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# Treeprint

## When emissions turn personal

ESG Report

Greenhouse gas emissions are personal as they ultimately are generated in order to accommodate our way of life.

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# Executive summary

The need for the world to address climate change appears obvious when viewed through the lens of the latest Assessment Report released by the IPCC in early August. In order to meet targets set under the 2015 Paris Agreement, greenhouse gas emissions (GHGs) need to be reduced 50% between 2020 and 2030 and reach 'net zero' by 2050. Much of the debate around climate change centres on what governments or companies say or do. However, we believe this ignores the ultimate driver of emissions: the consumer.

**At the end of the day, it is our daily lifestyle that drives emission levels.** Whether it is the car we drive, the flight we take, the products that we buy, or the house that we heat, all emissions globally are ultimately generated in order to accommodate consumer behavior and spending patterns. Therefore, the question is what is our emission footprint and what can be done to bring this in line with climate-change-related limits.

**In this report, we aim to make emissions more personal.** We do this by providing emission data for a wide range of activities covering eating and drinking, travel and tourism, entertainment, clothing, and domestic activities (in and around the house). Furthermore, we introduce four different consumer lifestyles to help readers benchmark the emission footprint of their own lives. We conclude that all four of our sample consumers generate emissions in excess of the 3,300kg of $CO_2$ equivalent upper limit that is in line with long-term climate change targets. In fact, for three of the four consumers, emissions need to fall more than 80% in order to reach this limit.

Despite our activity-based emission overview, we believe that some readers may struggle to understand what this emission data actually mean. The concept of a Gigaton (Gt) of emissions is likely to be an alien concept to most of us. This risks making the climate change debate a more theoretical exercise which, if true, hampers the chances of successfully reducing carbon emissions to levels that are in line with long-term climate change targets.

**Trees store carbon and could provide a potential solution.** In this report, we introduce the concept of 'Treeprint'. This stands for the number of mature trees that are needed in order to offset the emissions associated with a certain activity. We believe our concept of Treeprint will make it easier for readers to understand the environmental impact of their way of life. Once consumers appreciate how many trees are needed to offset their carbon footprint, they can either decide to reduce certain activities or plant the calculated number of trees in order to reduce their overall emission footprint.

**Creating a sustainable consumer.** Having reviewed the emission intensity of certain activities and lifestyles and calculating how many trees are needed to offset them, we turn the approach upside down. We ask ourselves what lifestyle has an emission footprint that is within the per capita boundaries implied by long-term climate change targets. Figure 36 on page 49 shows a lifestyle that on our estimates generated c2,600kg of $CO_2$ per year. The Treeprint of this sustainable consumer is c120 trees, based on our calculations.

We hope that this report will help the reader to understand which areas of his or her lifestyle are most environmentally intense. Furthermore, we hope that this report makes it clear that the biggest impact we can make on a personal level to reduce greenhouse gas emissions is through incorporating changes to our way of life and by planting trees.

David Bleustein
Global Head of Securities Research

# Trees as a solution for climate change

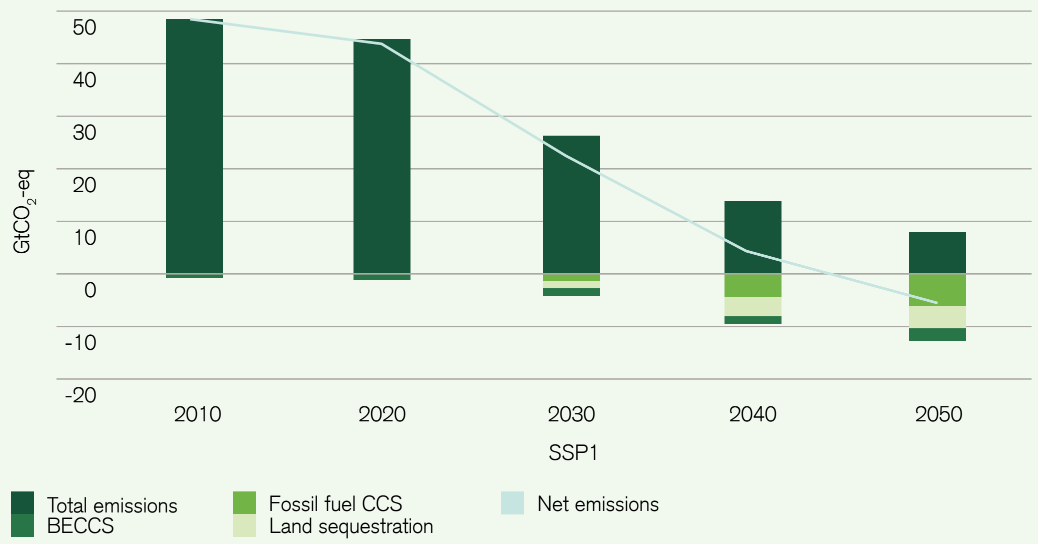
**In recent publications, we highlighted the potential that reforestation may provide in fighting climate change. Specifically, in Credit Suisse Research Institute: The global food system - Identifying sustainable solutions, we first showed that a change in diet would allow for a sharp decline in GHG emissions and free up agricultural land that could be used for reforestation.**

In Global ESG Research: The ROE of a Tree, we showed that this reforestation could in theory capture up to 80% of today's anthropogenic emissions and that planting trees could actually be a profitable activity for farmers too.

To outline the role that forests play in storing carbon (natural sequestration), we highlight the following statistics.

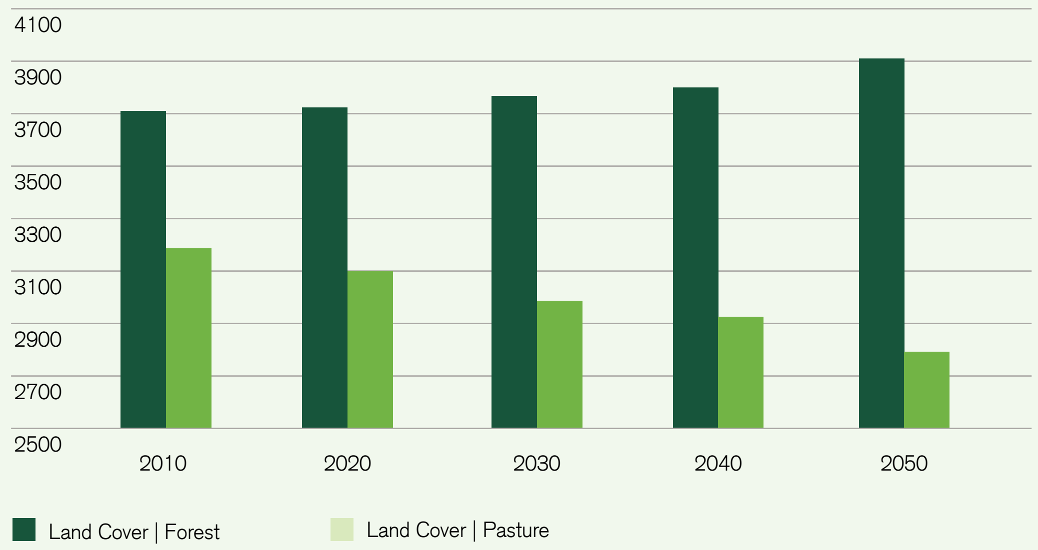
- Currently, approximately 30% of $CO_2$ emissions that are emitted each year get stored or captured by the world's forests, even though respiration and decomposition release some of this carbon back into the atmosphere. Some 47% of emissions remain in the atmosphere; however, calculations by the Intergovernmental Panel on Climate Change (IPCC) suggest that this share is set to grow under more extreme global warming scenarios and without aggressive (re)forestation plans.
- In addition to the carbon that is stored in trees directly, we note that carbon is also stored in soil, primarily through the remains of decomposing plant and animal tissue, and other dissolved organic material. Estimates from the Food and Agriculture Organisation (FAO) indicate that 44% of the carbon stored in forests sits in living biomass, whereas c45% resides in the soil.
- When thinking about using trees to capture carbon, we need to realize that carbon storage differs depending on the type of forest. For example, a 2019 study prepared for the 14th session of the UN Forum on Forests cited a study in Science that found that tropical and boreal (arctic) forests are similar in terms of carbon stock density. Temperate forests, on the other hand, have a carbon stock density that is c40% lower per hectare. We note that much uncertainty remains around these figures, not least because of a lack of data around how much carbon is stored in the soil and how deeply this carbon is stored.
- The fact that natural carbon sequestration is a relevant topic in the fight against climate change is also recognized by institutions such as the IPCC. Its so-called SSP1 scenario requires carbon sequestration through land use (e.g., forests) to more than double during the next 30 years. This, according to the IPCC, is to be achieved by increasing the amount of forest land by c200 million hectares, which could be achieved given that they estimate that the amount of land needed for livestock will decline by more than 300 million hectares.

**Figure 1: Natural sequestration is needed to get to net-zero according to IPCC calculations**



Source: IPCC

**Figure 2: The IPCC expects forest land to grow as the amount of pasture land declines owing to falling meat consumption (million ha)**



Source: IPCC

# Planting trees could be a potential solution

The potential for carbon storage by trees appears obvious; however, deforestation has consistently reduced the amount of forests and trees during the past few decades. Data from the FAO, for example, suggest that the total area globally that is classified as forest has declined by c178 million hectares since 1990.

Against this background, we note that the topic of reforestation is one that we believe needs to be treated with a greater degree of urgency. The good news is that an increasing number of countries are announcing forestation plans. For example, China recently announced reforestation plans for the next five years. It wants to plant 36,000 square kilometres of new forest (greater than the size of Belgium) per year until 2025 in order to increase its total forest coverage area to 24.1% by 2025 from 23.04% in 2020. China's announcement is part of a range of higher-profile reforestation plans that have been announced by various governments during the past few years. For example, the European Union plans to plant three billion trees by 2030 while the US intends to plant 24 billion trees over the next 20 years.

The question that is relevant in this case is whether these plans make a meaningful difference. In Figure 3, we show for a number of countries the percentage of annual emissions that would be captured by these newly planted trees, assuming that they store on average 22kg of $CO_2$ per year. We will address these assumptions later in this report. Our calculations suggest that these reforestation plans, while obviously positive, appear to address less than 15% of current annual $CO_2$ emissions.

**Figure 3: Tree planting targets for key countries**

| Country/ Region | Target | Target Year | Annual $CO_2$ Emissions (Million tonnes) | Total Trees planted (Million) | Annual $CO_2$ captured by mature planted trees (Million tonnes) | Annual $CO_2$ captured as % of current emissions |
|---|---|---|---|---|---|---|
| China | 36,000 square kilometres of new forest a year | 2025 | 10,175 | 27,000 | 594 | 6% |
| USA | 24 billion trees over 30 years (Trillion Trees Act) | 2040 | 5,285 | 24,000 | 528 | 10% |
| India | Add 10m ha of new forests and forest cover | 2030 | 2,616 | 15,000 | 330 | 13% |
| Spain | Nearly 4 million ha increase of forest area by 2032 | 2032 | 253 | 6,000 | 132 | 52% |
| EU | Plant 3 billion trees by 2030 | 2030 | 3,749 | 3,000 | 66 | 2% |
| Brazil | Reforesting 2 million hectares of land by 2030 | 2030 | 466 | 3,000 | 66 | 14% |
| UK | UK forestry cover from 13% to 17% (CCC objectives) | 2050 | 370 | 1,455 | 32 | 9% |
| Australia | One billion plantation trees by 2030 | 2030 | 529 | 1,000 | 22 | 4% |
| New Zealand | Plant one billion trees between 2018 and 2028 | 2028 | 37 | 1,000 | 22 | 60% |

Source: Credit Suisse estimates, Total trees planted by country and target year from government announcements

# Reforestation on a city level

One of the key challenges in addressing climate change is the need to create engagement with the public. Reforestation programs may act as a partial solution here, especially if these are set up on a more local level with the potential direct involvement of citizens. It appears to us that plenty of opportunities exist for local governments to establish reforestation programs. We have reviewed emission levels for some of the largest urban areas globally.

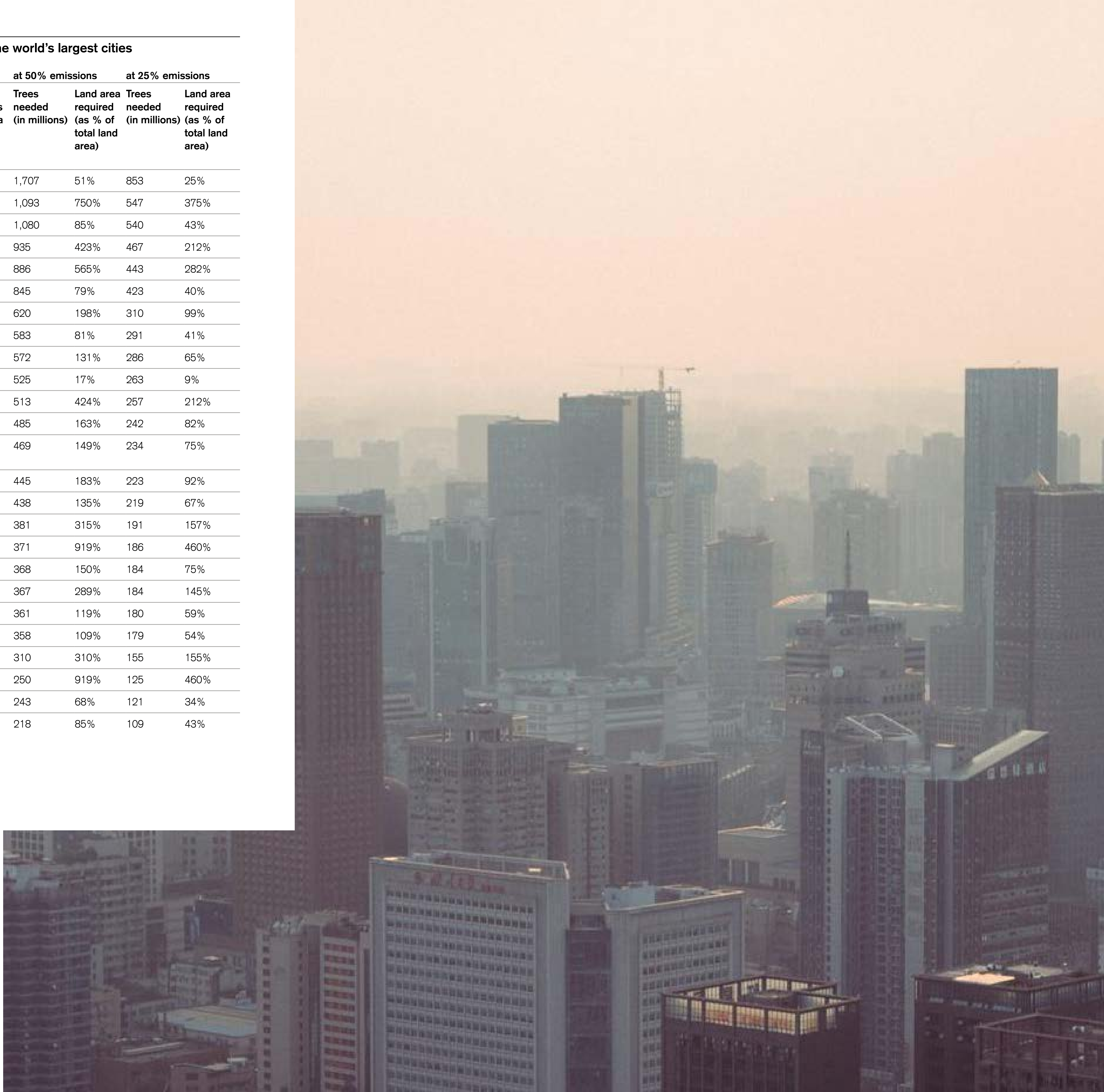
Figure 4 shows how many trees would have to be planted to offset 25% or 50% of current carbon emissions for some of the largest cities in the world. We have also worked these numbers into the size of forest land that would be needed.

What is apparent to us is that, for a number of these larger cities, a meaningful share of carbon emitted could be captured through reforestation. For example, in the case of Beijing, the city with the highest level of Scope 1 emissions based on 2010 data, we find that 25% of its emissions would be captured if an area equivalent to 25% of its city area were planted with trees. Santiago, Chile would need 9% of its city area to capture 25% of its emission levels.
For a number of other cities though, we find that reforestation would require a very substantial land area. For example, Singapore would need an area 3.75x its city land area in order to capture 25% of its current carbon emissions. Other cities that require a relatively large area for reforestation include Hong Kong and New York. Clearly, these cities emit a large amount of emissions relative to their size, which is likely due to their highly urbanized, high-rise, structure.

**Figure 4: Offsetting 25% or 50% of Scope 1 emissions for some of the world's largest cities**

| | | | | | | | at 50% emissions | | at 25% emissions | |
|---|---|---|---|---|---|---|---|---|---|---|
| **City** | **Country** | **Scope 1 Emissions (Million metric tonnes $CO_2e$)** | **Emission year** | **Land area (in square km)** | **Population (million)** | **Scope 1 Emissions per Capita** | **Trees needed (in millions)** | **Land area required (as % of total land area)** | **Trees needed (in millions)** | **Land area required (as % of total land area)** |
| Beijing | China | 75.1 | 2010 | 16807.8 | 20.9 | 3.59 | 1,707 | 51% | 853 | 25% |
| Singapore | Singapore | 48.1 | 2012 | 728.6 | 6.0 | 8.03 | 1,093 | 750% | 547 | 375% |
| Shanghai | China | 47.5 | 2010 | 6340 | 27.8 | 1.71 | 1,080 | 85% | 540 | 43% |
| Hong Kong | China | 41.1 | 2015 | 1104 | 7.6 | 5.41 | 935 | 423% | 467 | 212% |
| New York City | USA | 39.0 | 2015 | 784 | 8.2 | 4.73 | 886 | 565% | 443 | 282% |
| Istanbul | Turkey | 37.2 | 2010 | 5343 | 15.4 | 2.41 | 845 | 79% | 423 | 40% |
| Bangkok | Thailand | 27.3 | 2013 | 1569 | 10.7 | 2.55 | 620 | 198% | 310 | 99% |
| Lagos | Nigeria | 25.6 | 2015 | 3577 | 14.9 | 1.73 | 583 | 81% | 291 | 41% |
| Tokyo | Japan | 25.2 | 2017 | 2188 | 37.3 | 0.67 | 572 | 131% | 286 | 65% |
| Santiago | Chile | 23.1 | 2013 | 15403 | 6.8 | 3.39 | 525 | 17% | 263 | 9% |
| Seoul | South Korea | 22.6 | 2015 | 605 | 10.0 | 2.27 | 513 | 424% | 257 | 212% |
| Mexico City | Mexico | 21.3 | 2016 | 1485 | 21.9 | 0.97 | 485 | 163% | 242 | 82% |
| London | United Kingdom | 20.6 | 2013 | 1572 | 9.4 | 2.19 | 469 | 149% | 234 | 75% |
| Los Angeles | USA | 19.6 | 2013 | 1215 | 4.0 | 4.92 | 445 | 183% | 223 | 92% |
| Houston | USA | 19.3 | 2014 | 1625 | 2.3 | 8.29 | 438 | 135% | 219 | 67% |
| Chicago | USA | 16.8 | 2015 | 606 | 2.7 | 6.27 | 381 | 315% | 191 | 157% |
| Buenos Aires | Argentina | 16.3 | 2015 | 202 | 45.2 | 0.36 | 371 | 919% | 186 | 460% |
| Rio de Janeiro | Brazil | 16.2 | 2012 | 1224.6 | 13.5 | 1.19 | 368 | 150% | 184 | 75% |
| Toronto | Canada | 16.2 | 2013 | 634 | 6.3 | 2.58 | 367 | 289% | 184 | 145% |
| Sao Paulo | Brazil | 15.9 | 2011 | 1521 | 22.2 | 0.71 | 361 | 119% | 180 | 59% |
| Johannesburg | South Africa | 15.8 | 2014 | 1645 | 5.9 | 2.66 | 358 | 109% | 179 | 54% |
| Montreal | Canada | 13.6 | 2009 | 500 | 4.2 | 3.21 | 310 | 310% | 155 | 155% |
| Las Vegas | USA | 11.0 | 2014 | 136 | 0.7 | 16.48 | 250 | 919% | 125 | 460% |
| Bogota | Colombia | 10.7 | 2015 | 1776 | 11.2 | 0.96 | 243 | 68% | 121 | 34% |
| Manchester | United Kingdom | 9.6 | 2013 | 1277 | 2.8 | 3.49 | 218 | 85% | 109 | 43% |

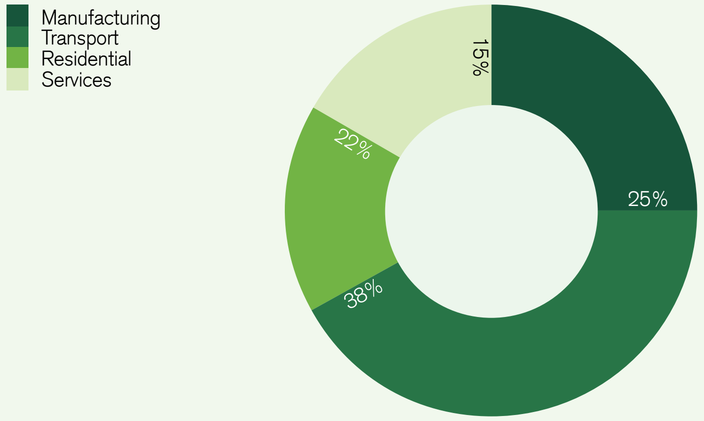
Source: Citycarbonfootprints.info, CDP, worldpopulationreview.com, Credit Suisse estimates



# When emissions turn personal

**The climate change debate typically focuses on the need for governments to incorporate emission targets and for corporates to cut their emission levels. While this is undoubtedly relevant, it does avoid a focus on the ultimate reason for emissions: the consumer.**

Figure 5: Final energy consumption by end use (2018)



Source: IEA

Direct residential energy consumption accounts for 22% of total final energy consumption according to the International Energy Agency (IEA). However, one could argue that at the end of the day it is our daily lifestyle that drives energy consumption and by implication emission levels from other sources. Whether it is the car we drive, the products that we buy, or the house that we heat, all emissions globally ultimately are generated by manufacturers or service providers in order to accommodate consumer behavior and spending patterns. The question, therefore, is what is our emission footprint and how can this be offset?

The current distribution of GHG emissions is very uneven across and within countries. For example, Chancel & Piketty ("Carbon and Inequality: from Kyoto to Paris", 2015) showed that the top 10% of GHG emitters globally make up c35% of GHG emissions. Otto et al ("Shift the focus from the super-poor to the super-rich", 2019) showed that the carbon footprint of a typical super-rich household of two is estimated at about 130t$CO_2$eq compared to a worldwide average of 3.4t$CO_2$eq per capita (Stadler et al, "EXIOBASE 3: developing a time series of detailed environmentally extended multi-regional input–output tables", 2018).

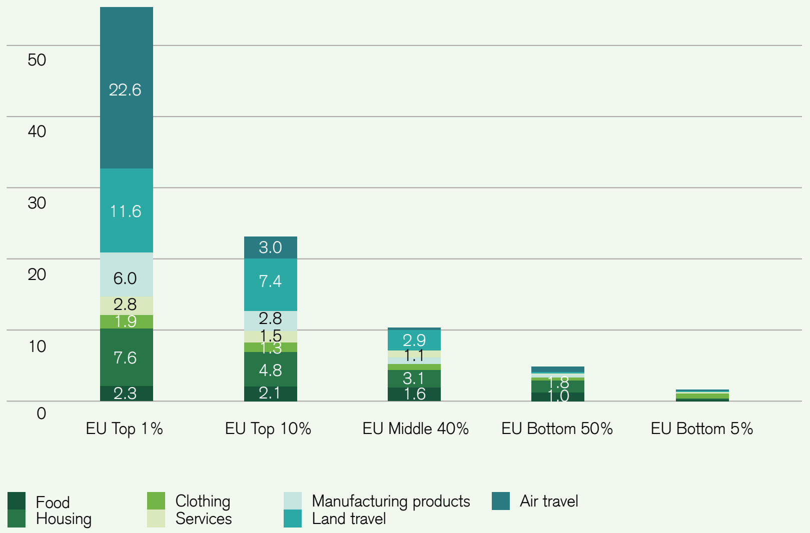
Cutting these per capita emission levels to those that are compliant with per-capita climate change targets will prove to be a very sizeable challenge. To put this in perspective, on a per capita basis, global emissions need to go down to c2.5-3.3t$CO_2$ by 2030, according to analysis from the Global Carbon Project.

Analysis done by Ivanova and Wood in 2020 ("The unequal distribution of household carbon footprints in Europe and its link to sustainability") provides further insight into emission profiles in Europe. They note that only 5% of EU households have emission footprints that are within the targets associated with the Paris Agreement. Strikingly, the top 1% of households by emissions emit c22 times the per capita climate targets (Figure 6).

When reviewing emissions by income category, Ivanova & Wood find that food-related emissions are relatively constant. This does not necessarily mean that people's diets do not change as income changes, but rather that the overall emission profile stays relatively similar.

Areas where emissions appear to change most as income rises include transport, especially air travel. Housing costs are relatively constant except for the top 20% of income levels, where disposable income and savings are likely to have reached sufficiently large sums to increase spending on more emission-intense housing products and services. In the remainder of this chapter, we will dive deeper into the emission profile of our personal activities in order to provide the reader with a better understanding of how our daily lives and choices impact the environment.

**Figure 6: The carbon footprint in Europe by income**



Source: Ivanova, D., & Wood, R. (2020). The unequal distribution of household carbon footprints in Europe and its link to sustainability.

**Figure 7: Carbon footprint by product and service**

Source: Ivanova, D., & Wood, R. (2020). The unequal distribution of household carbon footprints in Europe and its link to sustainability.

## Our daily lives

We spend our days going through what may often seem like an endless array of activities. Importantly, however, is that all of these activities, from taking a shower in the morning, preparing breakfast, ordering a latte on the way to work or school, having dinner, watching television to using an electric toothbrush, carry an emission footprint.

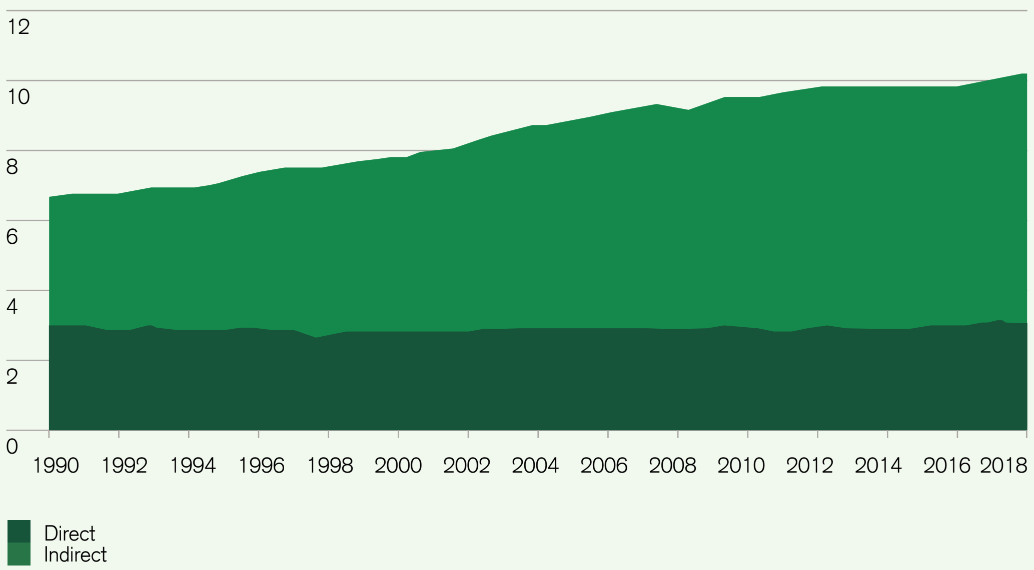
We believe that the average consumer is likely to underappreciate his or her personal emission footprint. This, in turn, might also help to explain why it appears difficult to get consumers to change their behavior in order to help reduce emissions to achieve climate change targets. With that in mind, we have put together an overview of the emission footprint for a range of ordinary activities. We hope that this will help the reader gain a better understanding of his or her environmental impact.

# In and around the house

In our quest to provide readers with insight into their potential personal emission footprint, we first review the carbon intensity of domestic activities or products. Emissions related to energy consumption in buildings have steadily increased. Emissions related to final energy consumption in buildings, for example, have increased by c3% since 1990. However, emissions associated with the upstream power generation needed for this increased by c95%, according to data from the IEA.

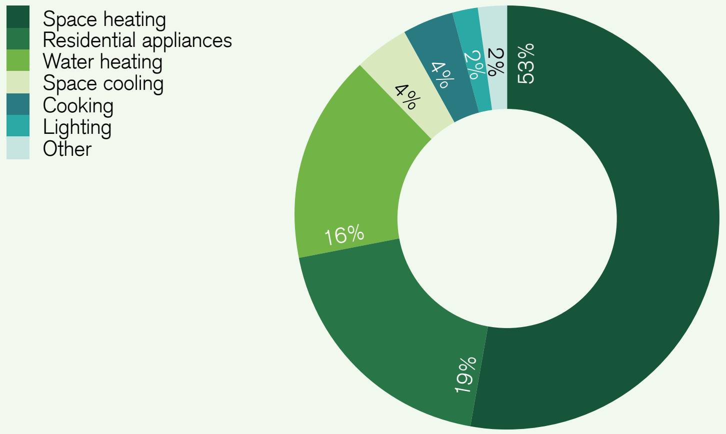
The IEA notes that building sector energy intensity or final energy use per m$^2$ of floor space has been declining between 0.5% and 1% per year since 2010. However, this has been more than offset by total floor space growth globally of about 2.5% annually since 2010. Furthermore, what is also apparent is that increased use of more energy efficient sources of building-related energy sources have not managed to replace fossil-fuel-related energy sources.

**Figure 8: Building sector energy-related $CO_2$ emissions**



Source: IEA

**Figure 9: Residential building-related energy consumption by end use**

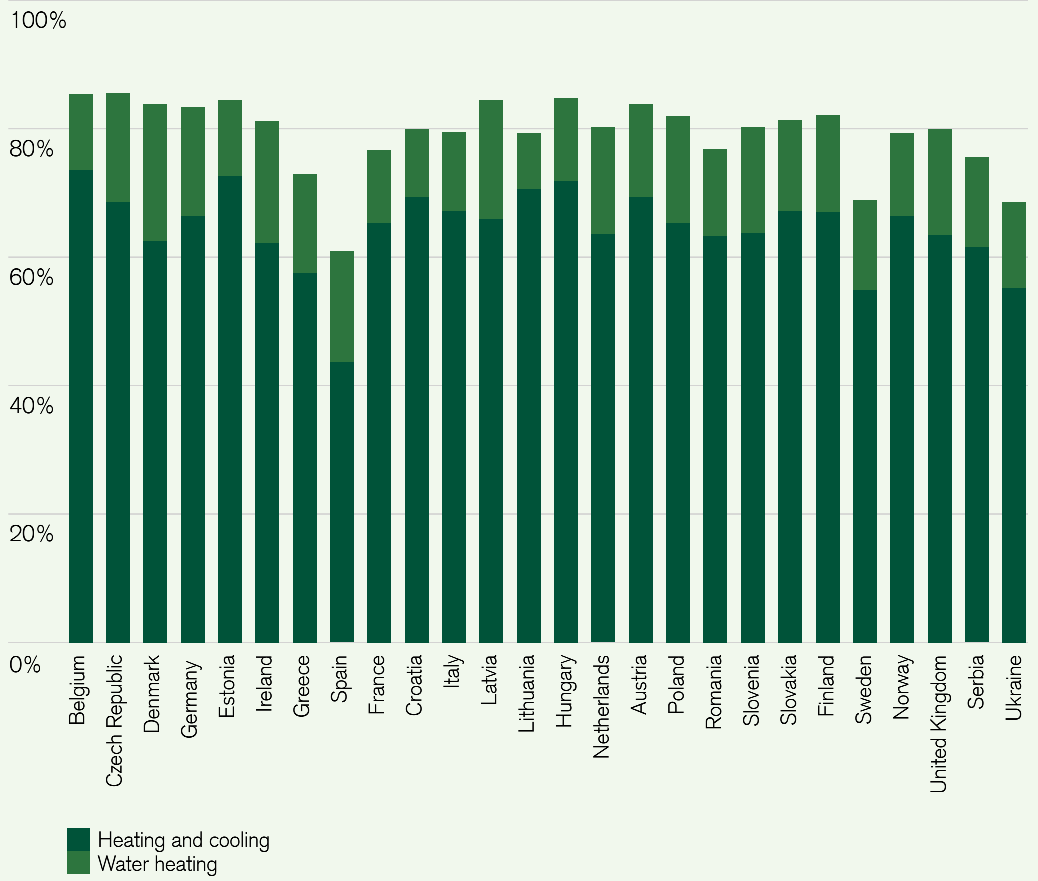


Source: IEA

# Building-related energy consumption

When reviewing residential energy consumption, we note that space heating and cooling make up the lion's share, with almost 60% on a global basis (Figure 10). Data from EuroStat for the EU underlines the relevance of heating and cooling in relation to total residential building energy consumption (Figure 11).

**Figure 10: Heating- and cooling-related energy consumption in the EU**



Source: ESTAT, Credit Suisse research

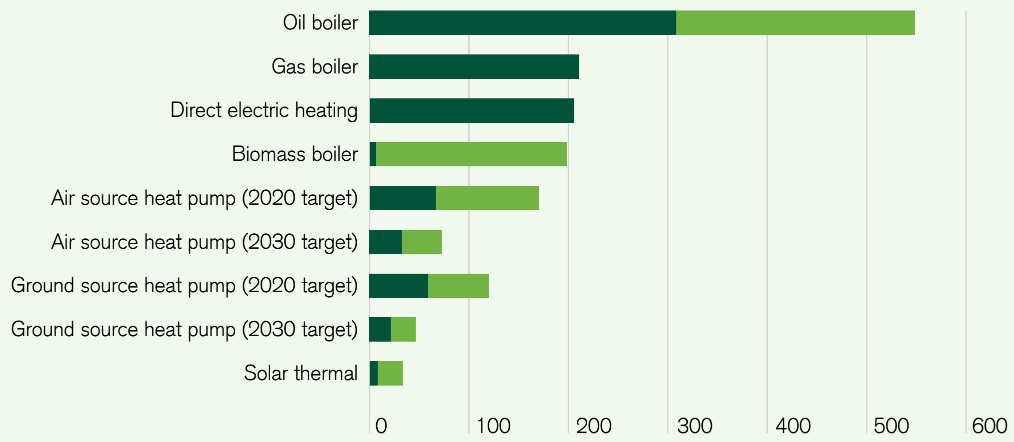
Given the high share that space heating and cooling contributes to total residential energy consumption and emission generation, it is vital that this is done in the most efficient way possible. This is even more relevant given that heat generated is lost. Typically, c35% of heat that is lost in buildings is lost through poorly insulated and constructed walls. Some 25% of heat loss occurs through windows and doors while the attic and the basement/floors typically account for 25% and 15% of heat loss, respectively. Overall, there are a number of ways space heating requirements in buildings can be reduced. These methods include:

1. Reducing the amount of heat lost through walls and windows through insulation. This includes loft and cavity-wall insulation but may also include insulated wall paper.
2. Making the building more airtight and applying heat recovery technologies.
3. Installing a more energy efficient heating system.
4. Keeping heat below 18°C. Each degree of heating saves around 10% of energy.

# Heating systems

Historically speaking, most heating systems use gas or oil as input. However these have a larger carbon footprint than technologies that have been developed more recently. In the chart below, we show the footprint range for a number of these technologies using analysis from the Parliamentary Office of Science and Technology in the UK and DRAXX. This shows that a substantial reduction in heating-related emission generation can be created by switching to heat pumps and the use of solar-generated heat, particularly when assuming that the energy mix overall continues to switch toward renewables.

**Figure 11: Carbon footprint range for heating technologies (gram of $CO_2$-eq. /kWh of heat)**



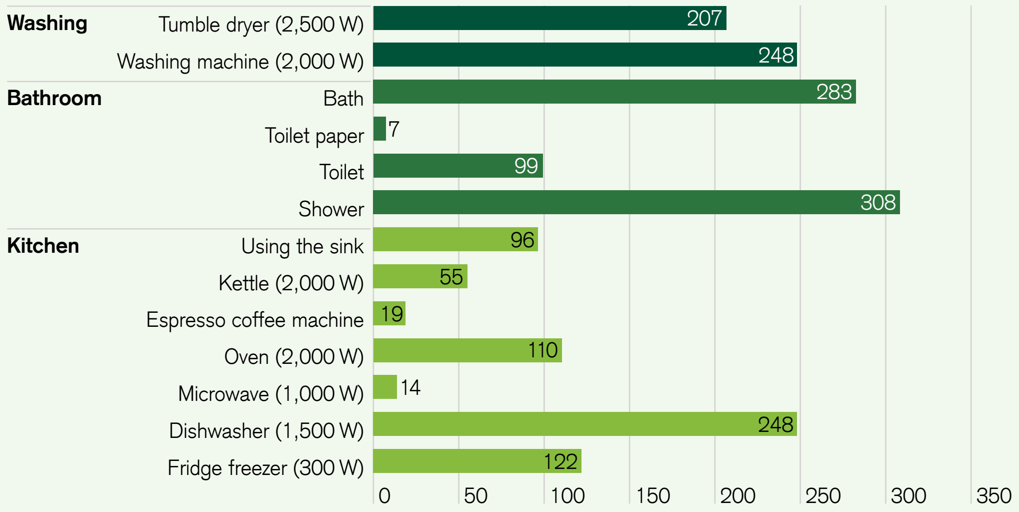
Source: The Parliamentary Office of Science and Technology

# Other appliances

In and around our homes, we use a range of devices, each of which creates its own emission footprint. Some of these devices such as washing machines and dishwashers have relatively high carbon footprints; however, one could say that in households these emissions would have to be divided by the number of people making up a family. Personal or private activities around the house that do have a high footprint, in our view, include taking a shower or bath and using the toilet.

In Figure 12, we show some assumptions around the usage of a range of domestic appliances. These range from using the shower for eight minutes each day, using a toilet twice per day, or using an espresso machine four times per day. We calculate the carbon intensity of these activities by multiplying the energy usage or water consumption per minute with the time per year that the appliance is used and then converting this into $CO_2$ using a conversion factor. This shows that showering and using a bath are relatively emission intense at c280–300kg of $CO_2$ per year. Appliances that, when used regularly, also generate sizeable carbon footprints are washing machines, tumble dryers, and dishwashers.

**Figure 13: Annual emission footprint (kg $CO_2$/year)**

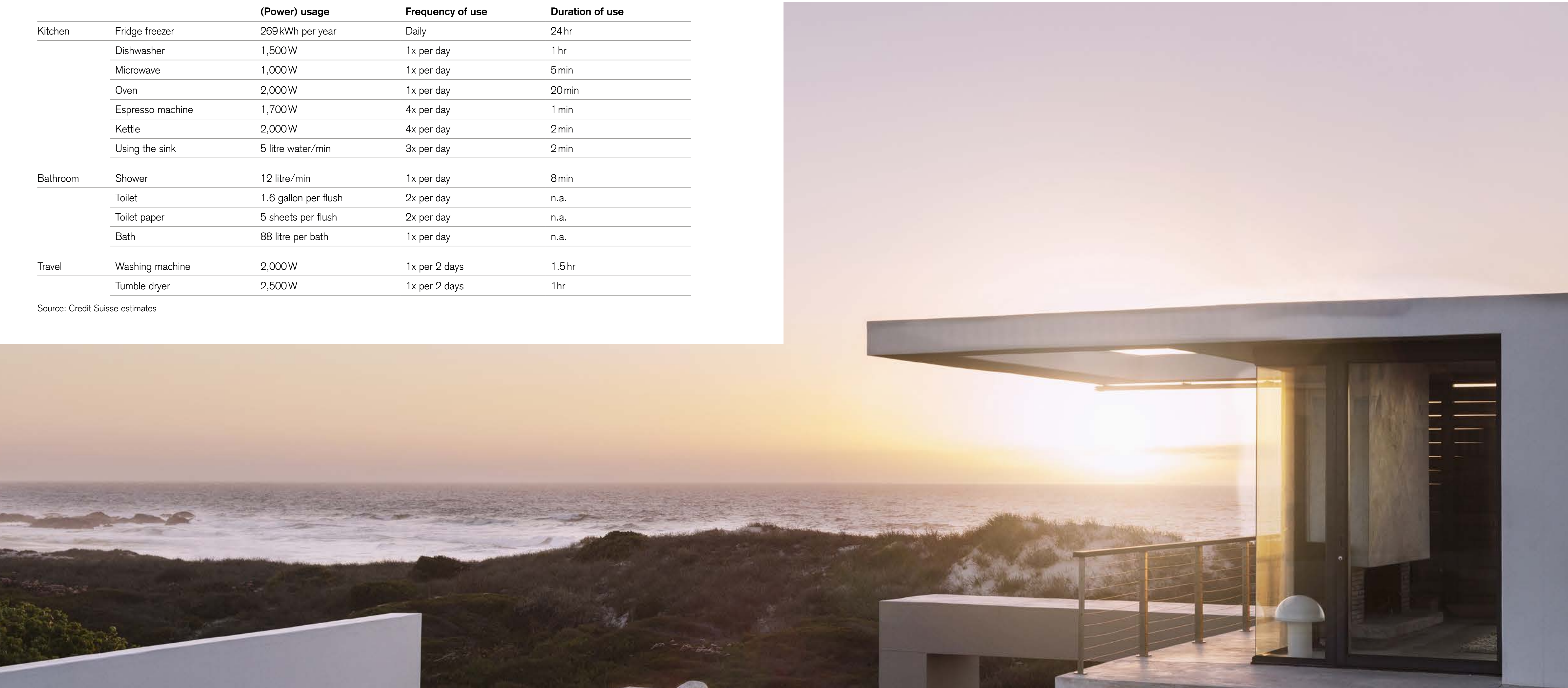


Source: Credit Suisse estimates

**Figure 12: Assumptions around usage of domestic appliances**

| | | (Power) usage | Frequency of use | Duration of use |
|---|---|---|---|---|
| Kitchen | Fridge freezer | 269 kWh per year | Daily | 24 hr |
| | Dishwasher | 1,500 W | 1x per day | 1 hr |
| | Microwave | 1,000 W | 1x per day | 5 min |
| | Oven | 2,000 W | 1x per day | 20 min |
| | Espresso machine | 1,700 W | 4x per day | 1 min |
| | Kettle | 2,000 W | 4x per day | 2 min |
| | Using the sink | 5 litre water/min | 3x per day | 2 min |
| Bathroom | Shower | 12 litre/min | 1x per day | 8 min |
| | Toilet | 1.6 gallon per flush | 2x per day | n.a. |
| | Toilet paper | 5 sheets per flush | 2x per day | n.a. |
| | Bath | 88 litre per bath | 1x per day | n.a. |
| Travel | Washing machine | 2,000 W | 1x per 2 days | 1.5 hr |
| | Tumble dryer | 2,500 W | 1x per 2 days | 1 hr |

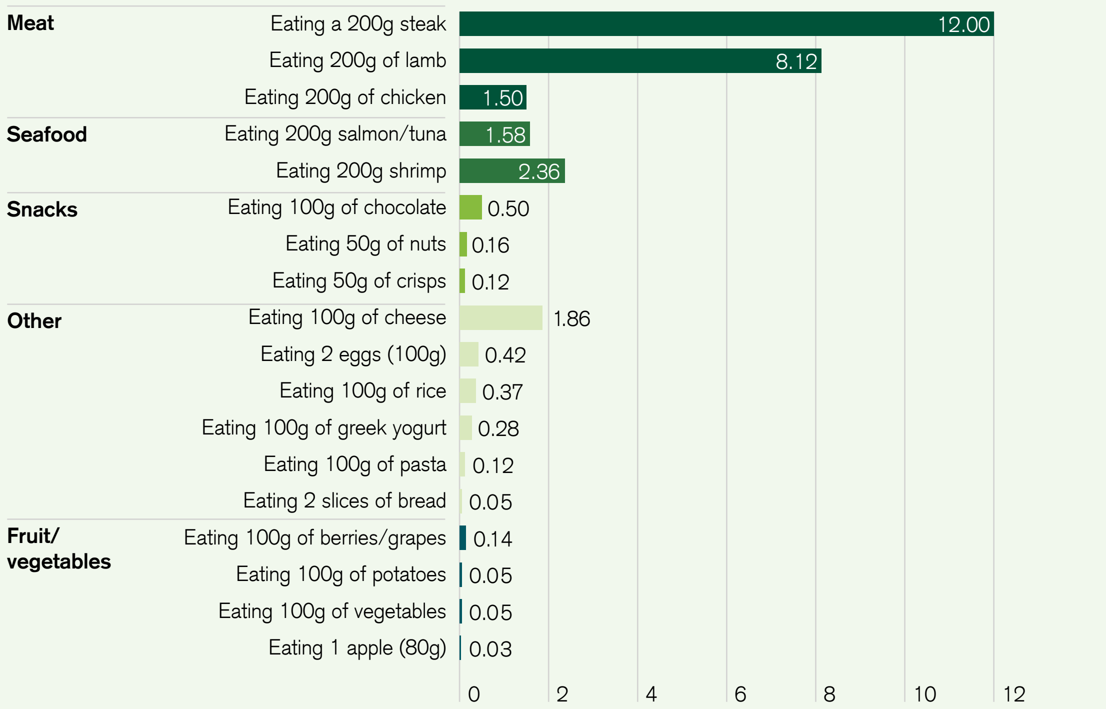
Source: Credit Suisse estimates



# Eating and drinking

As we highlighted in our recent Credit Suisse Research Institute report (The global food system), what we eat and drink has a substantial impact in terms of climate change. For the purpose of this report, we highlight the carbon footprint of a range of food and beverage products in Figure 14 and Figure 15.

Figure 14: Median carbon footprint of different food servings (kg $CO_2$)

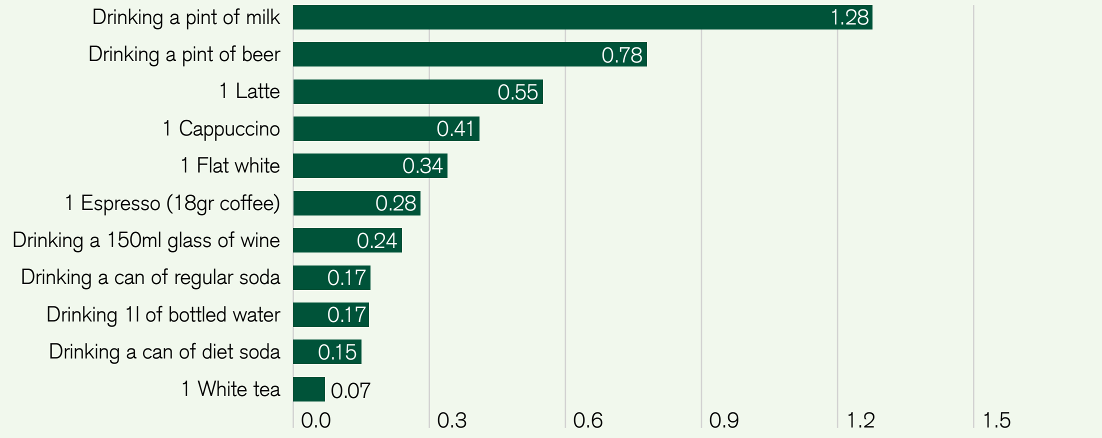


Source: Credit Suisse estimates

Food-related emission data as shown in Figure 14 probably reinforces what most of us have heard before. Eating meat has a far greater emission footprint than a more plant-based or vegetarian diet. However, it is worth highlighting that other food items such as chocolate and cheese have a relatively high emission profile too.

Beverages are far less emission intense than food; however, significant differences between them exist (Figure 15). For example, drinking a pint (just over 500ml) of milk generates 1.28kg of $CO_2$ whereas a pint of beer is almost half that at 0.78kg. Consumers worried about their personal carbon footprint might be pleased to learn that a tea with milk has the lowest carbon footprint even when assuming that the amount of water that is boiled for tea tends to be double the actual amount used for making a cup of tea.

Figure 15: Carbon footprint of different drinks (kg $CO_2$)

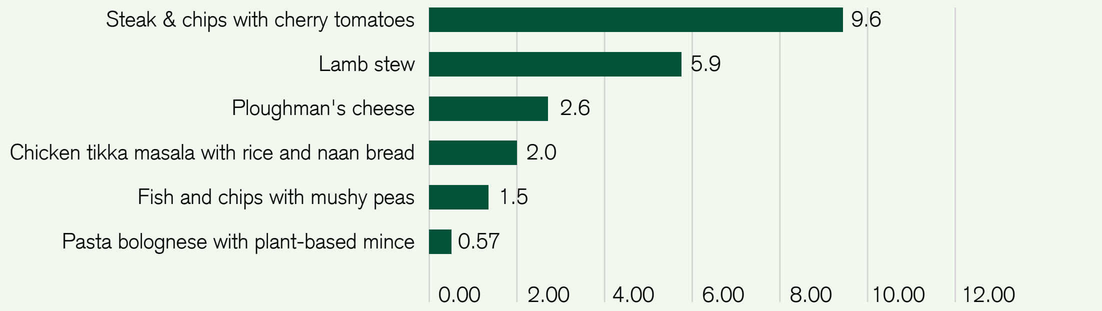


Source: Credit Suisse estimates

While these individual statistics are interesting, they may not necessarily provide most people with a sense of the carbon intensity of their meals. To provide an indication of this, we have put together a few ordinary dinners and calculated their total footprint.

For example, a meal consisting of fish and chips with mushy peas has an average $CO_2$ emission profile of c1.5kg. Having a steak with fries and cherry tomatoes on the other hand generates close to 10kg of $CO_2$. We also included a vegetarian dish consisting of pasta bolognese with a plant-based meat alternative. The footprint for this meal is the lowest of all, at just over 0.5kg of $CO_2$. In other words, a switch from a 'steak frites' to the vegetarian bolognese would result in a 94% drop in emissions.

Figure 16: Average carbon footprint for a one person dinner (kg $CO_2$)



Source: WWF, BBC Good Food, Credit Suisse estimates

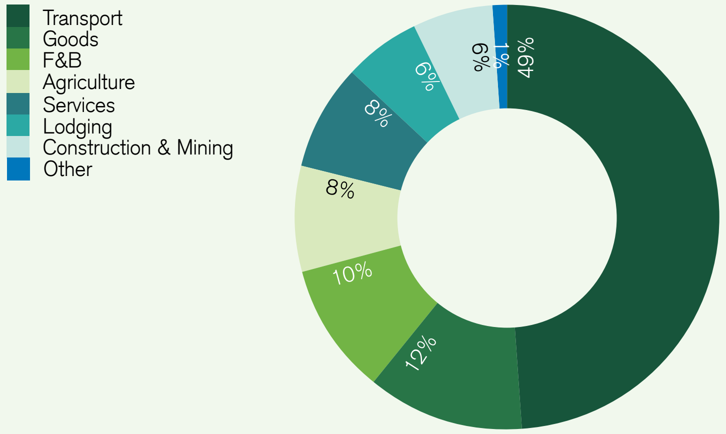
# Travel and tourism

Travel has for years been one of the structural growth themes that we track at Credit Suisse. The expanding middle class across emerging markets and the introduction of low-cost airlines created an environment that provided structural growth in airline travel and tourism as the cost of travel fell. Beyond this, though, we note that travel across all transport modes has seen strong growth during the past few decades. The downside of this, however, is that all travel modes come with sizeable carbon footprints especially when one takes a full life cycle analysis of this into account.

A study published in 2013 by Lenzen et al concluded that global tourism contributed c8% to greenhouse gas emissions (see: The carbon footprint of global tourism | Nature Climate Change). By breaking this down into the various components, the study found that almost 50% of these emissions related to the different transport modes that were used. Other areas that contributed significantly to the overall footprint included consumer goods (12%), food & beverage (10%) and agriculture (8%) (Figure 17).

In 2019 and as part of COP25 in Madrid, the World Tourism Organisation (UNWTO) published its findings in relation to transport-related $CO_2$ emissions of the tourism sector (see: Transport-related $CO_2$ Emissions of the Tourism Sector). It predicted that the number of tourist trips globally was expected to reach more than 37bn by 2030, up 85% from c20bn in 2016. Total transport-related tourism emissions were forecast by the UNWTO to reach close to 2Gt of $CO_2$ which would represent 5.3% of the overall forecast man-made emissions that were forecast by the IEA in the current policies scenario. This compares to 5% in 2016 and 3.7% in 2005. The growth in tourism trips outweighs the benefits from more fuel efficient transport modes.

**Figure 17: Carbon footprint of the global tourism industry**



Source: Nature Climate Change (2018)

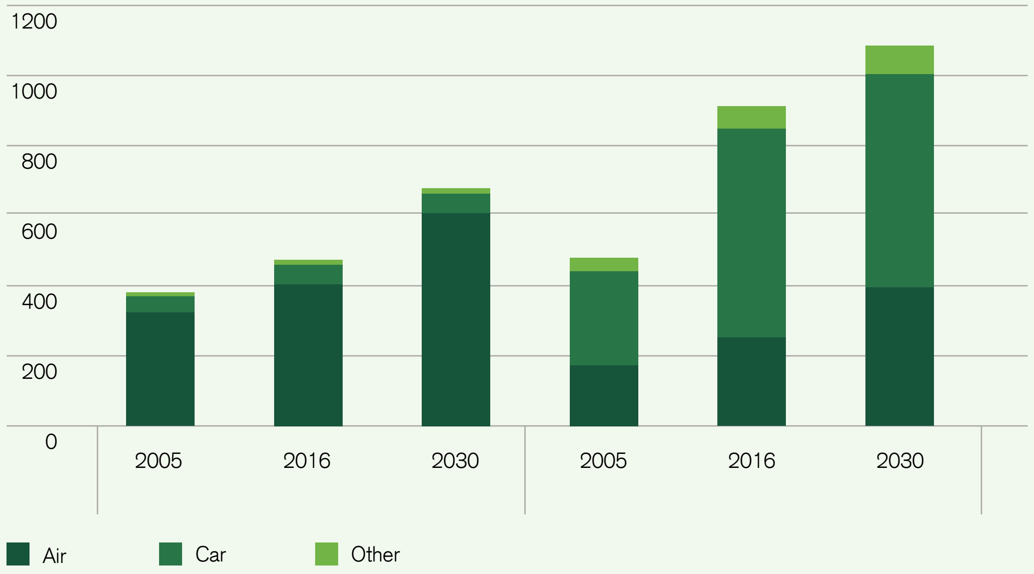


**Figure 18: Transport-related emissions from tourist arrivals by mode of transport (Mt of $CO_2$)**

Source: UNWTO

Based on the UNWTO calculations as shown in Figure 18, we draw two conclusions. Firstly, and perhaps not surprisingly, air-related emissions make up the majority of international travel. These look set to increase by c50% between 2016 and 2030. Perhaps more important is the rapid growth seen in domestic-related tourism, which we believe is largely a function of the developing middle class across emerging countries. These trips, however, are often undertaken by using cars as transport mode. By 2030 the UNWTO believes that car-related emissions will make up 56% of all domestic travel-related transport emissions and almost 40% of all tourist trips, including international ones. In order to assess how consumers can make a difference, it is therefore important to know how emission intensity differs among transport modes.

The data in Figure 19 show that long-haul flights (especially when sitting in business or first class) are the most emission-intense travel modes. The least intense are, perhaps not surprisingly, trips taken by bicycle or an e-bike.

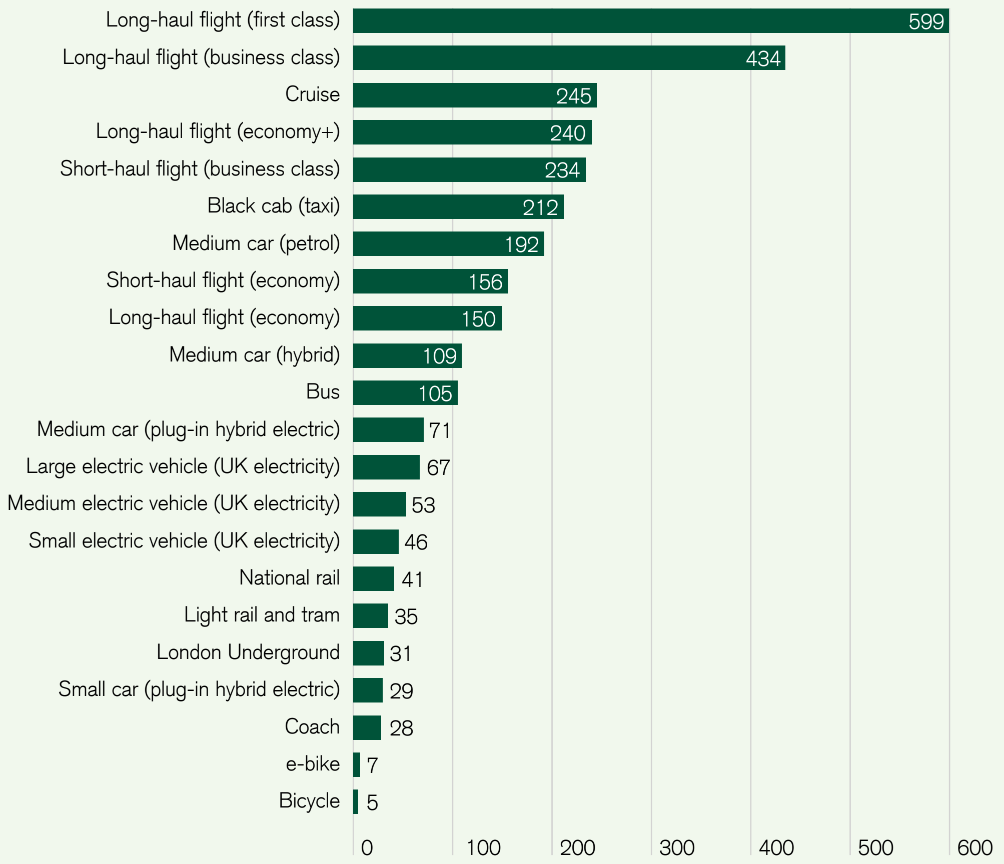
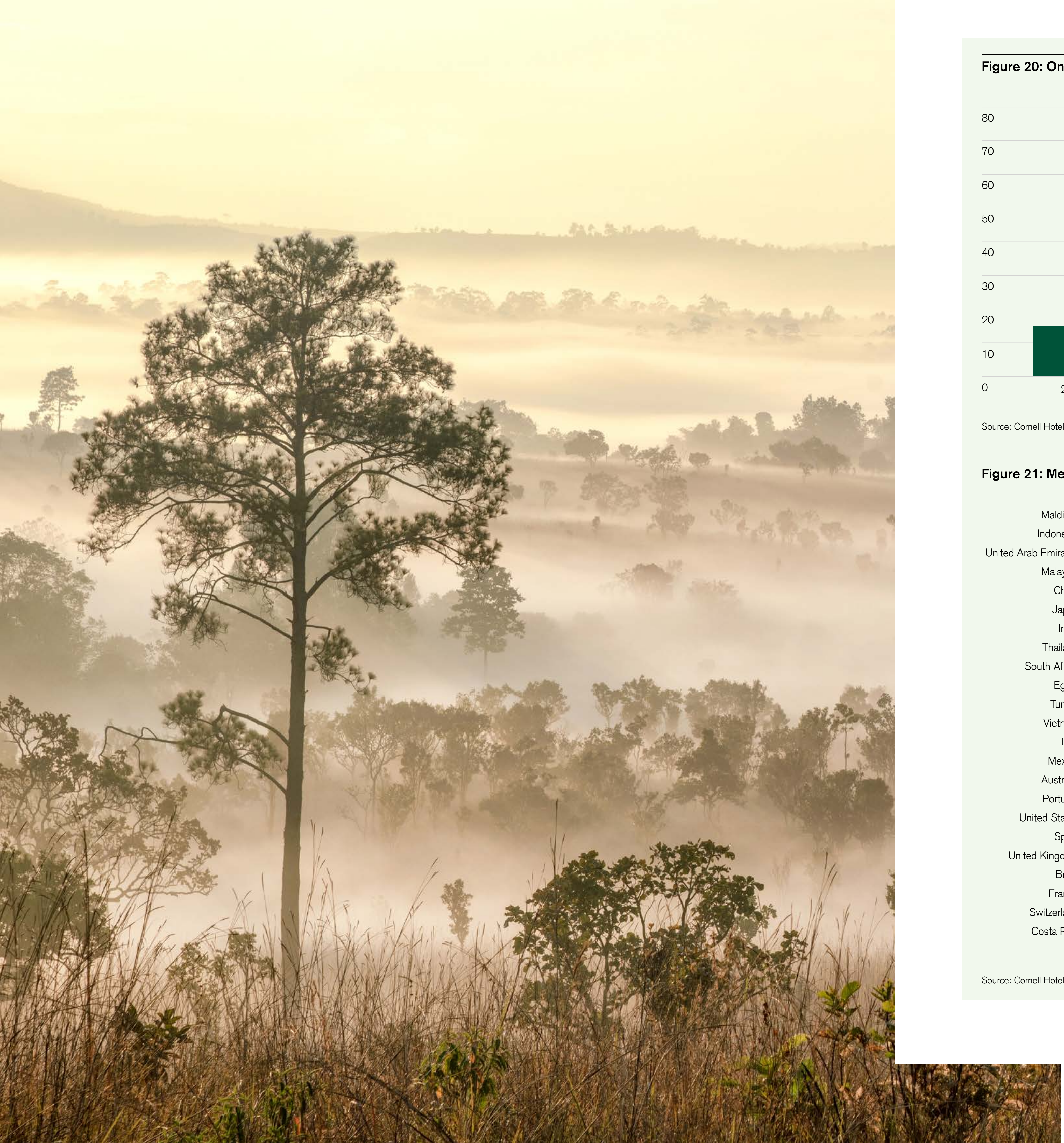


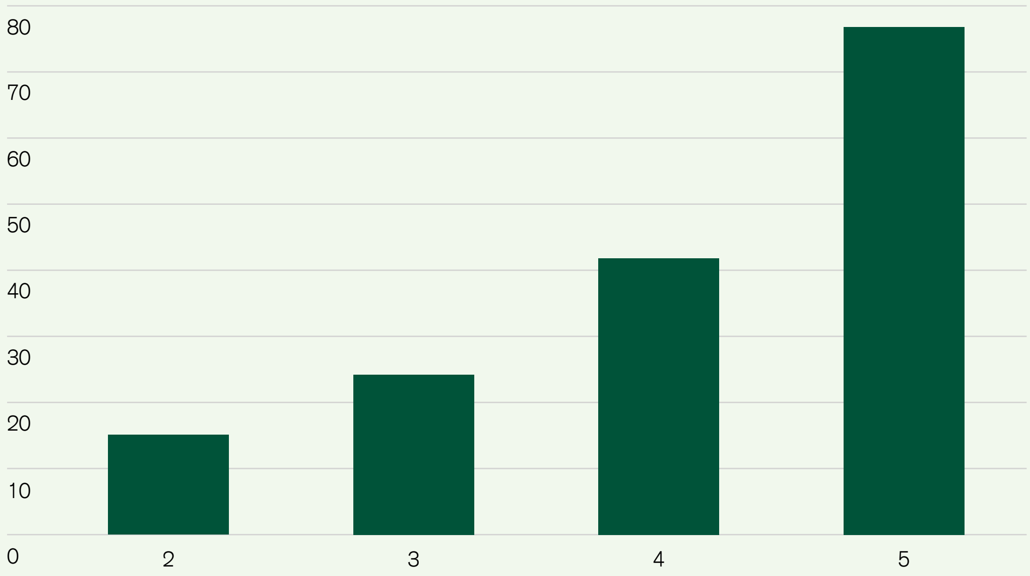
**Figure 19: Carbon footprint per km by travel mode (grams of $CO_2$)**

Source: Credit Suisse estimates

Tourism not only contributes to emissions via the travel that one needs to undertake to get to a destination but also during the stay at a hotel or resort. With this in mind, we show in Figure 20 the average carbon footprint for hotels based on their star-ranking. We use the Cornell Hotel Sustainability Benchmarking Index for this. The data show that staying one night at a two-star hotel has a median carbon footprint of c15kg of $CO_2$. For a five-star hotel, however, the emission intensity increases nearly fivefold to almost 80kg of $CO_2$.

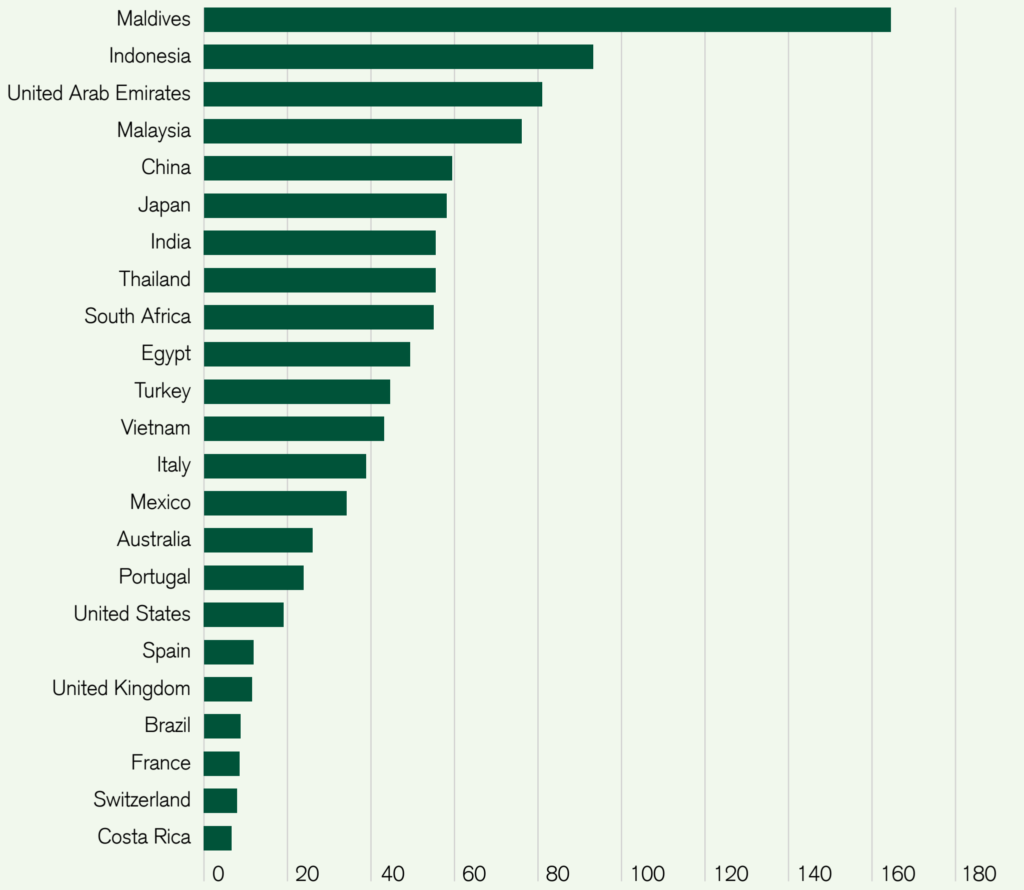


## Figure 20: One-night carbon footprint by hotel rating (kg $CO_2$)



Source: Cornell Hotel Sustainability Benchmarking Index, Credit Suisse Research

## Figure 21: Median carbon footprint for hotels (kg $CO_2$/night)



Source: Cornell Hotel Sustainability Benchmarking Index

From an environmental perspective, it matters a lot where and how you go on holiday. Data from Cornell's hotel sustainability index show that the average hotel or resort in the Maldives generates more than 160kg of $CO_2$ per night. In Costa Rica and Switzerland, on the other hand, this is less than 10kg of $CO_2$ per night (Figure 21).

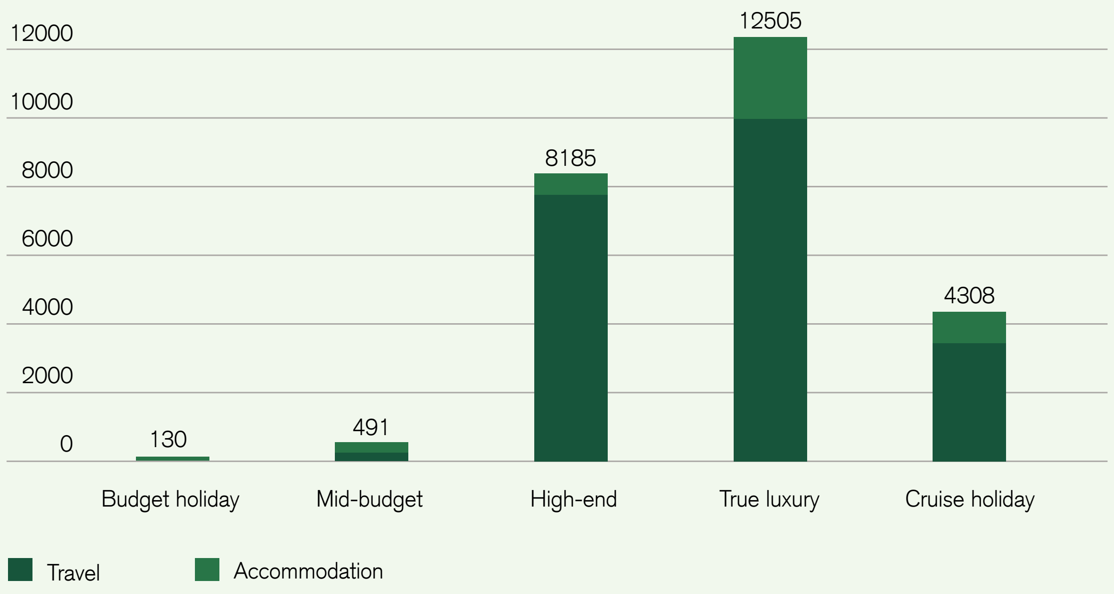
In order to make the emission intensity of travel and tourism more understandable, we have put together different types of holidays and calculated their emission profiles. These holidays range from budget holidays in two-star hotels to luxury stays at a resort and a cruise holiday.
By incorporating travel distances to the various destinations and the emission intensity per kilometre for the various transport modes assumed, we can calculate the combined total emissions for these holidays. Our results show that a true luxury two-week stay at a resort could have an emission footprint that is almost 100x that of a one-week budget holiday taken domestically. Cruise holidays are often seen to be highly emission intense. Our calculations for our cruise holiday suggest that emissions generated while on board are substantially higher than if we were to stay at a hotel. However, these cruise-related emissions would still be lower than those generated when staying at a high-end resort as our calculations for the 'True luxury' holiday suggest.

**Figure 22: Four types of holidays: budget to luxury**

| Holidays | Nights | Destination | Travel mode | Accommodation |
|---|---|---|---|---|
| Budget holiday | 7 | UK domestic | Train | 2-star hotel |
| Mid-budget | 7 | London - Nice | Air, Economy class | 3-star hotel |
| High-end | 14 | London - Los Angeles | Air, Business class | 4-star hotel |
| True luxury | 14 | London - Maldives | Air, First class | 5-star resort |
| Cruise holidays | 7 | London - Miami | Air, Premium economy | "Cruise liner (3622km round trip)" |

Source: Credit Suisse Research

**Figure 23: Emission profile for our holidays (kg $CO_2$)**

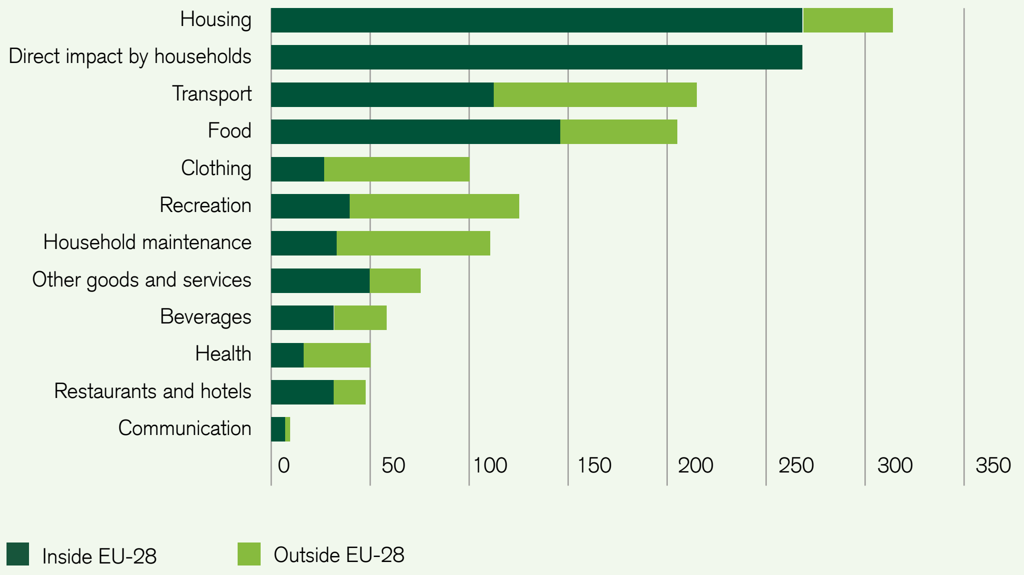


Source: Credit Suisse estimates

# Clothing and shopping

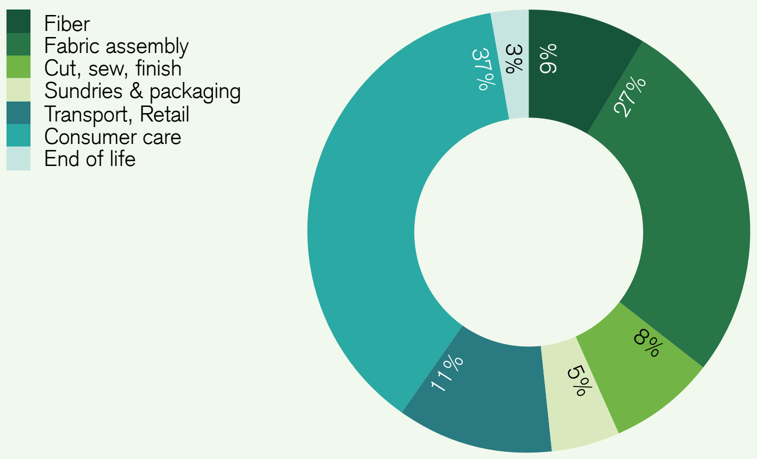
Shopping, particularly fashion, is another highly relevant area of activities that we need to consider when trying to understand our personal emission footprint. The reason for this is that estimates from various sources, such as the UN, McKinsey, and the Ellen MacArthur Foundation, put the contribution of the fashion industry to global greenhouse gas emissions at up to 10%. To put this into context, European Parliamentary Research Service (EPRS) and the UN estimate that the fashion industry's emission intensity is greater than that of all international flights and maritime shipping combined.
Fashion has a sizeable carbon footprint, is often associated with social and labor-related issues, and has a significant environmental impact in terms of water and pesticide usage. For example, the United Nations Environment Programme (UNEP) estimates that the fashion industry is the second-biggest consumer of water and produces 20% of global wastewater. Figure 24 shows for the EU-28 countries how the greenhouse gas emission profiles for the various activity areas differ. Importantly, this chart also shows what share of these emissions are generated locally and what share is imported because products are produced elsewhere. The chart highlights two important aspects in our view. Firstly, it underlines the relevance of clothing as an emission-intense activity for households. Secondly, it shows that clothing is the activity for which emissions are highly global in nature.

**Figure 24: GHG emissions (upstream) of EU-28 households (2017, indexed to textile/clothing consumption)**



Source: Netherlands Organisation for Applied Scientific Research, EU

**Figure 25: Emission intensity of one pair of Levi's 501 jeans throughout its life cycle is 33.4kg of $CO_2$ equivalent**



Source: Levi Strauss

# Fashion's footprint: not wearing clothes purchased worsens the issue

A wide range of detailed studies have explored the footprint of the broader clothing or fashion industry. Levi Strauss in 2015 produced a detailed life cycle assessment of its 501 jeans, which we believe provides a clear insight into the drivers behind the intensity of fashion more broadly. The company found that one pair of its 501 jeans is responsible for 33kg of $CO_2$ emissions throughout its life. In 2018, more than 4.5 billion pairs of jeans were sold globally. Using Levi Strauss's analysis, we calculate that one year of jeans sales alone contribute c150 million tonnes of $CO_2$ to global greenhouse gas emissions.

Other studies that provide insight into the emission footprint of the fashion industry include those produced by WARP in the UK (A Carbon Footprint for UK Clothing and opportunities for savings, 2012) and Roos et al (Environmental Assessment of Swedish fashion consumption, 2015). The conclusions of these studies are in line with the work done by Levi's and show that a significant driver to overall emission intensity relates to the post-production phase (e.g., washing and drying).

However, of equal relevance is the fact that a significant share of clothes are hardly or ever worn, suggesting that all emissions associated with the production, transportation, and retail of these were for nothing. For example, analysis from Weight Watchers in the UK (weightwatchers) showed that 55% of the clothes in an average woman's wardrobe and 47% of clothes in a man's wardrobe are never worn. A survey done by VoucherCloud among women in the US in 2017 found that c20% of the respondents' wardrobes were never worn.

# Shopping online is not helping fashion's footprint

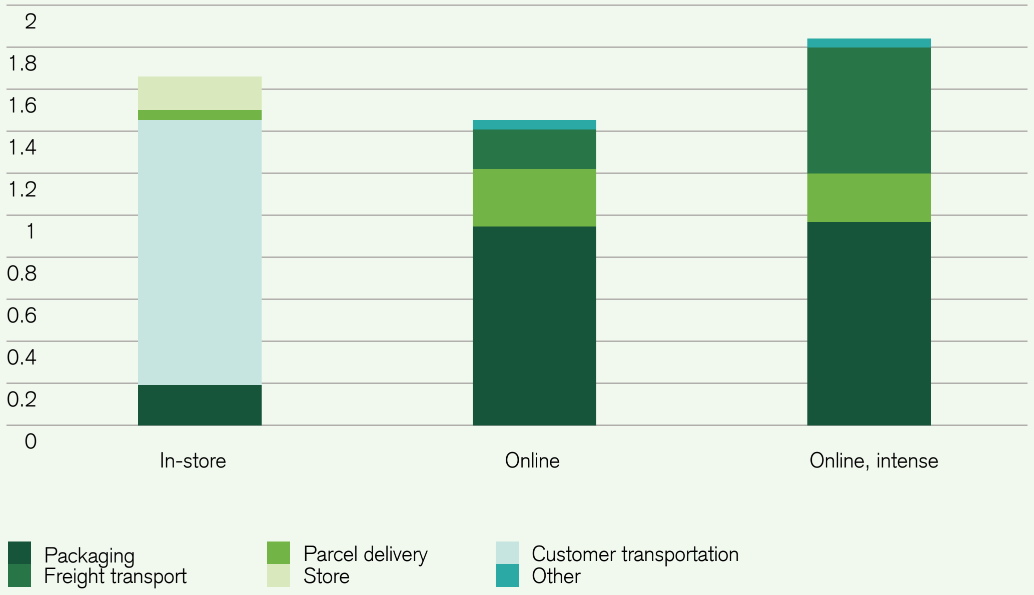
One other aspect that is worth mentioning relates to the impact of online versus offline shopping on the clothing footprint. Analysis by MIT's Center for Transportation and Logistics ("Environmental Analysis of US Online Shopping") showed that online shopping has a slightly better emission footprint than when consumers shop in-store (Figure 26). The carbon footprint of a website is smaller than that of a store, whereas parcel carriers are likely to use a more efficient delivery system than a consumer that drives to a store.

However, this conclusion changes when the buying behavior of a 'rushed consumer' is reviewed. Consumers that use 'same-day delivery' options or that order multiple pieces of the same item with the idea to return all but one put significant stress on the delivery system, which significantly increases the emission footprint of the item. In fact MIT's conclusion was that this type of online behavior was less environmentally friendly than if a consumer were to buy in-store.

Solutions to reducing the carbon footprint of clothing appear obvious, as these include investing in higher-quality clothing that lasts longer, wearing items more often, washing them less frequently and at lower temperatures, and not using tumble dryers but air-drying clothes when possible. A life cycle emission footprint would further improve if consumers opted for in-store shopping, especially when using public transport, walking, or cycling as ways to get to their shops.

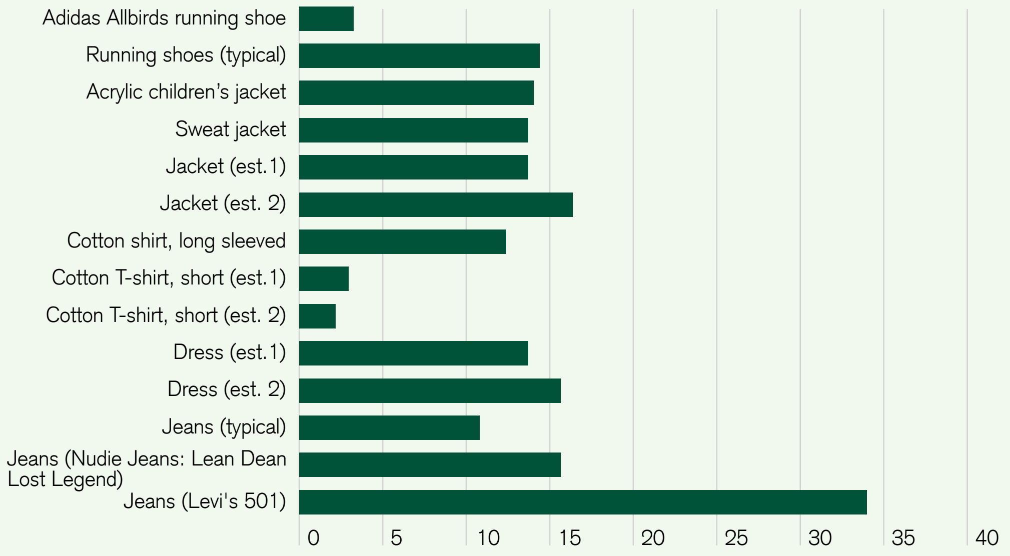
In Figure 27, we provide carbon footprint data for a range of clothing items. Our analysis suggests that estimates differ even for the same type of item. On average, however, it appears that larger clothing items tend to have a carbon intensity of 10–15kg $CO_2$ equivalent. Smaller items such as short-sleeved T-shirts emit less than 5kg of $CO_2$ equivalent during their lifespan.

**Figure 26: Emission comparison of in-store vs online shopper**



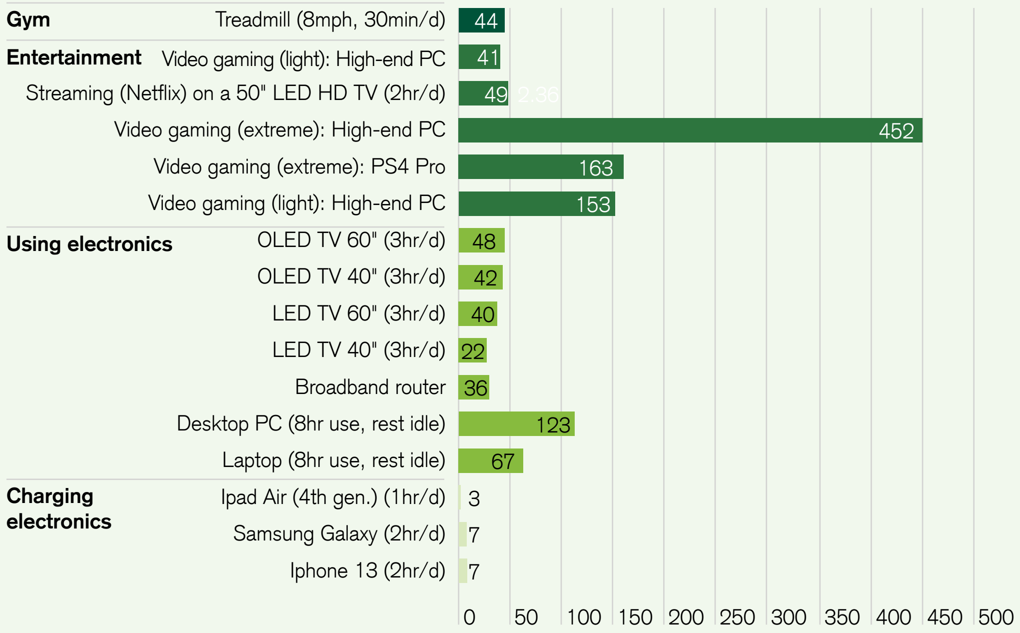
Source: MIT, Credit Suisse Research

Figure 27: Carbon footprint for a range of clothing (kg $CO_2$-e)



Source: Levi Strauss, WRAP, Roos et al (2015), Jungmichel (2010), Adidas, Mistra Future Fashion, KTH Royal Institute of Technology

Figure 28: Annual emission profile for entertainment and related activities (kg $CO_2$)



Source: Company data, IEA, batteryequivalents.com, Mills et al (2014), Greening the Beast, Credit Suisse Research

# Fitness and entertainment

Food, travel, and fashion are activities that receive a lot of attention in relation to emission intensity; however, they are not the only ones that need to be considered, in our view.

Entertainment is one area that might be overlooked by consumers as being emission intense, whether it is watching television, playing videogames, using streaming services, charging a mobile phone or tablet, running on a treadmill or using an exercise bike at the gym. All of this has a carbon footprint. In Figure 28, we summarize what these daily activities contribute to emissions.

Relative to other entertainment activities, we find that videogaming is highly emission intense. An 'extreme' gamer using a high-end PC might be generating more than 450kg of $CO_2$ per year. This compares to the 49kg of $CO_2$ that is generated by someone who streams a Netflix series for two hours each day on a 50" LED television.

Going to the gym is arguably a positive idea from a health perspective. However, if one also cares about the environment, then it stands to reason that running outside is preferred, given that we estimate a treadmill generates some 44kg of $CO_2$ per year when used for 30 minutes each day at a speed of 8 miles per hour.

# Treeprint:

## converting emissions into trees

The previous chapter outlined the emission profile for a wide range of activities that consumers are likely to undertake in the course of their daily lives. Based on this, one could draw the conclusion that in order to address climate change we would all simply need to start drinking tea, not go on holiday anymore, read a book rather than use consumer electronics, wash less frequently, and become a vegetarian. While we see some merit in these activities, individually, we believe it is unrealistic to assume that the majority of consumers globally will adopt such a lifestyle. The question, therefore, is whether something else can be done to reduce the total net impact of a consumer's lifestyle on the environment. We believe that reforestation programs can be an answer or at least part of a solution to this question.

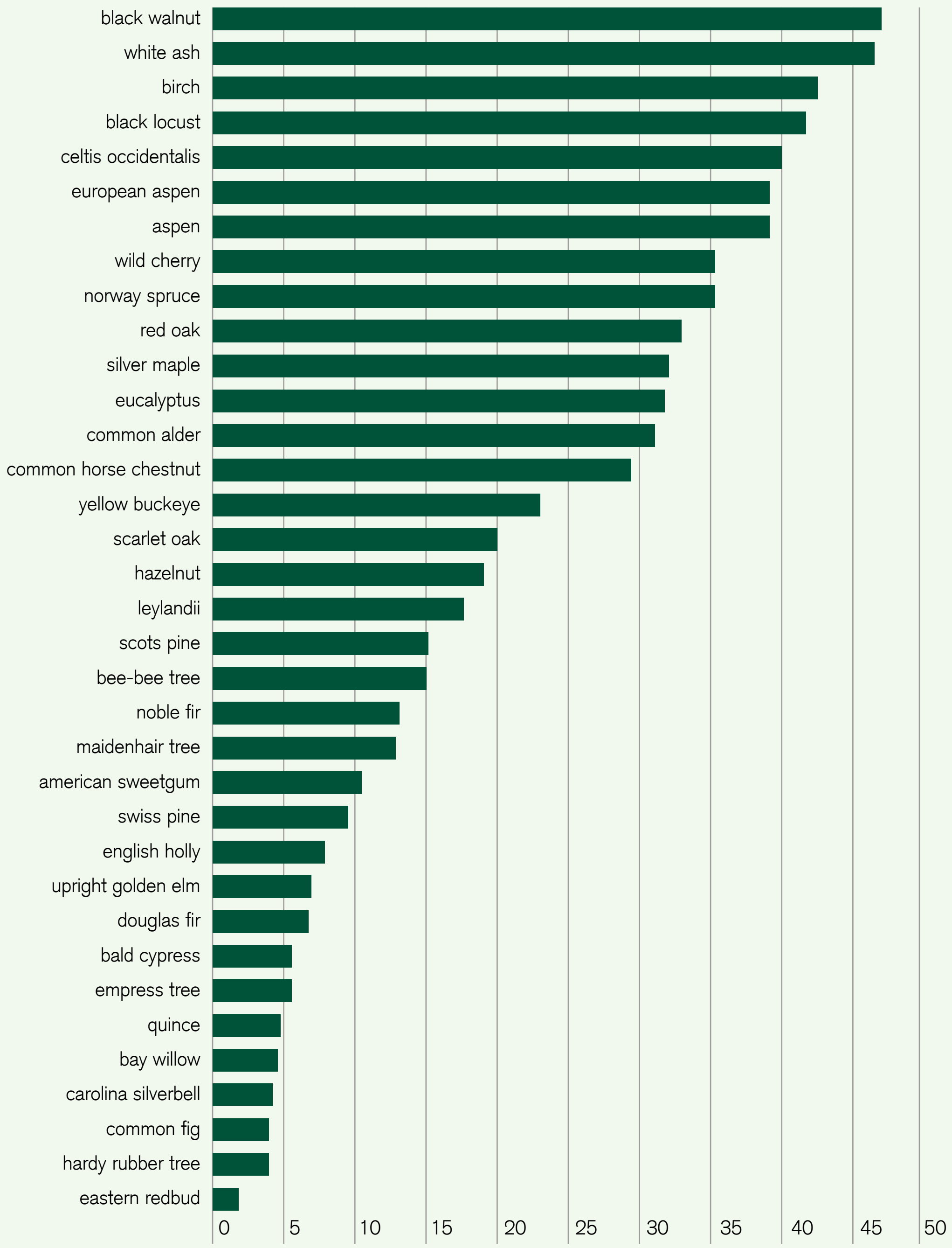
### Trees help to explain our emission footprint

The ability that trees have to store carbon is arguably a good reason for introducing reforestation as a topic in relation to climate change. However, we believe that the concept of trees can also help in making the topic of climate change and the impact of one's personal lifestyle on it more real and less academic. It likely remains difficult for most consumers to grasp how bad an individual activity is from a climate impact point of view. In other words, we believe that most people do not know how to interpret a certain number of kilograms of CO$_2$.

In order to make it easier for readers to understand the climate impact of individual activities, we introduce the concept of Treeprint, or the number of mature trees that are needed to offset the emissions generated with a certain activity. Knowing that one has to plant, say, 100 trees to offset the emission intensity of a certain activity is, in our view, more likely to resonate with the average consumer than saying that this activity generates 1,000 kilograms of CO$_2$. Trees, therefore, function both as a conceptual solution as much as a real-life answer to reducing climate change.

We recognize that estimating how many trees are needed to offset a certain level of emissions is not an exact science. A great number of variables play a role including the type of tree, the age of the tree, and where and how the tree is planted. In our **The ROE of a Tree** report, we highlighted that average carbon storage for mature trees could be more than 20kg of CO$_2$ per year. Work from the Barcham nursery in the UK is helpful here as it provides very granular data in terms of life expectancy both in rural and urban environments and total carbon storage potential at maturity for hundreds of different tree types (see: Barcham). Figure 29 provides implied annual storage numbers for just some of these. Based on Figure 29 alone, we conclude that our assumption that average carbon storage for a tree of 20–25kg per year is achievable.

## Figure 29: Implied carbon storage potential per year



Source: Barcham, Credit Suisse research

Based on this data, we have recalculated the emission intensity of the activities highlighted on the previous pages into the number of mature trees that are needed to offset these emissions. In order to indicate the impact of planting trees in different climates, we show the number of trees that are needed for each activity using three different trees that can be planted in a temperate, boreal or, tropical climate.

For example, on our analysis, a steak and chips dinner requires 12 mature Birch trees in a temperate climate to offset the related emission footprint. Taking an eight-minute shower each day requires up to ten trees, whereas that luxury holiday would need up to almost 400 trees. If you have two lattes per day, then you need 13 tropical trees to go net zero on this.

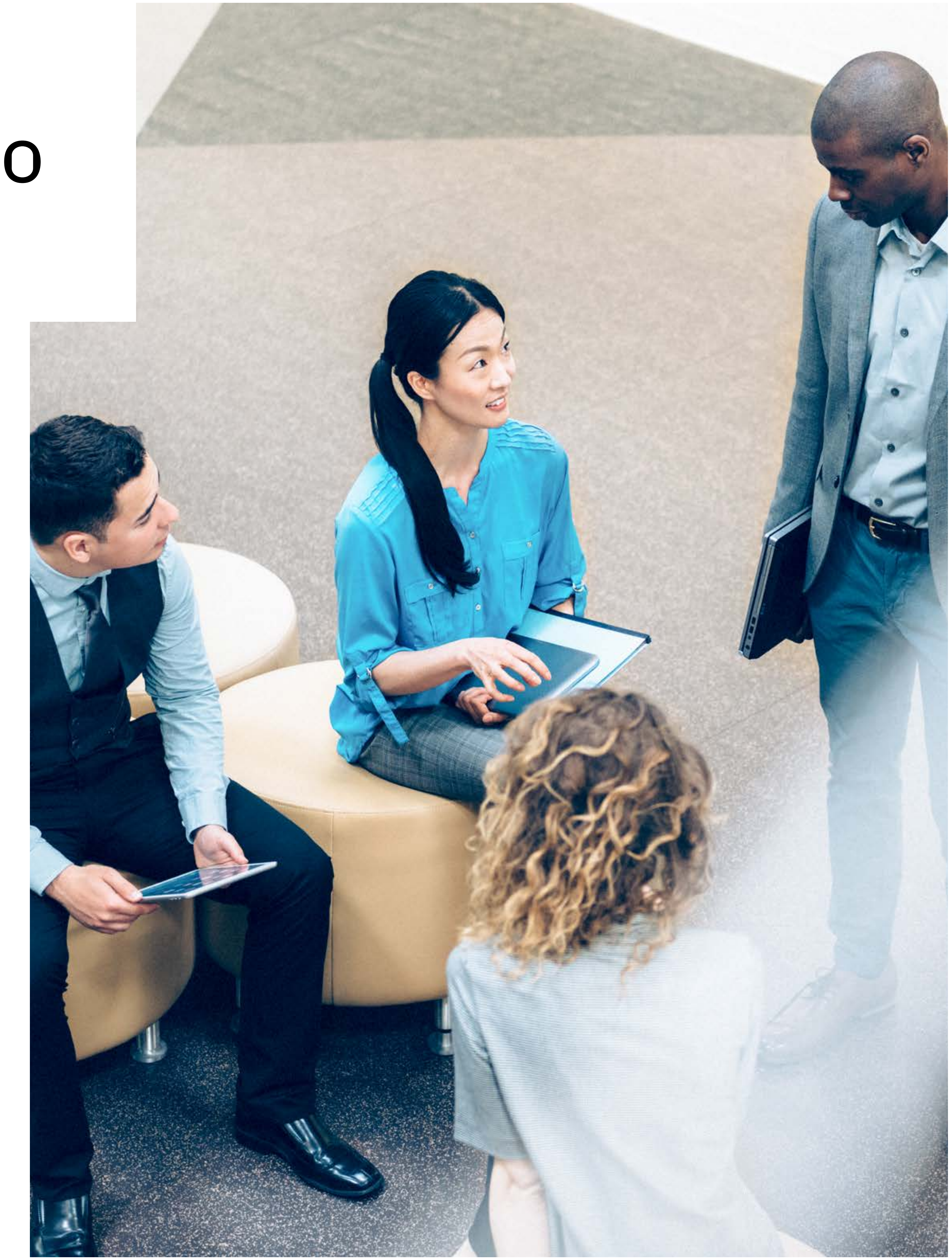
## Figure 30: The Treeprint of individual activities

| | | | | | | Trees to offset annual emissions by forest type | | |
|---|---|---|---|---|---|---|---|---|
| **Category** | **Activity** | **Emissions** | **unit** | **Assumptions** | **Annual $CO_2$ emissions (in $kgCO_2$)** | **Temperate - Birch tree (43kg $CO_2$/year)** | **Boreal - Spruce tree (36kg $CO_2$/year)** | **Tropical - Eucalyptus tree (32kg $CO_2$/year)** |
| **Eating and drinking** | | | | | | | | |
| **Meat** | Eating a 200g steak | 12.0 | kg $CO_2$ | 3 times a week | 1872 | 44 | 52 | 59 |
| | Eating 200g of lamb | 8.1 | kg $CO_2$ | 3 times a week | 1267 | 30 | 36 | 40 |
| | Eating 200g of chicken | 1.5 | kg $CO_2$ | 3 times a week | 234 | 6 | 7 | 8 |
| **Seafood** | Eating 200g salmon/tuna | 1.6 | kg $CO_2$ | Twice a week | 164 | 4 | 5 | 6 |
| | Eating 200g shrimp | 2.4 | kg $CO_2$ | Twice a week | 123 | 3 | 4 | 4 |
| **Snacks** | Eating 100g of chocolate | 0.5 | kg $CO_2$ | 1 per week | 26 | 1 | 1 | 1 |
| | Eating 50g of nuts | 0.2 | kg $CO_2$ | 2 times per week | 17 | 1 | 1 | 1 |
| | Eating 50g of crisps | 0.1 | kg $CO_2$ | 3 times per week | 19 | 1 | 1 | 1 |
| **Other** | Eating 100g of cheese | 1.9 | kg $CO_2$ | 100g per week | 97 | 3 | 3 | 4 |
| | Eating 2 eggs (100g) | 0.4 | kg $CO_2$ | Four times a week | 87 | 3 | 3 | 3 |
| | Eating 100g of rice | 0.4 | kg $CO_2$ | Three times a week | 58 | 2 | 2 | 2 |
| **Fruit/vegetables** | Eating 100g of berries/grapes | 0.1 | kg $CO_2$ | 2 times per week | 15 | 1 | 1 | 1 |
| | Eating 100g of potatoes | 0.1 | kg $CO_2$ | 2 times per week | 5 | 1 | 1 | 1 |
| | Eating 100g of vegetables | 0.1 | kg $CO_2$ | 4 times per week | 10 | 1 | 1 | 1 |
| | Eating 1 apple (80g) | 0.0 | kg $CO_2$ | 4 times per week | 7 | 1 | 1 | 1 |
| **Beverages** | Drinking a pint of milk | 1.3 | kg $CO_2$ | 1 per day | 466 | 11 | 13 | 15 |
| | Drinking a pint of beer | 0.8 | kg $CO_2$ | 1 per day | 285 | 7 | 8 | 9 |
| | 1 Latte | 0.6 | kg $CO_2$ | 2 per day | 402 | 10 | 12 | 13 |
| | 1 Cappuccino | 0.4 | kg $CO_2$ | 2 per day | 299 | 7 | 9 | 10 |
| | 1 Flat white | 0.3 | kg $CO_2$ | 2 per day | 248 | 6 | 7 | 8 |
| | 1 Espresso (18g coffee) | 0.3 | kg $CO_2$ | 2 per day | 204 | 5 | 6 | 7 |
| | Drinking a 150ml glass of wine | 0.2 | kg $CO_2$ | 1 glass of 150 ml per day | 88 | 3 | 3 | 3 |
| | Drinking a can of regular soda | 0.2 | kg $CO_2$ | 1 per day | 62 | 2 | 2 | 2 |
| | Drinking 1l of bottled water | 0.2 | kg $CO_2$ | Two litres a day | 121 | 3 | 4 | 4 |
| | Drinking a can of diet soda | 0.2 | kg $CO_2$ | 1 per day | 55 | 2 | 2 | 2 |
| | 1 White tea | 0.1 | kg $CO_2$ | 2 per day | 51 | 2 | 2 | 2 |
| **One person dinner** | Pasta bolognese with plant-based mince | 0.6 | kg $CO_2$ | Once a week | 30 | 1 | 1 | 1 |
| | Fish and chips with mushy peas | 1.5 | kg $CO_2$ | Once a week | 80 | 2 | 3 | 3 |
| | Chicken tikka masala with rice and naan bread | 2.0 | kg $CO_2$ | Once a week | 106 | 3 | 3 | 4 |
| | Ploughman's cheese | 2.6 | kg $CO_2$ | Once a week | 135 | 4 | 4 | 5 |
| | Lamb stew | 5.9 | kg $CO_2$ | Once a week | 308 | 8 | 9 | 10 |
| | Steak and chips with cherry tomatoes | 9.6 | kg $CO_2$ | Once a week | 499 | 12 | 14 | 16 |
| **Entertainment and related activities** | | | | | | | | |
| **Charging electronics** | Iphone 13 (2hr/d) | 7.49 | kg $CO_2$ | 2hrs a day, once every two days | 7 | 1 | 1 | 1 |
| | Samsung Galaxy (2hr/d) | 7.49 | kg $CO_2$ | 2hrs a day, once every two days | 7 | 1 | 1 | 1 |
| | Ipad Air (4th gen.) (1hr/d) | 3.00 | kg $CO_2$ | 1hr a day, once a week | 3 | 1 | 1 | 1 |
| **Using electronics** | Laptop (8hr use, rest idle) | 67.29 | kg $CO_2$ | 8hr use, 250 work-days | 67 | 2 | 2 | 3 |
| | Desktop PC (8hr use, rest idle) | 123.10 | kg $CO_2$ | 8hr use, 250 work-days | 123 | 3 | 4 | 4 |
| | Broadband router | 35.95 | kg $CO_2$ | All time use, 365 days a year | 36 | 1 | 1 | 2 |
| | LED TV 40" (3hr/d) | 22.47 | kg $CO_2$ | 3 hours a day | 22 | 1 | 1 | 1 |
| | LED TV 60" (3hr/d) | 39.54 | kg $CO_2$ | 3 hours a day | 40 | 1 | 2 | 2 |
| | OLED TV 40" (3hr/d) | 32.35 | kg $CO_2$ | 3 hours a day | 32 | 1 | 1 | 2 |
| | OLED TV 60" (3hr/d) | 48.08 | kg $CO_2$ | 3 hours a day | 48 | 2 | 2 | 2 |
| **Entertainment** | Video gaming (light): PS4 Pro | 40.62 | kg $CO_2$ | Once a week | 41 | 1 | 2 | 2 |
| | Video gaming (light): High-end PC | 153.05 | kg $CO_2$ | Once a week | 153 | 4 | 5 | 5 |
| | Video gaming (extreme): PS4 Pro | 163.31 | kg $CO_2$ | Once a week | 163 | 4 | 5 | 6 |
| | Video gaming (extreme): High-end PC | 451.78 | kg $CO_2$ | Once a week | 452 | 11 | 13 | 15 |
| | Streaming (Netflix) on a 50" LED HD TV (2hr/d) | 48.67 | kg $CO_2$ | 2 hours a day | 49 | 2 | 2 | 2 |
| **Gym** | Treadmill (8mph, 30min/d) | 44.33 | kg $CO_2$ | 30mins/d, five days a week | 44 | 2 | 2 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **In and around the house** | | | | | | | | |
| **Kitchen** | Fridge freezer (300w) | | | | 122 | 3 | 4 | 4 |
| | Dishwasher (1500W) | | | | 248 | 6 | 7 | 8 |
| | Microwave (1000W) | | | | 14 | 1 | 1 | 1 |
| | Oven (2000W) | | | | 110 | 3 | 4 | 4 |
| | Espresso coffee machine | | | | 19 | 1 | 1 | 1 |
| | Kettle (2000W) | | | | 55 | 2 | 2 | 2 |
| | Using the sink | | | | 96 | 3 | 3 | 4 |
| **Bathroom** | Shower | | | | 308 | 8 | 9 | 10 |
| | Toilet | | | | 99 | 3 | 3 | 4 |
| | Toilet paper | | | | 7 | 1 | 1 | 1 |
| | Bath | | | | 283 | 7 | 8 | 9 |
| **Washing** | Washing machine (2000W) | | | | 248 | 6 | 7 | 8 |
| | Tumble dryer (2500W) | | | | 207 | 5 | 6 | 7 |
| **Travel and tourism** | | | | | | | | |
| **Transportation** | Bicycle | 5.0 | g $CO_2$ per km travelled | 5 kilometres per day for 200 days | 5 | 1 | 1 | 1 |
| | e-bike | 7.0 | g $CO_2$ per km travelled | 5 kilometres per day for 100 days | 4 | 1 | 1 | 1 |
| | Coach | 27.8 | g $CO_2$ per km travelled | 10 kilometres per day for 250 days | 69 | 2 | 2 | 3 |
| | Small car (plug-in hybrid electric) | 29.4 | g $CO_2$ per km travelled | 10 kilometres per day for 250 days | 73 | 2 | 3 | 3 |
| | London Underground | 30.8 | g $CO_2$ per km travelled | 10 kilometres per day for 250 days | 77 | 2 | 3 | 3 |
| | Light rail and tram | 35.1 | g $CO_2$ per km travelled | 10 kilometres for 100 days | 35 | 1 | 1 | 2 |
| | National rail | 41.2 | g $CO_2$ per km travelled | 1000 kilometres a year | 41 | 1 | 2 | 2 |
| | Small electric vehicle (UK electricity) | 45.7 | g $CO_2$ per km travelled | 20 kilometres a day for 250 days | 183 | 5 | 6 | 6 |
| | Medium electric vehicle (UK electricity) | 53.2 | g $CO_2$ per km travelled | 20 kilometres a day for 250 days | 213 | 5 | 6 | 7 |
| | Large electric vehicle (UK electricity) | 66.9 | g $CO_2$ per km travelled | 20 kilometres a day for 250 days | 268 | 7 | 8 | 9 |
| | Medium car (plug-in hybrid electric) | 70.8 | g $CO_2$ per km travelled | 20 kilometres a day for 250 days | 283 | 7 | 8 | 9 |
| | Bus | 104.7 | g $CO_2$ per km travelled | 10 kilometres per day for 250 days | 262 | 7 | 8 | 9 |
| | Medium car (hybrid) | 109.0 | g $CO_2$ per km travelled | 20 kilometres a day for 250 days | 436 | 11 | 13 | 14 |
| | Long-haul flight (economy) | 149.8 | g $CO_2$ per km travelled | 2 trips a year (London - New York, 5571 km One-way) | 3,338 | 78 | 93 | 105 |
| | Short-haul flight (economy) | 155.7 | g $CO_2$ per km travelled | 2 short haul trips a year (London - Paris, 345 km One-way) | 215 | 5 | 6 | 7 |
| | Medium car (petrol) | 192.3 | g $CO_2$ per km travelled | 20 kilometres a day for 250 days | 769 | 18 | 22 | 25 |
| | Black cab (taxi) | 211.8 | g $CO_2$ per km travelled | 10 kilometres a day for 250 days | 424 | 10 | 12 | 14 |
| | Short-haul flight (business class) | 233.6 | g $CO_2$ per km travelled | 2 short haul trips a year (London - Paris, 345 km One-way) | 322 | 8 | 9 | 11 |
| | Long-haul flight (economy+) | 239.7 | g $CO_2$ per km travelled | 1 trip a year (London - New York, 5571 km One-way) | 2,671 | 63 | 75 | 84 |
| | Cruise | 245.0 | g $CO_2$ per km travelled | 1 trip of 3622km | 887 | 21 | 25 | 28 |
| | Long-haul flight (business class) | 434.5 | g $CO_2$ per km travelled | 2 trips a year (London - New York, 5571 km One-way) | 9,682 | 226 | 269 | 303 |
| | Long-haul flight (first class) | 599.3 | g $CO_2$ per km travelled | 1 trips a year (London - New York, 5571 km One-way) | 13,354 | 311 | 371 | 418 |
| **Hotel stay by property rating** | One night stay at a 2-star hotel | 15.1 | kg $CO_2$ | 7 nights stay a year | 106 | 3 | 3 | 4 |
| | One night stay at a 3-star hotel | 24.2 | kg $CO_2$ | 7 nights stay a year | 170 | 4 | 5 | 6 |
| | One night stay at a 4-star hotel | 41.8 | kg $CO_2$ | 7 nights stay a year | 293 | 7 | 9 | 10 |
| | One night stay at a 5-star hotel | 76.8 | kg $CO_2$ | 7 nights stay a year | 538 | 13 | 15 | 17 |
| **Hotel stay by country** | Costa Rica | 6.6 | kg $CO_2$ | 7 nights stay a year | 46 | 2 | 2 | 2 |
| | Switzerland | 8.0 | kg $CO_2$ | 7 nights stay a year | 56 | 2 | 2 | 2 |
| | France | 8.5 | kg $CO_2$ | 7 nights stay a year | 60 | 2 | 2 | 2 |
| | Brazil | 8.7 | kg $CO_2$ | 7 nights stay a year | 61 | 2 | 2 | 2 |
| | United Kingdom | 11.5 | kg $CO_2$ | 7 nights stay a year | 80 | 2 | 3 | 3 |
| | Spain | 11.8 | kg $CO_2$ | 7 nights stay a year | 83 | 2 | 3 | 3 |
| | United States | 19.1 | kg $CO_2$ | 7 nights stay a year | 134 | 4 | 4 | 5 |
| | Portugal | 23.8 | kg $CO_2$ | 7 nights stay a year | 167 | 4 | 5 | 6 |
| | Italy | 26.0 | kg $CO_2$ | 7 nights stay a year | 182 | 5 | 6 | 6 |
| | Australia | 34.1 | kg $CO_2$ | 7 nights stay a year | 239 | 6 | 7 | 8 |
| | Mexico | 38.8 | kg $CO_2$ | 7 nights stay a year | 271 | 7 | 8 | 9 |
| | Vietnam | 43.1 | kg $CO_2$ | 7 nights stay a year | 302 | 8 | 9 | 10 |
| | Turkey | 44.6 | kg $CO_2$ | 7 nights stay a year | 312 | 8 | 9 | 10 |
| | Egypt | 49.3 | kg $CO_2$ | 7 nights stay a year | 345 | 9 | 10 | 11 |
| | South Africa | 55.0 | kg $CO_2$ | 7 nights stay a year | 385 | 9 | 11 | 13 |
| | Thailand | 55.4 | kg $CO_2$ | 7 nights stay a year | 388 | 10 | 11 | 13 |
| | India | 55.5 | kg $CO_2$ | 7 nights stay a year | 389 | 10 | 11 | 13 |
| | Japan | 58.1 | kg $CO_2$ | 7 nights stay a year | 407 | 10 | 12 | 13 |
| | China | 59.4 | kg $CO_2$ | 7 nights stay a year | 416 | 10 | 12 | 13 |
| | Malaysia | 76.1 | kg $CO_2$ | 7 nights stay a year | 533 | 13 | 15 | 17 |
| | United Arab Emirates | 81.0 | kg $CO_2$ | 7 nights stay a year | 567 | 14 | 16 | 18 |
| | Indonesia | 93.3 | kg $CO_2$ | 7 nights stay a year | 653 | 16 | 19 | 21 |
| | Maldives | 164.5 | kg $CO_2$ | 7 nights stay a year | 1,151 | 27 | 32 | 36 |
| **Holiday** | Budget holiday | | kg $CO_2$ | 7 nights UK domestic budget holiday at 2-star hotel, travel by train | 130 | 4 | 4 | 5 |
| | Mid-budget | | kg $CO_2$ | 7 nights mid-budget holiday in Nice at 3-star hotel, air travel by economy class from London | 491 | 12 | 14 | 16 |
| | High-end | | kg $CO_2$ | 14 nights high-end holiday at 4-star hotel, air travel by business class from London | 8185 | 191 | 228 | 256 |
| | True luxury | | kg $CO_2$ | 14 nights luxury holiday at 5-star hotel, air travel by first class from London | 12505 | 291 | 348 | 391 |
| | Cruise holiday | | kg $CO_2$ | 7 nights cruise holiday of 3622km round trip including air travel by premium economy from London to Miami | 4308 | 101 | 120 | 135 |

Source: Credit Suisse estimates

# Consumer profiles: who are you?



We reviewed the emission intensity of individual activities so that our readers can appreciate how damaging these in isolation might be from an environmental perspective. We hope that this is helpful; however, we appreciate that readers might also want to understand how big their overall footprint is likely to be and may want to understand what they can do to offset such an emission footprint. In this chapter, we aim to provide an answer to both these questions.

Firstly, we introduce four hypothetical consumers, each of whom has a different consumption and, therefore, emission profile. Then we calculate how many mature trees would be needed to offset each consumer's emission profile. Our four different types of consumers are as follows:

- **The low travel and online consumer:** This consumer is assumed to have a diet that has a below average exposure to more emission-intense products such as red meat and dairy. He or she consumes alcohol, although this is less than the consumption of soda and teas. Travel intensity is low and focused on stays in lower star accommodations. We assume that this consumer is more active online, especially via streaming and gaming, and buys more clothing items per year.
- **The upwardly mobile consumer:** This consumer is assumed to be developing a career. As a result, we believe that this consumer will have an increased travel intensity privately but importantly also business or work related. We assume that this consumer has a somewhat greater focus on health and wellbeing, which translates into going to the gym more often.
- **The high carbon consumer:** This consumer is believed to travel extensively, likely work related. As far as spending on food and drink is concerned, we believe that this consumer likes to eat meat more than our previous two consumers. We also believe that this consumer drives a larger petrol car and uses domestic appliances more frequently.
- **The travel focused consumer:** For our final consumer, we assume that his or her lifestyle is focused on travelling, including luxurious holidays overseas. We believe that this consumer has an above-average intake of meat consumption but a below-average consumption of alcohol. Usage of bathroom facilities is assumed to be above average too.

On the following page, we provide an overview of the intensity with which a broad range of products and services are used by our four types of imaginary consumers. The reason for showing this is to enable our readers to assess how similar their lifestyle is to one of our consumers so that an estimate of their emission profile can be made.

**Figure 31: Lifestyles for four hypothetical consumers**

| | | | Hypothetical lifestyle profiles by generation | | | |
|---|---|---|---|---|---|---|
| **Category** | **Metric** | **Units** | | | | |
| | | Kg $CO_2$ per unit | Low travel online customer | Upwardly mobile customer | High carbon customer | Travel focused customer |
| **Eating** | Consumption of red meat (times per week, 100g each) | 6 | 1 | 2 | 3 | 4 |
| | Consumption of poultry (times per week, 100g each) | 0.75 | 3 | 3 | 3 | 2 |
| | Consumption of seafood (times per week, 100g each) | 0.79 | 1 | 2 | 1 | 1 |
| | Consumption of chocolate per week (g) | 0.005 | 100 | 50 | 25 | 0 |
| | Consumption of crisps per week (g) | 0.0024 | 100 | 75 | 50 | 25 |
| | Consumption of cheese per week (g) | 0.0186 | 10 | 20 | 25 | 25 |
| | Number of eggs eaten per week | 0.21 | 2 | 4 | 4 | 3 |
| | Consumption of bread (times per week, 2 slices each) | 0.05 | 6 | 3 | 4 | 5 |
| | Consumption of Greek yogurt (times per week, 100g each) | 0.28 | 1 | 4 | 3 | 2 |
| | Consumption of vegetables per week (times per week, 100g each) | 0.05 | 4 | 5 | 6 | 6 |
| | Consumption of fruit per week (times per week, 100g each) | 0.1 | 5 | 3 | 4 | 5 |
| | Consumption of rice per week (times per week, 100g each) | 0.37 | 3 | 3 | 3 | 2 |
| | Consumption of pasta per week (times per week, 100g each) | 0.12 | 3 | 2 | 2 | 1 |
| | Consumption of potatoes per week (times per week, 100g each) | 0.05 | 2 | 2 | 2 | 4 |
| **Drinking** | Number of beer units per week | 0.78 | 5 | 7 | 4 | 2 |
| | Number of wine units per week | 0.24 | 2 | 4 | 7 | 4 |
| | Number of (diet) soda cans per week | 0.16 | 7 | 7 | 3 | 1 |
| | Number of coffees per day | 0.40 | 1 | 4 | 5 | 3 |
| | Litres of bottled water per day | 0.17 | 0.5 | 2.0 | 1.5 | 1.0 |
| | Number of teas per day | 0.07 | 4 | 1 | 0 | 5 |
| | Number of units of milk per week | 1.28 | 4 | 2 | 2 | 2 |
| **Travel** | Number of times taking long-haul return flights per year (business class) (3500km) | 0.434 | 0 | 2 | 4 | 2 |
| | Number of times taking long-haul return flights per year (premier economy) | 0.24 | 0 | 1 | 1 | 0 |
| | Number of times taking short-haul return flights per year (business) (500km) | 0.234 | 0 | 0 | 2 | 0 |
| | Number of times taking short-haul return flights per year (economy) | 0.156 | 2 | 10 | 15 | 5 |
| | Average km in a car per year (large, petrol) | 0.283 | 0 | 0 | 10000 | 15000 |
| | Average km in a car per year (medium, petrol) | 0.192 | 0 | 5000 | 0 | 0 |
| | Average km in a car per year (small, petrol) | 0.154 | 1000 | | | |
| | Average km in a car per year (large, electric) | 0.067 | | | | |
| | Average km in a car per year (medium, electric) | 0.053 | | | | |
| | Average km in a car per year (small, electric) | 0.046 | | | | |
| | Number of days using intra city public transport per week | | 5 | 5 | 3 | 1 |
| | Average distance travelled by public transport each time (km) | 0.033 | 5 | 20 | 14 | 10 |
| | Number of times using long distance rail/bus travel per month | | 2 | 1 | 0 | 0 |
| | Average distance travelled by long distance rail each time (single, km) | 0.0345 | 200 | 100 | | |
| | Average km cycling per week | 0.005 | 50 | 50 | 0 | 0 |
| **Tourism** | Average nights spent in a 2-star hotel per year | 15.1 | 5 | | | |
| | Average nights spent in a 3-star hotel per year | 24.2 | 5 | | | |
| | Average nights spent in a 4-star hotel per year | 41.8 | | 10 | | 5 |
| | Average nights spent in a 5-star hotel per year | 76.8 | | 10 | 20 | 10 |
| | Average nights spent in high-end luxury hotel/cruise per year | 145 | | | | 10 |
| **Fitness** | Number of times used treadmill per week (30min each) | 0.12 | 3 | 5 | 3 | 2 |
| **Entertainment** | Average time per day spent watching regular broadcast TV (in hours) | 0.02 | 1.0 | 1.0 | 1.0 | 2.5 |
| | Average time per day spent watching streaming TV (e.g., Netflix) (in hours) | 0.066 | 1.0 | 2.0 | 2.0 | 2.0 |
| | Average time per day spent video gaming (hours) | 0.10 | 2.5 | 1.0 | 0.0 | 0.0 |
| | Use of a broadband router | 36 | 1 | 1 | 1 | 1 |
| | Average time per day using a desktop (hours) | 100 | 3.0 | 8.0 | 6.0 | 1.0 |
| | Average time per day using a laptop (hours) | 50 | 3.0 | 1.0 | 1.0 | 1.0 |
| | Average time per day charging a smartphone (hours) | 25 | 2.0 | 2.0 | 2.0 | 1.0 |
| **In and around the house** | Number of times using washing machine per week (1.5hr wash each) | 1.2 | 1 | 2 | 3 | 2 |
| | Number of times using the shower per week (8min each) | 0.8 | 7 | 7 | 6 | 5 |
| | Number of times taking a bath per week (88 litres each) | 0.8 | 0 | 0 | 1 | 2 |
| | Number of times flushing a toilet per day (1.6 gallons of water each) | 0.1 | 2 | 2 | 3 | 4 |
| | Use of a fridge freezer | 122 | 1 | 1 | 1 | 1 |
| | Number of times a dishwasher is used per week (1500W, 1hr) | 0.6 | 1 | 3 | 5 | 3 |
| | Number of times an oven is used per week (2000W, 20min) | 0.3 | 3 | 4 | 5 | 5 |
| **Clothing/fashion** | Number of jeans/trousers bought per year | 20 | 3 | 3 | 2 | 2 |
| | Number of shirts bought per year | 11 | 4 | 4 | 4 | 3 |
| | Number of jackets bought per year | 13.5 | 2 | 1 | 2 | 0 |
| | Number of suits/dresses bought per year | 15 | 1 | 3 | 2 | 0 |
| | Number of t-shirts/underwear small items bought per year | 3 | 10 | 8 | 6 | 5 |

Source: Credit Suisse estimates

# Emission profiles

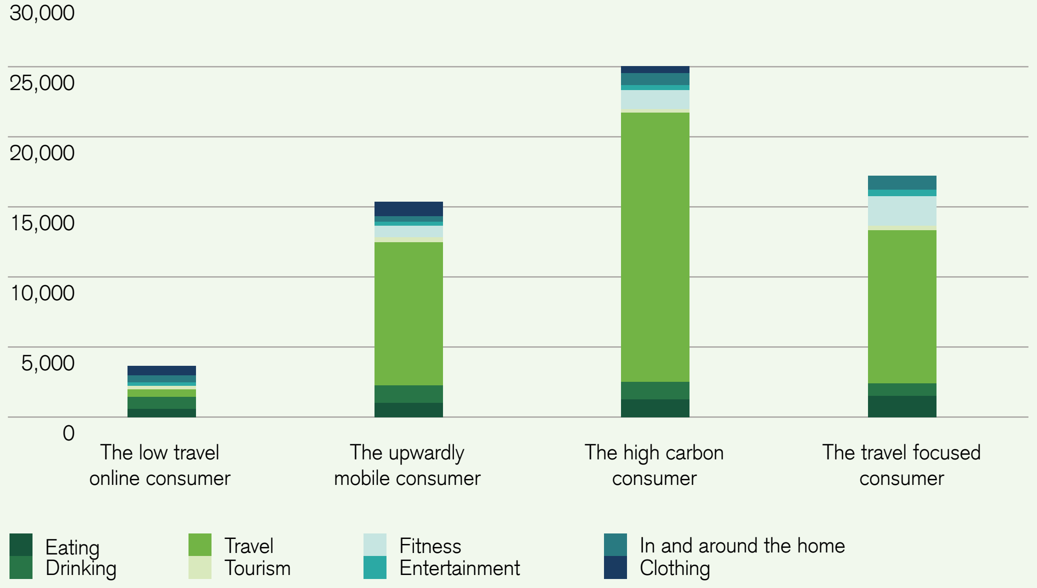
Based on the assumptions as highlighted in Figure 31 and using carbon intensity estimates for each of them, we can calculate the potential annual emission intensity for our four different types of consumers.

Our assumptions suggest that our 'high carbon' consumer generates c25,000kg of $CO_2$ per year, or roughly 8x the level generated by our 'low travel and online' consumer (Figure 32). The emission profiles of the other two consumers are fairly similar at 15–17 thousand kilograms of $CO_2$ per year.

To put these numbers into context, we refer back to page 13, where we highlighted that per capita emissions needed to be 2.5–3.3Gt of $CO_2$ per year in order to be in line with Paris Agreement related targets. Taking the midpoint of 2.9Gt of $CO_2$, we calculate that average emissions for our 'upwardly mobile', 'high carbon', and 'travel focused' consumers need to fall between 81% and 88%. Even for our 'low travel and online' consumer we note that emission levels are c20% too high.

Figure 32 shows the main factors in terms of emissions for each of our four consumers. The answer to the question of how to reduce emissions to sustainable levels appears obvious. Travel intensity needs to reduce or less emission-intense forms of travel or tourism need to be chosen. From an environmental perspective, it makes more sense to take a train and go camping domestically than to fly business class and stay in a five-star hotel far away.

**Figure 32: Total annual emission intensity of our four consumers (kg $CO_2$ equivalent)**



Source: Credit Suisse estimates

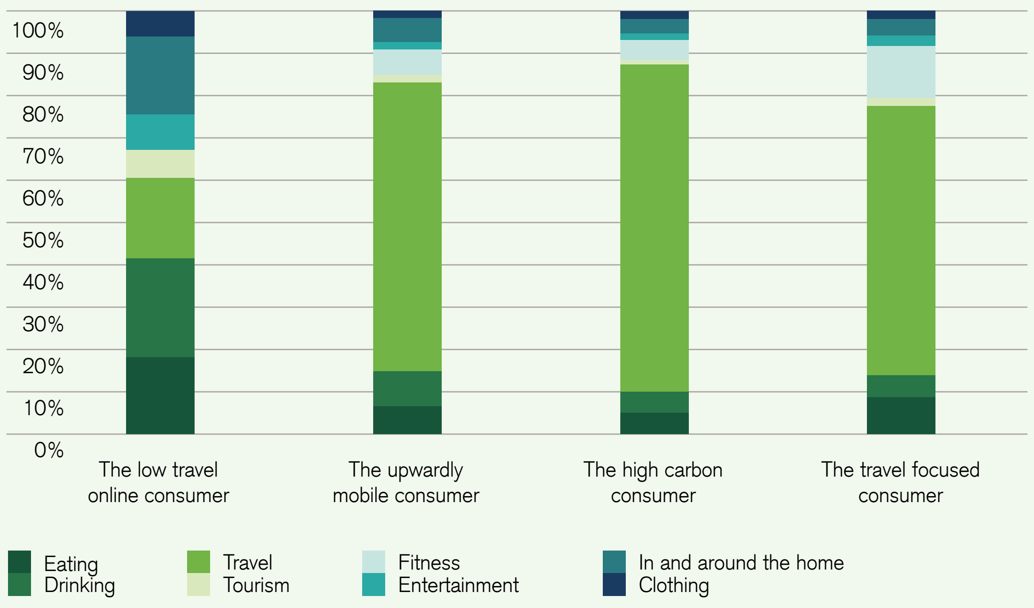


Figure 33: Share of annual emission intensity of our four consumers by category (kg $CO_2$ equivalent)

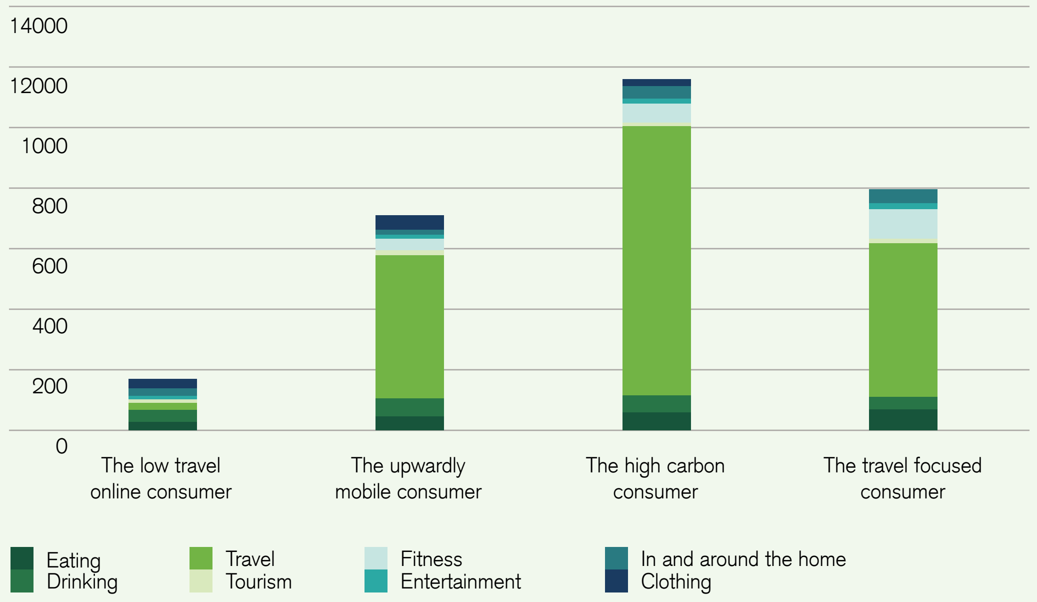
Source: Credit Suisse estimates

# The Treeprint of our four consumers

In addition to cutting or changing behavior in order to reduce one's carbon footprint, consumers can also opt for carbon offsetting schemes such as planting trees. Our data for carbon storage by different types of trees allow us to calculate how many mature trees are needed to offset a certain level of emissions. Based on the emission profiles for our four consumers, we have calculated how many trees they would need in order to arrive at a net-zero state (Figure 34). We also provide the number of trees needed to offset the activity with the greatest carbon footprint for each of our four consumers (Figure 35).

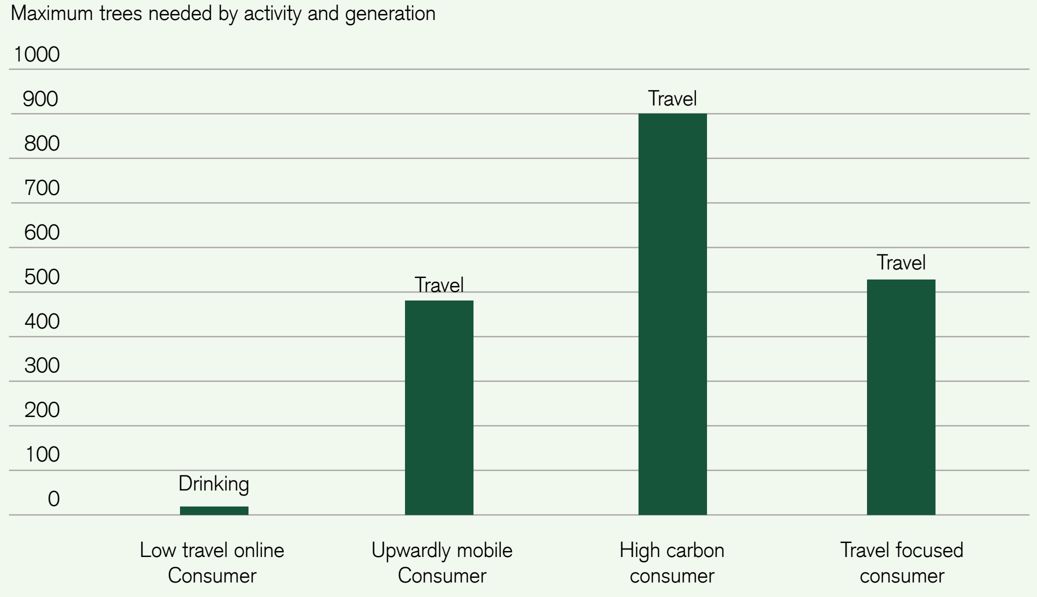
Our calculations indicate that consumers who like their meat, go on overseas holidays or travel and take a plane to get there, and that frequently use domestic appliances, including consumer electronics, require 700–1,140 mature trees in order to offset their private carbon footprint. Their Treeprint range is 700-1,140.

**Figure 34: Number of trees needed to offset emissions**



Source: Credit Suisse estimates

**Figure 35: Offsetting emissions for the activity with the highest contribution to overall emissions**



Source: Credit Suisse estimates

Some readers might decide that having a Treeprint of, say, 1,000 trees is great as this suggests that, by planting that many trees, they would apparently offset their personal carbon footprint and be able to live without altering their lifestyle. We highlight the following reasons why such a conclusion could be wrong.

- Firstly, we note that, for a number of activities highlighted previously, we only consider direct emissions rather than the full life cycle impact of that activity. Our Treeprint estimate is, therefore, likely to underappreciate the full impact of an activity or lifestyle.
- Secondly, we note that our calculations are based on the carbon storage potential of mature trees. Planting trees now is obviously a good decision but, in most cases, it will take quite a few years before these trees reach their maximum annual carbon storage potential. During these initial years, a consumer planting trees would therefore not lead a "net-zero lifestyle".
- Thirdly, our Treeprint calculation provides the number of mature trees that are alive and store carbon. Not all trees that are planted today, however, will survive long enough to reach maximum carbon storage potential; therefore, consumers would need to plant more trees than our Treeprint estimate.
- Finally, there is a practical limitation to consider. Currently, there are some 5bn people globally between the ages of 20 and 79. Most of these, however, live in developing economies, suggesting that their Treeprint is unlikely to reach anywhere near the levels suggested for our hypothetical consumers. However, if we were to assume that only 20% of all adults have a meaningful Treeprint of, say, 500 trees, we would already be looking at a tree planting requirement of 0.5 trillion trees. That alone represents 16% of the current total number of trees globally of c3trn.

# Creating a sustainable lifestyle

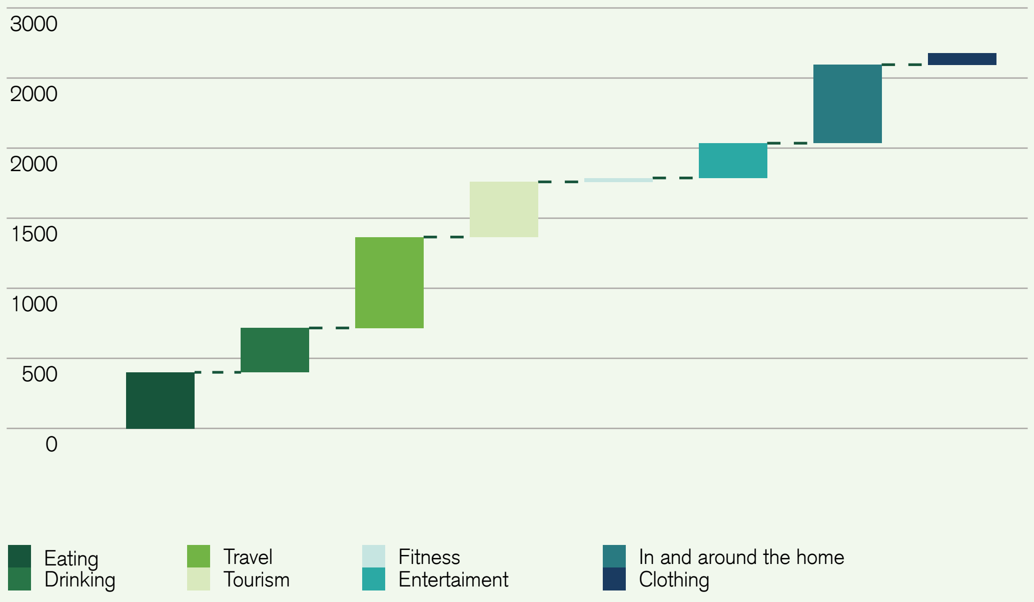
Up until now, we have reviewed consumer profiles of different types of consumers, estimated their emission footprint, and concluded that these were not sustainable in that the average emissions generated per person were higher than the limit that is deemed in line with long-term climate change targets. We now turn our quest upside down and ask ourselves what sort of lifestyle is sustainable or has an emission profile of 2,500–3,300kg of $CO_2$ equivalent per year.

We obviously know that there is no one lifestyle that is sustainable and that personal choice will ultimately determine how one becomes sustainable if that is what one wants to achieve. Below we show one example of a lifestyle that has an emission profile that meets the $CO_2$ boundary condition of less than 3,330 Gt of $CO_2$ per year. We make the following comments about our assumptions for the three largest areas.

- **Eating and Drinking:** The key emission drivers here are: i) red meat, ii) beer, iii) milk, and iv) coffee consumption. Our sustainable consumer has swapped these for poultry, sea food, tea, and some wine.
- **Travel:** As shown before, travel is emission intense. Therefore it stands to reason that living sustainably means limited (long haul) flying and reduced use of large petrol cars. Our sustainable consumer takes one holiday per year consisting of a short-haul economy class flight and a four-star hotel. He or she has opted for an electric rather than petrol car and drives 5,000km per year. The remainder of the time rail, inner-city public transport, and a bicycle are used.
- **In and around the house**: This is a difficult one given that most of the related activities (e.g., washing, cleaning) are those that are most difficult to change. Our sustainable consumer takes six showers per week but for four minutes each rather than the usual eight. The washing machine is used two times per week, however, on a shorter program of 1hr rather than the usual 1.5hr. Finally, the dishwasher is used only once per week as our consumer has opted for hand washing the dishes during the other days.

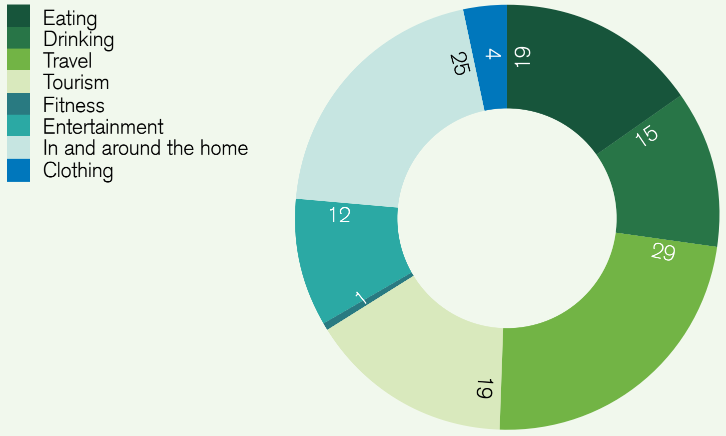
Overall, we estimate that the lifestyle of our sustainable consumer generates c2.6Gt of $CO_2$ per year, putting it well within the maximum boundary for a sustainable lifestyle. The Treeprint of this consumer is c120 trees, based on our calculations. For some readers, adopting such a lifestyle in order to live sustainably may be difficult to accept; however, we note that in order to make our world more sustainable the a "no-change" scenario is simply unrealistic. We hope that this report will help the reader to identify which areas of his or her lifestyle are most environmentally intense and how many trees need to be planted in order to minimize his or her carbon footprint.

**Figure 36: Emission profile of a sustainable consumer (kg of $CO_2$eq)**

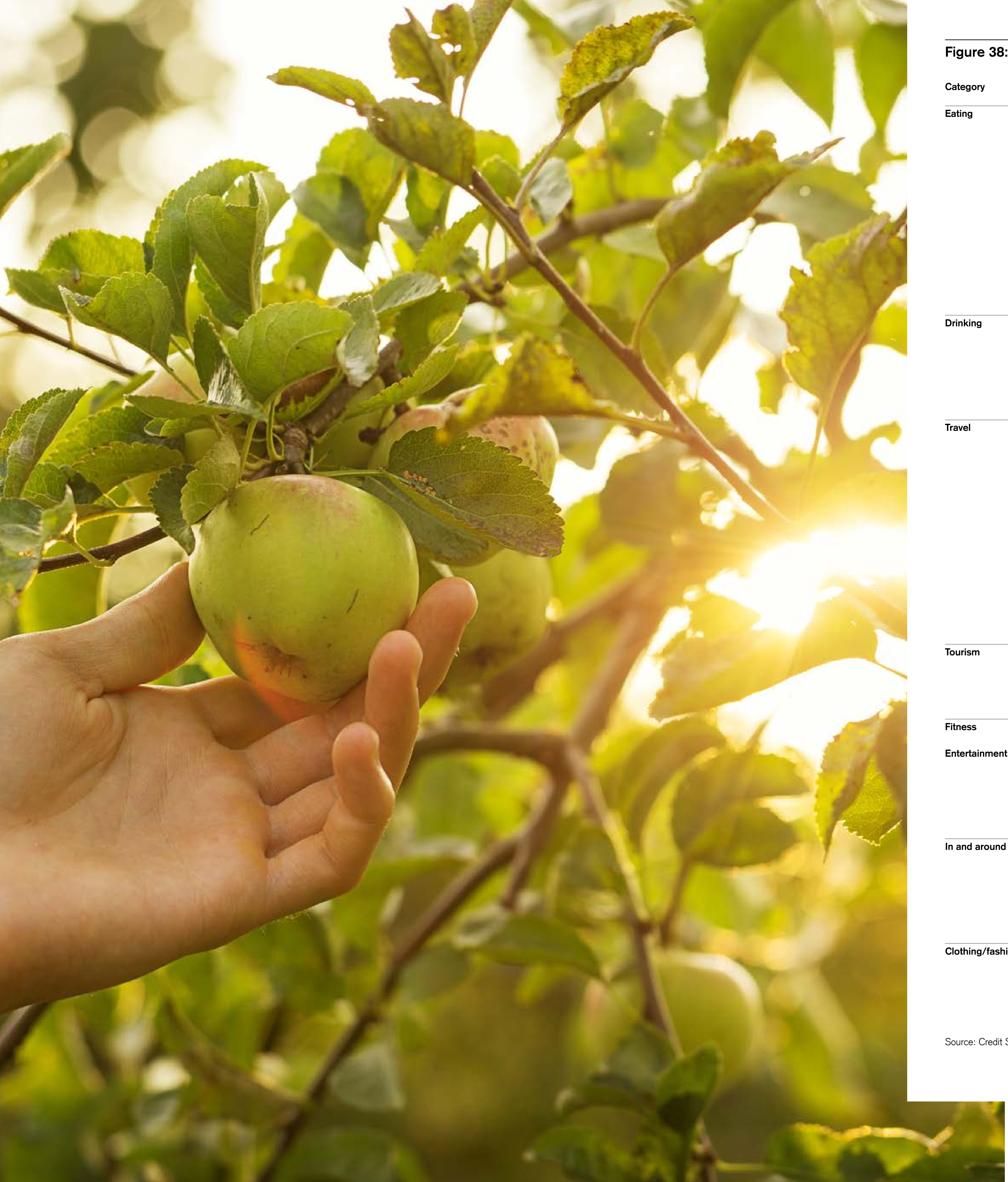


Source: Credit Suisse estimates

**Figure 37: Treeprint profile of a sustainable consumer (number of trees per activity category)**



Source: Credit Suisse estimates



## Figure 38: Hypothetical lifestyle for a consumer with a sustainable carbon footprint

| Category | Metric | Frequency of activity of the sustainable consumer |
|---|---|---|
| **Eating** | Consumption of red meat (times per week, 100g each) | 0 |
| | Consumption of poultry (times per week, 100g each) | 2 |
| | Consumption of seafood (times per week, 100g each) | 2 |
| | Consumption of chocolate per week (g) | 50 |
| | Consumption of crisps per week (g) | 50 |
| | Consumption of cheese per week (g) | 25 |
| | Number of eggs eaten per week | 2 |
| | Consumption of bread (times per week, 2 slices each) | 3 |
| | Consumption of greek yogurt (times per week, 100g each) | 3 |
| | Consumption of vegetables per week (times per week, 100g each) | 7 |
| | Consumption of fruit per week (times per week, 100g each) | 5 |
| | Consumption of rice per week (times per week, 100g each) | 3 |
| | Consumption of pasta per week (times per week, 100g each) | 2 |
| | Consumption of potatoes per week (times per week, 100g each) | 2 |
| **Drinking** | Number of beer units per week | 0 |
| | Number of wine units per week | 4 |
| | Number of (diet) soda cans per week | 4 |
| | Number of coffees per day | 0 |
| | Litres of bottled water per day | 2 |
| | Number of teas per day | 4 |
| | Number of units of milk per week | 0 |
| **Travel** | Number of times taking long-haul return flights per year (business class) (3500km) | 0 |
| | Number of times taking long-haul return flights per year (premier economy) | 0 |
| | Number of times taking short-haul return flights per year (business) (500km) | 0 |
| | Number of times taking short-haul return flights per year (economy) | 1 |
| | Average km in a car per year (large, petrol) | 0 |
| | Average km in a car per year (medium, petrol) | 0 |
| | Average km in a car per year (small, petrol) | |
| | Average km in a car per year (large, electric) | |
| | Average km in a car per year (medium, electric) | 5000 |
| | Average km in a car per year (small, electric) | |
| | Number of days using intra city public transport per week | 4 |
| | Average distance travelled by public transport each time (km) | 5 |
| | Number of times using long distance rail/bus travel per month | 2 |
| | Average distance travelled by long distance rail each time (single, km) | 200 |
| | Average km cycling per week | 30 |
| **Tourism** | Average nights spent in a 2-star hotel per year | |
| | Average nights spent in a 3-star hotel per year | |
| | Average nights spent in a 4-star hotel per year | 10 |
| | Average nights spent in a 5-star hotel per year | 0 |
| | Average nights spent in high-end luxury hotel/cruise per year | 0 |
| **Fitness** | Number of times used treadmill per week (30min each) | 3 |
| **Entertainment** | Average time per day spent watching regular broadcast TV (in hours) | 1 |
| | Average time per day spent watching streaming TV (e.g., Netflix) (in hours) | 1 |
| | Average time per day spent video gaming (hours) | 0 |
| | Use of a broadband router | 1 |
| | Average time per day using a desktop (hours) | 8 |
| | Average time per day using a laptop (hours) | 1 |
| | Average time per day charing a smartphone (hours) | 1 |
| **In and around the house** | Number of times using washing machine per week (1hr wash each) | 2 |
| | Number of times using the shower per week (8min each) | 3 |
| | Number of times taking a bath per week (88 litres each) | 1 |
| | Number of times flushing a toilet per day (1.6 gallons of water each) | 2 |
| | Use of a fridge freezer | 1 |
| | Number of times a dishwasher is used per week (1500W, 1hr) | 1 |
| | Number of times an oven is used per week (2000W, 20min) | 3 |
| **Clothing/fashion** | Number of jeans/trousers bought per year | 2 |
| | Number of shirts bought per year | 3 |
| | Number of jackets bought per year | 0 |
| | Number of suits/dresses bought per year | 0 |
| | Number of t-shirts/underwear small items bought per year | 5 |

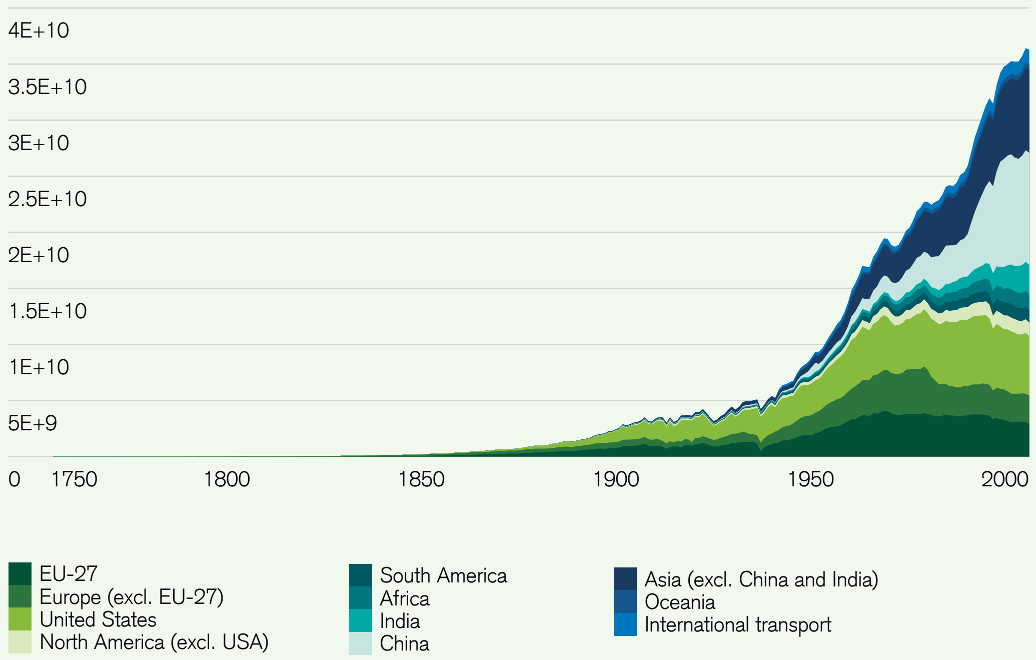
Source: Credit Suisse estimates

# Emissions: the challenge that lies ahead

In this report, we addressed the emission profile of more personal activities as this is, in our view, a significant factor in driving overall emissions. With that in mind, it might be helpful to summarize the challenge that the world faces in terms of emissions.

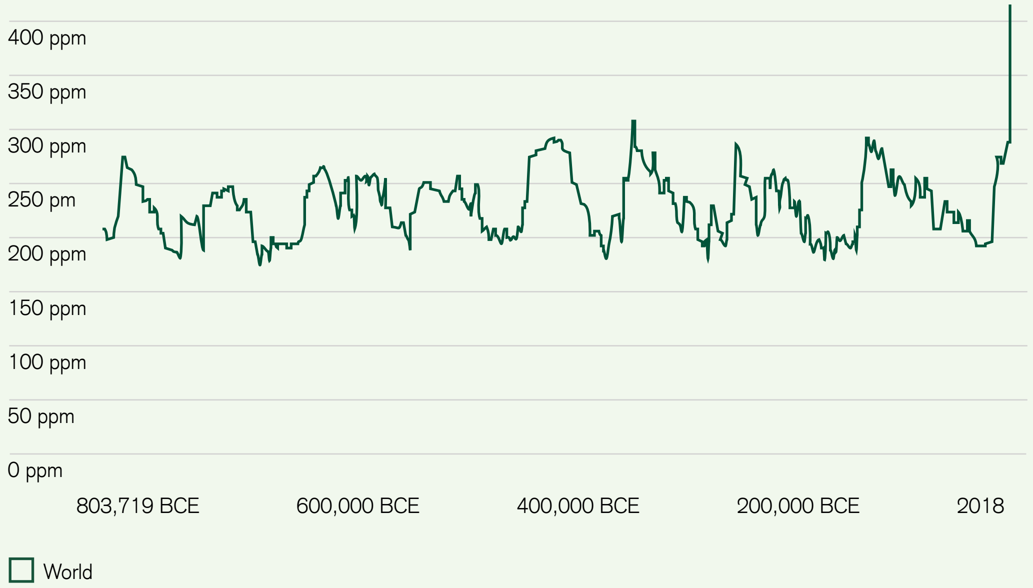
Annual greenhouse gas emissions which include carbon dioxide ($CO_2$) as well as a number of other gases such as methane ($CH_4$) and nitrous oxide ($N_2O$) are currently running at an annual rate of c50Gt of $CO_2$ equivalent. Carbon dioxide emissions alone have increased sevenfold since the 1950s and almost 10x during the past 100 years (Figure 39).

**Figure 39: Global CO$_2$ emissions (excluding land use change)**



Source: Our World in Data, Global Carbon Project

**Figure 40: Atmospheric concentration of carbon dioxide**



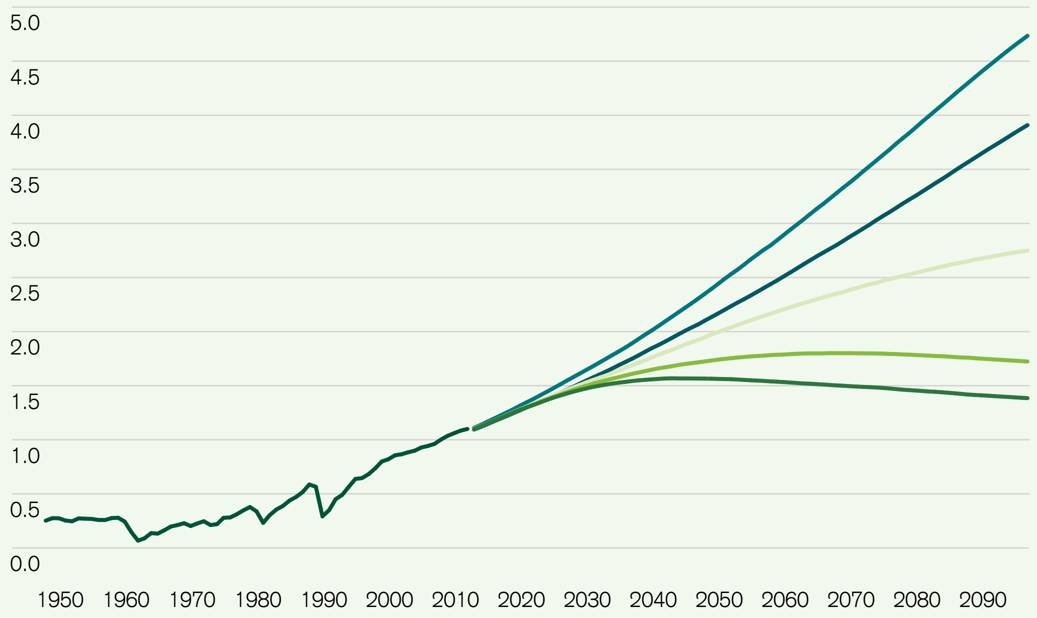
Source: EPICA Dome CO$_2$ record (2015), NOAA (2018), Our world in data

The implications of the rise in emissions are becoming ever more visible. Hot extremes (including heatwaves) have become more frequent since the 1950s, whereas cold extremes have become less frequent. Furthermore, the frequency of events such as flooding and hurricanes has also increased, resulting in significant economic and environmental damages and frequent loss of life.

In its latest report, the IPCC also notes that sea levels are likely to rise further as a result of global warming. These, they believe, could rise by 19–22 metres during the next 2,000 years if average temperatures rise by 5°C.

To underline how significant climate change may become, the IPCC has developed five scenarios. This shows that, without substantial changes to emission generation going forward, the world could indeed be heading for average temperature increases of more than 5°C by the end of this century. The IPCC also outlined what this could mean for extreme weather events. For example, extreme temperature events that currently occur once every ten years are likely to occur 9x more often if average temperatures increase by c5°C by 2100 from pre-industrial levels. The frequency of extreme rainfall events would increase c3x in this scenario while extreme agricultural and ecological drought is likely to occur 4x more often. The environmental, social, and economic implications of these developments cannot by overestimated, in our view, and suggest that strong action is needed.

**Figure 41: Global surface temperature change relative to 1850–1900 under five scenarios**

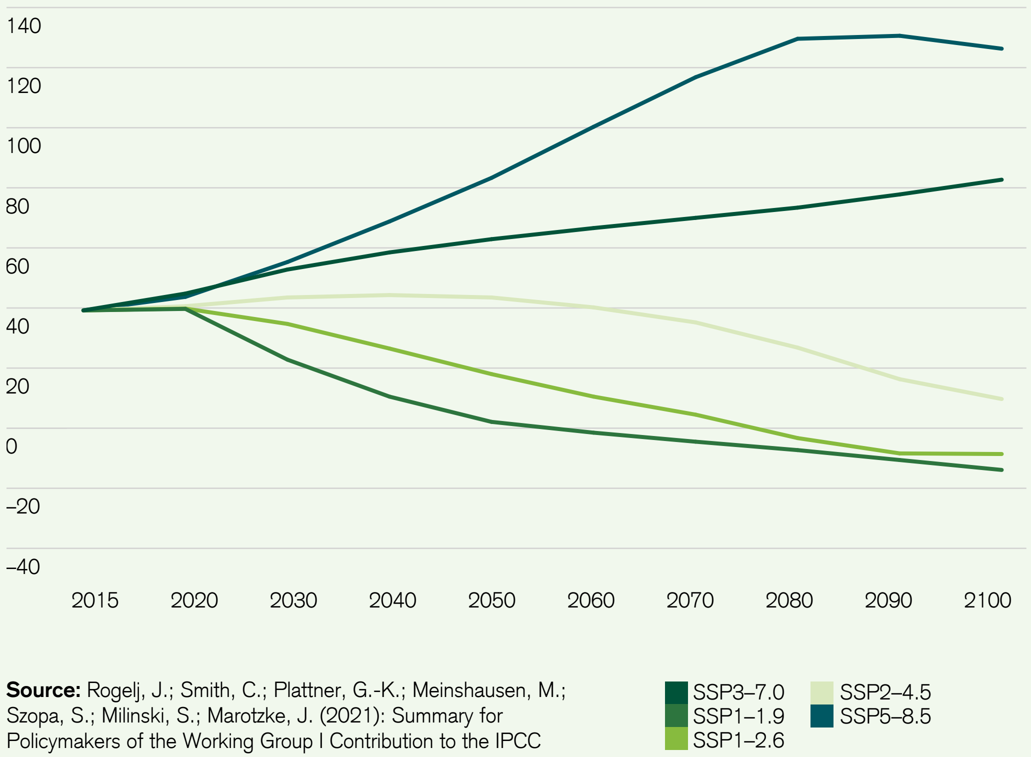


**Source:** yfe, J.; Fox-Kemper, B.; Kopp, R.; Garner, G. (2021): Summary for Policymakers of the Working Group I Contribution to the IPCC Sixth Assessment Report – data for Figure SPM.8 (v20210809). NERC EDS Centre for Environmental Data Analysis

Source: IPCC, AR6 Page 41

The IPCC has clearly outlined what needs to happen to emissions if the world is to minimize average temperature increases. For example, to limit average temperature increases to c1.5°C by the end of 2100, total $CO_2$ emissions need to fall c50% between 2020 and 2030; they then need to reach net zero by 2050 before declining further to reach a net-negative 10 Gt of $CO_2$ per year by 2100.

**Figure 42: $CO_2$ emission profiles associated with IPCC global warming scenarios**



**Source:** Rogelj, J.; Smith, C.; Plattner, G.-K.; Meinshausen, M.; Szopa, S.; Milinski, S.; Marotzke, J. (2021): Summary for Policymakers of the Working Group I Contribution to the IPCC Sixth Assessment Report - data for Figure SPM.4 (v20210809). NERC EDS Centre for Environmental Data Analysis

Source: IPCC

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