Carbon Footprinting Report for the Years 2009 to 2010

Client:

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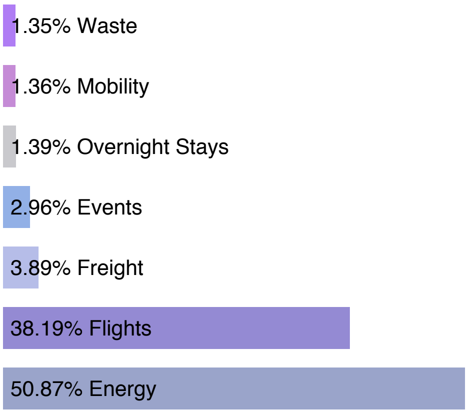
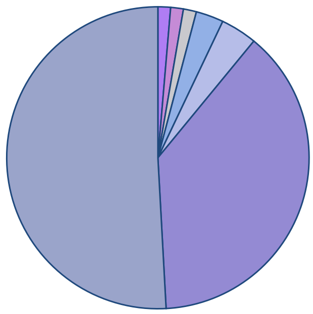
Disclaimer:

This is an automated footprinting report. It is fully dependent on the accuracy of information provided by the client. For a detailed footprinting report of all of your activities, enterprises or products, please contact: footprinting@southpolecarbon.com

Emissions Reported by Category:





The majority of emissions, corresponding to 50.87% of the total reported emissions, are coming from the category "Energy".

Waste:

2.238 tCO_2e in this category

with 2.238 tCO_2e emissions coming from:
1200 kg mixed waste, 680 kg consumed paper, 20 % recycled paper, 50 % paper recycled after use.

Some suggestions on how to reduce your emissions:

- Recycling is the best way to reduce emissions from waste.

Mobility:

2.254 tCO_2e in this category

with 2.237 tCO_2e emissions coming from:
3000 km travelled, 8 l/100km medium sized car, using gasoline, 4 staff or vehicles.

with 0.017 tCO_2e emissions coming from:
40 km travelled, by train, 7 staff or vehicles.

Some suggestions on how to reduce your emissions:

- Use your car more efficiently – The more people in a car, the less you emit per person.
- Consider public transport (e.g. sleeper trains) combined with car rental at destination for long distances.
- When you buy a new car: Consider fuel efficiency seriously and you will save on future emissions and money spent on fuel.
- Car pooling, public transport or biking to work, even if not every day, can reduce your annual carbon footprint by up to one ton of CO2.

Overnight Stays:

2.311 tCO_2e in this category

with 1.11 tCO_2e emissions coming from:
3 days, 4 star hotel, 20 people.

with 1.201 tCO_2e emissions coming from:
12 days, 3 star hotel, 7 people.

Some suggestions on how to reduce your emissions:

- Lower star hotels typically produce less emissions.

Events:

4.905 tCO_2e in this category

with 4.905 tCO_2e emissions coming from:
emissions from food/drinks included , 30 attendees, 3 days, arriving by car, 200 km travelled.

Freight:

6.445 tCO_2e in this category

with 0.578 tCO_2e emissions coming from:
1200 km distance, 3 tons of freight , 20 l/100km fuel efficiency of truck, 20 tons max tonnage of truck, 75 % average load factor of truck.

with 5.867 tCO_2e emissions coming from:
20000 km distance, .4 tons of freight , Airplane.

Some suggestions on how to reduce your emissions:

- Consider rail freight or ship freight whenever possible to emit less CO_2.

Flights:

63.354 tCO_2e in this category

with 5.292 tCO_2e emissions coming from:
2 flight(s) from LHR - London to JFK - New York return economy.

with 48.893 tCO_2e emissions coming from:
4 flight(s) from ZRH - Zurich to DEL - New Delhi via DXB - Dubai return first.

with 1.213 tCO_2e emissions coming from:
1 flight(s) from SXF - Berlin to BKA - Moscow return economy.

with 1.611 tCO_2e emissions coming from:
3 flight(s) from TOJ - Madrid to CIA - Rome one way economy.

with 6.345 tCO_2e emissions coming from:
4 flight(s) from MIA - Miami to CDG - Paris one way economy.

Flights map (thickness of lines corresponds to amount of flights):

Some suggestions on how to reduce your emissions:

- Think twice before you fly – flying is one of the quickest ways to produce large amounts of emissions.
- Do you really need to fly business class? This is not only expensive but also increases your emissions further.

Energy:

84.377 tCO_2e in this category

with 37.178 tCO_2e emissions coming from:
8 staff, Europe, Office, most locations have A/C, 2 years.

with 47.199 tCO_2e emissions coming from:
3 staff, USA/Canada/Australia, Mainly retail, 2 years.

Some suggestions on how to reduce your emissions:

- Most energy efficiency measures pay back quickly.
- Whenever you need to invest in a new heating or cooling system, this is when you should think about emissions – if you buy inefficient equipment, it will waste lots of energy and money for years to come.
- Avoid using standby of electronic devices by switching them off completely.
- Switch to a clean electricity tariff – a very simple way to reduce your emissions on a large scale.
- Plug electric devices such as computers, TVs, DVD players, etc. into a power strip that can turn them all off at once when not in use. Electrical appliances left on stand-by mode use up to 8% of a building's energy.
- Replace old light bulbs with CFLs as they burn out: Compact flourescent bulbs use about 80% less energy than incandescent bulbs.

Carbon Offset Project

The reported emissions are offset on behalf of client by South Pole Carbon Asset Management Ltd. using following emission reduction credits: Gold Standard Credits from a Methane Capturing Landfill Project in China

Committing to 2°C Path

The client commits to the 2°C path and has offset the occurred emissions by a factor of 2.5. A description on what the 2°C path is can be found on the next page.

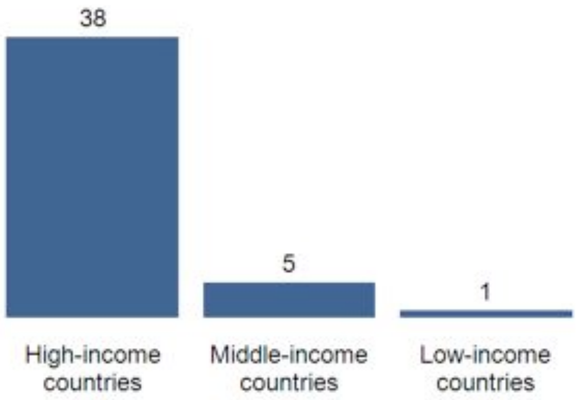
The 2°C Path

Governments worldwide are struggling to define binding targets for GHG emissions. The current pledges listed in the Copenhagen Accord will not allow us to reach the global goal of limiting average global warming to 2°. Even if the pledges are fulfilled, we are confronted with a probability of more than 50% that global warming will exceed 3° by the end of this century[1], leading to disastrous consequences[2]

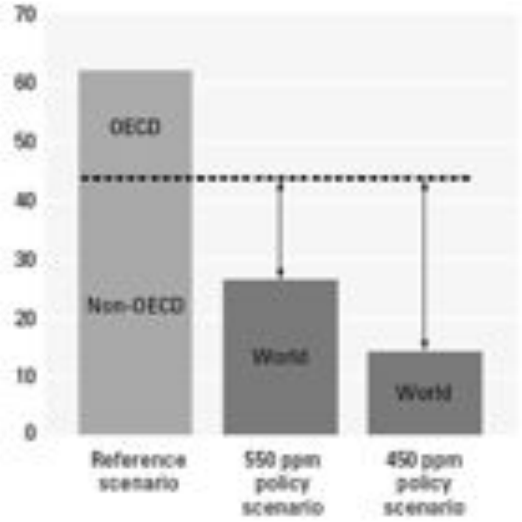
Given the urgency of the situation, international negotiations are taking longer than is reasonable. Climate neutrality is no longer a sufficient option. Due to the past emission track record of the OECD and developing countries, it is imperative that all industrialized nations take strong initiatives to get the world on track. But with economic development picking up quickly in the developing world, the 2° goal can no longer be achieved even by reducing OECD emissions to zero or going climate neutral.

Given the dire and urgent situation sketched above, South Pole is offering the option to compensate for emissions in a way that will (if adopted by all emitters in industrialized countries) allow the attainment of the 2° goal.

We calculated the amount of emission reductions needed in developing countries on top of climate neutrality in the industrialized world based on IEA[3] and World Bank[4] data and found that they are equivalent to 2.5 times the amount of our own emissions.



Cumulative historic per capita GHG emissions industrialization (indexed)



Even when reducing OECD Emissions to zero the 450 ppm (equivalent to 2°) goal cannot be reached

Sources:

[1] Malte Meinshausen, Joeri Rogelj et al, “Copenhagen Accord pledges are paltry”, Nature, 2010

[2] IPCC, Working Group II, “Impacts, Adaptation and Vulnerability”

[3] IEA, Energy Technology Perspective 2008: Scenarios and Strategies to 2050, 2008

[4] The World Bank, World Development Report, 2010

Flights:

Flight emissions are notoriously difficult to calculate. We did our best to get a realistic estimate based on the most reliable data sources available, in this case supplied by the UK Government.

We are following the DEFRA methodology[1] and using DEFRA data to calculate flight emissions. DEFRA is the UK Department for Environment, Food and Rural Affairs, and DEFRA's guidelines on calculations of GHG emissions are one of the de-facto standards of our industry, since they are one of the few reliable and up to date sources for data on flight emissions. DEFRA categorizes emissions into three different distance brackets: "domestic", "short-haul" and "long-haul". We run a regression on the DEFRA data[2] to derive a formula which makes emissions a function of flight distance so that we don't have to work with distance brackets:

Emissions (kg) = distance (km) x $0.6659^{-0.251}$

Based on that emission factor, we then calculate emissions for a given distance. Following DEFRA methodology, we apply a 9% uplift to the great circle distance between airports to account for inefficient routing, delays and circling. The DEFRA data, which is basis for our emission factor, already includes a 10% correction factor to correct the CORINAIR fuel consumption, this is discussed in detail in the DEFRA methodology.

On top of that, we apply multipliers for different seating classes, also following DEFRA, which indexes economy class at 1, with business class at 2.9, and first class at 4 times the emissions of economy class.

Finally, we apply a so-called radiative forcing index (RFI) of 2 to account for atmospheric greenhouse effects caused by air travel other than direct CO_2 emissions from fuels. This includes contrails, water vapour, NO_x emissions, etc. We follow Kollmuss (2009)[3] and use an RFI of 2 as compared to the minimum of 1.9 as suggested by DEFRA.

The final formula is therefore:

Emissions (kg) = distance (km) x 109% x $0.6659^{-0.251}$ x class factor x RFI

As DEFRA publishes new emissions data, we update our emission factor from time to time to account for the minor improvements in fuel efficiency in recent years.

Air Freight:

Air freight calculations are based on the same assumptions and data as passenger transports. Using DEFRA (2009) data and a power series for extrapolation plus the factor for non-CO_2 stratospheric effects gives the following formula:

Amount of CO_2 = 2*Distance*(31.606*$\text{Distance}^{-0.45}$) *tons of freight

Freight, including mail, are transported by two types of aircraft – dedicated cargo aircraft which carry freight only, and passenger aircraft which carry both passengers and their luggage, as well as freight. The CAA data show that almost all freight carried by passenger aircraft is done on scheduled long-haul flights. In fact, the quantity of freight carried on scheduled long haul passenger flights is nearly 5 times higher than the quantity of freight carried on scheduled long-haul cargo services. The apparent importance of freight movements by passenger services creates a complicating factor in calculating emission factors. The 2007 update emission factors for passenger services were calculated assuming all the CO_2 is allocated to the passengers. However, given the significance of air freight transport on passenger services there were good arguments for developing a method to divide the CO_2 between passengers and freight, which was developed for the 2008 update. The CAA data provides a split of tonne km for freight and passengers (plus luggage) by airline for both passenger and cargo services. This data may be used as a basis for an allocation methodology. There are essentially three options, with the resulting emission factors presented in Table 2:

[1] https://www.gov.uk/government/publications/2012-guidelines-to-defra-decc-s-ghg-conversion-factors-for-company-reporting-methodology-paper-for-emission-factors

[2] DEFRA 2012, p. 56, Table 33, Column "Total GHG", average value for domestic, economy for short- and long-haul.

[3] http://www.CO2 offsetresearch.org/PDF/SEI_Air_Travel_Emissions_Paper2_June_09.pdf

a. No Freight Weighting: Assume all the CO_2 is allocated to passengers on these services. ;

b. Freight Weighting Option 1: Use the CAA tonne km (tkm) data directly to apportion the CO_2 between passengers and freight. However, in this case the derived emission factors for freight are significantly higher than those derived for dedicated cargo services using similar aircraft.

c. Freight Weighting Option 2: Use the CAA tonne km data modified to treat freight on a more equivalent /consistent basis to dedicated cargo services. This takes into account the additional weight of equipment specific to passenger services (e.g. seats, galleys, etc) in the calculations.

Table 3: CO_2 emission factors for alternative freight allocation options for passenger flights based on 2009 GHG Conversion Factors

Freight Weighting	None		Direct		Equivalent	
Mode	Passenger tkm % of total	gCO_2 / pkm	Passenger tkm % of total	gCO_2 / pkm	Passenger tkm % of total	gCO_2 / pkm
Domestic Flights	100.0%	171.6	99.7%	171.0	99.7%	171.0
Short-haul Flights	100.0%	98.8	99.5%	98.3	99.5%	98.3
Long-haul Flights	100.0%	127.0	71.7%	91.0	88.4%	112.2

The basis of the freight weighting Option 2 is to take into account of the supplementary equipment (such as seating, galley) and other weight for passenger aircraft compared to dedicated cargo aircraft in the allocation. The Boeing 747 cargo configurations account for the vast majority of long haul freight services (and over 90% of all tkm for dedicated freight services). In comparing the freight capacities from BA World Cargo's website[4] of the cargo configuration (125 tonnes) compared to passenger configurations (20 tonnes) we may assume that the difference represents the tonne capacity for passenger transport. This 105 tonnes will include the weight of passengers and their luggage (around 100 kg per passenger according to IATA), plus the additional weight of seating, the galley, and other airframe adjustments necessary for passenger service operations. For an average seating capacity of around 350 passengers, this means that the average weight per passenger seat is just over 300 kg. This is around 3 times the weight per passenger and their luggage alone. In the Option 2 methodology this factor of 3 difference is used to upscale the CAA passenger tonne km data, increasing this as a percentage of the total tonne km – as shown in Table 2.

It does not appear that there is a distinction made (other than in purely practical size/bulk terms) in the provision of air freight transport services in terms of whether something is transported by dedicated cargo service or on a passenger service. The related calculation of freight emission factors (discussed in a later section) leads to very similar emission factors for both passenger service freight and dedicated cargo services for domestic and short-haul flights. This is also the case for long-haul flights under freight weighting Option 2, whereas under Option 1 the passenger service factors are substantially higher than those calculated for dedicated cargo services. It therefore seems preferable to treat freight on an equivalent basis by utilising freight weighting Option 2.

Option 2 was selected as the preferred methodology to allocate emissions between passengers and freight for the 2008 & 2009 GHG Conversion Factors.

'Real-World' Uplift

As discussed, the developed emissions factors are based on typical aircraft fuel burn over illustrative trip distances listed in the EMEP/CORINAIR Emissions Inventory Guidebook (EIG 2007)[7]. This information is combined with data from the Civil Aviation Authority (CAA) on average aircraft seating capacity, loading factors, and annual passenger-km and aircraft-km for 2006 (most recent full-year data available). However, the provisional evidence to date suggests an uplift in the region of 10-12% to climb/cruise/descent factors derived by the CORINAIR approach is appropriate in order to ensure consistency with estimated UK aviation emissions as reported in line with the UN Framework on Climate Change (UNFCCC), covering UK domestic flights and departing international flights. The emissions reported under UNFCCC are based on bunker fuel consumption and are closely related to fuel on departing flights. The 10% uplift is therefore based on comparisons of national aviation fuel consumption from this reported inventory, with detailed bottom up calculations in DfT modelling along with the similar NAEI approach, which both use detailed UK activity data (by aircraft and route) from CAA, and the CORINAIR fuel consumption approach. Therefore for the 2008 GHG Conversion Factors an uplift of 10% is included in the emission factors in all the presented tables, based on provisional evidence. No further evidence has since emerged, so the same uplift is applied in the 2009 GHG

Conversion Factors

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[4] British Airways World Cargo provides information on both passenger and dedicated freight services at: http://www.baworldcargo.com/configs/

The CORINAIR uplift is separate to the assumption that Great Circle Distances (GCD) used in the calculation of emissions should be increased by 9% to allow for sub-optimal routeing and stacking at airports during periods of heavy congestion. This GCD uplift factor is NOT included in the presented emission factors, and must be applied to the Great Circle Distances when calculating emissions. It should be noted that work will continue to determine a more robust reconciliation and this will be accounted for in future versions of these factors.

The revised average emission factors for aviation are presented in Table 3. The figures in Table 3 include the uplift of 10% to correct underestimation of emissions by the CORINAIR methodology (discussed above) and DO NOT include the 9% uplift for Great Circle distance, which needs to be applied separately (and is discussed separately later).

Table 4: Revised average CO_2 emission factors for passenger flights for 2009

Mode	Factors from 2007 update		Factors from 2008 update		Factors from 2009	
	Load Factor %	gCO_2 / pkm	Load Factor %	gCO_2 / pkm	Load Factor %	gCO_2 / pkm
Domestic Flights	65.0%	158.0	66.3%	175.3	65.2%	171.0
Short-haul Flights	65.0%	130.4	81.2%	98.3	80.9%	98.3
Long-haul Flights	79.7%	105.6	78.1%	110.6	77.8%	112.2

Seating Class Factors

The efficiency of aviation per passenger km is influenced by not only the technical performance of the aircraft fleet, but also by the occupancy/load factor of the flight. Different airlines provide different seating configurations that change the total number of seats available on similar aircraft. Premium priced seating, such as in First and Business class, takes up considerably more room in the aircraft than economy seating and therefore reduces the total number of passengers that can be carried. This in turn raises the average CO_2 emissions per passenger km.

At the moment there is no agreed data/methodology for establishing suitable scaling factors representative of average flights. However, for the 2008 update a review was carried out of the seating configurations from a selection of 16 major airlines[5] and average seating configuration information from Boeing and Airbus websites. 24 different aircraft variants were considered including those from the Boeing 737, 747, 757, 767 and 777 families, and the Airbus A319/320, A330 and A340 families. These represent a mix of the major representative short-, medium- and long- haul aircraft types. The different seating classes were assessed on the basis of the space occupied relative to an economy class seat for each of the airline and aircraft configurations. This evaluation was used to form a basis for the seating class based emission factors provided in Table 4. Information on the seating configurations including seating numbers, pitch, width and seating plans were obtained either directly from the airline websites or from specialist websites that had already collated such information for most of the major airlines (e.g. SeatGuru[6], UK-AIR.NET[7], FlightComparison[8] and SeatMaestro[9]).

For long-haul flights, the relative space taken up by premium seats can vary by a significant degree between airlines and aircraft types. The variation is at its most extreme for First class seats, which can account for from 3 to over 6 times[10] the space taken up by the basic economy seating. Table 4 shows the seating class based emission factors, together with the assumptions made in their calculation. An indication is also provided of the typical proportion of the total seats that the different classes represent in short- and long-haul flights. The effect of the scaling is to lower the economy seating emission factor in relation to the average, and increase the business and first class factors.

Table 5: Seating class based CO_2 emission factors for passenger flights for 2009

Flight Type	Size	Load Factor	gCO_2 /pkm	Number of economy seats	% of average gCO_2 /pkm	% Total seats
Domestic Flights	Average	65.2%	171.0	1.00	100%	100%
Short-haul Flights	Average	80.9%	98.3	1.05	100%	100%
	Economy class	80.9%	93.6	1.00	95%	90%
	First/Business class	80.9%	140.5	1.50	143%	10%

[5] The list of airline seating configurations was selected on the basis of total number of passenger km from CAA statistics, supplemented by additional non-UK national carriers from some of the most frequently visited countries according to the UK's International Passenger Survey. The list of airlines used in the analysis included: BA, Virgin Atlantic, Continental Airlines, Air France, Cathay Pacific, Gulf Air, Singapore Airlines, Emirates, Lufthansa, Iberia, Thai Airways, Air New Zealand, Air India, American Airlines, Air Canada, and United Airlines.

[6] See: http://www.seatguru.com/

[7] See: http://www.uk-air.net/seatplan.htm

[8] See: http://www.flightcomparison.co.uk/flightcomparison/home/legroom.aspx

[9] See: http://www.seatmaestro.com/airlines.html

[10] For the first class sleeper seats/beds frequently used in long-haul flights.

Long-haul Flights	Average	77.8%	112.2	1.37	100%	100%
	Economy class	77.8%	81.9	1.00	73%	80%
	Economy+ class	77.8%	131.1	1.60	117%	5%
	Business class	77.8%	237.5	2.90	212%	10%

We used the long-haul values for business and first class to estimate the values for other flight distances to allow a distinction between first and business class for other distances, too.

Freight, including mail, are transported by two types of aircraft – dedicated cargo aircraft which carry freight only, and passenger aircraft which carry both passengers and their luggage, as well as freight.

Data on freight movements by type of service are available from the Civil Aviation Authority (CAA, 2008). This data show that almost all freight carried by passenger aircraft is done on scheduled long-haul flights and accounts for almost 70% of all long-haul air freight transport. How this freight carried on long-haul passenger services is treated has a significant effect on the average emission factor for all freight services.

For more details on the calculation of freight emissions, please refer to the according section in DEFRA (2009) athttp://www.defra.gov.uk/environment/business/reporting/pdf/091013-guidelines-ghg-conversion-factors-method-paper.pdf

Other Factors for the Calculation of GHG Emissions:

Great Circle Fight Distances

We wish to see standardisation in the way that emissions from flights are calculated in terms of the distance travelled and any uplift factors applied to account for circling and delay. However, we acknowledge that a number of methods are currently used. A 9% uplift factor is used in the Act on CO_2 calculator and in the UK Greenhouse Gas Inventory to scale up Great Circle distances (GCD) for flights between airports to take into account indirect flight paths and delays, etc. This factor (also provided previously with previous GHG Conversion Factors) comes from the IPCC Aviation and the global Atmosphere 8.2.2.3, which states that 9-10% should be added to take into account non-direct routes (i.e. not along the straight line great circle distances between destinations) and delays/circling. The first version of the Act on CO_2 calculator only captured the number of flights taken and assumes average distance factors (plus the 9% uplift) for domestic, short-haul or long-haul flights. In the version 2 of the Act on CO_2 calculator due to be released late spring 2009, the option to perform a calculation based on airport origin and destinations for passenger flights will be included. This will allow a more precise calculation of CO_2 emissions using the Great Circle distances and the above uplift factor specific to the flight details entered.

It is not practical to provide a database of origin and destination airports to calculate flight distances. However, the principal of adding a factor of 9% to distances calculated on a Great Circle is recommended (for consistency with the existing Defra/DfT approach) to take into account of indirect flight paths and delays/congestion/circling.

Radiative Forcing

The emission factors provided in the 2009 GHG Conversion Factors Annex 6 and Annex 7 refer to aviation's direct carbon dioxide, methane and nitrous oxide emissions only. There is currently uncertainty over the other non-CO_2 climate change effects of aviation (including water vapour, contrails, NOx etc) which have been indicatively been accounted for by applying a multiplier in some cases. Currently there is no suitable climate metric to express the relationship between emissions and climate warming effects from aviation but this is an active area of research. Nonetheless, it is clear that aviation imposes other effects on the climate which are greater than that implied from simply considering its CO_2 emissions alone. The application of a 'multiplier' to take account of non-CO_2 effects is a possible way of illustratively taking account of the full climate impact of aviation. A multiplier is not a straight forward instrument. In particular it implies that other emissions and effects are directly linked to production of CO_2 which is not the case. Nor does it reflect accurately the different relative contribution of emissions to climate change over time, or reflect the potential trade-offs between the warming and cooling effects of different emissions. On the other hand, consideration of the non-CO_2 climate change effects of aviation can be important in some cases, and there is currently no better way of taking these effects into account. A multiplier of 1.9 is recommended as a central estimate, based on the best available scientific evidence. If used, this factor would be applied to the emissions factors set out here.

Please note that we updated the multiplier to 2 according to Kollmuss (2009) http://www.CO2 offsetresearch.org/PDF/SEI_Air_Travel_Emissions_Paper2_June_09.pdf

Energy:

The emission data for offices is mostly based on a survey of large companies in the UK. It distinguishes 4 types of offices with different space and electricity needs.

Energy consumption is very similar in industrialized countries offices[1]. We base our calculations on UK values[2] as there is most precise data available and used country specific electricity emission factors to extrapolate office emissions for other regions. There is some data from the US and Japan indicating that office energy use is very similar all over the industrialized world. We assume that western standard offices in developing countries have similar energy requirements and calculated the emissions accordingly. We used DEFRA (2009) values for Africa, Latin America, Middle East. As DEFRA (2009) doesn't provide a value for the Asian average electricity emission factor, we used the average of China, India and Indonesia and separated it from the value for South Korea and Japan as there are large differences in CO_2 intensity. Energy use in the UK offices is typically split into 80% electricity and 20% gas[2]. We have used this assumption for all regions. We did not include any considerations regarding weather conditions or insulation standards for the moment but are hoping to get better data. If your offices in developing countries are on significant lower standards you would need to assess their energy needs individually, as there are no benchmarks available.

Air conditioning / cooling contributes a large share to office electricity use. We based our calculations on Goodall [2] and Hitchin [3]. As the data in Goodall stems from a variety of offices throughout the UK, we had to estimate that their samples application of air condition is in line with the average for the country, i.e. covering roughly 20% of the floor area.[3]

Table 10: Average emissions from office operations per employee in tCO_2e per employee per year

Type of Office	Air Conditioning	EU	Australia	Africa	Latin America	Middle East	China, India, Indonesia	Japan & South Korea
Pure Office	With AC	2.32	4.99	3.91	1.58	4.26	5.13	2.64
	Without AC	1.62	3.27	2.61	1.15	2.82	3.36	1.81
Office and some Retail	With AC	2.81	5.98	4.7	1.92	5.11	6.15	3.18
	Without AC	2.1	4.27	3.39	1.49	3.67	4.38	2.35
Mostly Retail	With AC	4.56	9.58	7.56	3.15	8.21	9.85	5.15
	Without AC	3.85	7.87	6.25	2.72	6.77	8.08	4.32
Media and Entertainment	With AC	4.74	9.97	7.86	3.28	8.54	10.24	5.36
	Without AC	4.04	8.25	6.55	2.85	7.1	8.48	4.53

For the direct input of energy use, we used the standard values from DEFRA (2009). The calculation of electricity emissions is based on the EU average electricity mix.

[1] e.g. US Governement," Commercial Buildings energy consumption survey, consumption and expenditure, table C3A in the US and "Estimation of life cycle energy consumption and CO_2 emission of office buildings in Japan", Michiya Suzuki & Tatsuo Oka, 1998[2] "Carbon emissions and the service sector", Christian Goodall, 2007, available at http://www.lowcarbonlife.net

[3] "Local Cooling: Global Warming? UK Carbon Emissions from Air-Conditioning in the Next Two Decades" ,E R Hitchin, C Eng BSc MCIBSEMIGasE and C H Pout, BSc D Phil Building Research Establishment, Watford , UK, available at http://www.cibse.org

Events:

The Event calculations are mostly using the formulas described in the other categories (e.g. Mobility), except for food.

Emissions from meals can vary widely depending on what kind of food is consumed, where it comes from and how it has been cooled. Brookes[1] estimates the transportation related food print of a local meal ~8 times smaller than an overseas meal, with the overseas meal accounting with 5kg CO_2 for transport alone. There is no accepted standard for carbon footprint calculation for meals today, either. For some examples of food prints of different meals you can try out the calculator at: http://www.eatlowcarbon.org

As the footprint is heavily depending on food choice, we decided to calculate with an average of 5 kg CO_2 per meal, which is too low for beef based dishes and air freight transported tropical fruits and too high for locally sourced vegetable dishes.

[1] Will Brookes, “The Environmental Sustainability of the British Restaurant Industry: A London Case Study“, 2007

Freight:

The calculations for different types of freight are using CO_2e/tkm as primary unit. That is the amount of emissions associated with the transportation of 1 ton of freight for 1 km.

Air

See above chapter on "Flights".

Trucks

The calculations are based on DEFRA (2009) data. Unless you enter specific values for Vehicle Type, Efficiency and Load Factor, UK average values are used. To account for the differences in efficiency between fully loaded trucks and empty trucks, we followed the assumption of linearity and the average factors from DEFRA (2009).

Tables 6 and 7 (adapted from DEFRA (2009):

Difference between empty truck and full truck from halve load fuel efficiency in % of halve load fuel efficiency

3.5t – 7.5t, rigid	7.5t - 17t rigid	> 17t rigid	< 33t articulated	> 33t articulated	Fleet average
0.08	0.125	0.18	0.2	0.25	0.19

Typical maximum transport capacity

3.5t – 7.5t, rigid	7.5t - 17t rigid	> 17t rigid	< 33t articulated	> 33t articulated	Fleet average
2.025 t	6.243 t	9.545 t	15 t	19.1 t	12.9 t

The factors are based on road freight statistics from the Department for Transport (DfT, 2008)[13], from a survey on the average miles per gallon and average loading factor for different sizes of rigid and articulate HGVs in the fleet in 2007, combined with test data from the European ARTEMIS project showing how fuel efficiency, and hence CO_2 emissions, varies with vehicle load.

The miles per gallon (MPG) figures in Table 5.1 of DfT (2008) are converted to gCO_2 per km factors using the standard fuel conversion factor for diesel in the 2009 GHG Conversion Factors tables. Table 1.15 of DfT (2008) shows the percent loading factors are on average mostly between 40-60% in the UK HGV fleet. Figures from the ARTEMIS project show that the effect of load becomes proportionately greater for heavier classes of HGVs. In other words, the relative difference in fuel consumption between running an HGV completely empty or fully laden is greater for a large >33t HGV than it is for a small <7.5t HGV. From analysis of the ARTEMIS data, it was possible to derive the figures in Table 38 showing the change in CO_2 emissions for a vehicle completely empty (0% load) or fully laden (100% load) on a weight basis compared with the emissions at half-load (50% load). The data show the effect of load is symmetrical and largely independent of the HGVs Euro emission classification and type of drive cycle. So, for example, a >17t rigid HGV emits 18% more CO_2 per kilometre when fully laden and 18% less CO_2 per kilometre when empty relative to emissions at half-load.

It might be surprising to see that the CO_2 factor for a >17t rigid HGV is greater than for a >33t articulated HGV. However, these factors merely reflect the miles per gallon figures from the DfT survey that consistently shows worse mpg fuel efficiency, on average, for large rigid HGVs than large articulated HGVs once the relative degree of loading is taken into account. This might reflect the usage pattern for different types of HGVs where large rigid HGVs may spend more time travelling at lower, more congested urban speeds, operating at lower fuel efficiency than articulated HGVs which spend more time travelling under higher speed, free-flowing traffic conditions on motorways where fuel efficiency is closer to optimum. Under the drive cycle conditions more typically experienced by large articulated HGVs, the CO_2 factors for large rigid HGVs may be lower than indicated in our calculation. For the 2009 GHG Conversion Factors emission factors for CH4 and N2O have also been added for all HGV classes. These are based on the emission factors from the UK GHG Inventory (managed by AEA). CH4 and N2O emissions are assumed to scale relative to vehicle class/CO_2 emissions for HGVs.

Train

The factor can be expected to vary with rail traffic route, speed and train weight. Freight trains are hauled by electric and diesel locomotives, but the vast majority of freight is carried by diesel rail and correspondingly CO_2 emissions from diesel rail freight are over 90% of the total. Traffic-, route- and freight-specific factors are not currently available, but would present a more

[13] "Transport Statistics Bulletin: Road Freight Statistics 2007", June 2008, SB (08) 21. Available at: http://www.dft.gov.uk

appropriate means of comparing modes (e.g. for bulk aggregates, intermodal, other types of freight). CH4 and N2O emission factors have been estimated from the corresponding emissions for diesel rail from the UK GHG Inventory, proportional to the CO_2 emissions. The emission factors were calculated based on the relative passenger km proportions of diesel and electric rail provided by DfT for 2006-7 in the absence of more suitable tonne km data for freight.

Ship

Factors for representative ships are derived from information in the EMEP-CORINAIR Handbook (2003)51 and a report by Entec (2002)52. This included fuel consumption rates for engine power and speed while cruising at sea associated with different vessels. The factors presented in Table 47 refer to gCO_2 per deadweight tonne km. Deadweight tonnage is the weight of the cargo etc which when added to the weight of the ship's structure and equipment, will bring the vessel down to its designated waterline. This implies the factors are based on a fully loaded vessel. Because the ship's engines are propelling the weight of the ship itself, which is a significant proportion of the overall weight of the vessel and its cargo, reducing the cargo load from the deadweight tonnage will not lead to a proportionate reduction in the amount of fuel required to move the vessel a given distance. For example, decreasing the cargo load to half the ship's deadweight will not reduce the ship's fuel consumption by a half. As a consequence, the factors expressed in gCO_2 /tonne km freight will be higher than the figures in Table 47 for ships that are only partially loaded (i.e. loaded to less than the vessel's deadweight tonnage). Figures on the typical loading factors for different vessels are not currently available in the public domain. The CO_2 factors will be reviewed and updated when the loading factors become available to provide factors that are more representative of vessel movements from UK ports. Meanwhile, the factors in Table 47 should be regarded as lower limits. CH4 and N2O emission factors have been estimated from the corresponding emissions for shipping from the UK GHG Inventory for 2007, proportional to the CO_2 emissions.

Van / Light Transport Vehicle < 3.5 tons

An average load factor of 40% was assumed for each vehicle type, on the basis of DfT statistics from a survey of company owned vans. For the 2009 GHG Conversion Factors emission factors for CH4 and N2O have also been added for all van classes. These are based on the emission factors from the UK GHG Inventory (managed by AEA). N2O emissions are assumed to scale relative to vehicle class/CO_2 emissions for diesel vans. Emission factors per tkm were calculated from the average load factor of 40% in combination with the average freight capacities of the different vans.

Cooling

Transportation of refrigerated or frozen goods is associated with significantly higher emissions than other transport. Currently there is no appropriate data to account for the difference.

Mobility:

The calculations in this section are based on average driving behavior. Only emissions from fuel use are factored in, road and vehicle construction related emissions are excluded.

Cars

All emission calculations are based on DEFRA (2009).

All the fuel conversion factors presented in the 2009 GHG Conversion Factors are based on the default emission factors used in the UK GHG Inventory (GHGI) for 2007 (managed by AEA). The CO_2 emissions factors are based the same ones used in the UK GHGI and are essentially independent of application (assuming full combustion). However, emissions of CH4 and N2O can vary to some degree for the same fuel depending on the particular use (e.g. emission factors for gas oil used in rail, shipping, non-road mobile machinery or different scales/types of stationary combustion plants can all be different). The figures presented in the 2009 GHG Conversion Factors are based on an activity-weighted average of all the different CH4 and N2O emission factors from the GHGI. The standard emission factors from the GHGI have been converted into different energy and volume units using information on Gross and Net Calorific Values (CV) from the Digest of UK Energy Statistics 2008 (BERR), available at: http://www.berr.gov.uk

Two tables are presented in the 2009 GHG Conversion Factors; the first provides emission factors on a Net CV basis and the second on a Gross CV basis[11]. Emission factors per unit mass or volume are identical in these two tables. However values on an energy basis are different - emission factors on a Net CV basis are higher (see definition of Gross CV and Net CV in italics below). It is important to use the correct emission factor; otherwise emissions calculations will over- or under-estimate the results. When making calculations based on energy use, it is important to check (e.g. with the fuel supplier) whether the values were calculated on a Gross CV or Net CV basis and use the appropriate factor. UK Natural Gas consumption figures are quoted in kWh by suppliers (calculated from the volume of gas used) on a Gross CV basis.[12]

Train

The emissions of UK trains from DEFRA (2009) are used as a best source to estimate average train emissions. The emissions are mainly related to electricity consumption, so they may vary significantly for other electricity mixes. To get more precise estimate, one can divide train emissions by 0.50238 (UK electricity factor) and multiply by the electricity factor from each country. See DEFRA (2009), Annex 10 for a list of factors for several countries. Some trains still use diesel engines, so the estimate will still be slightly distorted. http://www.defra.gov.uk

The national rail factor refers to an average emission per passenger kilometre for diesel and electric trains in 2007-08. The factor is from the DfT Network Modelling Framework (NMF) Environmental Model and has been calculated based on total electricity and diesel consumed by the railways for the year (sourced from ATOC), and the total number of passenger kilometres (from DfT rail statistics). The factor for conversion of kWh electricity into CO_2 is based on the 2006 grid mix (the most recent figure available at the time). CH4 and N2O emission factors have been estimated from the corresponding emissions factors for electricity generation and diesel rail (from the UK GHG Inventory), proportional to the CO_2 emission factors. The emission factors were calculated based on the relative passenger km proportions of diesel and electric rail provided by DfT for 2006-7.

[11] Gross CV or higher heating value (HHV) is the CV under laboratory conditions. Net CV or 'lower heating value (LHV) is the useful calorific value in typical real world conditions (e.g. boiler plant). The difference is essentially the latent heat of the water vapour produced (which can be recovered in laboratory conditions).

[12] See information available on Transco website: http://www.transco.co.uk

Overnight Stays:

The emissions from hotels are based on a survey in Switzerland. It was the most detailed study available, and comparing with international data showed that the values are very similar.

Table 8

Hotel Star Rating	Average Energy Consumption	Average CO_2 Emissions per
Zero – Two Star	38 kWh	11.6 kg
Three Star	47 kWh	14.3 kg
Four Star	61 kWh	18.5 kg
Five Star	109 kWh	33.1 kg

This is calculated from the average energy consumption of hotels (according to class) and the average mix of energy sources. The differences in energy source mix is not taken into account as it was absent from the study. The energy supply for 0-3 star hotels was only available per turnover, so we used an estimate of the average price of 0-3 star hotels from a sample 25 hotels in each category located in the same region to calculate the per guest values.

Table 9

Average energy consumption mix	Average Energy Consumption
Electricity	36.8%
Fuel Oil	49.8 %
Gas	9.8%
Renewables	3.6%

Sources

http://www.hotelpower.ch

DEFRA, Green house gas conversion factors, 2009, http://www.defra.gov.uk

Additionally we had to estimate the average price of 0-3 star hotels from a sample 25 hotels in each category located in the same region as energy intensity was given in relation to turnover, not guests for these categories.

Waste:

Emissions from Waste result mostly from methane production in landfills. For paper waste, we also factor in production as it has a significant and well quantifiable impact on overall emissions.

On mixed waste:

The Ministry for the Environment of New Zealand[1] provides excellent data on the emissions from waste. We made the assumption that all waste is land filled without gas recovery, as this is prevailing practice of waste management in most countries. If your municipal waste is burned in a combined heat and power generating plant, do not account for the emissions from waste as this technology lowers the emissions from waste to almost zero.

[1] Ministry for the Environment of New Zealand, 2007, http://www.mfe.govt.nz

On paper:

Depending on type of paper, country of production and method of calculation the values for production vary between 0.5 and 2 tCO_2e/t Paper. We assume an average of 1t CO_2e/t Paper. Additional Emissions come from paper disposal: We estimate 1 tCO_2e/t Paper, including emissions from landfill. In Europe, about 75% of all paper goes to landfill, based on Van den Reek (1999). Using recycled paper reduces the emissions from paper production by an average of 76% while recycling paper reduces emissions from landfill by 100%.

Mainly based on:

Van den Reek (1999), Reduction of CO_2 emissions by reduction of paper use for publication applications, university of Utrecht, available at http://www.chem.uu.nl

with additional information from:

RWI, 1996, Band 2: Forschungsberichte der Verbaende, Verband Deutscher Papierfabrieken, CO_2-Monitoring der deutschen Industrie ökologische und ökonomische Verifikation, Untersuchungen des Rheinisch-Westfalischen Instituts für Wirtschaftsforschung; Essen, 134-150;

The State of the Paper Industry: Monitoring the Indicators of Environmental Performance - A collaborative report by the Steering Committee of the Environmental Paper Network (2007), available at http://www.environmentalpaper.com

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