CO_2 Calculation for Business Travel
VDR Standard

VERBAND DEUTSCHES REISEMANAGEMENT e.V.

Methodology
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Foreword

Over the last years, it has become ever more important to report CO_2 emissions generated by business travel. Many companies are aware of this issue and have commissioned CO_2 reports for their business trips.

Calculation methods for generating such CO_2 reports already exist in various other domains, such as industrial production processes for specific products, electric power generation and power consumption within a company, and the transportation of persons and goods. However, these methods do not define CO_2 emissions uniformly and determine emissions using different approaches and degrees of accuracy. Up to now there is still no method for calculating CO_2 emissions for business trips. However, since (depending on the type of company) these emissions can constitute the bulk of total CO_2 emissions generated by a company, this usually means that:

- CO_2 emissions are recorded unsystematically and with a high degree of imprecision
- CO_2 emissions from business trips cannot be compared or classified
- Recommendations for reducing CO_2 emissions cannot be generated from the report

The VDR Standard for CO_2 business travel reporting deals with these issues. It was initiated by the German Business Travel Association (VDR) and sets a standard for industry.

The VDR promotes efficient, economical, secure and worldwide travel options for companies. It represents the interests of the German economy with regard to general and competitive conditions for business trips and supports its members as a source of expertise by means such as current industry-related information, political activities, VDR purchasing advantages, the VDR academy and hotel certifications.

The VDR is aware of its extraordinary responsibility with respect to sustainable and innovative business trips. It thus goes without saying that sustainability issues are anchored in both the bylaws and charter of the VDR. In addition, the VDR founded an expert committee on sustainability in 2006.

atmosfair, a VDR partner, has also contributed its expertise and know-how to create an industry standard that is not only integral and goal-oriented from an environmental standpoint, but is also based on practical experience with business trips and can thus meet the industry’s needs.

Through its practical experience, VDR member Lufthansa AirPlus has assisted atmosfair and the VDR in drafting the standard in order to collect and consider the particular requirements of corporate customers while ensuring feasibility and data availability.

Opening words from Dr. Norbert Röttgen, Minister of the Environment

Dr. Norbert Röttgen, Federal Minister for the Environment, Nature Conservation and Nuclear Safety

Dear readers,

Today the number of people living on Earth has exceeded the seven billion mark. Within one generation we will already reach nine billion people on this planet – people who all want to live the way we do in rich industrial nations. Such a scenario threatens our future well-being since we know that there is limited space for depositing greenhouse gas emissions. The consequences of average temperatures rising by over 2 degrees Celsius would not only be an economic catastrophe for certain regions, but also create enormous costs for the global economy and threaten global stability.

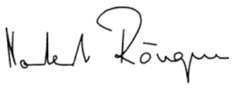
To avert this threat, we must take decisive measures now since what we do or fail to do today has irreversible consequences for the generations that follow. Both politics and business are equally obliged to take action. It is extremely encouraging that business has long since recognized its duty to protect our climate. Today, corporate climate reports that are both transparent and comparable have become an important criterion in assessing companies - not only for investors, but also for employees, customers and other stakeholders. Ever more companies and managers recognize that environmentally sound operations also yield better and more sustainable returns on investment in the long term.

However, dependable data is needed before we see a fundamental improvement in companies' climate footprint. The VDR thus deserves great credit for having developed a sophisticated standard for reporting the effects that business travel have on the climate, especially since the service sector is where CO_2 emissions generated by business travel can easily comprise the largest part of a company's total emissions. This makes it all the more important to examine this issue closely and draw up reports scientifically.

Creating such a report is a supremely challenging task. With the new standard for recording and calculating CO_2 emissions for business trips, the VDR has taken a large step forward for the sector: for the first time worldwide, the entire business trip, including all means of transport, hotels, tradeshows and conferences, can be fully and uniformly recorded using methods applicable across the globe. With atmosfair, the VDR has gained an experienced partner for developing the methodology. The quality of the atmosfair calculation methods has been affirmed by a variety of studies and ultimately by the German Environment Agency.

I am sure that not only the climate, but also companies, will benefit from the new standard for CO_2 reporting through greater energy efficiency and lower costs. I wish the VDR and the new CO_2 reporting standard success as it is put into practice and distributed internationally.

Sincerely,



Dr. Norbert Röttgen

I. Requirements for the VDR Standard

The VDR Standard for CO_2 business travel reporting meets the following requirements:

Completeness and relevance
The VDR Standard covers the main areas of business travel: hotel, train, flight, car and conferences (MICE). It covers the significant sources of CO_2 emissions and leaves out the negligible sources, such as use of public transport at the destination.

Worldwide applicability and assured minimum degree of accuracy
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 – a rental car in New Zealand should be as reportable as a domestic flight in China.

Comparability
The results of the individual CO_2 business travel reports can be compared due to the assured minimum degree of accuracy. Possible differences could only result from the use of more detailed data sources. The comparability extends across the entire industry so that the emissions from companies' business trips calculated according to the VDR Standard can be compared.

Calculation methods' assured minimum degree of accuracy
The calculation methods described in this document are sufficient to achieve the assured minimum degree of accuracy described.

Transparency and practicality
The calculation methods and the variables to be considered as well as possible data sources are described within the standard. This means that companies can account for business travel CO_2 emissions on their own or commission a travel agency, travel credit card or special vendor to carry out the reporting.

Basis for recommended courses of action
The VDR Standard is sufficiently detailed to serve as the basis for developing recommendations on measures to reduce CO_2 and costs, e.g., opting for a more efficient vehicle class, hotel room category, electromobility or CO_2 compensation, without the need to engage expensive consultants.

Scientific independence
The data come from independent sources. Wherever possible, the VDR Standard's methods are based on methods that already exist, e.g., IPCC[1], GHG-Protocol[2], etc. These are adapted and expanded as needed for the business travel sector.

[1] Intergovernmental Panel on Climate Change
[2] Greenhouse Gas Protocol

II. Glossary

Term	Explanation
Airline data	Airline data by Data Base Products, Inc.
City pair	City connection for air travel
CO_2	Carbon dioxide emissions
CO_2e	Carbon dioxide emission equivalents, which represent the total climate effect (including non-CO_2 emissions)
DEFRA	Department for Environment, Food and Rural Affairs
DEHOGA	German Hotel and Restaurant Association
DIN EN 16528	Standard draft of "Method for calculating and declaring the energy use and greenhouse gas emissions of transport services (freight and passenger transport)"
Emissions	All the emissions that affect the climate considered in the context of this standard
GHG	Greenhouse Gas Protocol
GWP	Global Warming Potential
IATA	International Air Transport Association
IATA WATS	IATA World Air Transport Services
ICAO	International Civil Aviation Organization
ICAO TFS	ICAO Traffic by Flight Stage Statistics
IEA	International Energy Agency
IFEU	Institute for Energy and Environmental Research in Heidelberg, Germany
IPCC	Intergovernmental Panel On Climate Change
MICE	Meetings, Incentives, Conferences, Events
NGO	Non-governmental organization
Non-CO_2	Emissions that affect the climate beyond CO_2
RF	Radiative forcing
Specific emissions	Emissions in relation to a specific unit, e.g., emissions per kilometer
Tank-to-wheel	Method for observing energy supply for motor vehicles, from fuel intake to conversion into useful energy
GHG	Greenhouse gases
UIC	International Union of Railways
VDR	German Business Travel Association
VfU	Association for Environmental Management and Sustainability in Financial Institutions
Well-to-wheel	Method of energy supply for motor vehicles along the entire chain of effects

Table 1: Glossary

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atmosfair gGmbH is the author of the CO_2 calculation standard for business travel.

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The content, title and authoritative designation of the CO_2 calculation standard for business travel may not be changed without the consent of atmosfair gGmbH.

All inquiries regarding the use of the CO_2 calculation standard for business travel must be made via the website:

https://www.atmosfair.de/en/standards/emissions_calculation/co2_reporting_for_companies/

IV. Motivation and target group

IV.I Why a standard for business travel?

The EU directive 78/660 / EEC regulates the presentation and analysis of companies' most important performance measures. Non-financial measures are also part of companies' management report, including environmental information[3].

It is therefore hardly surprising that companies in the EU as well as around the world are increasingly interested in recording and reporting their CO_2 emissions. The Carbon Disclosure Project (CDP), which regularly surveys 3,000 companies in over 60 countries around the world about their CO_2 emissions and climate strategies[4], provides important metrics about this. The CDP is run by more than 500 major institutional investors who are interested in sustainably aligning their assets of over 70 trillion USD in the long term. In the past years of the international financial crisis, more than 80% of companies surveyed responded in detail to CDP's requests. The CDP also cooperates with external financial analysts and corporate consultants in its work.

Besides investors and rating agencies, customers and other stakeholders are also increasingly interested in the sustainability of the companies with which they do business. For example, a study by Ernst & Young in 2010 found that 84% of entrepreneurs view stakeholders' increased expectations as an important or very important reason to develop a comprehensive climate protection strategy[5]. One of the first steps in doing this is to make an initial assessment of the situation, i.e., preparing a CO_2 report.

Since business trips can often make up the majority of a company's overall emissions, especially within the service sector, it is important to record them in a dependable and high-quality way. At present, however, there is no internationally established method for reporting business travel CO_2 emissions. The existing approaches are discussed in detail below. None of these approaches were designed for business travel.

1. **Lack of differentiation:**
   The existing methods can be applied to individual components of business travel, such as CO_2 emissions produced by cars or buildings. However, there is no method that consistently differentiates among the individual activities within a business trip. Thus, it is not clear, for example, whether a hotel's current energy consumption (which only produces CO_2 emissions indirectly via a power plant) must be counted as a business trip or whether a caterer's energy consumption must also be added to an event.

[3] EU Directive 78/660 / EEC, content of the management report, Article 46
(1) (b) As far as this is necessary for understanding business operations, performance or the company's situation, the analysis includes the most important financial and, where appropriate, non-financial performance measures that are relevant to the business in question, including information on environmental and workers' concerns.
[4] Information on the website of the CDP: www.cdproject.net
[5] "Action amid uncertainty," Ernst & Young, 2010

2. **Lack of specialization:**
   There is currently no method for calculating hotel emissions during business travel. Although there are methods for calculating the CO_2 emissions produced by buildings, there is no regulation on how these can be attributed to business travelers, individual booking classes or the hotel.

3. **Incompleteness:**
   Up to now, some sectors have not been methodically covered at all or only incompletely. For example, the UIC is a driving force for Europe in the area of railway emissions, but when it comes to rail travel in other places, e.g., in South America, it is possible that CO_2 emissions are not covered at all.

Existing approaches to CO_2 reporting are briefly described and discussed in the following.

IV.II Relationship to existing standards

The VDR Standard does not claim to replace all previous reporting approaches. It is a CO_2 reporting tool for those companies that, for reasons mentioned in Section IV.III, are seeking higher coverage and accuracy than the previous approaches can provide. The use of the VDR Standard is voluntary.

The following sections present some well known standards for calculating CO_2 emissions that are suitable for reporting parts of the business travel activities covered by the VDR Standard that regard CO_2 emissions. The standards are briefly described and discussed.

DIN EN 16258 (draft)
DIN EN 16528 is a draft of a European standard for calculating and designating CO_2 emissions for transport services (freight and passengers). Among other things, it contains the following elements:

- It pursues the objective of a minimum assured degree of accuracy in calculating CO_2.
- In addition to CO_2, it also considers other pollutants.
- If definitions or other parameters can reasonably be set differently and thus lead to different CO_2 values, it shows the different CO_2 results next to each other that could each be valid, depending on the circumstances.
- It takes emissions generated upstream in the supply chain into account (well-to-tank approach).

The VDR Standard closely follows the accounting methodology of DIN EN 16528 when discussing the system's limits and defining its principles.

ICAO Carbon Emission Calculator

The International Civil Aviation Organization (ICAO) has developed an online calculator for its website to determine the CO_2 emissions of a flight. The corresponding method is detailed, uses flight profiles with ascent and descent, differentiates different types of aircraft, and takes factors such as passenger occupancy and additional cargo into account. However, the ICAO calculator also has some disadvantages:

1. For a user who would like to calculate the CO_2 of a flight between a given city pair that is not located in the data sources of the ICAO computer the calculator yields no result. This continues to hold even after having updated the computer for some routes.
2. The ICAO computer only considers CO_2 emissions and not any additional greenhouse gases.
3. There are only two seat classes, economy and premium. For the latter, the ICAO computer calculates double the amount of CO_2 emissions compared to the former. Since the ICAO calculator does not differentiate within the premium class, first class and business class are treated equivalently in the CO_2 report.
4. For the seating configuration of the aircraft, the ICAO computer uses the full economy method, i.e., it assumes a hypothetical single class seating. Because business and first class seats reduce the number of seats on board due to larger space requirements, the real seat number and the number of seats accepted by the computer are different for several flights. This results in a higher occupancy rate and lower specific fuel consumption.
5. The type of aircraft cannot be specified in the ICAO computer. However, the type of aircraft can lead to a difference of approx. +/- 25% in specific CO_2 emissions.

As a consequence of points 3 and 4, the ICAO calculator significantly underestimates the specific CO_2 emissions per passenger.

DEFRA

The Department for Environment, Food and Rural Affairs (DEFRA) in the UK has developed a tool for calculating the CO_2 emissions from travel activities such as flights, train rides and car trips. In the air travel sector, the DEFRA method simplifies the calculation of the specific CO_2 emissions per passenger considerably. It considers only the following factors:

- Flight distance: large circle distance between airports, multiplied by a fixed factor to take detours into consideration
- Flight class: distinguishing among domestic, short international and long distance international based on the flight distance. Based on this classification, a factor of CO_2 per seat-kilometer is used.
- Booking class: differentiation among economy, business and first class.

Other factors are not, or only indirectly, taken into account (for example, passenger occupancy is included in the variable CO_2 per seat-kilometer). This methodology has the following disadvantages, among others:

- The domestic flight category within the DEFRA method is based on the domestic air travel market within the UK, which makes the method less precise for flights outside of the UK.
- The amounts of other pollutants are also shown, but not their environmental impact. Thus, the DEFRA method, like the ICAO calculator, only considers CO_2.
- The user does not have the option to include aircraft types or other factors, such as seating capacity, winglets, or airfreight. For a particular city pair (e.g., LHR - JFK) with a B747-400 at 50% capacity and a B777-200LR at 100% capacity, the DEFRA method yields the same amount of CO_2. This does not adequately reflect reality.

For these reasons, the calculation of CO_2 per flight can deviate by up to a factor of four from the real values. It often deviates by a factor of two, which has a significant impact on large companies' overall carbon footprint.

The railway sector, which is also covered by the DEFRA method, is designed for the British railways; for example, the CO_2 emission factors used are those that are relevant in the UK. This cannot readily be used to calculate CO_2 from train trips with the Swiss Federal Railways, for example. The VDR Standard aspires to be applicable worldwide, which means that the DEFRA rail method is unsuitable for the requirements of the VDR Standard (see Part I) since it is not applicable in other locations.

GHG

The Greenhouse Gas Protocol Initiative (GHG) has developed several standards for calculating CO_2 emissions in various industrial sectors. Determining the CO_2 emissions for flights, trains, car rides, and public transport is included in the so-called "Scope 3 emissions," but is not clearly described. A methodology for hotels and MICE is missing completely.

For flights, GHG uses a similar methodology as DEFRA by differentiating among short, medium, and long-haul flights as well as seat classes. Further essential factors (e.g., aircraft type, seats, etc.) are not included. Thus, the same problems arise as in the case of the DEFRA method: the result can differ by a factor of 2.

VfU

The Association for Environmental Management and Sustainability in Financial Institutions (VfU) has developed a key indicator system for calculating "operational ecological indicators." The transport sector is handled in a sub-section and takes rail travel, air travel and road transport into consideration. Like the GHG and DEFRA methods, the VfU tool simplifies the CO_2 calculation (flight comparable to DEFRA) and is similarly inaccurate.

Summary

Companies that are planning to calculate CO_2 emissions from their business trips and want to publish them in their sustainability report are currently free to choose the calculation method that they wish to use. In many cases, the methods mentioned above are used, but all have at least one of the following flaws:

- Nationwide or global calculations are not possible (e.g., Deutsche Bahn's CO_2 calculation tool)
- Calculations are not specific or accurate enough (e.g., GHG, DEFRA)

Despite these flaws, the VDR does not think that these methods should not be used for calculating CO_2 for business travel. It can sometimes make sense to perform calculations according to the approaches described above as a first step. However, VDR recommends using the VDR Standard if CO_2 reporting is an important component of management or sustainability reports.

IV.III To whom is the standard addressed?

As discussed in the previous section, the CO_2 reporting of business travel according to the VDR Standard is voluntary. The VDR Standard is primarily aimed at two user groups:

Companies

Many companies publish both annual and sustainability reports for their stakeholders. These reports include, among other things, reports on CO_2 emissions generated by the company's activities. Depending on the industry, business trips account for a significant share of total CO_2 emissions. The present VDR Standard gives companies that would like to account for their business travel the opportunity to do so.

The VDR Standard is primarily aimed at those companies that, for certain reasons, want to gain a high quality picture of their carbon footprint when it comes to business travel. For example, this may be important if business travel is the largest source of CO_2 emissions within the company. In this case, the VDR Standard's accuracy is worth the effort since other approaches produce numbers that deviate starkly from reality, for example by a factor of 2. The VDR Standard is also useful for companies that would like to develop ways to reduce emissions and need a deeper analysis and concrete courses of action. The VDR Standard can also be used if the company wants to refer to a quality seal for the sustainability report. In all of these cases, the phrase "created according to the VDR Standard CO_2 calculation for business travel" is helpful to the company.

Service providers

This refers particularly to business travel agencies and travel credit cards that collect the travel data that are the basis for any company reports. With the present VDR Standard, these companies can offer their customers uniform, high-quality and comparable CO_2

reports. These service providers can also provide the reports to their customers that are "created according to the VDR Standard CO_2 calculation for business travel."
The VDR Standard focuses on, but is not limited to, these two target groups. It is also aimed at other interested parties, e.g., associations or NGOs within Europe and worldwide.

V. Structure of the document

The VDR Methodology describes the CO_2 calculation methods for each sector (flight, train, hotel, car, taxi, public transport and MICE). All the factors to be considered are mentioned and discussed as well as the respective calculation method and relevant, freely available data sources.

VI. Use of the VDR Standard

The VDR Standard allows users to calculate the CO_2 emissions from their business travel activities. If users would like to report on an entire business trip within a certain time period according to the VDR Standard, the VDR Standard requires that at least the areas of flight, train, hotel, car and MICE be considered. Reporting on taxi and local public transport use is optional.

The following steps are necessary to do this:

1. Determine activity (flight, train, hotel, car, taxi, public transport and MICE).
2. Refer to the relevant chapter in the Methodology to find the CO_2 calculation formula.
3. Select the required data for the calculation and create a corresponding database using the public data sources specified in the chapter on this in the VDR methodology.
4. Specify user activity data (e.g., city pair and number of travelers for flights, number of overnight stays, country, and hotel class of hotel).
5. Use all data from 3 and 4 above in the calculation formula from 2 above and calculate the CO_2 emissions.

The table below summarizes the travel information that people using the VDR Standard must provide in order to calculate the CO_2 emissions for the various activities.

Term	Explanation
Flight	City pair, seat class, airplane family/type
Rail	Departure and arrival station (possibly countries passed through), seat class
Hotel	Destination country, hotel category (stars), room category, number of overnight stays
Car	Rental car: car type, distance driven Private/company car: fuel usage
Taxi	Destination country, fare of the ride
Public transport	Number of days of public transport use
MICE	Venue, duration, attendees For arrival and departure: see flight, rail, and car categories For overnight stays: see hotel category

Table 2: Travel information required for using the VDR Standard

1 System boundaries

In emissions reporting, be it for travel, industrial production, electricity generation, logistics, or other areas, which emissions exactly should be allocated to which company must be clarified.

1.1 Organizational boundaries

Firstly, it must be determined which actor is responsible for the emissions generated during a business trip. The following example illustrates this question:

A lawyer represents a client in legal matters. This activity presupposes visits at the client's office from time to time, so the attorney flies to the client at regular intervals. If the lawyer's firm and the client's company report their total emissions, the question arises as to which company should report the lawyer's flights in order to avoid double counting.

1.2 Operational boundaries

Next, it is necessary to clarify the type of emissions that will be considered when reporting for business travel.

1.2.1 Travel-specific emissions

In business travel reporting, it is intuitive to view the emissions emitted during the time that the respective service is provided and that are specifically related to travel (e.g., emissions from kerosene consumption during a flight) first. In contrast, emissions related to infrastructure (e.g., facility management of the airport building) and transport (e.g., construction and maintenance of the aircraft) are not exclusively examined during the business trip, but rather in the context of general investments, which benefits all users. A possible proportionate inclusion of these indirect emissions when accounting for a business trip must be discussed within the framework of determining the system's boundaries.

1.2.2 Emissions from the upstream part of the supply chain

In the combustion process of raw materials or fuels for the generation of useful energy, emissions that affect the climate are created directly. The type and amount depends on the nature and quantity of the fuel used as well as the technology and efficiency of the power plant or engine. The question then arises regarding the extent to which upstream processes and the associated emissions (for example, in the production and transport of fuels) must also be taken into account in CO_2 reporting.

1.2.3 Non-CO_2

During the combustion of fuels, other climate-relevant emissions (non-CO_2), such as nitrogen oxides (NOx) or soot, are emitted. Their physical and chemical properties affect the radiation drive in the atmosphere positively or negatively. While the environmental impact of non-CO_2 in near-surface combustion processes (e.g., driving a car) is small compared to the effect of CO_2, non-CO_2 (e.g., during air travel) has a considerable effect on the earth's radiation budget. Non-CO_2 acquires additional relevance when considering the upstream part of the supply chain described in section 1.2.1 since these emissions are released more intensively in the process of fuel mining. If accounting for business travel, it is therefore necessary to define the extent to which non-CO_2 is considered.

1.3 Principles of the VDR Standard

To ensure that the VDR Standard meets user requirements with the highest possible CO_2 reporting accuracy on the one hand and good manageability on the other hand, the VDR Standard has established four principles that are summarized and explained in Table 3.

	VDR standard principles		Distinct from
1.	The emissions incurred during a business travel activity are attributable to the person booking the trip (polluter pays principle).	⟺	Customer
2.	Reporting a business travel activity takes into account those emissions that specifically relate to the travel activity.	⟺	Infrastructure emissions
3.	Reporting a business travel activity takes the entire energy supply chain into account.	⟺	Conversion process of utility energy supply
4.	In addition to CO_2, accounting for a business travel activity also takes other climate-relevant emissions (non-CO_2) into account.	⟺	CO_2 only

Table 3: Principles of the VDR Standard

1.3.1 About principle 1:

Using the example mentioned above, this means that the lawyer's report is based on his or her own flights. The lawyer acts on behalf of his or her client; however, he or she makes the decisions about the type of trip (e.g., traveling by plane or by train, etc.) since he or she pays when the flight is booked. The fact that the lawyer can ultimately charge the flight to the client is irrelevant. However, if the client were to directly provide the flight tickets to the lawyer, the client would then be responsible for reporting the trip.

1.3.2 About principle 2:

In the VDR Standard, the emissions that arise directly in connection to a business trip are recorded. Thus, in accordance with DIN EN 16528, emissions from infrastructure and means of transport are not considered since these cannot be allocated to different users or user behavior using the existing data. In addition, the corresponding proportion of emissions is small compared to the emissions that directly arise from travel; therefore, these emissions can be ignored in the report.

1.3.3 About principle 3:

Business travel activity reporting according to the VDR Standard does not only consider the emissions that arise during the energy conversion process, but also all emissions along the entire energy supply chain. This includes the following processes:

Electricity:

- Dismantling and transport of primary energy carriers
- Construction and maintenance of the energy generation infrastructure
- Conversion of primary energy sources into electricity

Fuel:

- Dismantling and transport of primary energy carriers
- Construction and maintenance of the energy generation infrastructure
- Conversion of primary energy sources into fuels
- Conversion of fuels into mechanical energy

Heating/cooling energy:

- Dismantling and transport of primary energy carriers
- Construction and maintenance of the energy generation infrastructure
- Conversion of the primary energy carriers into heating/cooling energy

This approach follows from principle 2, which holds that all emissions specific to a trip should be considered.

This approach is based on the methodology from DIN EN 16528, which takes the entire energy supply chain into account for transport processes ("well-to-wheel"). Due to the VDR Standard's current imprecision for both methodology and data regarding the specific energy consumption, the upstream part of the supply chain is only considered for fuels. However, in the future, the standard will be extended step by step to include electricity and heat consumption. This is referred to separately in the chapters for each travel activity ("upstream part of the supply chain").

In the case of CO_2 reporting according to the VDR Standard, emissions are generally accounted for with those along the upstream part of the supply chain. The emissions that are not generated upstream in the supply chain can be optionally reported.

1.3.4 About principle 4:

In line with the methodology from DIN EN 16528, the VDR Standard includes climate-relevant emissions (non-CO_2) in addition to CO_2. These emissions include the greenhouse gases methane (CH_4), nitrous oxide (N_2O), fluorocarbons (HFC), perfluorinated hydrocarbons (PFC) and sulfur hexafluoride (SF_6).

In accordance with DIN EN 16528, the VDR Standard considers the climate efficiency of non-CO_2 using global warming potential (GWP). A CO_2-equivalent value that correlates the

climate efficiency of individual greenhouse gases with that of CO_2 can be calculated using the GWP. The GWP of greenhouse gases usually refers to a time horizon of 100 years. An exception to this is air traffic, for which the VDR Standard chooses a combination of different non-CO_2 metrics.
In the case of ground level combustion of primary fuels for energy generation, non-CO_2 plays a negligible role. However, significant non-CO_2 emissions are generated from the extraction of the primary fuels, such as the methane released in coal mining. Including non-CO_2 is therefore only important if, according to principle 3, the upstream part of the energy supply chain is considered.
In the case of air transport, this is different. The greenhouse gases that are generated from kerosene combustion have a considerable climate effect at high altitudes.

The methodology for considering non-CO_2 is explained again in the chapters on each travel activity ("non-CO_2").

Since reporting the emissions with the biggest climate impact is oriented towards reporting CO_2 emissions and these usually make up the majority of the emissions, this document uses the term "CO_2 reporting" for the sake of simplicity.

2 CO_2 reporting method – flights

Depending on the amount of flights, air travel can represent a significant part of CO_2 emissions created by business travel. This chapter describes how the VDR Standard measures flight emissions.

This chapter describes the VDR Standard for flights and discusses individual aspects related to this in the sections that follow. At the end of the chapter, the chapter is summarized again in a table.

2.1 Summary

The following factors determine the CO_2 emissions caused by air travel. Not all factors are necessary for creating sufficiently accurate CO_2 reports; however, the list begins with the most important factors that can potentially play a role. The decision as to which factors are included in the VDR Standard and how is discussed separately in the sections that follow.

- Distance and selected route (F1)
- Flight profile and cruising altitude (F2)
- Detours (F3)
- Type of aircraft (F4)
- Aircraft age (F5)
- Winglets (F6)
- Engines (F7)
- Taxiing (F8)
- Transported cargo load
- Seating (number of seats on board) (F9)
- Seat classes (type and number of seats) (F10)
- Additional cargo (F11)
- Passenger occupancy (F12)

The basis for calculating CO_2 for flights in the VDR Standard is a set of standard flight profiles that represent absolute fuel consumption (and thus absolute CO_2 emissions) by flight distance and aircraft type. The flight distance ranges from 250 to 1000 km. The standard profiles thus establish the influence of the factors distance (F1), flight profile and flight altitude (F2), type of aircraft (F4) and taxiing (F8).

2.2 Upstream part of the supply chain

For reporting flights, the VDR Standard takes well-to-wheel emission factors into account for kerosene. These are listed in DIN EN 16258 (see chapter 1.3.3).

2.3 VDR Standard for flights at a glance

The following table provides an overview of the VDR Standard for flights.

	Part of the VDR Standard		Accuracy within the VDR Standard		
Factor	**Part of the VDR Standard**	**Possible additional detail, but not necessary for the standard**	**Detailed**	**Estimate over multiple, occasionally different constants**	**Fixed estimate**
F1: Distance and route	x		x	-	-
F2: Flight profile and flight altitude	x		x	-	-
F3: Detours	x		-	-	x
F4: Airplane type	x		x	-	-
F5: Airplane age		x	-	-	-
F6: Winglets	x		-	-	x
F7: Engines		x	-	-	-
F8: Taxiing	x		-	-	x
F9: Seating	x		-	x	-
F10: Seat class	x		-	-	x
F11: Additional cargo	x		-	-	x
F12: Occupancy factors	x		x	-	-
F13: Other pollutants	x		-	x	-

Table 4: Factors included in the flight category

2.4 Variables and calculation formulas

The following steps and formulas are used for calculating CO_2 emissions for one passenger on one flight. The individual factors and their publicly accessible sources are then discussed in the sections that follow.

The following table displays the variables used in the calculations.

Variable	Description	Units	Described in
D_G	Large circle distance between two city pairs	km	VDR standard F1
D_R	Addition for detours, fixed amount according to D_G	km	VDR standard F3
D	Flight distance between two city pairs, (large circle distance + detours)	km	VDR standard F1
D_L	Standard distance above distance D of the flight	km	VDR standard F2
D_S	Standard distance below distance D of the flight	km	VDR standard F2
F_L	Absolute fuel consumption of the next longest standard flight above the flight distance	kg	VDR standard F2
F_S	Absolute fuel consumption of the next shortest standard flight below the flight distance	kg	VDR standard F2
F_D	Absolute fuel consumption of the flight	kg	-
f_W	Factor for the percentage of absolute fuel used by the winglets	%	VDR standard F6
f	CO_2 emissions factor for kerosene	kg CO_2/kg kerosene	-
f_C	Factor for seat class (economy, business, first)	-	VDR standard F10
f_f	Factor for subtracting the specific fuel consumption per passenger for the additional cargo	%	VDR standard F11
S	Seating capacity of the plane	-	VDR standard F9
f_l	Occupancy rate of the plane	%	VDR standard F12
f_{nco2}	Factor for the climate effect of non-CO_2	-	VDR standard F13
CO_{2sp}	Specific CO_2 emissions per passenger	kg	-

f_a	Percentage of the flight distance at altitudes over 9,000 m in relation to the total flight distance; necessary for quantifying the climate effects of non-CO_2 emissions	%	VDR standard F13
CO_2e	Non-CO_2	kg	VDR standard F13

Table 5: VDR Standard variables for the formulas in the flights category

The following formulas are required to calculate emissions (CO_2 and non-CO_2):

<u>Determination of the city pair distance</u>

$$D = D_G + D_R$$

<u>Calculation of specific CO_2 per passenger</u>

$$F_D = \frac{(F_L - F_S) * (D - D_S)}{(D_L - D_S)} + F_S$$

F_D is inserted in the following equation:

$$CO_2 = ((\frac{F_D}{S * f_l}) * f_W * f_C * f_f) * f$$

<u>Calculation of the climate effect of non-CO_2</u>

$$CO_{2e} = CO_2 * (1 - f_a) + CO_2 * f_a * f_{NCO_2}$$

The equation provides a way to calculate specific CO_2 emissions (kg per passenger on a given flight) that have a comparable climate effect. Here, all pollutants and additional effects of the flight (CO_2, vapor and vapor trails, cirrus clouds, nitrogen oxides, etc.) are combined.

2.5 The factors in detail

In this sub-chapter we discuss the individual factors as well as how they are covered in the VDR Standard.

2.5.1 F1 – Distance and route

The distance travelled has a decisive impact on fuel consumption and thus on the level of CO_2 emissions. Therefore, it must be specified as precisely as possible.

Generally, airlines are eager to fly the shortest possible route between two cities. However, the stipulated flight route is rarely a straight line, and the distance flown can often increase due to unforeseen circumstances.

Therefore, the distance between a city pair is determined using the large circle distance, to which a detour factor is added. The distance is calculated using the formula for large circle distances (orthodromes). These can be determined using calculators[6] available on the Internet.

VDR Standard F1
The CO_2 calculation for business travel reporting determines the exact distance between the city pairs of a given flight.

> Method: The names of the departure and destination airports are specified exactly using the IATA three-letter codes or standard text (e.g., TXL is the code for Berlin Tegel). These names can be found with the booking information and form the basis for calculating the distance between the airports using the formula for orthodromes (large circle distance). For this purpose, there are online calculators that determine the distance based on the three-letter codes or the standard text names.

2.5.2 F2 – Flight profile and airports

A flight is divided into the following phases: takeoff, ascent, cruising, descent, and landing. (Taxiing from terminal to taxiway and from landing to terminal is recorded in VDR Standard F8).
Takeoff and ascent require a particularly large amount of kerosene. This has more weight for short-distance flights than for medium and long-distance flights. Thus, the relative fuel consumption per passenger is higher for short distances than for medium distances. This issue must be considered in the emissions calculation.

VDR Standard F2
The CO_2 calculation for business travel reporting takes the different flight phases (i.e., ascent, cruising, descent) into account (specific consumption according to flight profile).

> Method: The specific fuel consumption is calculated from a flight profile that is interpolated using existing standard profiles with a maximum distance of 1000 km. The standard profiles can be found in the EMEP/CORINAIR Emission Inventory Guidebook (2007 version).

2.5.3 F3 – Detours

Actual flight routes rarely follow the great circle, i.e., the shortest possible route between two airports. Flying using airport approach corridors, holding loops, etc. ultimately increases the total flight distance. This is taken into account by means of adding a detour distance to

[6] E.g. www.luftlinie.org

the large circle distance. This detour factor is dependent on the total flight distance; in other words, the larger the circle distance between the city pairs, the larger the detour.

VDR Standard F3
The CO_2 calculation for business travel reporting includes detours.

> Method: A detour distance dependent on the total flight distance is added to the route distance determined in F1 to represent the real flight route distance. This covers routes that deviate from the shortest possible linear route, holding loops, detours due to local weather conditions, etc.
>
> The way that the detours themselves are classified is based on the methodology used for ICAO's flight emissions calculator.

2.5.4 F4 – Type of aircraft

Fuel consumption is strongly dependent on the type of aircraft. In civil aviation, a distinction is generally made between propeller airplanes (up to about 80 passengers), which are mostly used for short-distance flights, and airplanes with jet engines (jets), with which both short and long-distance flights are flown.
Manufacturers specify and optimize each aircraft for a certain range and passenger capacity. Using these aircrafts outside of their specifications generally means increased kerosene consumption per passenger. Depending on the airline and the aircraft operated, the CO_2 emissions per passenger can differ for the same city pair. Therefore, the type of aircraft must be included in the emissions calculation.
Many aircraft types have been technically modified based on an aircraft base model. This is due to high development costs, which can reach billions of euros. Thus, there are different aircraft families in the manufacturer's portfolio that contain several types of aircrafts. These are optimized for different passenger numbers or distances, but are largely composed of the same components and are therefore consuming similar amounts of fuel. For example:

Family	Related aircraft types
Airbus A320	A318, A319, A320, A321
Boeing B737 NG	B737-600, B737-700, B737-800, B737-900

Table 6: Examples of aircraft families

Because the CO_2, calculated using an average CO_2 emissions factor, e.g., using the DEFRA method, can differ from the specific CO_2 of a concrete type of aircraft by up to 25%, the type of aircraft must be included in the CO_2 emissions calculation. Obtaining data for a particular model (e.g., for a B737-800 Winglet) is difficult in some cases. Sometimes it is only possible to obtain data for the aircraft family (e.g., for the B737 family instead of the B737-800 Winglet that was actually used). Therefore, the VDR Standard only requires specification of the aircraft family. The user can also take the exact type of aircraft into consideration using the aircraft types and flight profiles contained in data Part II and the data package.

VDR Standard F4
The CO_2 calculation for business travel reporting requires at least the use of the aircraft family.

Method: At least the following aircraft families and their absolute consumption are included:

- Airbus (A300, A310, A320, A330, A340)
- Boeing (B717, B727, B737, B747, B757, B767, B777)
- Embraer (ERJ Series, E-Jets)
- Canadair (CRJ Series)
- Bombardier (Q Series)
- British Aerospace/Avro (BAe 146/RJ Series)

A more detailed breakdown is always possible within the framework of the VDR Standard. If the type of aircraft cannot be determined, a default aircraft can be used:

- Default aircraft

Depending on the travel agency, the aircraft used can already be taken from the booking information (for example Airbus A321 Industries). If not: the flight number is on the ticket. There are databases retrievable online, with which the user can have the aircraft issued by means of the flight number. If the aircraft used for the flight in question is determined, the corresponding flight profiles can be selected from the EMEP / CORINAIR Emission Inventory Guidebook (version 2007).

2.5.5 F5 – Aircraft age

Aircraft age has an influence on its fuel consumption. Here, two aspects must be taken into account: on the one hand, the age of an aircraft and, on the other hand, the year of manufacture within a model variant. For example, even within the B747-400 series, some aircrafts that were designed just one year earlier were constructed differently. During the life of an aircraft, wear and tear as well as machine fatigue may occur. For example, the aerodynamics can deteriorate and lead to greater fuel consumption. This phenomenon can be reduced or avoided with the help of good maintenance.
The year of construction also affects fuel consumption. Particularly in the case of models designed to last for a long time, more modern fuel-efficient technologies can be used in newer aircraft that were not yet available for the older aircraft.
Specifying aircraft age is not mandatory within the standard. The influence of aircraft lifespan and maintenance cannot be quantified. When it comes to construction-related differences, it can be assumed that older aircrafts can be retrofitted with the newer technologies, which helps to compensate potential differences.

2.5.6 F6 – Winglets

One of the innovations described in VDR Standard F5 that is dependent on construction year is winglets. Many older aircraft have been retrofitted with these to the extent that this is possible. Winglets or wing tips improve the aerodynamic properties of the aircraft and thus reduce fuel consumption. Reductions of up to 3% are possible.
Not all types of aircrafts can be retrofitted with winglets. For example, though Airbus models are standardly outfitted with wingtips or winglets, only a few types of Boeing model families (B737, B757, B767) can be retrofitted. Since the way that aircrafts are divided according to

the VDR Standard F4 is not detailed enough to distinguish, for example, a B737-800 from a B737-800, winglet rates are used. A winglet rate of 100% reduces the specific consumption by 3% [7], whereas a winglet rate of 0% does not reduce consumption at all. All other reductions for winglet quotas between 100 and 0% are linearly interpolated accordingly.

VDR Standard F6
The CO_2 calculation for business travel reporting takes aircraft models with and without winglets into account.

> Method: The distinction between aircrafts with and without winglets currently only concerns the aircraft families Boeing 737, 757 and 767. The Airbus models are all standardly equipped with winglets or wingtips; thus, optional retrofitting is not possible.
> If the flight in question is made by an aircraft from the abovementioned family, the user multiplies the specific fuel consumption by the respective winglet rate. This corresponds to the minimum degree of accuracy required by the VDR Standard.

2.5.7 F7 – Engines

Each aircraft model can be equipped with several different engine types from various manufacturers. Depending on the model, fuel consumption (and thus CO_2) as well as the emission of nitrogen oxides (NOx) can vary. Airlines pay close attention to fuel costs, so it can be assumed that the different engine models for a given aircraft type are almost identical when it comes to fuel consumption (otherwise this engine would no longer be ordered).
The differences among the engines only affect the climate via NOx emissions; however, these differences are small (approx. ± 2%). Thus, the engines do not need to be considered when using the VDR Standard.

2.5.8 F8 – Taxiing

Aircrafts must taxi from the terminal to the runway before takeoff. This requires fuel, which is not recorded in the flight profiles. The same applies to taxiing to the terminal after landing. The taxiing distance varies from airport to airport and with it, the amount of fuel consumed. Despite the relatively small impact of this effect, it cannot be ignored, but is taken into account by including it as a constant factor.

VDR Standard F8
The CO_2 calculation for business travel reporting includes taxiing.

[7] Boeing

Method: The standard profiles in the EMEP/CORINAIR Emission Inventory Guidebook include absolute fuel consumption for taxiing. Alternatively, 2.5 kg kerosene per passenger can be added to the consumption per passenger for the flight. The accuracy of both values is the same on average. The flight profiles in the data package also contain values for taxiing fuel consumption.

2.5.9 F9 – Seating

Selecting the type of aircraft already specifies the number of seats on board. However, airline-to-airline differences can occur based on the customer profile. Because the VDR Standard does not distinguish among airlines, the average amount seating can be used for each aircraft model (depending on the degree of accuracy with respect to VDR Standard F4). The aircraft manufacturers specify typical arrangements of 1, 2 or 3 seat classes. Within the framework of the VDR Standard, using multiclass seating is preferred; otherwise, inconsistencies may occur since it is not possible to assume standard full economy seating when making calculations for a first-class business trip. Thus, the highest possible typical multiclass seating must always be selected for factor F9. Generally, narrow-body jets have two classes (business and economy), while wide-body jets have three classes (first, business, and economy).

VDR Standard F9
The CO_2 calculation for business travel reporting considers the number of seats on board.

Method: Based on standard F4, the typical number of seats on board is stored for each aircraft model (e.g., A319). Aircraft manufacturers provide a standard layout in the technical spec sheets that can be viewed online. Always use the highest possible number of classes (i.e., three classes before two classes before full economy).

2.5.10 F10 – Seat classes

Aircrafts can be arranged differently depending on the customer segment served. Not only the number of seats and seat row distances can vary, but also the ratio of first class, business and economy seats. Furthermore, business seats occupy more space than economy seats. Therefore, the former are associated with higher absolute fuel consumption than the latter.

VDR Standard F10
The CO_2 calculation for business travel reporting considers the seat class used.

Method: A distinction is made among the different seat classes. A business class passenger is assigned more specific CO_2 emissions than an economy class passenger. There are factors that describe how the specific fuel consumptions of economy, business, and first class seats compare.

The factors are contained in the atmosfair flight emissions calculator documentation.

2.5.11 F11 – Additional cargo

Many airlines carry additional freight alongside the passengers in the cargo compartment of the lower decks. Ultimately this is, like it is for passengers, additionally utilized load capacity. The exact amount of additional freight is also dependent on the number of passengers on board. In any case, passengers should not account for the fuel consumption due to this freight.

VDR Standard F11
The CO_2 calculation for business travel reporting takes additional cargo into account.

Method: The cargo load is calculated from the specific fuel consumption per passenger. To make this feasible, the following standard simplification is used:

- 1 standard factor for wide-body aircrafts
- 1 standard factor for standard aircrafts

The hull type of a given aircraft can be found on the website of the respective aircraft manufacturer. For the factors users without access to accurate data can use the following simplification: subtracting 2% for narrow-body jets and 5% for wide-body jets.

2.5.12 F12 – Occupancy rate

The aircraft seating in conjunction with the occupancy rate yields the passenger load that is actually transported, which is essential for calculating fuel consumption and flight emissions.

VDR Standard F12
The CO_2 calculation for business travel reporting takes the flight's passenger occupancy rate into account.

Method: In the VDR Standard, the passenger occupancy rate is specified with a degree of accuracy comparable to the ICAO method, which provides an occupancy rate by aircraft type (narrow-body and wide-body) and region. The VDR Standard follows this method, but includes additional data sources beyond those of ICAO (e.g., IATA or AirlineData). The user determines in which regions the departure and destination airports are located and the type of aircraft used. Based on this information, the user can search for the correct occupancy rate value.

Users without accurate datacan apply the following simplification: 2% reduction for narrow-body aircrafts and 5% reductions for wide-body aircraft.

2.5.13 F13 – Other pollutants

In addition to CO_2, other gases and particles that impact the climate are produced by aircraft engines. These include H_2O, NO_x, soot, SO_x, CO, VOC (Volatile Organic Compounds) and particles. These gases and particles only have a climate effect in the upper troposphere or lower stratosphere. Although the altitude of this atmospheric layer fluctuates depending on the geographical latitude, a standard threshold of 9,000 m is assumed as a simplification. Above this altitude, these pollutants have a significant climate impact.
Since the mid-1980s, international research has striven to record these effects both qualitatively and quantitatively. The international special report of the IPCC, which summarized the state of knowledge for the first time, was published in 1999[8]. Since then, the results of research in the field of air traffic and climate have regularly been included in the IPCC's status reports and thus at the highest level of climate science for decision-makers.

The current state of research knowledge reveals that for the most important non-CO_2 effects, the mechanisms of action are essentially understood and quantified to varying degrees. This particularly applies to line-shaped contrails, ozone formation, methane degradation, and soot shielding. The last major gap in understanding air-induced cirrus clouds was provisionally closed in early 2011 with a new impact model for cloud formation[9]. The open question now is how to deal with the remaining quantitative uncertainties and the conversion of non-CO_2 emissions into CO_2 equivalents or climate effects (question on the so-called metric).

There are currently three different approaches:

1. Non-CO_2 is not taken into account with reference to remaining residual uncertainties.
2. Non-CO_2 is converted to CO_2 using absolute global warming potentials (AGWPs) and a resulting emission weighting factor (EWF) analogous to the general IPCC standard method (GWPs) for the mass-related conversion of non-CO_2 into CO_2 equivalent (CO2-eq.) using the international time horizon of 100 years set in the Kyoto Protocol. These methods have the advantage that the conversion factor is constant (as long as the research results do not change). On the other hand, since short-lived gases have stronger effects (in particular cloud formation), this approach only makes sense for air traffic with considerable limitations since extremely short-lived effects are calculated using a time horizon of 100 years due to the fact that the original GWP concept was designed for long-lived gases.
3. Non-CO_2 is directly compared with CO_2 via its current radiation drive (radiative forcing, RF)[10] and thereby its climate effect. This procedure is recommended by the German Federal Environmental Agency and has the advantage of being able to provide information about the current climate impact of air traffic via the conversion factor. It has the disadvantage that the implicit time horizon is shorter than 100 years

[8] IPCC 1999, Special Report on Aviation and the Global Atmosphere

[9] Ulrike Bruhardt and Bernd Kärcher, Global Radiative Forcing from Contrail Cirrus, Nature Climate Change, March 2011

[10] Radiative Forcing, Radiation Propulsion

and that the conversion factor changes (it becomes smaller over the years). This is because in the case of constant air traffic, CO_2 emissions accumulate in the atmosphere, and thus their RF increases, whereas the RF of non-CO_2 emissions (clouds, ozone, etc.) remains constant when air traffic remains constant.

The conversion factor from CO_2 to non-CO_2 in the second approach is 1.9 on average, with an upper limit of 2.8 and a lower limit of 1.2[11]. The conversion factor in the third approach is 2.8 on average, with a lower limit of 1.4 and an upper limit of 5.0[12]. Therefore, the lower limit of the third approach coincides with the best estimate of approach 2, and the upper limit of approach 2 with the mean value of approach 3. Consequently, the middle values for approaches 2 and 3 overlap if the extreme values are not considered. When the multipliers between CO_2 and non-CO_2 are compared purely quantitatively without considering the metric and its dimensions, they are between 1.2 and 5 with an average value of 3.

At present, the VDR Standard cannot answer the question of what the ideal metric and its quantification are since this question has not yet been resolved scientifically. On the other hand, it is clear that simply converting to pure CO_2 (approach 1) underestimates the climate effect from an environmental perspective. After more than 20 years of international research and publication of results at the IPCC level, national authorities such as the German Environmental Bureau and governmental organizations such as the Council of the European Union[13] are now assuming that the climate impact of air traffic is significantly influenced by additional pollutants beyond just CO_2. For this reason, the VDR Standard includes a combination of all three approaches, which provides a more comprehensive picture.

This means that in the VDR Standard, the pure CO_2 emissions are first reported separately and that the non-CO_2 emissions are then also calculated using a multiplier of 2 with pure CO_2 in order to capture the overall climate impact. Taking the different metrics and available quantitative assessments into account, the overall climate effect for non-CO2 thus lies exactly in the middle of the range of impact currently discussed.

The VDR will continue to pursue scientific developments in this important area and adjust its standard if scientific advances allow for this at a user-friendly level.

VDR Standard F13
CO_2 business travel reporting displays the pure CO_2 emissions from air transport. For this reason, the climate impact of other pollutants (non-CO_2) is also shown separately.

> Method: Based on its flight profile, each aircraft model is calculated by the number of kilometers flown above an altitude of 9,000 m or more. The climate impact of non-CO_2 is calculated using a conversion factor of 2 times the amount of CO_2 over 9000 m.

As a result, the company has two figures for CO_2 emissions in the air transport sector:

- The pure CO_2 emissions.

[11] Peeters and Williams, 2009

[12] Calculated according to Lee et al., 2009

[13] Directive 2008/101/EC of the European Parliament and of the Council on the inclusion of air transport in emissions trading, recital.

- The sum of pure CO_2 emissions and the climate impact of non-CO_2 emissions, which yields the total climate impact.

The company decides whether and which of the two values it includes in the company's overall carbon footprint (both values are recommended). If it only uses the value with pure CO_2 emissions in the overall footprint, it indicates that, in the case of air travel, other pollutants that damage the climate are emitted in addition to CO_2, whose climate impact, according to scientists, is roughly the same as that of pure CO_2.

2.6 VDR Standard method for flights at a glance

The following table displays the individual VDR Standard methods for flights:

Factor	Method	Freely available data source
F1: Distance and route	Calculation with the formula for orthodromes (large circle distance) between the airports, performed using three-letter codes or standard text in special calculators	- IATA codes (three-letter codes)3 - Distance calculator
F2: Flight profile and cruising altitude	Standard flights for every aircraft are on file, from which a standard value for consumption is derived. For the real distance of the flight, a linear interpolation between the respective flight profiles is used in order to determine the flight's real consumption. The maximum distance in the standard profile is 1,000 km.	EU Corinair System (EMEP/CORINAIR Emission Inventory Guidebook 2007)
F3: Detours	A detour that is dependent on flight distance is added to the total distance	Documentation of the ICAO Flight Emission Calculator
F4: Aircraft type	Fuel consumption of at least the following models' is considered: - Airbus (A300, A310, A320, A330, A340) - Boeing (B707, B717, B727, B737, B747, B757, B767, B777) - Embraer ERJ/E-Jet - Bombardier Q-Series - BAe/Avro 146/RJ	EU Corinair (EMEP/CORINAIR Emission Inventory Guidebook 2007), or documentation from the ICAO Flight Emission Calculator
F6: Winglets	Adding a winglet rate for aircraft families B737, B757, B767 (reduction of the specific consumption by 3 for a winglet rate of 100% and 0% at a winglet rate of 0%; all others are interpolated linearly	JP Airline Fleets International
F8: Taxiing	Value from Corinair or a fixed value of 2.5 kg kerosene per passenger will be added to the specific consumption per passenger	- EU-Corinair-System (EMEP/CORINAIR Emission Inventory Guidebook)

F9: Seating	A specific number of seats per aircraft type is assumed	Technical spec sheets from aircraft manufacturers
F10: Seat classes	A standard factor is used for all aircrafts	Documentation from atmosfair flight emissions calculator
F11: Additional cargo	Taken into account by subtracting a fixed value from the specific consumption per passenger; differentiated by type of aircraft (narrow-body vs. wide-body jets)	VDR Standard
F12: Occupancy rate	Occupancy rate for all flights within different regions worldwide	Documentation from the ICAO flight emission calculator
F13: Other pollutants	The number of kilometers flown at 9,000 m and above are calculated using the real distance of the flight. Here, the climate impact of non-CO_2 = CO_2*2 at an altitude above 9,000 m	VDR Standard

Table 7: VDR Standard methods for flights

2.7 Accuracy of the VDR Standard flight factors

The individual methods of the standard achieve the following accuracy:

Factor	Relative optimization potential CO_2	Factor accuracy (data sources)	Error percentage points of the CO_2 result
F2: Flight profile and cruising altitude	20 %	±5 %	1%
F3: Detours	1%	± 10 %	0.1 %
F4: Aircraft type	25 %	±5 %	1.25 %
F6: Winglets	3%	±5 %	0.15 %
F8: Taxiing	1%	±5 %	0.05 %
F9: Seating in total	10 %	± 15 %	1.5 %
F10: Distribution of seat classes	10 %	± 10 %	1%
F11: Additional cargo	5%	± 20 %	1%
F12: Occupancy rate	25 %	± 15 %	3.75 %
Sum	100%		9.8 %

Table 8: Optimization potential and accuracy of the factors within the VDR Standard for flights

Table 8 displays the accuracy of the individual factors as well as of the data on which they are based. These are used to calculate a flight's CO_2. Their optimization potential is also displayed. Optimization potential means the following: assuming that the value for a given factor, e.g., aircraft type or seating is altered by one standard deviation of all known aircraft or seating types, the optimization potential indicates how much CO_2 can be saved through the improvement of the factor. If this is repeated for each factor, and the total absolute CO_2 savings are normalized to 100%, the relative optimization potential indicates the weight of each factor in the optimization as a percentage. In other words, the relative optimization potential points out which factors can achieve the most with regard to CO_2 optimization.

The factor F1 “distance and route” is not included in this weighting. The reason for this is that CO_2 emissions are calculated over the absolute fuel consumption of the aircraft, which is based on the distance flown. As a result, the factor distance naturally receives the highest weight and almost no error due to the factor detours (less than 1%). Thus, this factor can be ignored here.
The factor F13 “other pollutants” does not affect a flight’s CO_2 and is therefore not listed here.

3 CO_2 reporting method – rail

Compared to air travel, travel by rail generally creates significantly less CO_2 emissions. This chapter describes how the VDR Standard calculates emissions for rail. The points are summarized again in tabular form at the end of the chapter.

3.1 Summary

The CO_2 emissions of a single train journey depend on different factors:

- Distance (R1)
- Topography (R8)
- Train type (R3)
- Seat class (R4)
- Energy carriers and emission factors (R4 and R5)
- Occupancy rate (R6)
- Age and efficiency of the train fleet (R7)

The basis for calculating CO_2 for rail using the VDR Standard is country-specific and type-specific CO_2 emission factors. Railway companies or ministries for the environment in the individual countries provide these factors, which together depict the CO_2 emissions per person-kilometer on a given rail journey with a certain degree of accuracy. These CO_2 emission factors thus take the type-specific energy consumption and respective energy carriers used as well as country-specific data on train occupancy and the current electricity mix into account.

For cross-border transport, several country-specific CO_2 emission factors may need to be considered. For these cases, the VDR Standard specifies the following procedure:

1. The distances are divided precisely, i.e., the rail-kilometers per country are precisely specified, and the country-specific CO_2 emission factor is applied according to the proportion of the total distance.
2. If this is not possible, for the sake of simplification, the total distance between the place of departure and the destination will be distributed equally among the countries concerned (half of them in two countries, one third in three countries, etc.).

3.2 Upstream part of the supply chain

Given the present degree of accuracy with regard to rail-specific energy consumption, the VDR Standard is currently assessing rail travel activity using the tank-to-wheel approach (see chapter 1.3.3).

3.3 VDR Standard for rail at a glance

	Part of the VDR Standard		**Accuracy within the VDR Standard**		
Factor	**Part of the VDR Standard**	**Possible additional detail, but not necessary for the standard**	**Detailed**	**Estimate over multiple, occasionally different constants**	**Fixed estimate**
R1: Distance	x		x	-	-
R2: Type of train	x		-	-	x
R3: Seat class	x		-	-	x
R4: Energy sources	x		-	x	-
R5: Electricity mix of the countries	x		-	x	-
R6: Occupancy rate	x		-	x	-
R7: Age and efficiency of the trains		x	-	-	-
R8: Topography		x	-	-	-

Table 9: Acquired factors within the train category of the VDR Standard

3.4 Variables and calculation formula

The CO_2 emissions of a rail journey with one or more passengers can be determined using the following formula:

<u>Calculation of the specific CO_2 per passenger</u>

$$CO_{2e} = (D * f_u) * f_c \ * f$$

Variable	Description	Units	Described in
CO_2e	Symbol for the specific CO_2 of a train journey	kg	-
D	Distance between the railway stations per large circle distance	km	VDR Standard B1
f_U	Detour factor	%	VDR Standard B1
f_C	Factor for the seat class (VDR Standard B3)	%	VDR Standard B3
f	CO_2 emissions factor in CO_2 per passenger-kilometer (dependent on the type of train and country, e.g. TGV or ICE)	kg CO_2/pkm	VDR Standard B2 and VDR Standard B4

Table 10: Variables in the calculation formula for the train category of the VDR Standard

3.5 The factors in detail

3.5.1 R1 – Distance

To calculate rail emissions, the distance between the departure and arrival stations must be determined. This is possible by using a large circle distance plus correction factors and is a component of the distance calculation method of the HAFAS [14]computer used in Deutsche Bahn's mobile check service.

VDR Standard R1

The CO_2 business travel reporting determines CO_2 emissions based on the distance travelled.

> Method: The distance is calculated according to the large circles between the railway stations. The cities in which the start and finish stations are located are determined. This information can be found in the booking data. A detour factor is added to the large circle distance.

3.5.2 R2 – Type of train

The type of train, as well as the speed taken, determine the amount of energy consumed and thus the amount of CO_2 emissions. These depend above all on the type of train. Therefore, it must be included in the calculation.

[14] HaCon Timetable-Information-System (HAFAS)

VDR Standard R2
The CO_2 calculation for business travel reporting differs by train type.

Method: At least the following train types must be differentiated:

- Regional train
- InterCity
- High-speed train (ICE, Thalys, TGV)

This information can be found on the train ticket or together with the booking information. In addition, the respective railway company provides information on the rail category of the journey.

3.5.3 R3 – Seat class

Generally, there are different seat classes on trains. Depending on the country, these differ in comfort, space, equipment and additional service. Seat class is associated with more or less space per passenger and thus with more or less CO_2 emissions per passenger.

VDR Standard R3
The CO_2 business travel reporting differentiates among seat classes on the train.

Method: A distinction is made between train classes (first and second class). A first-class passenger is assigned more emissions than a second-class passenger. For the VDR Standard, it is not necessary to look at any other classes.

The seat class can be found together with the booking information or on the ticket.

3.5.4 R4 – CO_2 emissions by country (energy mix, degree of electrification), and train system

As mentioned above, the amount of CO_2 emissions depends on the type of train and on the energy carrier used as well as speed. Trains have two types of engines: diesel-powered and electric. In the case of the former, the CO_2 emissions depend on the amount of diesel used; for the latter, the CO_2 emissions created by generating electricity count.
Thus, for each type of train (see VDR – Standard B2) and for each country, the ratio of diesel-powered to electric trains must be determined for the railway company, and a CO_2 emission factor should be assigned based on this.
Within the VDR Standard, the CO_2 per passenger-seat-kilometer, which is published by the railway companies or national ministries for the environment, is sufficient for this.

Distinguishing between diesel-powered and electric locomotives, which is dependent on country and railway company, is thus already considered in the CO_2 per passenger-kilometer.

VDR Standard R4
The CO_2 calculation for business travel reporting differs by rail system as well as by the degree of rail electrification within each country.

> Method: For each train type and country, an average distribution of electricity vs. diesel-powered locomotives is used:
> - High-speed train: electricity only
> - InterCity: electricity and diesel
> - Regional train: electricity and diesel
>
> An emissions factor (in g CO_2 per passenger-kilometer) is allocated per country and train type. If this is not possible, then
>
> 1. an average value for all the trains of a country is used. If this is not possible, either, then
> 2. a default value is used for all instances in which CO_2 emission factors cannot be determined.
>
> Calculations using the default value may not exceed more than 10% of all rail travel within a CO_2 report.
>
> The CO_2 emission factors (for each type of train and/or in total) can be found in the national railway company CSR reports.

3.5.5 R5 – National electricity mix

A large proportion of rail traffic runs on electricity, i.e., electricity is routed to the locomotive via an electrical overhead line. Countries generate electricity in a wide variety of ways. Thus, for example, the proportion of nuclear power in France is higher than in Germany, which ultimately has an effect on CO_2 emissions due to electricity generation.
This fact is already considered in VDR Standard B4 and does not need to be considered separately.

3.5.6 R6 – Occupancy rate

The train's occupancy rate determines the amount of specific CO_2 emissions. The CO_2 emissions factor described in VDR Standard B4 already includes the occupancy rate and thus does not need to be considered separately.

3.5.7 R7 – Age and efficiency of the fleet

When modern trains are developed or sold to respective railway companies, energy efficiency measures are often already pre-specified. In other words, the way that the trains perform is essential to the product and making decisions. Thus, it can be assumed that the trains produced by the train manufacturers are comparable in terms of energy consumption and therefore also in terms of emissions. Consequently, the efficiency of the trains within a railway company (and, as a rule, within a country) is comparable, and this point does not need to be considered separately.
Trains must be maintained regularly, on the one hand due to statutory requirements, but also because of wear and tear of train parts, especially the wheels and chassis. The standard assumes that no efficiency losses occur due to age.

3.5.8 R8 – Topography

The nature of the terrain can have a strong influence on how much energy the train uses. However, this is not included in the standard. High-speed train routes that avoid inclines are now being built, which makes it unnecessary to include this factor for high-speed and InterCity trains. Steep slopes must only be considered in the case of regional transport. However, regional train routes are also being adapted to avoid steep slopes, making it unnecessary to include topography as a relevant factor.

3.6 VDR Standard method for rail at a glance

Factor	Method	Freely available data source
R1: Distance	Calculation using long circle distance, station names in plain text plus a detour factor. Cross-border traffic will explicitly be taken into account.	- Formula for orthodromes - Distance calculator
R2: Type of train	Calculation of emissions based on the following types of trains: - High-speed - InterCity - Local	- Booking information
R3: Seat class	First and second class. A factor will assign more emissions to a first-class seat than to a second-class seat	- Booking information - IFEU[15]
R4: Energy source and engine type	Specific electricity mix and diesel per railway company will be indirectly taken into account in the CO_2 emissions factor (g CO_2 per passenger-kilometer) by country and type of train; if this is not possible, a default value will be applied (max. 10% of the train journeys in the reporting)	- IFEU - Railway company CSR reports

Table 11: VDR Standard methods for rail

3.7 Accuracy of the VDR Standard rail factors

The factors have the following degree of accuracy:

Factor	Relative optimization potential CO_2	Accuracy of the factor (data sources)	Error percentage of the CO_2 results
R2: Train type	10 %	±0 %	0%
R3: Seat class	10 %	±0 %	0%
R4: Engine and fuel type	80 %	± 40 %	32 %
Total	100 %		32 %

Table 12: Optimization potential and accuracy of the VDR Standard factors for rail

[15] Institute for energy and environmental research Heidelberg

Table 12 displays the accuracy of the individual factors as well as of the data on which they are based. These are used to calculate the CO_2 of a train journey. Their optimization potential is also displayed. Optimization potential means the following: assuming that the value for a given factor, e.g., train type is altered by one standard deviation of all known train types, the optimization potential indicates how much CO_2 can be saved through the improvement of the factor. If this is repeated for each factor, and the total absolute CO_2 savings are normalized to 100%, the relative optimization potential indicates the weight of each factor in the optimization as a percentage. In other words, the relative optimization potential points out which factors can achieve the most with regard to CO_2 optimization.

The factor R1 “distance” is not included in this weighting. The reason for this is that the absolute CO_2 is calculated over the distance. As a result, the factor distance naturally receives the highest weight during the journey and almost no error due to the factor detours. Thus, this factor can be ignored here.

4 CO_2 reporting method – Hotel

4.1 Summary

This chapter describes how the VDR Standard calculates emissions for hotels. The points are summarized again in tabular form at the end of the chapter.

The CO_2 emissions that are generated during an overnight hotel stay depend on several factors:

- Energy consumption (H3)
- Energy carriers and emission factors (H4) – Water consumption (H5)
- Waste and wastewater management (H6)
- Booking category (H7)
- Occupancy rate (H8)

Unlike other business travel activities such as flights, train trips, and car rentals, rougher approximation methods must be applied for calculating hotel accommodation emissions. Energy and resource consumption, on which the calculation of emissions is based, depends on individual parameters and therefore varies widely from one hotel to another. To capture the exact emissions per overnight stay, precise data on energy consumption, room size, etc., for the hotel would have to be available, which is not feasible.

Therefore, the VDR Standard uses an empirical database that maps factors H3 through H8 as an aggregated function of the destination country and hotel class and considers this to be sufficiently accurate. The VDR Standard also requires the room category in the emissions assessment. The following explains the extent to which the parameters “destination country” and “hotel class” are sufficient as indicators for the amount of emissions:

1. Hotel class (stars)
   Hotels are classified according to their facilities by the allocation of stars. There are several classification systems (for example, Michelin, DEHOGA). The decisive parameters for the star classification, such as room size and comfort, generally affect the energy and water consumption as well as the amount of waste and wastewater per night. Therefore, the number of stars assigned is correlated with these factors, with a higher number of stars being associated with higher resource consumption. The VDR Standard uses the Michelin classification.

Stars	*	**	***	****	*****
Room size (single)	8 m^2	12 m^2	14 m^2	16 m^2	18 m^2
Room Size (double)	12 m^2	16 m^2	18 m^2	22 m^2	26 m^2
Room facilities	Color television	Color television, other electronics	Color television, radio, blow dryer, mini bar	Color television and radio in every room, blow dryer, mini bar	Color television and radio in every room, blow dryer, mini bar
Catering	Restaurant, 2h lunch, 3h dinner	Restaurant, 2h lunch, 3h dinner	Restaurant, breakfast buffet, 2h lunch, 3h dinner	Restaurant, bar, breakfast buffet, 2h lunch, 3h dinner	Restaurant, bar, breakfast buffet, 2h lunch, 3h dinner
Additional facilities	-	-	-	Laundry service	Laundry service, spa area

Table 13: Excerpt from the hotel classification according to DEHOGA

2. Destination country
   Hotels with comparable facilities can differ in their energy and water consumption as well as in the amount of waste and sewage they produce depending on the country in which they are located. For example, climatic conditions impact heating and hot water requirements, the implementation of energy efficiency and waste management systems may depend on the political environment, etc. Also, both the occupancy and CO_2 emission factors of energy carriers vary from country to country. Therefore, these factors are directly or indirectly influenced by the destination country.

The relevant factors as well as the VDR Standard procedure for calculating emissions are explained below. A sample calculation for determining the proxy values can be found in Part II. When more detailed data is available, the proxy values can be replaced by the user, which results in higher accuracy of the emissions calculation.

4.2 Upstream part of the supply chain

Due to the existing data uncertainties, the VDR Standard is currently evaluating the travel activity “hotel” without considering the upstream part of the supply chain since this differentiation would make this method of calculating emissions appear more accurate than it actually is (see chapter 1.3.3).

4.3 Non-CO_2

Analogous to the consideration for the upstream part of the supply chain, differentiating non-CO_2 in the present reporting method would merely make the calculation appear more precise than it actually is. For hotels, the following applies: $CO_2 = CO_2e$.

4.4 Proposed VDR Standard for hotels at a glance

	Part of the VDR Standard		Accuracy of the VDR Standard		
Factor	**Part of the VDR Standard**	**Possible refinement, but not necessary for the standard**	**Detailed**	**Estimate over multiple, occasionally different constants**	**Fixed estimate**
H1: Hotel category	x		x	-	-
H2: Country	x		x	-	-
H3: Energy consumption	x		-	x	-
H4: Energy sources and emission factors	x		-	x	-
H5: Water consumption	x		-	x	-
H6: Waste and sewage water	x		-	-	x
H7: Booking category	x		-	-	x
H8: Occupancy rate	x		-	-	x

Table 14: Factors included in the VDR Standard for hotels

4.5 Creation of an empirical database

An empirical database that portrays the emissions created by staying in a hotel overnight by country and hotel class can be calculated on the basis of annual consumption values of individual hotels. For this, the VDR Standard takes energy consumption (electricity and heat), water supply, sewage and waste disposal as relevant emission sources into account. Country-specific emission and occupancy factors are used to determine the annual emissions and the emissions caused by an overnight hotel stay.

Subsequent calculation steps allow the emissions of a single overnight hotel stay to be calculated by taking all relevant factors into consideration. These can either be assessed empirically or researched.

Annual emissions of a hotel

$$CO_2e_a = (C_S * f_S + C_H * f_H) + (C_W * f_W) + (C_W * f_A) + (C_M * f_M)$$

Total emissions per overnight stay

$$CO_2e = \frac{CO_2e_a}{n * f_l} * f_B$$

Variable	**Description**	**Units**	**Described in**
CO_2e	Total emissions per overnight stay	-	-
CO_2e_a	Annual emissions	Kg	-
C_S	Hotel's annual energy consumption	KWh	VDRstandard H3
f_S	CO_2 emission factor for energy per country	Kg CO_2/KWh	VDR standard H4
C_H	Hotel's annual heating use	KWh	VDR Standard H3
f_H	CO_2 emission factor for heating per country	Kg CO_2/KWh	VDR standard H4
f_W	CO_2 emission factor for water consumption per overnight stay	CO_2/l	VDR standard H5
C_W	Hotel's annual water consumption	l	VDR Standard H5
C_M	Hotel's annual waste generation	kg	VDR standard H6
f_A	CO_2 emission factor for sewage water treatment	CO_2/l	VDR standard H6
F_M	CO_2 emission factor for waste disposal	CO_2/kg	VDR Standard H6
f_B	Factor for the booking class/room category	%	VDR standard H7
n	Number of rooms	-	VDR standard H8
f_l	Occupancy rate factor	%	VDR standard H8

Table 15: Variables for the VDR Standard calculation formula for hotels

4.6 The factors in detail

4.6.1 H1 – Hotel class

Hotels receive quality ratings based on their facilities (e.g., Michelin stars). Although this assessment is not uniform internationally, Michelin stars indirectly reflect the amount of CO_2 emissions generated by hotels since the parameters that are associated with a higher rating, such as room size and comfort, also have an impact on energy requirements and CO_2 emissions. For this reason, it is possible to use classifications other than those of the Michelin stars since the underlying parameters are identical.

Based on the number of stars a hotel has, the emissions per overnight stay can be calculated without knowing the exact consumption values of each hotel.

VDR Standard H1
The CO_2 calculation for business travel reporting takes hotel class into consideration.

> Method: Using Michelin or DEHOGA stars to classify the hotels.
>
> The hotel class can be found in the user's booking information, from business travel agencies, or the Internet.

4.6.2 H2 – Country

Calculating CO_2 emissions per overnight stay is not only based on stars, but also on the destination country. This is the second most important factor and must be used when applying the VDR Standard.

VDR Standard H2
The CO_2 calculation for business travel reporting takes the country into account.

> Method: The user specifies the country in which the hotel is located.
>
> The country can be found in the user's booking information, from business travel agencies, or the Internet.

4.6.3 H3 – Energy consumption

A hotel's absolute energy consumption depends on many different factors: hotel size, number and size of rooms, equipment (e.g., wellness area), comfort (e.g., technical equipment), local climatic conditions (i.e., use of heating and hot water), etc.

The proxy values found in the VDR Standard represent the average use of electricity and heating per night. By subdividing hotel stays by class (stars) and country, these values implicitly include the parameters listed above.

VDR Standard H3
The CO_2 calculation for business travel reporting takes hotels' energy consumption into account.

Method: The average energy consumption per hotel class per country (one value per star per country) is used for each overnight stay and bed.

The consumption data per overnight stay by country and star can be found in the CSR reports of the respective hotel chains.

4.6.4H4 – Energy carriers and emission factors

In order to calculate the CO_2 emissions created by staying in a hotel overnight based on the amount of energy consumed (see H1), the primary energy sources for generating energy must be known (energy mix) since different sources produce different amounts of CO_2 emissions. Hotels generate the energy they need in the form of electricity and heating and cooling (e.g., central heating, CHP), otherwise they are supplied with energy by power companies.

Specifying the individual energy mix of each hotel is not feasible. Therefore, the VDR Standard first approximates this using the average energy and heating mix in the respective country. These values can generally be obtained in freely available databases. The individual energy carriers' CO_2 emission factors are also freely available.

VDR Standard H4
The CO_2 calculation for business travel reporting takes the distribution and CO_2 intensity of the energy sources used into account.

Method: To calculate the emissions produced from energy consumption, the VDR Standard uses the electricity and heating mix at the country level as well as the corresponding emission factors. If available, more precise data regarding the energy mix can be used, but it is not required under the VDR Standard.

Information about the destination country can be found together with the booking information.

4.6.5 H5 - Water consumption

In addition to the energy required for heating, cooling and electricity, a hotel needs water for its operation. The production, processing and transportation of water requires energy, which also creates CO_2 emissions. This effect is not negligible, but of lesser importance compared to the emissions caused by energy consumption. Thus, water consumption is only included as a fixed factor per overnight stay in the CO_2 emissions calculation. The VDR Standard does not differentiate this value by country.

VDR Standard H5
The CO_2 calculation for business travel reporting takes hotel water consumption into account.

Method: A standard CO_2 emissions factor for water consumption is used. This is used as the average water consumption of an overnight hotel stay.

4.6.6 H6 – Waste and sanitation

In addition to energy and water consumption, hotels generate a lot of waste and wastewater. Disposal of waste and wastewater requires energy, which also produces CO_2. This effect is not negligible, but of lesser importance compared to the emissions caused by energy consumption. Thus, waste and wastewater are only included as a fixed factor per overnight stay in the CO_2 emissions calculation. The VDR Standard does not differentiate this value by country.

VDR Standard H6
The CO_2 calculation for business travel reporting takes hotel waste and sanitation into consideration.

> <u>Method:</u> A standard emissions factor is used for wastewater and waste disposal. For wastewater, the amount is assumed to be equal to water consumption; for garbage, the average quantity of waste generated per hotel overnight is used.

4.6.7 H7 – Booking category

There are several types of rooms available within hotels. Suites or larger accommodations require more energy and create more waste, especially when it comes to cleaning them. Furthermore, such rooms are generally better furnished, which also leads to additional energy consumption and therefore higher emissions. The VDR Standard takes the need for more energy and water into account by using a factor that allocates more CO_2 emissions to larger rooms.

VDR Standard H7
The CO_2 calculation for business travel reporting takes different room categories within a hotel into consideration.

> <u>Method:</u> Higher category rooms are allocated more CO_2 emissions. This factor is divided into the following room categories:
>
> - Standard single room
> - Standard double room
> - Suite
>
> The room category that has been booked can be found together with the booking information.

4.6.8 H8 – Occupancy rate

As in the case of trains and aircraft, the occupancy rate plays an important role in the distribution of the overall hotel emissions to the guests. Therefore, it must be included.

VDR Standard H8
The CO_2 business travel reporting takes the occupancy rate of hotels into account.

> Method: An occupancy rate is used for all hotels by country. If there is information for individual hotels beyond the data found within the standard, this data is used. If no information is available, the default occupancy rate is 70%.

4.7 VDR Standard method for hotels at a glance

Factor	Method	Freely available data sources
H1: Hotel category	Classification by number of Michelin stars	Booking information
H2: Country	Determination of the destination country	Booking information
H3: Energy consumption of the hotel	Set values per country and star – there is one energy consumption value per bed and overnight stay for each category	CSR reports hotel chains
H4: Energy sources and emission factors	The average energy mix of the destination country is used	OECD energy mix, GHG
H5: Water consumption	CO_2 emission factor for water supply * average water consumption per overnight stay	VDR Standard
H6: Sewage water and waster	CO_2 emission factor for sewage water treatment * average water consumption/average waste generation per overnight stay	VDR standard
H7: Booking category	Division into normal rooms and suites as well as into single and double standard rooms	Booking information
H8: Occupancy rate	Average occupancy rate of all hotels per country (e.g., 70% in GB), otherwise default value	Annual reports, information from associations

Table 16: VDR Standard methods for hotels

4.8 Accuracy of the VDR Standard hotel factors

Factor	Relative optimization potential CO_2	Accuracy of the factor (data sources)	Error percentage of the CO_2 results
H1: Hotel category	30 %	0%	0%
H2: Country	10 %	0%	0%
H3: Energy consumption of the hotel	10 %	± 50 %	5%
H4: Energy sources and emission factors	20 %	± 25 %	6.25 %
H5: Water consumption	2%	± 20 %	0.4 %
H6: Sewage water and waster	3%	± 20 %	0.6 %

H7: Booking category	10 %	0%	0%
H8: Occupancy rate	10 %	± 20 %	2%
Total	100 %		14.25 %

Table 17: Optimization potential and accuracy of the VDR Standard factors for hotels

Table 17 displays the accuracy of the individual factors as well as of the data on which they are based. These are used to calculate the CO_2 of a hotel overnight stay. Their optimization potential is also displayed. Optimization potential means the following: assuming that the value for a given factor, e.g., hotel category is altered by one standard deviation of all known hotel categories, the optimization potential indicates how much CO_2 can be saved through the improvement of the factor. If this is repeated for each factor, and the total absolute CO_2 savings are normalized to 100%, the relative optimization potential indicates the weight of each factor in the optimization as a percentage. In other words, the relative optimization potential points out which factors can achieve the most with regard to CO_2 optimization.

5 CO_2 reporting method – cars

This chapter describes how the VDR Standard calculates emissions for cars. The points are summarized again in tabular form at the end of the chapter.

5.1 Summary

The following factors influence the emissions produced by cars:

- Distance driven (distance) (C1)
- Vehicle type (C2)
- Engine (C3)
- Fuel (diesel, gasoline) (C4)
- Driving behavior, vehicle equipment (C5)
- Transmission type: manual or automatic (C6)
- Number of passengers (additional weight) (C7)

In general, cars can be divided into four categories:

Area	Explanation
Rental car	Rental car from car rental companies
Company car	Covers all cars that are part of the company's vehicle fleet
Private car used for business	Cars that are not part of the company's vehicle fleet, but are used for business purposes by employees who own them privately
Taxi	Covers all taxi rides

Table 18: Division of cars according to the VDR Standard

The simplest and most precise way to calculate emissions created by a car ride is from the amount of fuel consumed, which is then multiplied by the appropriate emissions factor (kilograms of CO_2 per liter). Information on tank volumes is mostly available for company and private vehicles since these are usually refueled by the company producing the report or its employees.

Alternatively, the emissions can be calculated based on the number of kilometers travelled, which is generally recorded by car rental companies. In this case, an emissions factor (kilogram of CO_2 per kilometer) is applied that is based on the four-digit vehicle classification ACRISS and approximates the specific CO_2 emissions according to the corresponding class characteristics. Because the first ACRISS letter (car category) and the last ACRISS letter (fuel/air conditioning) have the highest impact on fuel consumption, the VDR Standard considers differentiation of the emissions using the first and last letters to be sufficiently accurate.

In contrast to the other travel activities, the emissions calculation refers to one car trip. If more than one person travels per car, emissions are added to the person paying for the car trip (see chapter 1.3.1).

5.2 Upstream part of the supply chain

The VDR Standard considers fuel-to-wheel or well-to-wheel emission factors for fuels according to DIN EN 16258 in the fuel-based reporting for cars (private cars). This differentiation is applied to the specific emissions in the kilometer-based reporting method (car rental).

5.3 Non-CO_2

The emission factors in DIN EN 16258 include the climate impact of non-CO_2 using the GWP.

5.4 Proposed VDR Standard for cars at a glance

	Part of the VDR Standard		**Accuracy within the VDR Standard**		
Factor	**Part of the VDR Standard**	**Possible refinement, but not necessary for the standard**	**Detailed**	**Estimate over multiple, occasionally different constants**	**Fixed estimate**
C1: Distance	x		x		-
C2: Car type	x		-	x	-
C3: Engine	x		-	x	-
C4: Energy source and drive type	x		-	x	-
C5: Driving behavior		x	-	-	-
C6: Manual vs. automatic transmission	x		-	x	-
C7: Number of passengers	X		X	-	-

Table 19: Factors included in the VDR Standard for cars

5.5 Calculation formula

The formula for calculating the CO_2 emissions produced by rental cars is:

<u>CO_2 calculation for a rental car</u>

$$CO_2e = D * f_A$$

The formula for calculating the CO_2 emissions produced by company cars as well as private cars used by the company is:

CO_2 calculation for company and private cars

$$CO_2e = F * f_F$$

Variable	Description	Units	Described in
CO_{2D}	Rental car CO_2 emissions	kg	-
f_A	CO_2 emissions factor for ACRISS car category	g CO_2/km	VDR Standard M1
D	Distance driven	km	VDR Standard M2
F	Volume of the fuel tank	l	VDR Standard M4
f_{Ft}	CO_2 emissions factor of the fuel used	l	VDR standard M4

Table 20: Variables used to calculate emissions using the VDR Standard for cars

5.6 The factors in detail

5.6.1 C1 – Distance

The distance travelled is crucial for calculating the level of CO_2 emissions. In theory, the driver can calculate this using the car's mileage; however, in practice, this is often not possible. Since the cost of a rental car depends on the kilometers driven, bills usually state the distance travelled.

VDR Standard C1
The CO_2 calculation for business travel reporting specifies the distance travelled.

Method:

- Rental car: The exact distance travelled must be determined in order to calculate the CO_2 emissions.
- Company and private cars: this is only required for individual trips.

The kilometers travelled can be found from the car rental bill or logbook.

5.6.2 C2 – Vehicle type

The vehicle used has a great impact on CO_2 emissions. Therefore, the car model used must be considered. The emissions per kilometer it produces depend mainly on the car's engine. The simplest way to identify the vehicle type is using the ACRISS code. Its four letters indicate vehicle, engine, transmission, equipment, etc. In order to simplify the CO_2 emissions calculation for rental cars within the VDR Standard, only the first two letters of the ACRISS code (category and type, design) are required. This is user-friendly, but does not affect the accuracy.

VDR Standard C2

The CO_2 calculation for business travel reporting differentiates according to vehicle types.

Method:

- Rental car: Cars are distinguished by class (ACRISS codes). Each model has a specific CO_2 emissions factor in g CO_2 per kilometer. The level of accuracy specified for ACRISS uses all four letters.
- Company and private cars: this is not required

The ACRISS codes and cars that it contains can be found at: http://www.acriss.org.

5.6.3 C3 – Engine

The engine is a crucial driver of fuel consumption and CO_2 emissions. Consumption varies depending on cylinder capacity and performance. Especially in the case of larger engines, consumption per kilometer increases in urban areas. Since the ACRISS codes already include the engine, it is not necessary to examine this factor separately.

VDR Standard C3

The CO_2 calculation for business travel reporting takes the car's motor into account.

Method:

- Rental car: The motor is included in the ACRISS code.
- Company and private cars: The motor is indirectly recorded based on the type of fuel used

5.6.4 C4 - Fuel and drive type

The fuel used has an influence on the amount of CO_2 emissions produced. However, it is not necessary to examine this factor more closely since the ACRISS codes already include the engine.

VDR Standard C4

The CO_2 calculation for business travel reporting takes various types of fuel into consideration.

Method:

- Rental car: The engine type (engine, diesel or other) of the rental car is already included in the ACRISS code.
- Company and private cars: Information about the type of fuel can be found on the refueling receipt.

5.6.5 C5 – Driving behavior, equipment

Driving behavior is unique to individuals and cannot be included within the framework of the standard. The most important feature of modern vehicles that consumes gasoline is air-conditioning, which in most cases is standardly installed. Use of air condition is also based on individual preferences, so C5 is not considered separately in the standard.

5.6.6 C6 – Transmission type

The transmission type is displayed in the ACRISS code with the third letter. Thus, it is not necessary to examine this factor separately.

VDR Standard C6
The CO_2 calculation for business travel reporting takes different transmission types into consideration.

Method:

- Rental car: The rental car's transmission (automatic, manual, or semi-automatic) is already included in the ACRISS code.
- Company and private cars: This is not required.

5.6.7 C7 – Number of occupants (additional vehicle weight)

A car's fuel consumption is impacted by its weight, which can be increased with additional passengers and luggage. In the case of company cars and private cars, the additional consumption is directly reflected in increased fuel consumption due to other occupants.

According to the CO_2 limit formula in the EU regulation for reducing passenger car CO_2 emissions (EG 443/2009), an additional vehicle weight of 100 kg[16] corresponds to an increase in specific CO_2 emissions of 4.57 g per kilometer[17]. Depending on the type of vehicle, this translates into an increase in specific emissions by an average of 2% to a maximum of 5%. In light of the degree of accuracy of the present VDR Standard, the increase in emissions due to additional occupants can thus be neglected.

[16] 100 kg corresponds to approximately one passenger including luggage. This value is taken from the 100 kg mass passenger + baggage used for flights.

[17] EC Regulation 443/2009, Annex I

5.7 VDR Standard method for cars at a glance

Factor	Method	Freely available data sources
C1: Distance	Information on distance driven	Rental car bill
C2: Car type	Cars are identified by their ACRISS code (all four letters)	ACRISS code, car rental company
C3: Engine	The engine is identified by the ACRISS code	ACRISS code
C4: Energy source and drive type	Fuel and drive type are by the ACRISS code	ACRISS code, DEFRA
C6: Manual vs. automatic transmission	Transmission type is identified by the ACRISS code	ACRISS code

Table 21: VDR Standard methods for cars

5.8 Accuracy of the VDR Standard car factors

The degree of accuracy within the standard is:

Factor	Relative optimization potential CO_2	Accuracy of the factor (data sources)	Error percentage of the CO_2 results
C2: Car type	30 %	± 10 %	3%
C3: Engine	50 %	± 10 %	5%
C4: Energy source and drive type	10 %	±0 %	0%
C6: Manual vs. automatic transmission	10 %	±0 %	0%
Total	100 %		8%

Table 22: Optimization potential and accuracy of the VDR Standard factors for cars

Table 22 displays the accuracy of the individual factors as well as of the data on which they are based. These are used to calculate the CO_2 of a car ride. Their optimization potential is also displayed. Optimization potential means the following: assuming that the value for a given factor, e.g., car type is altered by one standard deviation of all known car types, the optimization potential indicates how much CO_2 can be saved through the improvement of the factor. If this is repeated for each factor, and the total absolute CO_2 savings are normalized to 100%, the relative optimization potential indicates the weight of each factor in the optimization as a percentage. In other words, the relative optimization potential points out which factors can achieve the most with regard to CO_2 optimization.

6 CO_2 reporting method – taxi

Since taxis contribute relatively few emissions to total business trip emissions and travel agencies and travel credit cards often cannot provide information on their use, reporting on taxi use is considered optional under the VDR Standard.

This chapter describes how the VDR Standard calculates emissions for taxis. The points are summarized again in tabular form at the end of the chapter.

6.1 Summary

In contrast to cars, companies compiling reports do not have information on the distance travelled, the amount of fuel consumed or the car type for taxis. The only data available is from the taxi receipt. The VDR Standard has therefore developed a method of calculating emissions for taxis that is based solely on the travel costs. As in the case of traveling by car, taxi emissions are charged to the person paying for it when there are several passengers.

The basis for the calculation method is the assumption that the amount of emissions depends primarily on the distance traveled. The number of kilometers traveled for a certain price depends on various factors such as region, taxi company and service. The greatest variance results from the country-specific price disparities.

The VDR Standard therefore considers an empirical database that represents the average kilometers traveled per euro by country to be sufficiently accurate. Furthermore, the VDR Standard assumes an average emissions factor of 0.2 kg CO_2 per km. Both figures are summarized as an emission factor with respect to the fare.

The present taxi method represents a compromise between accuracy and user-friendliness while maintaining a minimum degree accuracy that is compatible with the other travel activities.

6.2 Upstream part of the supply chain

In the present reporting method, differentiation of fuel emissions according to well-to-wheel (WTW) and tank-to-wheel (TTW) approaches are not considered since this would make this method of calculating emissions appear more accurate than it actually is.

6.3 Non-CO_2

Analogous to the consideration for the upstream part of the supply chain, differentiating non-CO_2 would give an illusion of accuracy that is not present in the current reporting method. The following applies to public transport: $CO_2 = CO_2e$.

6.4 VDR Standard for taxi at a glance

The influential factors correspond to those that are relevant for cars. Of these, the factors C1 and C4 correspond directly, the others are only implicitly represented by the average CO_2 emission factors.

	Part of the VDR Standard		Accuracy of the VDR Standard		
Factor	**Part of the VDR Standard**	**Possible refinement, but not necessary for the standard**	**Detailed**	**Estimate over multiple, occasionally different constants**	**Fixed estimate**
C1: Distance	x		-	x	-
C2: Car type		x	-	-	-
C3: Engine		x	-	-	-
C4: Energy source and drive type	x	-	-	-	-
C5: Driving behavior		x	-	-	-
C6: Manual vs. automatic transmission		x	-	-	-
C7: Number of passengers		x	-	-	-

Table 23: Factors included in the VDR Standard for taxi

6.5 Variables and formulas

The formula for calculating taxi CO_2 emissions is:

Total emissions taxi

$$CO_2e = P * f$$

Variable	Description	Units	Described in
P	Price of the taxi ride	€	6.1
f	Emissions factor per country	kg CO_2 / €	6.1
CO_2e	Total emissions of the ride	kg	

Table 24: Variables in the VDR Standard method for taxis

6.6 The factors in detail

6.6.1 C1 – Distance

The distance travelled determines the amount of CO_2 emissions. The distance is represented indirectly by the travel costs and is then used explicitly for calculating the emissions.

VDR Standard C1

The CO_2 calculation for business travel reporting takes the distance travelled into consideration.

<u>Method:</u> The average distance travelled (country-specific) is represented by the travel cost.

6.7 VDR Standard method for taxi at a glance

Factor	**Method**	**Freely available data sources**
C1: Distance	Determined retrospectively using the taxi fare	Own estimate or research
C4: Energy source and drive type	Assumption of a fixed emissions factor	Own estimate or research

Table 25: VDR Standard methods for taxi at a glance

7 CO_2 reporting method – public transport

Like for taxis, trips made by public transport contribute relatively few emissions to total business trip emissions, and travel agencies and travel credit cards often cannot provide information on public transport use for individual business travelers. Thus, reporting for trips made by public transport is optional under the VDR Standard.

This chapter describes how the VDR Standard calculates emissions for public transport. The points are summarized again in tabular form at the end of the chapter.

7.1 Summary

The following factors have an impact on the amount of emissions created by a public transport journey:

- Distance driven (distance) (P1)
- Transport (including energy carriers) (P2)
- Occupancy rate (P3)

Due to a lack of detailed information, reporting emissions from public transport trips can only be estimated. For an individual public transport journey, it is usually not possible to identify which means of transport were used or which route was taken.

The VDR Standard assumes a fixed emission value for public transport that reflects the average emissions from public transport per day. This is based on the assumption that a business traveler's daily use of public transport is a round trip to and from the event location, assuming an average distance of 10 km per trip[18]. Furthermore, a global average emissions factor of 0.1 kg CO_2 per passenger-kilometer is assumed[19]. This results in an average public transport emission factor of 2.0 kg CO_2 per day of public transport use.

7.2 Upstream part of the supply chain

In the present reporting method, there is no differentiation between considering and not considering an upstream part of the supply chain since this would make this method of calculating emissions appear more accurate than it actually is.

7.3 Non-CO_2

Analogous to the consideration for the upstream part of the supply chain, differentiating non-CO_2 would give an illusion of accuracy that is not present in the current reporting method. The following applies to public transport: $CO_2 = CO_2e$.

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[18] DESTATIS 2012, DFT 2011

[19] VDV 2012, DOT 2009

7.4 VDR Standard for public transport at a glance

The influential factors correspond to those that are relevant for cars. Of these, the factors C1 and C4 correspond directly, the others are only implicitly represented by the average CO_2 emission factors.

	Accuracy of the VDR Standard		
Factor	**Detailed**	**Estimate over multiple, occasionally different constants**	**Fixed estimate**
P1 – Distance	-	-	x
P2 – Means of transport	-	-	x
P3 – Occupancy rate	-	-	x

Table 26: Factors included in the VDR Standard for public transport

7.5 Variables and formula

The formula for calculating the CO_2 emissions produced by public transport is:

<u>Total emissions public transport</u>

$$CO_2e = T * f$$

Variable	**Description**	**Unit**	**Described in**
T	Number of days using public transport	-	7.1
f	Fixed emissions factor	kg CO_2/travel day	7.1
CO_2e	Total emissions	kg	-

Table 27: Variables of the method of the VDR Standard category public transport

7.6 The factors in detail

The influential factors correspond to those that are relevant for cars. Of these, the factors C1 and C4 correspond directly, the others are only implicitly represented by the average CO_2 emission factors.

7.6.1 P1 – Distance

The distance travelled determines the amount of CO_2 emissions. The distance is represented indirectly by the travel costs and is then used explicitly for calculating the emissions.

VDR Standard P1
The CO_2 calculation for business travel reporting takes the distance travelled into consideration.

> <u>Method:</u> The VDR Standard uses the average distance travelled per travel day.
>
> The distance travelled is based on the assumption that business travelers make a 20 km round trip on public transport per day.

7.6.2 P2 – Means of transport (including energy carriers)

The type of public transport (bus, subway, suburban train, tram) has a large influence on the level of specific emissions because the various modes of transport have very different physical characteristics (size and weight, type of drive and energy carriers, etc.). Details about each mode of transport are not discussed further here since they largely overlap with factors already mentioned for rail and car and are not relevant within the present degree of accuracy within the standard.
The means of transport used for a public transport journey cannot be taken into account explicitly in the standard, but are implicitly incorporated in the average emission factor via the transport frequency distribution.

VDR Standard P2
The CO_2 calculation for business travel reporting takes different means of transport and the amount of CO_2 they produce into consideration.

> Method: The VDR Standard uses an average value across modes of transport.
>
> The means of transport used is the average use of transport for typical large cities.

7.6.3 P3 – Occupancy rate

The public transport system occupancy rate has a large influence on the specific emissions since the absolute emissions of a trip are distributed proportionally by the number of passengers. Within the present degree of accuracy, it is not possible to specify the occupancy rate for individual public transport journeys. The occupancy rate is used as an average value in calculating the average emissions factor.

VDR Standard P3
CO_2 business travel reporting takes account of occupancy rate.

> Method: The VDR Standard makes an assumption about the average intermodal occupancy rate.

7.7 VDR Standard method at a glance

Factor	Method	Freely available data sources
P1 – Distance	Estimate of average distance covered	Own estimate or research
P2 – Means of transport	Estimate of average means of transportation used	Own estimate or research
P3 – Occupancy rate	Taken into account by using average values	Own estimate or research

Table 28: VDR Standard method for public transport at a glance

8 CO_2 reporting method – MICE

8.1 Summary

This chapter describes the VDR Standard for MICE (Meetings, Incentives, Congresses, Events).

8.2 VDR Standard for MICE at a glance

	Part of the VDR Standard		Accuracy of the VDR Standard		
Factor	Part of the VDR Standard	Possible refinement, but not necessary for the standard	Detailed	Estimate over multiple, occasionally different constants	Fixed estimate
M1: Venue: energy consumption	x		x	-	-
M2: Venue: energy mix	x		-	x	-
M3: Venue: CO_2 intensity	x		-	x	-
M4: Venue: water consumption	x		x	-	-
M5: Venue: sewage water and waste	x		x	-	-
M6: Arrival and departure	x		x	-	-
M7: Overnight stays	x		x	-	-
M8: Catering	x		-	-	x
M9: Transport of goods	x		-	-	x

Table 29: Factors included in the VDR Standard for MICE

8.3 Variables and formulas

The following formulas are required to calculate the total emissions of an event:

Emissions from the venue

$$CO_{2}e_{V} = (C_S * f_S + C_H * f_H) + (C_W * f_W) + (C_W * f_A) + (C_M * f_M)$$

Emissions from catering

$$CO_2e_C = C_C * f_C$$

Emissions from transport of goods

$$CO_2e_W = \sum_i D^i * f_D^i$$

Total emissions

$$CO_2e = CO_2e_V + CO_2e_R + CO_2e_U + CO_2e_C + CO_2e_W$$

Variable	Description	Unit	Described in
C_S	Energy consumption per day	kWh	VDR Standard V1
C_H	Heat consumption per day	kWh	VDR Standard V1
C_W	Water consumption per day	l	VDR Standard V3
C_M	Waste production per day	kg	VDR Standard V4
f_s	Emissions factor for power by country	kg CO_2/kWh	VDR standard V2
f_H	Emissions factor for heat by country	kg CO_2/kWh	VDR standard V2
f_W	Emissions factor for water collection by country	kg CO_2/l	VDR standard V3
f_A	Emissions factor for sewage water treatment by country	kg CO_2/l	VDR standard V4
f_M	Emissions factor for waste treatment by country	kg CO_2/kg	VDR Standard V4
C_C	Total cost of the catering	€	VDR Standard V7
f_C	Emissions factor for catering	kg CO_2/€	VDR standard V7
D^i	Distance driven by transport vehicle type (i)	km	VDR Standard V8
f_D^i	Emissions factor by transport vehicle type (i)	kg CO_2/km	VDR Standard V8
CO_2e_R	Emissions from arrival and departure	kg	VDR standard V5
CO_2e_U	Emissions from overnight stays	kg	VDR standard V6
CO_2e_C	Emissions from catering	kg	VDR standard V7
CO_2e_W	Emissions from the transport of goods	kg	VDR standard V8
CO_2e_V	Emissions from the venue	kg	-
CO_2e	Total emissions of the event	kg	-

Table 30: Variables in the VDR Standard method for MICE

8.4 The factors in detail

8.4.1 Factors affecting the CO_2 emissions produced by MICE

Events, congresses and conventions are characterized by a high level of energy consumption. Participants' travel to and from the venue, overnight stays, and catering must all be considered in addition to the emissions produced directly by the venue itself. The following points thus affect the emissions produced by MICE:

- Event location (henceforth referred to as “venue”)
- Arrival and departure
- Accommodation and overnight stays
- Catering
- Transport of goods

8.4.2 M1 – Energy consumption of the venue

The venue, i.e., the building or grounds where the event takes place, contributes a share of the CO_2 emissions related to the event. Typical sources of emissions include heating, electricity, fresh water, sewage and waste disposal. In principle, the methodology for calculating these is comparable with that for hotels. However, in contrast to hotel accommodations, there is a better way to get the necessary data for MICE. It is relatively easy to measure consumption using various bills, e.g., the electricity bill. The operator of the venue is usually able to provide the necessary data.

VDR Standard M1
The CO_2 calculation for business travel reporting takes the venue’s energy consumption into account.

Method: Energy consumption includes electricity and heating/cooling (kWh). It is determined as follows:

- The venue operator estimates daily energy needs required using electricity, gas and hot water bills and informs the user about them.
- If this is not possible, the VDR Standard provides a default value for energy consumption based on the duration of the event as well as the number of participants.

The venue’s energy consumption will be applied proportionally to the event in question, i.e., proportionally to the size of the rented area and dependent on the event duration. If only 50% of the premises of the venue are used, then only 50% of the energy consumption should be attributed to the event.

8.4.3 M2 – Energy mix of the venue

As in the case of hotels, various energy sources are used for event venues, e.g., electricity, gas, oil, coal and district heating. The exact ratio of primary energy carriers to one another is called the energy mix. Each energy carrier has a different CO_2 emission factor, so the share of each must be included when calculating an event's CO_2 emissions from energy consumption.

VDR Standard M2
The CO_2 calculation for business travel reporting takes the energy mix of the venue into account.

Method:

- If the venue generates electricity and hot water itself for variable M1, the CO_2 is calculated directly from this.
- If power and hot water are sourced externally for variable M1 or this is estimated using a default value, an average energy mix (generally the average for the country) is used.
- Data on the energy mix can be from the OECD electricity mix or IEA sources

8.4.4 M3 – CO_2 intensity of energy carriers within a country

CO_2 emissions for energy production can vary from one country to another, especially for electricity and district heating. Thus, the CO_2 intensity of the energy carriers within a country must be included in the venue's emissions calculation.

VDR Standard M3
The CO_2 calculation for business travel reporting takes the CO_2 intensity of energy carriers into consideration.

Method: If the venue produces the electricity and/or the heating and cooling itself, the CO_2 is calculated directly as follows:

- Energy consumption in kWh with CO_2 emissions factor of the energy carrier used (oil, gas, coal)

If the venue sources electricity and energy for cooling/heating externally, CO_2 is calculated as follows:

- Electricity, heating, cooling in KWh, calculated using average energy mix of the country

The CO_2 intensity of electricity in the country can be calculated using the GHG tool "GHG emissions from purchased electricity":

http://www.ghgprotocol.org/calculation-tools/

The other CO_2 emission factors are standardized and can be taken from freely available literature.

8.4.5 M4 – Water consumption of the venue

In addition to the energy required for heating, cooling and electricity, the venue also needs water during operations, especially for the operation of sanitary and gastronomic facilities. This consumption must be included in the CO_2 emissions calculation. As for water consumption in hotels, this factor is somewhat less important, but not negligible. Therefore, this factor is handled using a fixed value.

VDR Standard M4
The CO_2 calculation for business travel reporting takes the venue's water consumption into account.

Method: A standard emissions factor for water consumption is used. The amount of water consumed is either read off the water bill directly or estimated based on the event duration and number of participants.

8.4.6 M5 – Waste and sanitation of the venue

In addition to the energy supply and water consumption, a lot of waste and wastewater are generated during events. Their disposal costs energy and therefore also causes CO_2.

VDR Standard V5
The CO_2 calculation for business travel reporting takes the venue's waste and sewage disposal into consideration.

Method: A standard CO_2 emission factor is used. For wastewater, the amount is assumed to be equivalent to the amount of water consumed; for garbage, an average amount of accumulated waste per event is used.

8.4.7 M6 – Arrival and departure

Event participants' travel activities must be included within the scope of business travel reporting. This includes:

- Flight
- Train ride
- Rental car
- Public transportation
- Taxis

– Transfer services

VDR Standard M6
The CO_2 calculation for business travel reporting includes CO_2 emissions for all participants' transport.

> <u>Method:</u> The CO_2 emissions of journeys made by train, flight and car are determined using the VDR Standard's methodology. The CO_2 emissions for taxis and public transport are added as fixed amounts.

8.4.8 M7 – Accommodation

If events and congresses last several days, they usually require participants to stay overnight. These are part of the event and must therefore be included in the calculation.

VDR Standard M7
The CO_2 calculation for business travel reporting includes the emissions from all participants' overnight stays.

> <u>Method:</u> The VDR Standard methodology outlined in chapter 4 is used.

8.4.9 M8 – Catering

Buffets and other culinary offers are often part of events and responsible for a significant amount of CO_2 emissions. The catering service's overall revenue can be used to estimate the CO_2 emissions caused by catering.

VDR Standard M8
The CO_2 calculation for business travel reporting includes catering emissions.

> <u>Method:</u> The amount of CO_2 emissions is estimated using the catering service's revenue.
>
> The CO_2 emission factors can be obtained via the atmosfair event calculator.

8.4.10 M9 – Transport of goods

The transport of trade fair items such as set up and technical equipment (projector, lighting, etc.) is usually transported to the venue using one or more trucks. Their fuel consumption causes CO_2 emissions that must be included.

VDR Standard M9
CO_2 emissions from the transport of materials (trade fair stands, etc.) are included in the business travel reporting.

Method: The CO_2 emissions are determined on the basis of the average consumption of the means of transport (usually a truck) and the transport route. The route length can either be taken from the corresponding order form or by using the distance calculator (such for flights and train trips).

8.5 VDR Standard method for MICE at a glance

Factor	Method	Freely available data source
M1: Venue: energy consumption	• Consumption values determined by energy and warm water provider • Estimate based on event duration and number of participants	Data from the venue
M2: Venue: energy mix	Using the energy mix of the destination country	IAE
M3: Venue: CO_2 intensity	One emissions factor for power and heat production per country	IAE, GHG
M4: Venue: water consumption	Emissions factor for water collection * average water consumption of the event	VDR Standard, atmosfair
M5: Venue: sewage water and waste	Emissions factor for sewage water/waste treatment * average water consumption/waste production per overnight stay	VDR standard, atmosfair
M6: Arrival and departure	Flight, rail, (rental car) – see respective categories within the VDR Standard)	VDR Standard
M7: Overnight stays	See respective categories within the VDR Standard	VDR Standard
M8: Catering	Estimate	atmosfair
M9: Transport of goods	Calculation based on tkm (ton-kilometers) and fuel consumption of the truck	GHG, DEFRA, own transport documents, atmosfair

Table 31: Methods of the VDR Standard category MICE

8.6 Accuracy of the VDR Standard MICE factors

The degree of accuracy within the standard is:

Factor	Relative optimization potential CO_2	Accuracy of the factor (data sources)	Error percentage of the CO_2 results
M1: Venue: energy consumption	10 %	±5 %	0.5 %
M2: Venue: energy mix	5%	± 25 %	1.25 %
M3: Venue: CO_2 intensity	5%	± 25 %	1.25 %
M4: Venue: water consumption	5%	±5 %	0.25 %
M5: Venue: sewage water and waste	5%	±5 %	0.25 %
M6: Arrival and departure	50 %	± 10 %	5%
M7: Overnight stays	5%	± 25 %	1.25 %
M8: Catering	5%	± 20 %	1%
M9: Transport of goods	10 %	± 20 %	2%
Total	100 %		11.75 %

Table 32: Optimization potential and accuracy of the factors of the VDR Standard for MICE

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