes	yes	excel based app
EUSTEPs University Footprint Calculator	European Union	Universities	Ecological Footprint Accounting	paper, food, IT equipment, furniture, cleaning services	business travel, commuting	waste, water, food at home, internet and electricity at home	Yes	yes	online tool
GES 1point5	France	Research Institutes	GHG Protocol, Bilane Carbone	Digital equipment, lab supplies	business travel, commuting		yes	yes	online tool
Normative Business Carbon Calculator	Worldwide	SMEs	GHG Protocol	all value chain sources (based on expenses)	business travel, logistics	-	no	yes	online tool
Business Carbon Footprint Calculator	Worldwide	SMEs, large businesses	GHG Protocol	-	business travel, commuting	-	no	no	online tool
Carbon Fund Business Emission Calculator	USA	SMEs, large businesses	GHG Protocol	-	business travel, logistics	-	no	yes	online tool
Cool Climate	USA	SMEs	EPA	paper, lab chemicals, IT equipment	business travel, commuting	waste, construction	no	yes	online tool
myclimate	Worldwide	SMEs, large businesses	IPCC	paper, food, IT equipment	business travel, commuting	waste	no	no	online tool
Terrapass Calculator	USA	Individuals, SMEs, large business	EPA		business travel, commuting, logistics		no	no	online tool

Table 1: Analysis of existing carbon footprint calculators

The EUSTEPs University Footprint Calculator was developed by four European universities and became available to the public in 2022. The tool is based on the ecological footprint methodology and includes emission categories such as energy use, food, cleaning services, travel and commuting. The EUSTEPS calculator is web-

based and can be accessed for free on the website. However, it only provides emission factors for the countries that are members of the European Union. The calculator also allows for partial evaluation of a university's emissions if data for all emission sources are unavailable.

The next calculator is CO2UNV, which was recently introduced in an article by Valls-Val and Bovea (2022) but is not publicly available. The Scope three emission sources included in the calculator were determined by the rate at which they are being reported by universities. Sources that were calculated and reported by more than 40 percent of universities are included in the tool and are as follows: water consumption, food consumption, electronic equipment, laboratory chemicals, commuting, business travels and waste. Moreover, it allows universities to add other emission sources excluded from the tool. The emission factors included in the tool are mainly from the Spanish government, as the tool is developed by a Spanish university. However, similar to emission sources, users are given the possibility to add their coefficients. Table 1 provides an overview of these tools in more detail.

3.2.4 In Practice

Studies show that most universities adopt the GHG Protocol as the basis for assessing their GHG impact on the environment (Valls-Val and Bovea, 2021; Robinson et al., 2017). Out of the 25 universities studied by Valls-Val and Bovea (2021), 54% were using the GHG Protocol, followed by IPCC guidelines, which were used by 20%, and ISO 14064-1, which was adopted by 11% of the studied universities. An overview of recent reports by universities across Europe by the author showed similar results (see Figure 3). This is mainly due to the absence of an internationally recognised framework specific to universities (Helmerts et al., 2021). Additionally, because of the inherent differences between higher education institutions and other industries, many universities only partially adopt the GHG Protocol (Valls-Val and Bovea, 2021).

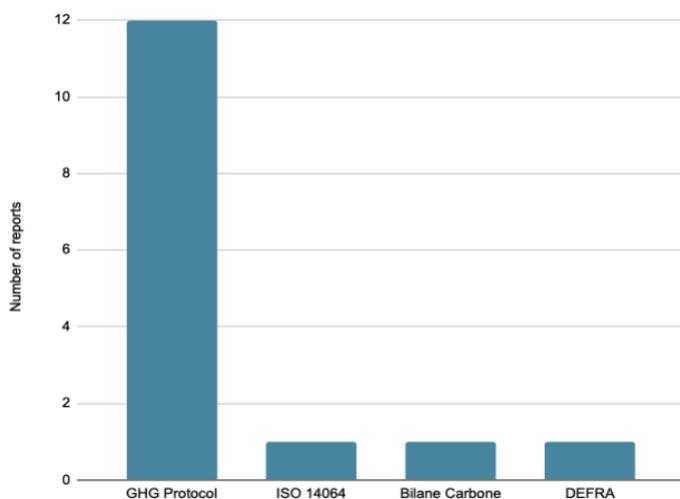


Figure 3: Distribution of adopted frameworks among reviewed universities.

Universities differ significantly when it comes to the tools they utilise to calculate their carbon footprint. The only exception is the US, where most universities employ the Campus Carbon Calculator (CCC) to calculate their emissions (Santovito and Abiko, 2017). The majority of universities that publish their CF do not specify the calculation tool that was used. Among the ones who do, spreadsheets are still the most popular calculation tool (Valls-Val and Bovea, 2021). This is followed by some commercial tools that are not intended for the context of universities and LCA calculators, such as Umberto (Evers et al., 2022). This variation in the existing tools can be partially attributed to the lack of a standardised framework. Bailey and LaPoint (2016), who attempted to compare the CF of nine US universities that implemented the same calculation tool, had to normalise each university's scope, boundaries and emission sources. Another reason for the diversity of the calculation tools and the lack of a standard tool is explained by the absence of national policies and the lack of a comprehensive database of country-specific emission factors (Evers et al., 2022).

3.3 Towards a Framework for University CF Calculation

3.3.1 Scopes of Emission

As mentioned earlier, due to the absence of university-specific standards, most universities adhere to the GHG Protocol for measuring their carbon footprint. The GHG Protocol defines the carbon footprint as the total amount of emissions an organisation

produces through its direct and indirect activities. The protocol breaks down the emissions generated by an organisation into three categories:

Scope 1: All direct emissions that occur on-site and originate from sources owned or controlled by the organisation. Examples include emissions from the combustion of boilers, fuelling owned vehicles, and refrigerant leakage.

Scope 2: Indirect emissions generated off the site, resulting from the purchase of electricity, heating, and steam. These emissions are treated differently from Scope 1 emissions since they are not directly controlled by the organisation.

Scope 3: All the other indirect emissions that occur off-site but result from activities that take place on-site. This category encompasses emissions from purchases of goods and services, transmission loss of utilities, waste generation, business travel, and commuting to and from the organisation.

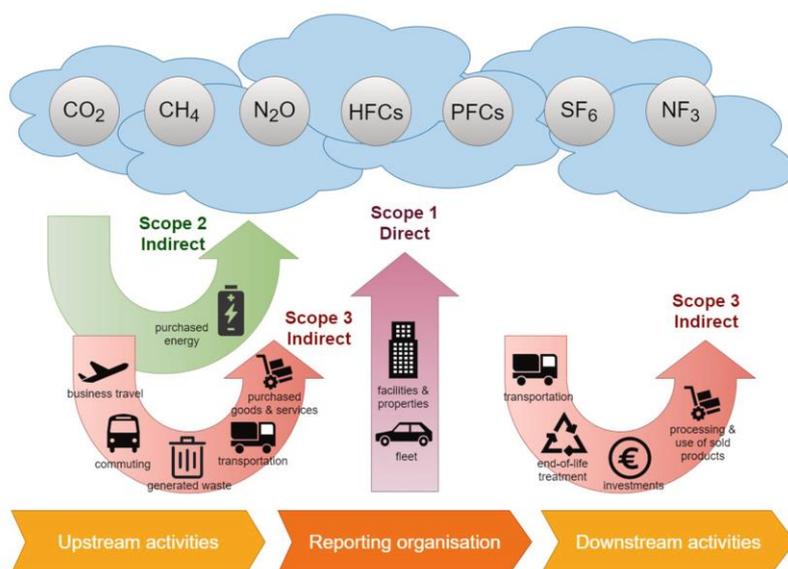


Figure 4: Scope of Emissions (WRI and WBCSD, 2011)

According to most standards, such as the GHG Protocol, an organisation's GHG inventory is considered complete when Scope 1 and 2 emissions are accounted for. The methods and the requirements for including the first two Scopes are well-documented and clearly defined within these references. However, they are less strict regarding including Scope 3 emissions, leading to many universities not reporting these emissions at all. According to a recent survey among over 550 universities, only half report their Scope 3 emissions (Times Higher Education, 2021). There is also a noticeable variation in the extent of Scope 3 emission coverages between universities

based on factors such as data availability, their level of expertise, and their previous experiences.

This implies that the true impacts of universities on the climate are often not entirely known, particularly considering that Scope 3 emissions constitute approximately half of a university's carbon footprint (Valls-Val and Bovea, 2021; Helmers et al., 2021). This proportion is even higher among universities that have attempted to comprehensively measure their Scope 3 emissions. For example, Oxford University attributed 80% of its total carbon footprint to Scope 3 emissions (Oxford, 2022), while the University of Delft demonstrated that 82% originated from Scope 3 emissions (Herth and Blok, 2022). Therefore, it is crucial for universities aiming to achieve carbon neutrality and net-zero emissions in the future to monitor all three emission Scopes.

3.3.2 Defining Boundaries

Before universities begin calculating and reporting their carbon footprint, boundaries should be clearly defined. A clear definition of boundaries is important in guiding the data collection process and provides more meaningful results for the interested parties so that positive changes in emission reduction can be achieved. Furthermore, it can provide an avenue for an efficient and meaningful comparison of universities' results. This is particularly significant since universities depend highly on case studies for measuring their carbon footprint, as there is no standardised framework for measuring the carbon footprint of universities. The most important boundaries that need to be established are geography (organisational boundary) and emission sources (operational boundary). The geographical boundary for a university can either be a single campus, a single building, or the whole university. The operational boundary determines primarily the inclusion of Scope 3 emission sources as both Scope 1 and Scope 2 are required to be included by the GHG Protocol (2004). Both boundaries are critically assessed later in this chapter.

Other notable boundaries that should be established before measuring the university's carbon footprint are time and gases (Santovito and Abiko, 2017). GHG inventories are often developed based on different time frames such as fiscal year, calendar year or, in the case of educational institutions, academic year. Establishing a common time boundary for universities is critical as they share a relatively similar timeline (Santovito

and Abiko, 2017). Commonly applied frameworks do not specify which timeframe to use, however, Valls-Val and Bovea (2021) recommend the use of a fiscal year since emission factors are published every year.

Finally, concerning gases, IPCC has identified 18 that have a global warming potential, out of which the six gases of the Kyoto Protocol are used for carbon accounting by both the GHG Protocol and ISO 14064. These GHG gases are Carbon Dioxide, Methane, Nitrous Oxide, Hydrofluorocarbons, Perfluorocarbons, and Sulphur hexafluoride.

3.3.3 Geographical Boundary: Campus, Building or the whole university?

A review of various university carbon footprint reports revealed that the majority of institutions focused on analysing a single campus in their calculation, followed by the analysis of the whole university, with only 9 per cent examining emissions from a single university building (Valls-Val and Bovea, 2021). The argument for selecting a single campus for analysis is that campuses often act independently of each other. Therefore, examining each campus separately can lead to more meaningful results and consequently, better mitigation strategies and actions can be planned (Santovio and Abiko, 2017). These differences are particularly evident in the emission categories, such as commuting and purchased energy, which are highly dependent on the location of the campus. For instance, at the University of Talca, the campus with the highest carbon footprint per person had the most remote location among campuses and, as a result, had the highest rate of car commuters (Yañez et al., 2020). Similar results are seen at Metropolia University of Applied Sciences, where a noticeable difference was observed in the travel habits of students at each of the campuses (Ojala et al., 2022). Another advantage of choosing a campus rather than the whole university is that it improves the data collection process as administrative hierarchies match, and the overlap of responsibilities can be avoided (Santovio and Abiko, 2017).

The selection of a single building or department for emissions analysis can also have its merits. A study at NTNU University (Larsen et al., 2013) analysed and compared emissions from each department and found a considerable difference between them. The medicine department's share of carbon footprints per person was almost eight times higher than that of the social sciences. While both the engineering and the

medicine departments were responsible for an equally high share of the university's emissions, the reason behind their contribution was quite different. However, this approach requires more time and effort, and many universities do not have the data available for each of their buildings. The latter is also why many universities opt to measure their carbon footprint for the whole university instead (Valls-Val and Bovea, 2021).

3.3.4 Operational Boundary: Which emission sources should be included?

Not only are Scope 1 and Scope 2 emissions clearly defined by the GHG Protocol, but they are also largely consistent across all sectors. Scope 1 emissions include the fuels consumed by university vehicles, as well as the combustion of natural gas in on-site boilers. Scope 2 emissions encompass all the electricity and heating purchased to meet the energy needs of the university campus. On the other hand, Scope 3 emissions differ across sectors, and the frameworks commonly adopted by universities are not tailored to the university context. For instance, the GHG Protocol Corporate Standard (2011), which is frequently adopted by universities, divides Scope three emissions into 15 categories. Out of which, the downstream emissions (related to sold goods and services) do not apply to the product that a university sells. Therefore, universities only partially adopt the protocol and define their own boundaries regarding Scope 3 emissions (Kiehle et al., 2023).

Given their significance, it is important to study and compare universities' approaches to measuring their carbon footprint. This section delves further into emissions to determine which sources are commonly reported and what their impacts are on a university's total carbon footprint. Furthermore, a critical assessment of reduction potentials and mitigation strategies, as well as data availability for each emission source, is conducted. Recent carbon footprint reports from several European universities were collected and analysed (See Table 2 for the full list of the analysed universities).

University	Country	year	Standard	Carbon Footprint (tCO ₂ e)	Largest contributor
Metropolia University of Applied Sciences	Finland	2022	GHG Protocol	14051	commuting
University of Oulu	Finland	2019	GHG Protocol	19072	district heating
LUT University	Finland	2021	GHG Protocol	2046	commuting
University of Helsinki	Finland	2019	GHG Protocol	58217	procurement
Leuphana University of Lüneburg	Germany	2016	GHG Protocol	8360	commuting
University of Potsdam	Germany	2019	GHG Protocol	26154	commuting
UC Birkenfeld	Germany	2017	GHG Protocol	2971	commuting
Ghent University	Belgium	2019	Bilane Carbone	47572	heating
University of Twente	Netherlands	2021	GHG Protocol	19100	electricity
Delft University	Netherlands	2018	GHG Protocol	106000	procurement
Oxford University	UK	2020	GHG Protocol	39800	procurement
Manchester University	UK	2019	DEFRA	45734	procurement
University of Bologna	Italy	2018	ISO 14064	54702	commuting
KTH University	Sweden	2019	GHG Protocol	33548	business travel
NUI Galway	Ireland	2019	GHG Protocol	59396	procurement

Table 2: Overview of the analysed CF reports

3.3.5 Commonly Reported Emissions

All reviewed universities have measured their Scope 3 emissions. However, the extent to which they are being reported varies significantly. Commuting and business travels were the only emission sources that were tracked unanimously but to a slightly different degree. Except for two universities that only reported the employees commuting emissions, all universities calculated both staff and student commuting. However, only half of them show the results separately for each category. Oxford University and the University of Manchester also reported students' inter-term travels to their home country. For business travels, the approaches were slightly different. Three universities only reported air flights, while others measured other modes, such as cars and taxis. Furthermore, overnight hotel stays were measured by two universities.

Emissions caused by generation and handling of waste was the third most reported category, with 14 out of 15 universities reporting it. Procurement of goods and materials was another popular category, while the extent to which they were reported varied significantly. IT and electronic equipment purchases were followed by paper and, lab and research emissions. Construction and maintenance were reported by 60% of the

universities. Emissions caused by food consumption are another emission category gaining attraction as universities realise its impact on the climate. This was followed by water, which was reported by six universities, while four tracked wastewater as well.

Compared to categories such as commuting and waste, there were also other categories that were rarely reported. These categories include transmission and distribution loss of utilities, followed by logistics, which was reported by two of the universities. Furthermore, categories such as student inter-term travels, university investments, and student housing were reported by one university.

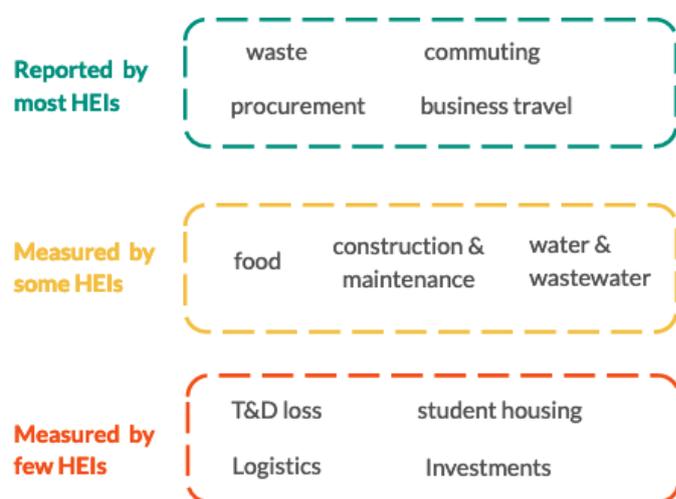


Figure 5: Reporting rate of emission sources by the assessed universities

These findings are in line with those from other similarly conducted studies. Valls-Val and Bovea (2021), who reviewed the carbon footprint of 26 universities from across the world, found commuting, waste, business travel, and consumption of paper and water to be the most reported Scope 3 emission sources. Furthermore, Kiehle et al. (2023) identified business travel and procurement as the most reported emission categories.

3.3.6 Emission Sources with Largest Impact

Few emission categories determine the overall carbon footprint of a university. Commuting, energy-related emissions (Scope 1 and 2) and procurement comprise over 90% of all GHG emissions. According to Valls-Val and Bovea (2021) and Helmers

et al. (2021), emissions from energy consumption followed by commuting have the most significant impact on the overall carbon footprint of universities. However, some articles analysed in these studies are over 10 years old. In addition, universities are shifting towards sustainable energy sources, which has lowered the energy share of their overall emissions. For instance, most universities in Finland purchase electricity that is 100 per cent from renewable energy sources.

Furthermore, none of the analysed universities included monetary-based emissions from their purchases, which significantly under-represented their procurement impact. Therefore, while energy emissions are still a major contributor to the total carbon footprint of universities, they fell to the third spot after commuting and procurement based on the author’s analysis of recent university reports.

Mobility-related emissions were the most significant contributor to the assessed universities’ total carbon footprint. The contribution range for commuting staff and students varied from 4 percent at Delft University, which is largely due to the prevalence of bike commuting, to as high as 84 percent at UCB Birkenfeld in Germany. Emissions from commuting are highly dependent on the availability of sustainable modes of transport and the provision of student housing on or near the campus.

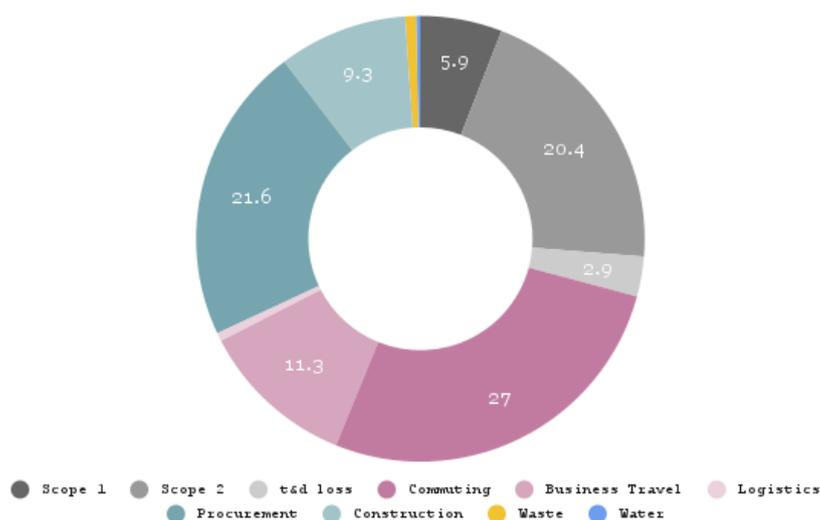


Figure 6: Contribution of emission sources to overall CF of universities

Business travel, on average, accounted for over 11 percent of the universities’ total emissions. There also seems to be a heavy correlation between a higher education institution’s research portfolio and business travel emissions. For example, at KTH

University, a top research university, business travel accounted for 55 percent of its carbon footprint, making it the largest contributing factor. Although the inter-term travel of students to their home countries was measured only by two universities, it significantly impacted their CF (after procurement, inter-term travel was the second largest emitter at Oxford University). According to a recent report by the Royal Anniversary Trust (2023), international flights by students contribute to 12% of university emissions in the UK.

Procurement was another major contributor to university emissions, however, there was a noticeable discrepancy between each university in the methods they use and emission sources they account for in their calculation. Universities that included monetary-based emissions in their calculations showed a significantly higher share of emissions than the rest that didn't include or partially included them. For instance, 55% of Manchester University and 58% of NUI Galway emissions were procurement-related, as they included all emissions from expenses in their final calculation. Purchases related to IT and Electronic equipment were found to have the most considerable impact in this category, followed by construction and maintenance and restaurant services. On the other hand, procurement of paper and office supplies accounts for less than 1 percent of university emissions.

Compared to emissions from sources mentioned above, freshwater and wastewater, waste generation and transportation of goods have a very minimal impact on the total carbon footprint of universities. On average, these emissions contribute to less than 1 percent of a university's carbon footprint. While some references (EAUC, 2022; GHG Protocol, 2011) recommend excluding these marginal emissions (less than 1%), It is still important to note that some sources have a high reduction potential.

3.3.7 Emission Sources with Highest Reduction Potential

One aim of performing a carbon footprint calculation annually is to identify emission reductions and evaluate the impact of implemented mitigation measures. Some commonly applied reduction strategies include increasing the share of renewable energy sources, implementing energy-saving policies, renovating older buildings and reducing the opening hours to lower energy-related emissions. Encouraging

sustainable commuting, decreasing the number of working days, and replacing them with virtual meetings and online lectures were identified as effective in reducing travel-related emissions. Other mitigation strategies worth noting are implementing greywater and rainwater in new buildings to reduce water emissions, incentivising waste prevention, and implementing environmentally friendly procurement policies.

Emission Sources	Applied/proposed measures to reduce the CF of Universities
Business Travel	teleconference Avoiding the use of air travel for short trips
Commuting	Working from home Transition to a four-day workweek Campaigns to encourage employees and students to switch from own vehicle to bicycles and public transport Installing charging facilities for electric vehicles Increasing number of bicycle parkings
Waste generation	Reuse or recycling of waste before sending it to landfill Incentives for waste prevention regularly conducted assessment of emissions and subsequent communication of the results
Food	Switching to/encouraging a more vegetable-based diet Promote food footprint literacy Reduce food waste
Water	Promoting the reduction of water consumption Renewing the water pipeline system and checking for leakage
Paper	Promoting digital reading Purchasing recycled paper
IT	Implementing green cloud storage
Laboratory Chemicals	Reducing solvents used in the laboratory Adopting a laboratory efficiency assessment framework

Table 3: Emission mitigation measures identified in the literature

An overview of emission mitigation strategies in universities shows that some emission categories, such as energy use, food, waste, and commuting, have a higher potential for reduction than others. In recent years, energy-related emissions (Scope 1 and 2) have noticeably had the most significant reduction among universities. All reviewed universities that reported their year-by-year carbon footprint exhibited a reduction in energy emissions over time. This is primarily caused by the continued energy efficiency measures and the increasing use of renewable sources to generate heating and electricity. Commuting and other mobility-related emissions have a high reduction potential as well. Anglia Ruskin University reduced its carbon footprint by 76 tCO₂e after implementing an online platform for students and staff to compete and win

vouchers based on their use of sustainable transportation modes (Royal Anniversary Trust, 2023). Another study estimated that a 33 per cent reduction in business travel combined with increased public transport use among students could reduce the sector's carbon footprint by 9% (Royal Anniversary Trust, 2023). In addition, it was shown that implementing sustainable water and waste management practices can considerably lower emissions from those categories. However, less attention is paid to them because of their marginal impact on the overall carbon footprint.

3.3.8 Ease of access to reliable data

Data availability is one of the most prominent challenges universities faces when calculating their emissions and, therefore, is considered the main reason for excluding specific emission sources (Robinson et al., 2017). For some emission sources, physical data is, in most cases, available. These sources include Scope 1 and Scope 2 emissions as well as waste and water consumption. On the other hand, acquiring reliable data for commuting is quite challenging, as it is highly dependent on the survey's quality, the year it was conducted, and its response rate. While all reviewed universities included commuting in their calculations, the response rate among students was between 2% and 9%. Furthermore, only two universities used a survey conducted in the same year.

Procurement is another category that universities tend to struggle with during the data collection process. Purchased goods and services are highly dependent on the availability of supplier data, which is a very time-consuming process. Furthermore, suppliers are often hard to identify; if identified, they might not receive the information they seek (Robinson et al., 2017). That is why many universities depend on their expenditures to calculate emissions from purchasing goods. Although this methodology allows for more comprehensive tracking of procurement emissions, it has limitations, elevating the final result's uncertainty level. Basing emissions on expenditure implies that lower spending equals lower emissions. However, that is not always the case, as sustainable products are often more expensive. Furthermore, this method depends highly on how each university's accounting system categorises them. A notable portion of a university's spending is often categorised in a way that does not convey what was included. Finally, it cannot account for emission reductions over time,

which is particularly significant for the renovation and construction of buildings (Herth and Blok, 2022).

Emission Sources	Data Management Recommendations
Energy Use	To provide the annual consumption of electricity or energy for heating, cooling and hot water generation, data can be more easily collected from the bills of each utility referring to the year of reference.
	If disaggregated data by buildings is not available, values referred to the whole campus can be provided.
Mobility	For HEI it can be a challenge, as well as time-consuming, to count the total number of km per mode of transportation of staff and students if data is not well organized. HEI can then set up a system for which the reimbursement of travel expenses of students and staff requires mandatory inclusion of the mode of transportation and the length (km) of the travel made.
	Due to data availability and Institutional-level arrangements, it may be necessary to combine methodologies with different degrees of accuracy: e.g. Taxis booked via corporate accounts and taxi journeys booked by staff and claimed as expenses.
	For transparency, different types of data should be reported separately.
	If institutions use a travel company then they may be able to provide carbon data (check their methodologies however!).
Procurement	Product-based emissions reporting: where actual product consumption or use data is available (e.g. weight for materials used or food delivered, or data centres), use this data to calculate emissions by applying relevant Life Cycle Assessment (LCA)-based emission factors (e.g. CO ₂ e/kg, CO ₂ e/unit, CO ₂ e/kWh).
	Service-based emissions reporting: for services where no product-specific emissions data are available collect and apply supplier- based spend data (i.e. CO ₂ e/£) based on the suppliers' Scope 1 and 2 and relevant Scope 3 emissions (most commonly Category 1 and 4).
Waste generation	Report separately for each waste material/source that has a different treatment route as required.
	the weight of waste should be considered at the point of origin (e.g., at the University), not at the point of destination (e.g., landfill or recycle premises).
Water	In the absence of wastewater meter readings, purchased water volume data is also used to estimate wastewater volume (used to report Scope 3 - 5. Waste generated in operations).
	European HEI can use the waste classification of the European Waste List to support data collection.

Table 4: Identified data management strategies for each emission category to enhance accessibility

4 An EFEU Tool For Carbon Footprint Measurement

The EFEU Carbon Footprint Calculator is designed to cater to the unique requirements of universities' administration by providing a streamlined approach to quantify their carbon footprint. Its principal aim is to empower academic professionals with a simple means of assessing their environmental impact and pinpointing avenues for emission reduction. By allowing seamless input of activity data, the calculator provides accessible and comparable results among universities from different European countries in both table and graph format. Its user-friendly features make it an essential resource for academic institutions committed to informed decisions for sustainability.

The EFEU Calculator is developed as part of the EFEU (Emission Free European Universities) project - an ongoing project funded by the Erasmus + program and the German Academic Exchange Service (DAAD) and is carried out by a strategic partnership between four European universities: Baden-Württemberg Cooperative State University (DHBW) of Germany, the Polytechnic Institute of Leiria (IPL) of Portugal, Metropolia University of Applied Sciences of Finland, and the Polytechnic University of Hauts-de-France (UPHF) in France. The project's main objective is to reduce greenhouse gas emissions of European universities and to support them on their way to becoming carbon-neutral.

4.1 Behind the Calculator - Approach

Our approach in developing the EFEU Calculator was primarily based on the needs and requirements of universities identified in the previous chapter. Throughout our analysis, the most important criteria for the development of the tool were the conceptual design, emission categories that are most relevant to universities and the corresponding emission factors. During the design of the calculator, the following requirements were taken into consideration:

- It should be based on the GHG Protocol, which is considered the most established and widely used carbon footprint framework among universities (see Table 2).
- It should be user-friendly, especially given that the tool's primary users are academic staff who may not be familiar with advanced terminologies and technicalities related to carbon footprint assessment.

- It should feature a simple interface and be developed using software that is easily available and well-known to our target group (i.e., Microsoft Excel).
- It should encompass all Scope 1 and Scope 2 emission sources, along with Scope 3 emissions most relevant to universities and having a significant impact on their total carbon footprint (more than 1%). Furthermore, the calculator should provide flexibility for users to input emission sources based on available data (e.g., both monetary and physical emission sources for procurement).
- Emission factors incorporated into the tool should be country-based, recent, and sourced from trustworthy sources.
- It should perform calculations automatically without requiring unnecessary information from the user and present the final results in both table and graphical formats.
- It should offer users the option to calculate the carbon footprint of the entire university or a single campus.
- It should include guidelines and explanations on how to use the calculator.

Emission sources: The selection of emission sources to be incorporated into the calculator was based on a review and analysis of literature on the topic, as well as recent carbon footprint reports from various European universities (refer to Table 2). The criteria for including emission categories are as follows:

- The extent to which they are considered and reported by universities. Emission sources that are rarely reported (by fewer than two universities) or not reported at all by any of the universities were excluded (see Figure 3).
- The materiality of the emission sources, considering their impact on a university's total carbon footprint. Emission sources with minimal impact (less than 1% of the total carbon footprint) were excluded.
- The reduction potential of emission sources and their relevance to the academic community (e.g., whether or not they can be reduced through measures taken by academic staff).
- The availability of data was another deciding factor in determining which emission sources to include.

Emission Factors: As recommended by most CF standards, such as the GHG Protocol, to achieve better and more accurate results, emission factors should be calculated for the region where the university is located. Therefore, the EFs incorporated in the tool are country-specific and correspond to the four countries where the EFEU university partners are located (Finland, Germany, Portugal and France). These EFs come from official and government sources of each of the countries (Syke, 2022; Ademe, 2021; UBA, 2022) as well as other international sources such as Defra (2022) and AIB (2022).

For emission sources lacking an officially published list of corresponding EFs, The EFs were either calculated or other peer-reviewed journals were used. Given that many universities typically store only the amount spent on procurement data, monetary emission factors are also integrated into the tool. To achieve this, the Exiobase 3 database, an environmentally extended multi-region input-output (EEMRIO) database, was selected. The complete list of emission factors used in the calculator, along with detailed explanations, can be found in Appendix 2 of this report and the 'Behind the Calculator' tab within the tool.

4.2 Structure of the Calculator

The EFEU Calculator is designed in Microsoft Excel, utilising a tool that is widely known and easily accessible to the public. The calculator is structured into various categories of input data, output data and information spreadsheets. The tabs requiring user input (input data) are colour-coded differently and are categorised based on emission categories. Additionally, at the top of each tab, there are guidelines providing assistance and explanations on how to use the calculator and fill in the required information. The output data are presented under the results tab where the outcome of the calculation is presented. While the computations and emission factors are thoroughly explained in both the report and the calculator, they are discreetly hidden within the calculator's interface to enhance its ease of use. The full layout of the calculator can be found in Appendix 3.

The EFEU Calculator collects general information about the university as well as data regarding the operations and services vital to the core activities of the higher education sector. These services and operations are often the major contributors to a university's

emissions and are directly or indirectly controlled by the institution. The data that is collected by the EFEU calculator are as follows:

- **General Information** about the university includes its name, country (for EFs), year of analysis, number of employees and students and whether the data is for the whole building or a campus.
- **Energy use** for the operation of the university's infrastructure and facilities including electricity, heating, and hot water.
- **Business travel** and accommodation
- **Commuting** by both students and employees to and from the university, which is highly dependent on the available modes of transport.
- **Procurement** of key materials, equipment, and services for the university.
- **Waste** generated on the university premises.

Energy Use

This section collects the data on the annual energy consumption of the university campus, including electricity, heating, and hot water. Data should be collected from the periodic bills of each utility. This section is comprised of three parts:

Electricity: Enter the annual consumption in kilowatt hours (kWh). For electricity source, select *renewable* if the purchased electricity is generated from renewable sources. Select *unknown mix* if the supplier mix of energy is unknown. Another option is to select *country average* in which the average emission intensity of grids in the selected country will be used for the calculation.

District Heating and Steam: Enter the annual consumption in kilowatt hours (kWh). If the emission factor is provided by the supplier, enter it, otherwise the country average emission factor will be applied.

Heating Fuels: Enter the annual consumption of fuels used for heating and steam in this part. Only data related to the specific applicable energy sources should be entered.

Electricity	Electricity consumption (kWh)	<input type="text"/>
	Electricity source	<input type="text" value="Country average"/>
	Emission Factor (KgCO ₂ e/kWh)	<input type="text"/>
Emissions (KgCO₂e)		0
District Heating and Steam	District heating (kWh)	<input type="text"/>
	Emission factor provided by supplier?	<input type="text"/>

Introduction
Your University
Energy Use
Business Travel
Commuting
Procurement
Waste
Results

Figure 7: Overview of an input spreadsheet

After calculating the university's carbon footprint, the EFEU calculator presents the results in both tabular and graphical formats (Figure 10). In addition to the university's annual carbon footprint, the calculator also provides carbon intensity metrics per surface area, per student, and per employee, facilitating a more effective comparison of results across universities.

5 Results from the piloting of the tool

Following the completion of the EFEU calculator's development, a decision was made to initiate a piloting phase aimed at assessing its practicality and accuracy. This phase specifically focused on testing the tool's capability to accurately calculate the carbon footprint of university campuses associated with the EFEU project. The overarching goal was not only to confirm the applicability of the tool in a real-world context but also to pinpoint any challenges that academic staff might encounter during the data collection and calculation process.

5.1 Case studies

Metropolia University of Applied Sciences is a Finnish higher education institution with 16,400 students and 920 staff members, consisting of four campuses. Myllypuro Campus, the largest campus of the university, was selected as one of the four case studies for piloting the tool. The campus was finished in 2019 and has around 6000 registered students and 500 staff members. The campus houses the faculty of Healthcare and Wellbeing as well as the faculty of Construction, and Facility and Building services. Metropolia aims for carbon neutrality by 2030 and has been measuring its carbon footprint since 2021.

The Baden-Wuerttemberg Cooperative State University (Duale Hochschule Baden-Württemberg/DHBW) was founded in 2009 and is located in different cities of Baden-Wuerttemberg in Germany. The university is mandated by law to become carbon-neutral by 2040. However, they have only recently adopted a sustainability strategy, and to date, they haven't measured and reported their carbon footprint. The DHBW Stuttgart Campus consists of three faculties (Management & Economics, Engineering and Social Work) and has around 7600 enrolled students and 460 full-time employees. The technical faculty of DHBW Stuttgart, with approx.100 full-time employees (FTEs) and 1790 enrolled students, was used as the case study.

The Polytechnic of Leiria (IPL) is a Portuguese higher education institution located in the western region of Portugal. It has five faculties and accommodates 13,000 registered students and 1,600 employees.

Finally, the Polytechnic University of Hauts-de-France (Université Polytechnique Hauts-de-France: UPHF) is a French higher education institution in Valenciennes. It was established in 1964, and its Le Mont Houy Campus accommodates around 11000 registered students and over 1200 full-time employees.

5.2 Data collection

The data collection for Metropolia was a comparatively smooth process as they have consistently measured and reported their carbon footprint since 2021. Additionally, the university has a dedicated department specifically tasked with managing this responsibility. This organisational structure facilitated identifying where to access and gather the required activity data. However, it's important to note that Metropolia's carbon footprint measurement is conducted for the entire university. Consequently, most of the stored and collected activity data pertained to the university as a whole. Only information related to the energy usage of individual buildings and the generated waste was available separately for each campus.

To compensate for the lack of campus-specific data in certain areas, estimations were made based on various criteria. For instance, data for activities like cleaning services were estimated as a percentage of the total based on gross area. Similarly, estimations were made using the number of students and employees for activities such as commuting and procurement. It is crucial to acknowledge that such estimations have their limitations. For example, in the case of mobility, the location of the campus plays a significant role in determining the mode of transportation used by students and employees for their daily commute.

DHBW Stuttgart, on the other hand, encountered numerous challenges during their data collection process. Unlike Metropolia, DHBW lacks a dedicated climate protection or sustainability manager, leading to difficulties in effectively coordinating the data collection. The most challenging aspect was locating the precise information required to complete the calculator. Due to the lack of dedicated personnel, this information is not actively monitored, and therefore, finding the right person to contact was a very time-consuming process. Even after finding and contacting them, most were reluctant to respond or cooperate as they were not obligated to do so.

The absence of a regulated data processing system, combined with data confined to the accounting department, added further complexity.

The facility and asset-related data such as energy use, waste generation, furniture and cleaning services were the easiest to collect and were retrieved from the Buildings and Assets department of Baden-Württemberg. For the commuting data, the latest survey conducted in 2018 is used, and it only includes the commuting data of students. For business travel, the available data were for the whole university, which made it hard to measure the extent to which they are attributed to the technical faculty. Collecting the information related to procurement was the most time-consuming as each emission category had to be collected from a different source, which led to a partial measurement of its emissions.

Similarly, the Polytechnic of Leiria encountered challenges while collecting activity data. A substantial portion of the required data was unavailable, as they are managed by a separate state office and not shared with the university group. Moreover, significant variations in data availability across different sectors and services within the university hindered the creation of a comprehensive and standardised dataset for carbon footprint measurement. For example, electronic waste and discarded IT equipment are not quantitatively recorded but only booked from the inventory. Furthermore, the university has not collected any data on the commuting patterns of their students and employees, and information on purchases is notably limited.

UPHF did not face any of the challenges encountered by the Polytechnic of Leiria or the DHBW, as they have a sustainability office responsible for gathering and processing the data required to measure the carbon footprint of their university campuses. All the required data for the piloting phase were retrieved from this office. One notable problem was the data related to commuting. The collected data did not differentiate between the commuting habits of employees and those of the students.

5.3 Carbon Footprint (CF) Results

After the data were collected, processed, and refined for each case study, the data were introduced into the EFEU calculator. In general, the results show the significant impact of energy use and commuting on the total carbon footprint of the university campuses (see Figure 8). Furthermore, it can be seen from the results that the emissions from purchases are also of great significance, especially when they are fully accounted for. Due to the size differences among the campuses, a considerable variation in the total carbon footprint can be observed, making it challenging to compare the final results. However, comparing the carbon intensity results by the number of users or surface area reveals a more comparable outcome (see Figure 9). The only notable difference is the University of Leiria, which shows a much smaller amount that can be attributed to missing both commuting and procurement results.

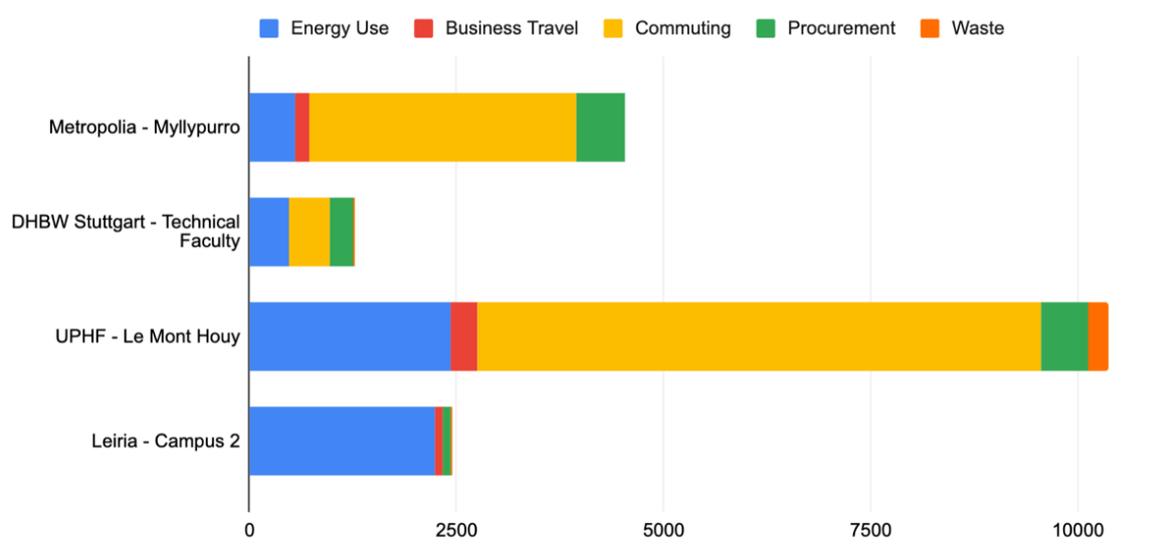


Figure 8: Carbon Footprint results of the piloting phase (t Co2e)

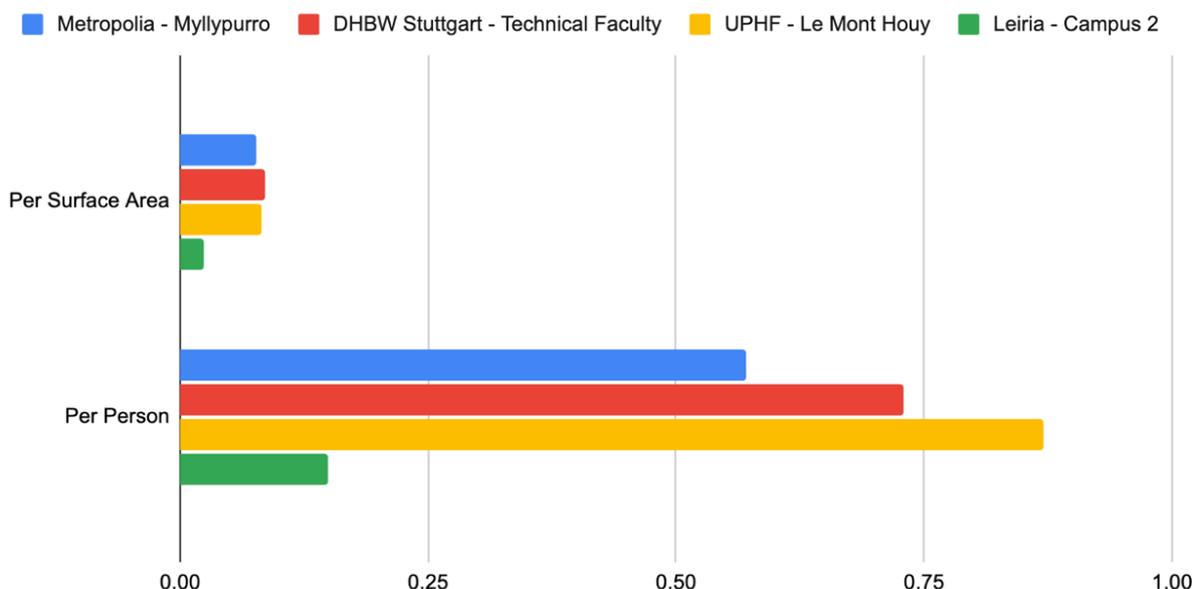


Figure 9: Carbon intensity results of the piloting phase (t CO₂e)

The results from Metropolia show that, by far, the largest contributor to its total carbon footprint is commuting, followed by procurement and energy use. To check the tool's accuracy, the results were compared with the CF report that the university published; the total CF measured by the EFEU calculator is around 20% lower. There are two reasons for this: first, the construction-related emissions, which are not included in the EFEU calculator and second, the procurement, which only considers purchases related to education and research (e.g. administrative and security costs were not included in the calculator). However, the results are almost identical when looking at the other categories, such as commuting, energy use and business travel.

Carbon Footprint Report - Metropolia Myllypurro Campus

Category	Emission Source	KgCo2e
Energy Use	Electricity	0
	District Heat	546 738
	Heating Fuels	0
Business Travel	Air Travel	151 881
	Passenger Cars	11 631
	Other Modes of Transport	1 644
	Hotel Stay	9 225
	Students Commuting	2 868 140
Commuting	Employees Commuting	358 554
	IT Equipment and Services	239 996
Procurement	Paper and Printed Materials	81 381
	Research & Lab (Core Business)	188 617
	Other Purchases	79 041
	Waste Management	16 286

Total Emissions (Kg Co2e) 4 553 135,55
4553,14 t Co2e

Total Emissions	Carbon Intensity
Per Surface Area	0,077 t Co2e
Per Employee	8,248 t Co2e
Per Student	0,610 t Co2e
Per Person	0,568 t Co2e

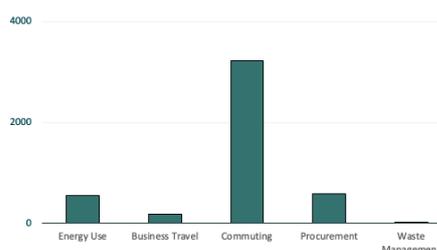


Figure 10: Carbon footprint results of Metropolia Myllypurro Campus

For DHBW, commuting and energy use, with around 38 percent, are the largest emitters of carbon footprint, followed by procurement, which contributes to 22 percent of their total CF. However, as mentioned earlier, data related to the community habits of employees were missing, which, if included, would have even further increased its share of emissions. Emissions caused by the purchase of IT equipment and services were by far the most significant procurement-related emissions. On the other hand, paper purchases and waste had a minimal impact on their total CF.

Carbon Footprint Report - DHBW Stuttgart - Technical Faculty

Category	Emission Source	KgCo2e
Energy Use	Electricity	251 570
	District Heat	228 353
	Heating Fuels	0
Business Travel	Air Travel	0
	Passenger Cars	0
	Other Modes of Transport	0
	Hotel Stay	0
Commuting	Students Commuting	493 608
	Employees Commuting	0
Procurement	IT Equipment and Services	184 145
	Paper and Printed Materials	12 361
	Research & Lab (Core Business)	0
	Other Purchases	91 103
Waste Management		13 445
Total Emissions (Kg Co2e)		1 274 584,07
		1274,58 t Co2e

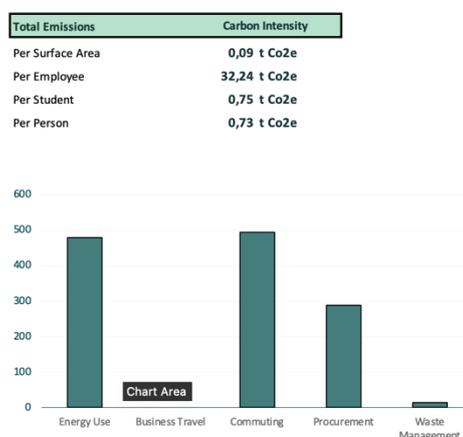


Figure 11: Carbon footprint results of DHBW Stuttgart’s Technical Faculty

The results from UPHF also indicate that commuting is the primary contributing factor to their overall carbon footprint. This is followed by energy use, which is mainly due to the use of natural gas as the main source of energy. For Leiria, energy use was the predominant contributor to their carbon footprint. However, their calculation does not include commuting as they did not conduct a mobility survey for the year of analysis, and their procurement data is not complete due to the problems mentioned in the previous section.

Carbon Footprint Report - UPHF - Le Mont Houy

Category	Emission Source	KgCo2e
Energy Use	Electricity	252 191
	District Heat	0
	Heating Fuels	2 173 915
Business Travel	Air Travel	288 800
	Passenger Cars	20 669
	Other Modes of Transport	21 294
	Hotel Stay	0
Commuting	Students Commuting	6 799 702
	Employees Commuting	0
Procurement	IT Equipment and Services	533 239
	Paper and Printed Materials	16 997
	Research & Lab (Core Business)	0
	Other Purchases	13 628
Waste Management		246 270

Total Emissions (Kg Co2e) **10 366 704,24**
10366,70 t Co2e

Total Emissions	Carbon Intensity
Per Surface Area	0,08 t Co2e
Per Employee	8,61 t Co2e
Per Student	0,97 t Co2e
Per Person	0,87 t Co2e

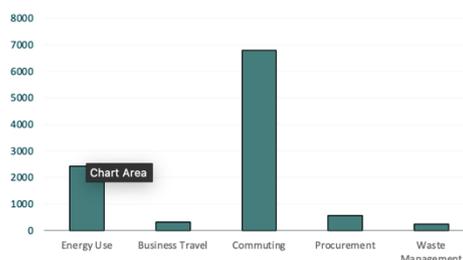


Figure 12: Carbon footprint results of UPHF Le Mont Houy

Carbon Footprint Report - Polytechnic of Leiria

Category	Emission Source	KgCo2e
Energy Use	Electricity	0
	District Heat	0
	Heating Fuels	2 247 004
Business Travel	Air Travel	0
	Passenger Cars	81 127
	Other Modes of Transport	0
	Hotel Stay	0
Commuting	Students Commuting	0
	Employees Commuting	0
Procurement	IT Equipment and Services	0
	Paper and Printed Materials	107 890
	Research & Lab (Core Business)	0
	Other Purchases	0
Waste Management		2 498

Total Emissions (Kg Co2e) **2 438 519,37**
2438,52 t Co2e

Total Emissions	Carbon Intensity
Per Surface Area	0,024 t Co2e
Per Employee	1,576 t Co2e
Per Student	0,165 t Co2e
Per Person	0,149 t Co2e

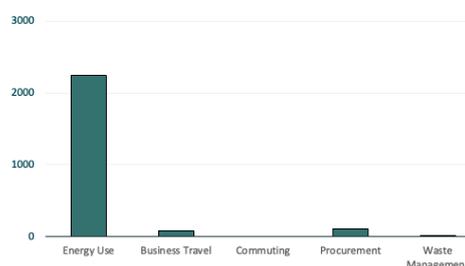


Figure 13: Carbon footprint results of Polytechnic of Leiria

6 Discussion and Recommendations on Data Management

The results from the piloting phase demonstrate the critical importance of proper data management for universities and academic staff in accurately measuring their carbon footprint. First, the responsibilities for data gathering should be clearly defined. The type of data, particularly those crucial for their CF calculation, should be identified, and the calculator results should be systematically utilised to help universities achieve their carbon-neutral goals. The identified recommendations are as follows:

- **Coordination and Leadership Support**: Ensure that data collection and analysis are coordinated by a dedicated team, with strong support from the university's leadership, to enhance efficiency and reliability. The results from the piloting of the tool showed that the universities with a centralised and dedicated team had a much easier job collecting and measuring their carbon footprint.
- **Awareness and Engagement**: Increase awareness among administrative and management staff about the calculator's purpose. Insights from pilot universities suggest that well-informed and engaged staff contribute more actively. Consider sending a general email from university leadership or authorised sustainability office members before data collection to underscore the importance of collaboration.
- **Better Data Categorisation**: Ensure the data is collected and categorised by the campus rather than by the university. Most of the universities studied in this report, and those used for piloting the EFEU Calculator categorise their data for the whole university. However, campuses have different characteristics based on their type of studies and geographical location.
- **Streamlined Communication**: Facilitate communication between university leadership and relevant administrative and management staff to emphasise the importance of their collaboration in the data collection process. This helps create a shared sense of responsibility and engagement.

7 Conclusion

This report addressed the shortcomings of current approaches to assessing universities' carbon footprints. The absence of a standardised university-specific framework has led to the use of various calculation methodologies, boundaries, emission factors, and inventories by universities. Consequently, tracking performance, comparing results, and achieving verifiable net-zero emissions have become challenging.

First, a review of existing carbon footprint frameworks and calculation tools was conducted to assess their applicability and weigh their benefits and limitations. By analysing recent carbon footprint reports and the literature, we identified emission sources crucial for determining the carbon footprint of universities. We then evaluated their impact and capacity for reduction. Finally, we examined and presented best practices for data management and collection in the university context. The outcome of this analysis was utilised to develop a transparent and effective carbon accounting tool capable of tracking university emissions and producing comparable results.

A pilot phase was conducted to validate the EFEU Calculator and identify potential challenges encountered by academic staff in assessing their campus/department's environmental impact. The calculation results underscored the significant impact of commuting, procurement, and energy use on the total carbon footprint of the university. These aspects warrant further attention, particularly since they can be significantly influenced by the actions of academic staff. Additionally, the pilot phase revealed challenges in collecting activity data for carbon footprint calculation, particularly in cases where universities lack dedicated personnel for sustainable management.

Subsequently, the report utilised the insights gained from the tool's pilot phase to provide recommendations for universities looking to measure their emissions. These recommendations are categorised into three groups: defining responsibilities for data gathering, identifying crucial data for collection, and systematically utilising calculator results to assist universities in achieving their carbon-neutral goal.

References

Bailey, G., & LaPoint, T. (2016). Comparing greenhouse gas emissions across Texas universities. *Sustainability*, 8(1), 80.

EAUC. (2022). *Standardised Carbon Emissions Reporting for Further and Higher Education*, The Alliance for Sustainability Leadership in Science

Evers, V., Srinivasan, M., Tsirulneva, L. & Yakub., L. (2022). *NTU carbon footprint framework for universities*, Nanyang Technology University

Gao, T., Liu, Q., & Wang, J. (2014). A comparative study of carbon footprint and assessment standards. *International Journal of Low-Carbon Technologies*, 9(3), 237-243.

Gómez, N., Cadarso, M. Á., & Monsalve, F. (2016). Carbon footprint of a university in a multiregional model: the case of the University of Castilla-La Mancha. *Journal of Cleaner Production*, 138, 119-130.

Helmerts, E., Chang, C. C., & Dauwels, J. (2021). Carbon footprinting of universities worldwide: Part I—objective comparison by standardized metrics. *Environmental Sciences Europe*, 33, 1-25.

Herth, A., & Blok, K. (2022). Quantifying universities' direct and indirect carbon emissions—the case of Delft University of Technology. *International Journal of Sustainability in Higher Education*, 24(9), 21-52.

Jain, S., Agarwal, A., Jani, V., Singhal, S., Sharma, P. and Jalan, R. (2017), "Assessment of carbon neutrality and sustainability in educational campuses (CaNSEC): a general framework", *Ecological Indicators*, Vol. 76, pp. 131-143.

Kiehle, J., Kopsakangas-Savolainen, M., Hilli, M., & Pongrácz, E. (2023). Carbon footprint at institutions of higher education: The case of the University of Oulu. *Journal of Environmental Management*, 329, 117056.

Larsen, H.N., Pettersen, J., Solli, C. & Hertwich, E.G. (2013). "Investigating the carbon footprint of a University - The case of NTNU", *Journal of Cleaner Production*, Vol. 48, 39-47.

Ojala, I., Pekkarinen, L. & Vainikka, M. (2023). *Metropolia's sustainability report 2022*. Metropolia University of Applied Sciences

Pires, S. M., Pulselli, F. M., Malandrakis, G. (2022). *Ecological footprint reduction recommendations for Higher Education Institutions*. Universidade de Aveiro

Robinson, O. J., Tewkesbury, A., Kemp, S., & Williams, I. D. (2018). Towards a universal carbon footprint standard: A case study of carbon management at universities. *Journal of Cleaner Production*, 172, 4435-4455.

Royal Anniversary Trust. (2022). *Accelerating towards Net Zero*.

Simpson, W. (2009). Cool Campus! A How-To Guide for College and University Climate Action Planning. *Association for the Advancement of Sustainability in Higher Education*.

Santovito, R. F., & Abiko, A. K. (2018). Recommendations for preparation of anthropogenic greenhouse gases emission inventory for University Campuses. *Towards Green Campus Operations: Energy, Climate and Sustainable Development Initiatives at Universities*, 297-313.

UNEP (2021), "Over 1,000 universities and colleges make net-zero pledges as new nature initiative is unveiled", Glasgow

UNIFI. (2020). *Theses on sustainable development and responsibility*.

Valls-Val, K., & Bovea, M. D. (2021). Carbon footprint in Higher Education Institutions: a literature review and prospects for future research. *Clean Technologies and Environmental Policy*, 23(9), 2523-2542.

Valls-Val, K., & Bovea, M. D. (2022). Carbon footprint assessment tool for universities: CO2UNV. *Sustainable Production and Consumption*, 29, 791-804.

World Business Council for Sustainable Development and World Resources Institute (2004), *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, Rev. ed., World Business Council for Sustainable Development; World Resources Institute, Geneva Switzerland, Washington, DC

World Business Council for Sustainable Development and World Resources Institute (2011), *Corporate Value Chain (Scope 3) Accounting and Reporting Standard - Supplement to the GHG Protocol Corporate Accounting and Reporting Standard*. Report, world resources institute, Geneva, Switzerland, Washington, DC

Yañez, P., Sinha, A., & Vásquez, M. (2019). Carbon footprint estimation in a university campus: Evaluation and insights. *Sustainability*, 12(1), 181.

ANNEXES

Annex 1

Detailed comparison of the reviewed universities' emission sources

University	Country	Year	Scope 1			Scope 2						
			Stationary	Car Fleet	Refrigerant	Heating	Electricity	Commuting	Business Travel	Hotel Stays	Procurement	IT
Metropolia University of Applied Sciences	Finland	2022	0.1	0.1		8.0	0.0	56.0	2.5		21.0	
Oulu University	Finland	2019	1.5	0.2		41.0	0.0	7.5	8.6		22.2	
LUT	Finland	2021				29.6	0.0	41.0	3.9		31.1	10.8
University of Helsinki	Finland	2019	1.4	0.8	0.0	19.7	23.8	7.2	8.9		34.1	4.2
Leuphana Universität Lüneburg	Germany	2016				26.8	4.0	48.7	20.0			
University of Potsdam	Germany	2019		0.2		26.6	6.0	49.5	15.2			
UCB Birkenfeld	Germany	2017	0.0	0.4		7.7	0.9	84.0	6.4			
Ghent University	Belgium	2019	34.0		0.4	5.0	9.0	18.0	31.0			
University of Twente	Netherlands	2021	7.7	0.1		2.7	65.9	12.4	1.5	2.0	1.3	0.2
Delft University	Netherlands	2018	17.0				1.0	4.0	9.0		18.0	8.0
Oxford University	uk	2020	11.4	0.2			14.7	4.5	1.9		19.8	7.3
Manchester University	UK	2019	6.0	0.1	0.0		8.0	20.0	1.7		55.3	32.0
Bologna University	italy	2018	14.5			11.2	0.0	72.4			2.3	2.2
KTH Royal Institute of Technology	Sweden	2019			0.0	7.0	2.0	4.0	55.0		25.0	6.1
The National University of Ireland	Ireland	2019	0.3	0.5		5.4	9.8	16.2	7.6	0.1	40.8	19.3

University	Scope 3										
	Paper and Print	office supply	Learning and Research	purchased services	Food	construction and maintenance	T&D Loss	Water	Wastewater	Waste	Logistics
Metropolia University of Applied Sciences						6.5			0.1	0.1	
Oulu University					13.0	5.0		0.2		1.3	
LUT	6.6			13.7	12.8					2.0	
University of Helsinki	1.9		10.2	7.6	7.5	5.5		0.1	0.2	1.0	
Leuphana Universität Lüneburg									0.3		
University of Potsdam										2.3	
UCB Birkenfeld										0.1	
Ghent University							1.0			1.0	1.0
University of Twente	0.6	0.2	0.1	0.1	0.1	2.3		0.2		4.0	
Delft University	1.0		5.0	4.0	5.0	26.0		0.0		0.0	
Oxford University			12.1	0.4		15.6	5.8			0.4	0.3
Manchester University	2.0		5.1	16.1	0.3	5.9	2.7	0.1	0.1	0.0	
Bologna University	0.1							0.2		0.1	
KTH Royal Institute of Technology			5.7			7.0				0.0	
The National University of Ireland	5.4	0.4	3.5	12.2	0.6	18.3				0.1	

Annex 2

Layout of the EFEU Calculator's input spreadsheets

General Information

Enter the general information about your university in this section. Here you can select whether your data is for the whole university or an individual campus. Fill in the rest of the information (surface area, number of employees and students) based on that selection.

Country: Make sure to select the country where your university is located before continuing with the rest of the calculation as the emission factors are country-based.

Number of employees: Enter the number of employees in full-time equivalent (FTE). For example, if 40 hours per week is considered full-time, and there are two employees working 20 hours per week, those two employees would count as 1.0 FTE.

Number of students: Only include the students that were enrolled during the reporting year. Inactive students (not enrolled) as well as outgoing exchange students should not be counted.

Your University	<input type="text" value="Metropolia University of Applied Sciences"/>
Country	<input type="text" value="Finland"/>
Analysis Year	<input type="text" value="2022"/>

Is your data for the whole university or for a single campus?	<input type="text" value="Campus"/>
Campus Name	<input type="text" value="Myllypuro"/>
Surface Area	<input type="text" value="58 918"/> sqm
Number of Employees	<input type="text" value="552"/>
Number of Students	<input type="text" value="7 463"/>

Energy Use

This section collects the data on the annual energy consumption of the university campus, including electricity, heating, and hot water. Data should be collected from the periodic bills of each utility. This section is comprised of three parts:

Electricity: Enter the annual consumption in kilowatt hours (kWh). For electricity source, select *renewable* if the purchased electricity is generated from renewable sources. Select *unknown mix* if the supplier mix of energy is unknown. Another option is to select *country average* in which the average emission intensity of grids in the selected country will be used for the calculation.

District Heating and Steam: Enter the annual consumption in kilowatt hours (kWh). If the emission factor is provided by the supplier, enter it, otherwise the country average emission factor will be applied.

Heating Fuels: Enter the annual consumption of fuels used for heating and steam in this part. Only data related to the specific applicable energy sources should be entered.

Electricity	Electricity consumption (kWh)	<input type="text" value="4 270 006"/>
	Electricity source	<input type="text" value="Renewable"/>
	Emission Factor (KgCO ₂ e/kWh)	<input type="text" value="0"/>
	Emissions (KgCO₂e)	0
District Heating and Steam	District heating (kWh)	<input type="text" value="3 529 620"/>
	Emission factor provided by supplier?	<input type="text" value="No"/>
	Emission Factor (KgCO ₂ e/kWh)	<input type="text" value="0,1549"/>
	Emissions (KgCO₂e)	546 738
Heating Fuels	Natural Gas (m ³)	<input type="text"/>
	LPG (litres)	<input type="text"/>
	Gas oil (litres)	<input type="text"/>
	Fuel oil (litres)	<input type="text"/>
	Emissions (KgCO₂e)	0
Total Emissions (KgCO₂e)		546 738,14

Business Travel

The data on the transportation of employees for business purposes and related activities (Hotel stays) are collected here. The modes of transport that are included are planes, cars, taxis, trains, buses and Ferries. Note that the unit of measurement for some of the categories are in passenger kilometers (pkm). For example 2 people travelling 100 kilometres on board a vehicle is equal to 200 pkm.

Flights Enter the annual flight distances in pkm. Air travel is split into three categories: *domestic* (>1000km), *short-haul* (within Europe) and *long-haul* (intercontinental travels). Distances between airports can be checked using online distance calculators e.g. airportdistancecalculator.com

Rental cars & Grey Fleet Enter the annual distance travelled by rental cars or claimed in km under the right fuel type. If the fuel type is not known add the travelled distance under the unknown fuel.

Other Modes of transport: Depending on the data available, taxi trips can be calculated either by the annual spend on taxi fares (in Euro) or by the distance travelled (in pkm).

Flights	Domestic (pkm)	9 983	1 745,03
	Short-haul (pkm)	461 916	77 786,65
	Long-haul (pkm)	612 095	72 349,63
	Emissions (KgCO₂e)		151 881,31
University-owned and Rental Cars	Diesel (km)	29 667	5 013,72
	Petrol (km)	11 049	2 110,36
	Electric (km)		
	Hybrid (km)		
	Unknown fuel (km)	24 765	4 507,23
	Emissions (KgCO₂e)		11631,31
Other Modes of Transport	Taxi (pkm)		
	Taxi (€)	7 188	1 150,00
	Train (pkm)		
	Bus (pkm)		
	Ferry (pkm)	2 857	494,26
	Emissions (KgCO₂e)		1644,26
Hotel Stay	Room per night	484	
	Emissions (KgCO₂e)		9225,04

Procurement

This section collects the data on the purchases of equipment and services done by the university throughout the year. For some categories, you have the option to either enter the spend data (the amount of money spent) or the physical data (number of items purchased) based on data availability. However if you have access to both data types, only enter the physical data as it is more accurate.

IT Equipment and Services Enter the number of specific IT devices purchased in the calculation year here. Alternatively, enter the amount of money spent on these devices (in Euro) under *IT Devices* .

Paper and Printed Materials Enter the annual consumption of both virgin and recycled paper in kg and the annual amount of money spent on all printed materials including books and publications.

Research & Lab Enter the annual amount of money spent on all equipment, supplies and services purchased for research study and teaching purposes.

Other Purchases Enter the annual spendings on furniture and furnishing which includes items such as desks, chairs, closets, filing cabinets, whiteboards, blackboards, shelves, bookcases/bookshelves and etc. The amount of money spent on cleaning services and supplies is gathered here as well.

IT Equipment and Services	Desktop Computer (Item)	<input type="text"/>	
	Laptop (Item)	<input type="text"/>	
	Monitor (Item)	<input type="text"/>	
	Tablet (Item)	<input type="text"/>	
	Phone (Item)	<input type="text"/>	
	IT Devices (€)	<input type="text" value="833 282"/>	<input type="text" value="141 657,86"/>
	IT Software and Licences (€)	<input type="text" value="893 983"/>	<input type="text" value="98 338,09"/>
Emissions (KgCO2e)			<input type="text" value="239 995,95"/>
Paper and Printed Materials	Paper - Virgin (Kg)	<input type="text"/>	
	Paper - Recycled (Kg)	<input type="text"/>	
	Literature & Printed Materials (€)	<input type="text" value="626 011"/>	<input type="text" value="81 381,43"/>
	Emissions (KgCO2e)		
Research & Lab (Core Business)	Equipment & Supplies (€)	<input type="text" value="447 804"/>	<input type="text" value="85 082,76"/>
	Education Services (€)	<input type="text" value="502 591"/>	<input type="text" value="75 388,65"/>
	Research & Dev Services (€)	<input type="text" value="144 561"/>	<input type="text" value="28 146,03"/>

Commuting

This section calculates the annual emissions of the transportation of employees and students from their home to the university campus. For the first part, please enter the annual distance covered by students for each mode of transportation and for the second part enter the same data but for the employees.

Commuting by Students	Bus (pkm)	6 295 626	607 527,91
	Train (pkm)	6 104 919	92 794,77
	Metro and Tram (pkm)	3 376 720	0,00
	Diesel Car (km)	4 975 726	840 897,69
	Petrol Car (km)	6 709 255	1 281 467,71
	Electric Car (km)	456 440	14 606,08
	Hybrid Car (km)	236 090	28 340,24
	Motorbike (km)		
	Mopeds and Scooters (km)	30 166	2 505,59
	Emissions (KgCO₂e)		2 868 139,99
Commuting by Employees	Bus (pkm)	318 617	30 746,54
	Train (pkm)	623 573	9 478,31
	Metro and Tram (pkm)	361 101	0,00
	Diesel Car (km)	911 512	154 045,53
	Petrol Car (km)	765 628	146 234,95
	Electric Car (km)	171 939	5 502,05
	Hybrid Car (km)	104 517	12 546,22
	Motorbike (km)		
	Mopeds and Scooters (km)		
	Emissions (KgCO₂e)		358 553,59

Waste Management

Please enter the annual amount of waste generated by the university (in tonnes) on this tab. Waste products that are commonly generated on university campuses are included in this section. Consumption data should be collected from invoices or the waste contractor reports.

Waste Management	Paper (tonnes)	1,48	107,37
	Glass (tonnes)	2,59	34,11
	Metal (tonnes)	9,69	3,36
	Plastic (tonnes)	1,70	621,98
	Cardboard (tonnes)	7,24	386,83
	WEEE (tonnes)		
	Biowaste (tonnes)	25,73	1 440,77
	Mixed Waste (tonnes)	34,23	13 692,00
	Emissions (KgCO₂e)		16286,42

Total Emissions (KgCO₂e) 16 286,42

Annex 3

Detailed list of emission factors incorporated in the EFEU Calculator

Calculator Tab

Activity

Information (sources, assumptions, etc.)

Energy Use

Electricity

The emission factors for this section are taken from the Association of Issuing Bodies (AIB,2022). Both residual and production mix factors are included in the calculator. According to the Finnish Environmental Office (SYKE,2021) the EF of green electricity is 0. The emissions caused during the transmission and distribution are not included in this section.

District Heat

Emission intensity of the district heating for each country is provided based on the country's average mix of fuels used for heating. The emission factor for Finland was taken from Statistics Finland (2020). The data for Germany was retrieved from UBA's Emissionsbilanz erneuerbarer Energieträger Report 2021.

Heating Fuels

Fuel source included in the calculator are selected based on an overview of more than 20 universities in Europe. Emission Factors for Germany are taken from the German Environmental Agency (UBA,2021), while DEFRA's report (2022) was used for the other countries.

Business Travel and Commuting

Flights

The emission factors for flights in Finland were taken from the Finnish Environmental Institute (SYKE), which is based on specific flight paths undertaken by Finnair in 2019 and were multiplied by an RFI factor of 2. The data for France is taken from Base Carbone (ADEME, 2021). For other countries, EFs were retrieved from Defra (2022)

Cars & Taxis

For simplicity, all cars are assumed to be average-sized. The same assumption was taken for taxis. Emission factors were retrieved from LIPASTO database for Finland, Base Carbone Database for France And UBA for Germany.

Motorbikes and Mopeds

EFs for Germany are retrieved from UBA's report Flüssiger "Verkehrkehr" für Klimaschutz und Luftreinhaltung" (2023). For France the conversion factor is taken from Base

Carbone (ADEME, 2021). The rest of the factors are taken from Defra (2022). Defra's emission factor for small motorbikes are used for mopeds and scooters.

Other modes of transport

Tremod's emission factors are used for Germany (IFEU, 2022). The derived EFs are based on mapping motorised traffic and their GHG emissions across Germany. For Finland, emission factors for long distance travels (bus, train, ferry) were taken from LIPASTO database, Metro and Tram from the Regional Transport. The EFs for France are from the Base Carbone's database (ADEME, 2021).

Hotel Stay

Emission intensity of average hotel nights in different countries were gathered from HotelFootprint website and DEFRA (2022). The calculated average of these EFs are used here.

Procurement

General

The spend-based emission factors (kg CO₂e per Euro spent) in this category were all retrieved from the EXIOBASE v3.8.2 using the 2019 data from all the countries that are included in the calculator.

IT

Emission factors for electronic and IT devices were calculated using the carbon footprint of products from three of the most popular brands (Apple, Samsung and Lenovo) that are published on their websites.

Paper and Printing

Emission factors for paper consumption are taken from UBA's report on life cycle assessment of paper products (2022) and Defra's emission factor database (2022). EF for printed materials and literature are retrieved from EXIOBASE v3.8.2 "printed matter and recorded media"

Waste Management

Emission factors for Finland are retrieved from the Finnish Environment Institute (2021). The rest are taken from Defra's report (2022).