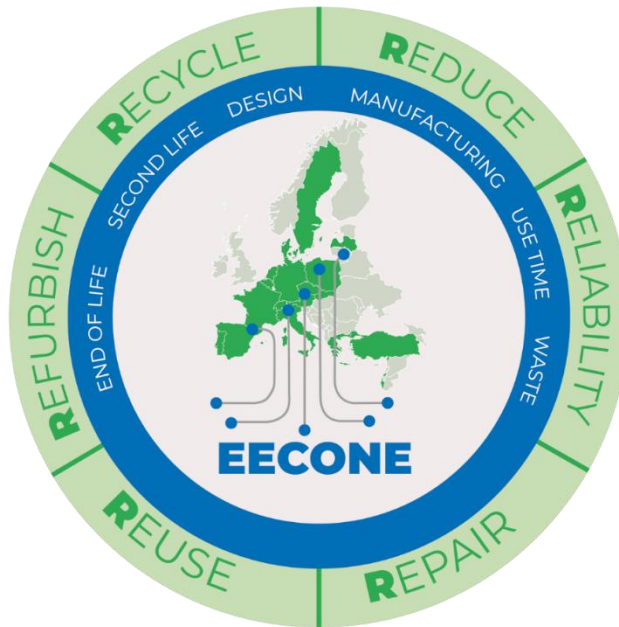


EECONE PROJECT: European ECOsystem for Green Electronics



Engineering Research Project
Master in electrical engineering in Smart Grids and Buildings
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1. Abstract

The management of electronic waste (e-waste) is a critical environmental concern that significantly contributes to climate change. The EECONE project aims to address this issue by establishing a comprehensive European ecosystem for green electronics, aligning with the Green Deal objectives and the Circular Economy Action Plan. This project involves innovative research and transformative approaches to mitigate the environmental impact of e-waste, focusing on the entire value chain from raw material suppliers to consumers.

The project emphasizes the development of robust models and methodologies to accurately estimate and reduce CO₂ emissions at the project level, incorporating environmental considerations into decision-making processes. Key objectives include defining green electronics, developing sustainable techniques for reducing, repairing, reusing, refurbishing, and recycling electronic components and systems (ECS), and showcasing green solutions across various sectors.

Through interdisciplinary collaboration and comprehensive data collection, the project aims to create an automated model for calculating CO₂ emissions, fostering transparency and accountability. The ultimate goal is to advance towards a zero-waste electronics industry guided by the "6R concept" (Reduce, Reliability, Repair, Reuse, Refurbish, Recycle), positioning Europe as a leader in environmentally sustainable electronics.

2. Introduction

Background

The management of electronic waste, or e-waste, is a pressing environmental concern contributing to climate change. This issue is particularly critical in Europe, where it aligns with the Green Deal objectives and the Circular Economy Action Plan.

Addressing e-waste is crucial not only for mitigating its direct environmental impacts but also for reducing the greenhouse gas emissions associated with the production and disposal of electronic devices.

Achieving circularity in the electronics industry is a highly complex task, as it requires the involvement of the entire value chain - from raw material suppliers to consumers.

Additionally, navigating the intricate material composition of electronic devices and managing various competing interests within the industry further adds to this complexity. Therefore, innovative research and transformative approaches are needed to effectively address e-waste and its broader environmental implications. This emphasizes the urgent need for a fundamental shift in how we approach this critical issue.

Problem Statement

Model Development: Developing a robust model to accurately estimate CO2 emissions at the project level is essential. This model will serve as a valuable tool for project planners, environmental scientists, and policymakers, empowering them to make informed decisions and implement strategies to reduce environmental impact.

Methodology Formulation: Our goal is to establish a robust methodology that centers on optimizing and reducing CO2 emissions during project-related meetings. We seek to develop a methodological framework within the context of project proceedings. This entails creating a systematic approach to precisely estimate CO2 emissions from different sources, such as financial expenditures and the project workforce. By integrating environmental considerations into our decision-making processes, our overarching objective is to diminish the project's carbon footprint.

Collect data: Create survey questionnaires to collect crucial data from all participants in order to calculate the total CO2 emissions from our meetings. This data will be integrated with our automated model for a comprehensive analysis. Additionally, we need to gather data from a comprehensive literature review and the GDR Labo1point5 database to identify correlations for CO2 emissions. We should also develop a separate questionnaire to estimate CO2 emissions from our workforce and all project partners.

Automation Challenge: The task at hand is to effectively automate this process. It's essential to develop a system that can manage different types of data, such as information about project managers, work locations, work categories, building types, modes of travel, project expenses, and the correlation between euros and CO2 emissions. This system should smoothly integrate with our current workflows while ensuring high efficiency.

Purpose

The EECONE project is committed to significantly reducing e-waste across Europe. It takes an interdisciplinary approach, considering social, economic, technological, and policy dimensions to create a European ecosystem for green electronics and position Europe as a leader in environmentally sustainable electronics.

The project aims to mitigate e-waste in Europe by enhancing e-waste management, developing innovative tools to improve the lifespan and recyclability of electronics, implementing best practices at the European level, and fostering a robust ecosystem in this domain. The ultimate goal is to advance towards a zero-waste electronics industry, guided by the "6R concept" (Reduce, Reliability, Repair, Reuse, Refurbish, Recycle).

Within the EECONE project, G2ELab and C-SCOP are specifically responsible for modeling and assessing the CO₂ emissions of the project for all partners. Their objective is to identify the hotspots for CO₂ emissions within the project and explore how tools can be developed to reduce the project's overall carbon footprint.

3. Objectives

EECONE project objectives: Mitigation of E-waste

The EECONE project is focused on the significant reduction of e-waste across Europe. This initiative is particularly crucial for Europe as it aligns with the Green Deal objectives and the Circular Economy Action Plan. The project aims to involve the entire value chain of the electronics industry, from raw material suppliers to consumers, in order to address the complex challenges of achieving circularity. The growing volume of e-waste, driven by increasing industrialization, urbanization, and consumption rates, underscores the urgency of this initiative. EECONE brings together 48 entities from 16 European countries, representing diverse sectors, to develop effective strategies for e-waste reduction. This interdisciplinary approach encompasses social, economic, technological, and policy dimensions, creating a European ecosystem for green electronics and positioning Europe as a leader in environmentally sustainable electronics.

Objective 1: Define Green

EECONE envisions the development and integration of constraints related to managing the end-of-life of Electronic Components and Systems (ECS) from the initial product or process design stages. The project aims to establish clear, open tools for designing ECS with circularity in mind, creating a framework to help producers evaluate eco-design choices. By implementing life cycle analysis tools and novel strategies in eco-design, EECONE seeks to integrate the 6R (Reduce, Reliability, Repair, Reuse, Refurbish, Recycle) concept into electronic system design processes. This initiative aims to cover at least 80% of the electronic system design process with 6R assessment metrics, fostering European leadership in the green transition.

Objective 2: Make Green ECS

To achieve a zero-waste electronics industry, EECONE will develop innovative techniques for reducing, repairing, reusing, refurbishing, and recycling ECS. The project will leverage the expertise of industry partners and research organizations to create eco-designed smart systems and improve recovery and recycling solutions. The goal is to significantly reduce e-waste, targeting a realistic 25% reduction through the introduction of new materials, technologies, and designs. This includes enhancing product reliability, facilitating repairs, enabling the reuse of components, and improving recycling rates, particularly for critical materials.

Objective 3: Showcase Green Solutions

EECONE aims to demonstrate the potential, usability, and versatility of green solutions along the value chain. The project will deliver climate-neutral and low environmental footprint ECS solutions across various sectors, implementing 10 use cases for green ECS in all application areas of the ECS-SRIA. These use cases will showcase innovative solutions with reduced environmental footprints, catalyzing the green transition in the electronics sector. By achieving these objectives, EECONE seeks to position Europe as a leader in environmentally sustainable electronics, moving towards a zero-waste electronics industry.

My purpose in EECONE project

In the EECONE project, G2ELab and C-SCOP are collaborating to develop a model that can analyze and assess the CO2 emissions associated with the project. The objective is to create an automated model and design questionnaires that can be integrated with the model. By inputting survey data into the model, the estimation of CO2 emissions can be generated automatically. The primary goal is to identify specific areas within the project that contribute the most to CO2 emissions and analyze the results. In addition, the project aims to explore potential strategies for using a tool to minimize the environmental impact of CO2 emissions at different stages of the project. Ultimately, the project aims to create a comprehensive model capable of accurately calculating total CO2 emissions and integrating its use throughout the project lifecycle, with a particular focus on its application in the European context.

Deliverables

The first step involves comprehensive data collection and the development of user-friendly survey forms to ensure an accurate assessment of emissions. By simplifying data collection, we can improve efficiency and foster collaboration, laying a solid groundwork for further analysis.

Another critical component is the creation of an automated model for calculating CO2 emissions associated with travel. This model will facilitate assessments and enable real-time adjustments to achieve optimal environmental results.

A third approach entails estimating emissions from all project partners, fostering transparency and accountability. Collaborative estimation of emissions sets the stage for concerted action to reduce them.

The final aspect introduces a tool for selecting environmentally responsible meeting venues, empowering decision-makers to minimize environmental impact without compromising operational needs. The integration of environmental considerations into venue selection processes promotes sustainability and supports initiatives to address climate change.

4. Methodology

Model Development

To estimate the total CO2 emissions from the EECONE project, we developed a comprehensive model divided into two main components: emissions from meetings and emissions from partners.

Emissions from Meetings

We have developed a model to identify potential sources of CO2 emissions associated with meetings. This comprehensive model takes into account the entire journey of participants, from their homes to the meeting venue. Key parameters considered include:

The model encompasses emissions generated during the participants' journey, covering travel from home to the airport, time spent at the airport, flights (including connecting flights), and travel from the airport to the hotel. Additionally, emissions during the meeting are calculated based on travel from the hotel to the conference venue and other activities post-conference, such as shopping, dining, and short trips.

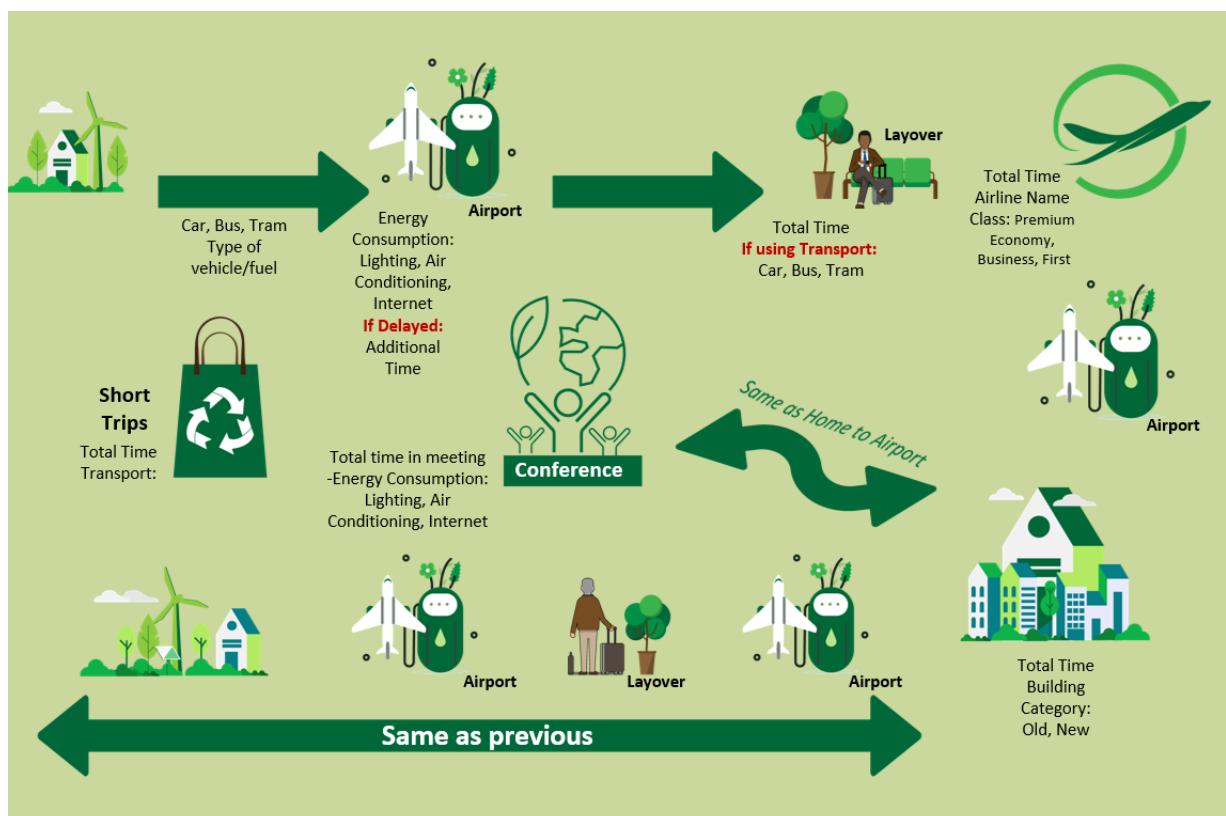


Figure 1: Model illustration.

While our initial model includes all these factors, it is not always possible to incorporate every detail due to data constraints. For instance, obtaining information on participants'

personal activities such as shopping or dining, as well as the specific energy consumption of those activities, is often impractical.

Regarding travel, the model takes into account primary modes of transportation (plane, train, car) and secondary modes (car, tram, bus, taxi). We also consider emissions from ICT usage during the conference, including the number of electronic devices used and online participation based on time and media used. Emissions from hotel stays are estimated based on the type of hotel and the duration of the stay.

Emissions from Partners

The emissions from all project partners are categorized into two groups: emissions based on total costs for each partner and emissions resulting from staff activities.

1. Cost-Based Emissions:

- Equipment costs
- Costs of other goods and services
- Internally invoiced goods and services costs

2. Staff-Based Emissions:

- Total person-months
- Electricity consumption
- Emissions from heating and cooling systems

Incorporating these elements, the model furnishes an exhaustive assessment of the aggregate CO₂ emissions linked to the EECONE project. This aids in pinpointing avenues for emission cutbacks and enhancing sustainable methodologies within the project's structure.

Methodology Formulation

In order to develop a comprehensive methodology for optimizing and reducing CO₂ emissions during project-related meetings, we undertook a series of calculations and data collection steps. Initially, we calculated the total travel distance for primary

transportation by considering the departure and arrival cities, including any connecting flights. This was done by using the latitude and longitude of the cities to derive the total distance. Subsequently, we computed the total CO2 emissions by multiplying the travel distance by the appropriate emission factor obtained from the "Plateforme Labos 1point5," which offers various factors based on travel distance, assuming that all participants travel in economy class for flights. For secondary travel, we gathered data on travel distances through surveys and computed the CO2 emissions using the relevant emission factors. This methodology ensures precise calculation of CO2 emissions from both primary and secondary travel, thus helping to optimize and minimize the environmental impact during project-related meetings.

Category	Subcategory	Subsubcategory	Unit	Name	Year	Emission Factor	ef.unit
Transport	Plane	Short haul (< 1000 km)	km	Short haul plane, without contrails	2022	0.1416	kg CO2e/km
Transport	Plane	Medium haul (< 1001 - 3500km)	km	Medium haul plane, without contrails	2022	0.1027	kg CO2e/km
Transport	Railway	TGV > 200 km	km	TGV	2021	0.0033	kg CO2e/km
Transport	Railway	Train < 200 km	km	Not available	2019	0.018	kg CO2e/km
Transport	Bus	bus.intercity	km	Bus - Intercity travels	2021	0.0306	kg CO2e/km
Vehicles	Car	Gasoline	km	Private car, average fleet, gasoline engine	2018	0.2234	kg CO2e/km
Vehicles	Car	Electric	km	Private car - Core range - Compact vehicle - Electric	2020	0.1034	kg CO2e/km

Figure 2: Emission factor for different transportation modes.

In order to calculate the CO2 emissions from all project partners involved in the EECONe project, we have devised two methodologies. The initial approach focuses on estimating the total cost across various categories, such as equipment, other goods and services, internally invoiced goods and services, and subcontracting. To achieve this, we have utilized emission factors provided by "Plateforme Labos 1point5," aligning with the cost descriptions outlined in the EECONe project proposal document.

The second method aims to calculate the total CO2 emissions from staff activities. It involves two specific approaches: one for electricity consumption and another for heating systems. These estimates consider the carbon intensity of each country and are calculated on a monthly basis per participant. In this context, we follow the classification of work into five categories.

WP1	Administration
WP2	Experimental
WP3	Software
WP4	Experiment
WP5	Networking and administration

Figure 3: Category of 5 work packages

In the analysis of the heating system, we take into account the total operational hours, the percentage breakdown of heating sources (such as gas, heating oil, biomethane, urban heating, and electricity), energy usage in various building types, total surface area, and the specific heating systems employed.

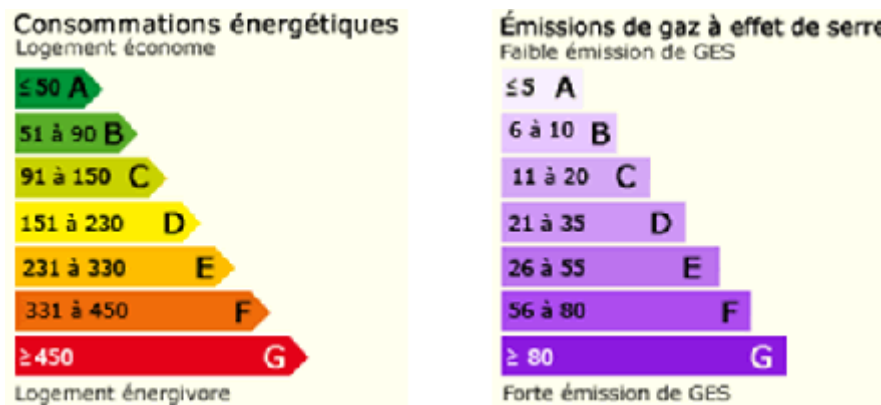


Figure 4: Energy-efficient buildings in Europe.

Category	Sub-category	Sub sub category	Unit	Name	Year	Emission factor	CO2 eq unit
Heating	Gas	Natural gas	kWh PCI	Natural gas, medium mix	2022	0.24	kg eCO2/kWh PCI
Heating	Heating oil	Heating oil	kWh PCI	Heating oil	2014	0.3243	kg eCO2/kWh PCI
Heating	Biomethane	Biomethane	kWh PCI	Biomethane - Injected...	2020	0.0444	kg eCO2/kWh PCI
Heating	Urban heating	0101c	kWh PCI	01 Bourg-en-bresse O...	2020	0.194	kg eCO2/kWh PCI

Figure 5: Emission factor for the Heating system from GES 1point5

In order to estimate CO2 emissions stemming from electricity consumption, it is important to take into account several key factors. These include the total work hours, the carbon intensity of electricity generation across various countries, and the energy consumption rate of electricity.

Carbon intensity of electricity generation, 2023

Carbon intensity is measured in grams of carbon dioxide-equivalents¹ emitted per kilowatt-hour² of electricity generated.

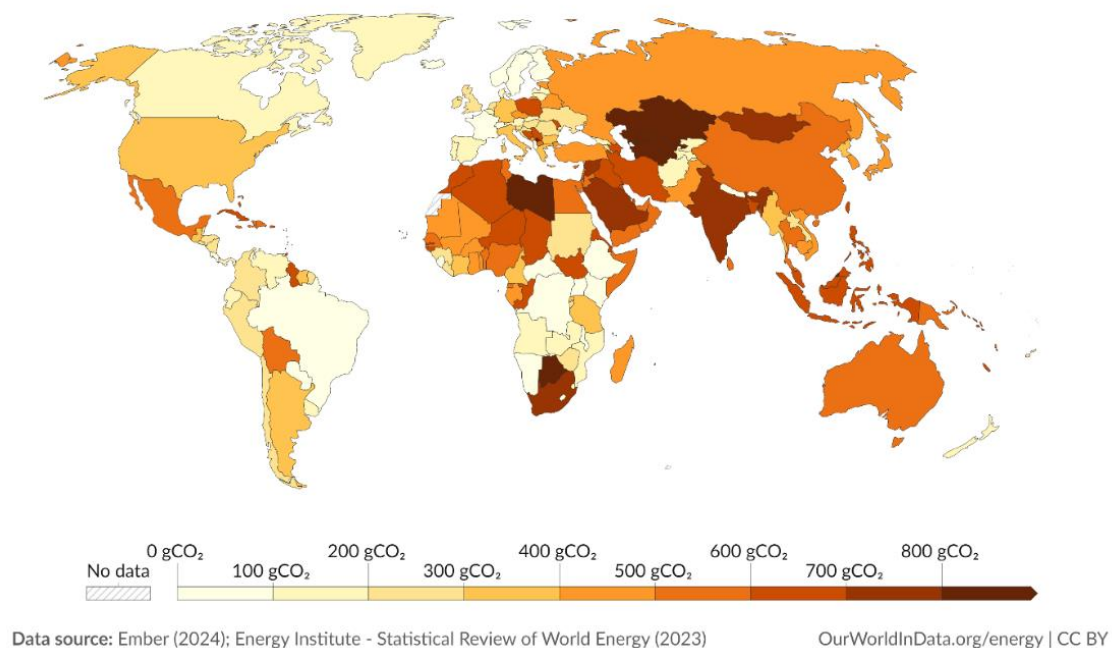


Figure 6: Carbon intensity of electricity generation, 2023.

Methodology formulation is the most vital part of this project.

Developing a sound methodology is crucial for the success of this project. The accuracy and dependability of the results hinge on a well-crafted methodology. Each step must be executed with precision to ensure accurate data collection. The main challenge lies in automating this methodology, given the diverse and extensive data types involved. These data types encompass partner-specific information such as project management details, work locations, types of work and buildings, travel modes, project expenses, as well as €/CO₂ correlations.

To create an effective system that seamlessly integrates with existing workflows, it is imperative to accommodate the varying nature of these data types. Due to time constraints, we were unable to collect data from all partners for estimation purposes. Therefore, we conducted thorough research and made certain assumptions for the calculations. These assumptions included estimates for the surface area of work, energy consumption for five different work categories, and the percentage of energy used in heating systems.

This approach ensures that the methodology is robust and capable of handling the complexity of the data, leading to accurate and reliable results that align with the project's objectives.

Data Collection

In order to gather pertinent data for our automated model, we have created a survey form. This form is intended to gather specific data pertaining to CO₂ emissions from transportation. By involving participants in the survey, we are ensuring a thorough and comprehensive collection of data. This survey-based approach directly informs our emissions estimates and contributes to our sustainability objectives. Moreover, the survey is seamlessly integrated with our automated model, enabling us to input the data automatically, thereby streamlining the process and yielding immediate results. It is essential to ensure that the survey is user-friendly and time-efficient to facilitate easy data collection.

Additionally, we have devised an extra survey form to gather data on total energy consumption from individuals and our partners. This data is crucial for the calculation of overall energy consumption and further supports our sustainability goals.



Figure 7: Surve form for collecting data

Automation Challenge

Our main goal is to automate the process of estimating CO2 emissions. This entails creating a system that can handle a variety of data types, including information about project managers, work locations, work categories, building types, modes of travel, project expenses, and the correlation between euros and CO2 emissions. The system should seamlessly integrate with existing workflows while ensuring high efficiency.

The challenge lies in effectively managing this diverse and extensive data set to automate the CO2 emissions estimation process. A robust system must be designed to accommodate the different nature of these data types and ensure they are processed efficiently and accurately. This will streamline the calculation process, reduce manual effort, and improve the reliability of the emissions estimates. In summary, the Automation Challenge emphasizes the need for a sophisticated system that integrates varied data types into the CO2 emissions estimation model. This system aims to enhance efficiency and accuracy, making it an essential part of the project's methodology.

5. Tools and Methodologies

Numerical Tools Used

In this project, we utilize a range of online tools to accurately calculate CO2 emissions. To estimate travel-related emissions, we use the 1point5 simulator in conjunction with other calculators like the Carbon Footprint Calculator, World Land Trust Carbon Calculator, and ICAO Carbon Emission Calculator, ensuring that we select the most suitable tool for each scenario. Furthermore, we employ online calculators to assess emissions from online participation and hotel stays.

GES 1point5

"The GES 1point5 tool, created by Labs 1point5, is specifically designed to measure the carbon footprint and evaluate the greenhouse gas balance (BGES) of laboratories. This tool serves two primary purposes: conducting scientific research on the carbon footprint of French public research, with a focus on France and its overseas territories,

and facilitating discussions on methods to reduce the impact of research activities on greenhouse gas emissions at both national and local levels."

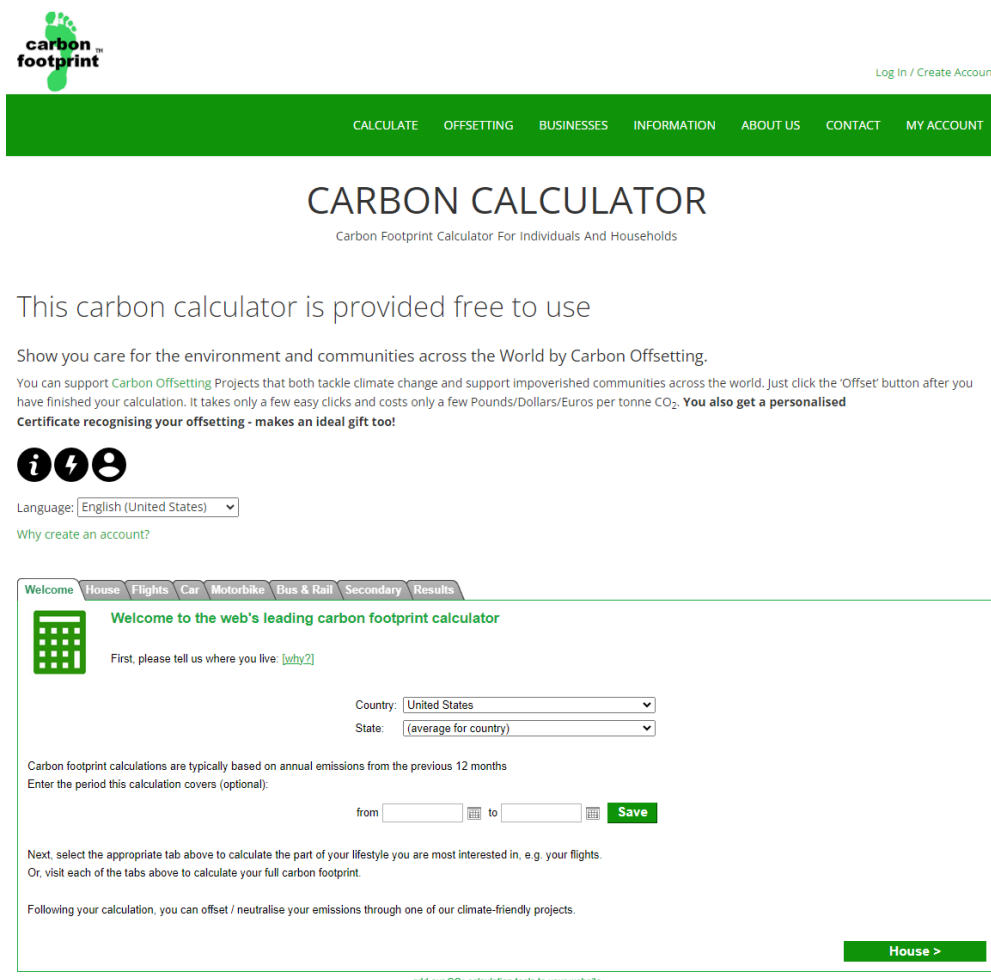
Figure 8: GES 1point5 calculator

The tool is in compliance with French regulations and utilizes the 1point5 Simulator to estimate CO2 emissions based on travel distances and modes of transportation. It calculates the distance between departure and destination cities, applying specific multiplying factors for different modes of travel such as cars, trains, metros, buses, trams, and taxis. The distance is calculated using geonames, measuring the straight-line distance between the cities of departure and destination. For car travel, a multiplying factor of 1.3 is applied, while for trains and suburban trains, it is 1.2; for the metro, it is 1.7; and for buses and trams, it is 1.5. Additionally, for air travel, an extra 95 km is added to the straight-line distance. The tool also takes into account emissions associated with electricity consumption and distribution.

The average fuel mix and consumption values for continental France are obtained from the Base Carbone, with these values being updated annually. Similarly, data for the

French overseas departments and territories are sourced from the Carbon Database. These choices were made in consultation with experts to ensure transparency and accuracy.

Carbon Footprint Calculator



The screenshot shows the Carbon Footprint Calculator website. At the top, there is a green navigation bar with the 'carbon footprint' logo on the left and links for 'Log In / Create Account' on the right. Below the navigation bar, the main heading 'CARBON CALCULATOR' is displayed, followed by the subtitle 'Carbon Footprint Calculator For Individuals And Households'. A paragraph states: 'This carbon calculator is provided free to use'. Below this, a section titled 'Show you care for the environment and communities across the World by Carbon Offsetting.' explains that users can support Carbon Offsetting Projects. It mentions that users can have finished their calculation with a few clicks and costs only a few Pounds/Dollars/Euros per tonne CO₂, and that they also get a personalised Certificate recognising their offsetting - makes an ideal gift too! Below this text are three icons: an information icon, a lightning bolt icon, and a person icon. A language dropdown menu is set to 'English (United States)' with a link 'Why create an account?'. The main content area has a tabbed interface with tabs for 'Welcome', 'House', 'Flights', 'Car', 'Motorbike', 'Bus & Rail', 'Secondary', and 'Results'. The 'Welcome' tab is active, showing a calculator icon and the text 'Welcome to the web's leading carbon footprint calculator'. It prompts the user to 'First, please tell us where you live: [why?]' and provides dropdown menus for 'Country: United States' and 'State: (average for country)'. It also includes a section for 'Carbon footprint calculations are typically based on annual emissions from the previous 12 months' with a date range selector from 'from' to 'to' and a 'Save' button. Below this, it instructs the user to 'Next, select the appropriate tab above to calculate the part of your lifestyle you are most interested in, e.g. your flights.' or to 'visit each of the tabs above to calculate your full carbon footprint.' and mentions that users can offset/neutralise their emissions through one of their climate-friendly projects. A 'House >' button is visible at the bottom right of the main content area.

Figure 9: Carbon footprint calculator

The online calculators have been developed based on the methodology outlined by the UK Government, utilizing the "Greenhouse gas reporting: conversion factors 2023." However, there are certain deviations from this approach. These calculators provide a comprehensive range of publicly available country-specific electricity emissions factors, free of charge, along with their respective sources. These factors encompass emissions originating from both electricity generation and transmission & distribution (T&D) losses. Additionally, the new Sustrax branded calculators incorporate Well to Tank (WTT) emissions, which are associated with the extraction, refining, distribution, and storage of fuels utilized in power stations.

For non-UK countries, the WTT electricity emissions are based on DEFRA's 2021 emissions factors, as subsequent data is unavailable. The calculators employ emissions factors that account for all greenhouse gases (CO₂, N₂O, methane, etc.) released by the activities, with the results presented in metric tons of CO₂ equivalent (CO₂e).

Regarding flights, distances between selected airports are calculated using the great circle method. This distance is then multiplied by the relevant emissions factor specific to the type of flight (UK domestic, short-haul, or long haul) and the class of seat chosen (e.g., economy class, business class, etc.). The emission factors also incorporate adjustments for flights not following the most direct route (e.g., flying around international airspace, stacking, etc.). Furthermore, these factors assume an average plane occupancy and allocate emissions among occupants in different seat classes.

World Land Trust Carbon Calculator

The screenshot displays the 'World Land Trust Carbon Calculator' interface. At the top, there are four circular icons representing different categories: 'FLIGHTS' (with a plane icon), 'TRANSPORT' (with a truck icon), 'HOUSEHOLD' (with a house icon), and 'FIXED' (with a leaf icon). Below these icons, the 'FLIGHTS' section is active, showing a progress bar at '0% Complete' and a '1 of 2' indicator. The main heading is 'FLIGHTS' with the sub-heading 'CALCULATE YOUR CO₂ EMISSIONS'. The 'Flight Journey Details' section includes a 'From' field, a 'Via' checkbox, a 'To' field, a 'Journey Type' dropdown menu (set to 'Please select'), and a 'Number of passengers' field (set to '1'). At the bottom of this section are two buttons: 'Add Another Journey' and 'Remove This Journey'. A large orange 'CALCULATE' button is positioned at the bottom of the form.

Figure 10: World Land Trust Carbon Calculator

Established in 2005, the Carbon Balanced program by the World Land Trust offers individuals and organizations a practical means to address climate change. Through this program, individuals and organizations can assess their carbon footprint and undertake measures to reduce it. Unavoidable emissions can then be offset by supporting forest preservation projects that sequester harmful carbon dioxide (CO₂). The program adopts a balanced approach to emissions, employing a three-step process to first measure and minimize emissions and then compensate for the remaining emissions through impactful conservation initiatives. This process entails considering factors such as travel distance, transit points, types of journeys, and the number of individuals involved. The overall cost is calculated based on the amount of CO₂ emitted.

ICAO Carbon Emissions Calculator

The image shows the ICAO Carbon Emissions Calculator interface. At the top, there is a header with icons for CO₂, an airplane, and a calculator, followed by the text "CARBON EMISSIONS CALCULATOR". Below this, there are two tabs: "Passenger" and "Freighter". Under the "Passenger" tab, there are two dropdown menus for "Departure" and "Destination". Below these are two buttons: "Add Destination +" and "Delete All Locations -". Further down, there are three input fields: "Number of Passengers" (with a value of 1), "Cabin Class" (with buttons for "Economy" and "Premium"), and "Trip" (with buttons for "Round Trip" and "One Way"). At the bottom of the form is a large blue button labeled "Calculate". The footer of the page contains the ICAO logo, the text "© International Civil Aviation Organization", and several links: "Learn More About Environmental Tools", "Terms & Conditions", "FAQ", "API Service", "Methodology", and "Contact Us".

Figure 11: ICAO's carbon emission calculator

ICAO's Carbon Emissions Calculator employs a robust and comprehensive methodology for quantifying carbon dioxide emissions associated with air travel. The process initiates with the meticulous gathering of industry data, encompassing

variables such as aircraft classifications, route-specific particulars, passenger occupancy rates, and cargo volumes. Passenger-related inputs necessitate information regarding the departure and arrival airports for non-stop flights. Subsequently, scheduled flight operations are juxtaposed to ascertain the aircraft types utilized and their frequency. Each aircraft is classified into one of 312 equivalent types to streamline fuel consumption computations. Fuel usage is approximated based on the distance between airports, with adjustments made for passenger occupancy rates and cargo proportions. A weighted mean fuel consumption value is computed, factoring in the departure frequency of each equivalent aircraft type. This figure is then multiplied by 3.16 to determine the carbon footprint per economy-class passenger. Likewise, for cargo aircraft, fuel consumption is estimated utilizing ICAO Fuel Formulas, with load factor data utilized to attribute emissions to cargo weight. An averaged emission value is subsequently calculated based on aircraft type and flight frequency. This methodology encompasses non-stop flights between air freighter route pairs listed in the Common Operations Database (COD). Overall, the methodology offers a standardized and dependable approach for gauging the environmental ramifications of air travel, utilizing publicly accessible data to ensure simplicity and uniformity.

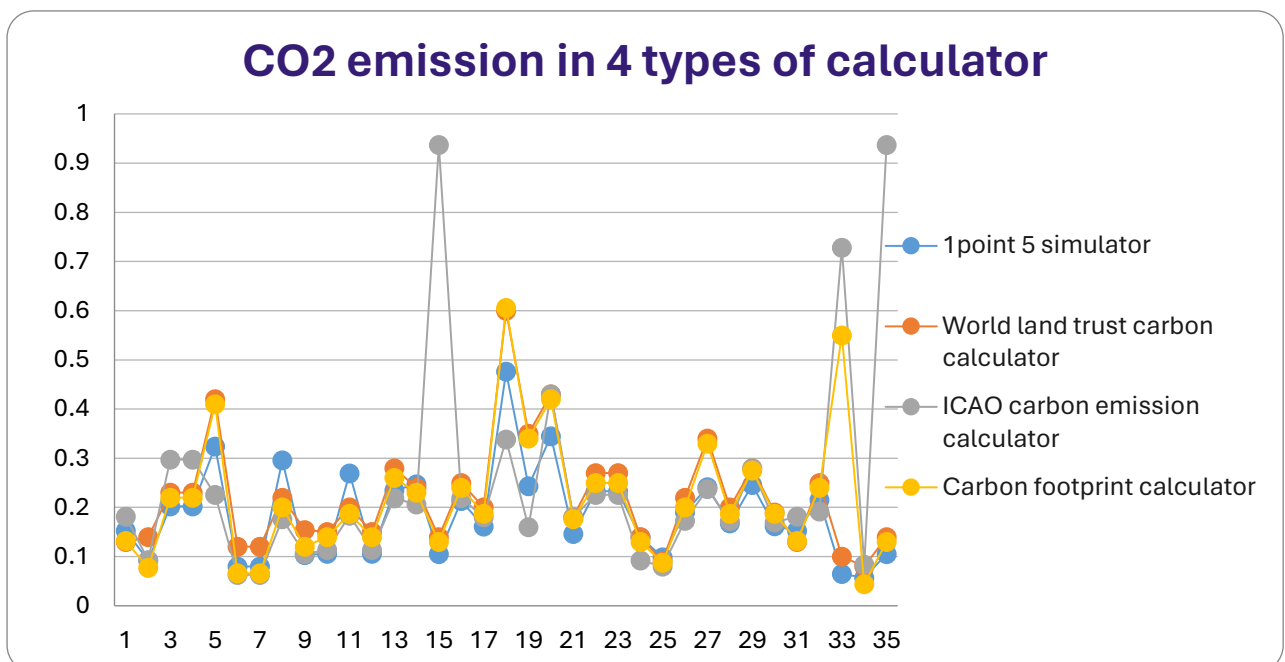
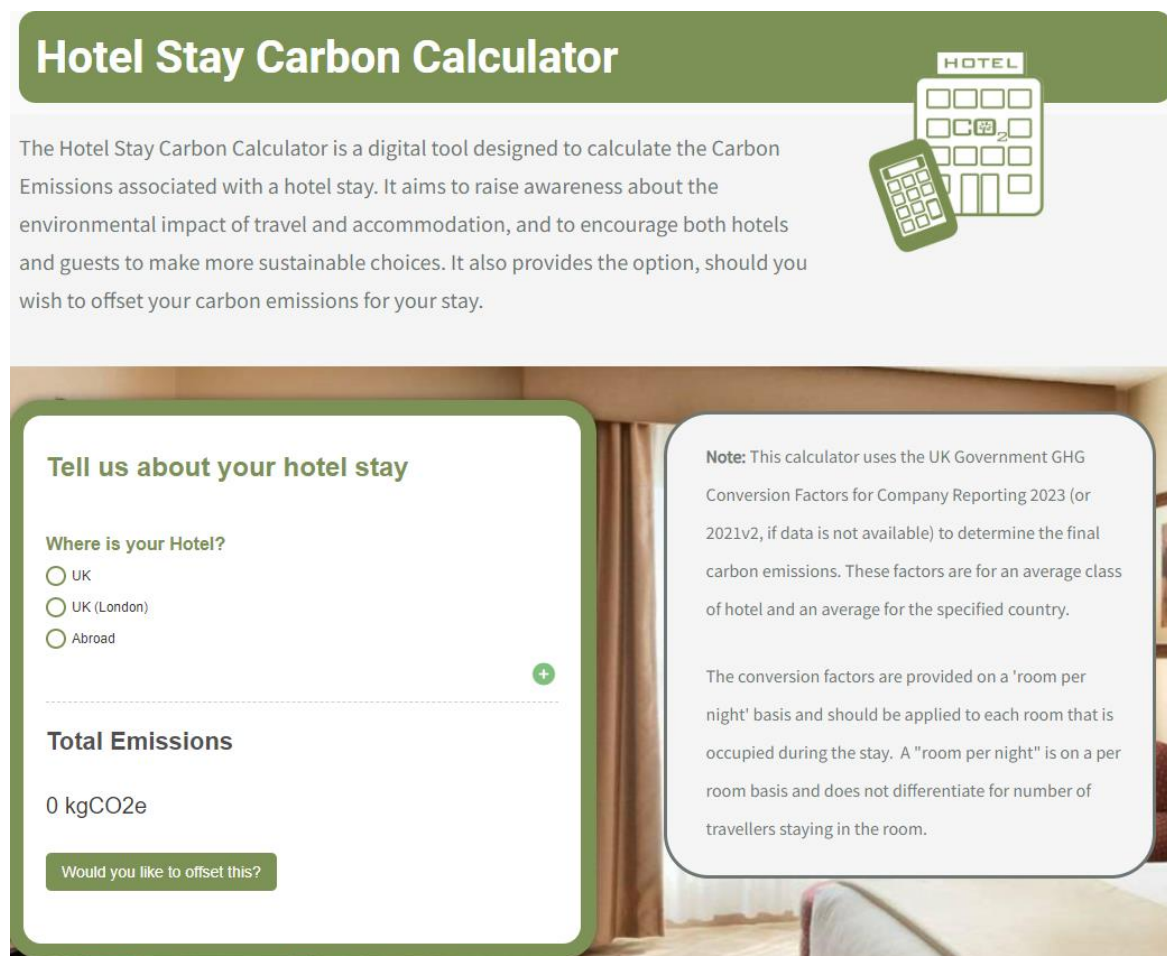


Figure 12: Comparison of results from 4 online calculators

During the inaugural meeting, we assessed CO2 emissions through a comparative analysis of four distinct calculators to ensure precision in our results. Our investigation revealed a high degree of consistency among all tools. Consequently, we selected the GES 1point5 calculator due to its robust and thorough methodology.

Hotel Stay CO2 Emission Calculator

The carbon emissions of the Company are determined using the UK Government GHG Conversion Factors, tailored to an average class of hotel and specific to the designated country. These conversion factors, provided on a per room per night basis, are applied to each occupied room during the stay. The metric is calculated for each room and remains constant regardless of the number of travelers in the room. We have chosen to utilize this calculator model and methodology to generate our estimations. The web application underwent rigorous testing to extract pertinent correlation parameters for integration into our tool.



The screenshot displays the 'Hotel Stay Carbon Calculator' interface. At the top, a green header contains the title 'Hotel Stay Carbon Calculator' and an illustration of a calculator with a 'HOTEL' label. Below the header, a descriptive paragraph explains the tool's purpose: to calculate carbon emissions for hotel stays, raise awareness of environmental impact, and provide an offset option. The main form area is divided into two sections. The left section, titled 'Tell us about your hotel stay', includes a 'Where is your Hotel?' question with radio button options for 'UK', 'UK (London)', and 'Abroad'. Below this, it shows 'Total Emissions' as '0 kgCO2e' and a button labeled 'Would you like to offset this?'. The right section contains a 'Note' explaining that the calculator uses UK Government GHG Conversion Factors for Company Reporting 2023 (or 2021v2 if unavailable) and that conversion factors are provided on a 'room per night' basis, which is applied to each occupied room regardless of the number of travelers.

Hotel Stay Carbon Calculator

The Hotel Stay Carbon Calculator is a digital tool designed to calculate the Carbon Emissions associated with a hotel stay. It aims to raise awareness about the environmental impact of travel and accommodation, and to encourage both hotels and guests to make more sustainable choices. It also provides the option, should you wish to offset your carbon emissions for your stay.

Tell us about your hotel stay

Where is your Hotel?

☐ UK

☐ UK (London)

☐ Abroad

Total Emissions

0 kgCO2e

Would you like to offset this?

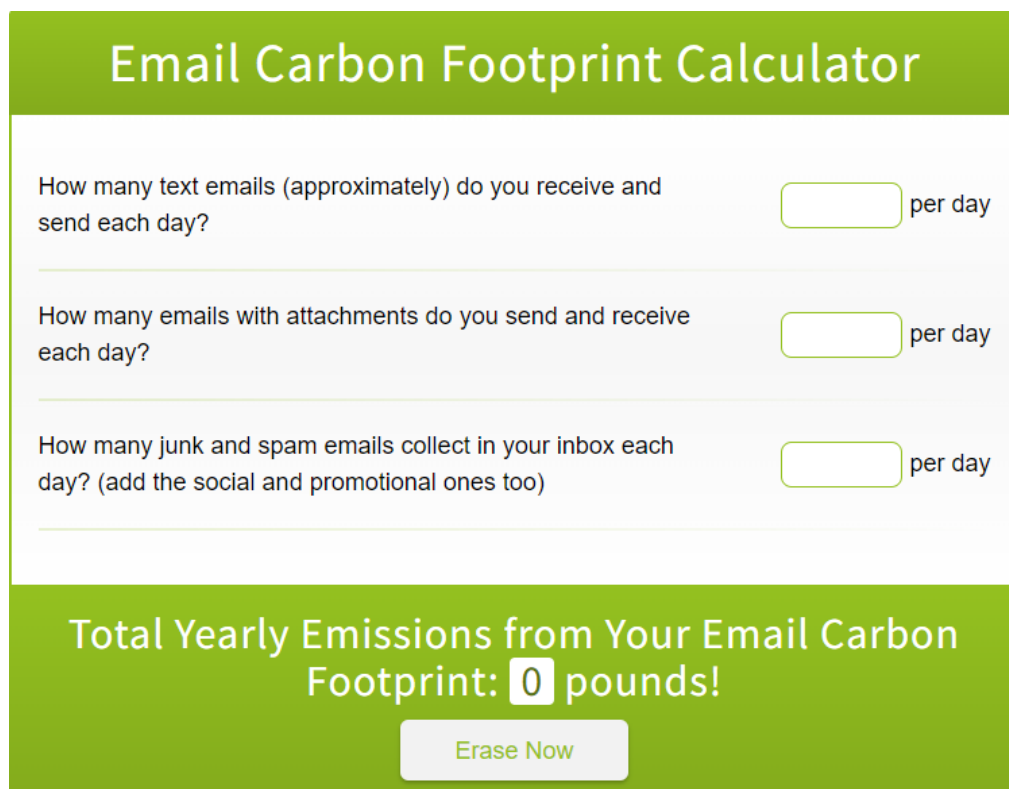
Note: This calculator uses the UK Government GHG Conversion Factors for Company Reporting 2023 (or 2021v2, if data is not available) to determine the final carbon emissions. These factors are for an average class of hotel and an average for the specified country.

The conversion factors are provided on a 'room per night' basis and should be applied to each room that is occupied during the stay. A "room per night" is on a per room basis and does not differentiate for number of travellers staying in the room.

Figure 13: Hotel Stay CO2 Emission Calculator

Zoom Emission Calculator

The carbon footprint calculator evaluates CO₂ emissions for video calls by considering various factors such as call type (audio/video), video resolution, meeting duration, and the number of participants. To estimate CO₂ emissions per video call, the first step involves determining the bandwidth utilized per hour based on Zoom's recommended bandwidth requirements. For 1:1 video calls, bandwidth usage per hour is determined as follows: 600kbps for high-quality video, 1.2Mbps for 720p HD video, 1.8Mbps for receiving 1080p HD video, and 1.8Mbps for sending 1080p HD video. In the case of group video calls, the requirements are as follows: 800kbps/1.0 Mbps for high-quality video, 1.5Mbps/1.5Mbps for 720p HD video, 2.5Mbps for receiving 1080p HD video, and 3.0Mbps for sending 1080p HD video.



The image shows a web-based calculator titled "Email Carbon Footprint Calculator". It has a green header and footer. The main content area is white with three input fields, each followed by "per day". The first field is for "How many text emails (approximately) do you receive and send each day?". The second field is for "How many emails with attachments do you send and receive each day?". The third field is for "How many junk and spam emails collect in your inbox each day? (add the social and promotional ones too)". Below these fields, a green bar displays "Total Yearly Emissions from Your Email Carbon Footprint: 0 pounds!". At the bottom of this bar is a button labeled "Erase Now".

Question	Input
How many text emails (approximately) do you receive and send each day?	
How many emails with attachments do you send and receive each day?	
How many junk and spam emails collect in your inbox each day? (add the social and promotional ones too)	

Total Yearly Emissions from Your Email Carbon Footprint: 0 pounds!

Erase Now

Figure 14: Email carbon emission footprint calculator

Subsequently, electricity consumption is calculated based on the determined bandwidth usage to estimate emissions. The electricity consumption is determined using the 2019 electricity intensity of fixed-line internet data transmission (0.015kWh/GB), converting data from bits to gigabytes. For a 1-hour 1:1 video call,

network traffic ranges from 0.54GB to 1.62GB, resulting in electricity consumption ranging from 0.0081kWh to 0.0243kWh. For group calls, network traffic ranges from 0.81GB to 2.475GB per participant, resulting in electricity consumption ranging from 0.01215kWh to 0.037125kWh.

Finally, by utilizing the UK electricity emissions conversion factor for 2020, estimated emissions per call in kilograms of CO₂ are calculated, allowing for comparison with emissions from driving a mile in an average petrol car. The web application has undergone testing to derive relevant correlation parameters for incorporation into the tool.

Methodological Innovations

In our study, we applied specific multiplier factors to different modes of transportation to ensure accurate distance calculations. This process involved utilizing various calculators to select the most suitable one for estimating each aspect of CO₂ emissions. This ensured the reliability and validity of the results. Additionally, we identified the most relevant questions for participants in the EECONE project, ensuring their active engagement in the survey and facilitating easy data delivery, which was essential for our research objectives. Furthermore, we implemented an Excel-based model to enhance accessibility and comprehensibility for all partners, thereby informing and sensitizing them to CO₂ emissions in research activities.

6. Results

CO₂ Emissions Estimation

The total CO₂ emissions from the kick-off meeting held last year in Toulouse, France, were calculated. Our model underwent rigorous testing through the analysis of CO₂ emissions from the project's kick-off meeting. By comparing manual calculations with the results obtained from the new model, we demonstrated its effectiveness.

Particularly noteworthy is the model's capability to handle multiple data options and provide reliable estimates, marking a significant advancement. Both manual calculations and the total result from our automated model yielded nearly identical

results. However, due to missing data in our survey, we utilized average values to calculate emissions for the missing data points. Consequently, the final emission estimate for the kick-off meeting was determined to be 25,000 kilograms of CO₂.

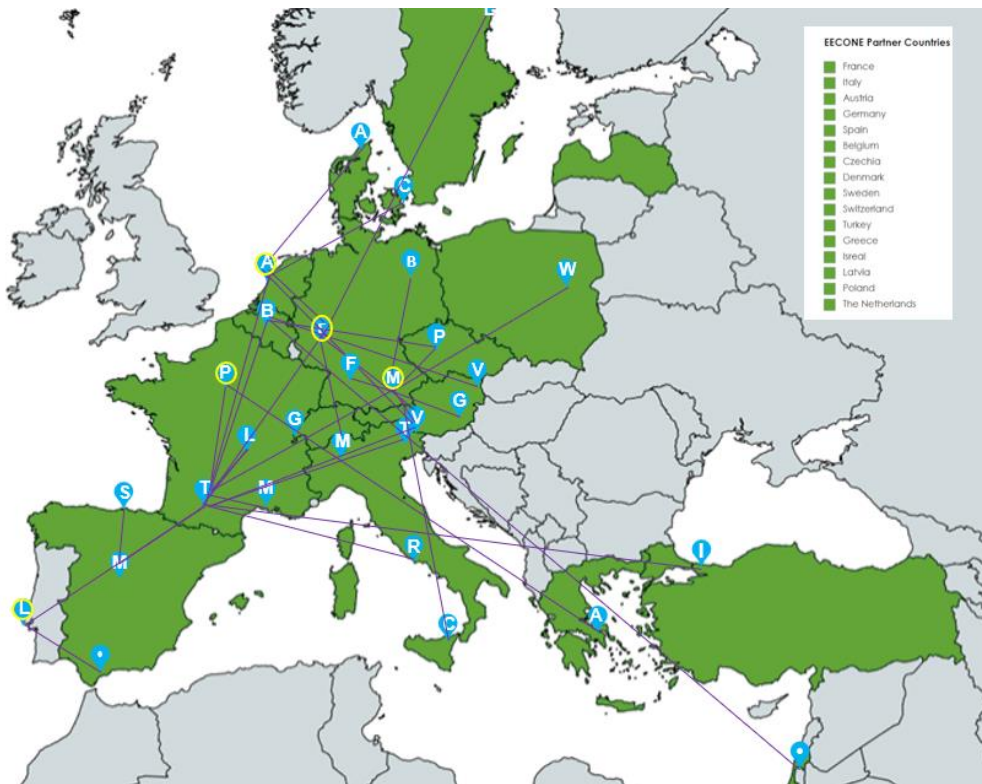


Figure 15: Plane route in the kick-off meeting.

Given that the EECONE project involves a kick-off meeting and three yearly meetings, the total CO₂ emissions from these meetings are estimated to be approximately 100,000 kilograms.

Total CO2 Emission (kg) from Primary tavel		Online Participant		ICT		Hotel	
7736	kg	325	kg	46	kg	923	kg
one way							
Total CO2 Emission (kg) from Auxilary tavel		For travel total CO2 emission					
454	kg					16379 Kg	
49 participants total CO2 emission 17673 kg							
22 participants total CO2 emission 7935 kg							
Total CO2 emission from the cick-off meeting 25609 Kg							

Figure 16: Total CO₂ Emission Summary of Kick-off Meeting

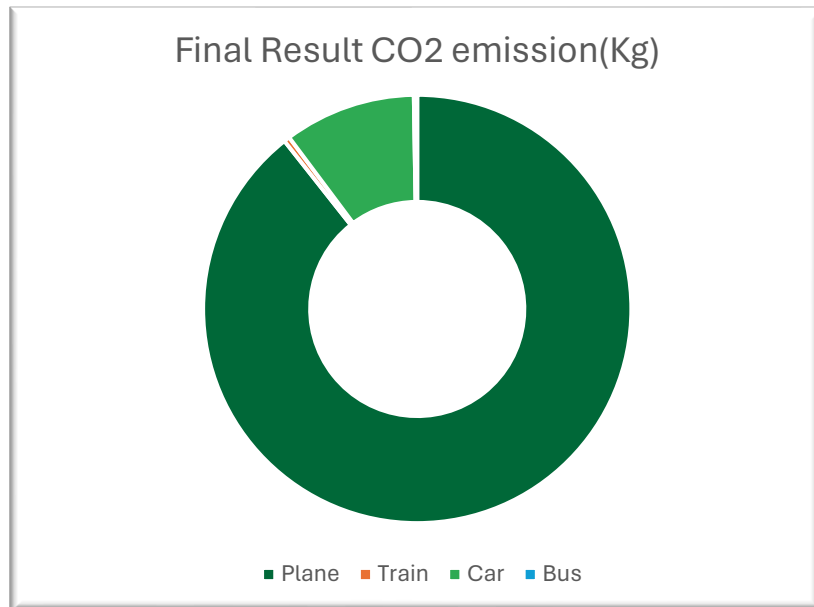


Figure 17: Result analysis of CO2 emission per transportation mode.

Upon analysis of the data, it was revealed that over 95% of emissions originate from air travel, as evidenced by the consistent preference for air transportation among participants. Out of the 49 participants surveyed, 36 individuals identified planes as their primary mode of transportation. Notably, a striking finding emerged: while one participant's air travel results in emissions of 412 kg per person, the emissions per person for car travel amount to 100 kg, and for train travel, a mere 4 kg, rendering trains the most environmentally friendly mode of transportation.

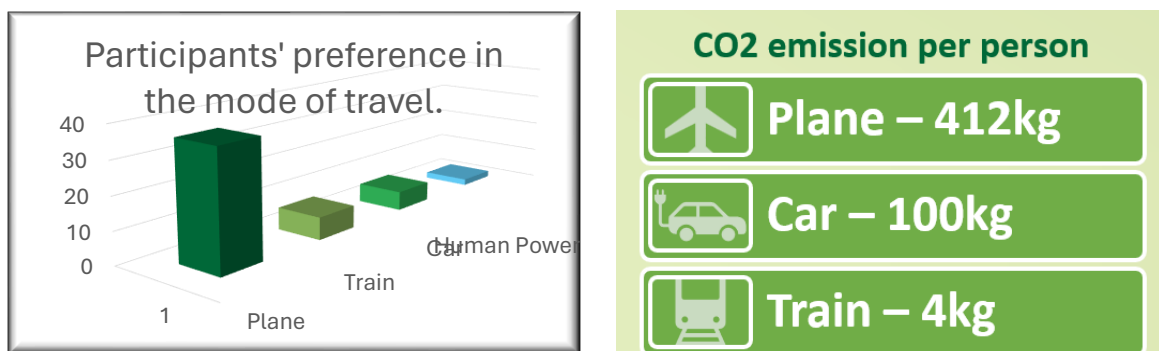


Figure 18: Analysis of participant preference and CO2 emission per person.

The comprehensive analysis of CO2 emissions from our partners revealed noteworthy findings, particularly concerning emissions stemming from equipment costs. Surpassing 1 million kilograms, these emissions, in conjunction with those from our partners, culminate in a total of 1,177,832 kilograms.

Co2 emission from the cost of all partner			Co2 emission from the staff of all partner		
Type of Purchase costs	Total Co2 emission in kg		Type of Category of emission	Total Co2 emission in kg	
Equipment Cost (€)	477798	Kg	CO2 emission from heating system (CO2 Kg)	39550	Kg
Other goods and services Cost (€)	382286	Kg	CO2 emission from electricity consumption (No heating) Kg CO2	93932	Kg
Internally invoiced goods & services Cost (€)	120247	Kg			
Sub-contracting costs	64020	Kg			
Total emission from cost	1044350	Kg	Total co2 emission from electricity consumption and heating system	133482	Kg
Total Co2 emission from all partner			1177832	Kg	

Figure 19: Summary of total CO2 emissions from all the partners.

At the conclusion of our analysis, the total approximate CO2 emissions resulting from the EECONE project amounted to 1,120,000 kilograms. Remarkably, only 8% of these emissions were attributed to meetings, while 91% originated from various activities conducted by project partners.

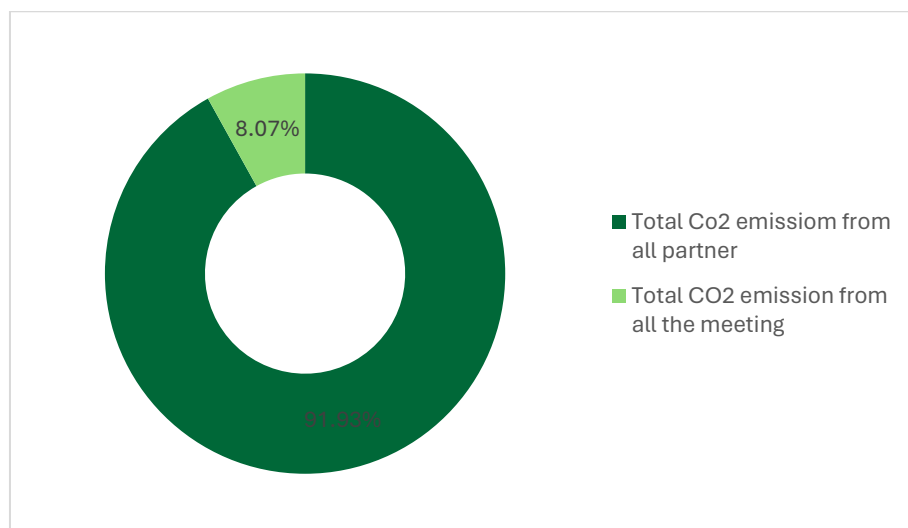


Figure 20: Total percentage of CO2 emission from the two parts.

Significantly, over 80% of the emissions were found to stem from equipment procurement costs incurred by the partners.

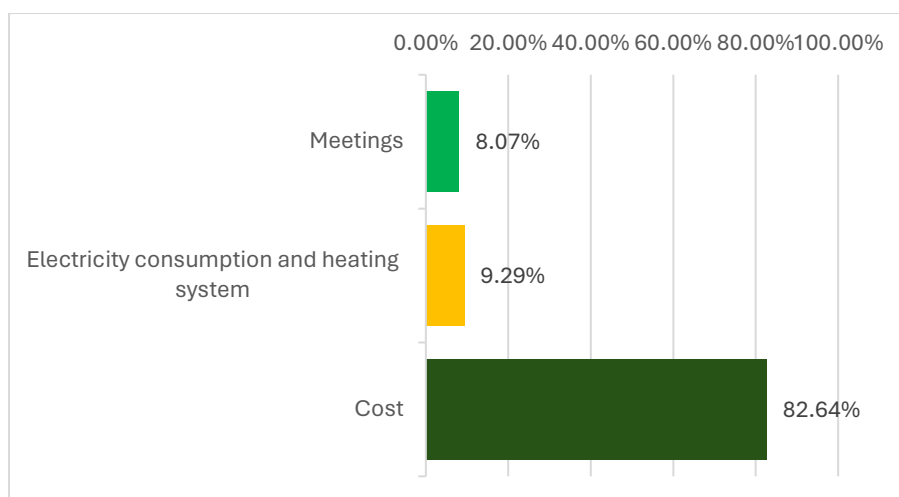


Figure 21: total percentage of CO2 emission from different categories

Strategic Location Selection

In our research project, we conducted a thorough evaluation of our model's efficacy by comparing CO2 emissions stemming from the kick-off meetings of various projects. By contrasting manual calculations with the outcomes generated by our new model, we effectively demonstrated its reliability and efficiency. Of particular note is the model's capacity to accommodate diverse data inputs and furnish dependable estimations, marking a significant advancement in our methodology.

Meeting Place	Location city	Distance (km)	Number of participants	CO2 emission Plane	CO2 emission Car	CO2 emission Train	Travel distance (km)		Possibilities to choos travelling mode		
	Munich						above	below			
	Grenoble	553	1	91.8	74.3	2.2			Plane(%)	Train(%)	Car(%)
	Istanbul	1583	1	172.3	212.8	6.3		200	0	0.7	0.3
	Leoben	276	1	52.5	37.1	1.1	200	500	0.2	0.5	0.3
	Stuttgart	190	1	40.4	25.5	0.8	500	1000	0.25	0.75	0
	Paris	683	1	110.2	91.8	2.7	1000		0.8	0.2	0
	Louvain-la-Neuve	576	1	95.0	77.4	2.3					
	Taastrup	836	1	131.8	112.4	3.3					
	Vélizy-Villacoublay	695	1	111.9	93.4	2.8					
	Grenoble	553	1	91.8	74.3	2.2					
	Munich	0	1	13.5	0.0	0.0					
	Grenoble	553	1	91.8	74.3	2.2					
	Athens	1496	1	163.4	201.1	5.9					
	Sommariva del Bosco	474	1	80.6	63.7	1.9					
	Prague	298	1	55.6	40.1	1.2					
	Villach	239	1	47.3	32.1	0.9					

Result:

2416 kgCO2 tests One way

Total CO2 emission 4832 Kg

Figure 22: Automated tool to estimate CO2 emission from meeting.

Given the multitude of projects underway in Europe and globally, understanding the carbon footprint of the EECONe initiative was imperative. Our analysis unveiled a striking revelation: more than 95% of the total CO2 emissions were attributable to air travel. In response, we developed a sophisticated tool tailored to identify the most

environmentally sustainable meeting venues. This tool integrates factors such as travel distance, transportation modalities, and participant numbers. By manipulating these variables, users can observe the corresponding shifts in CO2 emissions, aiding in the identification of the most eco-conscious options.

Furthermore, our tool considers varying distances for different transportation modes, distinct emission factors corresponding to these distances, and the flexibility in selecting the mode of travel. Though seemingly minor, this initiative represents a crucial stride towards environmental conservation. By embracing smarter meeting practices, we not only reduce our ecological footprint but also enhance our overall quality of life.

Remarks:

The objective was to accurately calculate the total CO2 emissions generated by the EECONE project. However, due to insufficient data availability, the calculated emissions are not entirely precise. During the kickoff meeting, data for 22 participants was missing, necessitating the use of average data for calculation. Additionally, due to time constraints arising from administrative processes, the staff survey form could not be completed, leading to the need for estimation based on assumed data. Consequently, the resulting emissions calculation lacks complete accuracy.

7. Discussion

Limitations

The model presented in this research project exhibits several limitations that should be considered:

Firstly, during meetings, the model may not be able to calculate all parameters as precisely as illustrated. This could potentially affect the accuracy of the results derived from the model when applied in real-world scenarios.

Secondly, the effectiveness of the model is heavily reliant on the availability and quality of data. Insufficient or inaccurate data inputs may lead to erroneous outputs, undermining the reliability of the model's predictions and analyses.

Furthermore, it's important to note that the model utilizes the "Geography" menu feature in Excel to automatically extract latitude and longitude coordinates. However, this functionality may not be universally accessible to all Excel users, thereby limiting the widespread applicability of the model.

Overall, while the Excel-based model offers valuable insights and analytical capabilities, its limitations highlight the importance of careful data management and consideration of alternative methods for users who may not have access to certain functionalities.

Future Directions

In our research project, we are moving towards several key milestones aimed at better understanding and mitigating the environmental impact of our activities.

Our primary objective is to estimate the total CO₂ emissions generated from project meetings. This initial step is crucial as it lays the groundwork for our comprehensive environmental impact assessment.

We have successfully developed and implemented an automated model specifically tailored for estimating CO₂ emissions. This model has been designed to streamline the calculation process, resulting in improved efficiency and accuracy.

To support our automated model, we have created and deployed a survey aimed at gathering relevant data. This data plays a vital role in refining our CO₂ emission estimates, ensuring they accurately reflect real-world scenarios.

The data collected from our survey is seamlessly integrated into our automated model. This integration enables us to conduct efficient and precise emissions calculations, thereby enhancing our ability to make informed decisions regarding environmental sustainability.

We have made significant progress in addressing traveling emissions within the project. Moving forward, our focus will shift towards extending similar efforts to consider all other CO₂ emissions within the project scope, including those related to building and expenses.

8. Conclusion

The EECONE project represents a pivotal step towards addressing the pressing environmental challenge of electronic waste in Europe. By leveraging an interdisciplinary approach that integrates social, economic, technological, and policy dimensions, EECONE is setting a new standard for green electronics. The project's comprehensive strategies—from developing robust CO₂ emission models to creating innovative recycling and refurbishing techniques—demonstrate a commitment to sustainability that aligns with the Green Deal objectives and the Circular Economy Action Plan.

EECONE's focus on the entire value chain, from raw material suppliers to end consumers, ensures that the solutions developed are holistic and impactful. The project's dedication to transparency, accountability, and collaboration across 48 entities from 16 European countries underscores its potential to significantly reduce e-waste and CO₂ emissions. By fostering a robust ecosystem for green electronics and integrating the "6R concept" (Reduce, Reliability, Repair, Reuse, Refurbish, Recycle), EECONE is poised to drive Europe towards a zero-waste electronics industry.

The methodologies and tools developed through EECONE not only provide valuable insights and practical solutions for current environmental challenges but also pave the way for future advancements in sustainable electronics. By embracing these innovative approaches, we can mitigate the adverse effects of e-waste, reduce greenhouse gas emissions, and position Europe as a global leader in environmentally sustainable practices.

In conclusion, the EECONE project is not just a response to an urgent environmental issue; it is a proactive, forward-thinking initiative that embodies the principles of sustainability, innovation, and collaboration. It is an invitation to join a transformative journey towards a greener, more sustainable future for the electronics industry and the planet.

The implications of this work are noteworthy for the field. The user-friendly nature of the work allows for seamless continuation by subsequent researchers, as all documents and progress provide robust support for further development. This aspect greatly

facilitates the ability to build upon existing work, eliminating the need to start anew and ensuring a smoother transition for future endeavors in this area of study.

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