EMISSION-FREE EUROPEAN UNIVERSITIES

Strategic Development of Students' Sustainability Competences

in Engineering Sciences

Work Package #4 Part A

State-of-the-art analysis for universities

on their way to emission neutrality

Part A – Activity 4.1: EFEU Mobility Survey Report

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List of Abbreviations and Acronyms

CFC – Carbon Footprint Calculator

ECTS – European Credit Transfer and Accumulation System

EFEU – Emission Free European Universities

ESD – Education for Sustainable Development

DHBW - Duale Hochschule Baden-Württemberg (Baden-Wuerttemberg Cooperative State University)

FTEs – Full-Term Employees

HEIs – Institutes for Higher Education

IPL – Polytechnic University of Leiria

Metropolia - Metropolia University of Applied Sciences

PC - Project Coordinator

PEB - Pro-environmental behaviour

PM - Project Management

SCF – Sustainable Competence Framework

SD - Sustainable Development

SDGs - Sustainable Development Goals

SDSR - Sustainable Development Social Responsibility

WPs – Work Packages

About this Publication

This publication presents the first report from Work Package 4 of the Erasmus+ Strategic Partnership project *Emission Free European Universities (EFEU).*

The report outlines the findings of a mobility survey conducted among staff and students at the partner universities. Its primary objectives are to assess and identify prevailing mobility patterns and behaviours, and to analyse and compare the extent to which different teaching methods influence the carbon footprint.

The overarching goal is to support university administrations, in collaboration with local municipalities, in implementing practical, evidence-based measures that promote low-carbon mobility solutions while addressing the needs of both the academic community and the wider public.

This report is available on the project website at:
https://www.dhbw-stuttgart.de/forschung-transfer/technik/projekte/efeu/project-outcomes/

EXECUTIVE SUMMARY

The Emission Free European Universities (EFEU) project aims to enhance sustainability competencies and achieve carbon neutrality in engineering programs at four partner institutions: Baden-Württemberg Cooperative State University (DHBW-Stuttgart), Polytechnic University of Leiria (IPL) in Portugal, Metropolia University of Applied Sciences in Helsinki, and Polytechnic University of Hauts-de-France (UPHF) in Valenciennes. One of the key focal points is to reduce the carbon footprint associated with the commuting habits of these institutions. To this end, the EFEU team developed the Mobility Survey. The main objectives are to determine the mobility habits of students and staff and examine the relationship between teaching methods and carbon footprint. The survey results will also be used to publish a best practices guide for sustainable mobility habits.

A structured, quantitative, and inductive research approach was adopted. The study combined case analyses of the four partner universities with a comprehensive online survey. The survey, available in English, Portuguese, French, German, and Finnish, collected both quantitative and qualitative data between January and March 2024. Responses were analysed using QuestionPro and Microsoft Excel, complemented by data from the EFEU Carbon Footprint Calculator, which was developed under Work Package #2.

The findings reveal substantial variation in commuting patterns influenced by infrastructure, institutional culture, and teaching formats. Car dependency remains high across most institutions, particularly at IPL and UPHF, whereas DHBW and Metropolia demonstrate lower reliance due to their central urban locations and stronger public transportation networks. Public transport, though widely accessible, remains underused due to perceived inefficiencies.

The analysis further establishes a strong link between teaching modes and carbon intensity. Institutions implementing blended and online learning show lower emissions per student, largely due to reduced commuting frequency and optimised facility usage. Metropolia recorded the lowest per capita emissions among partners, while more traditional, in-person institutions such as DHBW and UPHF exhibited higher values.

Overall, the report highlights that reducing weekly on-campus attendance from five to four days, through hybrid models or timetable restructuring, could significantly reduce CO_2 emissions. These insights underscore the potential of integrating flexible teaching methods and sustainable mobility strategies as key enablers in the decarbonisation of higher education. The forthcoming Leading Practice Publication will translate these findings into actionable

recommendations to guide HEIs toward more sustainable, inclusive and efficient mobility systems.

1 Introduction

Higher education institutions (HEIs) play a critical role in promoting sustainable practices and influencing the communities in which they operate. As such, they are expected to model the values they teach (Ramakreshnan et al., 2020; Ramchunder & Ziegler, 2021).

Universities have begun to actively contribute to environmental sustainability by implementing measures such as natural resource conservation, energy efficiency, and waste management (Ares-Pernas et al., 2020). Additionally, there is growing evidence of the successful use of university campuses as 'living laboratories' for the testing and implementation of sustainability initiatives (Ramchunder & Ziegler, 2021).

Considering sustainable mobility and teaching methods of students and staff is essential in the discourse. However, research focusing specifically on the adoption of sustainable transport practices from an institutional management perspective remains limited (Silva et al., 2024). Consequently, implementing a mobility survey is key to determining the mobility habits of students and staff. Mobility as a service can be the future (Coppola et al., 2025), but to do so, it is essential to understand trends and challenges in commuting behaviours so that proposed strategies are suitable for the contextual needs of users.

1.1 Background: Challenges, Opportunities and Critical Activities

While many HEIs have implemented policies, programs, and practices to promote sustainability, research indicates that university campuses still carry significant carbon footprints and other negative environmental impacts, presenting a challenge in meeting the goals of the 2030 Agenda.

This raises the critical question: How can universities accelerate the adoption of sustainable practices and integrate necessary changes into their educational activities to enhance overall sustainability performance?

Transportation management within higher education institutions (HEIs), particularly through the promotion of alternative transport modes and the encouragement of more sustainable and safer commuting practices, plays a pivotal role in shaping societal behaviour (Oestreich et al., 2024). By influencing students' mobility choices, HEIs contribute to the gradual adoption of sustainable practices.

The EFEU project team is a critical resource, as the team will determine mobility habits at each campus, identify sustainability trends and propose innovative approaches to foster the eco-friendly transformation of mobility with the potential for broader application in other higher education institutions and within the communities in which they exist.

1.2 Project Partners

The project consortium is made up of four universities:

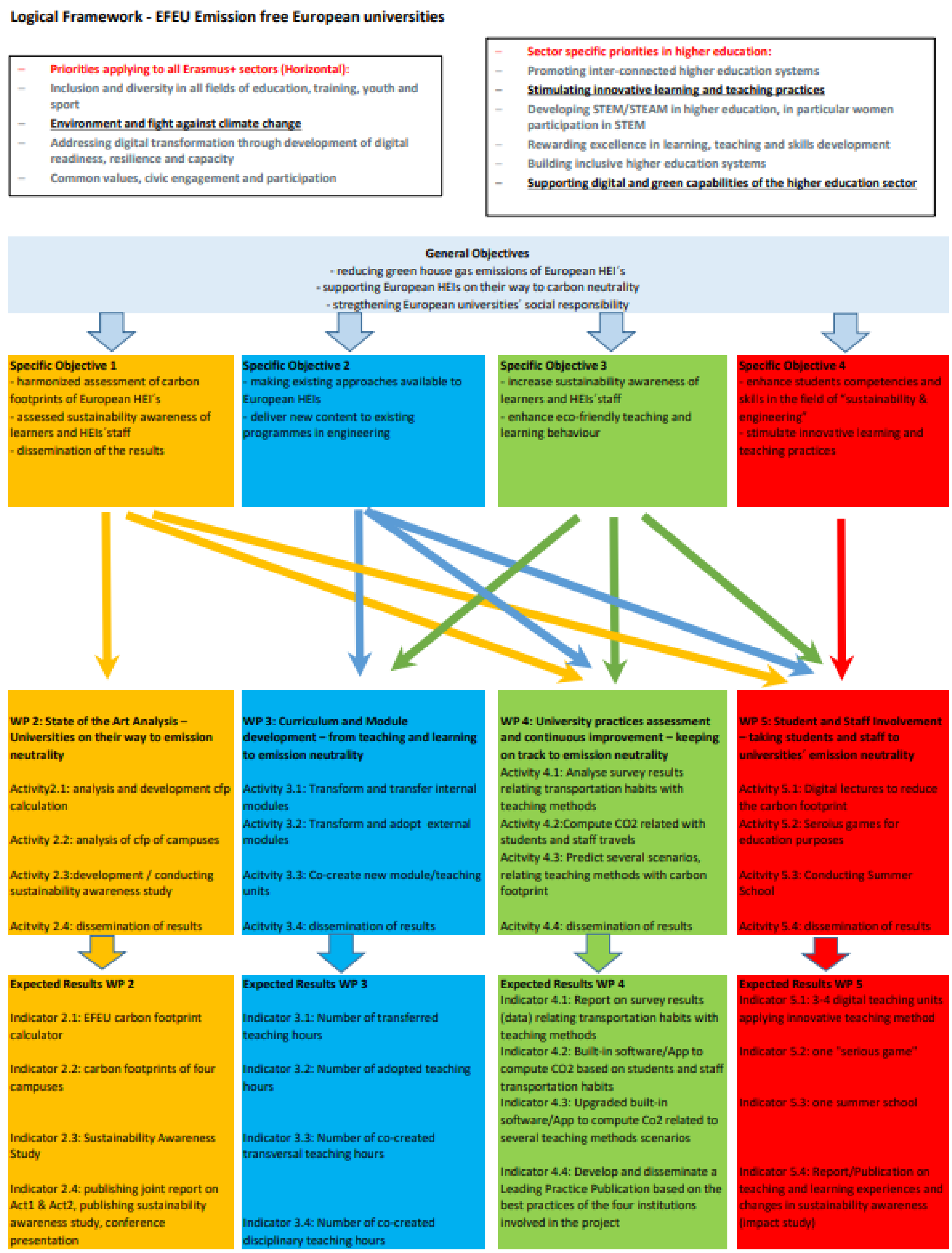
- the Baden-Württemberg Cooperative State University in Stuttgart (DHBW Stuttgart, Germany) as project coordinator and represented by the Department of Industrial Engineering & Management and the Department of Electrical Engineering;
- the Instituto Politécnico de Leiria (IPL, Portugal), represented by the Department of Mechanical Engineering;
- the Metropolia Ammattikorkeakoulu Oy (Metropolia UAS, Finland), represented by the Department of Real Estate and Building Services; and
- 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

The project is structured into five work packages (WP) (Figure 1). WP1 focuses on the project management activities. The leader of this WP is the DHBW, whom the project partners will strongly support.

Figure 1: Project Overview EFEU – Work Packages



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 ensure the timely and accurate submission of information related to project activities, results and progress, as well as financial matters.

The aims of WP2 are 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 (CFC). This tool, intended to be open-source, will be used by partner universities and eventually by universities outside 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 collect data about their university campuses and determine the carbon footprint of at least one university campus. The calculation tool should be viewed as a tracker that enables each university to monitor its levels of carbon emissions and track progress in implementing sustainability strategies and climate targets. The carbon footprint assessment results 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 create the content of WP3, WP4, and WP5, and therefore, the curricula, teaching methods, and learning 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: to develop critical competences and skills in future mechanical, electrical, industrial, and business engineers in the field of sustainability. The outcomes will be critical to the planned activities of WP5. 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:

- 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.
- Disciplinary modules that belong to existing programs. Generally, it will not be possible to create an additional module 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-term emphasis on SDSR aspects in various disciplinary modules, representing 20% of the module content. 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 SDSR 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.

WP4 will focus on the development and application of a built-in software to compute CO_2 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.
- Analyse 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 to the carbon footprint. This platform will feature built-in software to calculate CO2 emissions based on individual 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 goal of Work Package 5 is to determine the most effective 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.

Specific methodologies, procedures, and approaches established by the EFEU team will be utilised in the execution of the EFEU project and its individual work packages. As the project progresses, more specific approaches will be chosen to implement activities forming part of these work packages. These methodologies, proceedings, and approaches are presented and discussed in the following chapter.

2 Methodology

This chapter outlines the general methodologies and procedures approved by the EFEU team for developing project activities and executing 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, utilising a mixed-methods approach, resulting in five comprehensive reports and various implementations. The methods employed include a 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 the 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, CO_2 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 CFC, 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. CO_2 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 necessary actions to enable proper decision-making, supervising the consortium´s activities concerning administrative, financial, legal, and contractual aspects, monitoring 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 secure 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 a regular team meeting.

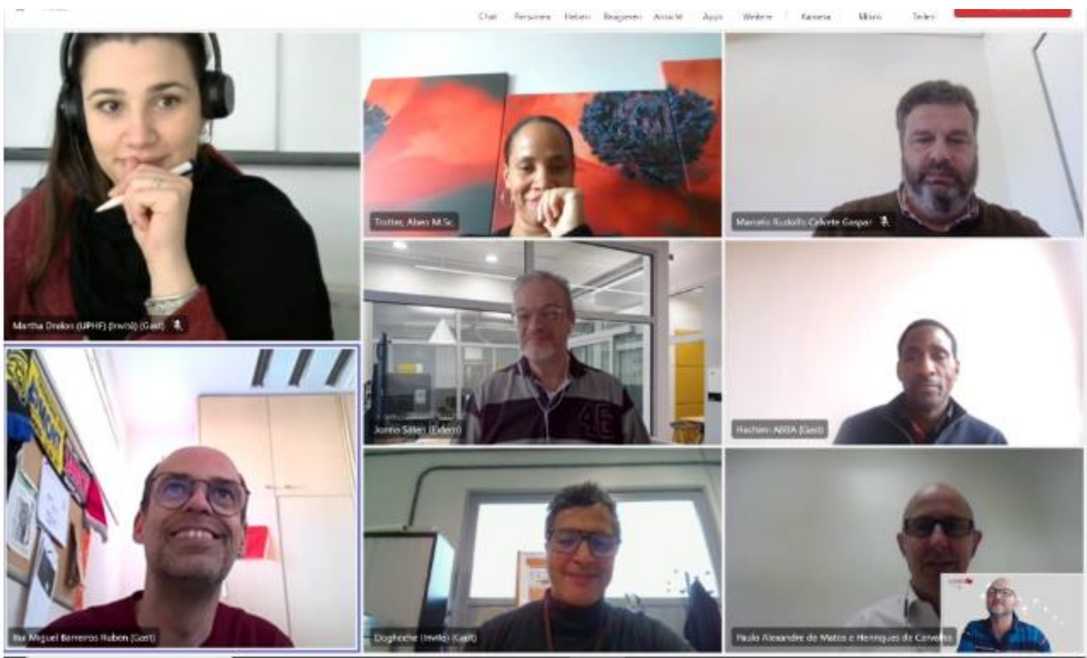


Figure 2: Online delivery via MS Teams

2.3 Methodology of EFEU Work Package #4

Practice Publication based on the best mobility practices and new proposals of the four institutions involved in this project. The platform will have built-in software to calculate carbon footprint based on mobility habits. The publication can be used by city councils to improve the public transport network, create better car parking, define new cycling roads, etc. This Publication should be the first step toward the final goal of Mobility as a Service.

The EFEU survey aimed to collectively evaluate mobility habits among students and staff. The information collected in the study is essential for preparing the digital platform and is the first step in producing the Leading Practice Publication.

2.4 Development of the EFEU Mobility Survey and Report

2.4.1 Study Design

This report follows a structured sequence of standard activities, as shown in Figure 3. Initially, a comprehensive literature review was conducted to establish a theoretical foundation for the study. This was followed by a systematic collection of data, that were presented clearly and concisely. Subsequently, these findings are discussed, and recommendations are provided based on the analysis. Finally, the study concludes by summarising the remarks.

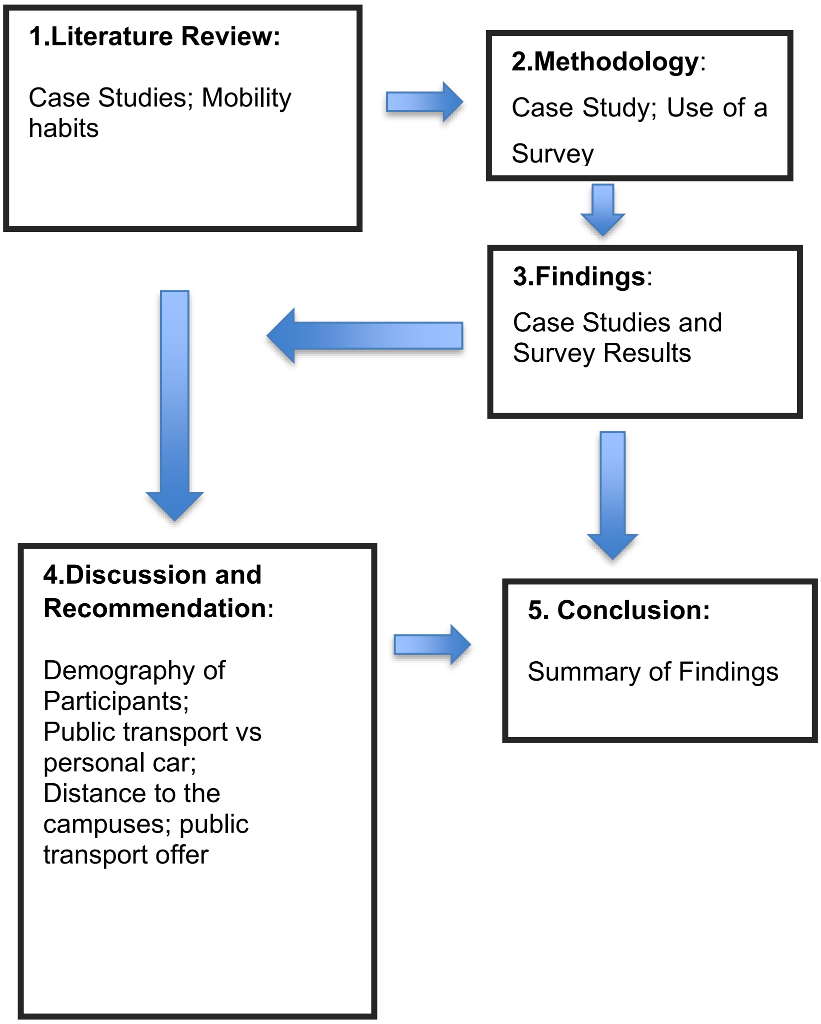


Figure 3: Study Design Matrix

2.4.2 Study Approach

This study adopts an inductive approach, as findings will be used to develop a theory, solutions, or conclusions. A quantitative approach was used. Quantitative research uses empirical assessment based on numerical measurements, and within the quantitative methods, the survey is the most commonly used data collection process (Abdus-Samad et al., 2020).

This study also involved the application of case studies. According to Robson (2002), a case study is a research strategy that includes an empirical investigation of a particular contemporary phenomenon within its real-life context. This strategy is relevant to the nature of this study, as four partner universities are focused on understanding the mobility habits of students and staff.

2.4.3 Study Development

First, case studies were reviewed to determine the significant and distinguishable features of each campus. Subsequently, a literature review was conducted to identify themes related to sustainable mobility on HEI campuses. There is a small number of research papers on the sustainable mobility of HEI students and staff (Silva et al., 2024). Thus, the EFEU project and research can play an important role in the decarbonization of education-related mobility. However, HEIs are increasing attention to mobility and pedestrian security on the campuses (Tolentino et al., 2024). Survey questions try to understand mobility habits and reasons for mobility choices. Clarification of relevant terms, significant findings and arguments in the literature are provided in Chapter 3.

The development of the survey was also based on the insights and feedback of the project team members, whose backgrounds and experience with sustainability and mobility helped with the editing and finalisation of the questions.

The survey consisted of quantitative and qualitative questions and was divided into three major parts. The first part was dedicated to determining the socio-demographic background of the participants, the second part aimed to understand their mobility habits and distance to campuses, and the third part sought to understand the reasons for using or not using public transport.

The survey was first developed in English and then translated into the languages of the project partners (Portuguese, French, German and Finnish). It was only available online via the Questionpro platform. The survey was first conducted with staff members from each partner university. The feedback was integrated to improve usability and ensure its effectiveness.

The students and staff of the engineering faculties/schools of partner universities were invited to participate via email, intranet notification, and digital signage. Respondents had the opportunity to participate from January 23rd to March 4th, 2024.

The results were analysed using QuestionPro and Microsoft Excel's analytical tools and presented in various graphical formats. Results from the EFEU Carbon Footprint

Calculator, developed during work package 2, were also integrated into this study to compare the carbon intensity of the four partner universities and their teaching methods. The data sets were then discussed, building on and exploring the theoretical framework to identify patterns, provide explanations, present key findings, and offer suitable recommendations.

2.4.4 Ethical Consideration

To administer the survey, it was necessary to obtain permission from participants in a transparent and voluntary manner. Consequently, a General Data Protection Regulation statement was provided, with the objectives of the research fully explained, and a guarantee that any acquired information would be treated with confidentiality.

3 State-of-the-Art Analysis: Mobility Habits

3.1 Introduction

Mobility habits have a significant impact on global greenhouse gas emissions. In 2019, cars were responsible for 60.6% of the GHGs in the EU. Comparatively, civil aviation emissions accounted for only 13.4% (European Parliament, 2024a). Nowadays, city councils offer good quality public transport; however, a significant number of students and staff at university campuses prefer using a personal car. Private cars have been the preferred mode of commuting to many universities around the world, as argued by various researchers, including Cappelletti et al. (2021), Perez-Neira et al. (2020), and Perez-Lopez et al. (2021).

Smooth forms of mobility, such as walking, cycling, and scooting, are increasingly being promoted as they are recognised as important ways to reduce the carbon emissions of institutions and communities. For example, universities worldwide are adopting policies to discourage car trips to campuses and encourage the use of public transportation and active modes, due to the recognised environmental and health benefits (Ribeiro and Fonseca, 2022). Despite these efforts, universities around the world are still classified as major traffic generators (Shannon et al., 2006; Romanowska et al., 2019). Accordingly, this survey is particularly timely and relevant in understanding mobility aspects and proposing workable solutions.

3.2 Mobility habits and carbon footprint

The transport sector accounts for around 20% of global CO_2 emissions and accounted for 57% of global oil demand and 28% of total energy consumption (United Nations, 2021). Thus, mobility is an important issue when considering the issue of mitigating carbon dioxide emissions. In Figure 4, we can observe that cars are responsible for more than 50% of greenhouse gas emissions in the EU.

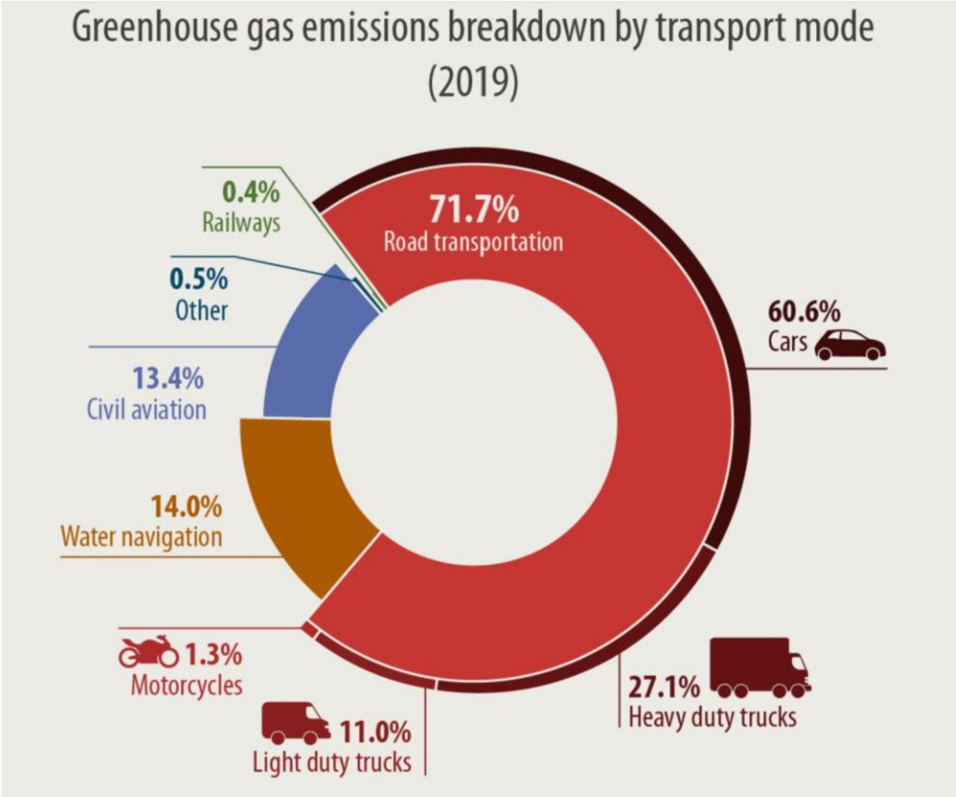


Figure 4: Greenhouse gas emissions by transport mode in the EU (EU Parliament, 2024b)

Domestic transport is, in fact, one of the most significant contributors to Emissions produced in the EU (European Parliament, 2024b). As observed in Figure 5, industry and energy supply emissions are reducing; however, domestic transport is still increasing.

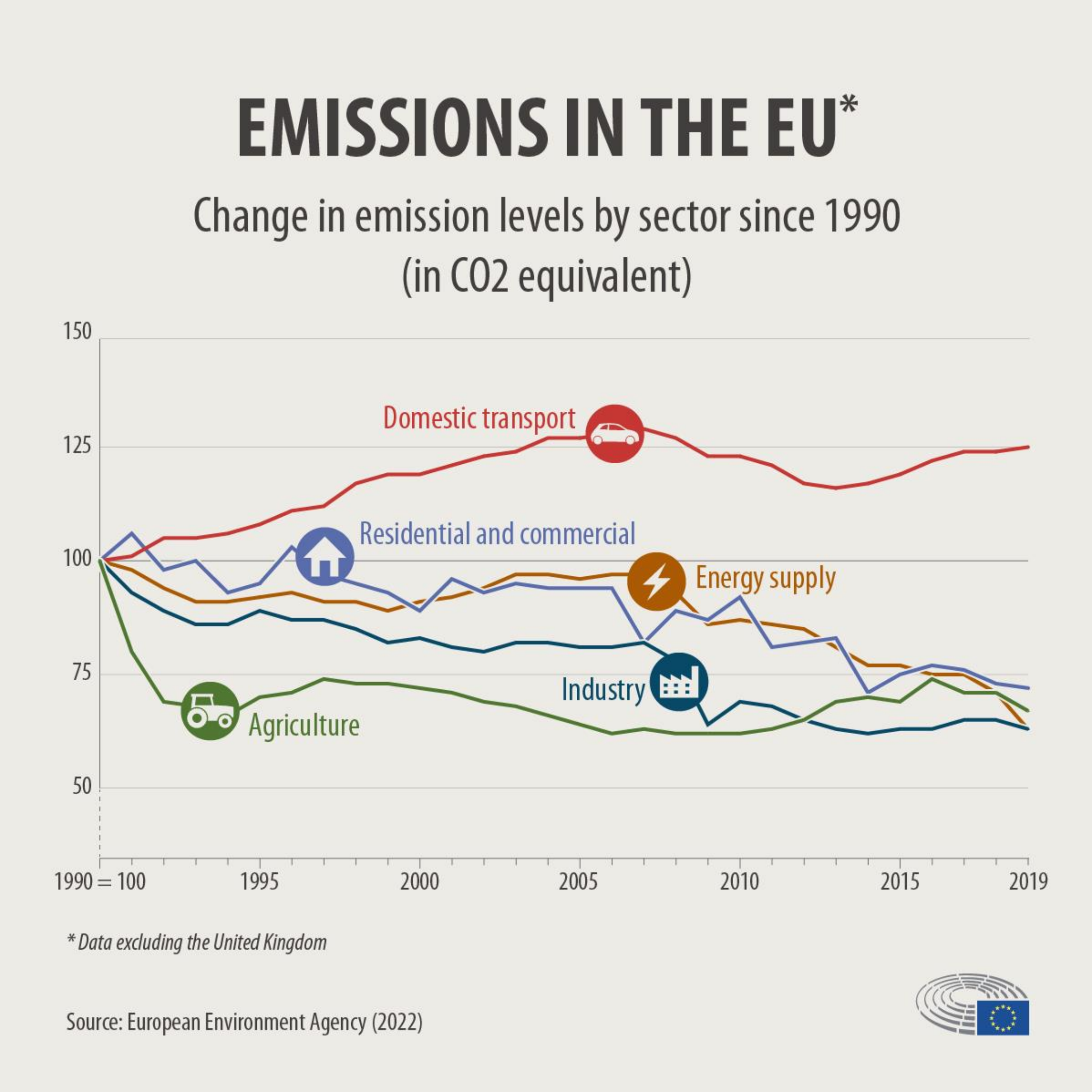


Figure 5: Emissions in the EU, 2019 (European Parliament, 2024b)

Personal cars have a significant impact on the carbon footprint (Noussan et al., 2022). They also have a growing effect on air quality, noise levels, and traffic congestion, occupying valuable urban space and preventing open and green spaces, as well as hindering kids' play and independence, or further social use of places (Thomsen, 2024). As a result, car dependence is a concept that is drawing considerable interest in mobility studies, due to the difficulty in identifying the full range of factors that contribute to this phenomenon (Muñoz et al., 2024). A few easily identifiable factors, as explained by Blaudin et al. (2021), are centred on the size of families, the lack of alternatives, and poor public transportation services.

At universities, the high use of private cars has a significant impact on the carbon footprint. For example, at San Diego State University (USA) and the Politecnico di Milano (Italy), approximately 40% of the total carbon emissions are attributed to commuting by car to the campuses (Appleyard et al., 2018; Bertolin et al., 2019).

Students represent the largest demographic within the university community, and for that reason, their mobility often shapes the transportation requirements of any city (Nguyen-Phuoc et al., 2018). Students are recognised for being a diverse population with considerable freedom and autonomy in their travel choices. As students are generally young, they are less likely to have a car and a driver’s license, and, as many live near campuses, they tend to travel by public transport and active modes (Lundberg and Weber, 2014; Danaf et al., 2014; Ma, 2015). They are also known for being more environmentally conscious and open-minded to new ideas, including in the transport domain (Gurrutxaga et al., 2017). However, researchers, including Ribeiro and Fonseca (2022), explain that many students prefer commuting by car due to the convenience that it provides.

3.3 Sustainable Mobility

Mobility is influenced by several factors, including public transportation infrastructure, ticketing systems, parking spaces, pedestrian paths, and cycling infrastructure (Silva et al., 2024). The sustainable mobility approach, on the other hand, involves policies, actions, and strategies that promote green transformation while addressing issues of accessibility, well-being, and inclusivity (Muñoz et al., 2024). The application of this approach generates a range of benefits, including environmental, health and security, transportation, and social benefits. For instance, in the city of Barcelona, after the introduction of the “Superblocks” solution, pollution and noise levels were reduced. For example, $NO2$ levels dropped by 25%, while noise levels decreased by 9 decibels (Sohn and Yun, 2009).

Mobility as a Service (MAAS)

Mobility as a service can facilitate the integration of various mobility types and transport players (Coppola et al., 2025). Real-time information and communication, as well as ticket and payment integration for various mobility services, are essential components of mobility integration aimed at reducing personal car use. Figure 4 illustrates the sustainable development scenario from 2000 to 2070, where the necessity of reducing the use of internal combustion engine vehicles is apparent.

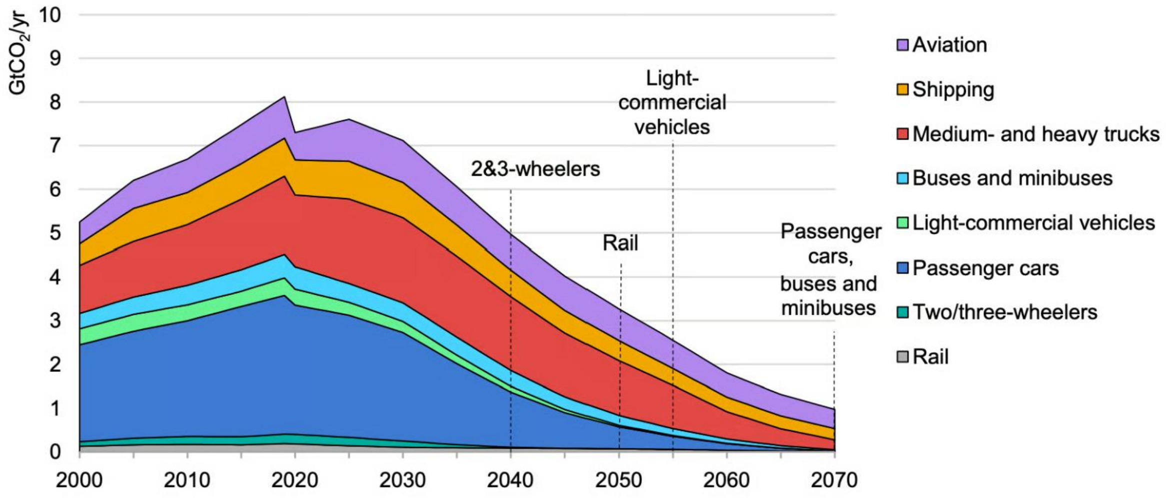


Figure 4: Global CO2 emissions in transport in Sustainable development scenario 2000-2070 (IEA – International Energy Agency)

However, mobility as a service has some barriers, such as difficulty combining different transport modes, no affinity to new technologies, and "low reliability on the new mobility services" (Lopez-Carreiro et al., 2024). In general, people are psychologically complex, and mobility behaviour is no exception. Inertia to change is prevalent in most of the population (Lopez-Carreiro et al., 2024). The inertia to change and the low affinity to new technologies are major feelings that are less present in younger persons (Zijlstra et al., 2020). HEIs students can be a key to the success of Mobility as a Service (Matyas and Kamargianni, 2021).

University Practices

Universities are unique communities with rapidly expanding populations in need of transportation options; simultaneously, they are capable of fostering an educational environment that promotes sustainability (Gulc and Budna, 2024). Numerous universities have begun planning a shift in their transportation sectors away from the use of private automobiles and toward the use of sustainable modes of transportation (Mahdavian et al., 2021). In a study conducted by Handayani et al. (2024), the effect of the Emission-Free Day on reducing emissions from motorised vehicles on a college campus was analysed. The results indicate a 4.62% reduction in emissions within the campus area. The researchers, therefore, called for stricter and more widespread measures, such as parking management, ridesharing, and further the use of public transport, to substantially reduce emissions.

The popularity and acceptance of online services are gaining momentum worldwide due to the increasing availability of low-cost mobile devices, supporting infrastructure for mobile technology, and affordability (Okai-Ugbaje et al., 2020). Although the COVID-19 pandemic was a significant challenge with notable global impacts on economic and social development, Yin et al. (2022) explained that it also increased learning possibilities for the global Higher Education (HE) sector. Online education was extensively adopted worldwide as a substitute for traditional in-person learning, resulting in significantly reduced energy consumption and lower carbon emissions (Bilecen, 2020). As pointed out by Yin et al. (2020), there is a lack of empirical studies on whether and to what extent changes to the education model can reduce carbon emissions. They, however, explained that in the field of higher education alone, the carbon emissions reduction caused by online education in half a year is equivalent to the total carbon emissions in 1.296 h in China, 2.688 h in the United States, 5.544 h in India, 12 h in Japan and 3.864 h in the OECD European countries. The findings highlight the potential of implementing online learning formats to mitigate the significant carbon footprint associated with on-campus commuting.

3.4 Conclusion

Mobility habits significantly impact the carbon footprint of university communities. Despite increasing awareness of climate change and the environmental impact of transport-related emissions, private car use remains the dominant mode of university commuting. This preference persists even in cities with well-developed public transport systems, highlighting the complexity of mobility choices, which are influenced by personal habits, infrastructure availability, convenience, and perceived reliability.

Universities, as institutions of knowledge, innovation, and cultural influence, are uniquely positioned to lead in the transition toward sustainable mobility. Their responsibility extends beyond education and research to embodying the principles of sustainability in their daily operations. While many universities have adopted policies to encourage walking, cycling, and public transport, they still contribute significantly to local traffic and emissions. The discussed examples illustrate the high proportion of campus-related emissions attributable to commuting.

Encouragingly, students represent a critical population in this shift. As generally younger, more environmentally conscious individuals who are open to adopting new technologies and ideas, they can serve as catalysts for change within their institutions and broader communities. In conclusion, addressing transport-related greenhouse gas emissions in higher education institutions requires a multifaceted approach that combines planning, education, innovation, and student engagement. By prioritising sustainable mobility in their policies and campus cultures, universities can significantly reduce their carbon footprint while modelling the transformative change needed to meet global sustainability goals, particularly those outlined in the 2030 Agenda for Sustainable Development.

To evaluate mobility patterns at the partner universities and address identified research gaps, this study aims to:

1. Assess the mobility habits of students and staff;
2. Examine the relationship between teaching methods and carbon footprint; and
3. Contribute to the development of a Best Practices Guide for Sustainable Mobility.

4 Case studies and mobility survey results

The following section presents a detailed account of the findings derived from both the case study analysis and the survey responses. These results are discussed to highlight key trends, patterns, and insights that emerged from the combined data sources.

4.1 Background

The four case studies that have been analysed are the four project partners: Metropolia University of Applied Sciences, Duale Hochschule Baden-Württemberg/DHBW-Stuttgart, Polytechnic University of Leiria (IPL), and Polytechnic University of Hauts-de-France.

The Metropolia University of Applied Sciences is a Finnish higher education institution with 16,400 students and 920 staff members, consisting of four campuses. The Myllypuro Campus, the university's largest campus, was selected for this study. The campus was finished in 2019 and has approximately 6000 registered students and 500 staff members. The campus houses the School of Healthcare and Wellbeing and the School of Real Estate and Construction. In the School of Real Estate and Construction there are to main modes of teaching: daytime studies and blended studies. For the daytime studies, students attend classes on campus on 3 days per week. Before the pandemic in 2020-2021, this used to be 4 to 5 days. Some of the online teaching practices and pedagogical solutions applied during the pandemic are still used, which has helped to reduce the number of days on campus. In the blended learning mode, students attend campus one day per week. A significant portion of learning occurs through the Moodle learning platform and online lectures. Recognition of prior formal and informal learning also reduces the need to attend classes on campus. Approximately 40% of Metropolia students study in a blended learning mode.

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 DHBW Stuttgart Campus consists of three faculties (Management & Economics, Engineering and Social Work) and has approximately 7,600 enrolled students and 460 full-time employees. The technical faculty of DHBW Stuttgart, comprising approximately 100 full-time employees (FTEs) and 1,790 enrolled students, served as the case study. At DHBW Stuttgart, the majority of lectures is given face-to-face. Each module is awarded 5 ECTS points, corresponding to a workload of 150 hours. On average, each module has 60 hours of face-to-face classes and 90 hours of self-learning time. However, there is always the possibility of switching from face-to-face classes to online classes on short notice. MS Teams channels are prepared for each course that can be used whenever needed. These channels are used at the teacher's discretion. Reasons for switching are sometimes didactic reasons, but in most cases, because the (external) teacher needs to avoid the journey to Stuttgart for reasons of his job, or because of external reasons or force majeure like train strikes or extreme weather conditions. There are also modules that are taught online entirely. Among all classes, the rate of online lectures compared to face-to-face classes is about 20%.

The Polytechnic University of Leiria (IPL) is a Portuguese higher education institution founded in 1980, located in the western region of Portugal. It has five schools: the School of Education and Social Sciences, the School of Technology and Management, the School of Health Sciences, the School of Arts and Design, and the School of Tourism and Maritime Technology. The university accommodates a total of 13,000 registered students and 1,600 employees. Currently, all IPL classes are conducted in person. Each class is held five days per week. There are some master classes that take place only three or four days a week. On average, each student has 5 hours of in-person classes per day. In alignment with the EFEU project's objective to reduce the carbon footprint of university activities, plans are being developed to shift from a five-day to a four-day weekly schedule. The plan involves two key strategies: reducing the total number of contact hours and increasing the number of contact hours per day.

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 11,000 registered students and over 1,200 full-time employees. The University generally prohibits online courses, except through its local MOOCs or European Alliance (EUNICE). These MOOCs include Polytechnic modules, 36-hour interdisciplinary courses co-taught by professors from different fields, and Openness modules, which allow students from one discipline to attend classes in another. Since the initiative began, 382 modules have been created, including 66 Polytechnic modules. Of these, 259 are entirely in-person, 42 are hybrid, and 81 are online. Within EUNICE, all courses are fully online (about 80 modules in parallel). The alliance also supports rotating, multi-university Master's programs.

Carbon Intensity Results

As this study examines the relationship between teaching methods and carbon footprints among the consortium partners, the carbon footprint results from Work Package 2 are presented in the table below.

Values (Expressed in tCO2e)	Metropolia University of Applied Sciences	DHBW-Stuttgart	IPL	UPHF
Per Surface Area	0,077	0.09	0,024	0,08
Per Employee	8,248	32,24	1,576	8,61
Per Student	0,610	0,75	0,165	0,97
Per Person	0,568	0,73	0,149	0,87

Table 1: Results of Carbon Footprint Calculation obtained from Work Package 2

It is important to acknowledge that significant challenges were encountered in the data collection process across the consortium partners. These challenges included the absence of dedicated personnel for carbon footprint reporting, the use of outdated datasets, and considerable inconsistencies in how data were measured and collected. In many cases, activity data were aggregated at the institutional level, making it challenging to isolate figures specific to teaching-related activities. Furthermore, distinctions between the commuting patterns of employees and students were often not available. As a result, many estimations had to be made using various assumptions and criteria.

In contrast, data collection for Metropolia University of Applied Sciences was comparatively smooth, as the institution has been consistently measuring and reporting its carbon footprint since 2021.

The results show that IPL (Instituto Politécnico de Lisboa) reported the lowest CO_2 emissions among the partners, despite offering most of its teaching activities in person. However, the Polytechnic of Leiria faced notable difficulties in obtaining activity data. Much of the required information was unavailable because it is managed by a separate state entity and not shared with the university. Additionally, discrepancies in data availability across different departments and services within the institution limited the ability to produce a comprehensive and standardised carbon footprint dataset.

Among the three partners with comparable datasets—Metropolia, DHBW , and UPHF -Metropolia demonstrated the lowest carbon footprint. This institution was the only one that offered a wide range of teaching models, including a daytime study mode in which students attend campus three days per week, and a blended learning model, where students attend campus one day per week. Notably, at least 40% of Metropolia students are enrolled in the blended learning mode. These varieties likely contribute to their lower carbon emissions. Based on the insights gained from the data collection activities, it is essential to consider factors beyond teaching models—such as energy efficiency, transport infrastructure, data collection and reporting practices—and the significant role they play in the reported values of institutional carbon footprints.

4.2 Survey Results

4.2.1 Profile of Participants

Of the 855 participants from the four campuses, DHBW-Stuttgart had the highest representation, comprising 37% of the total participants (318 respondents), followed by Metropolia with 27% (219 participants). The IPL and UPHF accounted for 20% (168 participants) and 18% (150 participants), respectively.

A total of 650 participants completed the entire survey. The number of completed surveys per campus, varied only slightly. The numbers were as follows: DHBW: 246, IPL: 101, Metropolia: 173, and UPHF: 130 (see Figure 7 for a visual representation). These figures indicate a satisfactory distribution of participants among the partner universities.

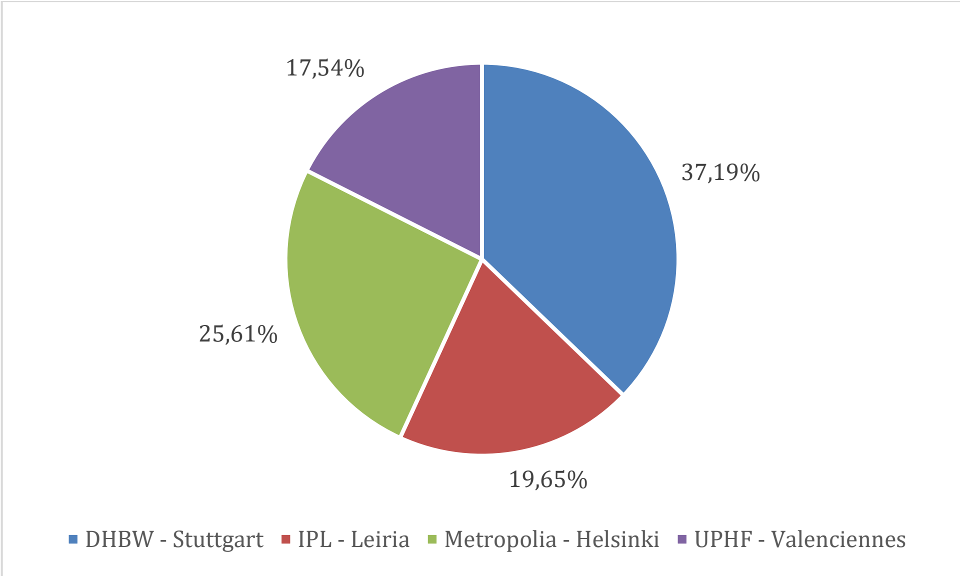


Figure 5: Percentage of Participants Per Campus

The survey predominantly comprised students, accounting for 85% (717) of the total participants, while staff (lecturers and administration) constituted 15% (127) of the respondents (see Figure 6 and Table for a detailed breakdown). Regarding survey completion, 565 students, 85 lecturers, and 85 administrative personnel completed the survey. This yields a ratio of 7 students to every staff member: a good representation of the engineering departments of each university.

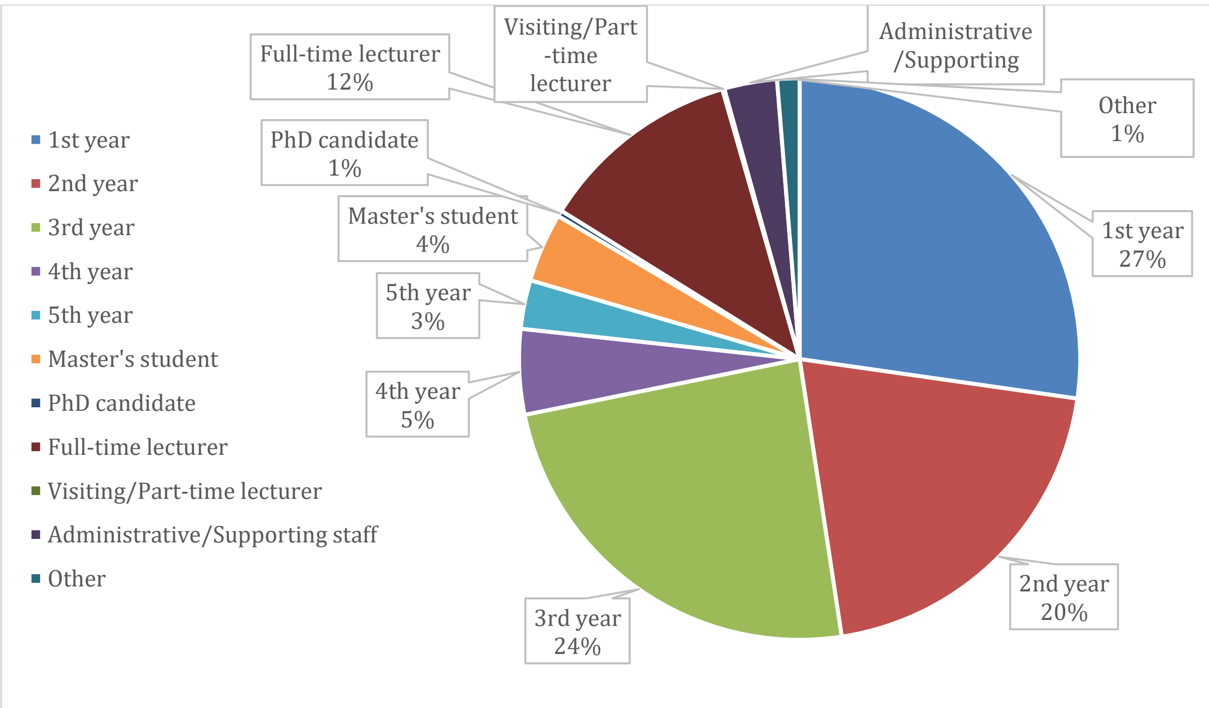


Figure 6: Profile of Participants

Table 2: Profile of Participants Per Campus

	DHBW - Stuttgart	IPL - Leiria	Metropolia - Helsinki	UPHF - Valenciennes	Total
1st year	107	26	39	61	233
2nd year	42	36	63	33	174
3rd year	100	44	52	11	207
4th year	5	4	14	19	42
5th year	16	2	2	4	24
Master's student	1	13	17	3	34
PhD candidate	3	0	0	0	3
Total no. of Students	274	125	187	131	717
Full-time lecturer	25	35	24	16	100
Visiting/Part-time lecturer	0	1	0	0	1
Administrative/ Supporting staff	13	3	7	3	26
Total no. of Lecturers/Staff	38	39	31	19	127
Other	6	4	1	0	11
Total	318	168	219	150	855

4.2.2 Mobility Habits

4.2.2.1 Students

The majority of students commute to University five days a week, as shown in Figure 9, this was followed by a four-day per week commute.

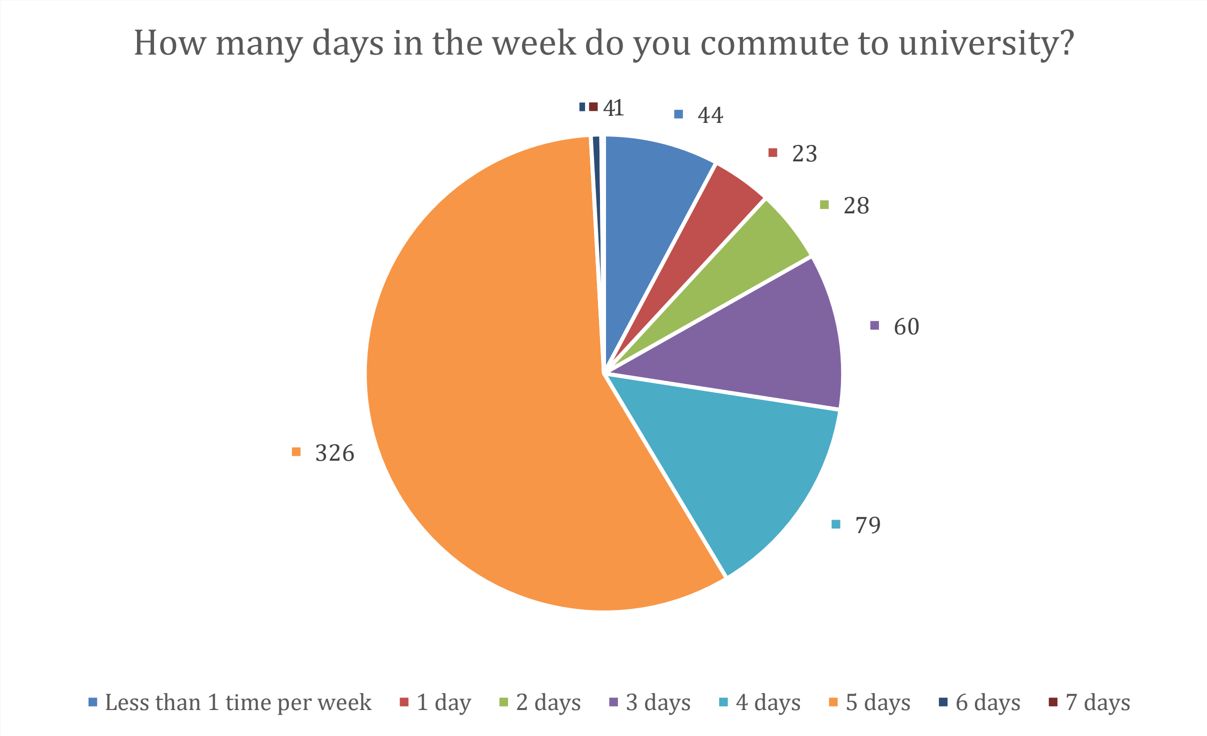


Figure 9: The number of days that students commute to university

Over the five-day period, French students had the highest commute rate (88%), while Metropolia students had the lowest (9%). In contrast, during the four-day period, Metropolia students recorded the highest commute rate (25%), with DHBW-Stuttgart students commuting the least (9%). Figures are illustrated in Table 3.

Table 3: Number of weekdays that students commute to university

Institution	5 days %	4 days %
DHBW – Stuttgart	73.06	8.68
IPL – Leiria	62.82	14.10
Metropolia – Helsinki	9.27	25.17
UPHF – Valenciennes	88.03	9.40
Total Students	**57.70**	**13.98**

Regarding the most used mode of transportation, analysis of the data, included in Table 4, revealed that more than 40% of the students use their internal combustion engine vehicles for at least 5 minutes every day.

Table 4: Mode or modes of transportation and travel time typically used by students to get to campus

Statment	Does not apply	Less than 5 minutes	5-10 minutes	11-20 minutes	21-30 minutes	31-40 minutes	41-60 minutes	61-90 minutes	More than 90 minutes	Overall

By foot	224	52	118	101	38	15	9	2	6	565
	39.65%	9.20%	20.88%	17.88%	6.73%	2.65%	1.59%	0.35%	1.06%	100%
Bicycle/scooter	504	9	16	22	4	5	1	2	2	565
	89.20%	1.59%	2.83%	3.89%	0.71%	0.88%	0.18%	0.35%	0.35%	100%
E-byke/E-scooter	537	2	10	4	6	3	2	0	1	565
	95.04%	0.35%	1.77%	0.71%	1.06%	0.53%	0.35%	0.00%	0.18%	100%
Motorcycle	532	5	8	7	5	5	3	0	0	565
	94.16%	0.88%	1.42%	1.24%	0.88%	0.88%	0.53%	0.00%	0.00%	100%
Car	330	31	50	57	40	32	14	4	7	565
	58.41%	5.49%	8.85%	10.09%	7.08%	5.66%	2.48%	0.71%	1.24%	100%
Carpool/taxi/uber	518	10	19	7	5	4	1	1	0	565
	91.68%	1.77%	3.36%	1.24%	0.88%	0.71%	0.18%	0.18%	0.00%	100%
E-car	540	4	7	5	2	2	1	0	4	565
	95.58%	0.71%	1.24%	0.88%	0.35%	0.35%	0.18%	0.00%	0.71%	100%
Bus	359	19	61	48	33	21	14	7	3	565
	63.54%	3.36%	10.80%	8.50%	5.84%	3.72%	2.48%	1.24%	0.53%	100%
Train/tram	237	18	29	79	67	47	59	16	13	565
	41.95%	3.19%	5.13%	13.98%	11.86%	8.32%	10.44%	2.83%	2.30%	100%

As shown in Table 5, DHBW students who use their own cars tend to travel relatively long distances. However, only a small proportion of DHBW students use cars at all. This may be due to the university's location in the heart of Stuttgart, where no student parking facilities are available. Additionally, Stuttgart offers an efficient public transportation system with frequent trains and buses. A closer look at the results shows that few Stuttgart students commute by car, but those who do travel considerably longer distances, increasing the overall average.

A similar scenario is observed for Metropolia. The average kilometres travelled by Metropolia students is also high, where parking facilities are available, but public transportation is also convenient, with a metro station located next to the campus.
In contrast, at Valenciennes and Leiria, most students commute by car, including those living nearby. As a result, the average travel distance in these institutions is considerably lower.

Table 5: The average number of km that students use a car

Institution	Average km	% that uses car usually
DHBW – Stuttgart	21.70	35
IPL – Leiria	11.56	87
Metropolia – Helsinki	25.91	42
UPHF – Valenciennes	17.84	65
Total Students	**19.19**	**50**

To understand the impact of car users on emissions levels, the types of vehicles used by participants were also examined. As shown in Figure 10, over 12 students reported using electric cars, while the majority—238 students—used internal combustion engine vehicles (gasoline or diesel). Only one student reported using an LPG-powered vehicle.

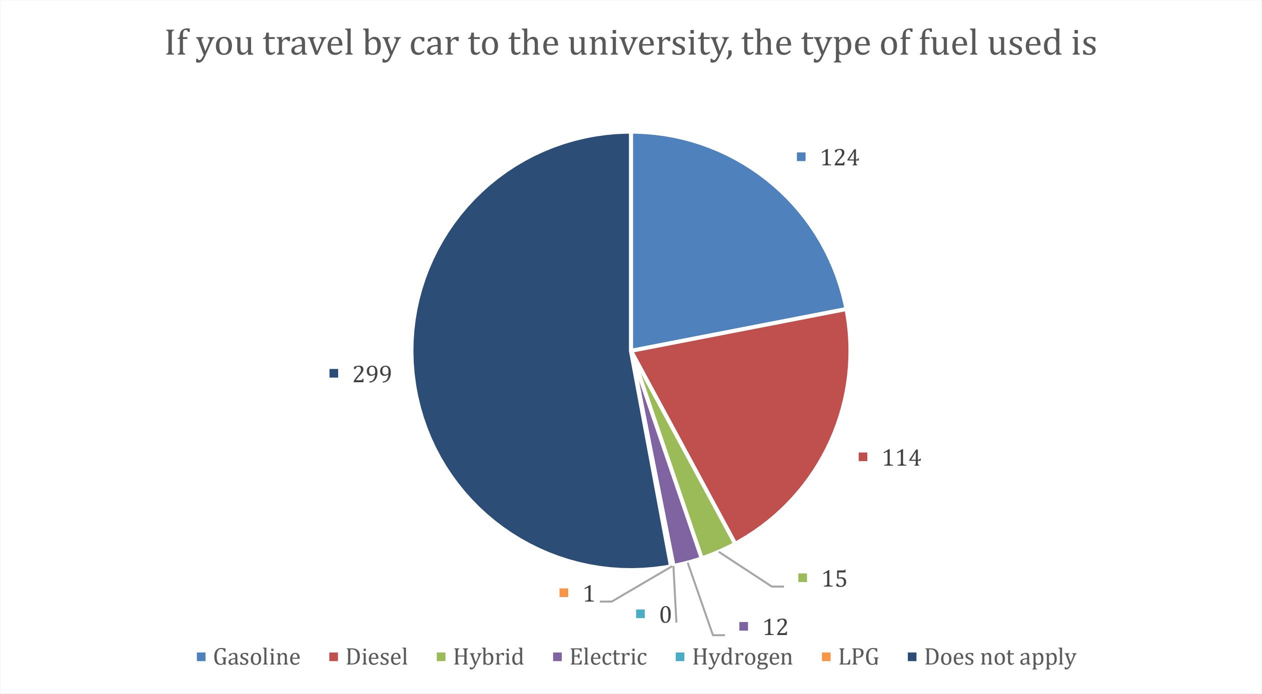


Figure 10: Type of fuel used by students

As shown in Figure 11, only 30% of students live away from their family homes and return regularly. It is not surprising, therefore, that the majority of participants felt that the question 'In what situations would you increase the number of home trips?' did not apply to them (Figure 12). Although reducing the number of in-person classes is expected to decrease commuting trips to campuses, the responses suggest little effect on return-home trips. Interestingly, the results shown in Figure 12 are consistent across all partner institutions.

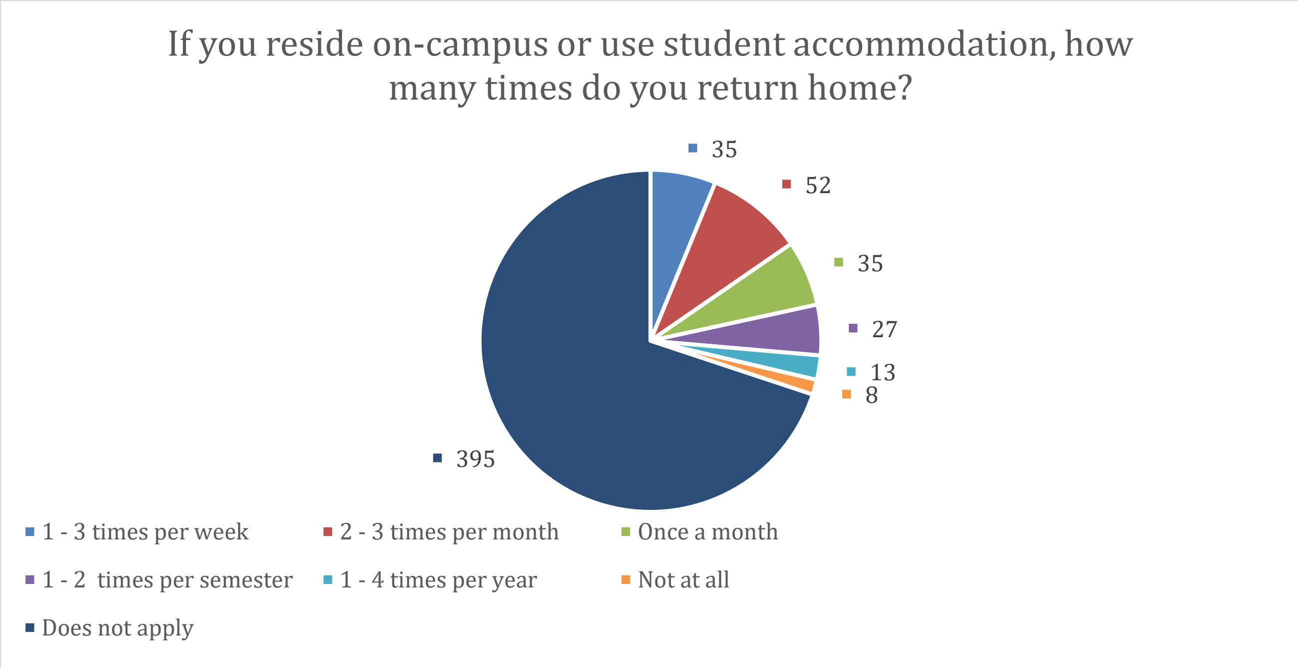


Figure 11: Quantification of time that students usually use to return home

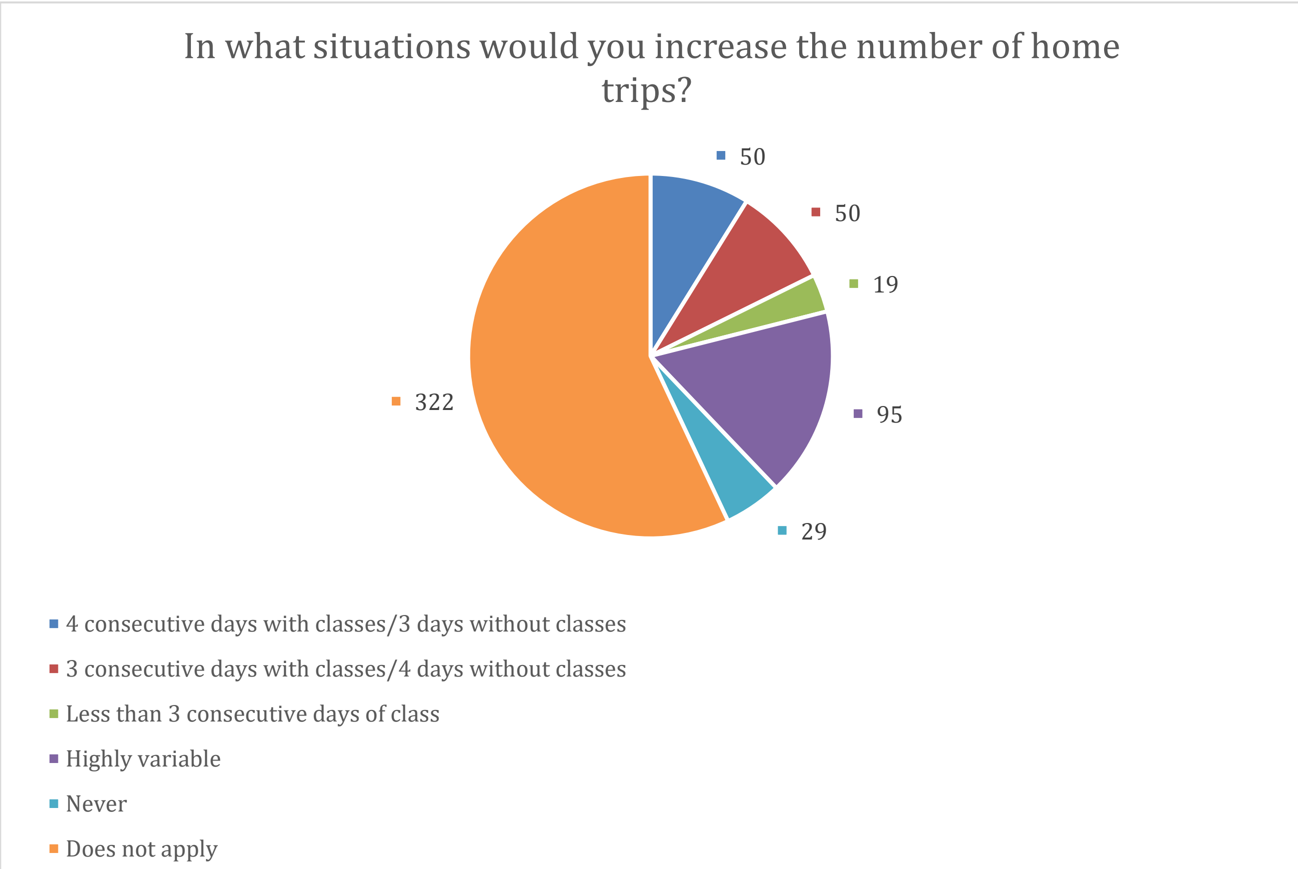


Figure 12: Quantification of situations in which students increase their number of home trips

4.2.2.2 Staff

The percentage of staff who commute 4 days or 5 days to the University is almost the same when compared to the student population. The values are provided below in Figure 13.

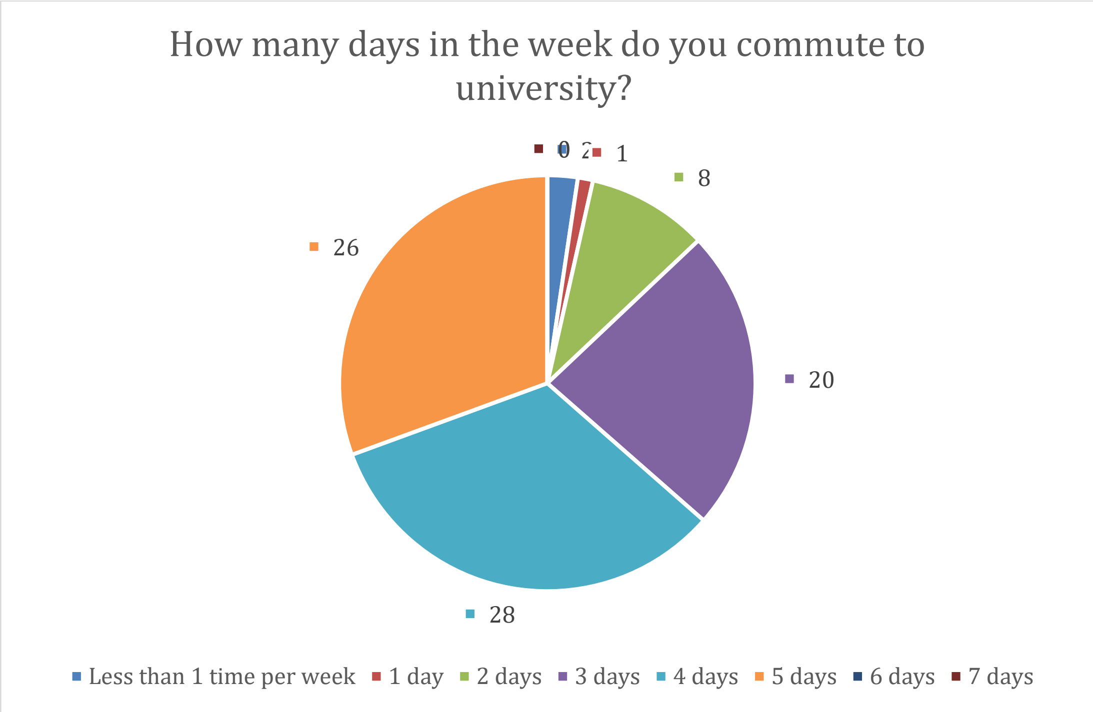


Figure 13: Number of weekdays that staff commute to university.

As indicated in Table 6, the university staff who commutes the most for the five work-week is UPHF (77%), which is followed by IPL (35%). During the four-day period, IPL staff travelled the most, with DHBW-Stuttgart staff travelling the second most. Staff members at UPHF, like students, are present on campus for the majority of the week.

Table 6: Number of weekdays that staff commute to university

Institution	5 days %	4 days %
DHBW – Stuttgart	22.22	33.33
IPL – Leiria	34.78	43.48
Metropolia – Helsinki	9.09	31.82
UPHF – Valenciennes	76.92	15.38
Total Staff	**30.59**	**32.94**

Similarly, the type of cars being used by staff was also considered. Figures from Table 7 show that almost 65% of the staff use their own internal combustion engine vehicle for at least 5 minutes every day.

Table 7: Mode or modes of transportation and travel time typically used by staff to get to campus

Statement	Does not apply	Less than 5 minutes	5-10 minutes	11-20 minutes	21-30 minutes	31-40 minutes	41-60 minutes	61-90 minutes	More than 90 minutes	Overall
By foot	62	3	5	7	4	3	1	0	0	85
	72.94%	3.53%	5.88%	8.24%	4.71%	3.53%	1.18%	0.00%	0.00%	100%
Bicycle/scooter	74	0	4	4	2	1	0	0	0	85
	87.06%	0.00%	4.71%	4.71%	2.35%	1.18%	0.00%	0.00%	0.00%	100%
E-byke/E-scooter	80	0	0	4	0	1	0	0	0	85
	94.12%	0.00%	0.00%	4.71%	0.00%	1.18%	0.00%	0.00%	0.00%	100%
Motorcycle	82	0	0	0	2	0	0	0	1	85
	96.47%	0.00%	0.00%	0.00%	2.35%	0.00%	0.00%	0.00%	1.18%	100%
Car	30	4	14	14	9	2	8	2	2	85
	35.29%	4.71%	16.47%	16.47%	10.59%	2.35%	9.41%	2.35%	2.35%	100%
Carpool/taxi/uber	80	0	2	0	0	0	3	0	0	85
	94.12%	0.00%	2.35%	0.00%	0.00%	0.00%	3.53%	0.00%	0.00%	100%
E-car	78	0	1	2	1	2	0	1	0	85
	91.76%	0.00%	1.18%	2.35%	1.18%	2.35%	0.00%	1.18%	0.00%	100%
Bus	66	0	4	7	3	3	1	0	1	85
	77.65%	0.00%	4.71%	8.24%	3.53%	3.53%	1.18%	0.00%	1.18%	100%
Train/tram	56	1	0	6	3	6	8	2	3	85
	65.88%	1.18%	0.00%	7.06%	3.53%	7.06%	9.41%	2.35%	3.53%	100%

When the question "If you travel by car, how many km do you travel between your residence and campus?" was asked, 74% of the staff use a car, and the average number of kilometres is 25.95. Metropolia staff reported the highest commuting distance, averaging 37.18 km per trip between home and campus, as shown in Table 8.

Table 8: Average Distance Travelled by Staff Using Cars and the Percentage of Staff Who Commute by Car

Institution	Average km	% that uses car ~~usually~~
DHBW - Stuttgart	21.54	48
IPL – Leiria	17.59	96
Metropolia - Helsinki	37.18	77
UPHF – Valenciennes	24.82	85
Total staff	**25.95**	**74**

With Figure , it is possible to see that more than 25 staff cars are diesel. Only 6 staff members reported having an electric vehicle.

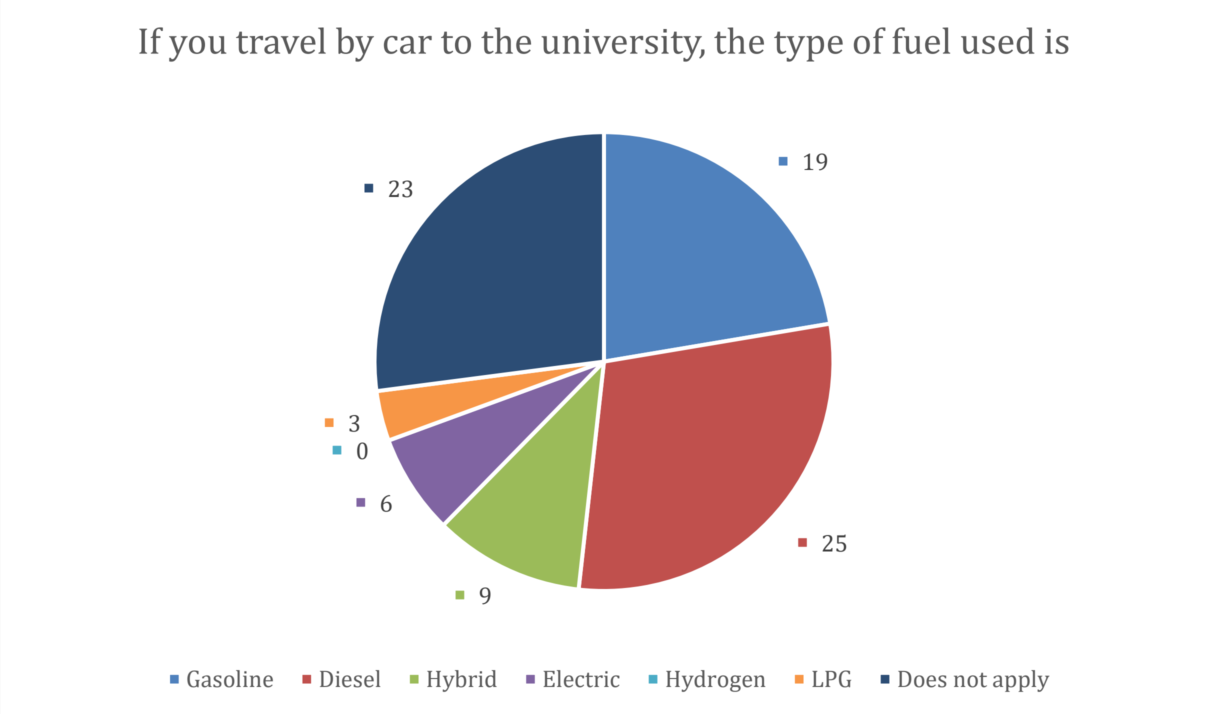


Figure 14: Type of fuel used by staff

4.2.3 Reasons for Mobility Habits

4.2.3.1 Students

According to student responses, the primary reason for using public transport is its affordability, followed by convenient routes and timetables (See Table 9).

Table 9: Reasons for Using Public Transportation - Students

Reason	DHBW - Stuttgart	IPL - Leiria	Metropolia - Helsinki	UPHF - Valenciennes	Total (%)
Lack of alternatives	86	11	26	27	150 (12.55)
Convenient route/Timetable	82	4	80	18	184 (15.40)
Comfortable seating	19	2	11	4	36 (3.01)
Cost-effective	130	18	71	43	262 (21.92)
Simple ticketing system	51	6	23	9	89 (7.45)
Avoid weather extremes	50	4	24	11	89 (7.45)
Sustainable nature	87	7	48	23	165 (13.81)
Security	9	1	10	12	32 (2.68)
Other	25	2	9	15	51 (4.27)
Does not apply	20	51	26	40	137 (11.46)
TOTAL	559	106	328	202	1195

Conversely, the most frequently cited reason students gave for not using public transport was the inconvenience of routes or timetables. This trend was consistent across all four institutions, as shown in Table 10.

Table 10: Reasons for Not Using Public Transportation - Students

Reason	DHBW - Stuttgart	IPL - Leiria	Metropolia - Helsinki	UPHF - Valenciennes	Total (%)
Unavailable	42	15	11	11	79 (9.00)
Inconvenient route or timetable	70	47	38	42	197 (22.44)
Overcrowding/Lack of privacy	38	11	15	23	87 (9.91)
Lack of comfort/Security concerns	31	10	12	16	69 (7.86)
Too costly	18	5	8	13	44 (5.01)
Complicated/unavailable ticket stations	5	6	2	4	17 (1.94)
Weather conditions	17	3	9	8	37 (4.21)
Prefer more active or sustainable forms of mobility	8	4	5	5	22 (2.51)
Other	20	9	16	4	49 (5.58)
Does not apply	117	19	89	52	277 (31.55)
TOTAL	366	129	205	178	878

As illustrated in Figure 15, nearly 80% of students have access to a public transport stop within a 10-minute walk from their homes. Despite this proximity, many still report issues with inconvenient routes or timetables, highlighting a need for further analysis and potential optimization of public transport networks to better meet student needs.

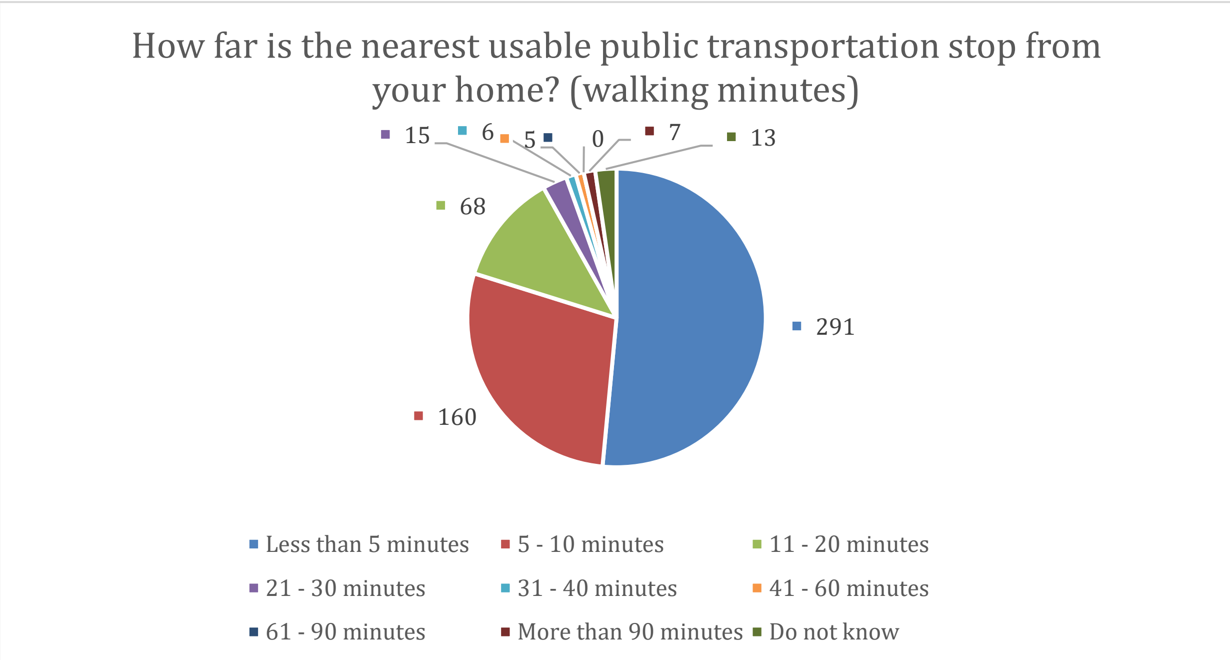


Figure 15: Number of walking minutes necessary for students in the case of usable public transportation stop from home

Through cross-tabulation, it is possible to observe, by institution, the mean and median distance travelled with internal combustion engine vehicles and the distance to a public transportation stop (Table 11). The majority of students who use fuel-powered cars daily have access to a public transport stop within a 10-minute walking distance—a pattern consistent across all the case studies.

Table 11: Student Usage of Non-Electric Cars: Average Distance and Proximity to Transport Stops.

	DHBW – Stuttgart	IPL - Leiria	Metropolia – Helsinki	UPHF - Valenciennes
Mean time driving (min)	21 – 30	11 - 20	21 – 30	11 - 20
Mean distance (km)	33.45	11.19	27.90	15.90
Mean transport stop distance (min)	11 – 20	11 - 20	5 – 10	5 - 10
Median time driving (min)	11 – 20	5 - 10	21 - 30	11 - 20
Median distance (km)	12.00	8.00	19.00	10.00
Median transport stop distance (min)	5 – 10	5 - 10	Less than 5	5 - 10

Table 12 shows the reasons students (per partner university) who use non-electric cars do not use public transport. By cross-linking Tables 10 and 11, it is possible to conclude that a significant number of students use a car for short distances. Although students have transport stops in close proximity, they do not use public transport because of inconvenient routes or timetables.

Table 12: Reasons Students (Using Non-Electric Cars) Do Not Use Public Transport

	DHBW - Stuttgart	IPL - Leiria	Metropolia - Helsinki	UPHF - Valenciennes
Unavailable	9.73%	14.71%	6.67%	8.06%
Inconvenient route or timetable	25.66%	39.22%	32.38%	29.03%
Overcrowding/Lack of privacy	17.70%	7.84%	11.43%	16.94%
Lack of comfort/Security concerns	15.93%	6.86%	10.48%	10.48%
Too costly	6.19%	4.90%	6.67%	7.26%
Complicated/unavailable ticket stations	1.77%	5.88%	0.95%	2.42%
Weather conditions	6.19%	1.96%	7.62%	6.45%
Prefer more active or sustainable forms of mobility	2.65%	0.98%	0.95%	3.23%
Other	5.31%	7.84%	12.38%	1.61%
Does not apply	8.85%	9.80%	10.48%	14.52%

4.2.3.2 Staff

Regarding staff´s responses, the primary reason for using public transport is affordability, followed by convenient routes and timetables (see Table 13).

Table 13: Reasons for Using Public Transportation - Staff

Reason	DHBW - Stuttgart	IPL - Leiria	Metropolia - Helsinki	UPHF - Valenciennes	Total (%)
Lack of alternatives	3	0	2	2	7 (4.22)
Convenient route/Timetable	15	2	9	1	27 (16.27)
Comfortable seating	3	0	1	0	4 (2.41)
Cost-effective	16	3	9	0	28 (16.87)
Simple ticketing system	10	1	3	0	14 (8.43)
Avoid weather extremes	5	0	3	1	9 (5.42)
Sustainable nature	14	2	9	3	28 (16.87)
Security	2	0	3	1	6 (3.61)
Other	5	3	0	0	8 (4.82)
Does not apply	2	17	7	9	35 (21.08)
TOTAL	75	28	46	17	166

The most commonly cited reason staff gave for not using public transport is inconvenient routes or timetables, as seen in Table 14. This trend is consistent across all four institutions, with approximately 50% of respondents at UPHF and IPL indicating this as their primary concern.

Table 14: Reasons for Not Using Public Transportation - Staff

Reason	DHBW - Stuttgart	IPL - Leiria	Metropolia - Helsinki	UPHF - Valenciennes	Total (%)
Unavailable	5	4	2	1	12 (11.76)
Inconvenient route or timetable	7	12	8	7	34 (33.33)
Overcrowding/Lack of privacy	2	0	2	0	4 (3.92)
Lack of comfort/Security concerns	0	1	2	0	3 (2.94)
Too costly	0	1	3	1	5 (4.90)
Complicated/unavailable ticket stations	0	0	0	0	0
Weather conditions	1	0	1	0	2 (1.96)
Prefer more active or sustainable forms of mobility	0	1	0	1	2 (1.96)
Other	4	4	3	1	12 (11.76)
Does not apply	16	1	8	1	28 (27.45)
TOTAL	35	24	29	12	102

Figure 16 shows that nearly 70% of staff have access to a public transport stop within a 10-minute walk from their homes. However, the high rate of personal car usage suggests that proximity alone is insufficient to encourage public transport use. Additional factors—such as efficient routes, reliable timetables, and cost-effectiveness—must also be taken into account.

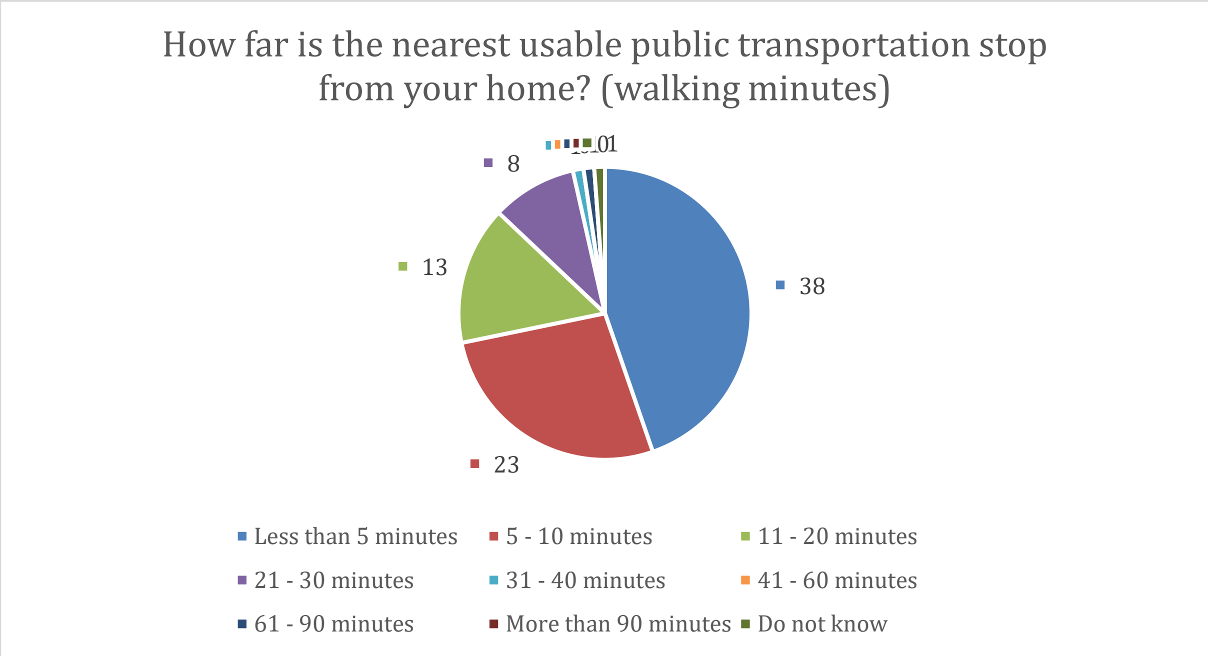


Figure 16: Number of walking minutes necessary for staff in the case of a usable public transportation stop from home

5. DISCUSSION

5.1 Mobility habits of students and staff

The survey results reveal distinct commuting patterns among students and staff across the four partner universities—DHBW-Stuttgart, IPL-Leiria, Metropolia-Helsinki, and UPHF-Valenciennes—highlighting how local infrastructure, campus location, and institutional culture shape mobility choices and, by extension, carbon intensity.

Among students, commuting five days per week remains predominant, with French students at UPHF showing the highest five-day commute rate (88%), compared with just 9% at Metropolia, where 25% of students commute four days a week. This reflects the greater flexibility in Finnish higher education, where blended and online formats allow students to reduce on-campus presence, aligning with findings by Yin et al. (2020) that online or hybrid learning reduces transport-related emissions.

The analysis of transport modes reveals a continued reliance on private cars, with approximately 50% of students using their own vehicles, mostly internal combustion engin cars. Car dependence is especially high at IPL (87%) and UPHF (65%), institutions where parking is readily available and car travel is culturally embedded. Conversely, at DHBW, only 35% of students use cars regularly, likely due to the campus's central location in Stuttgart, the absence of student parking, and a well-developed public transport system. Metropolia presents a mixed pattern—although 42% of students commute by car, the average travel distance (25.9 km) is the highest among all institutions. These findings confirm earlier research (Appleyard et al., 2018; Bertolin et al., 2019) that indicates a heavy reliance on personal cars among university commuters.

Public transport remains underused despite its proximity and affordability. Around 80% of students and 70% of staff have a public transport stop within a 10-minute walk, yet many still cite inconvenient routes or timetables as the main deterrent. This perception aligns with Blaudin et al. (2021), who noted that poor route connectivity and time inefficiency perpetuate car dependency even where infrastructure is sufficient. Moreover, short-distance car use is prevalent: many students who live near campus and have accessible transport options still drive short distances due to convenience, privacy, or poor weather conditions.

For staff, commuting intensity is comparable to that of students, with UPHF showing the highest proportion (77%) of five-day commuters, followed by IPL (35%). On average, 74% of staff travel by car, often over longer distances (25.95 km), further amplifying emissions. Metropolia staff report the longest car commutes (37.18 km), demonstrating that distance from campus and dispersed residential locations significantly affect transport emissions.

To conclude, the survey results show varied commuting patterns across DHBW-Stuttgart, IPL-Leiria, Metropolia-Helsinki, and UPHF-Valenciennes. These patterns are influenced by campus location, infrastructure, and institutional culture. Most students commute five days a week, with UPHF having the highest rate (88%) and Metropolia the lowest (9%), reflecting Finland's blended learning options that reduce on-campus trips. Car use remains dominant, with around 50% of students relying on personal vehicles, especially at IPL (87%) and UPHF (65%). Despite nearby transit stops, inconvenient routes limit the use of public transportation. Staff commuting patterns mirror those of students, with 74% driving long distances, thereby increasing emissions.

5.2 Determining the relationship between teaching methods and carbon footprint

The results indicate a clear relationship between teaching modes and the carbon intensity of higher education institutions. Institutions offering a wider range of blended and online teaching models, such as Metropolia University of Applied Sciences, generally display lower carbon emissions per student and per person. At Metropolia, approximately 40% of students study in blended mode, attending campus only once per week, while the rest participate in a reduced on-campus schedule of three days per week. This flexibility in attendance, supported by online learning platforms, has likely contributed to a reduction in commuting-related emissions. Consequently, Metropolia reported one of the lowest carbon intensities among the consortium partners (0.610 tCO_2e per student and 0.568 tCO_2e per person).

In contrast, the Baden-Wuerttemberg Cooperative State University (DHBW) primarily relies on face-to-face instruction, with only about 20% of teaching conducted online.

This more traditional mode of delivery is associated with higher carbon intensity values (0.75 tCO_2e per student and 0.73 tCO_2e per person). While DHBW has the infrastructure to switch to online teaching when needed, its regular reliance on in-person sessions increases daily commuting and on-campus energy use, both of which elevate its overall emissions.

The Polytechnic University of Leiria (IPL) presents a particular case. Despite conducting all teaching activities in person, IPL reported the lowest emissions per student (0.165 tCO_2e). However, this result must be interpreted with caution, as significant data limitations were reported, including reliance on aggregated institutional data and missing records related to commuting and facility usage. Therefore, the low emission values may reflect data constraints rather than actual performance.

At the Polytechnic University of Hauts-de-France (UPHF), the dominant teaching mode remains in-person, with only a small portion of courses offered online through MOOCs or the EUNICE European Alliance. Its carbon intensity (0.97 tCO_2e per student) remains comparatively high, likely due to a combination of factors, including its limited adoption of hybrid or blended learning models, and the energy demands of an extensive, multi-campus infrastructure. Additionally, the university has well-established and streamlined data collection methods for its CO_2 emissions.

Overall, the analysis suggests that institutions incorporating flexible, blended, or online teaching models tend to achieve lower carbon intensities, mainly due to reduced travel requirements and optimised use of facilities. However, the results also highlight that teaching mode alone does not fully explain carbon performance. Energy efficiency, infrastructure management, and data quality play equally crucial roles in determining institutional carbon footprints.

5.3 Mobility Impact on CO2 Emissions

The survey highlights that mobility has a significant impact on students' CO_2 emissions. Many students and staff rely on personal internal combustion engine (ICE) vehicles daily, rather than using public transport.

Each kilometer driven emits approximately 0.27 kg CO_2e for diesel or petrol cars, 0.12 kg CO_2e for hybrid vehicles, and 0.08 kg CO_2e for electric vehicles (EEA, 2023). Therefore, a 10 km round trip, five days a week in a diesel car, generates annual emissions equivalent to three medium European return flights (~3,000 km each).

Daily commuting, therefore, substantially contributes to carbon emissions. The survey shows an average student trip of 25.11 km. Over a three-year bachelor program, reducing commuting from five to four days per week could cut emissions by roughly one return European flight per student.

Adopting four-day on-campus schedules could be an effective strategy. While only 21% of students believe online learning is as effective as face-to-face instruction, 36% are open to a small proportion of online classes. Emissions reductions could be achieved either by introducing a modest share of online classes or by concentrating classes into four days without relying on online learning.

6. Conclusion

Higher Education Institutions (HEIs) play a pivotal role in driving the transformative shift required to cultivate long-term sustainable thinking, attitudes, and behaviours for commuting habits. To fulfil this role, universities must further policies and practices that promote more equitable and efficient transportation systems within the campuses and associated communities.

The analysis of mobility habits, teaching methods, and their combined impact on CO_2 emissions across the four partner universities—DHBW Stuttgart, IPL Leiria, Metropolia Helsinki, and UPHF Valenciennes—demonstrates a clear interconnection between institutional practices and environmental outcomes. Commuting patterns are largely influenced by campus location, transport infrastructure, and teaching formats. Institutions situated in central urban areas with strong public transport networks, such as DHBW, show lower car dependency, whereas universities with suburban or multi-campus structures, such as UPHF and IPL, experience higher reliance on private vehicles.

The findings also reveal that teaching modalities have a significant impact on carbon intensity. Universities integrating blended or online learning, such as Metropolia, achieve lower per capita emissions by reducing commuting frequency and optimising facility use. In contrast, institutions relying predominantly on face-to-face instruction report higher emissions due to daily travel and on-site energy consumption. Nevertheless, teaching mode alone cannot account for overall carbon performance; factors such as energy management efficiency, data accuracy, and institutional culture are equally critical.

The data suggest that reducing weekly on-campus attendance from five to four days—either through hybrid teaching or timetable restructuring—can substantially mitigate emissions without compromising educational quality. Encouraging sustainable transport behaviours, improving public transit accessibility, and promoting flexible teaching schedules collectively represent strategic pathways toward decarbonising university operations and aligning institutional practices with broader sustainability goals.

The findings of this report will inform the development of a publication on leading practices, offering actionable recommendations for the higher education community. The publication will present a range of strategies, emphasising the importance of reducing mobility and adopting more sustainable teaching approaches—such as hybrid, face-to-face, and fully online learning models. By promoting these methods, institutions can effectively lower students' carbon footprints while simultaneously enhancing their overall quality of life.

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