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atmosfair

# Methodology for the atmosfair $CO_2$ event calculator

Version 1.0 August 2024

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# Foreword

The development of this $CO_2$ event calculator has been undertaken by *atmosfair* to provide a transparent, accurate, and user-friendly tool for quantifying the greenhouse gas (GHG) emissions associated with events. This tool aims to support event organisers in understanding and reducing the carbon footprint of their events.

## About *atmosfair*

*atmosfair* is a non-profit organization focused on actively protecting the climate by promoting, developing, and financing renewable energy projects in over 30 countries worldwide. By developing this tool to calculate emissions, we aim to provide event organizers with the means to make informed decisions that contribute to global climate protection efforts.

## Supersession

This is the first version of this *atmosfair $CO_2$ event calculator* methodology; therefore, no previous versions are being superseded.

## Use of this document

This document serves as a manual for our online tool, helping users understand its functionalities and the methodology behind the calculations. It is intended to provide transparency and clarity, showing our commitment to accurate carbon reporting and engaging stakeholders in understanding event-related emissions. By documenting our calculation methods, we aim to make carbon reporting more accessible and precise for the public.

This document has been prepared by *atmosfair*. *atmosfair* retains its ownership and copyright and reserves the right to update or amend this document to reflect the latest technical and scientific advancements. Future versions will be published to incorporate any such updates, ensuring the tool remains accurate and effective.

This document is not to be regarded as an official standard but as a comprehensive guide to support the responsible and informed use of the *atmosfair $CO_2$ event calculator*.

# 1. Introduction

Globalisation and its new demands for interconnectedness, coupled with positive socio-economic development worldwide and reduced barriers to travel, have spurred a substantial growth witnessed in the global event industry within recent decades. This expansion has concurrently imposed a considerable strain on endeavours aimed at mitigating the impacts of global climate change.[1]

In 2017, over 1.5 billion participants across more than 180 countries attended business events.[2] The frequency of regular international events (with 50 or more participants) doubles approximately every ten years, and the trillion-dollar events industry is projected to grow by 11.2% in the current decade.[3] This burgeoning industry, however, has a significant environmental impact. Several LCA studies have been conducted to evaluate the carbon footprint of events. The carbon footprint can vary significantly depending on the event's size, duration, and various other factors. In some instances, the carbon footprint per participant can reach up to 3,000 kg $CO_2$ equivalent, representing a particularly high impact.[4]

In addressing this concern, the *atmosfair $CO_2$ event calculator* has been developed to function as a tool for quantifying the carbon footprint associated with events. This document is developed to provide guidance and transparency on the calculation of GHG emissions in the *atmosfair $CO_2$ event calculator*. It positions the tool and its applicability within larger corporate climate strategy, details use cases based on data availability, defines boundaries and geographical scopes, explains data sources and calculation formulas and provides best practices on how to utilise results.

## 1.1 Purpose and applicability

Within the context of events, certain GHG emissions are unavoidable. It is therefore important to quantify the volume of emissions directly caused by and indirectly related to any such event. The *atmosfair $CO_2$ event calculator* serves as a tool to provide such quantification by means of calculation through a series of interlinked steps which are explained in more detail in the section on system boundaries and geographical focus (see Section 1.3).

1 Tao, Y., Steckel, D., Klemeš, J.J. et al. Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy. Nat Commun 12, 7324 (2021).

2 Event Industry Council: Global Economic Significance of Business Event

3 International Congress and Convention Association. A Modern History of International Association Meetings - Update: 1963–2017

4 Tao, Y., Steckel, D., Klemeš, J.J. et al. Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy. Nat Commun 12, 7324 (2021).

The *atmosfair $CO_2$ event calculator* and this methodology provide a transparent way of benchmarking GHG emissions within the process of larger climate strategies. While measurement of emissions is key to understanding the status quo to spur action, it must be seen as just one step of many. The usage of the *atmosfair $CO_2$ event calculator* should therefore be complemented by rigorous avoidance and reduction measures. This tool and its methodology are designed to:

1. Provide a scientifically grounded benchmark for knowledge on event-related GHG emissions
2. Review and visualise progress on GHG-related Key Performance Indicators
3. Facilitate well-informed decisions regarding the offsetting of unavoidable emissions
4. Inform future climate action in event planning

In addition to the *atmosfair $CO_2$ event calculator*, *atmosfair* has developed a set of guidelines, aimed at curtailing emissions across each step covered by the calculator. The *atmosfair* "Guidelines for Sustainable Event Planning" are structured to assist companies in integrating a comprehensive and environmentally conscious approach throughout the event organization process.

## 1.2 Accuracy and flexibility

The *atmosfair $CO_2$ event calculator* has been designed to cater to a wide range of use cases, accommodating events of varying scales and formats. The availability of emission-relevant data to the event organizer is contingent upon numerous factors and therefore subject to significant variation.

Therefore, this tool places an emphasis on affording organizers maximum flexibility concerning data availability while ensuring precision in all calculations. In instances where data is lacking, the tool employs proxy default settings based on current statistics to offer default estimates when personalized data entry is not possible. This strategic approach serves to diminish the entry barrier for developing insights into the climatic impacts of events, acting as a conduit for the integration of more sustainable planning practices in the future. Additionally, it facilitates adherence to the principle of continuous improvement, allowing users to refine their calculations progressively as they accrue experience in sustainable event planning and data collection.

Simultaneously, the *atmosfair $CO_2$ event calculator* is engineered to adhere to the fundamental principles of credible carbon footprint calculations, aligning with global standards right from its inception. The tool employs scientific emission factors to calculate emissions, ensuring accuracy even when user inputs are based on estimates. Upholding this standard of quality requires the use of sophisticated sources as elaborated in Section 2, which are regularly reviewed to incorporate the latest insights from academia and research into the methodology of the *atmosfair $CO_2$ event calculator*.

## 1.3 System boundaries and geographical focus

To accurately assess emissions for any event, defining clear system boundaries is essential, delineating which aspects and corresponding emissions are included within the specified scope.

Two authoritative approaches exist which can be used as guidelines in GHG reporting of events: the corporate approach—GHG Protocol Corporate Standard and ISO 16064-1—which aims at calculating the GHG inventory of an organization in a given time frame; and the product approach—GHG Protocol Product Standard and ISO 14067—which aims at calculating the GHG emissions along the whole life cycle of a product. The GHG protocol defines direct GHG emissions and indirect emissions by introducing the concept of "scope" to differentiate sources of emissions.

The *atmosfair $CO_2$ event calculator* is designed to extend its scope to the whole supply chain of any event-related process, going beyond borders traced by individual responsibility. This is to get a clear image of all emissions related (directly or indirectly) to the event under review. The results can then be integrated into the corporate approach or be utilized as a stand-alone project depending on the client's preferences.

## Organizational Boundaries

Clear delineation of organizational boundaries is imperative to allocate emissions attributable to an event. The *atmosfair $CO_2$ event calculator* and its methodology establish these boundaries to include direct emissions occurring at the venue of the event as well as emissions more indirectly linked to the event (e.g. emissions from overnight stays of the participants). Moreover, emissions originating from participants themselves are included within the organizational boundaries given their substantial contribution to overall emissions (e.g. from travel and food consumption). Finally, emissions stemming from the organising process (e.g. transporting equipment before or after the actual event) are considered to be within the scope of calculation. The specific emissions taken into account are further detailed in the subsequent section.

## Operational Boundaries

**Event**

The *atmosfair $CO_2$ event calculator* accounts for emissions across five distinct categories related to the event:

- **Arrival and Departure**: Encompassing emissions from participant and organizer travel to and from the event premises, including local mobility during the event, spanning various transportation modes and travel classes.
- **Overnight Stay**: Facilitating the calculation of emissions stemming from overnight stays, such as for early arrivals or multi-day events, categorizing hotels based on class.
- **Catering**: Assessing emissions related to food and beverage provision, discerning between different dietary behaviours and beverage choices.
- **Venue**: Evaluating emissions originating from the event venue itself, offering insights into the climatic impact of the building, its electricity and heating provision, as well as water and waste consumption.
- **Transport of Goods**: Quantifying emissions associated with the mobilization of goods to and from the event site, considering diverse transportation modes.

**GHG Inventory**

Within each category, GHG emissions are computed based on activity data and corresponding emission factors. While primarily reported in $CO_2$, other greenhouse gases with climatic impacts, such as methane and nitrous oxide, are also accounted for. These gases, recognized as Kyoto Gases by the IPCC, are converted into $CO_2$ equivalents using their respective global warming potentials (See Table 1), and are displayed as $CO_2$eq.

The GHG inventory for each category in the *atmosfair $CO_2$ event calculator* is displayed as follows (see Table 2). For transparency, we also share information about the life cycle assessment system boundaries used in the database.

Consequently, the *atmosfair $CO_2$ event calculator* yields results in $CO_2$ equivalents, encompassing -where relevant - other greenhouse gases from this grouping, thus offering a comprehensive assessment of emissions.

*Table 1: Types of GHG and its GWP according to IPCC*

| | Greenhouse Gas<br>*Kyoto Gasses (IPCC 2021 – 6th Assessment Report Values) | Global Warming Potential (GWP) (Unit: $CO_2$eq) |
|---|---|---|
| 1 | Carbon Dioxide ($CO_2$) | 1 |
| 2 | Methane ($CH_4$) | 29.8 |
| 3 | Nitrous Oxide ($N_2O$) | 273 |
| 4 | Hydrofluorocarbons (PFCs) | 5-14,600 |
| 5 | Perfluorocarbons (PFCs) | 78-12,400 |
| 6 | Sulfur hexafluoride (SF6) | 25,200 |
| 7 | Nitrogen Trifluoride (NF3) | 17,400 |

**Geographic Focus**

The current version of the *atmosfair $CO_2$ event calculator* is tailored geographically to cater primarily to events within Germany. Consequently, some emission factors are tailored to Germany-specific conditions (e.g. electricity grid emission factors). Likewise, statistical data used for initial assumptions prioritizes German sources for the most precise estimations, supplemented by proxy emission factors where necessary, such as European averages.

However, certain emissions, like those associated with air travel—a significant emission source for most events—are calculated globally, facilitating the tool's international applicability with minor potential discrepancies. For events falling outside the tool's geographic scope, *atmosfair* recommends a 5-10 % "security buffer" to be added to final results before offsetting, mitigating the risk of emissions underrepresentation and potential greenwashing.

In future iterations, plans are underway to broaden the geographical scope, incorporating country-specific emission factors for multiple international locations, and providing users with individually selectable options for enhanced accuracy on a global scale.

*Table 2: Overview of GHG and the life cycle perspective for databases used in the atmosfair $CO_2$ event calculator*

| | Database and Source | $CO_2$ | Non-$CO_2$ | Life cycle perspective |
|---|---|---|---|---|
| Arrival and Departure | HBEFA | Yes | $CH_4$, $N_2O$ | Direct emission and end energy consumption upstream process |
| | VDR standard | Yes | $CH_4$, $N_2O$, and more | Well-to-Wheel approach for Kerosene; Tank-to-Wheel approach for rail-specific energy consumption |
| Overnight Stay | VDR Standard | Yes | No | Upstream of the supply chain is excluded |
| Catering | Natural Food Journal | Yes | $CH_4$, $N_2O$ | Food production and sourcing included |
| | ifeu | Yes | $CH_4$, $N_2O$ | System boundary "supermarket checkout": Upstream process for agriculture production, food processing, packaging, and distribution process included. |
| Venue | ProBas | Yes | GHG according to IPCC | Cradle to Grave |
| | DEFRA | Yes | GHG according to IPCC | Cradle to Grave |
| | Genesis 5.0 | Yes | GHG according to IPCC | Cradle to Grave |
| Transport of Goods | HBEFA | Yes | $CH_4$, $N_2O$ | Direct emission and end energy consumption upstream process |
| | TREMOD | Yes | $CH_4$, $N_2O$ | The direct emissions are taken into account, including evaporation emissions and those emissions that occur in the End energy consumption upstream process chain. |

## 1.4 From measuring to climate action

The *atmosfair $CO_2$ event calculator* serves as a recurring benchmarking mechanism, extending beyond a one-time step and operating within a cycle of avoidance, reduction, and offsetting measures. Its primary goal is to establish an initial emissions benchmark, facilitating the early identification of emission hotspots and the derivation of reduction potentials at the start of the event planning process.

Throughout the process, as the event approaches and climate-conscious decisions are made during the organizational phase, activity data can be adjusted and iterated based on the measures taken. This enables continuous monitoring of results and the assessment of the effectiveness of individual actions.

Upon completion of the event planning process, the *atmosfair $CO_2$ event calculator* serves two main purposes. Firstly, it furnishes the event organizer with a final emissions report detailing all remaining unavoidable emissions. This report forms the basis for taking climate action. Through the website, emissions can be offset in externally monitored climate protection projects in the Global South, certified by the UN and the Gold Standard. Additional information on *atmosfair* projects and its quality standards can be found here.

Secondly, for recurring events, such as annual gatherings, the finalized event emissions report becomes a cornerstone for subsequent events. The *atmosfair $CO_2$ event calculator* is designed to duplicate any event calculations, facilitating quick reiteration of activity data and making quick adjustments where necessary. This continual process aims to raise the bar of climate ambition, optimizing and reducing emissions in successive events. Furthermore, it acts as a conduit to stimulate the collection of more accurate activity data for future calculations, enhancing understanding of emission sources and hotspots.

# 2. References

## 2.1 Sources and databases for emission factors

### German Federal Environment Agency

**HBEFA & TREMOD**

The Federal Environment Agency routinely releases the Handbook of Emission Factors for Read Transport (HBEFA), an extensive repository of air pollutant emissions stemming from road transportation. This handbook provides emission factors for key air pollutants and details the fuel consumption of motor vehicles. The data is organized according to various technical and traffic parameters, such as vehicle type (car, truck, bus, etc.), exhaust gas treatment (regulated, unregulated catalytic converter, etc.), propulsion type (petrol, diesel, electric engine, etc.), and traffic conditions (urban, rural, motorway, etc.). Additionally, it facilitates differentiation between the contributions of freight and passenger transportation to pollutant emissions.

The current version 4.2 of the HBEFA is supported by the computer program TREMOD (Transport Emission Model, Version 6.51), developed and regularly updated by the Institute for Energy and Environmental Research Heidelberg (ifeu gGmbH) on behalf of the Federal Environment Agency.

Calculations of pollutant emissions in road transportation rely on the emission factors outlined in the HBEFA manual. These emissions encompass nitrogen oxides, hydrocarbons (differentiated into methane and non-methane hydrocarbons), benzene, carbon monoxide, particulates, ammonia, nitrous oxide, carbon dioxide, and sulphur dioxide. Direct emissions, including evaporative emissions and emissions generated in the upstream process chain of final energy consumption, are analysed.[5]

**ProBas**

With the ProBas database, the Federal Environment Agency has been making process data available to the public free of charge since the 1990s, as required, for example, for life cycle assessments or operational reporting.

ProBas stands for "Process-oriented basic data for environmental management instruments". Numerous publicly available data sources are included in the ProBas database to provide the broadest possi-

5 *German Federal Environment Agency: HBEFA & TREMOD Database – Emissions data*

ble spectrum of life cycle data. Using extensive search and filter functions, more than 20,000 data sets can be searched and downloaded in standard export formats.[6]

## VDR Standard

In cooperation with the German Business Travel Association (VDR), *atmosfair* has developed the VDR standard for the $CO_2$ calculation of corporate travel. This standard covers the entire span of business travel (flights, hotels, rental cars, rail and conferences) and satisfies demands for worldwide application, accuracy, comparability and independence.

$CO_2$ business travel reporting according to the VDR Standard should be applicable worldwide. This means the ability to compute the $CO_2$ emissions of every business trip in the world with an assured minimum degree of accuracy.

The VDR Standard is based on the following approaches and methods: ICAO Carbon Emissions Calculator, ifeu (Institute for Energy and Environmental Research), IPPC (Intergovernmental Panel on Climate Change), DIN EN 16258 (draft) - Method for the calculation and declaration of energy consumption and GHG emissions for transport services (freight and passenger transport). The data comes from independent sources.[7,8]

## ifeu – Institute for Energy and Environmental Research Heidelberg

ifeu researches and advises on all important environmental and sustainability issues worldwide. With over 40 years of experience, it is one of the most important ecologically oriented research institutes in Germany.[9] It adopts a transdisciplinary approach in order to respond to urgent environmental and sustainability issues.[10]

The specific data provided by the ifeu which is utilised in the *atmosfair $CO_2$ event calculator* was partly funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety within the framework of the KEEKS project as well as by the Federal Environment Agency within the framework of the project “Online consumer information on sustainable consumption: scientific database for assessment tools and social science evaluations”.

## DEFRA

The UK Government Conversion Factors for GHG reporting are published and continuously updated by the Department for Energy Security and Net Zero and the Department for Environment, Food & Rural Affairs (DEFRA).

The *atmosfair $CO_2$ event calculator* uses the 2023 dataset (Version 1.1) published on June 7th and last updated on June 28th, 2023. As the geographic scope is UK-centric, this database is only utilised as a fallback option where Germany-focused emission factors are unavailable or considered to be of poor quality. This is namely the case for water supply and treatment and waste disposal. In both cases, the emissions factors are supported by Germany-centric consumption statistics taken from the Genesis 5.0 database of the Federal Statistical Office of Germany.

## Nature Food – Academic Journal

*Nature Food* is a monthly online journal that publishes high-quality research, reviews, comments, and opinions on food-related topics. It spans various disciplines within the natural, applied, and social scien-

6 *German Federal Environment Agency: ProBas database*

7 *atmosfair $CO_2$ Reporting Standards for Companies: VDR standard*

8 *VDR Standard for $CO_2$ Calculation in Business Travel*

9 *Institute for Energy and Environmental Research (ifeu)*

10 *Institute for Energy and Environmental Research: ifeu's Vision and Approach*

ces. The journal offers a wide range of evidence and expert insights aimed at helping researchers and policymakers optimize and secure future food systems.[11] Articles submitted to Nature Food undergo peer review, with all editorial decisions handled by a dedicated team of full-time professional editors. The journal's electronic international standard serial number (EISSN) is 2662-1355.

The data utilised by the *atmosfair $CO_2$ event calculator* stems from a published article in July 2023 as part of the seventh issue of volume four of the academic journal and relies on a dietary dataset of over 55.400 consumers. The dietary information is linked with food-level data on GHG emissions, land use, water use, eutrophication risk, and potential biodiversity loss. The study further draws on 570 life cycle assessments covering over 38,000 farms across 119 countries, enabling direct comparisons of environmental indicators for the dietary groups under review.

## 2.2 Sources and databases for other statistics

In addition to utilizing emission factors for precise and scientifically grounded calculations, several reputable sources serve as the foundation for preset conditions in situations where activity data is unavailable. These sources form the basis of initial assumptions aimed at reducing entry barriers to emissions calculations for events while maintaining a minimum quality standard for estimations. The following sources were employed and are detailed again in the individual steps of calculations where appropriate:

### Arrival & Departure

- **DEHOGA**: DEHOGA statistics provide comprehensive data on the hospitality industry in Germany, including arrival and departure patterns. This helps in determining default splits for event-related travel analysis.

### Catering

- **Federal Ministry of Food and Agriculture (Ernährungsreport 2023)**: provides national data on dietary behaviour and preferences to better estimate food choices.
- **Statista Consumer Market Outlook**: Based on calculations by the Federal Ministry of Statistics this source supports beverage-specific consumption estimations. This data is partially triangulated with data provided by the German Coffee Association.

### Venue

- **Federal Statistical Office of Germany - GENESIS Database**: Provides detailed statistical data on various aspects of the German economy, including energy consumption in venues.
- **Federal Association of Energy and Water Industries (BDEW)**: Supplies data on energy and water usage, essential for calculating venue-related emissions.
- **Heizspiegel by $CO_2$online**: Funded by the Federal Ministry for Economic Affairs and Climate Action, this survey provides data on heating consumption, important for assessing venue energy use.
- **Odyssee-Mure**: This EU-funded project provides comprehensive data on energy efficiency and policy measures in Europe. It pools data from various national sources to provide detailed information on energy consumption per square meter in buildings, aiding in accurate emission calculations.

### Transport of Goods

- **Federal Statistical Office of Germany - GENESIS Database**: The GENESIS-Online database offers reliable statistical data for calculating Freight Tonne-Kilometres, aiding in the assessment of emissions from goods transport

11 *Nature Food Journal Information*

## 2.3 Updates

To uphold the accuracy and currency of the *atmosfair $CO_2$ event calculator*, its methodology will undergo routine updates as outlined in a predefined product management plan. This ensures that all emission factors and sources are comprehensively reviewed at least once annually. This proactive approach enables the timely integration of new scientific discoveries into the calculation methodology, facilitating transparent and scientifically sound assessments of event-related emissions.

Important updates to the calculator will be reflected in new versions of the methodology in the future to maintain our commitment to transparency. This approach also enables clients to track any pertinent changes in the tool's functionality and methodology over time.

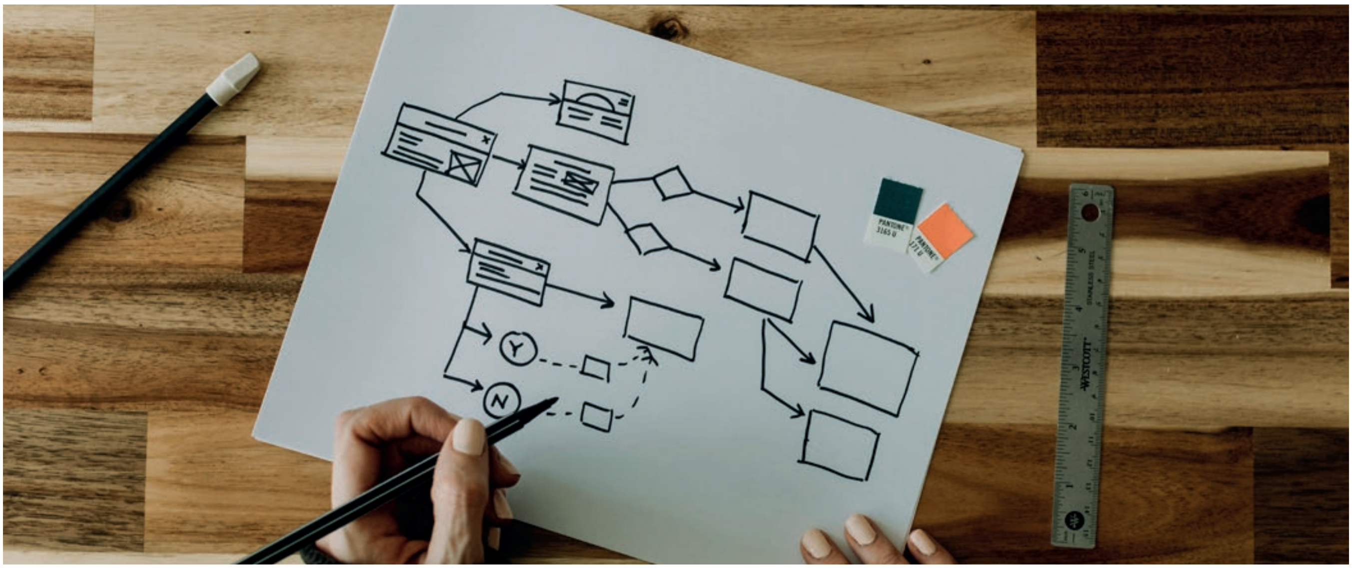
# 3. Terms and Definitions

## 3.1 Definitions

- **Event**: an organised, purpose-determined, time-limited event in which a group of people participate on-site and/or via media.
- **Hotel Class**: Classification of hotels based on facilities, such as room size and comfort, affecting energy and water consumption. The hotel classification within this methodology encompasses the commonly used range of five classifications, ranging from one to five stars.
- **Destination Country**: The country where a hotel is located, which affects energy and water consumption as well as waste production due to climatic conditions, political environment, and efficiency of local energy and waste management systems.
- **Catering**: Food and drinks provided at events, with emissions linked to dietary preferences.
- **Catchment Area**: The typical arrival distance of participants, affecting travel distances and required overnight stays.
- **Emission Factor (EF)**: Quantity of greenhouse gas emissions per unit of activity data (e.g., kg $CO_2$eq per km travelled).
- **Activity Data**: Quantitative information reflecting the magnitude of activities, such as distance travelled, overnight stays, and energy consumption.
- **GHG Inventory**: The calculated inventory of greenhouse gas emissions, including $CO_2$, methane ($CH_4$), and nitrous oxide ($N_2O$), expressed as $CO_2$ equivalents.
- **System Boundaries**: The defined limits of what emissions are included in the analysis, such as direct emissions at the event venue and indirect emissions from participant travel.
- **Proxy Data**: Default estimates are used when specific data is unavailable, based on current statistics and averages.
- **Carbon Footprint**: The total amount of greenhouse gases emitted directly or indirectly by an event, expressed in $CO_2$ equivalents.

## 3.2 Abbreviations

- **GHG**: Greenhouse Gas
- **$CO_2$**: Carbon Dioxide
- **$CH_4$**: Methane
- **$N_2O$**: Nitrous Oxide
- **LCA**: Life Cycle Assessment
- **EF**: Emission Factor
- **km**: Kilometer
- **kg**: Kilogram
- **$CO_2$eq**: Carbon Dioxide Equivalent
- **UBA**: Umweltbundesamt (German Federal Environment Agency)
- **DESTATIS**: Federal Statistical Office of Germany
- **TREMOD**: Transport Emission Model
- **VDR**: German Business Travel Association
- **DEFRA**: Department for Environment, Food & Rural Affairs (UK)
- **HBEFA**: Handbook of Emission Factors for Road Transport
- **ifeu**: Institute for Energy and Environmental Research Heidelberg
- **ProBas**: Process-oriented Basic Data for Environmental Management Instruments



# 4. Calculation Methodology

This chapter handles the emission calculation of the *atmosfair $CO_2$ event calculator*. The sub-chapters will focus on each step of the calculator and its respective calculation methodology.

The general formula for any entry is always:

*Equation 1*

$$\sum CO_2 \text{ Emissions} = \sum_x (\text{activity data} \times \text{Emissions factor})_x$$

- **Activity data** refers to the quantitative information that reflects the extent or magnitude of activities in each emission category. For example, activity data includes metrics such as the distance travelled by participants, the number of overnight stays, the amount of food served, the energy consumption of the venue, and the volume of goods transported etc.
- The **Emission factor** is the respective emission factor (EF) of the item or process and is based on the data sources detailed in Section 2.1.

The user can adjust the activity data or other documented input at any point. Each change will result in a recalculation of the emissions. Users cannot alter the emission factors. They are diligently investigated and integrated directly into the tool. The emission factors remain subject to potential adjustments contingent upon the most recent updates derived from official and dependable statistical sources.



## 4.1 Base Data

### 4.1.1 Background

The "Base Data" step encompasses key event-related information crucial for calculating total event emissions. It serves as the foundational step for estimating emissions, particularly in scenarios with limited data input. Based on the primary input from this step, the *atmosfair $CO_2$ event calculator* performs initial calculations for subsequent stages, allowing for adjustments and refinements where more precise data is available.

### 4.1.2 Calculation Method

**Initial Conditions**

The *atmosfair $CO_2$ event calculator* requires a minimum of three specific parameters ("Number of participants," "Duration in days," and "Catchment area") to begin calculations, which cannot be preconfigured. These essential elements serve as the minimum required information to initiate the calculation process.

**User Input**

The following data (see Table 3) can be input into this section before moving on to any of the detail pages. Information marked with an asterisk is required to be filled in before any of the subsequent pages can be edited.

The catchment area indicates how widespread the typical arrival distance of the participants is. It will preset the estimates on travel distances and required overnight stays for the following sections. However, it represents a distribution rather than the actual distance travelled by each participant. Details can be adjusted in the following step(s).

*Table 3: Input parameters for "Base Data" (User Input): Requirements and conditions*

| Variable | Datatype | Unit | Required? | Conditions |
|---|---|---|---|---|
| Name of the event | Text | - | Optional | - |
| Organizer of the event | Text | - | Optional | - |
| Location of the event | Text | - | Optional | - |
| Number of participants* | Integer | Person(s) | Required | > 0 |
| Duration* | Integer | Day(s) | Required | > 0 |
| Start date | Date | - | Optional | Duration = End date – Start date<br>Adjust the duration to end-start when both dates are set |
| End date | Date | - | Optional | The end date is auto-selected when duration is given and the start date is selected. |
| Catchment area* | Selection from list | Km | Required | Must be selected from the list below |

**Plausibility Check**

To facilitate users in using the *atmosfair $CO_2$ event calculator* and to minimize the risk of unrealistic inputs due to data errors, the tool incorporates rigorous plausibility checks guided by predefined rules governing the provided data. These checks distinguish between **warning symbols** and **error messages**. Warning symbols alert users to potentially illogical input data, allowing them to proceed with calculations at their discretion. Conversely, errors prevent users from advancing until the issue is rectified, thereby ensuring that critical errors are addressed before proceeding with calculations.

In this step, an error message will be displayed when:

- The duration of the event to be created is left empty or equal to zero.
- The catchment area is empty. This occurs when nothing is selected from the drop-down menu and prevents the user from advancing to the subsequent step.
- The number of participants is left empty or equal to zero.

*Table 4: Preset travel distance estimates by catchment area*

| Name | Preset travel distance in km |
|---|---|
| Local | 20 |
| Regional | 100 |
| National | 500 |
| International | 1000 |
| Intercontinental | 65000 |


## 4.2 Arrival & Departure

### 4.2.1 Background

The arrival and departure of participants significantly impact the environmental footprint of any event. The emission levels associated with passenger travel vary depending on factors such as the event format (virtual or in-person) and its scale. Life cycle assessment (LCA) studies reveal that travel-related emissions can contribute up to approximately 70% of the overall emissions from an event.[12] This highlights the critical need to carefully consider and accurately account for these emissions in event planning methodologies.

### 4.2.2 Calculation Method

In the assessment of emissions from passenger travel, the methodology aggregates the total emissions produced by all passengers utilizing various modes of transportation. Specifically, the emissions attributable to passengers using a particular mode of transport are derived as follows: multiplying the distance travelled via this mode by the number of participants utilizing it, and subsequently multiplying this product by the emission factor associated with the mode of transport. The calculation of GHG emissions attributable to passenger travel is formulated as:

*Equation 2*

$$\sum \mathrm{CO_2\ Emissions\ (Travel)} = \sum_a N_{\mathrm{distance},a} \times N_{\mathrm{passenger},a} \times EF_{\mathrm{travel},a}$$

| | Parameter | Unit | Description |
|---|---|---|---|
| $a$ | Mode of transport | n/a | The modes of transport integrated in this version of event calculator include:<br>• Cars<br>  • Petrol<br>  • Diesel<br>  • Hybrid<br>  • Electric<br>• Public transport systems<br>• Coach Buses<br>• Taxi services<br>• Bicycle and pedestrian travel<br>• Regional rail transport<br>• Long-distance rail transport<br>• Air Travel |
| $N_{\mathrm{distance,a}}$ | Distance travelled by means of transport | km | - |
| $N_{\mathrm{passenger,a}}$ | Number of participants utilizing the mode of transport a | Number (integer) | - |
| $EF_{\mathrm{travel,a}}$ | Emission factor for mode of transport a | kg $CO_2$eq/pkm* | - |

*/pkm – per passenger per kilometre

12 *Tao, Y., Steckel, D., Klemeš, J.J. et al. Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy. Nat Commun 12, 7324 (2021).*

*Table 5: Preset conditions for parameters in "Arrival & Departure": Tier 1 and Tier 2*

| Parameter | Preset Tier 1 | Preset Tier 2 |
|---|---|---|
| Number/Proportion of people from the local catchment area (up to 20 km) | When selected in the "Base Data" step:<br>• 75 % local<br>• 15 % regional<br>• 10 % national | Initial split for the mode of transport in this catchment area:<br>• 60 % car<br>• 30 % public transport<br>• 10% taxi |
| Number/Proportion of people from the regional catchment area (up to 100 km) | When selected in the "Base Data" step:<br>• 30 % local<br>• 58 % regional<br>• 10 % national<br>• 2 % international | Initial split for the mode of transport in this catchment area:<br>• 60 % car<br>• 32 % long-distance train<br>• 8 % regional train |
| Number/Proportion of people the from national catchment area (up to 500 km) | When selected in the "Base Data" step:<br>• 17 % local<br>• 22 % regional<br>• 56 % national<br>• 35 % international<br>• 5 % intercontinental | Initial split for the mode of transport in this catchment area:<br>• 50 % plane<br>• 25 % car<br>• 3 % regional train<br>• 22 % long-distance train |
| Number/Proportion of people from the international catchment area (up to 1000 km) | When selected in the "Base Data" step:<br>• 10 % local<br>• 20 % regional<br>• 30 % national<br>• 35 % international<br>• 5 % intercontinental | Initial split for the mode of transport in this catchment area:<br>• 95 % plane<br>• 5 % long-distance train |
| Number/Proportion of people from the intercontinental catchement area (up to 6500 km) | When selected in the "Base Data" step:<br>• 5 % local<br>• 15 % regional<br>• 20 % national<br>• 25 % international<br>• 35 % intercontinental | Initial split for the mode of transport in this catchment area:<br>• 100% plane |
| Number/Proportion of people from a customizable catchment area | Not selectable in the "Base Data" step, must be added manually and be assigned a specific distance in Km | The initial split for the mode of transport depends on the distance specified when creating the catchment area. It then follows the split of the other catchment areas as follows:<br>• 0-20 km: local split<br>• 21-100 km: regional split<br>• 101-500 km: national split<br>• 501-1000 km: international split<br>• > 1000 km: intercontinental split |

### Initial conditions

This analysis of transportation modes utilized by travellers to reach the venue operates across three tiers. First, it assesses the demographic distribution across catchment areas within the total participant pool. Next, it estimates the transportation mode preferences based on their proximity to the venue. Lastly, it applies an additional factor to journeys taken by train and plane services, specifically focusing on anticipated travel class preferences within these transportation modes among the total participant cohort. Additionally, it depicts varying fuel types of automobiles.

### Tier 1

Based on the selected catchment area within the "Base Data" step, a presumed distribution of participants is established across various distances, assuming not all participants will travel from the specified distance of the catchment area radius. (See Table 5, column "Preset Tier 1")

### Tier 2

Different modes of transport are allocated to each catchment area with varying initial splits for distinct catchment areas. These splits are based on the probability of passengers selecting any specific mode of transport within a certain distance. (See Table 5, column "Preset Tier 2"). These presumed splits can be personalized at any point in time.

### Tier 3

For certain modes of transportation, further specifications are made to more accurately measure emissions. For travel by aeroplane or train, various seating classes are available to better allocate the total emissions of the vehicle to the individual travelling. For travels by car, further distinctions are made between the type of fuel powering the vehicle. The presets of tier 3 are shown in Table 6.

### User input

The Tier 1 and Tier 2 splits and Tier 3 default settings illustrated in Table 5 and Table 6 above are considered as a preset for all parameters. However, all preset parameters in the "Arrival & Departure" step can be adjusted. This can be done by changing either the number of travellers or percentages. Personalized data entry is considered user input as described in Table 7 below.

*Table 6: Preset conditions for parameters in "Arrival & Departure": Tier 3*

| Parameter | Preset Tier 3 |
| --- | --- |
| Train Passenger Class Distribution | The classification of train class derived from the VDR standard encompasses three categories:<br>• not specified (unknown)<br>• Second Class<br>• First Class<br>The preset of passengers to specific train classes by default is set to "Not specified (unknown)". |
| Plane Passenger Class Distribution | The classification of plane class derived from the VDR standard encompasses five categories:<br>• not specified (unknown)<br>• Economy Class<br>• Premium Economy Class<br>• Business Class<br>• First Class<br>The preset of passengers to the specific plane by default is set to "Not specified (unknown)". |
| Car Fuel Type Distribution | The classification of fuel type for cars encompasses five categories:<br>• not specified (unknown)<br>• Petrol<br>• Diesel<br>• Hybrid<br>• Electric<br>The preset of fuel type by default is set to "Not specified (unknown)". |

### Plausibility Check

A warning message is displayed when:

- The total number of travellers is less than the total number of participants initially input in the "Base Data" step
- The total number of travellers is more than the total number of participants initially input in the "Base Data" step. The user can continue as potential external people not participating in the event might still be within the scope of calculation for travel emissions.
    - **Note**: Should the user want to include transportation by multiple means of transport for one person this can be done on tier two by adjusting the transport to include more rides than travellers.

Users can continue to the next step despite the warnings.

*Table 7: User input for parameters in "Arrival & Departure": Participant distribution across catchment areas*

| Parameter | Preset | User Input |
| --- | --- | --- |
| Number/Proportion of people from local catchment area (up to 20km) | Tier 1, 2 & 3 as presented above | Adjustable based on number of people or percentage of total people |
| Number/Proportion of people from regional catchment area (up to 100km) | | |
| Number/Proportion of people from national up to (up to 500km) | | |
| Number/Proportion of people from international (up to 1000km) | | |
| Number/Proportion of people from intercontinental (up to 6500km) | | |
| Number/Proportion of people from customizable catchment area | | |

An error message is displayed under three conditions:

- The sum of rides from all modes of transport within one catchment area is less than the number of total travellers within the same catchment area. This prevents accidental underrepresentation of mobility, based on the fact that each participant must at least utilise one mode of transportation to get to the event location.
- The travel distance of a newly created customised catchment area is left empty or equals zero.
- The number of rides on tier 3 to select travel class or fuel type does not equal the number of rides previously selected on tier 2.

Users cannot proceed to the next step until these issues are corrected.




## 4.3 Overnight Stay

### 4.3.1 Background

In 2020, accommodation services emitted 742 kilotons of $CO_2$ equivalents[13], making them the fourth largest source of tourism-related emissions. These emissions arise from substantial energy use for electricity, heating, and cooling, significant water consumption, and waste generation within the hospitality industry. While eco-friendly measures can reduce emissions, they remain considerable and must be accounted for when assessing the carbon footprint of events, especially those of longer duration.

### 4.3.2 Calculation Method

The number of overnight stays is multiplied by the emission factor defined by the selected hotel class. Calculation of GHG emissions attributable to overnight stay of guests requires input data on the number of guests and their respective duration of stay. The calculation of GHG emissions attributable to overnight stays is formulated as:

*Equation 3*

$$\sum \mathrm{CO_2\ Emissions\ (Overnight)} = \sum_b N_{\mathrm{guests}} \times N_{\mathrm{nights}} \times EF_{\mathrm{hotels},b}$$

| | Parameter | Unit | Description |
|---|---|---|---|
| *b* | Hotel Class | n/a | The hotel class is categorised as:<br>Unknown (default)<br>• 1-star hotel<br>• 2-star hotel<br>• 3-star hotel<br>• 4-star hotel<br>• 5-star hotel |
| $N_{guests}$ | Number of guests | Number (Integer) | - |
| $N_{nights}$ | Number of nights | Number (Integer) | - |
| $EF_{hotel,b}$ | Emission factor for hotels based on hotel class b | kg $CO_2$eq per Participant per night | - |

The emission factors for hotel classes in the *atmosfair $CO_2$ event calculator* are derived from the VDR standard database. These factors vary by hotel class and destination country. The "unknown" variable is calculated using a weighted average based on the occurrence of hotel classes in Germany. Currently, country-specific proxy emission factors are not implemented for consistency.

The VDR standard considers factors like energy consumption, water use, waste management, booking category, and occupancy rate. Note that the VDR standard excludes upstream supply chain and non-$CO_2$ emissions of overnight stay due to limited data accuracy and availability.

13 *DESTATIS: Energy, Greenhouse Gases, and Raw Materials in Transport and Tourism*

**Initial Conditions**

The parameters are initially set during the "Base Data" step upon the initial input (as shown in Table 8), and users can configure them at any point in the process as the "Arrival & Departure" subsequently acts as the basis of calculation.

"Number of persons" is pre-set to the count of travellers from all catchment areas taken from the "Arrival & Departure" section, excluding local participants. This initial conditionv works with the hypothesis that local participants do not typically necessitate additional accommodations.

"Hotel class" is preset to "unknown" for conservative considerations.

"Number of nights" is preset to the value of the duration of the event minus one day. This assumption is based on the consideration that participants may potentially stay one night less than the full event duration due to factors such as early departure and late arrivals.

*Table 8: Preset conditions for parameters in "Overnight Stay"*

| Parameter | Preset |
|---|---|
| Number of persons | Number of total travellers (Integer) minus the number of travellers from catchment area "local" |
| Hotel class | unknown |
| Number of nights | Duration of event (in days) minus one |

**User input**

"Number of persons" can be modified by users either through precise numerical values or by inputting a percentage relative to the total count. It is noteworthy that the percentage input is automatically rounded to the nearest integer, as fractional representations ("partial participants") are not accommodated.

Adjustments to "Number of nights" can be made by entering the relevant number of nights, allowing for contingencies – such as participants arriving a day earlier.

In case participants are distributed across various hotel classes, users have the option to delineate these groups by creating a new hotel class through the "Add hotel class" feature. This additional functionality serves to enhance precision in the calculation.

- **Note:** User input has higher priority than the preset parameter for the "Overnight Stay" section. This means that, after personalized changes are made to "Overnight Stay", any personalized adjustments made to the previous section (Arrival & Departure) will have no consequence on the "Overnight Stay" section. Any retrospective adjustments made in the "Arrival & Departure" step need to be adjusted manually in the "Overnight Stay" section to reflect the changes.

User input for "customized catchment area" is not reflected in the "Overnight Stay" section. This means that any such adjustment has no consequence on the recognition of "local" and "non-local" in the "Overnight Stay" section. The manual implementation of changes in the number or proportion of individuals for "Overnight Stay" is required, resulting from user input for a customized catchment area in the context of "Arrival & Departure," both prospectively and retrospectively.

*Table 9: User Input for parameters in "Overnight Stay"*

| Parameter | Preset | User Input |
|---|---|---|
| Number of persons | Number of total travellers minus Number of travellers from catchment area "local" (Note: Customized catchment area of less than 20km is not automatically considered as "local" in the "overnight stay" section, this adjustment needs to be implemented manually by users) | Adjustable based on Number of people or percentage of total people |
| Hotel class | unknown | Selection of service class through Drop Down |
| Number of nights | Duration of days - 1 | Number of nights |

**Plausibility Check**

A warning message is displayed under three conditions:

- When the "Number of persons" in this section is observed to be lower than the count of non-local travellers in the "Arrival & Departure" section. This precaution is implemented to avoid the underestimation of emissions, grounded in the assumption that individuals travelling from distances exceeding 20km likely necessitate hotel accommodations. Nevertheless, users retain the option to progress to the subsequent step despite the alert.
- When the "Number of persons" surpasses the total number of travellers in the "Arrival & Departure" section, the user is also notified but can advance the subsequent step to allow for external people not participating in the event but still requiring accommodation to be accounted for.
- When "Number of nights" in this section is observed to be higher than the total duration of the event. This precautionary measure acknowledges that participants typically do not extend their stay beyond the designated event duration. However, users retain the flexibility to modify this parameter in alignment with actual occurrences or their premeditated plans.

Users can continue to the next step despite the warnings.

An error message is displayed when:

- When the 'number of nights' input is empty or the number is 0, an error message is displayed. The entire section must instead be removed should this input be intended.

Users cannot proceed to the next step until this issue is corrected.

CATERING

## 4.4 Catering

### 4.4.1 Background

Catering plays a crucial role in event hosting, and it is essential to not disregard the emissions linked to the food system. The IPCC's special report on climate change and land delineates an emission range spanning from 10.8 to 19.1 billion tons of $CO_2$eq for food emissions annually[14], making up 21% to 37% of global emissions.[15] The total emissions from the food system result from various sources, including agriculture and land use/land-use change activities, supply chain operations such as food processing, packaging, and transport, as well as post-retail activities initiated by consumers.[16]

### 4.4.2 Calculation Method

In determining the catering-related emissions, the calculation involves emissions from both food and drinks. The calculation for food-related emissions is derived by multiplying the total number of meals by an emission factor assigned to distinct dietary choices. Conversely, the calculation for drink-related emissions multiplies the quantity of each type of drink by the emission factor corresponding to the respective category. The calculation of GHG emissions attributable to catering is formulated as:

*Equation 4*

$$\sum \mathrm{CO_2\ Emissions\ (Catering)} = \sum_c (N_{\mathrm{meal},c} \times EF_{\mathrm{meal},c}) + \sum_d (N_{\mathrm{drink},d} \times EF_{\mathrm{drink},d})$$

$N_{meal,c}$ is extrapolated by the percentage of participants opting for diet $c(w_c)$ multiplied by the total number of meals ($N_{meal,total}$):

*Equation 5*

$$N_{\mathrm{meal},c} = w_c \times N_{\mathrm{meal.total}}$$

Where:

*Equation 6*

$$N_{\mathrm{meal},total} = N_{\mathrm{participants}} \times N_{\mathrm{days}} \times f_{\mathrm{meal}}$$

*Equation 7*

$$N_{\mathrm{drinks},d} = N_{\mathrm{participants}} \times N_{\mathrm{days}} \times f_{\mathrm{drinks},d}$$

The emission factors for the catering category are based on a peer-reviewed study by Scarborough et al.[17] for dietary categories and a publication by ifeu titled "Environmental Footprints of Food Products and Dishes in Germany". The system boundaries for beverages include agricultural production, food processing, packaging, and distribution.

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14 Mbow, C. et al. Food Security in Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems (IPCC, 2019).

15 Hannah Ritchie (2021) - "How much of global greenhouse gas emissions come from food?" Published online at OurWorldInData.org

16 Crippa, M., Solazzo, E., Guizzardi, D. et al. Food systems are responsible for a third of global anthropogenic GHG emissions. Nat Food2, 198–209 (2021).

17 Scarborough, P., Clark, M., Cobiac, L. et al. Vegans, vegetarians, fish-eaters and meat-eaters in the UK show discrepant environmental impacts. Nat Food 4, 565–574 (2023).

| | Parameter | Unit | Description |
|---|---|---|---|
| $c$ | Dietary type | n/a | Plant-based Diet:<br>• Vegan<br>• Vegetarian<br>Animal-based Diet:<br>• Pescetarian<br>• Low Meat Content Diet (less than 50 grams)<br>• Medium Meat Content Diet: (less than 100 grams)<br>• High Meat Content Diet: (more than 100 grams) |
| $N_{meal,c}$ | Number of meals from dietary type c | Number (Integer) | - |
| $w_c$ | Percentage of participants opting for diet type c | % | - |
| $N_{meal,total}$ | Total number of meals | Number (Integer) | The total number of meals served during the event. It can be estimated directly, or it can be derived from Equation 6, by multiplying the number of participants ($N_{participants}$), the duration of the event ($N_{days}$), and the estimated meals per participant per day ($f_{meal}$). |
| $EF_{meal,c}$ | Emission factor for selected dietary type c | kg $CO_2$eq per meal | The emission factor for each dietary type is derived from research conducted by Scarborough et al. (2023) |
| $d$ | Drink type | n/a | The drink type for this version of the methodology consists of:<br>• Water<br>• Coffee<br>• Juice/Lemonade<br>• Beer<br>• Wine |
| $N_{drinks,d}$ | Quantity of drink type d | Number (Integer) | The quantity of drinks type d served during the event. It can be estimated directly, or it can be derived from Equation 7, by multiplying the number of participants ($N_{participants}$), the duration of the event $N_{days}$), and the estimated drinks type j per participant per day ($f_{drink,d}$). |
| $EF_{drinks,d}$ | Emission factor for drink type d | kg $CO_2$eq per serving | The emission factors for each drink type are derived from a publication by ifeu (Institute for Energy and Environmental Research Heidelberg). |

**Initial Conditions**

The parameters are initially set during the "Base Data" step upon the initial input, and users can configure them at any point in the process (see Table 10).

"Number of people" is preset to the number of participants taken from the "Base Data" step, under the assumption that all participants will require sustenance.

"Number of meals per person per day" is preset to 3 meals per day, assuming all participants require breakfast, lunch and dinner.

The calculation for "Total meals" involves multiplying the "Number of people" by the "Number of meals per person per day" and the duration of the event, determined during the "Base Data" step (according to Equation 6).

*Table 10: Preset conditions for parameters in "Catering": Number of meals and Total meals*

| Parameter | Preset |
|---|---|
| Number of meals per person per day | 3 meals per day |
| Total meals (optional) | It is calculated as "number of people" multiplied by "number of meals per person per day" and duration. I |

The initial distribution of participants among the five dietary categories described in Scarborough et al. (2023) is based on statistics from two sources: the BMEL nutrition report (BMEL-Ernährungsreport 2023)[18] and a private-sector nutrition report (2022)[19].

The initial estimates for the proportion of meals within a specific dietary category relative to the total number of meals are as follows (Table 11):

*Table 11: Preset conditions for parameters in "Catering": Dietary preferences among event participants*

| Parameter | Preset |
|---|---|
| Percentage of vegan meals | 2% of total meals |
| Percentage of vegetarian meals | 8% of total meals |
| Percentage of pescatarian meals | 2.4% of total meals |
| Percentage of low meat content meals | 46% of total meals |
| Percentage of medium meat content meals | 20.8% of total meals |
| Percentage of high meat content meals | 20.8% of total meals |

This methodology employs five distinct beverage categories: water, coffee, juice/lemonade, beer, and wine. Two serving sizes, classified as small and large, are assigned to each beverage category. In the initial setting, the default serving size for all beverage categories is established as the small serving size. Drawing upon consumption statistics of alcoholic and non-alcoholic beverages from the Statista Consumer Market Outlook[20] and ZDF[21], predefined quantities for all beverage categories are established.

The specific volumes for different serving sizes across the beverage categories as well as the assumed average consumption per participant per day are detailed in Table 12. The total consumption of drinks is calculated based on Table 12 and is initially displayed in the tool, however, users have the option to view detailed consumption breakdowns.

*Table 12: Preset conditions for parameters in "Catering": Beverage serving sizes and daily consumption*

| Parameter | Serving Size (in Liters) | | Preset |
|---|---|---|---|
| | **Small (default)** | **Large (alternative)** | **Consumption per participant per day** |
| Water | 0.2 | 1 | 1.8 |
| Coffee | 0.15 | 1 | 2.9 |
| Juice/Lemonade | 0.2 | 1 | 1.2 |
| Beer | 0.33 | 0.5 | 0.8 |
| Wine | 0.2 | 0.7 | 0.3 |

**User Input**

"Number of people" is subject to user customization, allowing for precise numerical adjustments. This offers users more flexibility, as the requisite catering capacity may diverge from the total number of participants.

Similarly, the parameter "Number of meals per person per day" is amenable to modification. This adaptability accounts for potential deviations from the initial assumption of three meals per day, accommodating more realistic scenarios. Decimals can be used to reflect snacks between meals.

If "Total meals" is selected and manually adjusted, it supersedes the preceding inputs of "Number of people" and "Number of meals per person per day." Consequently, "Total meals" serves as the foundational metric for calculating the emissions attributable to the food component of catering.

18 *Germany, how it eats - the BMEL Nutrition Report 2023*

19 *Results of the current nutrition study in Germany by Veganz*

20 *STATISTA: Per capita consumption of soft drinks in Germany by type of beverage from 2012 to 2023 (in liters)*

21 *Zdfheute: This is how much coffee Germany drinks (Article)*

*Table 13: User Input for parameters in "Catering": Number of people, meals and total meals, Percentage of meals with specific dietary relative to the total number of meals*

| Parameter | Preset | User Input |
|---|---|---|
| Number of People | Total number of participants | Adjustable to reflect precise or estimated number of people at the event |
| Number of meals per person per day | 3 meals per person per day | Adjustable to reflect precise or estimated number of meals per day. (Decimals are possible) |
| Total meals (optional) | It is calculated as the "number of people" multiplied by the "number of meals per person per day" and the duration of the event. | Directly adjustable to reflect the known total number of meals |
| Percentage of meals with specific dietary relative to the total number of meals | Percentages as defined in table 11 | Adjustable to reflect the precise or estimated percentage of each type of diet. (Decimals are possible) |

The variable "Percentage of meals with a specific diet type" is subject to user adjustment, permitting precision through the input of a percentage relative to the total count. This level of customization is imperative given that the preset condition relies on statistical averages derived from German consumer behaviour. It is acknowledged that actual circumstances may deviate from these averages, and users are provided with the option to input data reflective of real events.

The allocations for various drink categories are subject to user customization based on precise information or individual estimations. Users retain the autonomy to select or omit specific beverage categories by adjusting the litres to "0". The consumption data for different beverages is presented through parameters such as "Serving size," "People," and "Drinks per person per day" all of which are modifiable at the user's discretion. The calculation of "Total litres" is automated based on this user input or adjustable directly as well.

It is noteworthy that distinct beverages are associated with varying sizes in which they are served, aiming to facilitate the estimation of each type of drink by depicting reality as best as possible.

In the event of an erroneous entry in the process of estimating total litres, hitting the "reset" icon will prompt a return to default settings for all associated parameters. This mechanism ensures the integrity of data inputs and facilitates accurate customization by users.

*Table 14: User input for parameters in "Catering": Beverage serving sizes and daily consumption*

| Parameter | Preset | User Input |
|---|---|---|
| Type of drink | For all types of beverages, the small serving size is the default as defined in Table 12<br>The drinks per person per day based on this preset are:<br>• Water: 1.8 drinks of 0.2 L (glass)<br>• Coffee: 2.9 drinks of 0.15 L (cup)<br>• Juice/Lemonade: 1.20 drinks of 0.2 L (glass)<br>• Beer: 0.8 drinks of 0.33 L (bottle)<br>• Wine: 0.3 drinks of 0.2 L (glass) | The user can:<br>• Directly input the total litres<br>Or for estimation:<br>• Select between small or large serving sizes<br>• Adjust the number of people consuming this drink<br>• Adjust the number of drinks per person per day |

**Plausibility Check**

A warning message is displayed under the following conditions:

- Number of people for meals or drinks exceeding total participants: When the "number of people" in the meals section or when any of the "number of people" fields for drinks (e.g., coffee, water, etc.) is higher than the total number of participants. This precaution is implemented to avoid the over-estimation of emissions, ensuring that the catering is not planned for more individuals than are attending the event. However, users can choose to proceed despite the alert, recognizing that the catering count may include additional personnel such as venue staff or other support staff, which can justify the higher number.
- Number of people for meals less than total participants: When the "number of people" in the catering section is observed to be lower than the total number of participants. This precaution is implemented to prevent underestimation of emissions, ensuring that the catering accounts for all event participants. However, users can choose to proceed despite the alert, considering that not all attendees may require catering services at the event.

An error message is displayed under the following conditions.

- Empty Input for optional total meals: When the "optional total meals" option is selected and the corresponding input field is empty, an error message is displayed. Users must either provide the total number of meals or deselect the option to ensure accurate emissions calculation.
- Calculated total meals by diet not matching provided total meals: when the sum of total calculated meals from specified percentages of distinct diets is not 100%. This error ensures that calculated meals do not misrepresent the provided meals.

Users cannot proceed to the next step until these issues are corrected.



## 4.5 Venue

### 4.5.1 Background

The venue plays a pivotal role in any event, the related emissions fall into the category of GHG emissions from energy use in buildings. As per the European Environment Agency (EEA), the building sector constitutes a significant contribution to GHG emissions, accounting for 35% of energy-related EU emissions in 2021[22]. These emissions result from the direct use of fossil fuels in buildings and the production of electricity and heat for building use. Therefore, accounting for venue emissions is of utmost importance in addressing environmental concerns associated with event planning.

### 4.5.2 Calculation Method

The calculation of venue-related emissions involves consideration of four distinct categories: electricity consumption, heat consumption, water consumption, and waste generation. Emission factors within each category are derived from the distinctive energy sources employed in the process of energy production. Consumption factors employed in the initial consideration are determined through various metrics. In the context of electricity consumption, these metrics are grounded in the overall building area. Heating consumption factors encapsulate considerations such as the building's age, the specific heating system in use, and the overall building area. Initial water consumption metrics rely on the average daily water consumption per person, while waste generation presets are grounded in the average daily waste generation per person.

The calculation of GHG emissions attributable to the venue is formulated as:

*Equation 8*

$$\sum \mathrm{CO_2\ Emissions\ (Venue)} = (N_{\mathrm{electricity},e} \times EF_{\mathrm{electricity},e}) + (N_{\mathrm{heating},f} \times EF_{\mathrm{heating},f}) + (N_{\mathrm{water}} \times EF_{\mathrm{water}}) + (N_{\mathrm{waste}} \times EF_{\mathrm{waste}})$$

Where:

*Equation 9*

$$N_{\mathrm{electricity},e} = n_{\mathrm{electricity},e} \times A_{\mathrm{venue}} \times N_{\mathrm{days}}$$

*Equation 10*

$$N_{\mathrm{heating},f} = n_{\mathrm{heating},f} \times A_{\mathrm{venue}} \times N_{\mathrm{days}}$$

*Equation 11*

$$N_{\mathrm{water}} = n_{\mathrm{water}} \times N_{\mathrm{participants}} \times N_{\mathrm{days}}$$

*Equation 12*

$$N_{\mathrm{waste}} = n_{\mathrm{waste}} \times N_{\mathrm{participants}} \times N_{\mathrm{days}}$$

22 *European Environment Agency: Greenhouse gas emissions from energy use in buildings in Europe (2023)*

VENUE

| | Parameter | Unit | Description |
|---|---|---|---|
| $e$ | Type of energy source for electricity generation in the event venue | n/a | The energy sources include:<br>• Unknown<br>• Conventional: national grid mix<br>• Renewable:<br>  • Unknown renewable source: Renewable electricity mix<br>  • Hydropower<br>  • Onshore wind energy<br>  • Offshore wind energy<br>  • Biomass (biogas, solid biomass and biogenic waste included)<br>  • Solar power |
| $f$ | Type of heating system | n/a | The heating system comprises:<br>• Unknown<br>• Natural Gas<br>• Heating Oil<br>• District Heating<br>• Heat Pump |
| $A_{venue}$ | Total event area | $m^2$ | Total event area ($A_{venue}$) can be determined directly, or it can be estimated by the average event area per person ($a_{area}$) multiplied by the number of participants ($N_{particpants}$):<br>$A_{venue} = a_{area} \times N_{particpants}$ |
| $N_{days}$ | Duration of Event | Number (Integer) | - |
| $N_{participants}$ | Number of Participants | Number (Integer) | - |
| $N_{electricity,e}$ | Total amount of electricity consumption from energy source e | kWh | The total amount of electricity consumption can be determined directly, or it can be estimated according to Equation 9, by average electricity consumption per $m^2$ per day multiplied by the total venue area and the duration of the event. |
| $n_{electricity,e}$ | Average electricity consumption from energy source e per m2 per day | KWh per $m^2$ per day | Estimation based on the Odyssee-Mure database |
| $EF_{electricity,e}$ | Emission factor for electricity generation from energy source e | kg $CO_2$eq/kWh | Emission factors for electricity differ based on different energy sources. |
| $N_{heating,f}$ | Total amount of heating consumption | kWh | The total amount of heating consumption can be determined directly, or it can be estimated according to Equation 10, by the average heating consumption per $m^2$ and duration of the event. |
| $n_{heating}$ | Average heating consumption per m2 per day | KWh per $m^2$ per day | The estimation for average heating consumption per $m^2$ per day depends on the infrastructure of the event venue.<br>The assessment of the building infrastructure is based on the 2023 heating survey (Heizspiegel) and derived from the following three variables:<br>• Building's age<br>• Building's total area<br>• Heating system |
| $EF_{heating,f}$ | Emission factor for heating generation from heating system type f | kg $CO_2$eq/kWh | The emission factor for heating generation is influenced by the type of heating system installed in the venue. |
| $N_{water}$ | Total amount of water consumption (non-potable water usage) | $m^3$ | The total amount of water consumption can be determined directly or can be estimated according to Equation 11, by average water consumption per person per day multiplied by the number of participants per day and the duration of the event. |
| $n_{water}$ | Average water consumption (non-potable water usage) per person per day | $m^3$ per person per day | Estimation based on Federal Environment Agency statistics (2022) |
| $EF_{water}$ | Emission factor for water consumption (non-potable water usage) | kg $CO_2$eq/ $m^3$ | - |
| $N_{waste}$ | Total amount of waste generation | metric t | The total amount of waste generated can be determined directly or can be estimated according to Equation 12, by the average waste generation per person per day by the number of participants and the duration of the event. |
| $n_{waste}$ | Average waste generation per person per day | t per person per day | Estimation based on the Federal Statistical Office of Germany (2023) |
| $EF_{waste}$ | Emission factor for treating waste generated from the event | kg $CO_2$eq/kWh | - |

*Table 15: Preset Conditions for parameters in "Venue": Event Area and Area per person*

| Parameter | Preset |
|---|---|
| Event Area | "Number of people" multiplied by "Area per person (2 $m^2$ per person)" |
| Area per person | 2 $m^2$ per person |

For initial estimates, the venue category uses data from the Odyssee-Mure database (2023) for electricity consumption and the 2023 heating survey (Heizspiegel) for heating. Water consumption estimates come from Federal Environment Agency statistics, and waste generation data is from DESTATIS. Emission factors for electricity and heating are sourced from the Federal Environment Agency's ProBas database, while water and waste emission factors are from the DEFRA database.

**Initial Conditions**

The parameter "Number of people" is initially established during the "Base Data" step in the initial input.

The "Event area" is predetermined as the product of the "Number of people" and the "Area per person," with the latter set at 2 $m^2$ per person as an average requirement for space during the event. This specific value is highly variable, as diverse event types may indeed necessitate distinct area requirements per person. Currently, the derivation of the value relies on numeric sources within the event planning sector. However, it is anticipated that in the future, more precise and comprehensive information will be available from our own extensive database

The parameters, including "Building age," "Heating," and "Electrical power type," are initially marked as unknown. This classification remains until users input more accurate and precise details about these parameters. The specific categories will be further addressed in the user input section.

All consumption-related parameters serve as the foundation for quantifying the emissions. Estimations for each consumption-related parameter are calculated based on the equations 9-12 (see Table 17), and are displayed as numeric values.

*Table 16: Preset Conditions for parameters in "Venue": Building age, Heating system, Electrical power type*

| Parameter | Preset |
|---|---|
| Building Age | Unknown |
| Heating System | Unknown |
| Electrical power type | Unknown |

**User Input**

The initial conditions applied to the "Venue" are considered presets for all parameters and all can be personalized. Personalized data entry is considered as user input.

The "Event area" can be personalized by users, enabling precise numerical adjustments. This parameter can also be adjusted by modifying the "Area per person," leading to automatic adjustments in the "Event area." This feature provides users with flexibility, accommodating variations in the event venue for different occasions.

The initial setting of "Building age" as unknown is adopted for a conservative approach. Users have the flexibility to personalize this parameter by selecting various building age categories. These categories comprise "Unknown Building Age", "Before 1978", "1979 – 1983", "1984 – 1994", "1995 – 2001", and "Af-

*Table 17: Preset Conditions for parameters in "Venue": Building age, Heating system, Electrical power type*

| Parameter | Preset |
|---|---|
| Electricity Consumption (kWh) | Estimation is displayed as a numeric value based on Equation 9 |
| Heat consumption (kWh) | Estimation is displayed as a numeric value based on Equation 10 |
| Water consumption (kWh) | Estimation is displayed as a numeric value based on Equation 11 |
| Waste consumption (kWh) | Estimation is displayed as a numeric value based on Equation 12 |

*Table 18: User input for parameters in "Venue": Event area and Area per person*

| Parameter | Preset | User Input |
|---|---|---|
| Event Area | "Number of people" multiplied by "Area per person (2 $m^2$ per person)" | Adjustable on precise or estimated total venue area |
| Area per person | 2 $m^2$ per person | Adjustable |

ter 2002". Buildings of different ages exhibit varying heating efficiencies, generally following the principle that newer buildings tend to have superior insulation, resulting in higher heating efficiency and lower total emissions.

Similarly, "Heating system" is initially designated as unknown for conservative considerations, providing users with the option to personalize it by choosing from different heating system categories, including "Unknown Heating System", "Gas Heating", "Oil Heating", "District Heating", and "Heat Pump". Distinct heating systems are associated with diverse emission factors and heating efficiencies.

*Table 19: User input for parameters in "Venue": Building age, Heating system, Electrical power type*

| Parameter | Initial Condition | User Input |
|---|---|---|
| Building Age | Unknown | Adjustable by selecting the following categories:<br>• Unknown building age<br>• Before 1978<br>• 1979 – 1983<br>• 1984 – 1994<br>• 1995 – 2001<br>• 2002 or later |
| Heating System | Unknown | Adjustable by selecting the following categories:<br>• Unknown heating system<br>• Natural gas<br>• Heating Oil<br>• District heating<br>• Heat pump |
| Electrical power type | Unknown | Adjustable by selecting the following category:<br>• Unknown<br>• Conventional: national grid mix<br>• Renewable:<br>  • Unknow renewable source: Renewable electricity mix<br>  • Hydropower<br>  • Onshore wind energy<br>  • Offshore wind energy<br>  • Biomass (biogas, solid biomass and biogenic waste included)<br>  • Solar power |

The default setting of "Electrical power type" as unknown is driven by conservative considerations, allowing users to choose from various categories based on reality. Users can select "Unknown Energy Source", "Conventional Energy Source" (representing the national grid mix), and "Renewable Source" – comprising "Unknown Renewable Source", "Hydropower", "Onshore Wind Energy", "Offshore Wind Energy", "Biomass" (including Biogas, Solid Biomass, and Biogenic Waste), and "Solar Power". It is essential to note that the national grid mix represents the German grid mix, and the unknown renewable energy source is a weighted average of the mentioned renewable sources to represent the renewables mix in Germany. The weighting factors are determined by renewable energy source percentages in Germany derived from 2023 Federal Environment Agency statistics, ensuring alignment with empirical data.

The initial settings provide estimated numerical values for "Electricity consumption," "Heat consumption," "Water consumption," and "Waste consumption." Users can change these numbers based on real-world data or their estimations, improving the accuracy of the calculations according to specific needs. If incorrect data is entered, users can simply return to the original estimates by deactivating the personalised option.

*Table 20: User input for parameters in "Venue": Electricity, Heat, Water, Waste consumption*

| Parameter | Initial Condition | User Input |
|---|---|---|
| Electricity Consumption (kWh)<br>Heat consumption (kWh)<br>Water consumption (kWh)<br>Waste consumption (kWh) | Estimation is displayed in numeric value based on equations 9-12 (see Table 17) | Adjustable by manual input |

**Plausibility Check**

An error message is displayed under the following conditions:

- Empty Event Area and Area Per Person: When both the "event area" and "area per person" fields are left empty. It is necessary to provide at least one of these inputs to accurately estimate the emissions related to the venue space.
- Empty Optional Inputs: When any of the optional inputs (e.g., optional total energy consumption, optional total water usage) are selected but their corresponding input fields are empty. To ensure accurate calculations, users must either provide the necessary data for the selected options or deselect them.

Users cannot proceed to the next step until these issues are corrected.



## 4.6 Transport of Goods

### 4.6.1 Background

Events frequently entail transport of goods, the volume depending on the nature and size of the event itself. Transport can involve the transportation of equipment, food and beverages, promotional material, decorations, and assorted supplies among others. It is imperative to acknowledge that transport of goods is always associated with emissions, highlighting the significance of considering such transportation when looking at event emissions.

### 4.6.2 Calculation Method

The methodology in this version considers the transport of goods, encompassing various supplies required for events, including the transport of catering goods. Emission factors associated with goods transportation are determined by the specific means of transport utilized, namely trucks, trains, and ships in this version of the methodology. Initial conditions for estimating transport weight rely on statistics from DESTATIS (Federal Statistical Office of Germany, 2023).

To calculate GHG emissions attributed to the transport of goods, crucial input data include the means of transport, total transport distance (one way), and the weight of the goods being transported. These parameters form the basis for assessing the environmental impact of goods transport. The calculation of GHG emissions attributable to the transport of goods is formulated as:

*Equation 13*

$$\sum \mathrm{CO_2\ Emissions\ (Transport\ of\ Goods)} = \sum_g N_{\mathrm{freight},g} \times EF_{\mathrm{freight},g}$$

Where:

For initial conditions:

*Equation 14*

$$N_{\mathrm{freight},g} = m_{\mathrm{freight},g} \times N_{\mathrm{participants}} \times N_{\mathrm{days}}$$

For User input:

*Equation 15*

$$N_{\mathrm{freight},g} = D_{\mathrm{freight},g} \times M_{\mathrm{freight},g}$$

| Parameter | Preset | Unit | Description |
|---|---|---|---|
| $g$ | Mode of freight transportation | n/a | In this methodology, the following means of freight transportation are included:<br>• Truck<br>  • 3.5 t Truck<br>  • 7.5 t Truck<br>  • 12 t Truck<br>  • Semi-trailer Truck<br>• Train<br>• Ship |
| $N_{freight,g}$ | Freight Tonne-Kilometres with mode of transport g | t*km | - |
| $EF_{freight,g}$ | Emission factor for transport of goods (freight) with mode of transport g | kg $CO_2$ eq per t per km | - |
| $m_{freight,g}$ | Mass of transported goods per participant per day | t per participant per day | - |
| $N_{participants}$ | | Number of participants | - |
| $N_{days}$ | Duration of the event | Day | - |
| $D_{freight,g}$ | Distance of transport of goods with mode of transport g | km | - |
| $M_{freight,g}$ | Mass of transported goods (freight) with mode of transport g | t | - |

The transport of goods category uses data from the GENSIS Database 5.0 and DESTATIS for estimating Freight Tonne-Kilometres. Emission factors for different transport modes are sourced from the Federal Environment Agency TREMOD database 6.51.

**Initial conditions**

The consideration of emissions associated with the transport of goods is an optional feature within the *atmosfair $CO_2$ event calculator*. Given the diverse nature and scale of events, transport of goods is presumed to be zero unless explicitly chosen by the user to be included in the calculations.

Upon selection, estimations are applied to the following parameters:

This category encompasses three means of transport, including trucks, trains and ships, each assigned a weighted factor based on usage statistics. The determination of the weighted factor is contingent on the proportion of means of transport for freight in Germany, as derived from DESTATIS.

The initial consideration for “Truck type” is designated as unknown until the user provides other input.

The ”Distance on way” parameter is defined as the weighted sum of the average transported distance for each mode of transportation. The average transported distance for each mode is sourced from DESTATIS.

“Round trip” is preselected in consideration of practicality, acknowledging that the transport of goods typically involves a journey from a location to the event, followed by a return trip.

The preset value for “Total weight of cargo” for each mode of transportation is determined by multiplying the weight of transported goods per participant per day by the number of participants and the duration of the event, as specified in Equation 14. The “Weight of transported goods per participant” is established based on the average annual overall mass of goods transported in Germany divided by the total population of Germany and adjusted to the duration of the event in days. The values for “Number of participants” and “Duration of the event” are drawn from the “Base Data” step. This assumption is grounded in the understanding that a greater number of participants and a longer duration will likely necessitate additional supporting equipment and supplies.

*Table 21: Preset conditions for parameters in "Transport of Goods": Means of transport, Distance (one way), Round trip, Total weight of freight*

| Parameter | Initial Conditions |
|---|---|
| Means of transport | Unknown |
| Distance one way | Average distance - weighted across transportation modes |
| Round trip | Round trip |
| Total weight of freight | The mass of transported goods per participant per day multiplied by the number of participants and the duration of the event, as specified in Equation 14 |

**User input**

The initial conditions applied to the "Transport of Goods" are considered presets for all parameters as illustrated in Table 21. Allpreset parameters for "transport of goods" can be personalized.

The "Means of transport" parameter is configurable through the selection of the categories "unknown", "Truck", "Train" or "Ship". The classification of "Truck" is subdivided according to the load capacity of the vehicle, delineating subcategories such as "3.5 t-truck", "7.5 t-truck", "12 t-truck", and "Semi-trailer truck". This functionality grants users the flexibility to adapt to variations in the logistical aspects of the event, affording the option of selecting "unknown" if so desired.

Both "Distance one way" and "Total weight of freight" are adjustable to user input, enabling a more tailored and precise outcome from the *atmosfair $CO_2$ event calculator*. This personalized input feature enhances the accuracy of the calculator's results.

The default setting for "round trip" can be manually deselected by the user to better align with the actual circumstances of the event. This manual adjustment feature allows for a more nuanced representation of the transportation dynamics associated with the event.

*Table 22: User Input for parameters in "Transport of Goods": Means of transport, Distance (one way), Round trip, Total weight of freight*

| Parameter | Initial Conditions | User Input |
|---|---|---|
| Means of transport | Unknown | Adjustable by selecting the following categories:<br>• Unknown<br>• Truck<br>  • 3.5t Truck<br>  • 7.5t Truck<br>  • 12t Truck<br>• Semi-trailer Truck<br>• Train<br>• Ship |
| Distance one way | Average distance - weighted across transportation modes | Adjustable by manual input |
| Round trip | Round trip | Adjustable by manual selection |
| Total weight of freight | The mass of transported goods per participant per day multiplied by the number of participants and the duration of the event, as specified in Equation 14 | According to Equation 15, and adjustable by manual input |

**Plausibility check**

An error message is displayed under the following conditions:

- Distance check: If the "Distance one-way" field is set to 0 km or left empty, an error message will be displayed. This check ensures that the user has provided a valid transport distance, as emissions cannot be calculated without knowing the distance travelled.
- Weight check: If "the total weight of cargo" field is set to 0 kg or left empty. This check ensures that the user has specified the weight of the transported cargo, which is essential for accurate emission calculations. If there is no cargo to transport, users can simply choose to remove the transport option for goods, avoiding unnecessary calculations and potential errors.

Users cannot proceed to the next step until these issues are corrected.

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