Section II

Hotspots and Options for Footprint Reductions

3 – Lifestyle Carbon Footprints

The focus of this report is on the daily activities of individuals determined by their lifestyle choices. To achieve this, the report uses the unit of lifestyle carbon footprints: GHG emissions both directly emitted and indirectly induced by household consumption, excluding those induced by government consumption and capital formation.[11] Through consumption-based accounting, and by excluding emissions from government expenditure and capital formation, lifestyle carbon footprints allow a strong focus on emissions resulting from deliberate individual choices and due to lock-in effects of sociotechnical systems, which inevitably constrain these choices (Akenji and Chen 2016).

Household resource consumption is classified into six domains, based on previous studies, e.g., Michaelis and Lorek (2004); Tukker et al. (2006); Kotakorpi et al. (2008); Seppälä et al. (2011); Lettenmeier et al. (2014), as follows:

Food: intake of all foodstuffs and beverages consumed at home and outside the home, e.g., meat, fish, dairy, cereal, vegetable and fruit, and alcohol and nonalcoholic beverages.[12]
Housing: housing infrastructure and supply of utilities, e.g., construction, maintenance, energy use, and water use.
Personal transport: use of owned transport equipment and transportation services for commuting, leisure, and other personal purposes, e.g., cars, motorbikes, public transport, air travel, and bicycles.[13]
Consumer goods: goods and materials purchased by households for personal use not covered by other domains, e.g., home appliances, clothes, furniture, daily consumer goods.[14]
Leisure: activities performed outside of the home, e.g., sports, culture, entertainment, and hotel services.
Services: services for personal purposes, e.g., insurance, communication and information, ceremonies, cleaning and public baths, and public services.[15]

The targets of lifestyle carbon footprints (carbon footprints from households) in the five shortlisted scenarios[16] (introduced in Chapter 2, Tables 2.2 and 2.3) are summarised in Figure 3.1–3.2. In terms of all GHGs, the ranges of the estimated lifestyle carbon footprint targets for 2030, 2040, and 2050 are respectively 3.2–2.5, 2.2–1.4, and 1.5–0.7 tCO_2e per capita (IGES et al. 2019). The ranges overlap due to different assumptions regarding negative emission technologies and temperature targets. The selection of targets between the lower and higher ends depends on assumed long-term availability

11 Examples of government consumption include road and infrastructure repairs and national defence; examples of capital formation include factories, transport equipment, and materials used for the future production of goods.

12 Direct emissions from cooking at home are included under housing, whereas emissions from operation of restaurants are included under leisure.

13 Emissions from business purpose trips are excluded here as they are included under respective domains of the products and services supplied.

14 Emissions from ingredients of food taken out of home are included in food, whereas direct emissions from leisure performed at home are included in housing.

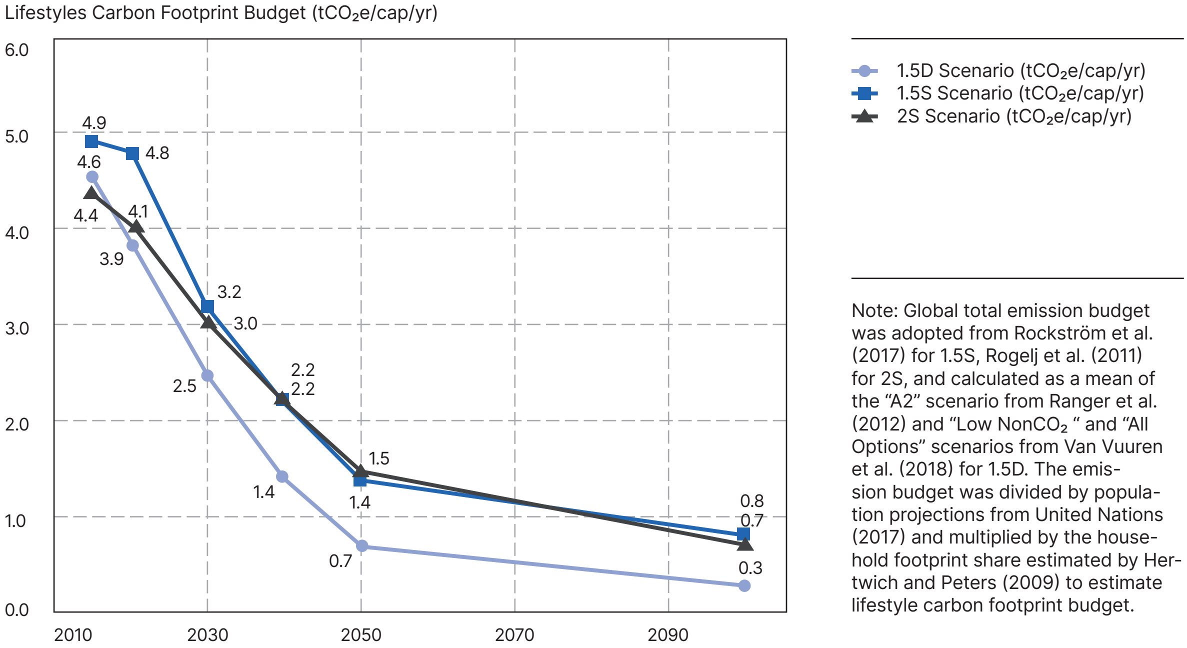
15 Public services covered by government expenditure are excluded from lifestyle carbon footprints.

16 Scenario 1.5D was calculated as the average of the three scenarios described in Table 2.2

of human carbon sinks or negative emissions technologies, such as BECCS, and the selection of the global average temperature targets, either 1.5°C or 2.0°C.

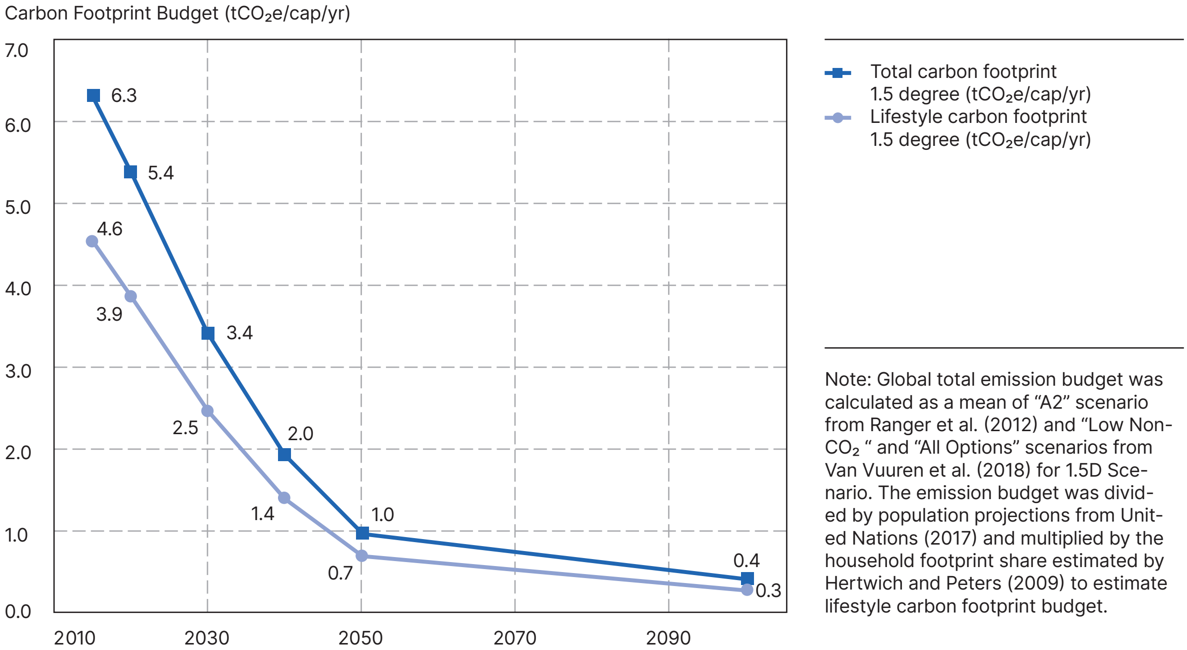
Based on our review of the emission scenarios, we need to aim for a lifestyle carbon footprints target of **0.7 tCO_2e by 2050, with proposed intermediary targets of 2.5 in 2030 and 1.4 tCO_2e by 2040.** These targets are in line with the 1.5°C aspirational target of the Paris Agreement and for global peaking of GHG emissions as soon as possible without relying on the extensive use of negative emission technologies.

Figure 3.1. Lifestyle carbon footprint budget from shortlisted mitigation pathways



Note: Global total emission budget was adopted from Rockström et al. (2017) for 1.5S, Rogelj et al. (2011) for 2S, and calculated as a mean of the "A2" scenario from Ranger et al. (2012) and "Low NonCO_2" and "All Options" scenarios from Van Vuuren et al. (2018) for 1.5D. The emission budget was divided by population projections from United Nations (2017) and multiplied by the household footprint share estimated by Hertwich and Peters (2009) to estimate lifestyle carbon footprint budget.

Figure 3.2. Lifestyle carbon footprint budget comparable with 1.5°C target (without or with less use of negative emission technologies)

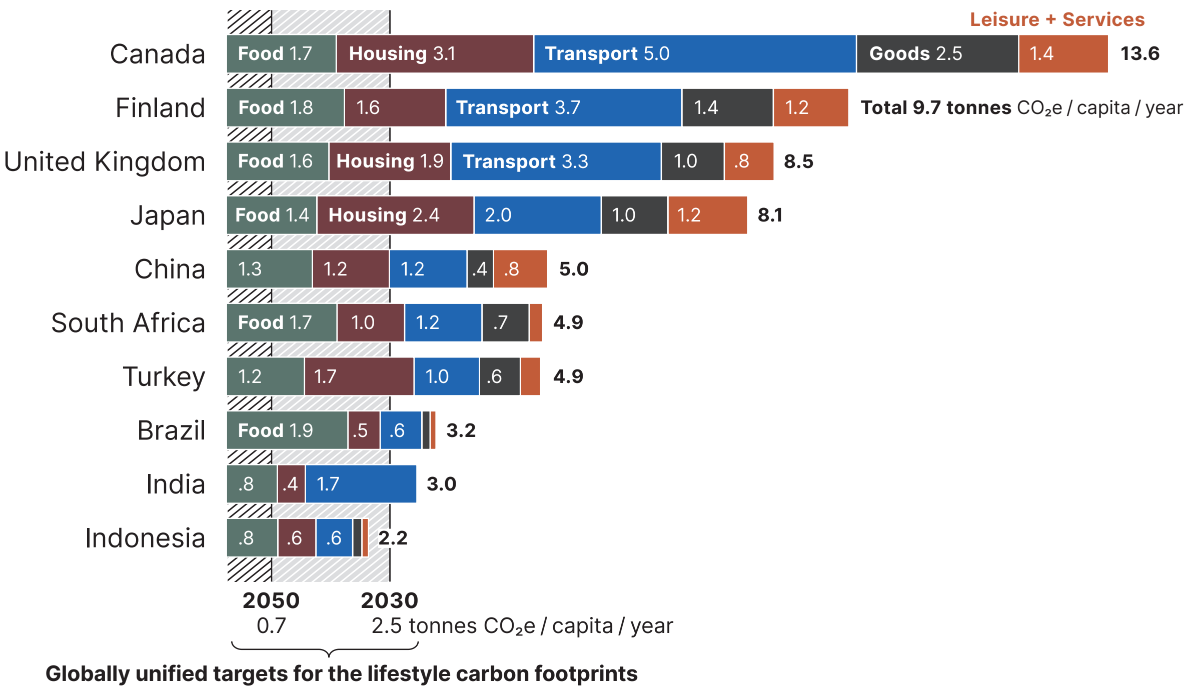


Note: Global total emission budget was calculated as a mean of "A2" scenario from Ranger et al. (2012) and "Low Non-CO_2" and "All Options" scenarios from Van Vuuren et al. (2018) for 1.5D Scenario. The emission budget was divided by population projections from United Nations (2017) and multiplied by the household footprint share estimated by Hertwich and Peters (2009) to estimate lifestyle carbon footprint budget.

3.1. Comparing lifestyle carbon footprints

Total average lifestyle carbon footprints vary notably between the countries analysed for this report—Canada has the highest at 13.6 tCO_2e per year, followed by Finland at 9.7, the United Kingdom at 8.5, Japan at 8.1, China at 5.0, South Africa and Turkey at 4.9, Brazil at 3.2, India at 3.0, and Indonesia at 2.2 tCO_2e. The results are visualized in Figure 3.3, which gives the total footprint and its breakdown into different components in tons CO_2e/cap/yr for each country. Compared with the carbon footprint target proposed for 2030 (2.5 tons per capita in terms of all GHGs), Canada, Finland, the United Kingdom, and Japan heavily exceed the targets; China, Turkey and South Africa overshoot moderately; and Brazil and India slightly. As a result, lifestyle carbon footprints need to drop by the following percentages by 2030: Canada 82%, Finland 74%, the United Kingdom 70%, Japan 69%, China 50%, South Africa 49%, Turkey 49%, Brazil 23%, and India 14%. Indonesia is already currently close to the target level set for 2030 (Table 3.1). The lifestyle footprint target for 2050 (0.7 tons per capita in terms of all GHGs) is exceeded in all case countries. Large footprint reductions of 95% and 93% are needed in Canada and Finland, respectively, 92% and 91% reductions are needed in the United Kingdom and Japan, and 86% reductions are needed in China, Turkey, and South Africa. Reductions are also needed in Brazil, India, and Indonesia of 78%, 76%, and 68%, respectively.

Figure. 3.3. Carbon footprint and its breakdown between consumption domain and globally unified targets for the lifestyle carbon footprints



Note: Average lifestyle carbon footprint of country estimated as of 2019. The horizontal lines indicate 1.5D footprint targets for 2030 and 2050 (1.5°C without/less use of negative emissions technologies).

Table 3.1. Current annual lifestyle carbon footprint per capita and reduction targets for case countries

Current annual lifestyle carbon footprint (tCO_2e/cap/year)										
Domain	**Canada**	**Finland**	**United Kingdom**	**Japan**	**China**	**South Africa**	**Turkey**	**Brazil**	**India**	**Indonesia**
Food	1.7	1.8	1.6	1.4	1.3	1.7	1.2	1.9	0.8	0.8
Housing	3.1	1.6	1.9	2.4	1.2	1.1	1.7	0.5	0.4	0.6
Transport	5.0	3.7	3.3	2.0	1.2	1.2	1.0	0.6	1.7	0.6
Goods	2.5	1.4	1.0	1.0	0.4	0.7	0.6	0.1	<0.1	0.1
Leisure & Services	1.4	1.2	0.8	1.2	0.8	0.2	0.3	0.1	<0.1	0.1
Total	**13.6**	**9.7**	**8.5**	**8.1**	**5.0**	**4.9**	**4.9**	**3.2**	**3.0**	**2.2**

Reduction targets for lifestyle carbon footprints										
2.5 tCO_2e/ person/ yr by2030	82%	74%	70%	69%	50%	49%	49%	23%	16%	
0.7 tCO_2e/ person/ yr by 2050	95%	93%	92%	91%	86%	86%	86%	78%	76%	68%

3.2. Overall patterns and analysis per economic grouping

This section elaborates country-specific results by comparing the overall patterns and hotspots of the average lifestyle carbon footprints per economic grouping. While differences in culture and infrastructure (Akenji et al. 2016; Akenji and Chen 2016) and availability of public services (Ottelin et al. 2018) shape lifestyle-related consumption patterns in countries, characteristics provide a clear point of comparison between countries, not only because related data is widely collected, but also because income levels correlate with levels of consumption and impacts of lifestyles (United Nations 2018). For country-specific data sources and details of estimation results, refer to Annex A.2 and B.

3.2.1. Food

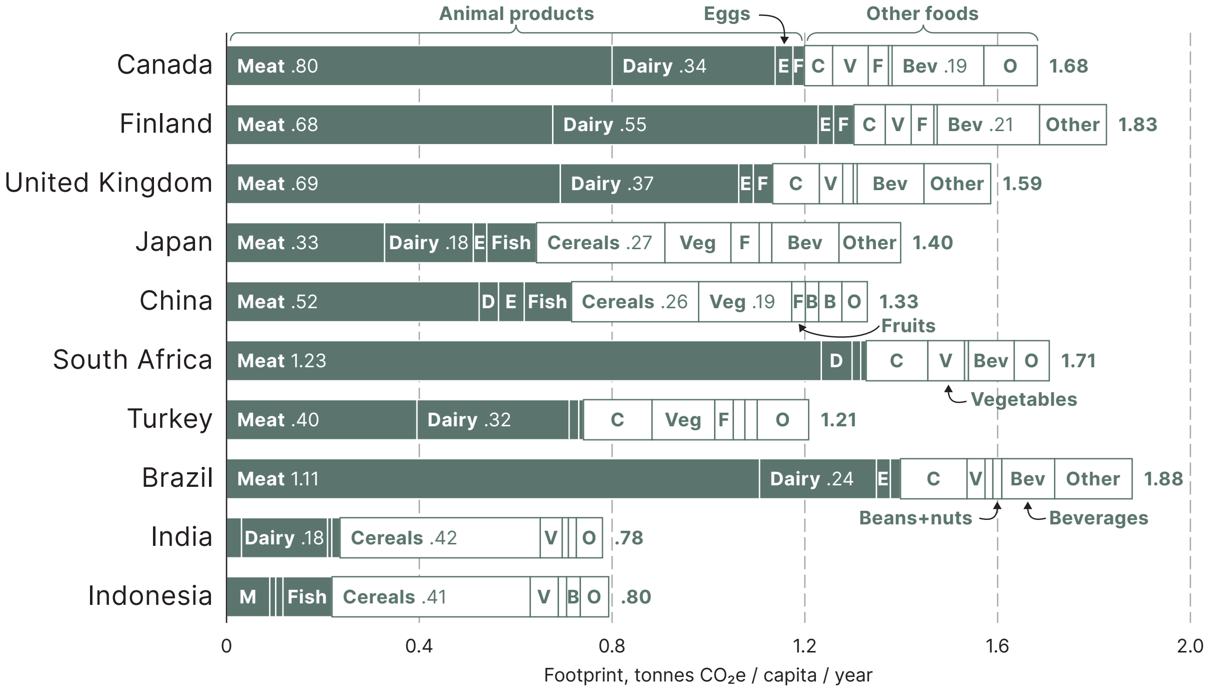
Overall the food domain is relatively similar in footprints between all case countries (Figure 3.4), except India and Indonesia where overall meat consumption is notably lower compared to other countries. In South Africa and Brazil, meat, especially beef, is reflected in the footprints due to relatively high consumption and notably higher carbon intensity compared to other countries. In addition to meat, dairy products are another major contributor to footprints, especially in high-income countries, such as Canada and Finland, due to high consumption of milk and carbon-intensive cheese.

Also different food cultures are reflected in the footprints as different consumption patterns between case countries: fish consumption is high in Japan, China, and Indonesia, whereas those countries have the lowest dairy consumption among all case countries; beans are eaten most in Japan, Turkey, India, and Indonesia, whereas meat consumption has the overall lowest share of the total food consumption in these case countries; high consumption of carbon-intensive rice reflects on the footprints in Japan, China, India and Indonesia.

In the **high-income countries**, meat consumption is the largest contributor to the average person's carbon footprint for food, varying across countries—from the 90 kg eaten in Canada to the 40 kg eaten in Japan, as shown in Figures 3.4 and 3.5. In Figure 3.5, the results are visualized using "skyline charts", which give the amount of consumption (x-axis) and the carbon intensity (y-axis) for the different components. The size of each rectangle thus expresses the component's carbon footprint, and the left-right order of the rectangles represents the highest-to-lowest footprint of components. In these charts, the average intensity and total consumption in each domain is indicated by dotted grey rectangles, and the 1.5-degree targets for 2030 and 2050 as red and blue rectangles, respectively. In the United Kingdom and Finland, most of the meat consumed is pork (31% and 39%, respectively) and chicken (38% and 33%, respectively). In Canada, half of the meat consumed is chicken (45%), yet, Canada has the highest beef consumption (28 kg) due to the overall high consumption of meat.

Dairy products are another significant contributor to the carbon footprint in Canada, Finland, and the United Kingdom. In Canada and Finland this is due to the large consumption of milk, carbon-intensive cheese, and other dairy products. In the United Kingdom, the total dairy

Figure. 3.4. Food-related carbon footprint (tCO_2e/cap/yr) and its breakdown between consumption components



consumption is only given in milk liters in the current data (Food and Agriculture Organization of the United Nations 2021). In Japan, dairy consumption is less than half of the other high-income countries, which could be due to cultural habits.

Other major contributors to food are cereals and beverages. Cereals have relatively high intensity in Japan due to rice consumption, which tends to have higher intensity than wheat and other cereals consumption. The share of beverages in the food footprint is explained in Finland by the relatively high consumption (10 kg/capita/year) of highly carbon-intensive coffee and in Canada and the United Kingdom by the relatively high consumption of relatively carbon-intensive alcohol products, such as beer. Beans are a relatively low-carbon and protein-rich food, but their consumption is very limited in high-income countries, with over 20 kg in Japan and less than 5 kg in Canada, Finland, and the United Kingdom.

In the **upper-middle income countries** the overall amount of food consumed is relatively similar to high-income countries.[17] The overall meat consumption is relatively similar to high-income countries: it varies from 104 kg in Brazil to 41 kg in Turkey. Indonesia is an exception where meat consumption is only 14 kg. Beef is responsible for the greatest share of the meat-related footprint due to it's high carbon intensity, especially in South Africa and Brazil. Yet, in Turkey, South Africa, Brazil, and Indonesia, most of the meat consumed is chicken (51%, 55%, 45%, and 52%, respectively). Indonesia has the highest fish consumption of all countries (45 kg) and it accounts for the second largest share (13%) of the country's total footprint, as it has relatively high intensity.

Cereals and vegetables often account for the largest share of total consumption but the related footprint for the most part remains small due to the notably lower carbon intensity. Share of total intake for cereals varies from 49% in Indonesia to 13% in Brazil, and for vegetables from 45% in China to 13% in Brazil. In China and Indonesia, cereals have a relatively high carbon footprint (20% and 52% of the food footprint), due to the high share of carbon-intensive rice consumption (In China 61% and in Indonesia 75% of the cereal consumption).

Dairy consumption varies a lot within middle income countries. Dairy plays only a minor role in the food carbon footprint in China, South Africa, and Indonesia (3%, 4% and 2%, respectively). In Turkey and Brazil total dairy consumption is close to that of high-income countries (179 kg and 142 kg, respectively). Dairy consumption is also trending upward in many countries (Food and Agriculture Organization of the United Nations 2021).

17 In comparison between the average intake of high-income, upper-middle income, and lower-middle income countries studied.

In India, the **lower-middle income country studied**, the total food consumption amount is the smallest compared to the high-income and upper-middle income countries studied. Most of the food consumed is plant-based (72%), as vegetarianism is a predominant diet. The main protein source together with beans and nuts are dairy products—the consumption of which is similar to high-income countries (approximately 110 kg). India has the highest consumption of beans and nuts (26 kg) among all countries.

Similar to Indonesia, only very little meat is consumed in India (less than 5 kg), of which more than half (54%) is chicken. Fish consumption is one of the lowest (only 7 kg), similar to Canada, Turkey, South Africa, and Brazil.

As indicated by the dotted rectangles in Figure 3.5, the food footprints of high-income countries need to be greatly reduced: by 47–60% by 2030 and by 75–81% by 2050. For upper-middle income countries, the food footprints need to be reduced by 7–61% by 2030 and 56–82% by 2050. For the lower-middle income country, India, the reduction required in the food footprint is 6% by 2030 and 56% by 2050. Yet, the estimated reduction required in food is below that of other domains as there is less variation in current footprints, reflecting that food is considered a necessity (see the first 1.5-Degree Lifestyles Report, Annex D (IGES et al. 2019) for more details). Shifting nutrition sources and reducing carbon intensity or physical consumption amounts where possible while satisfying nutritional requirements can contribute to reducing footprints.

Figure 3.5. A comparison of carbon footprints and their breakdown (food, in kgCO$_2$e/cap/year 2019) in higher-income countries (A) and upper and lower middle-income countries (B)

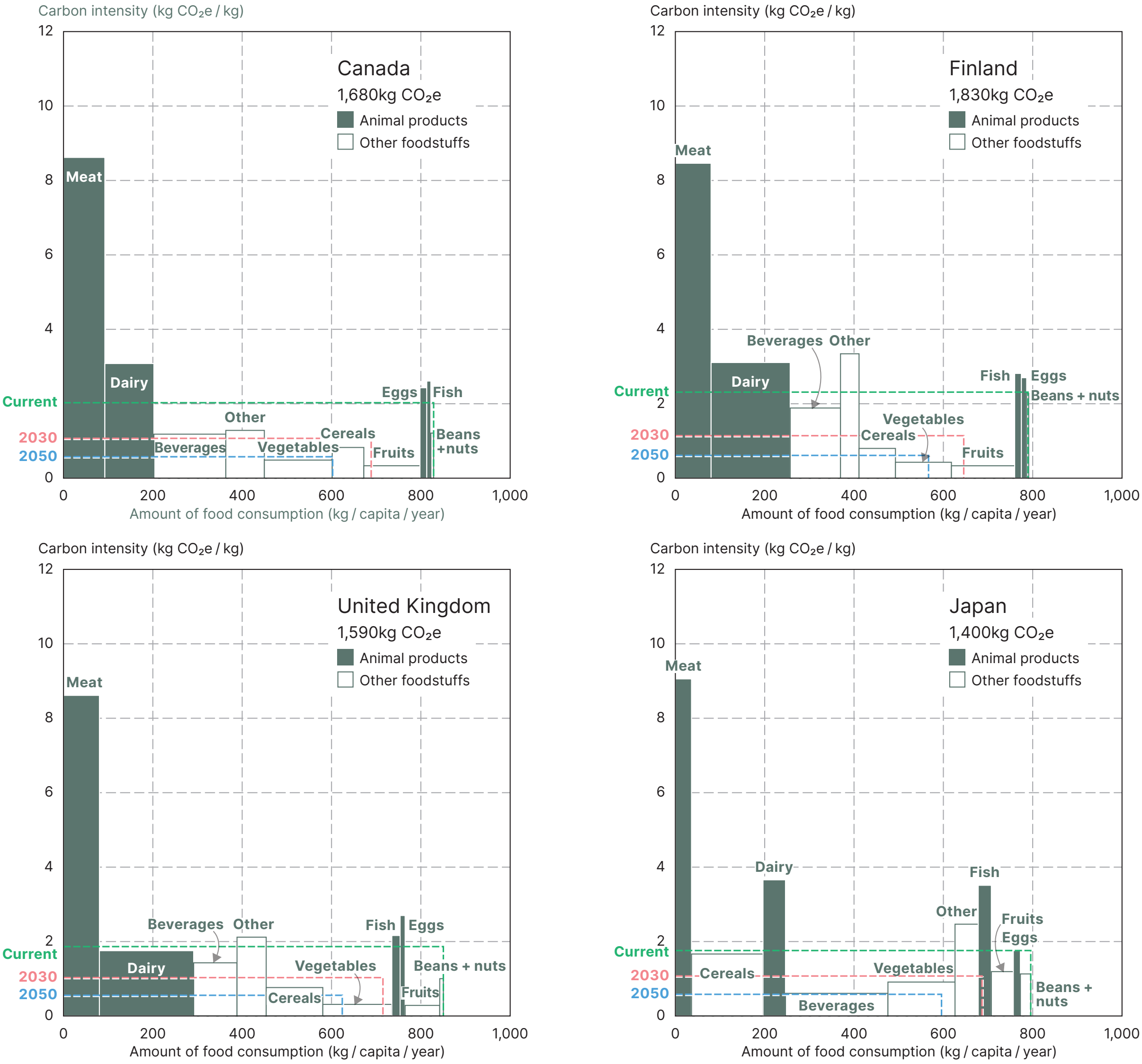
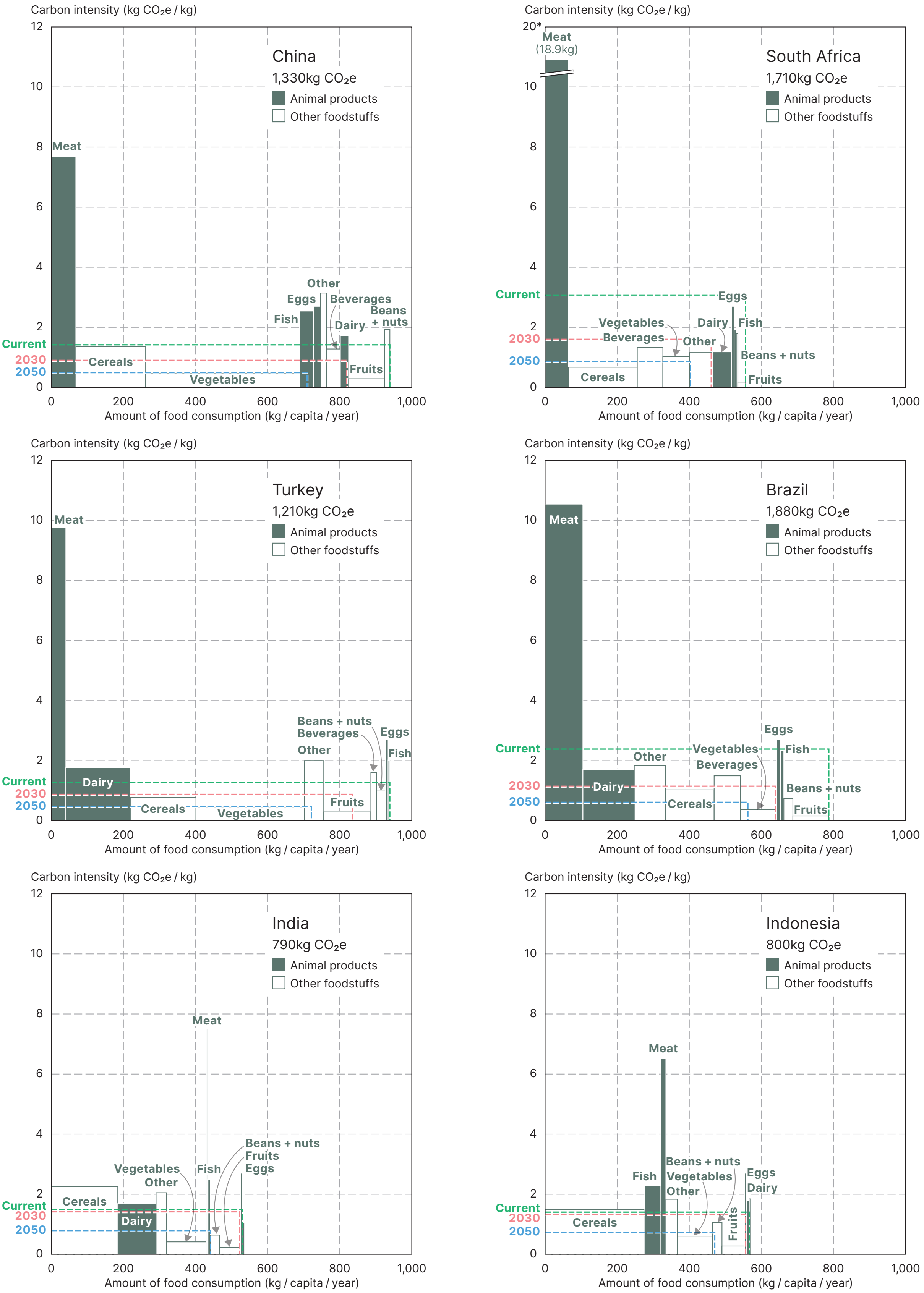


Figure 3.5. A comparison of carbon footprints and their breakdown (food, in kgCO_2e/cap/year 2019) in higher-income countries (A) and upper and lower middle-income countries (B)



* Different scale in y-axis compared to other countries.

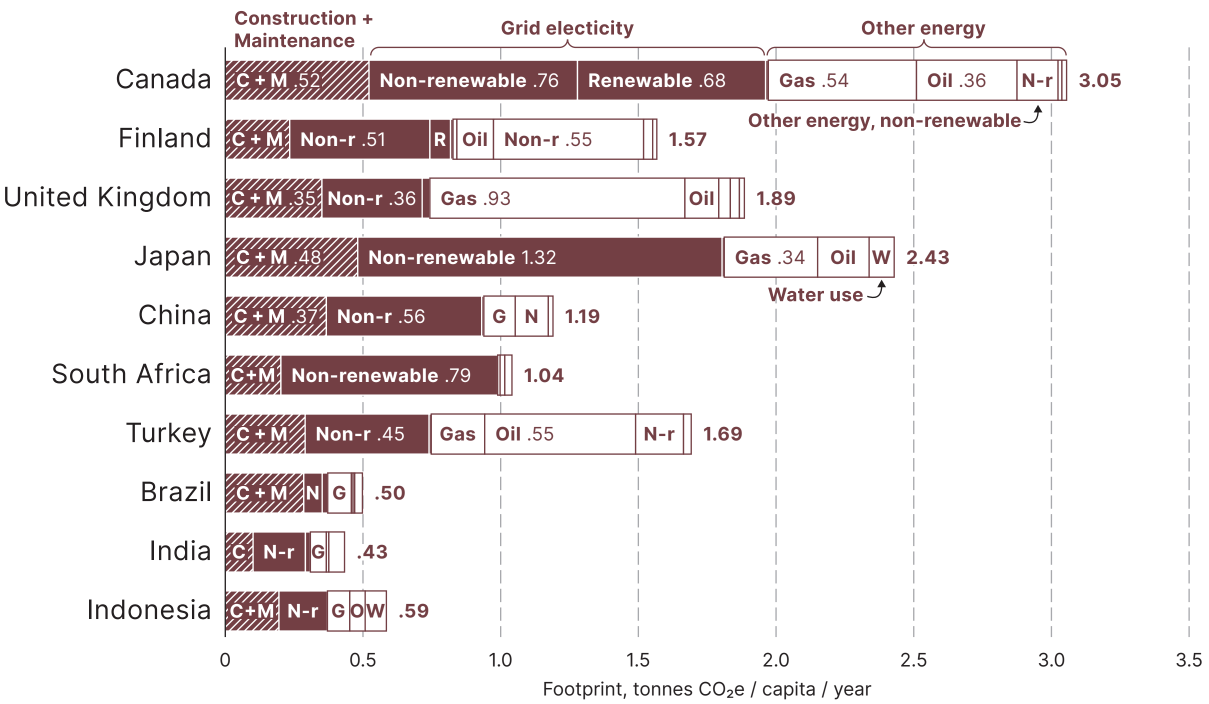
3.2.2. Housing

In the housing domain, non-renewable grid electricity is an important source of lifestyle carbon footprints in all countries, as shown in Figure 3.6. In addition, gas used for heating and cooking is another major contributor to the footprint for some countries, such as the United Kingdom, Japan, and Turkey. Large average living spaces and higher living standards are reflected as higher footprints in high-income countries. This is especially the case in Canada and Finland, where large living spaces together with long and cold winters increase the overall energy demand. Nevertheless, the housing footprint is notably higher in Canada due to relatively high consumption of carbon-intensive energy sources, such as natural gas. Also a high share of renewable grid energy is based on pumped hydropower, which has the highest carbon intensity compared to all other renewable energy sources. In Finland, a high share of the heating energy (the largest share of overall energy consumption) is based on district heating, which has lower intensity due to the relatively high share of renewable energy sources. In Japan, overall energy demand is the lowest of the high-income countries studied but is mostly based on non-renewable energy sources, which is similar in the upper and lower middle-income countries studied.

High-income countries have large living space per capita, varying from the United Kingdom's 39m² to Canada's 58m² per person, with construction and maintenance accounting for up to a fifth (from 15% for Finland up to 22% for the United Kingdom) of the footprint (see Figure 3.6). However, there are big differences in direct energy use (from Canada's 11,500 to Japan's 4,200 kWh) (see Figure 3.7), and energy use per living space (from Finland's 280 to Japan's 100 kWh per m²). This is partly because of the high energy demand for heating in Canada, Finland, and the United Kingdom—for indoor heating and water heating, 63–67% and 15–17%, respectively. In addition, 5% of the households' energy use is for sauna heating in Finland. Japan has a relatively high demand for hot water use of 29%, whereas indoor heating and cooling only account for, respectively, 22% and 2% of the home energy consumption (Agency for Natural Resources and Energy, Japan 2017).

Electrification of direct housing energy use with renewables can contribute to low-carbon lifestyles, but non-renewable electricity can be less efficient in comparison with non-electricity energy sources. Japan has the highest electrification rate of direct energy consumption in the housing domain among high-income countries, with 51% compared to lowest 22% in the United Kingdom. Typically, electricity-based room tem-

Figure 3.6. Housing-related carbon footprint (tCO_2e/cap/yr) and its breakdown between consumption components



Note: Construction/maintenance covers emissions related to the living space (m²/person).

perature control systems such as heat pumps have higher energy conversion efficiency at the household level. If fossil fuels are used to produce the grid electricity for home heating, it generally has higher carbon intensity than home-heating systems using non-renewable heating energy because the conversion efficiency of power plants is relatively low. Therefore, electrification of home energy sources should be promoted together with renewable-based grid electricity.

The carbon intensity of grid electricity in Canada, Finland, and the United Kingdom is about half that in Japan (0.15–0.31 vs 0.63 kgCO_2e/kWh), as a large share comes from renewables (37–65%), whereas 84% of Japan's electricity is generated from fossil fuel, over a third of which (39%) is coal. For Canada, over 90% of the renewable grid-electricity is hydropower and of that 40% is based on pumped hydropower, which has higher intensity compared to natural gas used for heat and power cogeneration. Thus, the average carbon intensity for Canadian grid electricity is twice as high compared to Finland and the United Kingdom yet only half of Japan's.

For non-electricity energy, Japanese homes typically use LPG and urban gas for heating and cooking, as well as kerosene for heating (49% of overall energy from housing). On the other hand, 48% of the energy used for room and water heating in Finnish homes is district heat, which has relatively low carbon intensity despite nearly half of it being non-renewable based,

Figure 3.7. A comparison of carbon footprints in higher-income countries (A) and upper and lower middle-income countries (B) (housing energy, in kgCO_2e/cap/year 2019)

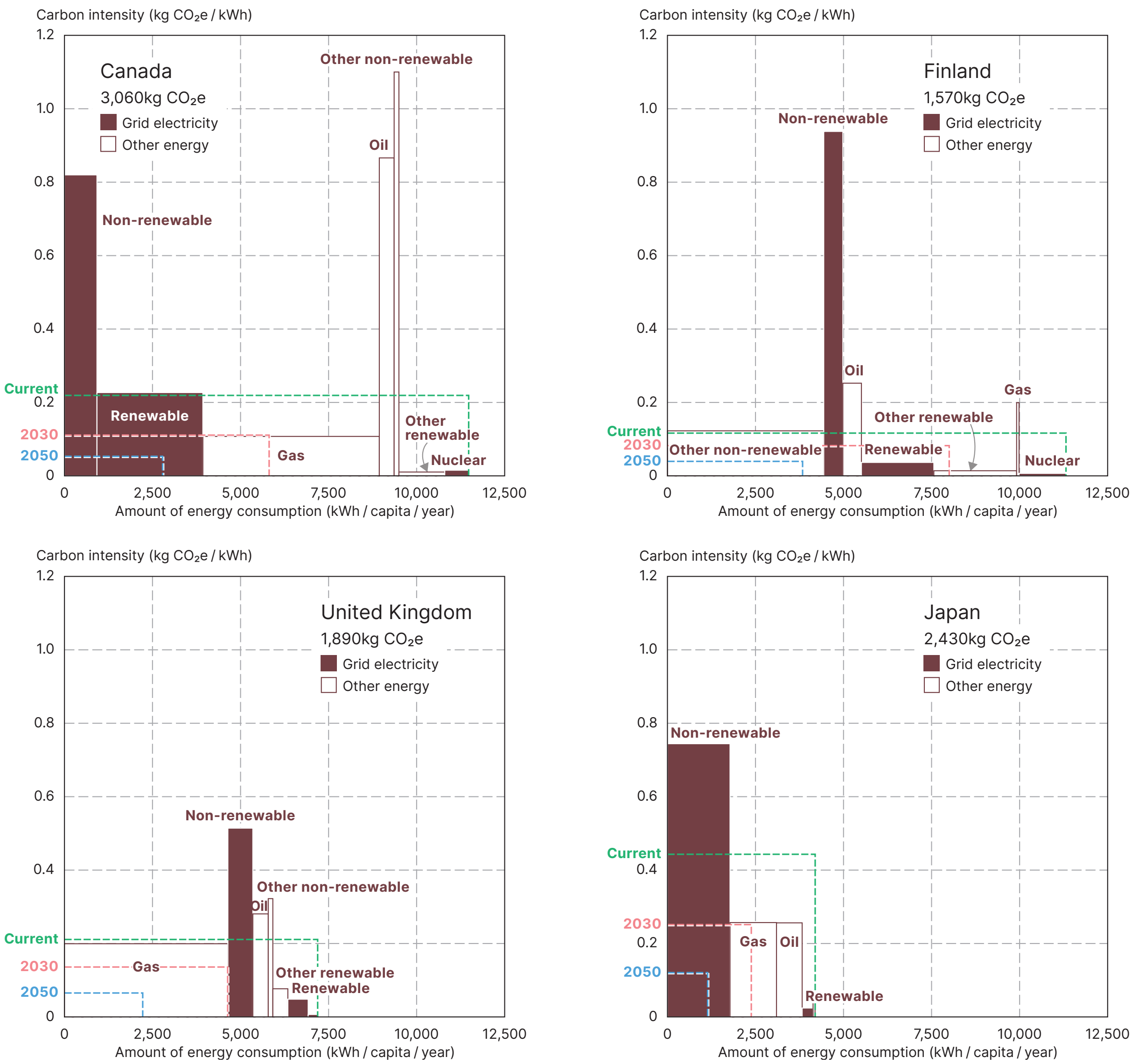
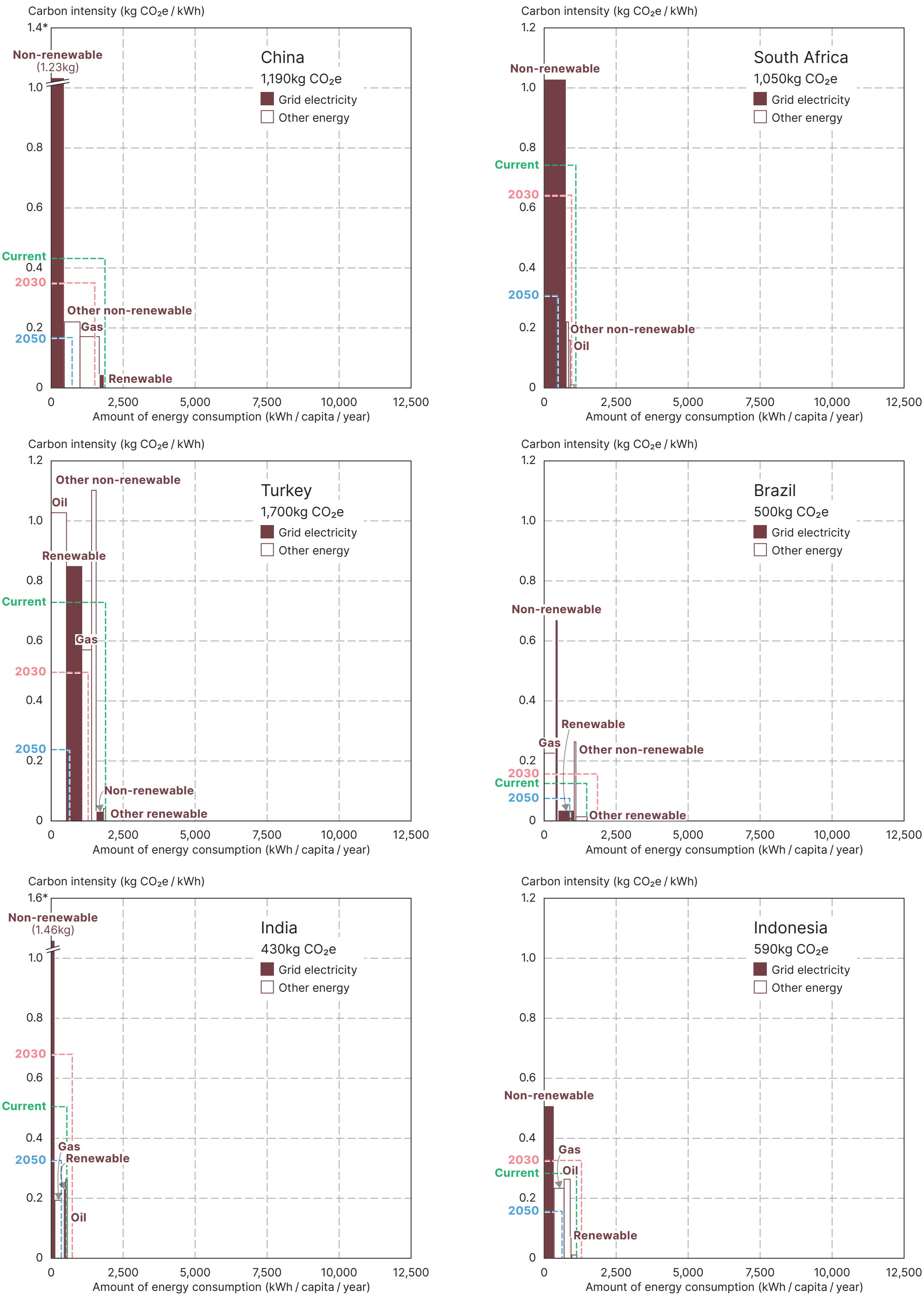


Figure 3.7. A comparison of carbon footprints in higher-income countries (A) and upper and lower middle-income countries (B) (housing energy, in $kgCO_2e/cap/year$ 2019)



* Different scale in y-axis compared to other countries.

and 34% of the energy used for room, sauna, and water heating is from wood, which is classified as carbon neutral (except for indirect emissions such as transport and production). Canada and the United Kingdom rely heavily on natural gas as the main energy source for heating, but the intensity for natural gas is over a fifth lower compared to LPG and urban gas used in Japan. As a result, for direct housing energy use, the overall renewable share in Canada and Finland is higher than in the United Kingdom and Japan (38–39% vs. 14–8%).

For **upper-middle income countries**, overall housing footprints, size of living space and energy demand are mainly lower compared to high-income countries (500–1,700 $kgCO_2e$, 19–41m^2, 1,100–1,900kWh, respectively, see Figure 3.7), resulting in a lower average carbon intensity per living space (36 $kgCO_2e/m^2$) compared to high-income countries (50 $kgCO_2e/m^2$). The smaller living space per person is due to the higher average number of household members. The lower energy demand is due to less use of appliances and electricity and the lower heating demand is explained by the fact that the upper-middle income countries are situated in warmer regions of the world. Compared to Brazil's high share of renewables in total energy demand (65%), that of Turkey, China, South Africa, and Indonesia is much lower (17%, 9%, 14% and 12%, respectively) so that also the carbon intensity of grid electricity in these countries is significantly higher. In Brazil, 83% of grid electricity is renewables, mainly hydropower. On the contrary, grid electricity is generated mainly with coal and its derivatives in other middle income countries.

Housing footprints are one of the smallest among all countries in the **lower-middle income country**, India (430 $kgCO_2e$, see Figure 3.6). Living space per person is the smallest (10 m^2) and the overall energy demand is one of the lowest (540 kWh) among all countries studied. A high share of the population living under poverty is reflected in an average living space (10 m^2) that barely fulfills decent living standards (Rao and Min 2018). The low use of energy is explained by the rudimentary living conditions on average and lower heating demand owing to the climate.

Non-renewables, mainly coal and oil based energy sources, play a major role in energy generation (48% of grid electricity and 90% of non-electricity energy). Renewables used are mainly hydropower.

In relation to the 1.5-degree targets for 2030 and 2050, the carbon footprint reductions required in the high-income countries studied are 50–74% and 90–94%, respectively, which should be achieved either by reduced consumption or improved efficiency (see Figure 3.7). The reduction required in the middle-income countries' housing footprint is 25–54% by 2030 and 64–89% by 2050. For the lower-middle income country, footprint reductions in the housing domain are not needed by 2030, but the needed reduction for 2050 is 52%.

3.2.3. Personal transport

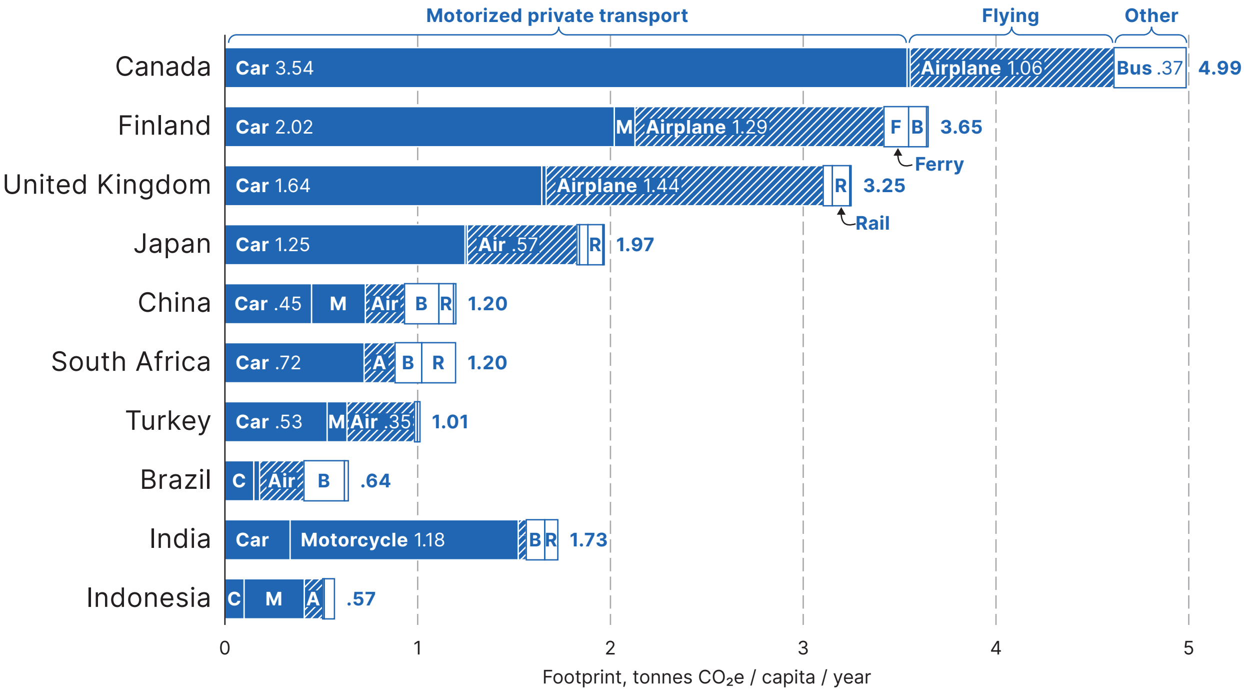
Personal transport related footprints are highest in high-income countries due to high overall transport demand and high share of car use and carbon-intensive air travel (Figure 3.8). Though Japan and India are an exception: Japan has a high mobility demand but a notably higher share of public transport use compared to other high-income countries; India has a transport demand similar to Finland but motorcycles are responsible for the largest share of transport demand and footprint. In countries with a lower share of car use, transport demand is mainly focused on public transportation (bus and train), except in India and Indonesia, where motorcycles are the biggest contributor to both mobility demand and footprints.

In **high-income countries**, the overall transport demand is higher compared to other countries, though India is an exception (see Figure 3.9). Canada has the highest transport demand at 22,200 km, compared with 17,500 km in Finland, 14,700 km in the United Kingdom and 11,000 km in Japan. Cars are the biggest contributor to the carbon footprint of personal transport in all the high-income countries studied. The modal share of cars varies a lot within high-income countries, from very high (70%) in Canada to moderate (46%) in Japan. The carbon intensity of cars is slightly higher in Japan compared to other high-income countries, probably due to selection of intensity data, which is based on global averages for different car classes and fuel types for countries other than Japan.

Air travel is the second largest contributor to transportation footprints (see Figures 3.8 and 3.9), though the modal share might be lower compared to other modes of transportation. For example in the United Kingdom, flights induce 1,400 kgCO_2e/capita (44% of the transport footprint), while only accounting for 29% of transport demand. Flights contribute more to the carbon footprint than other modes of transportation due to the notably higher carbon-intensity of air travel.

Travelling by land-based public transportation varies a lot within the high-income countries. Japan has the highest rate of public transportation use (3,600 km or 33% of the total transport demand), compared to other countries (from 9% in Finland to 15% in Canada), partly reflecting the higher service coverage supported by high population density in Japan. Japan has a notably higher use of trains (28% of transport demand) compared to Canada's 0.5% and to the United Kingdom's 8%. The use of buses is almost reversed—highest in Canada with 15% and lowest in Japan and the United Kingdom

Figure 3.8. Transport related carbon footprint (tCO_2e/cap/yr) and its breakdown between consumption components

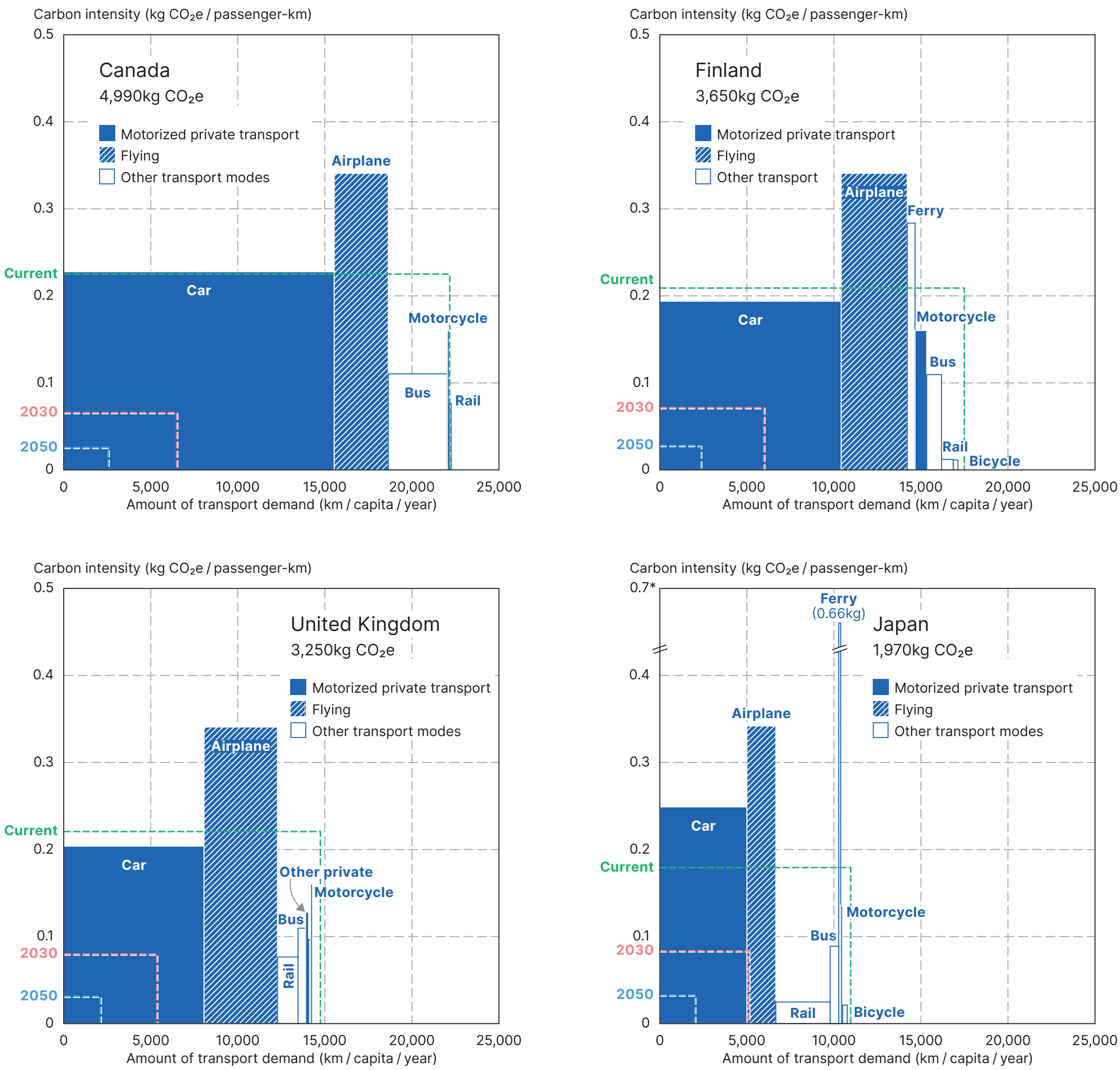


Note: Rail covers bullet, long-distance and local trains, as well as trams and metros; other public transportation covers local modes of transportation, such as auto-rickshaw in India and bajaj (three-wheelers) in Indonesia.

with 4% and 3%, respectively. The carbon-intensity of land-based public transportation is lowest in Finland due to the carbon-neutral policy of the national train service (VR Group Ltd. 2020). In Canada, a high share of the land-based public transportation is bus travel, which has notably higher carbon-intensity compared to train travel. Bicycles and walking account for a small share of the overall transport demand in high-income countries.

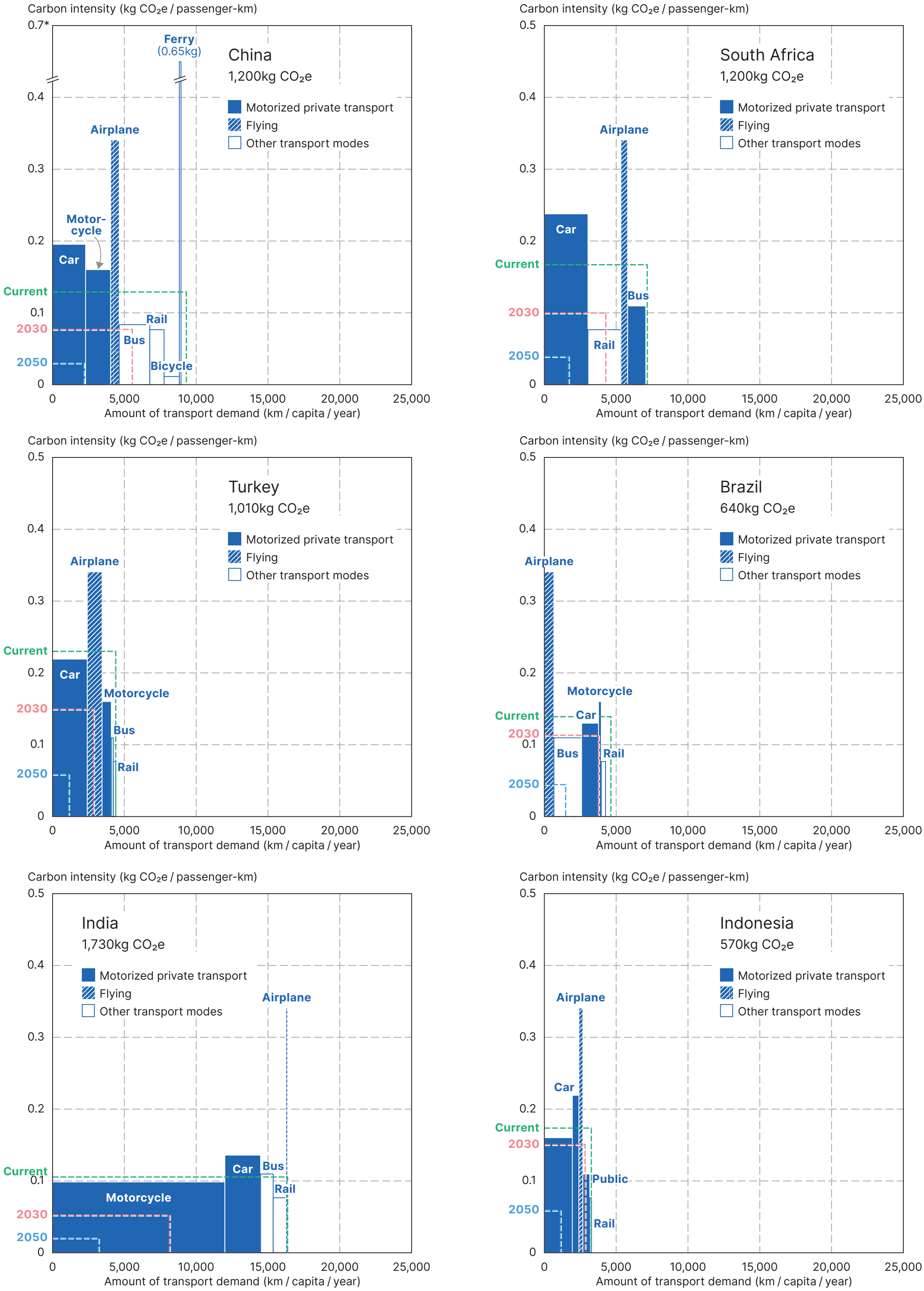
In the **upper-middle income countries** studied the average transport demand is only two-fifths of the demand of high-income countries (see Figure 3.9). China has the highest transport demand at 9,300 km, compared to 7,200 km in South Africa, 4,600 km in Brazil, 4,400 km in Turkey, and 3,300 km in Indonesia. Lower transport demand probably reflects lower consumption levels in upper-middle income countries compared to high-income countries. Of transport, cars are also the biggest contributor to the carbon footprint in the upper-middle income countries, except for Brazil and Indonesia, where it is buses and motorcycles, respectively. Modal share of cars are moderate, from 14% for Indonesia (460 km) to 55% for Turkey (2,400 km). Country-specific carbon intensities of cars are similar to high-income countries, except for Brazil where the car fleet is mainly flex fuel cars with lower carbon intensity compared to only fos-

Figure 3.9. A comparison of carbon footprints in higher-income countries (A) and upper and lower middle-income countries (B) and their breakdown (transport, in kgCO_2e/cap/year 2019)



* Different scale in y-axis compared to other countries.

Figure 3.9. A comparison of carbon footprints in higher-income countries (A) and upper and lower middle-income countries (B) and their breakdown (transport, in kgCO_2e/cap/year 2019)



* Different scale in y-axis compared to other countries.

sil fuel cars. The occupancy rate for cars in upper-middle income countries is similar to high-income countries though slightly lower, and the car fleet has a similar share of electric, hybrid, and alternative fuels using cars.

Air travel is the second largest contributor to the carbon footprint only in Turkey (see Figure 3.8), due to much higher transport demand for other modes of transportation in almost all upper-middle income countries. Land-based public transportation covers nearly half of the transport demand in China, South Africa, and Brazil (34%, 50%, and 48%, respectively). Turkey and Indonesia are an exception with a low share (7% and 18%, respectively) of public transportation. The share of trains of the total public transportation demand varies a lot among countries, from 13% in Brazil to 64% in South Africa. That also affects the carbon intensity of land-based public transportation, which is higher in countries with less train use. Motorcycles cover over half (55%) of the transport demand in Indonesia and nearly one-fifth in China and Turkey (19% and 15%, respectively), and although motorcycles have lower intensity than cars, it is still much higher than public transportation. In addition, other modes of public transportation cover altogether 15% of Indonesia's transport needs. High use of motorcycles and similar means of transportation probably reflects differences in cultural habits among the middle-income countries studied. Data for cycling and walking is inadequate and therefore their comparison within middle-income countries is not suitable.

In the **lower-middle income country**, India, overall demand for transport is similar to that of high-income countries (16,400 km in India, see Figure 3.8). Contrary to the countries of other income categories, motorcycles are responsible for the largest share of the transport footprint (68%) and transport demand (73%). Cars account for only 15% of the transport demand. Air travel is minor in transport demand, which probably reflects the role of air travel as a privilege of higher income classes, as over a fifth (22%) of the population live in poverty in India (World Bank Group 2020). Overall the share of public transportation is on a similar level with high-income countries (11%), but with the difference that other travel is not car-focused.

In relation to the 1.5-degree targets for 2030 and 2050, the reductions needed in high-income countries' personal transport are 78–91% and 97–99%, respectively (see Figure 3.9). For upper-middle income countries the needed reductions are 25–64% by 2030 and 88–95% by 2050. The lower-middle income country studied also needs to reduce its transport footprint greatly: by 75% by 2030 and 96% by 2050.

3.2.4. Other domain (consumer goods, leisure, and services)

Other domain footprints are strongly related with income levels, as shown in Figure 3.10. In particular, leisure related footprints are the lowest in countries with the lowest average per capita spending, such as India and Indonesia.

Consumer goods account for the greatest share of the footprint in most countries. Canada has a notably higher footprint compared to other countries, due in part to having the highest annual per capita spending but also due to notably higher spending on relatively high intensity consumer goods. In middle-income countries the spending is focused on necessities, such as clothing and furniture/room coverings.

The share of service-related footprints vary across countries and income groups. Although education and healthcare services are strongly subsidized by the government in Finland, the country has the highest service related footprint due to notably higher spending on finance/insurance related services.

The footprints of consumer goods, leisure, and services are highest in the **high-income countries** studied (see Figure 3.10), and the footprint varies among countries from Canada's highest footprint of 3,900 $kgCO_2e$ to the lowest of 1,700 $kgCO_2e$ in the United Kingdom. The spendings of high-income countries are also the highest among all case countries, and they vary from United Kingdom's pound equivalent[18] of 12,500 USD to Canada's dollar equivalent of 9,000 USD.

In Canada, Finland, the United Kingdom, and Japan consumer goods have the highest footprint, though the service domain has the greatest spendings. In the consumer goods domain, clothes have the highest spendings in all other countries, except in Japan, where clothes are the second highest after the category of other consumer goods (including jewelry, tobacco, and miscellaneous manufacturing products). In the service domain, finance and insurance-related services are clearly highlighted in all high-income countries. The leisure domain covers 17–26% of the summed up footprint and 12–29% of per capita spending in these three domains. Average carbon intensities for high-income countries are lowest for all three domains between case countries, possibly due to a higher share of renewables used for service production in industrialised countries compared to industrialising countries.

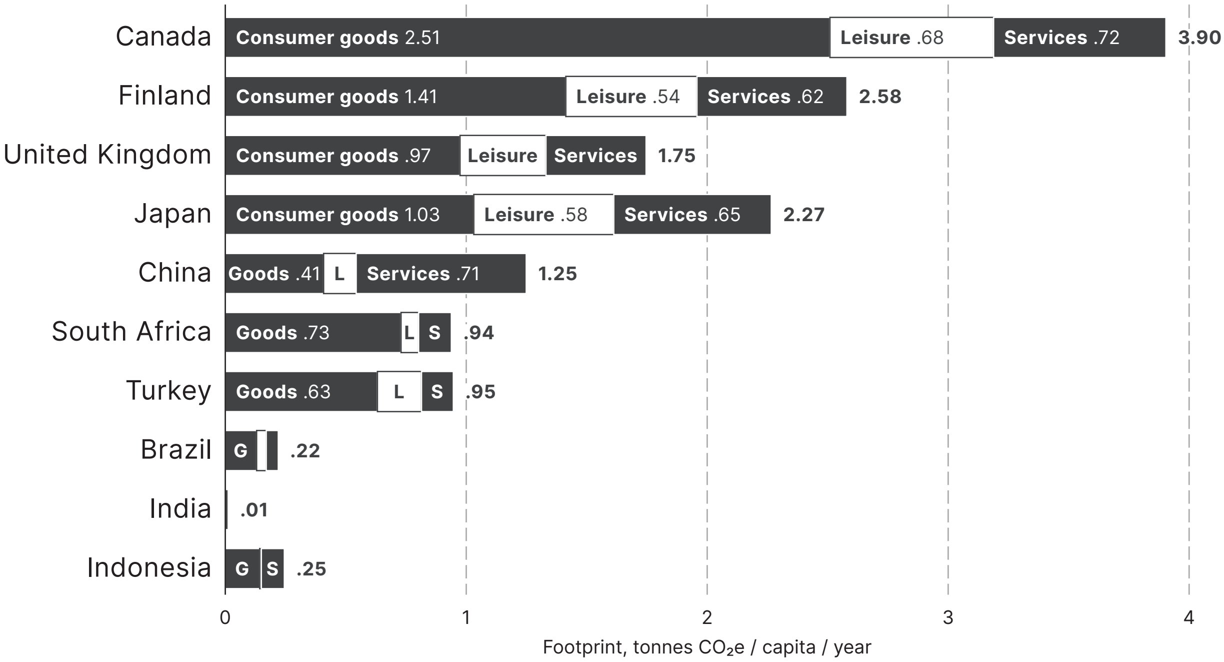
For **upper-middle income countries**, both the footprint and the spendings fall behind the high-income countries (see Figure 3.10). The average footprint is only one-fifth (19%: 720 $kgCO_2e$) and the per-capita consumer spending less than a tenth (8%: 1,100 USD) of high-income countries. Nevertheless, within upper-middle income countries, Indonesia has a notably lower footprint and per-capita consumer spending compared to other countries. In Turkey, South Africa, Brazil, and Indonesia, consumer goods account for the greatest footprint, as it covers over half (67%, 78%, 59% and 58%, respectively) of the summed up footprint of the three domains. In China, the highest are services (57%). Spending varies a lot among countries due to the different data quality and level of details available. Nevertheless, for China, South Africa, Brazil, and Indonesia a major part of the spending is targeted to services, though the use of different services vary between countries. In Turkey, consumer goods account for the greatest share of spendings, of which 67% is due to clothes and furniture/room coverings. Leisure is responsible for a minor part of spending in China, South Africa, Brazil, and Indonesia—only 6–28%—relatively similar to high-income countries.

For the **lower-middle income country**, India, the average footprint and spendings in these three domains are only a fraction compared to high-income countries (1%: 10 USD/capita) (see Figure 3.10). Although the summed up consumption of the three domains is distributed similarly in India and the upper-middle income countries—47% for consumer goods, 6% for leisure, and 47% for services—the overall consumption is vastly smaller. This is reflected in the footprint, which is only 15 $kgCO_2e$. It shows clearly that the average per-capita consumer spending is targeted to necessities, to clothes and footwear, education and welfare/medical services. Leisure-related annual consumption is less than 1 USD. Average carbon intensities for lower-middle income countries are the highest for all three domains, possibly due to a lower share of renewable energy sources used for product and service production and distribution.

In relation to the 1.5-degree targets for 2030 and 2050, the reductions needed in high-income countries' consumer goods, leisure, and services in total are 68–93% and 94–99%, respectively. For upper-middle income countries the needed reductions are 41–64% by 2030, except for Brazil and Indonesia where the footprints are already below the target, and 56–91% by 2050. The lower middle income country, India, has so far reached the 2030 and 2050 targets.

18 Country-specific currency converted into USD by using the average currency exchange rate for the year 2019. (X-Rates 2021)

Figure 3.10. Consumer goods, leisure, and services related carbon footprint (tCO_2e/cap/yr) and its breakdown between consumption components



4 – Options and Priorities for Shrinking Lifestyle Carbon Footprints

This chapter examines the reduction potentials of low-carbon lifestyle options towards meeting the 1.5-degree target, based on the estimates for current lifestyle footprints and proposed per-capita targets. Key approaches concerning low-carbon lifestyles are explained before evaluating country-specific impacts of low-carbon lifestyle options that could be applied.

4.1. Reduce, shift, improve

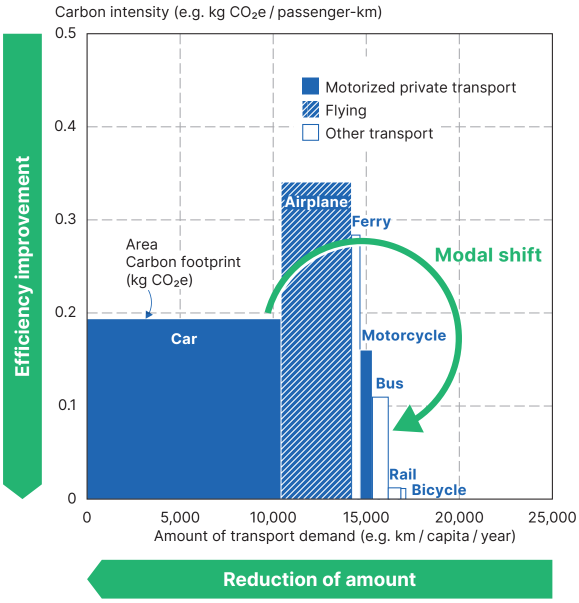
Analysis for this report estimates lifestyle carbon footprints based on the amount of consumption and the carbon intensity of the items. The report adopts three main approaches for reducing footprints: absolute reduction, modal shift, and efficiency improvement (Figure 4.1). These approaches are in line with analyses and recommendations from related literature (Vandenbergh et al. 2008; Jones and Kammen 2011).

I. Absolute reduction (Akenji et al. 2016) refers to reducing physical consumption of goods or services consumed, such as food, kilometers driven, energy use, or living space, as well as avoiding unsustainable options.

II. Modal shift (Nelldal and Andersson 2012) means changing from one consumption mode to a less carbon-intensive one, such as in adopting plant-based diets instead of eating excessive meat, using public transport instead of cars, or using renewable energy for electricity or heating instead of fossil fuels.

III. Efficiency improvement means decreasing emissions by replacing technologies with lower-carbon ones while not changing the amount consumed or used, such as in energy-efficient vehicles, appliances, or housing.

Figure 4.1. Key approaches for lifestyle carbon footprint reduction: absolute reduction, modal shift, and efficiency improvement



Source: IGES et al. (2019)

4.1.1. Rebound effects

When efficient products or environmentally sound behaviours are introduced, rebound effects need to be considered. Rebound effects refer to "the unintended consequences of actions by households to reduce their energy consumption and/or greenhouse gas (GHG) emissions" (Sorrell 2012). Rebound effects mean that efficiency improvements can be less effective than intended and can even increase total consumption and associated emissions (Schmidt-Bleek 1993). A review of the rebound effect of energy consumption concluded that direct rebound effects (rebound in the same consumption item) are expected to be up to 30%, while indirect and economy-wide rebound effects (rebound in other consumption items) can exceed 50% (Sorrell 2007). For example, introducing fuel-efficient cars might increase the total distance travelled by cars or the size of cars, which could potentially upset or even reverse the absolute amount of resource use or emissions. Rebound effects have also been considered in the context of other approaches including modal shift or absolute reduction (Buhl 2014; Ottelin et al. 2017). It is therefore important to examine cross-domain household behaviours to identify and try to address potential rebound effects.

Although theoretically, approaches such as the sharing economy can bring about significant synergies with low-carbon lifestyles, it also involves the possibility of rebound effects, depending on the options chosen (see Clausen et al. (2017) for potential negative effects). For example, car-sharing might increase the total distance of car use among citizens who were previously car-free, and increase car use especially outside rush-hours, thus potentially weakening demand for public transportation. Sharing options should not raise total carbon footprints by inducing additional demand or causing adverse shifts in consumption modes.

4.1.2. "Lock-in" effects

Another factor to consider when assessing the potential effectiveness of options for lifestyle changes is the "lock-in" effect (Sanne 2002; Akenji and Chen 2016). In facilitating low-carbon lifestyles, consideration of behavioural "lock-in" is important. While technological and institutional lock-in have been discussed in the context of blocking sustainable innovations (Unruh 2000; Foxon 2002), lock-in also applies to consumer choices and lifestyles in terms of products available on the market, infrastructure and public services, the consumer's community and social networks (Akenji and Chen 2016), as well as by economic framework conditions (Lorek and Spangenberg 2014). Consumers in the current society are to a certain degree locked-in by circumstances including work-and-spend lifestyles (Sanne 2002). Considering these challenges to behavioural change, there is a need also to improve production processes, improve the availability of low-carbon products or services by the private and public sectors, and bring about shifts in infrastructure as well as introduce national policies to enable the adoption of more low-carbon options and to phase-out carbon-intensive options. The shifts in lifestyles that are needed to meet the 1.5°C target thus need both systems and individual behaviour change (Akenji 2014). It remains with government and business and collaborative action by all stakeholders, especially those who are actively driving the current consumption modes.

4.2. Estimated impacts of low-carbon lifestyle options

In this report, the carbon footprint reduction of selected low-carbon lifestyle options were assessed for each country. The selected low-carbon options are based on a literature review presented in the first 1.5-Degree Lifestyles report, Annex E (IGES et al. 2019) and include both production and consumption side options; offering different point of views to reduction (absolute reduction, modal shift, efficiency improvement). The drastic reductions required to achieve the 2030 and 2050 targets (e.g. 60–82% by 2030 in high-income countries) highlight the need for high impact carbon reduction options.

Country-specific impacts of selected options were calculated based on data on physical consumption amount and carbon intensity (see Chapter 3). The reduction impacts were estimated based on the collected consumption and footprint data by changing the intensity and/or amount of relevant components depending on the nature of the options.

The percentage of the population changing their behaviour and the extent of change by each individual are critical, so both different adoption rates and depths of change are presented. "Full implementation" means that individuals fully implement a low-carbon option and realise the maximum reduction potential of that option. "Partial-adoption" means an option is partially adopted, either by individuals or by society. The "full implementation" practices of each option are defined as assumptions listed in Annex F in the first 1.5-Degree Lifestyles report (IGES et al. 2019) and the resulting maximum reduction potentials were estimated using LCA-based carbon footprint data by changing the carbon intensity and/or consumption amount of relevant components. Impacts from "partial-adoption" were estimated based on the following equation:

Partial adoption impacts
= full implementation impacts x adoption rate (%)

The results of the estimated carbon footprint reduction impacts for each country from full and partial implementation of options are summarised in Figures 4.2.–4.11. It should be noted that the selected low-carbon lifestyle options and their assumptions differ slightly among countries due to the applicability of options to local contexts and the availability of data.

In **high-income countries** the largest reduction potential of **500 to over 1,500 kg CO_2e/person/year** per option on average[19] are car-free private travel, reduction of international flights, vegan diet, electric car, vegetarian diet, renewable grid electricity, vehicle fuel efficiency improvement, renewable off-grid electricity, low-carbon protein instead of red meat, and renewable based heating and/or cooling.[20] Most options are based on a modal shift from carbon-intensive to other lower-intensity consumption modes, such as car to public transport, fossil fuel to renewable energy sources, and meat to vegetarian nutrition sources. High-impact efficiency improvement options, such as electric car and vehicle fuel efficiency improvements, are mainly found in the transport domain. The majority of the highest impact options are from the transport domain, while housing and food also offer major reduction potential through switching from non-renewables to renewable sources and through shifting dietary habits. In **upper-middle income** countries, the options exceeding the full potential of 500 kg per option on average[19] are vegan diet and low-carbon protein instead of red meat, making these the highest impact options. In **lower-middle income countries**, only living closer to the workplace (i.e. reducing commuting distance) exceeded 500 kg per option on average.[19]

Options with medium-high reduction potentials of **250 to 500 kg** *per option* on average[21] in **high-income countries** are living closer to the workplace, car-free commuting with electric bikes, ride sharing, smaller living space, hybrid car, car-free commuting with public transportation, closer weekend leisure, and efficiency improvement of home appliances. Options include modal shift, efficiency improvement, and absolute reduction, such as car-free commuting, ride sharing, and living closer to work, respectively. In **upper-middle income countries** the options exceeding the full potential of 250 kg per option on average[21] are vegetarian diets, renewable grid electricity, and renewable off-grid electricity. In **lower-middle income countries** the second largest potential per option on average[21] are vehicle fuel efficiency improvement, vegan diet, and vegetarian diet. In **middle income countries**, options are mainly based on modal shifts, such as switching from fossil to renewable energy sources and changing dietary habits.

Options with moderate impacts, **less than 250 kg** *per option* on average[22] in **high-income countries** are food production efficiency improvement, alternative dairy products, renting a guest room, telework, efficiency improvement of buildings, heat pump or air conditioner for temperature control[20], reduction of sweets and alcohol, reduction of domestic flights, household food loss reduction, saving hot water, lowering temperature at home and supply side food loss reduction, i.e., options based on efficiency improvement of production and products or absolute reduction of physical consumption amounts. In **middle-income** and **lower middle-income countries**, the majority of the options have an impact of less than 250 kg per option on average.[22]

When reading these findings, it's important to keep the limitations of this study in mind. First, the options analysed are not exhaustive but a selection based on available literature (see Annex E in the first 1.5-Degree Lifestyles report (IGES et al. 2019)). Second, the estimates are based on basic assumptions of changes in consumption amounts, modes, and/or carbon intensity, as well as the production side adopting the most ambitious company targets (see Annex C). Also, changes in energy systems, such as renewable electricity grid mix, were not systematically reflected in the estimation of every product and service but only as a specific option of direct energy use in the housing domain and as a general efficiency improvement in production in other domains (such energy system changes can be studied in future research). Last, this report does not consider the dynamic changes towards the future, such as interactions between demography, technology, economy, and consumption or comparisons with business-as-usual scenarios. The estimated impacts were calculated by altering amounts of consumption or carbon intensity of components based on the estimated footprints as of 2019, while the targets indicated for comparison relate to the future, such as 2030. A more comprehensive, dynamic modelling of future lifestyles is beyond the scope of this report.

---

19 Estimated to have more than 500 kgCO_2e/capita/year reduction potential in full implementation as a mean of potentials. Descending order by estimated mean reduction potentials.

20 The assumption varies depending on whether the energy is used for heating or cooling purposes in each country.

21 Estimated to have more than 250 kgCO_2e/capita/year reduction potential in full implementation as a mean of potentials. Descending order by estimated mean reduction potentials.

22 Estimated to have less than 250 kgCO_2e/capita/year reduction potential in full implementation as a mean of potentials. Descending order by estimated mean reduction potentials.

Figure 4.2. A comparison of estimated per-capita carbon footprint reduction impacts (kgCO$_2$e/capita/year) of low-carbon lifestyle options (Canada)

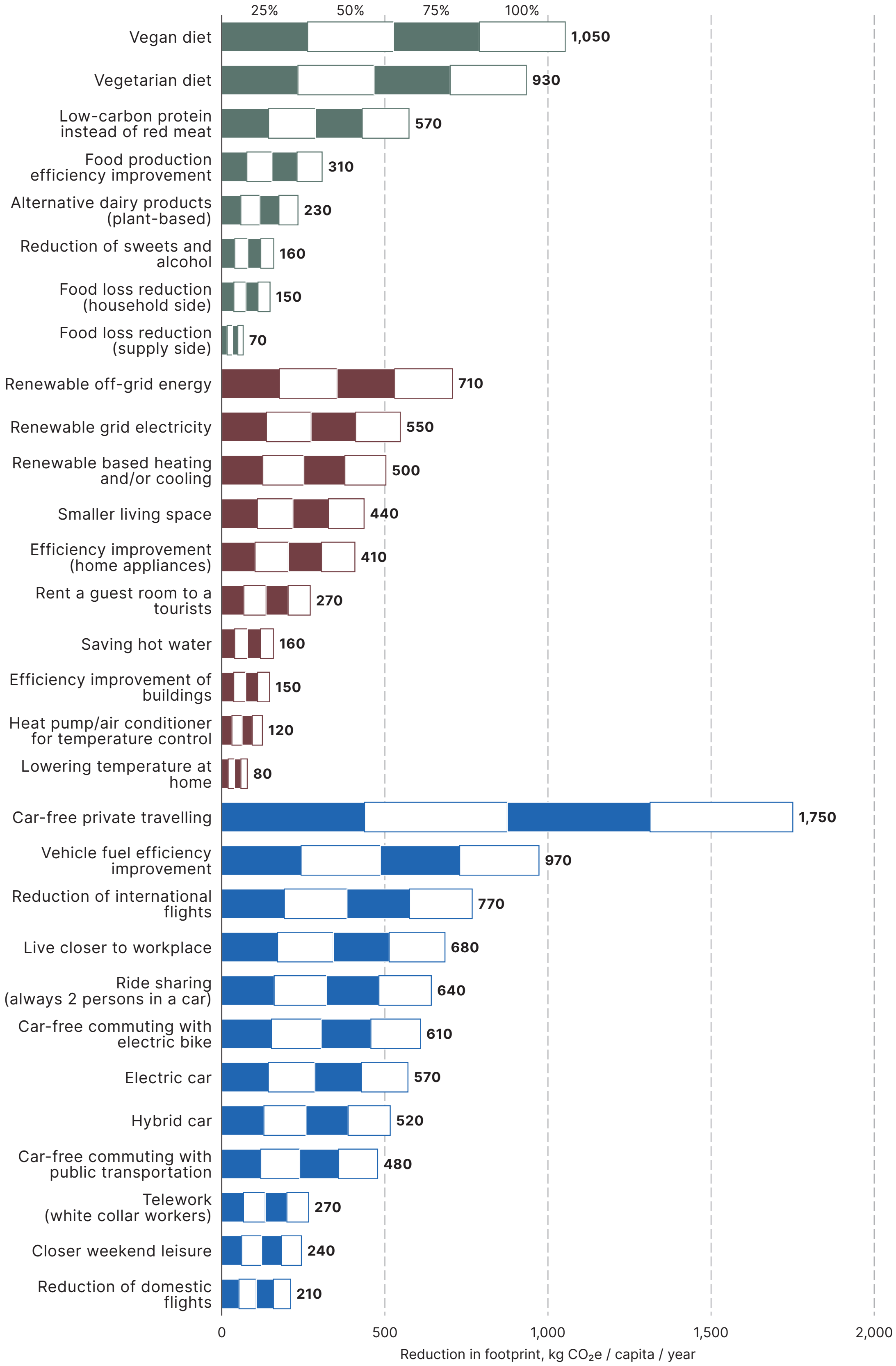


Figure 4.3. A comparison of estimated per-capita carbon footprint reduction impacts (kgCO_2e/capita/year) of low-carbon lifestyle options (Finland)

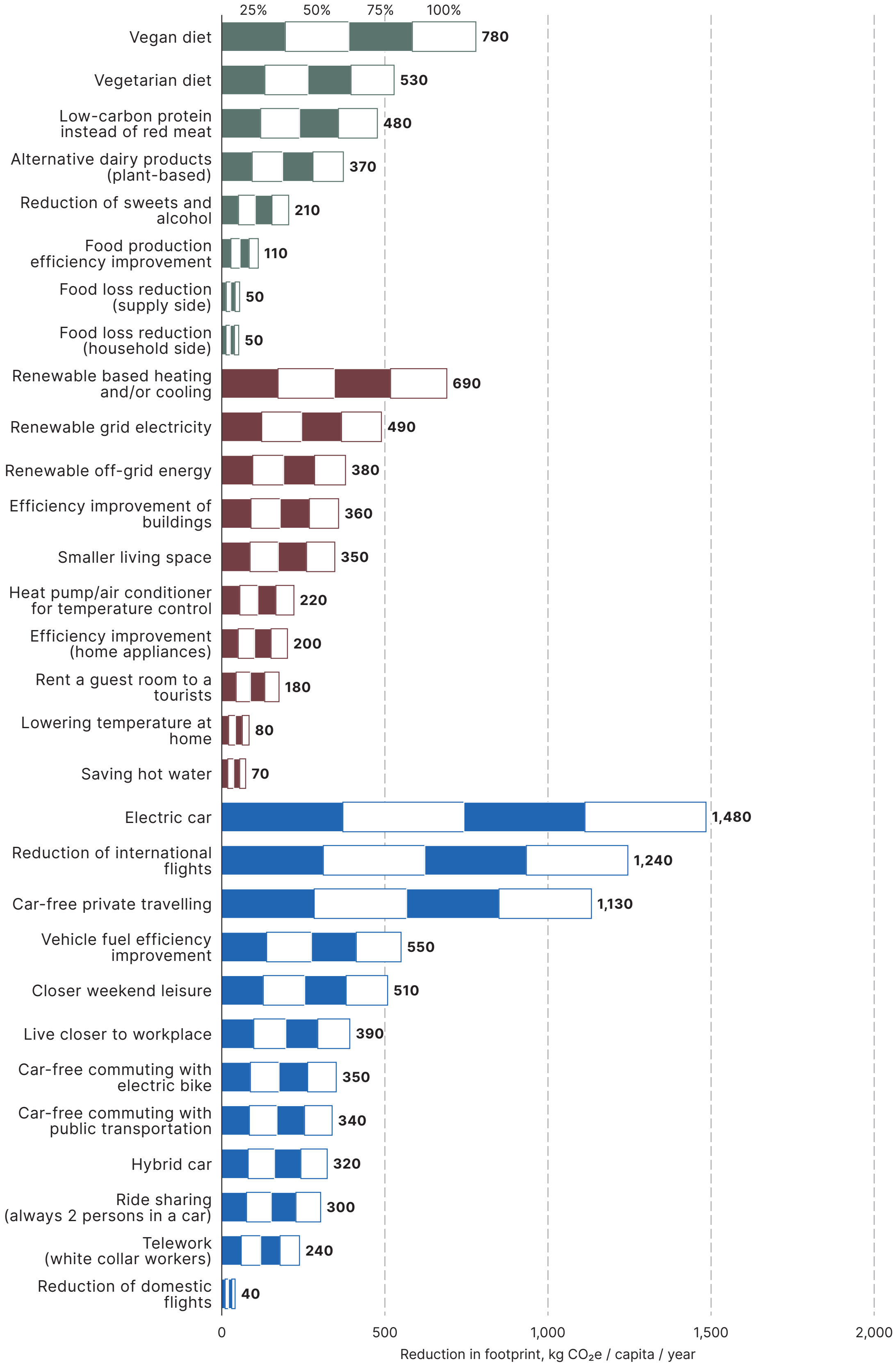


Figure 4.4. A comparison of estimated per-capita carbon footprint reduction impacts (kgCO_2e/capita/year) of low-carbon lifestyle options (United Kingdom)

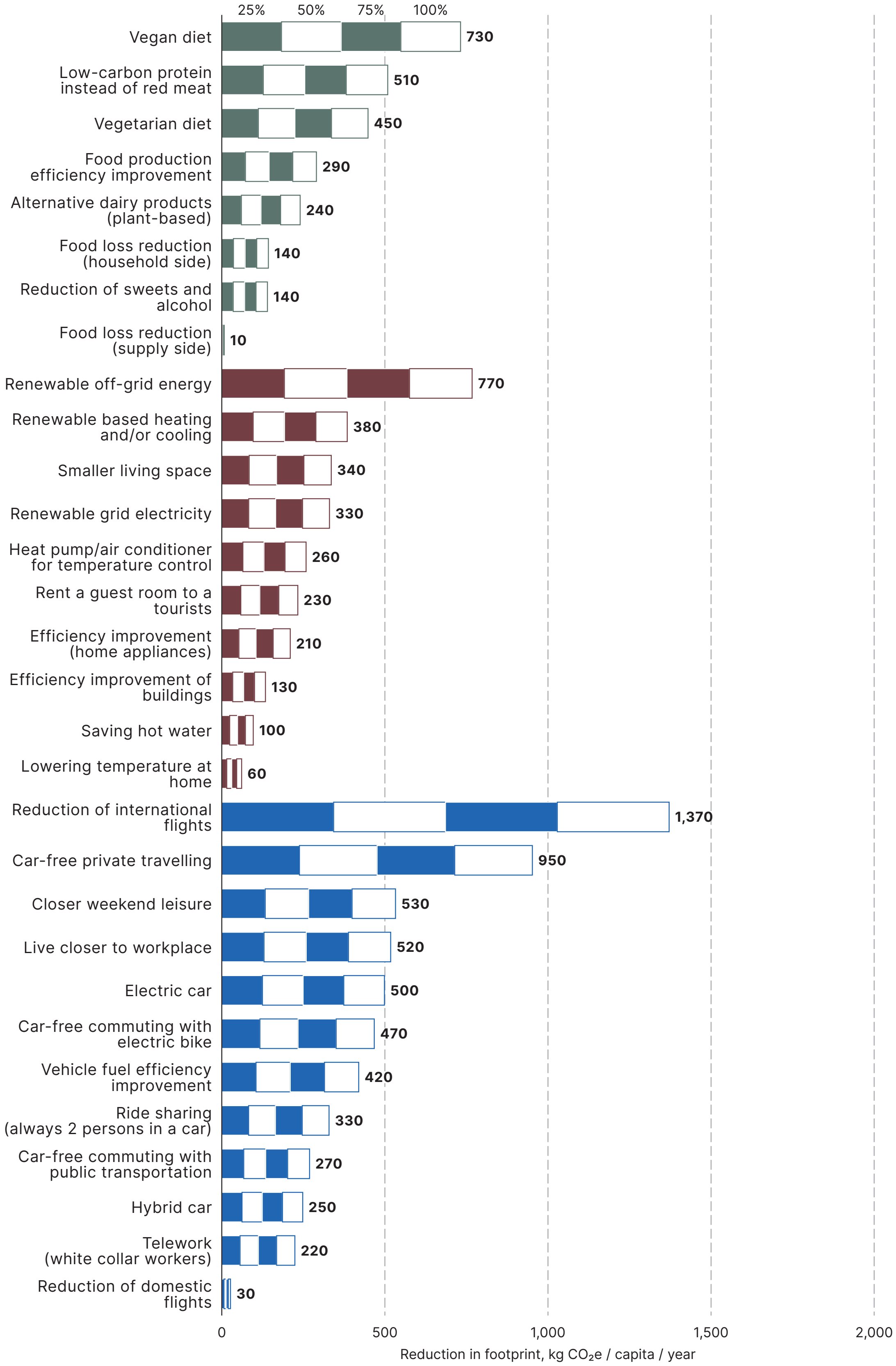


Figure 4.5. A comparison of estimated per-capita carbon footprint reduction impacts ($kgCO_2e$/capita/year) of low-carbon lifestyle options (Japan)

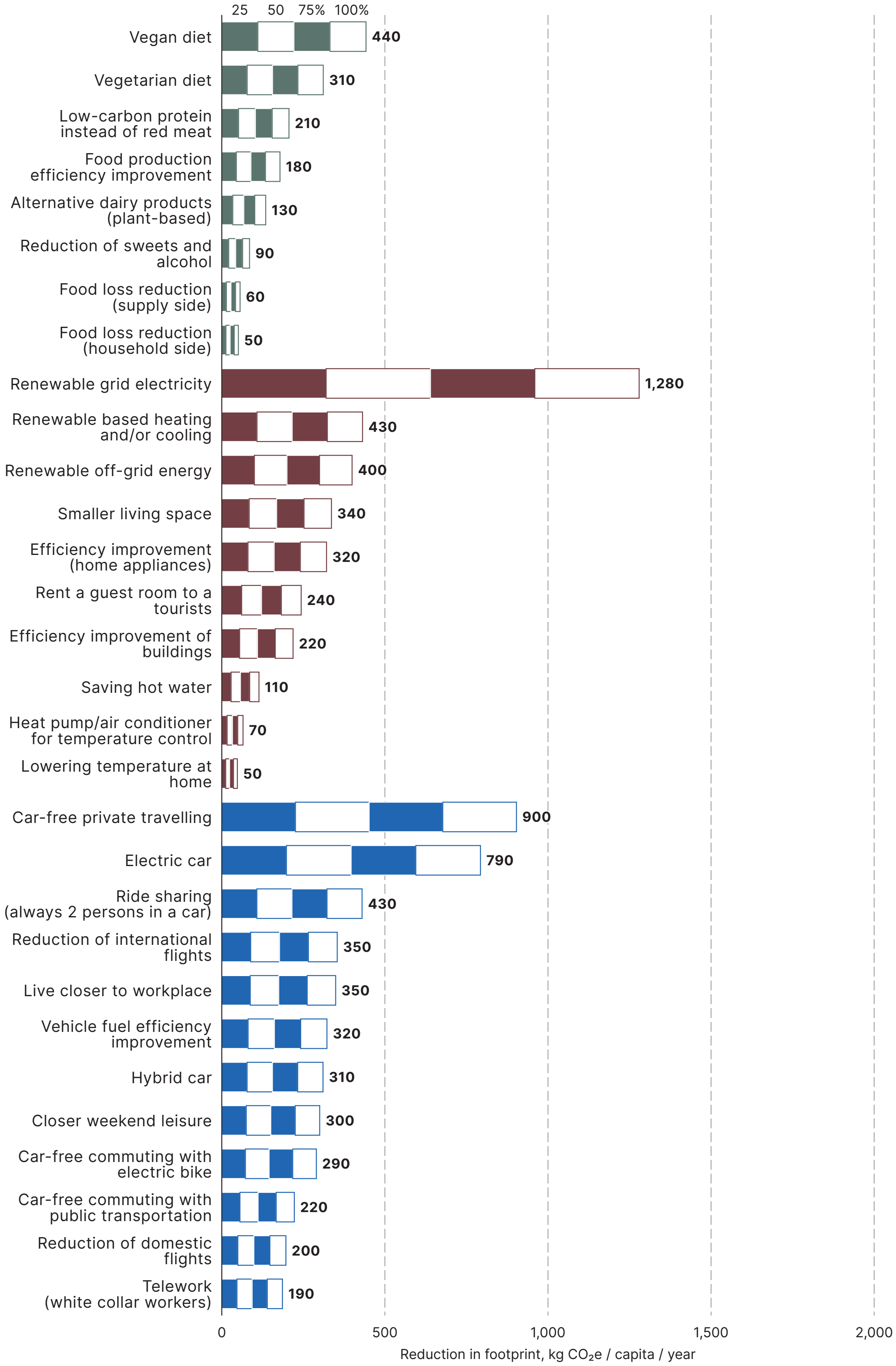


Figure 4.6. A comparison of estimated per-capita carbon footprint reduction impacts (kgCO_2e/capita/year) of low-carbon lifestyle options (China)

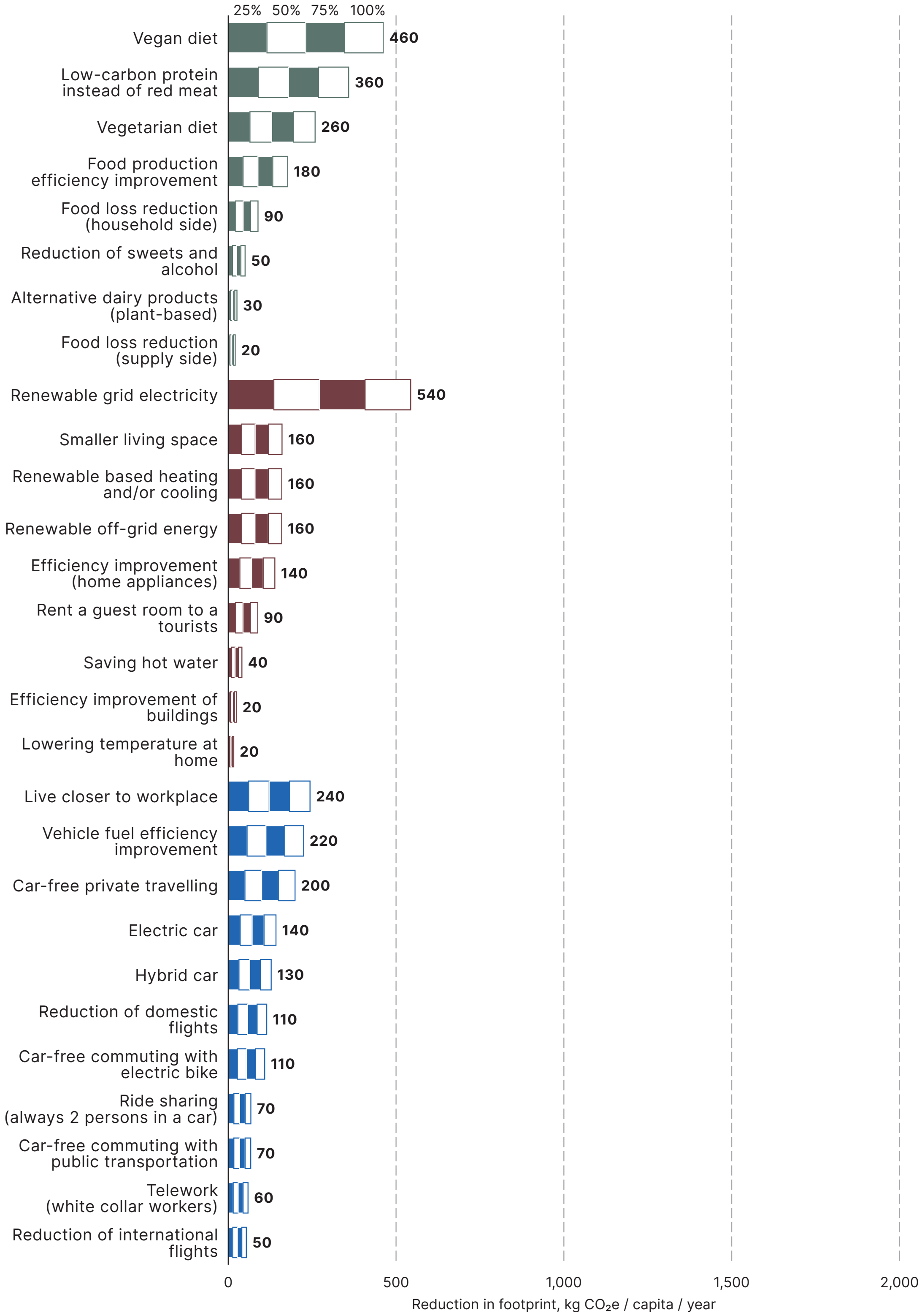


Figure 4.7. A comparison of estimated per-capita carbon footprint reduction impacts (kgCO_2e/capita/year) of low-carbon lifestyle options (South Africa)

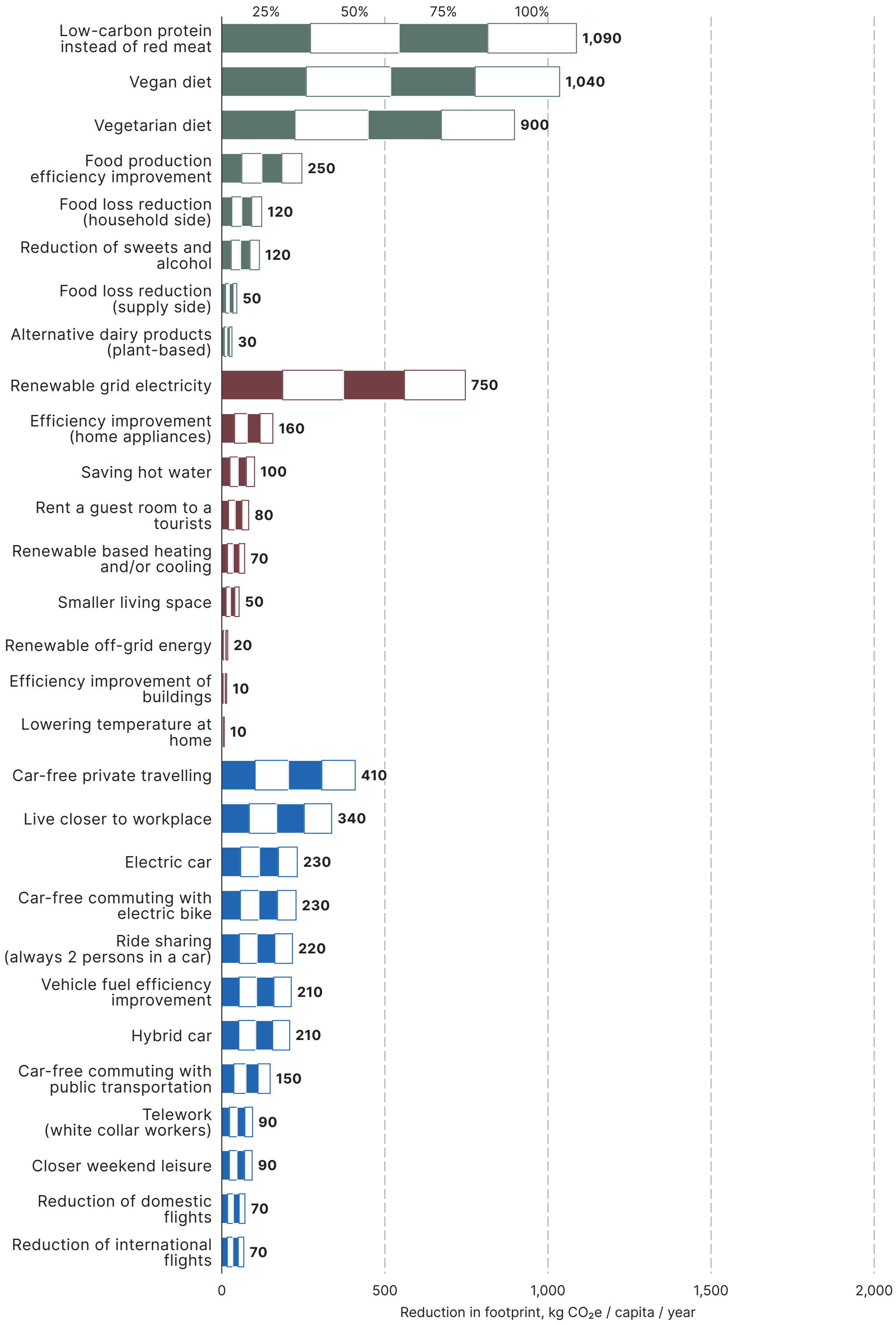


Figure 4.8. A comparison of estimated per-capita carbon footprint reduction impacts (kgCO_2e/capita/year) of low-carbon lifestyle options (Turkey)

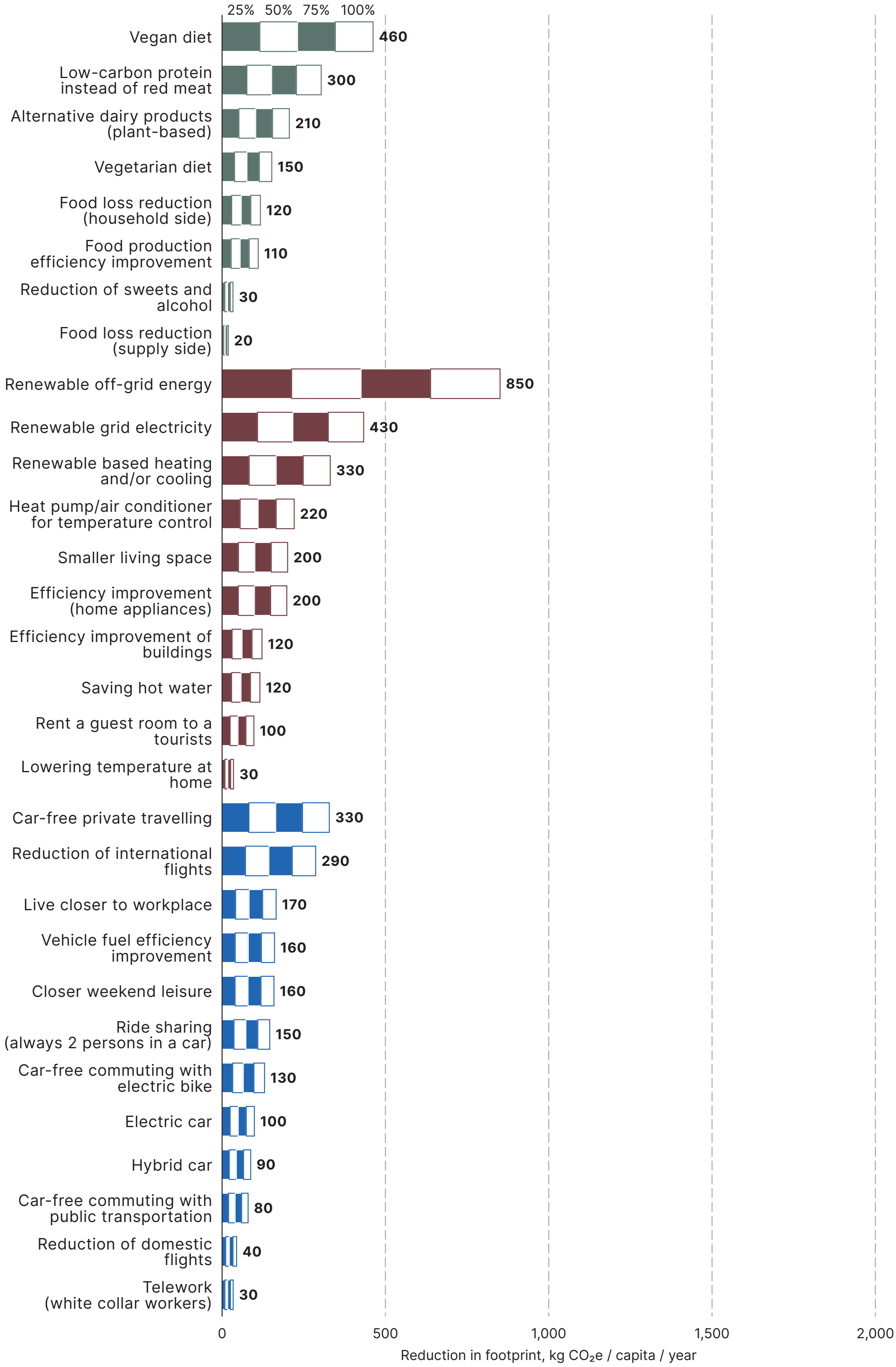


Figure 4.9. A comparison of estimated per-capita carbon footprint reduction impacts (kgCO_2e/capita/year) of low-carbon lifestyle options (Brazil)

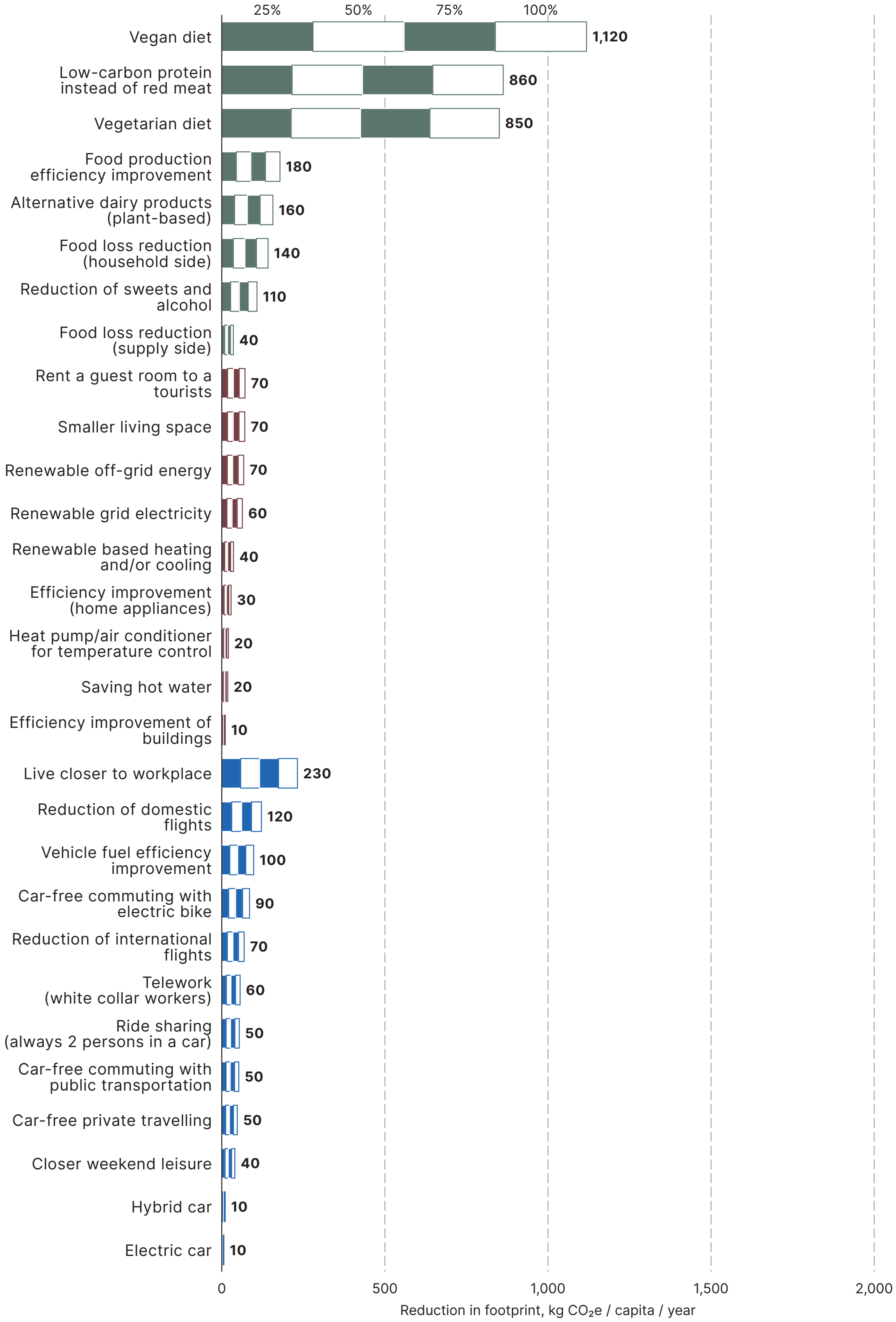


Figure 4.10. A comparison of estimated per-capita carbon footprint reduction impacts ($kgCO_2e$/capita/year) of low-carbon lifestyle options (India)

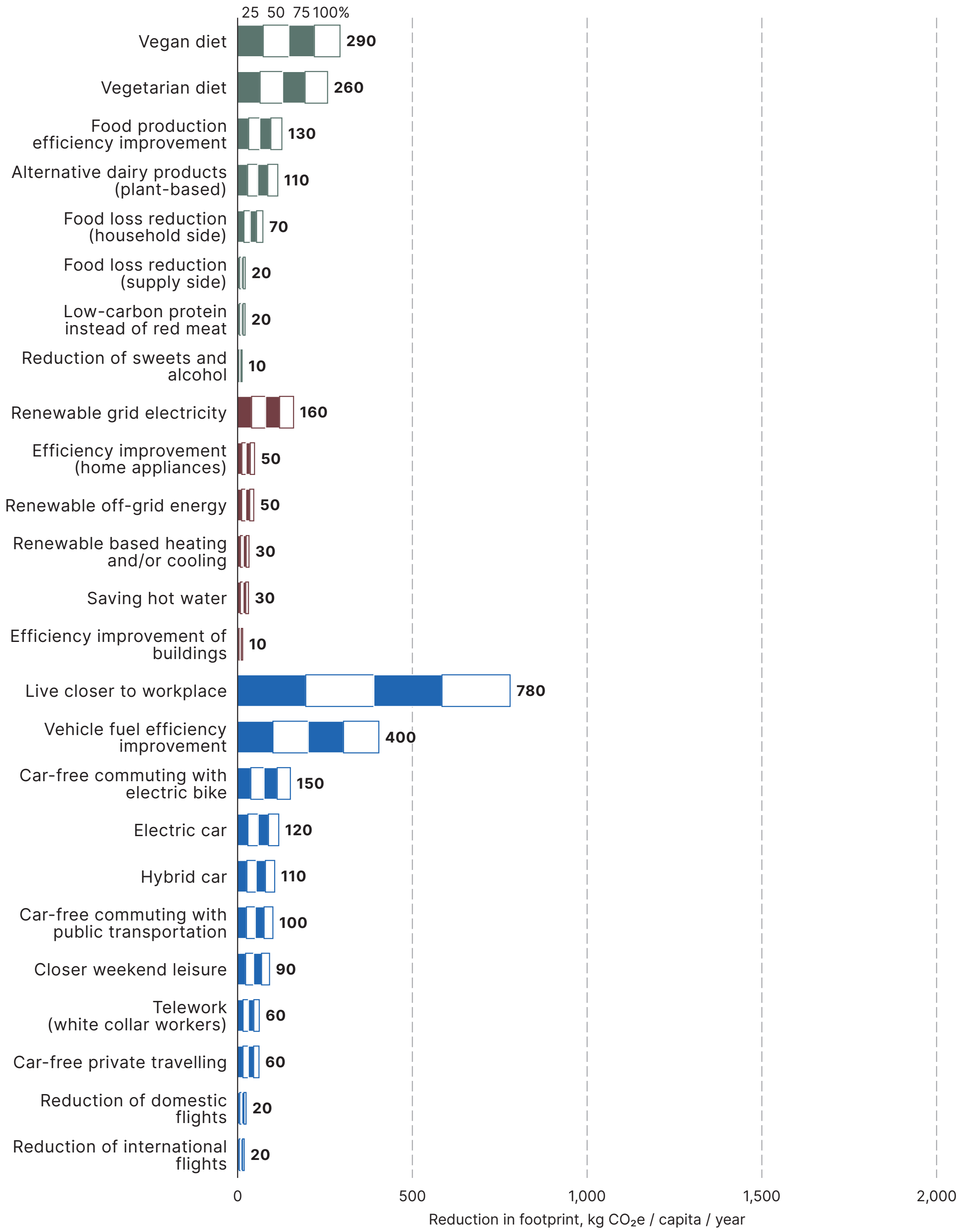


Figure 4.11. A comparison of estimated per-capita carbon footprint reduction impacts ($kgCO_2e$/capita/year) of low-carbon lifestyle options (Indonesia)