CO_2 Calculation for Business Travel VDR Standard

Part II: Application and sample calculations

Version 1.2 March 2016

1. Introduction

In the following, the VDR standard’s methodology for reporting CO_2 (Part I) is explained using sample calculations. For each of the travel activities flight, train, hotel, car and MICE, a sample calculation is shown in detail. Individual booking information and the data package are available to users (Part III).

2. Sample calculation for flights

Section 2.1.1 describes a fictional flight including the data required for CO_2 reporting. The corresponding CO_2 emissions are calculated in section 2.2.

2.1 Data

2.1.1 Travel Information

The following is a fictional business flight (one person, one way). The following booking information must be included in the calculation:

- **City pair**
  e.g., Frankfurt (FRA) - London Heathrow (LHR)
- **Aircraft family**
  e.g., Airbus A310
- **Seat class**
  e.g., economy class

2.1.2 City pair table

The city pair table contained in the data package (Part III) provides all the necessary data for calculating the CO_2 emissions solely relating to the route flown between a city pair. This includes:

- Distance (VDR Standard F1)
- Detours (VDR Standard F3)
- Non-CO_2 factor f_{alt}, the proportion of the flight distance flown above 9,000 m (VDR Standard F13)

Departure		Arrival		Great circle distance [km]	GCD correction [km]	City pair distance [km]	f_{alt}
LHR	EU1	FRA	EU1	655	100	755	0.821

Table 1: Distance for the city pair LHR-FRA

In addition, the region in which the respective airports are located, must be included. The user must use this to calculate the passenger load.

2.1.3 Aircraft table

The aircraft table contains the aircraft type-related data required:

- Number of seats (VDR Standard F9)
- Hull type
- Additional cargo load factor f_f (VDR Standard F11)
- Winglet factor f_w (VDR Standard F6)

Factor	Value
Airplane type	Airbus A310[1]
Number of seats	220
Hull type	Wide-body aircraft
Freight factor f_f	0.95
Winglet factor f_w	0

Table 2: Excerpt from the data package for Airbus A310

2.1.4 Fuel consumption table

The table for fuel consumption contains the absolute fuel consumption depending on airplane type and standard distance (i.e., obtained from the standard flight profiles in VDR Standard F2). The following is an excerpt from the EMEP/Corinair data for the Airbus A310:

Airbus A310										
Distance (nm)	125	250	500	750	1000	1500	2000	2500	3000	3500
Distance (km)	232	463	926	1389	1852	2778	3704	4630	5556	6482
Fuel (kg)										
Flight total	2810.6	3899.5	5990.4	8081.3	10172.2	14532.6	18981.6	23699.4	28675.3	33763.8
LTO	1540.5	1540.5	1540.5	1540.5	1540.5	1540.5	1540.5	1540.5	1540.5	1540.5
Taxi out	294.3	294.3	294.3	294.3	294.3	294.3	294.3	294.3	294.3	294.3
Takeoff	182.2	182.2	182.2	182.2	182.2	182.2	182.2	182.2	182.2	182.2
Ascent	472.5	472.5	472.5	472.5	472.5	472.5	472.5	472.5	472.5	472.5
Ascent/cruise/descent	1270.0	2358.9	4449.8	6540.7	8631.6	12992.0	17441.1	22158.8	27134.7	32223.3
Approach landing	297.3	297.3	297.3	297.3	297.3	297.3	297.3	297.3	297.3	297.3
Taxi in	294.3	294.3	294.3	294.3	294.3	294.3	294.3	294.3	294.3	294.3

Table 3: Excerpt from the Corinair table for the Airbus A310

2.1.5 Load factor table

The average load factor is found in the table "load factor," which is arranged by hull type and flight region (VDR Standard F12).

Route groups*	f_l – Narrow-body jets	f_l – Wide-body jets	f_l – Default
EU1 - NA1	63.78%	87.85%	80.70%

Table 4: Excerpt from the passenger load factor table of the data package

2.1.6 Seat class factor table

The seat class factor table provides the seat class factor. The following distinction is made within the framework of the VDR Standard:

[1] The Airbus A310 indicates the aircraft family, which includes the A310-200 as well as the A310-300. Occasionally, the (more imprecise) aircraft family is indicated in the flight plan data instead of the aircraft type.

- Economy class
- Premium Economy class
- Business class
- First class

2.1.7 Calculation formula

The formula for calculating CO_2 emissions for flights using the VDR Standard is provided in Part I, Chapter 2:

$$CO_{2sp} = \left(\left(\frac{F_D}{S * f_l}\right) * f_w * f_c * f_f\right) * 3.16$$

$$nCO_2 = CO_{2sp} * f_{alt} * f_{nCO_2}$$

Variable	Description	Unit
D_G	Large circle distance of the city pair	km
D_R	Fixed addition for detours, tiered according to large circle distances	km
D	Flight distance of a city pair (large circle distance + detour)	km
f_w	Factor for reducing fuel consumption due to winglets	-
F_s	Absolute fuel consumption of the next shortest standard flight below the flight distance	kg
F_L	Absolute fuel consumption of the next longest standard flight above the flight distance	kg
F_D	Absolute fuel consumption of the considered flight	kg
D_s	Standard distance below distance D of the flight	km
D_L	Standard distance above distance D of the flight	km
S	Seating capacity of the plane	-
f_l	Occupancy rate factor of the plane	-
f_f	Factor for reducing the specific fuel consumption per passenger for the freight load	-
f_c	Factor for seat class (economy, business, first)	-
f_{nco2}	Factor for the climate effect of non-CO_2	-
CO_{2sp}	Specific CO_2 emissions per passenger	kg
f_{alt}	Proportion of the flight distance flown at altitudes over 9,000 m in relation to the total flight distance; necessary for quantifying the climate effects of non-CO_2 emissions	-
nCO_2	Non-CO_2 emissions per passenger	kg

Table 5: Variables for calculating CO_2 for flights

2.2 Calculation

2.2.1 General information

The following is a description of how CO_2 is calculated for a business trip with the following parameters:

- Frankfurt (FRA)-London Heathrow (LHR)
- One passenger, one way
- Economy class
- Airbus A310

The user must now perform these steps using the VDR Standard:

2.2.2 Calculate the distance

The city pair distance is calculated as follows:

$$D = D_G + D_R$$

The user should follow these steps to determine the distance:

1. The user searches for the three-letter codes of the departure and destination airports. These are either included in the flight ticket or part of the booking documents. Frankfurt Airport's code is FRA, London Heathrow's is LHR.

2. In the data package (Part III), the user searches for the pair FRA-LHR in the table "city pairs." The large circle distance D_G can be found in the corresponding column and is 655 km. Users without data packages can determine the large circle distance by means of freely available online calculators.

3. The correct detour D_R is 100 km. The flight distance (i.e., large circle + detours) is thus 755 km.

$$D = D_G + D_R$$

$$D = 655\ km + 100\ km$$

$$D = 755\ km$$

2.2.3 Calculate the absolute fuel consumption

The following steps are necessary to calculate absolute fuel consumption:

1. The user determines the type of aircraft used using the booking documents, here the A310. In some cases, the type of aircraft cannot be found directly from the booking documents. The user can alternatively determine the type of aircraft by using the flight number and date.
   Each airline offers passengers the option of checking the flight status. When the flight number and date are entered, many airlines also show the type of aircraft used. Users that utilize this method should be aware of the fact that they must check the flight status request promptly (either a few days before or after the flight).

Once the aircraft type is determined, the user searches for the absolute fuel consumption of the next shorter and next longer standard flight from the “fuel consumption” table (see table 3):

- Next shorter standard flight FS with A310: D_S 463 km with 3899.5 kg kerosene
- Next longer standard flight FL with A310: D_L 926 km with 5990.4 kg kerosene
- Distance D of the flight considered: 755 km

The fuel consumption due to taxiing is already included here.

2. The values are then entered into the formula by the user:

$$F_D = \frac{(F_l - F_S) * (D - D_S)}{(D_l - D_S)} + F_S$$

$$F_D = \frac{(59990.4\ kg_l - 3899.5\ kg) * (755\ km - 463\ km)}{(926\ km - 463\ km)} + 3899.5\ kg$$

The result is:

$$\boldsymbol{F_D = 5218.2\ kg}$$

2.2.4 Calculate the specific passenger CO_2

The formula for this calculation is:

$$CO_{2sp} = \left(\left(\frac{F_D}{S * f_l} \right) * f_w * f_c * f_f \right) * 3.16$$

1. The aircraft used was an Airbus A310. The user already calculated the absolute fuel consumption F_D in section 2.2.3.

2. In the table "aircraft" in the data package, the user searches seating type S, which corresponds to 220 seats. The Airbus A310 is a wide-body jet.

3. London Heathrow (LHR) and Frankfurt (FRA) are both located in the EU1 region, which means that the user can use the occupancy rate for wide-body aircrafts in the EU1 region (69.7%).

4. As a wide-body jet, the proportion of cargo that needs to be included in the calculation is 5% (i.e., f_f is 0.95).

5. The winglet quota f_w is 1 since the A310 does not have optional, retrofitted winglets.

6. The seat class is Economy Class, and f_c is therefore 0.8.

7. Now the user can use the formula from above:

$$CO_{2sp} = \left(\left(\frac{5218.2\ kg}{220 * 0.697}\right) * 1 * 0.8 * 0.95\right) * 3.16$$

$$\boldsymbol{CO_{2sp} = 81.7\ kg}$$

2.2.5 Identify non-CO_2 emissions

In the first step, the user determines the share of the city pair distance, with altitudes over 9,000 m, in relation to the total city pair distance. This value is shown in Table 1 and is 0.821. These 0.821 were linearly interpolated by atmosfair as follows:

1. City pair distance: 755 km

2. For linear interpolation:

- Using a standard distance of 750 km, f_{alt} is 82% (0.82)
- Using a standard distance of 1,000 km, f_{alt} is 86.5% (0.865)

As a result of the corresponding linear interpolation, a city pair distance of 755 km yields a f_{alt} of 82.1% (0.821). In other words, 82.1% of the distance (~620 km) is flown at altitudes of 9,000 m or higher.

3. Now the user can calculate the amount of non-CO_2 emissions produced:

   f_{nCO2} = 2

   The environmental impact of non-CO_2 is calculated as follows:

$$nCO_2 = CO_{2sp} * f_{alt} * f_{nCO_2}$$

$$nCO_2 = 81.7\ kg\ CO_2 * 0.821 * 2$$

$$nCO_2 = 134.2\ kg\ CO_2$$

2.2.6 Result

The result according to VDR Standard therefore comprises the following two values:

Flight from LHR to FRA, one way, one passenger, economy, on an A310.

Pure CO_2:	81.7 kg
Climate impact CO_2 (pure CO_2 + non-CO_2):	215.9 kg

3. Sample calculation for rail

3.1 Data

3.1.1 GCD correction table

The table contains the detour factors that the user adds to the large circle distance between the cities. The factors are specific to the type of train:

Train type	GCD correction factor
High-speed train	1.35

Table 6: Detour factor for high-speed trains

The user can find calculators with the large circle distances between cities all over the world on the internet.

3.1.2 Table of CO_2 per pkm

The following is a sample table with the CO_2 per passenger-kilometer (pkm) by train type for China. The values correspond to kg CO_2 per pkm. The country code notation used is from ISO 3166 alpha-3.

Country	Train type	CO_2 per pkm [kg]
CHN	LT (local train)	0.052
CHN	RT (regional train)	0.038
CHN	HS (high-speed train)	0.038

Table 7: CO_2 per passenger-kilometer by country and train type. Source: atmosfair

3.1.3 Seat class table

This table, which can be found in the data package (VDR Standard Part III), contains the seating factors for the following classes:

- First class
- Second class

3.1.4 Calculation formula

The following calculation formula can be found in Part I of the VDR Standard in Chapter 3 “rail”:

$$CO_{2sp} = (D * f_U) * f_c * CO_{2p}$$

Variable	Description	Unit
CO_{2sp}	Specific CO_2 emissions for a train ride	kg
D	Large circle distance between the train stations	km
f_U	Detour factor	-

f_C	Factor for seat class	-
CO_{2P}	Country and train specific CO_2-emission factor; includes train type, energy source and occupancy rate	kg CO_2/pkm

Table 8: Variables for calculating train emissions according to the VDR Standard

3.2 Calculation without cross-border traffic

3.2.1 General

The following describes how to calculate CO_2 emissions for a train journey with the following parameters:

- Hong Kong to Beijing
- One passenger
- Second class
- High-speed train

The user should follow these steps based on the VDR Standard:

3.2.2 Determine the distance

1. First the user determines the large circle distance between the two cities using freely available Internet tools:

   The large circle distance D between Hong Kong and Beijing is 1.976 km.

2. Because of the train type, a detour factor f_u of 1.35 is used. Because both cities are located within China, the user does not have to take cross-border traffic into account.

3.2.3 Determine train type and seat class

The train type is HS, and the seat class is second class. Both of these pieces of information can be found on the train ticket or together with the booking documents. The second class is assigned a seat class factor f_c of 0.9 according to the VDR Standard. This value can be found in the data package (VDR Standard Part III).

3.2.4 Calculate the specific CO_2 per passenger

1. The user should select the corresponding CO_2 emissions factor (kg CO_2 per passenger-kilometer) from table 7. Since the rail journey took place in China on a high-speed train (HS), the factor to be used in this example is 0.038 kg CO_2/pkm.

2. The user can now use the values in the formula from 3.1.4:

$$CO_{2sp} = (D * f_U) * f_c * CO_{2p}$$

$$CO_{2sp} = (1.976\ km * 1.35) * 0.9 * 0.038 \frac{kg\ CO_2}{km}$$

$$\boldsymbol{CO_{2sp} = 91.2kg\ CO_2}$$

3.3 Calculation with traffic across borders

3.3.1 General information

The following describes how to calculate CO_2 emissions for a train journey with the following parameters:

- Toronto (Canada) to Chicago (USA)
- One passenger
- First class
- High-speed train

The user should follow these steps based on the VDR Standard:

3.3.2 Determine the distance

1. First the user determines the large circle distance between the two cities using freely available Internet tools:

   The large circle distance D between Toronto and Chicago is 705 km.

2. A detour factor f_u of 1.35 is used for this train type (HS).

3. Cross-border traffic: The user can apply the number of kilometers that take place in each country if this information is known. If it is not known, the VDR Standard allows users to apply half of the kilometers to each country for the sake of simplicity.
   Thus the user can apply 352.5 km of the journey to the USA and 352.5 km to Canada.

3.3.3 Determine train type and seat class

The train type is HS, and the seat class is first class. Both of these pieces of information can be found on the train ticket or together with the booking documents. The first class is assigned a seat class factor f_c of 1.4 according to the VDR Standard. This value can be found in the data package (VDR Standard Part III).

3.3.4 Calculate the specific CO_2 per passenger

1. Since the high-speed railway trip began in Canada to the USA, the user should select the two corresponding CO_2 emission factors (kg CO_2 per passenger-kilometer) from the data package (VDR Standard Part III). In this case, these are:

- For the USA: 0.038 kg CO_2/pkm
- For Canada: 0.06 kg CO_2/pkm

2. These values can now be inserted into the appropriate formula:
   For the part of the journey within the USA:

$$CO_{2sp} = (D * f_U) * f_c * CO_{2p}$$

$$CO_{2sp} = (325.5\ km * 1{,}35) * 1.4 * 0.038 \frac{kg\ CO_2}{km}$$

$$CO_{2sp} = 25.3\ kg\ CO_2$$

For the part of the journey within Canada:

$$CO_{2sp} = (D * f_U) * f_c * CO_{2p}$$

$$CO_{2sp} = (325.5\ km * 1.35) * 1.4 * 0.060 \frac{kg\ CO_2}{km}$$

$$CO_{2sp} = 40.0\ kg\ CO_2$$

For the entire route:

$$CO_{2sp} = 40.0\ kg\ CO2 + 25.3\ kg\ CO_2$$

$$CO_{2sp} = 65.3\ kg\ CO_2$$

3.3.5 Results

The VDR Standard yields the following results:

- A train ride from Hong Kong to Beijing with one passenger riding second class on a high-speed train produces 91.2 kg CO_2.
- A train ride from Toronto to Chicago with one passenger riding first class on a high-speed train produces 65.3 kg CO_2.

4. Sample calculation for hotels

4.1 Data

4.1.1 General information

The user can calculate the CO_2 produced by an overnight hotel stay in two ways:

1. By using the table "CO_2 per night" from the data package (VDR Standard Part III). This table is described in section 4.1.2.

2. By calculating CO_2 per night using data that the user must obtain from the hotel itself. This method is far more complex, but also more accurate. The way to calculate this is explained in section 4.1.3.

4.1.2 Using the CO_2 per night table

The data package (VDR Standard Part III) contains a table for each country by star category with the average CO_2 per night in kg/night:

Country	*	**	***	****	****
UK	18.19	20.03	22.62	25.54	27.06

Table 9: CO_2 (kg) per overnight stay in the UK by star category

The CO_2 values in table 9 represent the average CO_2 per overnight stay for different hotel categories in the UK. These emissions include:

- CO_2 produced by energy consumption (electricity and heating)
- CO_2 produced by water consumption
- CO_2 produced by wastewater disposal
- CO_2 produced by waste disposal

This CO_2 value can be used to calculate the CO_2 of an overnight stay if the user chooses the first calculation method from 4.1.1. The way to determine CO_2 values from Table 9 can be understood by reading section 4.1.3. This procedure is analogous to the second calculation method (section 4.1.2).

4.1.3 Using hotel data

If users would like to calculate the CO_2 per overnight stay by themselves, they must collect data from the hotel in which they have stayed. The following data is necessary for this (displayed here along with an example):

Factor	Value
Classification	4 stars
Country	USA
Beds	1,000
Rooms	900 standard double rooms, 100 suites

Occupancy rate	70%
Annual power consumption	3,500,000 kWh (regular power use)
Heat consumption	5,000,000 kWh (district heat)
Water consumption	120,000 m3
Waste management cost	$10,000

Table 10: Consumption and indicators for a hotel in the USA

CO_2 emissions produced by electricity and heating consumption

The electricity consumption (kWh) per room and night is calculated as follows:

$$C_S = \frac{Annual\ power\ consumption\ (kWh)}{Number\ of\ rooms * 365\ days * capacity\ utilization\ \ (\%)}$$

$$C_S = \frac{3{,}500{,}000\ (kWh)}{(1{,}000 * 365 * 70\ \%)}$$

$$C_S = 13.7\ kWh$$

The heating consumption (kWh) per room and night is calculated as follows:

$$C_H = \frac{Annual\ heat\ consumption\ (kWh)}{Number\ of\ rooms * 365\ days * capacity\ utilization}$$

$$C_H = \frac{5.000.000\ kWh}{(1{,}000 * 365\ days * 70\%)}$$

$$C_H = 19.6\ kWh$$

For the USA, the CO_2 emission factors f_S for electricity and f_H heating are: 0.33 kg CO_2 per kWh of electricity and 0.40 kg CO_2 per kWh of district heating.

$$CO_{2E} = (C_S * f_S) + (C_H * f_H)$$

$$CO_{2E} = 13.7\ kWH * 0.33 \frac{kg}{kWh} + 19.6\ kWh * 0.4 \frac{kg\ CO_2}{kWh}$$

$$\boldsymbol{CO_{2E} = 12.4\ kg\ CO_2}$$

The additional sources of CO_2:

- CO_2 for water consumption
- CO_2 for sewage water treatment
- CO_2 for waste management

These are described in chapter 4 of part 1 of the VDR Standard. atmosfair has calculated the values for these using a method analogous to the one for heating and electricity above.

The final results are displayed in VDR Standard Part III in the hotel section under "CO_2 per night."

4.1.4 Room category factors table

This table contains the room category factors, which allows the VDR Standard to assign larger rooms more CO_2 by using the room area (in m^2). The procedure for calculating emissions is analogous to accounting for flight or rail seat class.

The following room categories are differentiated within the VDR Standard:

- Standard single
- Standard double
- Premium single
- Premium double
- Suite

4.1.5 Calculation formula

The formula for calculating the CO_2 for one overnight hotel stay is provided in chapter 4 of Part I of the VDR Standard:

$$CO_{2D} = \left(\frac{CO_{2E} + CO_{2W} + CO_{2A} + CO_{2M}}{f_l}\right) * f_B$$

Variable	Description	Units
CO_{2D}	CO_2 emissions per overnight stay	kg
CO_{2E}	CO_2 emissions from electricity consumption per overnight stay	kg
CO_{2W}	CO_2 emissions from water consumption per overnight stay	kg
CO_{2A}	CO_2 emissions from sewage water treatment per overnight stay	kg
CO_{2M}	CO_2 emissions from waste management per overnight stay	kg
f_B	Room category factor	-
f_l	Occupancy rate factor	-

Table 11: Variables for calculating CO_2 emissions for hotels

Data package users can determine CO_{2D} from the table "CO_2 per night" in VDR Standard Part III by adding up CO_{2E}, CO_{2W}, CO_{2A} and CO_{2M} and dividing it by the occupancy rate f_l. The formula for these users is then:

$$CO_{2N} = CO_{2D} * f_B$$

4.2 Calculation

4.2.1 Sample calculation

Here, the following data determine the carbon footprint of an overnight hotel stay:

- 3 star hotel in London, UK
- Seven night stay
- Standard double room

The user should follow these steps based on the VDR Standard:

1. CO_{2D} is 22.62 kg of CO_2 per overnight stay (see table 9), the number of days is 7, and the factor f_B for the room category is 0.95.

2. The user can now insert the values into the formula:

$$CO_{2N} = CO_{2D} * f_B * days$$

$$CO_{2N} = 22.62 * 0.95 * 7$$

$$\boldsymbol{CO_{2N} = 150.4\ kg\ CO_2}$$

4.2.2 Result

The VDR Standard yields the following result:

- A seven-night stay in a 3 star hotel in the UK produces 150.4 kg CO_2.

5. Sample calculation for cars

5.1 Data

5.1.1 Table for grams of CO_2 per kilometer by ACRISS code

The following table shows the CO_2 emissions per kilometer for selected rental cars along with their ACRISS code. The values in the table are provided in grams of CO_2 per kilometer:

ACRISS Code	g CO_2 per km
CBMN	210
EWMR	145
FBMN	183
IDMR	176

Table 12: CO_2 emissions for sample rental cars along with ACRISS code

5.1.2 Calculation formula

$$CO_{2D} = f_A * D$$

Variable	Description	Units
CO_{2D}	CO_2 emissions produced by a car ride	g
f_A	CO_2 emissions factor by ACRISS rental car category	g CO_2/km
D	Distance driven	km

Table 13: Variables for calculating rental car CO_2 emissions according to the VDR Standard

5.2 Calculation

5.2.1 General information

The following parameters are used to calculate the CO_2 for a car rental:

- ACRISS code “IDMR”
- One driver
- Seven-day rental period with 520 kilometers driven

The user should follow these steps based on the VDR Standard:

5.2.2 Determine distance

The ACRISS code of the rented vehicle and kilometers driven can be found on the rental car bill since these two factors are what determine how high the bill is. In this example, a rental car coded IDMR was rented for seven days and driven 520 kilometers (*D*) during this time.

5.2.3 Calculate the specific CO_2

1. Using table 12 and the table "grams of CO_2 per kilometer by ACRISS code" in the data package (VDR Standard Part III), the user should search for the corresponding CO_2 emissions per kilometer. For this example, the user selects the value 176 g CO_2 per km for f_A .

2. Now the user can calculate the CO_2 of his rental car loan:

$$CO_{2D} = f_A * D$$

$$CO_{2D} = 520\ km * 176\ \frac{g\ CO_2}{km}$$

$$\boldsymbol{CO_{2D} = 91.5\ kg\ CO_2}$$

5.2.4 Result

The VDR Standard yields the following result:

- A rental car coded IDMR that was rented for seven days and driven 520 kilometers produces 91.5 kg CO_2.

6. Sample calculation for MICE

6.1 Data

6.1.1 General information

As described in the VDR Standard Part I, the user must be aware of the following factors when calculating CO_2 for MICE:

- CO_2 caused by arrival and departure
- CO_2 caused by use of the venue
- CO_2 caused by overnight stays

Examples for calculating these CO_2 emissions are included in chapters 2, 3 and 5. Chapter 4 describes the way that emissions can be calculated for an overnight stay. Thus, only the way to calculate CO_2 emissions produced by the venue is described here. This is analogous to calculating CO_2 emissions for hotels (see chapter 4.1.3ff).

6.1.2 Data to be collected from the venue

The necessary data for calculating the venue's emissions must be obtained directly from the venue itself. If this is not possible, there are several "average event venues" in the data package (VDR Standard Part III) that continue data values that can be estimated by the user. As for hotels, users must find out about:

- CO_2 caused by energy consumption (electricity and heating requirements)
- CO_2 caused by water consumption
- CO_2 caused by wastewater disposal
- CO_2 caused by waste disposal

6.2 Sample calculation

6.2.1 Sample event

Due to the complexity of the calculation for MICE, only CO_2 emissions created by the venue itself are calculated here.

A meeting was held with the following parameters:

- Location: Exhibition Center X in Detroit, USA
- Duration: Two days
- Number of participants: 300
- Rented area: the entire space was rented

In this example, the emissions are calculated using data for an "average event venue" that is rented 250 days per year:

	Annual	**Per day rented**

Power consumption	1,100,000 kWh	4400 kWh
Heat consumption	2,100,000 kWh	8400 kWh
Water consumption	7,000 m^3	28 m^3
Waste management cost	$10,000	$40

Table 14: Consumption data of the venue

6.2.2 Determination of the venue's absolute CO_2 emissions

$$CO_{2V} = (\sum (C_E * f_E)) + (C_W * f\_W) + (C_A * f\_A) + (C_M + f\_M)$$

1. Emissions for electricity and district heating in the USA are:

- 0.33 kg of CO_2 per kWh of electricity
- 0.40 kg of CO_2 per kWh of heating

The formula from above can now be used:

$$CO_{2V} = 4400kWh * 0.33 \frac{kg\ CO_2}{kWh} + 8400\ kWh * 0.4 \frac{kg\ CO_2}{kWh} + 28m^3 * 1.036 \frac{kg\ CO_2}{m^3} + 40\$ * 1 \frac{kg\ CO_2}{\$}$$

$$CO_{2V} = 4.910\ kg\ CO_2$$

2. For 2 days, 9820 kg of CO_2 will be charged for the operation of the venue.

6.2.3 Result

The VDR Standard yields the following result:

- The venue produced 9820 kg CO_2 during the meeting.

7. Sample calculation for public transport

7.1 Calculation form

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

$$CO_{2E} = f * T$$

Variable	Description	Units
CO_{2E}	CO_2 emissions for a journey by public transport	kg
T	Number of days using public transport	-
f	Fixed emissions factor	$kgCO_2/d$

Table 15: Variables for calculating public transport CO_2 emissions according to the VDR Standard

7.2 Calculation

7.2.1 General information

The following is a description of how CO_2 is calculated for a trip by public transport with the following parameters:

- Bus trip
- One passenger
- Two trips on two days

The user should follow these steps based on the VDR Standard:

7.2.2 Calculation of the specific CO_2

1. In the data package (VDR Standard Part III), the user searches for the overall CO_2 emissions factor. In this example, the user calculates the value f_A as 0.450 kg CO_2 per day (fictitious value).

2. Now the user can calculate the trip's CO_2 emissions:

$$CO_{2E} = f * T$$

$$CO_{2E} = 0.450 \frac{kg\ CO_2}{d} * 2d$$

$$\boldsymbol{CO_{2E} = 0.9\ kg\ CO2}$$

7.2.3 Result

The VDR Standard yields the following result:

- Two public transport trips on two days is produce 0.9 kg CO_2.