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1.5 DEGREE LIFESTYLES

Targets and options for reducing lifestyle carbon footprints

A summary

Michael Lettenmeier, Lewis Akenji, Viivi Toivio, Ryu Koide and Aryanie Amellina

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1.5-degree lifestyles
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This summary is based on a technical report **1.5-degree lifestyles: Targets and options for reducing lifestyle carbon footprints**
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Abbreviations

BECCS	Bioenergy with carbon capture and storage
CO_2	Carbon dioxide
COICOP	Classification of individual consumption by purpose
GHG	Greenhouse gas
IAMs	Integrated assessment models
INDC	Intended nationally determined contribution
I/O	Input-output tables
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LCA	Life-cycle assessment
LPG	Liquefied Petroleum Gas
UN Environment	United Nations Environment Programme

Foreword

This summary report is intended to serve as a fact base for discussions on how society can better limit global warming to within the 1.5-degree limit, the aspirational target of the Paris Agreement, from the perspective of lifestyles. This is a summary version of a comprehensive technical report *1.5-degree lifestyles: Targets and options for reducing lifestyle carbon footprints* (IGES et al. 2019). This summary is intended to serve as a starting point for policymakers, academics, corporate leaders and the general public when setting concrete targets and discussing how to best achieve required changes in our everyday lives. A prototype of an interactive tool for households has been added to this summary (see Appendix). The tool "1.5-degree lifestyles puzzle" intends to make the results and implications of the project approachable and understandable to both households and other stakeholders in order to foster discussion and actions around the required changes.

Changes in our consumption patterns and dominant lifestyles are a critical and integral part of how we can address the challenges of climate change. However, so far, limited efforts have been made in the scientific literature and policy approaches to show the potential contribution that changes in lifestyles could have in keeping global warming within the limit of 1.5 °C, the aspirational target of the Paris Agreement. The study conducted for this report is an attempt to fill that gap, and to begin to propose clear targets and the quantifiable benefits of climate change solutions from lifestyle changes. The results of the analysis are eye-opening, showing the need for reductions of over 90% in greenhouse gas emissions by 2050 from today's lifestyles. The report also offers solutions and creates hope by showing what kinds of changes are needed on an individual and household level. The time to act is now.

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Executive summary

This report proposes targets and options for how society can better limit global warming to within the 1.5-degree limit, the aspirational target of the Paris Agreement, from the perspective of lifestyles. To date, efforts to address this problem have been lacking, both in scientific literature and government policies the world over. The related literature tends to focus on footprints of specific products, organisations, cities or countries. The current discourse on solutions to climate change is largely based on technology, despite the importance of behavioural change and systemic infrastructural changes (Creutzig et al. 2016; Akenji and Chen 2016). The need for change, to urgently and drastically reduce GHG emissions, has been reinforced by the Intergovernmental Panel on Climate Change (IPCC) *Special Report on Global Warming of 1.5 °C* (IPCC 2018). The considerable influence of behaviour, lifestyles and culture, including consumption patterns and dietary changes on climate change has been recognised (IPCC 2014). Changing our lifestyles, especially in those areas of consumption not locked into the existing infrastructure (e.g., Lettenmeier, Laakso, and Toivio 2017) would make a visible impact, and quickly, in lowering carbon emissions.

We need to aim for per-person carbon footprint targets of 2.5 (tCO_2e) in 2030, 1.4 by 2040 and 0.7 by 2050.

This report has thus undertaken the challenge of examining GHG emissions and reduction potential from the consumption and lifestyle perspectives through the study of lifestyle carbon footprints, defined as GHG emissions directly emitted and indirectly induced from household consumption, excluding those induced by government consumption and capital formation such as infrastructure. To illustrate the full impact of household actions on climate change, we therefore assess the carbon footprint of the lifestyles of individuals – the goods and food we buy, our housing, how we get around and the services we use – to provide a more realistic perspective and a more useful platform on which to base efforts for reducing emissions. We estimate the carbon footprints of Finland and Japan, as well as Brazil, India and China, focusing on comparing levels of physical consumption with respect to both global targets and household-level solutions.

This report offers options for reducing these footprints, drawn from the available literature, and assesses the impact of such options in the Finnish and Japanese contexts. This report is a summary version of a technical report *1.5-degree lifestyles: Targets and options for reducing lifestyle carbon footprints* (IGES et al. 2019). The methodology, data sources and results of the estimates are detailed in the technical report and its annexes.

What we found – targets and gaps

The results highlighted the huge gaps between current per capita footprints and targets. Estimates of current annual average lifestyle carbon footprints of the populations of the countries we studied per person as of 2017 were: Finland: 10.4 (tCO_2e); Japan: 7.6; China: 4.2; Brazil: 2.8; and India: 2.0. In comparison, based on our review of the emission scenarios, this study proposes that we need to aim for per-person consumption-based targets of 2.5 (tCO_2e) in 2030, 1.4 by 2040 and 0.7 by 2050. 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. In terms of the gaps between actual lifestyle footprints and the targets, footprints in developed countries need to be reduced by 80–93% by 2050, assuming actions for a 58–76% reduction start immediately to achieve the 2030 target; even developing countries need to reduce footprints by 23–84%, depending on the country and the scenario, by 2050.

Hotspots

A closer examination of lifestyle carbon footprints based on physical consumption units revealed several hotspots, which are: meat and dairy consumption, fossil fuel-based energy, car use and air travel. The three domains these footprints occur in – nutrition, housing and mobility – tend to have the largest impact, approximately 75% of our total lifestyle carbon footprint. Some of the hotspots such as car use and meat consumption are common among case countries, while others are country-specific, such as dairy consumption in Finland and fossil fuel-based electricity in Japan, suggesting we need to consider local contexts and tailor-made solutions.

Options with potential

The options with large emission reduction potential as revealed in this study include: car-free private travel and commuting; electric and hybrid cars; vehicle fuel-efficiency improvement; ride sharing; living nearer workplaces and in smaller living spaces; renewable grid electricity and off-grid energy; heat pumps for temperature control; and vegetarian/vegan diets and substituting dairy products and red meat. If these options are fully implemented, they could reduce the footprint of each domain by a few hundred kilograms to over a tonne annually. The impacts we can expect vary according to what extent we adopt the options. Lifestyles could greatly contribute to achieving the 2030 1.5-degree target. This would require very ambitious levels of introduction in Finland and Japan, such as over 75% for around 30 options.

How to achieve 1.5-degrees lifestyles and how to act

This report represents one of the first of its kind in terms of proposing per capita footprint targets and assessing the gaps and solutions based on the physical amount of consumption across consumption domains. Its methods and approaches for highlighting the real impacts of current patterns of consumption and potential impacts of low-carbon lifestyles could be expanded for adoption in other dimensions and countries – such as evaluating broader types of low-carbon lifestyle options, facilitating action by stakeholders or creating interactive facilitative tools to assist stakeholders in identifying problem areas and solutions. The identified options can be tested in real households, neighbourhoods and communities, with government and private-sector support to gauge the feasibility and acceptability of all solutions.

At the individual household level, following the recommendations herein represents a colossal task, thus a combination of system-wide changes and a groundswell of actions is implicit in its undertaking. The required levels of reductions, exceeding 90% based on current lifestyle carbon footprints, imply a radical rethink of sustainability governance and the need for new business models to shift the paradigms on which we base infrastructure, economies and consumer lifestyles.

The capacities of all stakeholders will need developing, both in industrialised and industrialising countries, which places an additional burden on the latter to ensure their populations have their basic needs satisfied. Along with this challenge, however, comes opportunities, which this report identifies. Needless to say, the call for action could never be more urgent or overstated if we are to realise sustainability as a civilisation.

Tiivistelmä

Tämä raportti ehdottaa hiilijalanjälkitavoitteita ja vaihtoehtoja sille, miten yhteiskunta voi elämäntapamuutosten kautta rajoittaa ilmaston lämpenemisen enintään 1,5 asteeseen Pariisin ilmastosopimuksen tavoitteiden mukaisesti. Sekä aihetta käsittelevä kirjallisuus että poliittinen päätöksenteko ja liike-elämä ovat toistaiseksi keskittyneet lähinnä tiettyjen maiden, kaupunkien, organisaatioiden tai tuotteiden – muttei kuluttajien – hiilijalanjälkiin. Tämä on osaltaan heikentänyt ponnisteluja ilmastokriisin ratkaisemiseksi. Ilmastonmuutoksen ratkaisuista käyty keskustelu on pitkälti liittynyt teknologioihin, vaikka käyttäytymistä ja infrastruktuuria koskevilla systeemisillä muutoksilla on myös suuri merkitys (Creutzig et al. 2016; Akenji & Chen 2016). Hallitustenvälinen ilmastonmuutospaneeli IPCC (2018) korosti erikoisraportissaan *Global Warming of 1.5 °C* nopeiden muutosten tarvetta, jotta kasvihuonekaasupäästöjä voidaan vähentää merkittävästi. Käyttäytymisen, elämäntapojen ja kulutustottumusten merkittävä vaikutus ilmastonmuutokseen on tunnustettu (IPCC 2014a). Elämäntapojemme muuttamisella voisikin olla näkyvä ja nopea vaikutus hiilidioksidipäästöjen vähentämisessä erityisesti niillä kulutuksen osa-alueilla, jotka eivät ole lukittuneet olemassa olevaan infrastruktuuriin (esim. Lettenmeier, Laakso & Toivio 2017). Yksilö voi esimerkiksi helpommin muuttaa ruokavaliotaan vähäpäästöisemmäksi milloin tahansa tekemällä uudenlaisia ostopäätöksiä, kun taas yksityisautoilun ehdoilla suunniteltu kaupunkirakenne ja tieinfrastruktuuri voi tehdä vähähiilisistä liikkumisen vaihtoehdoista hitaita tai hankalia toteuttaa.

Henkeä kohden lasketun hiilijalanjäljen tavoitetaso olisi 2,5 tonnia CO_2e vuoteen 2030 mennessä, 1,4 tonnia 2040 mennessä ja 0,7 tonnia 2050 mennessä.

Tämä selvitys tarkastelee kasvihuonekaasupäästöjä ja niiden vähennyspotentiaalia kuluttamisen ja elämäntapojen näkökulmasta. Elämäntapojen hiilijalanjäljet on määritelty kotitalouksien kulutuksesta suoraan ja välillisesti aiheutuviksi kasvihuonekaasupäästöiksi, joihin ei ole laskettu mukaan julkisesta kulutuksesta ja pääoman muodostuksesta, kuten infrastruktuurista, aiheutuvia päästöjä. Kotitalouksien ja yksilöiden elämäntapojen – eli mitä ostamme ja mitä syömme, missä ja miten asumme, miten ja mihin liikumme – hiilijalanjälki tarjoaa perustan päästövähennystoimenpiteille. Tarkastelemme Suomen ja Japanin lisäksi Brasilian, Intian ja Kiinan asukkaiden määrällisestä kulutuksesta laskettua keskimääräistä hiilijalanjälkeä ja vertailemme sitä globaaliin tavoitetasoon. Raportti esittää kirjallisuuteen pohjautuvia vaihtoehtoja hiilijalanjäljen pienentämiseksi ja arvioi vähähiilisten elämäntapavaihtoehtojen päästövähennyspotentiaalia etenkin Suomessa ja Japanissa.

Tämä Sitran selvitys pohjautuu tekniseen raporttiin *1.5-degree lifestyles: Targets and options for reducing lifestyle carbon footprints* (IGES et al. 2019). Tutkimuksen menetelmät, tietolähteet ja arviointien tulokset on esitetty yksityiskohtaisesti teknisessä raportissa ja sen liitteissä.

Hiilijalanjälkien ja tavoitteiden välinen kuilu

Tuloksissa korostuu valtava kuilu nykyisten henkeä kohden laskettujen keskivertohiilijalanjälkien ja ilmastotavoitteiden välillä. Tutkimuksen kohteena olleiden maiden keskimääräinen elämäntapojen vuotuinen hiilijalanjälki oli vuonna 2017 henkeä kohden laskettuna seuraavanlainen: Suomessa 10,4 hiilidioksidiekvivalenttitonnia (t CO_2e), Japanissa 7,6 tonnia, Kiinassa 4,2 tonnia, Brasiliassa 2,8 tonnia ja Intiassa 2,0 tonnia. Päästövähennysskenaarioiden

pohjalta tässä tutkimuksessa ehdotetaan, että henkeä kohden lasketun kulutukseen perustuvan hiilijalanjäljen tavoitetaso olisi 2,5 tonnia CO_2e vuoteen 2030 mennessä, 1,4 tonnia vuoteen 2040 mennessä ja 0,7 tonnia vuoteen 2050 mennessä. Nämä tavoitteet ovat Pariisin ilmastosopimuksen 1,5 asteen tavoitteen mukaisia siten, että kasvihuonekaasupäästöjen maailmanlaajuinen huippu taitetaan mahdollisimman pian ja päästövähennysten aikaansaamiseksi turvaudutaan tulevaisuudessakin mahdollisimman vähän negatiivisiin päästöihin liittyviin eli hiilidioksidia jälkeenpäin takaisin maahan sitoviin teknologioihin.

Nykyisten elämäntapojen hiilijalanjälkeä on pienennettävä tässä selvityksessä tarkastelluissa vauraissa länsimaissa eli Japanissa ja Suomessa huimat 80–93 prosenttia vuoteen 2050 mennessä olettaen, että 58–76 prosentin vähennystoimet aloitetaan välittömästi vuoden 2030 tavoitteen saavuttamiseksi. Myös tarkasteltujen kehittyvien maiden eli Intian, Brasilian ja Kiinan on pienennettävä keskimääräistä elämäntapojen hiilijalanjälkeään 23–84 prosenttia vuoteen 2050 mennessä maasta ja skenaariosta riippuen.

Elämäntapojen hiilijalanjäljen painopisteet

Keskivertokulutuksen perusteella laskettusta elämäntapojen hiilijalanjäljestä noin 75 prosenttia muodostuu kolmesta osa-alueesta: elintarvikkeet, asuminen ja liikkuminen. Lähempi tarkastelu paljastaa useita runsaasti päästöjä aiheuttavia painopisteitä. Nämä ovat liha- ja maitotuotteiden kulutus, fossiilisiin polttoaineisiin perustuva kodin energiankulutus, yksityisautoilu sekä lentomatkustus. Osa painopisteistä, kuten autoilu ja lihatuotteiden kulutus, esiintyy kaikissa tutkituissa maissa, kun taas osa painopisteistä on maakohtaisia, kuten maitotuotteiden kulutus Suomessa ja fossiilisiin polttoaineisiin perustuva sähkö Japanissa. Tämä osoittaa, että elämäntapojen hiilijalanjäljen pienentämisessä on otettava huomioon paikallinen tilanne ja etsittävä räätälöityjä ratkaisuja.

Elämäntapavaihtoehtojen potentiaali

Vaihtoehtoja, joilla tämän tutkimuksen mukaan on suuri potentiaali pienentää hiilijalanjälkeä, ovat yksityisautoilun korvaaminen joukkoliikenteellä tai sähköpyörällä työ- ja vapaa-ajan matkoilla, sähkö- ja hybridiautojen käyttöönotto, ajoneuvojen polttoainetehokkuuden parantaminen, kimppakyytien lisääminen, asuminen lähempänä työ- tai opiskelupaikkaa, asunnon vaihtaminen pienempään, sähkön ja lämmitysenergian tuottaminen uusiutuvilla energialähteillä, maa- ja ilmalämpöpumppujen hyödyntäminen, kasvis- ja vegaaniruokavalion suosiminen, maitotuotteiden korvaaminen kasvipohjaisilla vaihtoehdoilla ja punaisen lihan korvaaminen kanalla tai kalalla. Vaihtoehdot ovat osittain päällekkäisiä, ja niiden vaikutukset vaihtelevat sen mukaan, miten laajamittaisesti ne otetaan käyttöön. Täysimääräisesti toteutettujen yksittäisten vaihtoehtojen avulla voidaan henkeä kohti laskettua hiilijalanjälkeä parhaimmillaan pienentää sadoilla tai jopa yli tuhannella kilolla (CO_2e) vuodessa.

Elämäntapojen hiilijalanjäljestä noin 75 prosenttia muodostuu kolmesta osa-alueesta: elintarvikkeet, asuminen ja liikkuminen.

Elämäntapojemme laajamittaisilla muutoksilla voitaisiin edistää merkittävästi 1,5 asteen ilmastotavoitteen saavuttamista vuoteen 2030 mennessä. Tämä edellyttäisi kuitenkin erittäin kunnianhimoista vähähiilisten vaihtoehtojen käyttöönottoa esimerkiksi Suomessa ja Japanissa. Raportissa esitetyt noin 30 vaihtoehtoa tulisi ottaa käyttöön vähintään 75-prosenttisesti. Tämä tarkoittaa ratkaisujen 75-prosenttista käyttöönottoa koko yhteiskunnan tai jokaisen yksilön tasolla tai näiden yhdistelmänä.

Miten 1,5 asteen elämäntapoihin päästään ja kenen pitäisi toimia?

Tämä raportti on yksi ensimmäisistä selvityksistä, joka ehdottaa globaaleja henkeä kohti laskettuja tavoitetasoja 1,5 asteen ilmastotavoitteen mukaisille elämäntapojen hiilijalanjäljille. Raportti arvioi käytännön toimenpiteitä kulutuksen eri osa-alueilla. Politiikan, hallinnon ja yritysten pitäisi laajamittaisesti tukea siirtymistä vähähiilisempiin elämäntapoihin. Interaktiiviset työkalut kuten tämän selvityksen liitteissä esitelty 1,5 asteen elämäntapojen palapeli auttaisivat niin kotitalouksia kuin poliittisia päätöksentekijöitä, hallintoa ja yrityksiä tunnistamaan hiilijalanjälkien pienentämiseen liittyviä ongelmakohtia ja kehittämään niihin ratkaisuja. Vähähiilisten ratkaisujen toteutettavuuden ja hyväksyttävyyden mittaamiseksi niitä tulee testata kotitalouksissa, asuinalueilla ja kunnissa julkisen ja yksityisen sektorin aktiivisella tuella. Raportin menetelmiä ja lähestymistapoja voidaan ottaa käyttöön myös muissa maissa.

Tämän raportin suositusten toteuttaminen kotitalouksissa on valtava haaste. Suositusten täytäntöönpano edellyttää yksittäisten ratkaisujen lisäksi koko tuotanto- ja kulutusjärjestelmän laajuisia muutoksia. Elämäntapojen hiilijalanjälkeä on pienennettävä jopa yli 90 prosenttia nykyiseen tasoon verrattuna. Siksi pitää muuttaa niitä ajattelutapoja, joihin taloutemme, infrastruktuurimme ja kulutusperusteinen elämäntapamme perustuvat. Tämä edellyttää radikaalia uudelleenajattelua niin politiikassa ja hallinnossa kuin myös liiketoimintamalleissa ja yksilöiden elämässä.

Kaikkien toimijoiden muutosvalmiutta tulisi kehittää sekä teollistuneissa että kehittyvissä maissa. Samalla pitää varmistaa muutosten sosiaalinen hyväksyttävyys. Erityisesti kehitysmaissa pitää varmistaa, että väestön perustarpeet tyydytetään samalla kun hiilijalanjäljet pienenevät. Tämä haaste tarjoaa kuitenkin myös mahdollisuuksia parempaan elämään ja kannattavaan liiketoimintaan. Sanomattakin on selvää, että toimenpiteillä on kiire, jos haluamme edetä kohti kestävää tulevaisuutta ja rajoittaa maapallon lämpötilan nousun 1,5 asteeseen.

Sammandrag

Denna rapport innehåller mål och alternativ för hur samhället genom levnadsvanorna kan begränsa uppvärmningen av klimatet till högst 1,5 grader, enligt målet i Parisavtalet. Både litteraturen i ämnet och det politiska beslutsfattandet har än så länge främst fokuserat på vissa produkter, organisationer, städer eller länder, men inte på konsumenternas koldioxidavtryck. Det har försvagat ansträngningarna för att lösa klimatproblemet. Diskussionen om lösningarna på klimatförändringen har i stor utsträckning handlat om teknologi, även om systematiska förändringar av beteende och infrastruktur har stor betydelse (Creutzig et al.. 2016; Akenji & Chen 2016). Klimatpanelen IPCC bekräftade i sin specialrapport *Global Warming of 1.5 °C* (IPCC 2018) att snabba förändringar behövs för att kunna minska växthusgasutsläppen betydligt. Det är känt att förändringar i beteende, levnadsvanor och kultur samt konsumtionsvanor och kost har betydande inverkan på klimatförändringen (IPCC 2014a). Genom att förändra våra levnadsvanor kan vi få en synlig och snabb inverkan på minskningen av koldioxidutsläppen, i synnerhet inom de delområden av konsumtionen som inte är fastlåsta i befintlig infrastruktur (t.ex. Lettenmeier, Laakso & Toivio 2017).

Koldioxidavtrycket som bygger på den beräknade konsumtionen per person borde vara 2,5 ton CO_2e år 2030, 1,4 ton år 2040 och 0,7 ton år 2050.

Den här utredningen tar itu med utmaningen och granskar växthusgasutsläppen och potentialen att minska dem med hjälp av förändrad konsumtion och levnadsvanor som koldioxidavtryck för levnadsvanor. De har definierats som växthusgasutsläpp som direkt och indirekt orsakas av hushållens konsumtion, och utsläpp som orsakas av offentlig förbrukning och bruttoinvestering, såsom infrastruktur, har inte räknats med. Koldioxidavtrycket från hushållens och individernas levnadsvanor – det vill säga de varor och livsmedel vi köper, våra bostäder, våra transportmedel och de tjänster vi utnyttjar – utgör grunden för åtgärderna för att minska på utsläppen. Vi tittar på det genomsnittliga koldioxidavtrycket för invånarnas kvantitativa förbrukning i Finland och Japan och dessutom i Brasilien, Indien och Kina och jämför det med den globala målsättningen. Rapporten lägger fram alternativ för att minska koldioxidavtrycket som bygger på vetenskaplig litteratur och bedömer potentialen hos koldioxidsnåla levnadsvanor, i synnerhet i Finland och Japan.

Den här utredningen grundar sig på den tekniska rapporten *1.5-degree lifestyles: Targets and options for reducing lifestyle carbon footprints* (IGES et al. (2019). Undersökningens metoder, källor och resultat har presenterats i detalj i den tekniska rapporten och bilagorna till den.

Klyfta mellan koldioxidavtrycken och målen

Resultaten visar att det finns en enorm klyfta mellan de beräknade koldioxidavtrycken och klimatmålen. Det årliga genomsnittliga koldioxidavtrycket för levnadsvanorna i de länder som var föremål för undersökningen var 2017 följande per person: Finland: 10,4 koldioxidekvivalentton (t CO_2e); Japan: 7,6 t CO_2e; Kina: 4,2 t CO_2e; Brasilien: 2,8 t CO_2e; och Indien: 2,0 t CO_2e. Utifrån utsläppsminskningsscenarierna föreslås det i den här undersökningen att koldioxidavtrycket som bygger på den beräknade konsumtionen per person borde vara 2,5 ton CO_2e år 2030, 1,4 ton år 2040 och 0,7 ton år 2050. Dessa mål motsvarar Parisavtalets mål på 1,5 grader så att den globala toppen av växthusutsläpp vänder neråt så snart som möjligt utan att man i stor omfattning tar till teknologi som ger negativa utsläpp. Koldioxidavtrycket från de nuvarande levnadsvanorna måste minska med 80–93 procent i de undersökta industriländerna fram till 2050 med antagandet att 58–76 procent av åtgärderna skulle inledas omedelbart för att uppnå målet för 2030. Även de undersökta utvecklingsländerna måste minska sitt avtryck med 23–84 procent fram till 2050 beroende på land och scenario.

Centrala punkter i koldioxidavtrycket för levnadsvanor

En närmare granskning av koldioxidavtrycken för levnadsvanor beräknat utifrån den kvantitativa förbrukningen avslöjade att det finns flera centrala saker som orsakar stora utsläpp. Dessa är konsumtionen av kött- och mjölkprodukter, hushållens energiförbrukning som bygger på fossila bränslen, bilkörning och flygresor. Dessa tre delområden – livsmedel, boende och transport – utgör cirka 75 procent av det totala koldioxidavtrycket för våra levnadsvanor. En del centrala punkter, såsom bilkörning och konsumtionen av köttprodukter, är vanliga i alla de undersökta länderna, medan en del är specifika för ett land, såsom konsumtionen av mjölkprodukter i Finland och elproduktion som bygger på fossila bränslen i Japan. Det här visar att man måste beakta den lokala situationen och hitta skräddarsydda lösningar för att minska koldioxidavtrycket från levnadsvanorna.

Levnadsvanornas potentiella alternativ

De alternativ som enligt denna undersökning har stor potential att minska utsläppen är att ersätta bilen med kollektivtrafik eller elcykel för fritids- och arbetsresor, el- och hybridbilar, förbättrad bränsleeffektivitet i fordon, samåkning, boende som ligger närmare arbetet och mindre bostäder, el och uppvärmning som produceras av förnybara energikällor, värmepumpar, vegetarisk och vegansk kost, att ersätta mjölkprodukter med växtbaserade alternativ och ersätta rött kött med broiler eller fisk. Om dessa alternativ utnyttjas fullt ut kan man med hjälp av dem minska koldioxidavtrycket för varje delområde av konsumtionen med några hundra eller rentav över tusen kilogram (CO_2e) per år. De förväntade effekterna varierar beroende på i hur stor omfattning alternativen införs. Med hjälp av levnadsvanorna kunde man på ett betydande sätt hjälpa till att uppnå målet på 1,5 grader fram till 2030. Det skulle dock förutsätta att väldigt ambitiösa koldioxidsnåla alternativ infördes i Finland och Japan. De omkring 30 alternativ som presenteras i rapporten borde införas till 75 procent. Det innebär att lösningarna skulle införas till 75 procent antingen i hela samhället eller på individnivå eller som en kombination av dem båda.

Dessa tre delområden – livsmedel, boende och transport – utgör cirka 75 procent av det totala koldioxidavtrycket för våra levnadsvanor.

Hur uppnår man levnadsvanor som motsvarar 1,5 grader och vem borde agera?

Den här rapporten är bland de första som kommer med förslag till mål för beräknade globala koldioxidavtryck och utvärderar praktiska åtgärder inom olika delområden av konsumtionen. Rapportens metoder och approach kunde utvidgas till andra delområden och andra länder också. Koldioxidsnåla levnadsvanor kunde utvärderas i ännu större utsträckning. Politiken, förvaltningen och företagen borde ge omfattande stöd till en övergång till koldioxidsnåla levnadsvanor. Interaktiva verktyg, såsom det pussel som presenteras i rapporten, skulle hjälpa både hushåll och politiskt beslutsfattande, förvaltning och företag att definiera problemområden och hitta lösningar. För att mäta hur genomförbara och hur godtagbara de koldioxidsnåla lösningarna är måste de testas i hushåll, bostadsområden och kommuner inom den offentliga och privata sektorn med hjälp av aktivt stöd.

Det är en enorm uppgift att få hushållen att följa rekommendationerna i den här rapporten. Genomförandet av rekommendationerna förutsätter därför både enskilda lösningar och förändringar av hela systemet. Koldioxidavtrycket från levnadsvanorna måste minska med över 90 procent jämför med nu. Därför måste man förändra de tänkesätt som vår infrastruktur, ekonomi och konsumtion grundar sig på. Det kräver radikalt nytänkande såväl inom politiken och förvaltningen som inom affärsmodellerna.

Alla aktörers beredskap inför förändring måste utvecklas både i industriländerna och utvecklingsländerna. Samtidigt måste man se till att förändringen är socialt godtagbar. I synnerhet i utvecklingsländer måste man se till att befolkningens basbehov uppfylls samtidigt som koldioxidavtrycken blir mindre. Den här utmaningen medför ändå enorma möjligheter för ett bättre liv och ny affärsverksamhet. Det säger sig självt att åtgärderna är brådskande om vi vill göra framsteg mot hållbar utveckling.

1. Background

Despite the importance and rapid mitigation potential of behaviour change, most policy approaches to climate change solutions have given it scant attention, choosing to focus instead on the application of technology (Creutzig et al. 2016). However, an increasing number of authoritative reports specifically highlight the considerable impacts of lifestyle changes, such as the Intergovernmental Panel on Climate Change (IPCC) *Special Report on Global Warming of 1.5 °C.* The threat of average global temperature rising by 1.5 °C between 2030 to 2052 if current trends continue, and by 3 °C by 2100 even with all countries' mitigation plans by 2030 combined paints a stark picture that delaying actions can only lead to increased costs, stranded assets and reliance on technologies which have potential trade-offs with sustainability (IPCC 2018).

This makes the case for redirecting lifestyles towards sustainability even more relevant. Scientists at the IPCC consider demand-side actions as key elements of pathways consistent with holding down the global temperature rise to 1.5 °C, and state that behaviour and lifestyle changes, as well as culture, including consumption patterns and dietary changes on emissions, can complement structural and technological changes (IPCC 2014, 2018). Changing our lifestyles can bring about results relatively quickly, especially in consumption domains that are not locked into existing infrastructure (Lettenmeier, Laakso, and Toivio 2017; Salo and Nissinen 2017; Moore 2013).

The majority of the existing emission scenarios for the 1.5 °C target still assume production-based measures and negative-emission technologies as primary mitigation measures (Rockström et al. 2017; Rogelj et al. 2015). Mitigation pathway scenarios incorporating demand-side reduction measures have emerged recently but are still limited (Van Vuuren et al. 2018). On the other hand, existing consumption-focused literature provides quantification of the mitigation potential of low-carbon lifestyles, but the reduction targets are not directly linked to a pathway leading to achieving the temperature targets of the Paris Agreement (Jones and Kammen 2011; Vandenbergh et al. 2008; Dietz et al. 2009). There is therefore a gap in the literature in terms of highlighting the potential contribution of lifestyle changes and the level of required changes to meet the specific targets of the Paris Agreement.

Consumption-based accounting and planetary boundaries

In this study, GHG emissions and reduction potential are examined using consumption-based accounting rather than production-based accounting (also referred to as territorial-based accounting). Production-based accounting covers only direct emissions from domestic production activities within the geographical boundaries and offshore activities under the control of a country, and does not consider embodied emissions from international trade (Boitier 2012; Moore 2013). The limitations of this accounting include the possibility of carbon leakage caused by international trade and the fact that it might mislead insights into mitigation efforts (Boitier 2012; Moore 2013). Conversely, consumption-based accounting (carbon footprinting) covers both direct emissions and embedded emissions caused by the imports of goods and services, which reflects the global impacts of final consumption and lifestyles of individuals.

This approach addresses the carbon leakage issue and promotes broader options for mitigation, while importantly also not burdening developing countries with excessive emission commitments (Peters and Hertwich 2008). In this study, the term "carbon footprint" refers not only to CO_2 but also to other greenhouse gases, thus is also sometimes referred to as "greenhouse gas footprint".

Footprints and emissions – Comparison of boundaries and scopes

Different boundaries and scopes are used to measure GHGs per capita.

Production-based emissions
GHGs directly emitted from households, governments and private-sector activities within the territorial boundary of a country or city, excluding indirect emissions caused by the consumption of products and services. This measurement is used in national GHG inventories and target setting.

Footprint of products
GHGs directly and indirectly emitted from the production, distribution, use and disposal of products, including those embedded in imported parts and products. This type of measurement is used for carbon footprint labelling and comparison of two or more types of options of products or processes and is typically based on a bottom-up process analysis of life-cycle assessment (LCA). The specification for this type of measurement is also published as the International Organization for Standardization (ISO) 14067(ISO 2018a).

Organisational footprint
GHGs emitted from the direct activities of organisations (scope 1), sourcing of energy (scope 2) and other indirect emissions through value chains including production, distribution, use and disposal of products sold (scope 3). The standards for this type of measurement include ISO 14064-1 (ISO 2018b) and GHG Protocol (Greenhouse Gas Protocol 2011) and this measurement is typically based on the hybrid method of bottom-up process analysis LCA and top-down input-output (I/O) analysis-based estimation.

Footprint of countries or cities
GHGs directly emitted from the activities of households and governments located in a country or city and those indirectly emitted from their final demands and capital investment. These footprints cover production, distribution, use and disposal of purchased products and services including products and services embedded in trades. This type of measurement is typically based on the top- down I/O analysis method. Examples of estimation are Environmental Footprint Explorers (Norwegian University of Science and Technology 2018) for countries and C40 (C40 Cities Climate Leadership Group 2018) for cities.

Lifestyle carbon footprint
This study focuses on the lifestyle carbon footprint, meaning the carbon footprint of an average household in a country, including its direct emissions from the use of fuels and indirect emissions embedded in products and services purchased. This can be considered as a household version of the organisational carbon footprint or household demand part of the footprint of countries or cities. In this study, "lifestyle carbon footprint" is defined as the GHG emissions directly emitted and indirectly induced from household consumption, excluding those induced by government consumption and capital formation.

Changing our lifestyles can bring about results relatively quickly, especially in consumption domains that are not locked into existing infrastructure.

2. Long-term lifestyle carbon footprint targets

The Paris Agreement in 2015 secured a clear global commitment to hold the global average temperature increase well within 2°C above pre-industrial levels as well as pursue efforts to limit it to 1.5 °C (UNFCCC 2015). In setting this target, a peak in emissions is assumed to occur as soon as possible, after which emissions are to rapidly drop, to achieve a society based on net-zero emissions in the latter half of the 21st century (ibid.). For the below-2 °C target, global emissions need to be limited to 40 gigatonnes in 2030, according to a UN decision based on the Paris Agreement (UNFCCC 2015) – and the decision also noted concern that this limit cannot be reached by the present Intended Nationally Determined Contributions (INDCs) of countries, which would result in 55 gigatonnes in 2030. This implies that emissions need to be reduced more drastically starting from now to limit the increase to below 1.5 °C.

In this report, we propose lifestyle carbon footprint levels that meet the Paris Agreement targets.

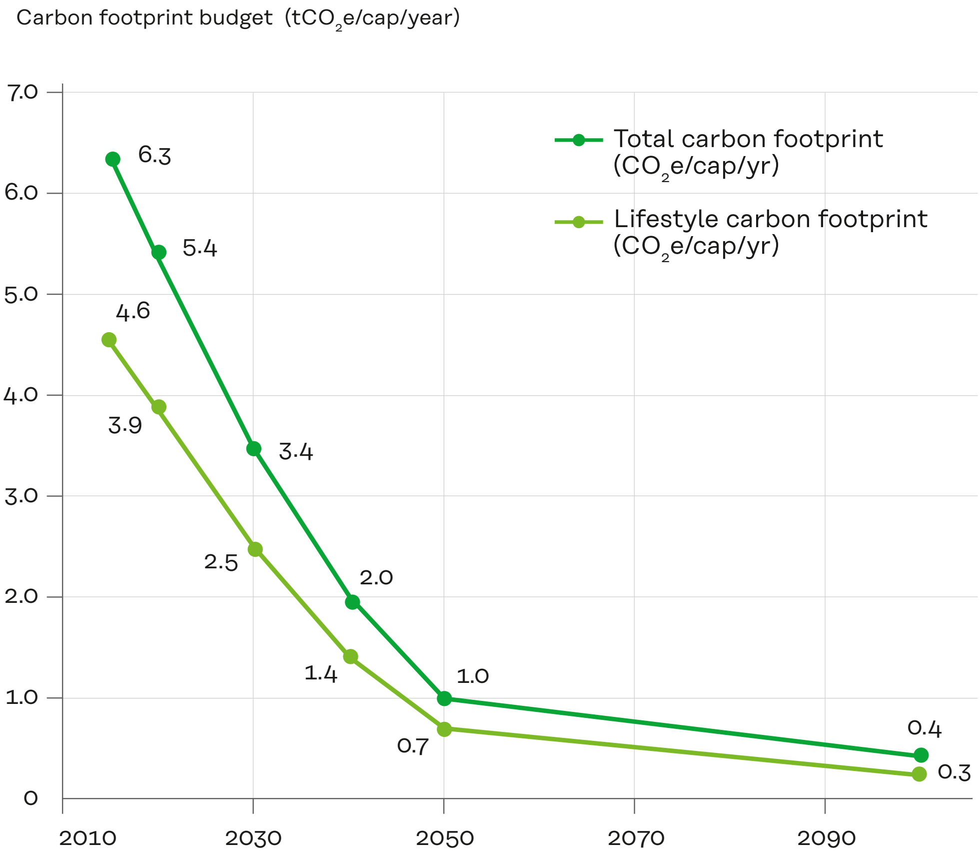
The 2 °C and 1.5 °C targets are based on long-running scientific research on GHG emissions projection, climate modelling and climate change impacts on Earth and humanity. Research activities on future emissions and their impact on climate, often utilising integrated assessment models (IAMs), provide us with projections of future global GHG emissions levels under different sets of assumptions and the maximum amount of GHGs allowed to remain in the atmosphere for a certain target. These projections, also known as "mitigation pathways", are frequently accompanied by measures to realise them.

In this report, we illustrate our proposed targets for lifestyle carbon footprints to meet the Paris Agreement targets based on total carbon footprint expressed in emission budget pathways found in the literature.

The targets of lifestyle carbon footprints in the four shortlisted scenarios we explored result in ranges of the estimated lifestyle carbon footprint targets for 2030, 2040 and 2050 of respectively 3.2–2.5, 2.2–1.4 and 1.5–0.7 tCO_2e per capita (for detailed information, see technical report, 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 the assumed long-term availability of human carbon sinks or negative-emission technologies, such as BECCS, and the selection of the global average temperature targets, either 1.5 °C (see Figure 1) or 2.0 °C.

Figure 1. Lifestyle carbon footprint budget comparable with 1.5 °C target

Global total emission budget was calculated as a mean of the 1.5 °C scenarios studied in a technical report (IGES et al.2019). The emission budget was divided by population projections from the United Nations (2017) and multiplied by the household footprint share estimated by Hertwich and Peters (2009) to estimate lifestyle carbon footprint budget.



3. Present-day lifestyle carbon footprints

3.1 Estimating and comparing carbon footprints

This study classifies household resource consumption 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, Liedtke, and Rohn 2014) as below (see Figure 2).

Lifestyle domains covered in the estimation

1. Nutrition: intake of all foodstuffs and beverages consumed at home and outside the home; e.g. vegetable and fruit, meat, fish, dairy, cereal, alcohol and non-alcoholic beverages.[1]
2. Housing: housing infrastructure and supply utilities; e.g. construction, maintenance, energy use and water use.
3. Mobility: use of owned transport equipment and transportation services for commuting, leisure and other personal purposes; e.g. cars, motorbikes, public transport, air travel, bicycles.[2]
4. 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.[3]
5. Leisure: leisure: leisure activities performed outside of the home; e.g. sports, culture, entertainment, hotel services.[4]
6. Services: services for personal purposes; e.g. insurance, communication and information, ceremonies, cleaning and public baths, public services.[5]

Comparing lifestyle carbon footprints

Total average lifestyle carbon footprints vary considerably – Finland has the highest at 10.4 tonnes (tCO_2e) per year, then Japan at 7.6, China at 4.2, Brazil at 2.8 and India at 2.0, with others as shown in Figure 3. Compared with the upper and lower limits of GHG emission targets proposed for 2030 (2.5–3.2 tonnes per capita in terms of all GHGs, see Figure 3.), Finland and Japan far exceed the targets, China overshoots moderately and Brazil slightly. As a result, GHG emissions of countries need to drop by following percentages: Finland 69–76%, Japan 58–67%, China 25–41% and Brazil up to 11% by 2030. The GHG emission target proposed for 2050 (0.7 tonnes per capita in term of all GHGs) is exceeded in all case countries. Notably, large GHG emission reductions of 86–93% and 80–91% are needed in Finland and Japan, respectively.

The following sections elaborate on the average lifestyle carbon footprints by comparing three domains: nutrition, housing and mobility. Shares of different sub-domains in carbon footprints and physical consumption are shown as doughnut charts, where the inner circles represent the share of physical consumption and the outer circles represent the share of carbon footprints. For specific data sources and details of estimation results, please refer to Annexes B and C of the technical report (IGES et al. 2019).

1 Direct emissions from cooking at home are included under housing, whereas direct emissions from the operation of restaurants are included under leisure.
2 Emissions from business purpose trips are included under the respective domain of the products or services supplied.
3 Direct emissions from electricity and fuels used by consumer goods are included under housing.
4 Emissions from ingredients of food used outside the home are included in nutrition, whereas emissions from leisure performed at home are included in housing.
5 Public services covered by government expenditure are excluded from lifestyle carbon footprints.

Figure 2. Estimation of lifestyle carbon footprints across domains

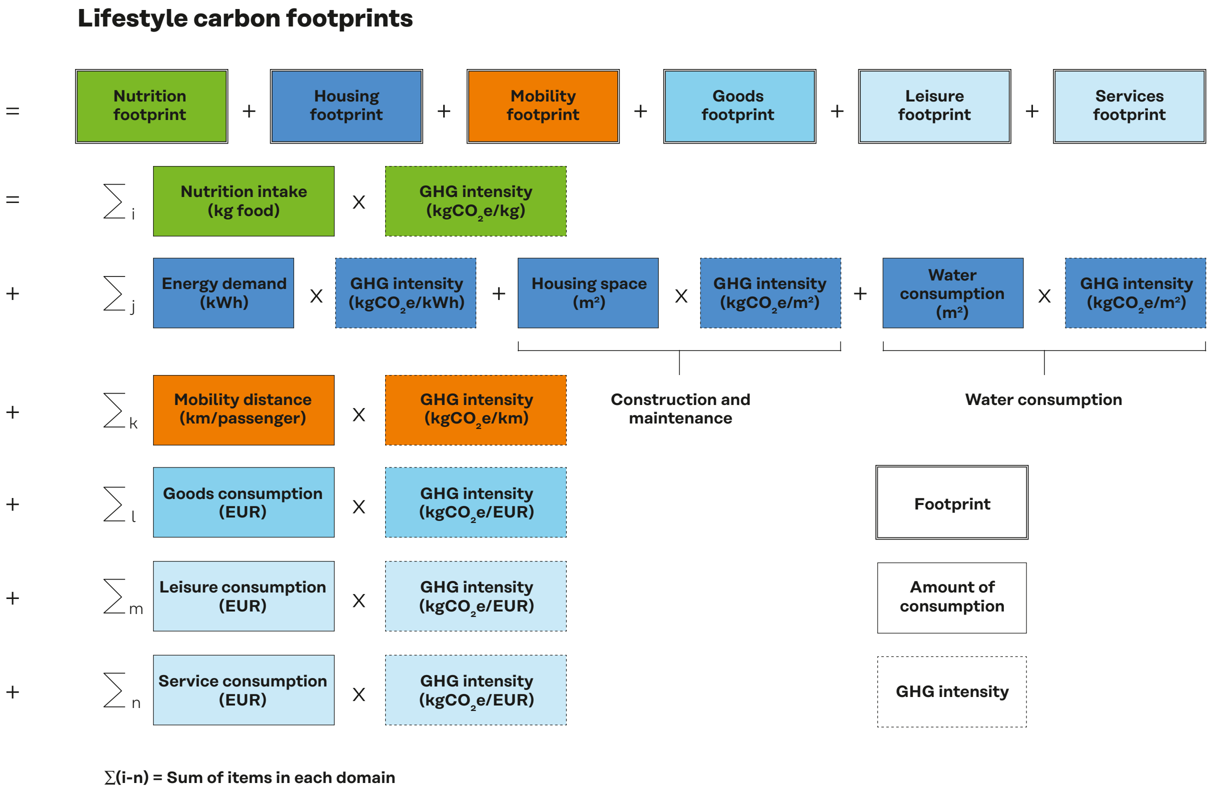
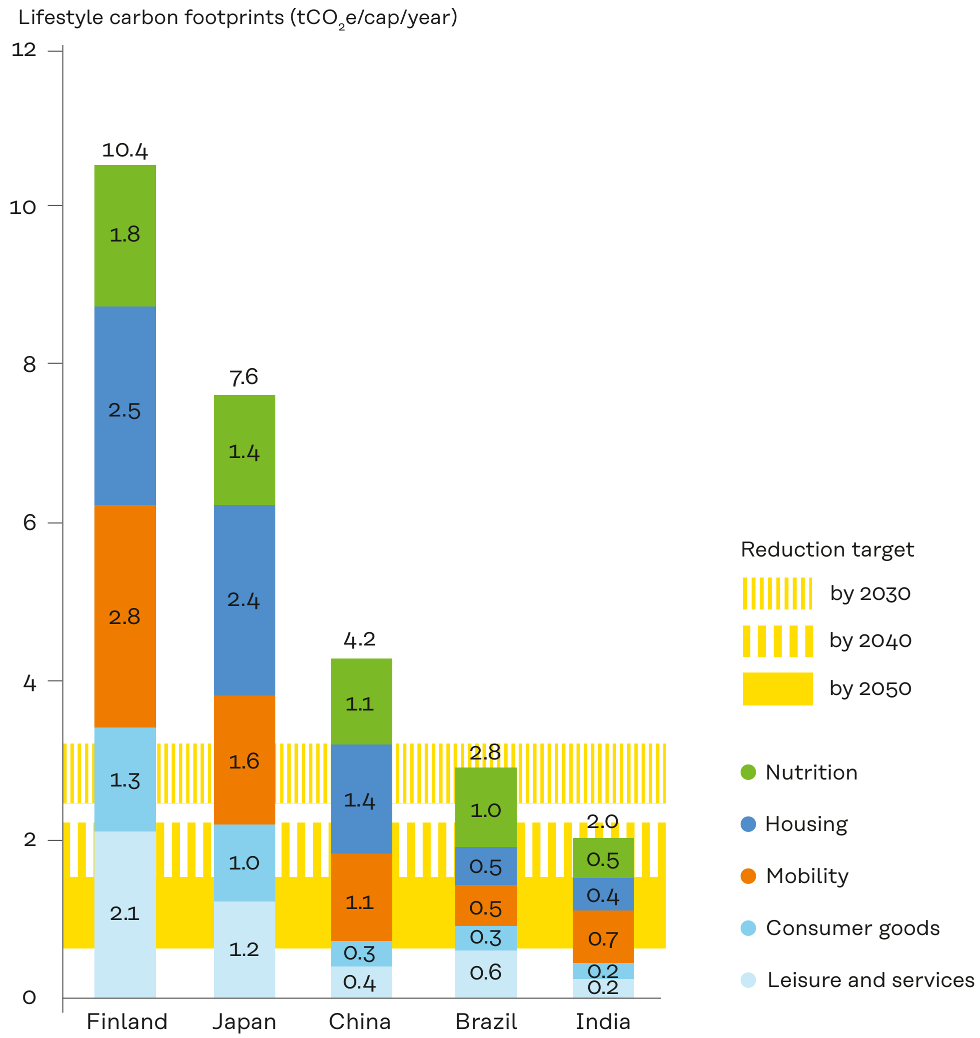


Figure 3. Carbon footprint and its breakdown between consumption domains and globally unified targets for the lifestyle carbon footprints

Average lifestyle carbon footprint of country estimated as of 2017. The lower and upper limits of yellow horizontal lines indicate 1.5 °C target without or with less use of CCS and 2 °C target with CCS, respectively. See the technical report (IGES et al. 2019) for more detailed information.



3.2 Nutrition

In most of the case countries, meat consumption is the largest contributor to a person's carbon footprint for nutrition, varying from over 80 kg (per person per year) eaten in Finland to about 35 kg eaten in Japan, with approximately 45 kg and 60 kg being eaten in Brazil and China respectively. In China and Finland, most of the meat consumed is pork (63% and 43% respectively) and poultry (22% and 29%). India is the exception, where little meat is consumed (under 5 kg), partly due to the predominance of vegetarianism.

Dairy products are significant contributor to Finland's carbon footprint, approaching meat, as a result of the large consumption (almost 200 kg per person) of dairy products, including cheese, whereas Indian, Japanese and Brazilian people consume much less – about 85, 50 and 35 kg respectively. Dairy consumption is also a growing trend in many countries (Food and Agriculture Organisation 2017).

Other major contributors to the nutrition carbon footprint are fish, cereals and beverages. Fish is a major contributor in Japan and China at 30 to 35 kg consumed per person per year. Cereals have relatively high carbon intensity in Japan and Brazil, probably due to rice consumption, which tends to have higher intensity than wheat and other cereals. Beans are a relatively low-carbon and protein-rich food and generally have low carbon intensity, but their consumption is limited in most of the case countries, with over 20 kg in Japan, 15 kg in India and less than 10 kg in Finland and China – Brazil is the exception, at 70 kg per person per year.

As indicated by the dotted rectangles in Figure 5, the nutrition footprints of Finland and Japan need to be greatly reduced: by 47 to 58% by 2030 and 75 to 80% by 2050. Yet, the estimated reduction required is below that of other domains as there is less variation in current footprints, implying nutrition is considered a necessity.

Furthermore, China, Brazil and India would also need to significantly reduce nutrition-related footprints by 2050, and the current per capita footprints in China and Brazil already exceed the 2030 target. Shifting nutrition sources and reducing carbon intensity or physical consumption amounts where possible while satisfying nutritional requirements can contribute to reducing footprints.

Figure 4.
A comparison of the share of nutrition carbon footprints and physical consumption in Finland and Japan

Average lifestyle carbon footprints and physical amount of consumption estimated as of 2017. Inner circles represent the share of physical amount of consumption. Outer circles indicate the share of carbon footprints.

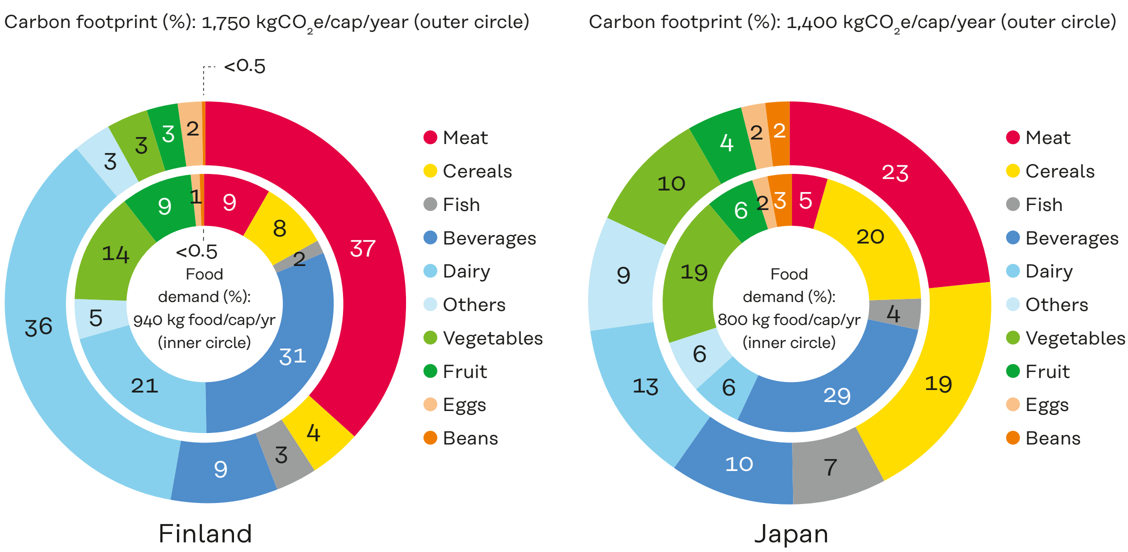


Figure 5a.
A comparison of nutrition carbon footprints and their breakdown in different countries

Coloured rectangles indicate the average lifestyle carbon footprints of each component. Width, height and size of the area represent the physical amount of consumption, carbon intensity and carbon footprints, respectively. Black dotted rectangles show the average intensity and total physical consumption as of 2017. Pink dotted rectangles show the 1.5-degree target by 2030 and blue dotted rectangles the 2050 target. The horizontal to vertical ratios are only indicative – if amounts cannot be reduced, intensity needs to be reduced instead. This can be an issue especially in the nutrition domain as it is considered as essential.

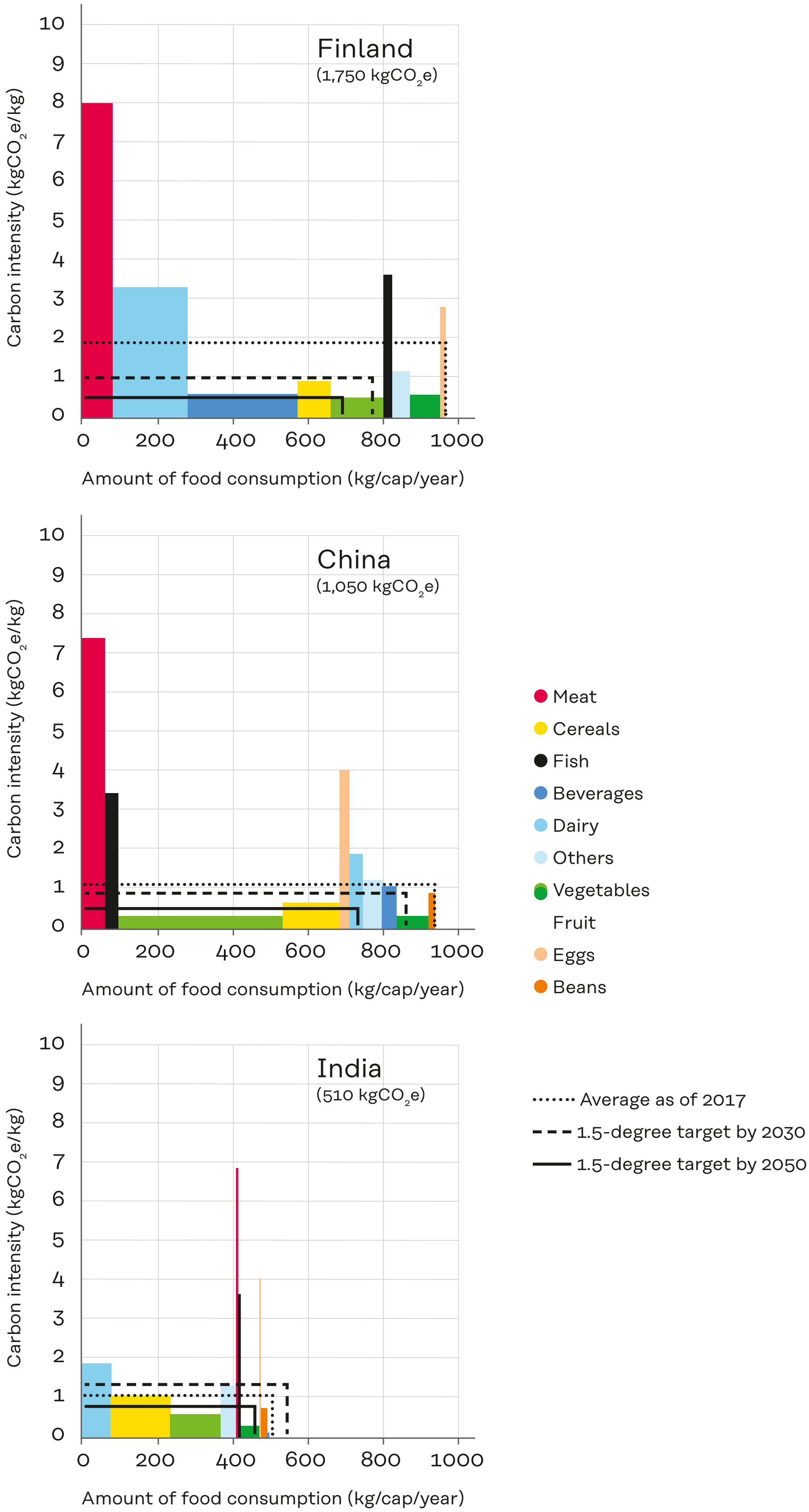
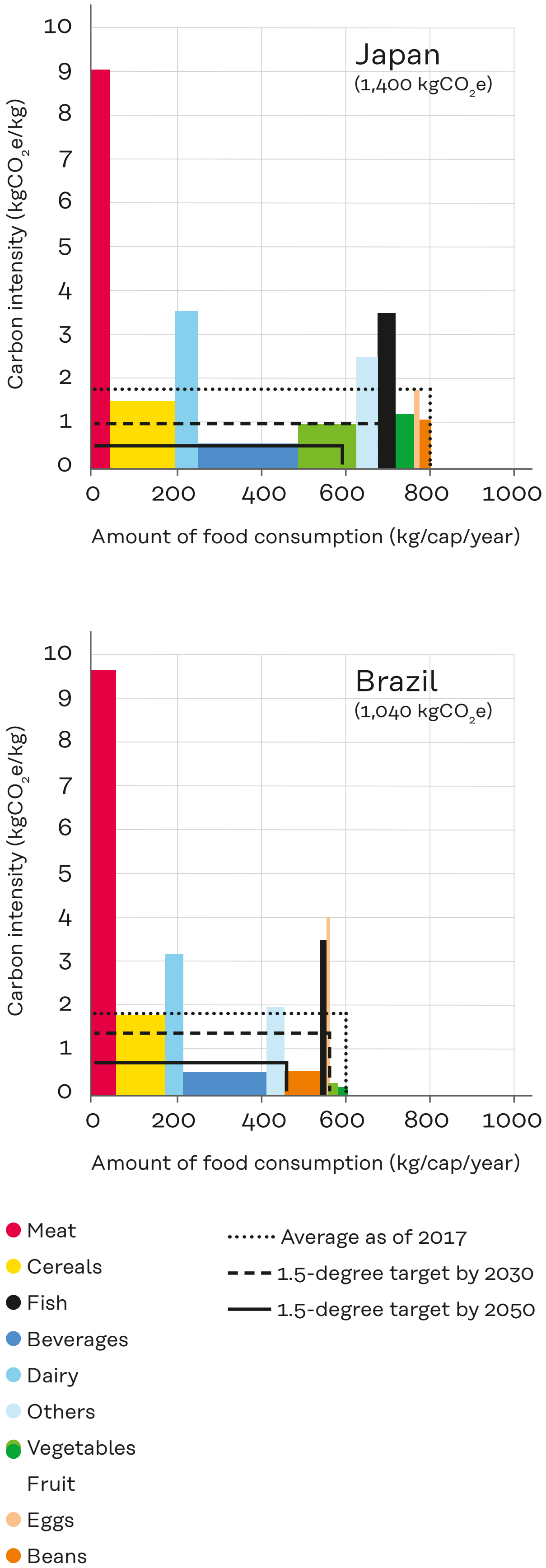


**Figure 5b.
A comparison of nutrition carbon footprints and their breakdown in different countries**

Coloured rectangles indicate the average lifestyle carbon footprints of each component. Width, height and size of the area represent the physical amount of consumption, carbon intensity and carbon footprints, respectively. Black dotted rectangles show the average intensity and total physical consumption as of 2017. Pink dotted rectangles show the 1.5-degree target by 2030 and blue dotted rectangles the 2050 target. The horizontal to vertical ratios are only indicative – if amounts cannot be reduced, intensity needs to be reduced instead. This can be an issue especially in the nutrition domain as it is considered as essential.



3.3 Housing

The two developed countries, Finland and Japan, have similar carbon footprint levels in housing of approximately 2,500 kg CO_2e/capita and a carbon intensity of approximately 60 kg (CO_2e per m²). These countries have similarly sized average living spaces of 40 m² per person, with construction and maintenance accounting for up to a fifth of the footprint. However, there are big differences in direct energy use, with Finland at 10,800 and Japan at 4,200 kWh per person, and energy used per living space, with 270 and 110 kWh per m², respectively. This is partly because of the high energy demand for heating in Finland – 65%, 15% and 5% of domestic energy use is for indoor heating, water heating and sauna heating respectively. Although Japan has a relatively high demand for hot water use of 29%, partly due to the custom of running hot water into a bathtub, indoor heating and cooling only account for 22% and 2% of energy consumption at homes (Agency for Natural Resources and Energy, Japan, 2018).

Electrification of direct housing energy use with renewables can contribute to low-carbon lifestyles, but fossil fuel-based electricity can be less efficient in comparison with non-electricity energy sources. Japan has a higher electrification rate of direct energy consumption in the housing domain, with 51% compared to 37% in Finland. Typically, electricity-based room temperature control systems such as heat pumps have higher energy conversion efficiency at the household level, unless they use fossil fuel-based grid electricity. Thus, electrification of home energy sources can reduce carbon footprints if the grid electricity is renewable-based, but probably not in other cases.

The carbon intensity of electricity in Finland is about a third of that in Japan, 0.22 vs 0.63 kg (CO_2e/kWh) as nearly half of it comes from renewables, whereas 84% of Japan's electricity is generated from fossil fuels, nearly a third of which is coal. For non-electricity energy, Japanese houses typically use LPG and urban gas for heating and cooking (32% of overall energy from housing), as well as kerosene for heating (17%), with off-grid renewables and steam under 1%. 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 being largely fossil fuel-based, and 34% of energy used for room, sauna and water heating is from wood, which is regarded as carbon neutral (except for indirect emissions such as transport and production). As a result, for direct housing energy use, Finland's overall renewable share is higher than Japan's, with 37% vs 8%.

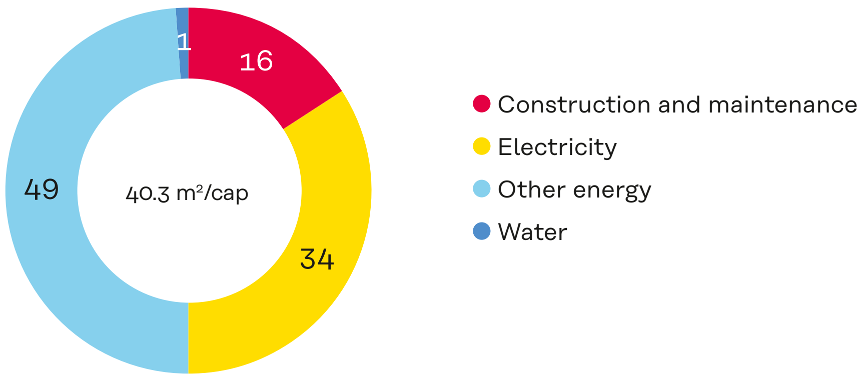
In comparison, the carbon footprint for housing in developing countries is much lower, from 1,350 in China to 400 (kgCO_2e) in India, as well as carbon intensity per living space, from 20 to 40 (kgCO_2e/m²). Spaces are smaller per person (35 m² in China, 21 in Brazil, 19 in India), and energy use from housing is low (1,500 kWh in China, 1,400 in Brazil, 800 in India) due to lower heating demand owing to the climate, less use of appliances and electricity, and larger households living in smaller spaces. Compared to Brazil's high share of renewables in total energy demand (38%), that of China and India are much lower, 6% and 5%, where the carbon intensity of grid electricity is significantly higher due to the high share of fossil fuels. In Brazil, 85% of grid electricity is from renewables, mainly hydropower. Other energy forms used in China, Brazil and India are mainly coal and derivatives, LPG and firewood, which increases the total share of non-renewables in energy consumption in China and Brazil.

Figure 6a.
A comparison of the share of carbon footprints and physical consumption in Finland and Japan (housing)

Average lifestyle carbon footprints and physical amount of consumption estimated as of 2017. Inner circles represent the share of physical amount of consumption. Outer circles indicate the share of carbon footprints.

Finland

Carbon footprint (%): 2,500 $kgCO_2e$/cap/year



Energy-related carbon footprints (%): 2,090 $kgCO_2e$/cap/year (outer circle)

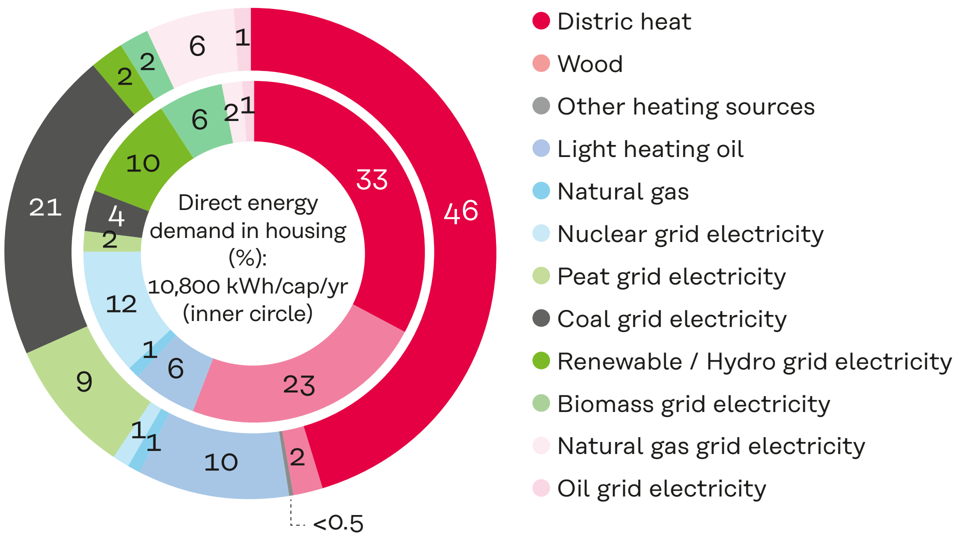
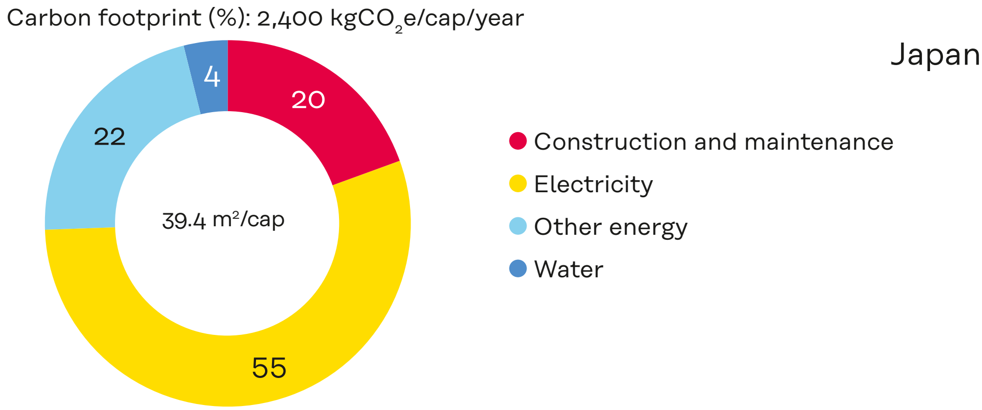


Figure 6b.
A comparison of the share of carbon footprints and physical consumption in Finland and Japan (housing)

Average lifestyle carbon footprints and physical amount of consumption estimated as of 2017. Inner circles represent the share of physical amount of consumption. Outer circles indicate the share of carbon footprints.



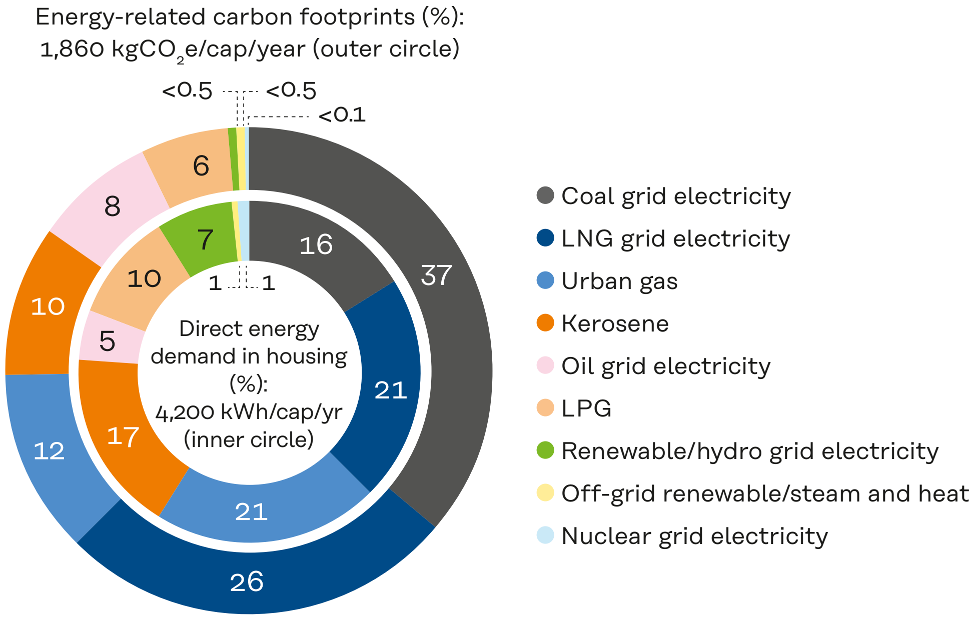


**Figure 7a.
A comparison of carbon footprints and their breakdown (housing energy)**

Coloured rectangles indicate the average lifestyle carbon footprints of each component. Width, height and size of the area represent the physical amount of consumption, carbon intensity and carbon footprints respectively. Black dotted rectangles show the average intensity and total physical consumption as of 2017. Pink dotted rectangles show the 1.5-degree target by 2030 and blue dotted rectangles the 2050 target. The horizontal to vertical ratios are only indicative – if amounts cannot be reduced, intensity needs to be reduced instead.

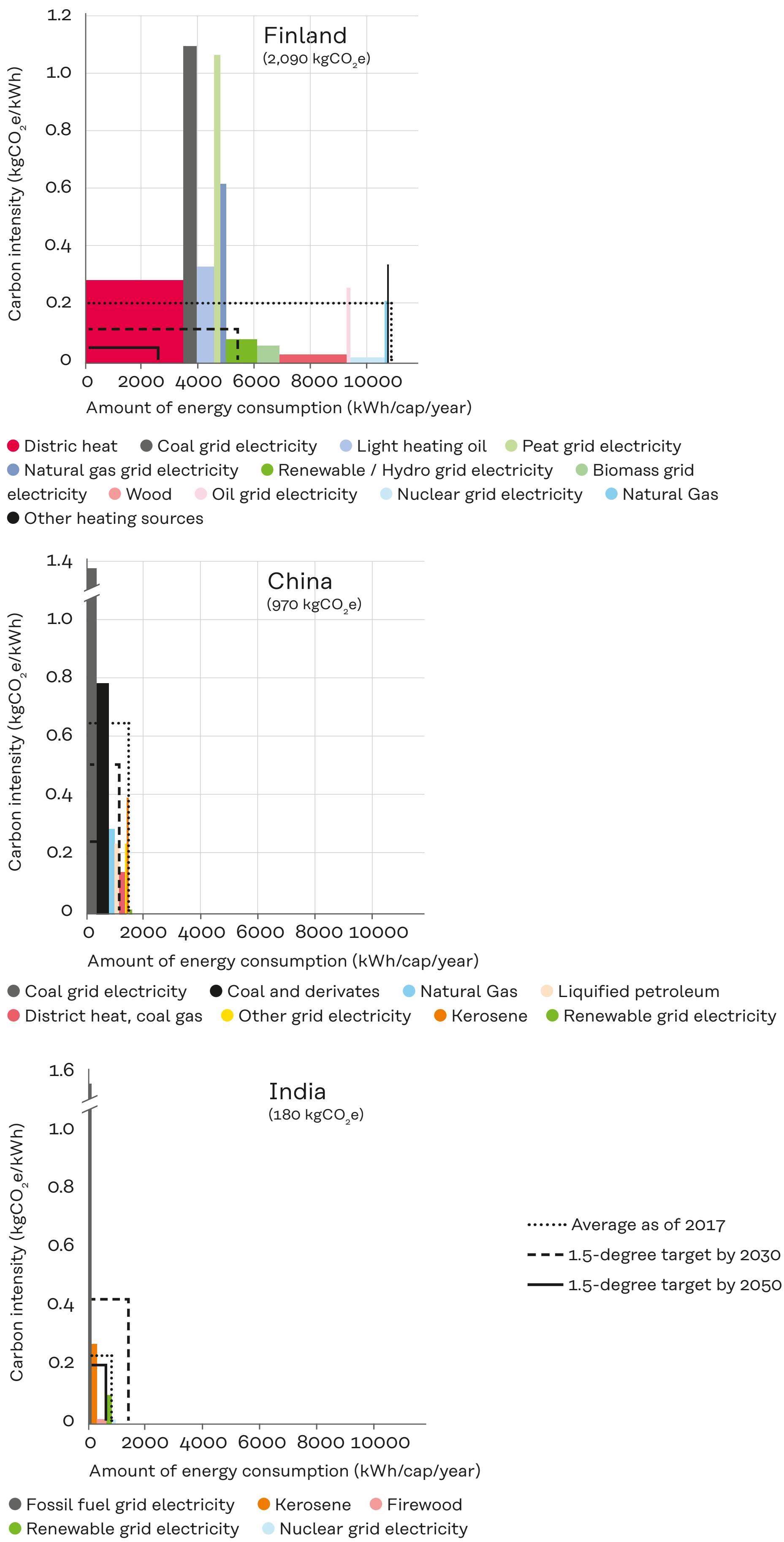
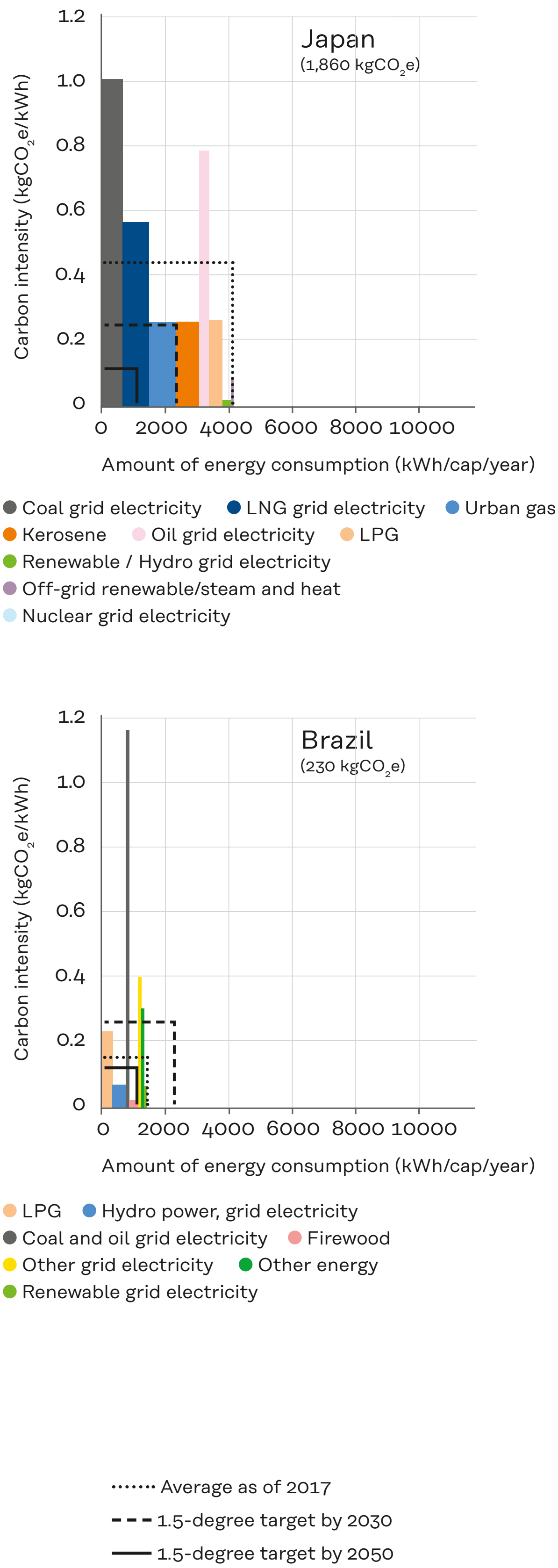


Figure 7b.
A comparison of carbon footprints and their breakdown (housing energy)

Coloured rectangles indicate the average lifestyle carbon footprints of each component. Width, height and size of the area represent the physical amount of consumption, carbon intensity and carbon footprints respectively. Black dotted rectangles show the average intensity and total physical consumption as of 2017. Pink dotted rectangles show the 1.5-degree target by 2030 and blue dotted rectangles the 2050 target. The horizontal to vertical ratios are only indicative – if amounts cannot be reduced, intensity needs to be reduced instead.



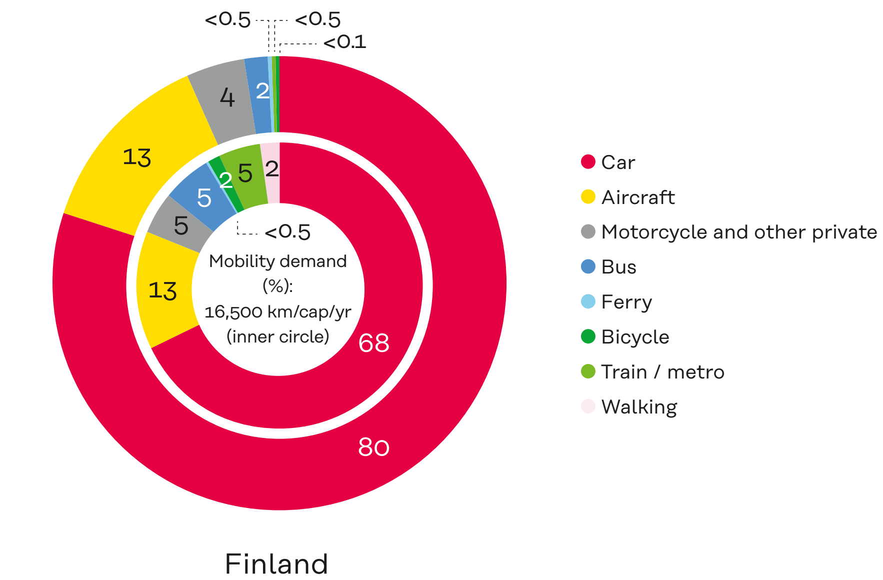
3.4 Mobility

In the international comparison, Finland has the highest mobility demand at 16,500 km per person per year, compared with 11,000 km in Japan and only 4,000 to 8,000 km in the other three countries. This probably reflects the higher population density and metropolitan development in Japan than in Finland, with lower consumption levels in developing countries.

Of mobility, cars are the biggest contributor to carbon footprint in most case countries except for Brazil, where it is buses. The modal share of cars is very high at 68%, or 11,200 km, in Finland, moderate at nearly 46% (5,000 km) in Japan, relatively low at 22–27% (1,100–1,800 km) in China and Brazil, and much lower at 15% (800 km) in India. The carbon intensity of cars is slightly higher in Japan than in Finland. Carbon intensity is much higher in China and India, partly because of lower fuel efficiency of the cars, and lower in Brazil because of higher share of renewable-based fuels.

Figure 8. A comparison of the share of carbon footprints and physical consumption in Finland and Japan (mobility)

Average lifestyle carbon footprints and physical amount of consumption estimated as of 2017. Inner circles represent the share of physical amount of consumption. Outer circles indicate the share of carbon footprints.



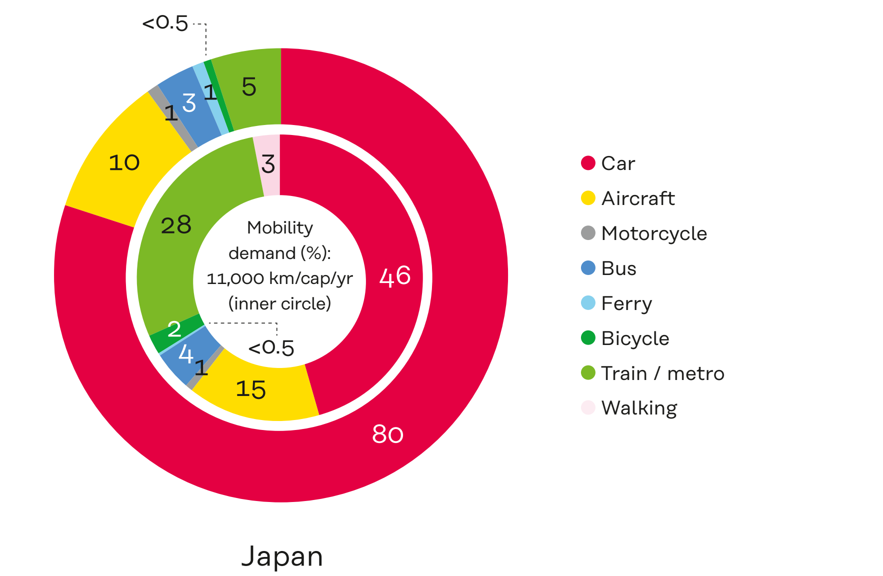


Figure 9a.
A comparison of carbon footprints and their breakdown (mobility)

Coloured rectangles indicate the average lifestyle carbon footprints of each component. Width, height and size of the area represent the physical amount of consumption, carbon intensity and carbon footprints, respectively. Black dotted rectangles show the average intensity and total physical consumption as of 2017. Pink dotted rectangles show the 1.5-degree target by 2030 and blue dotted rectangles the 2050 target. The horizontal and vertical ratios of the red and blue dotted rectangles are indicative only. If amounts cannot be reduced, intensity needs to be reduced instead.

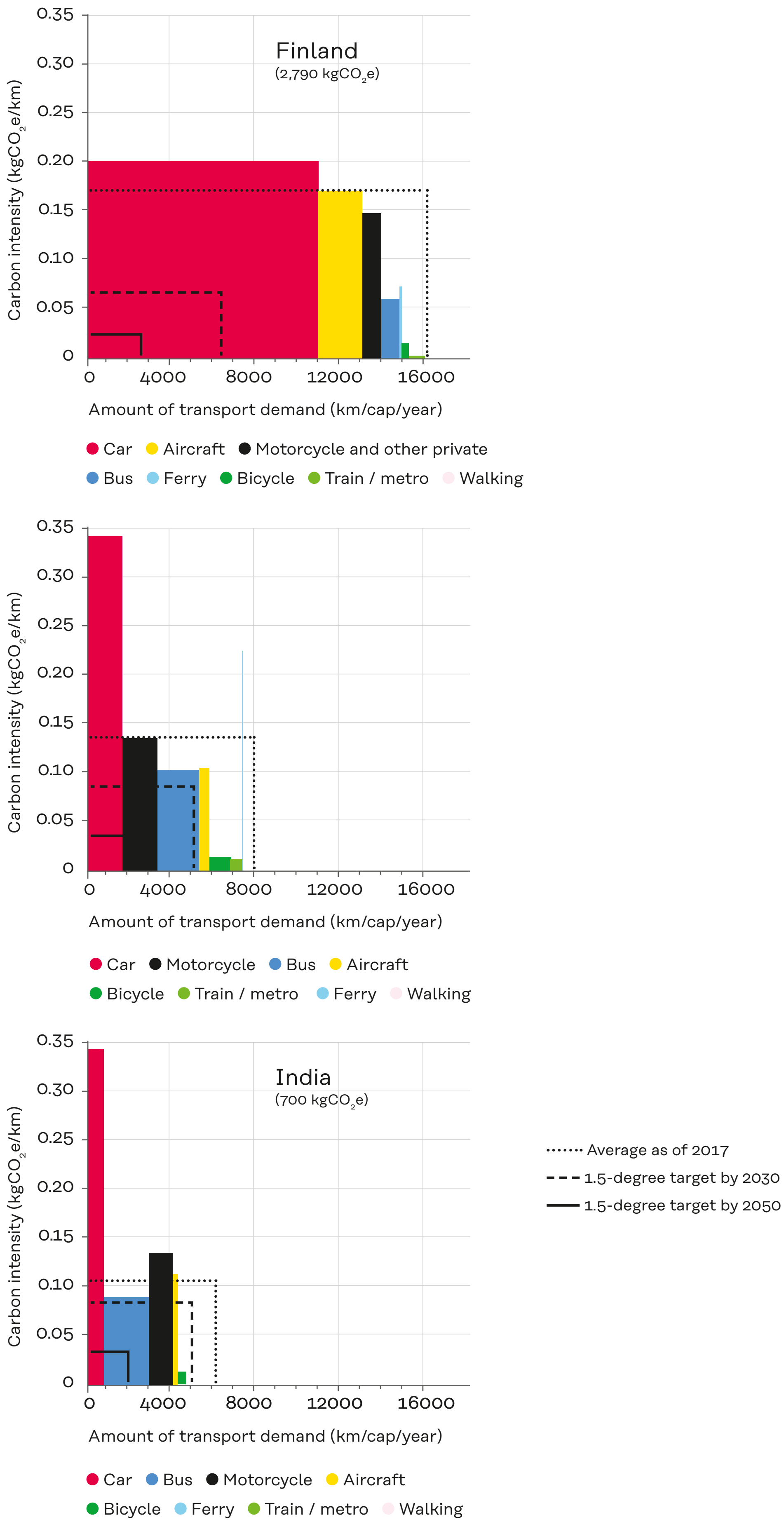
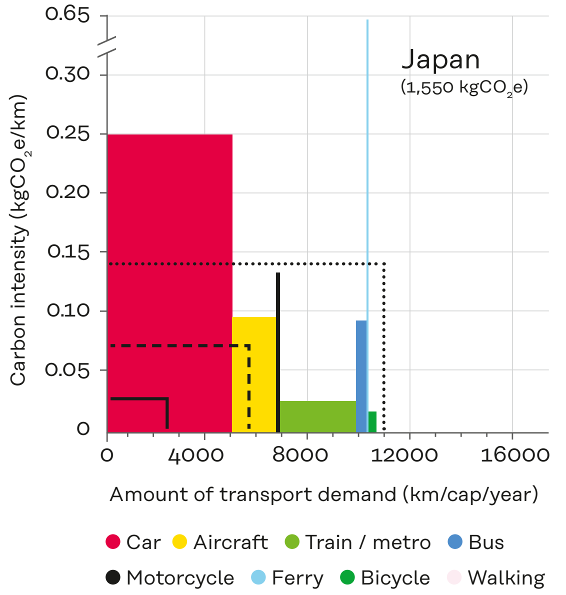
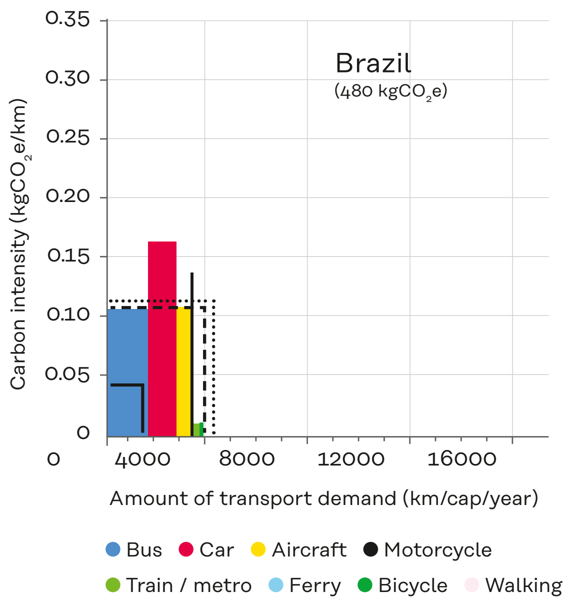


Figure 9b.
A comparison of carbon footprints and their breakdown (mobility)

Coloured rectangles indicate the average lifestyle carbon footprints of each component. Width, height and size of the area represent the physical amount of consumption, carbon intensity and carbon footprints, respectively. Black dotted rectangles show the average intensity and total physical consumption as of 2017. Pink dotted rectangles show the 1.5-degree target by 2030 and blue dotted rectangles the 2050 target. The horizontal and vertical ratios of the red and blue dotted rectangles are indicative only. If amounts cannot be reduced, intensity needs to be reduced instead.





······ Average as of 2017
– – – 1.5-degree target by 2030
—— 1.5-degree target by 2050

Air travel is the second largest contributor to the footprints in the two developed countries. In Finland, flights induce 370 kg (CO_2e/capita) while only accounting for nearly 2,200 km (13%) of mobility demand. In Japan, flying contributes 150 kg and is also only accounting for low distance, 1,600 km (15%) of mobility needs. Flights contribute more to carbon footprint in Finland than Japan partly because of the higher intensity of flights with lower occupancy rates, and probably also because of the availability of more recent data in Japan.

Land-based public transport is used more in Japan than Finland (33% and 3,600 km vs 10% and 1,640 km), partly reflecting the higher service coverage supported by high population density. Japan has a higher share of trains, meeting 30% of mobility demand, than Finland, but both countries use buses to similar extents. Trains have low carbon intensity in Japan but are almost zero intensity in Finland due to the carbon-neutral policy of the national train service (VR Group Ltd 2017). Land-based public transport is used more in developing countries, with 31–49% in Brazil, China and India, and accounts for nearly half of mobility demands in Brazil. In these countries, trains are less used, while buses play a greater role. In China, motorcycles are used more, and although they have lower carbon intensity than cars, it is still much higher than public transport. Cycling is highest in China and India, with 1,100 km and 500 km, and low in other countries, at around 250 km per person per year.

3.5 Consumer goods, leisure and services

The average Finn has a slightly higher footprint than the average Japanese from consumer goods (1,330 vs 1,030 kg (CO_2e)), possibly due to slightly more spending (over 3,000 euros in Finland compared to the yen equivalent of 2,700 euros) and slightly higher carbon intensity in Finland than Japan (0.44 vs 0.36 kg/EUR). Note that consumer goods data is not directly comparable – Finnish data is derived from product groups based on the Classification of Individual Consumption by Purpose (COICOP) and thus cannot be split further, and goods data might include some products or services that would be classified differently in Japanese data.

For leisure services, both countries have a similar carbon footprint of 600 kg per capita, but Japan has a higher footprint from restaurants and hotels while the distribution of the leisure footprint in Finland is broader: recreational and cultural activities, travel abroad and hotel services. Data for Japan does not include consumption during travel abroad, and this data is not directly comparable owing to different estimation methodologies.

The Japanese carbon intensity data implies that the shift from material purchases to leisure and experience consumption may not immediately contribute to low-carbon lifestyles. On average, the carbon intensity of each unit of monetary value for consumer goods and leisure services are almost the same (0.29 kg per 100 yen) including the footprint induced from food ingredients, which implies that shifting expenditure from material-based consumption to experience or service-based consumption may not immediately reduce carbon footprints to the extent that low-carbon leisure activities or low absolute amounts of goods consumption would. Non-leisure service consumption accounts for approximately 650 kg per capita in Japan, with a slightly lower carbon intensity of 0.15 kg per 100 yen, partly reflecting the labour-intensive and less material-intensive characteristics of the service industry.

4. How to reduce carbon intensity in our lifestyles

4.1 Key ideas for low-carbon lifestyles

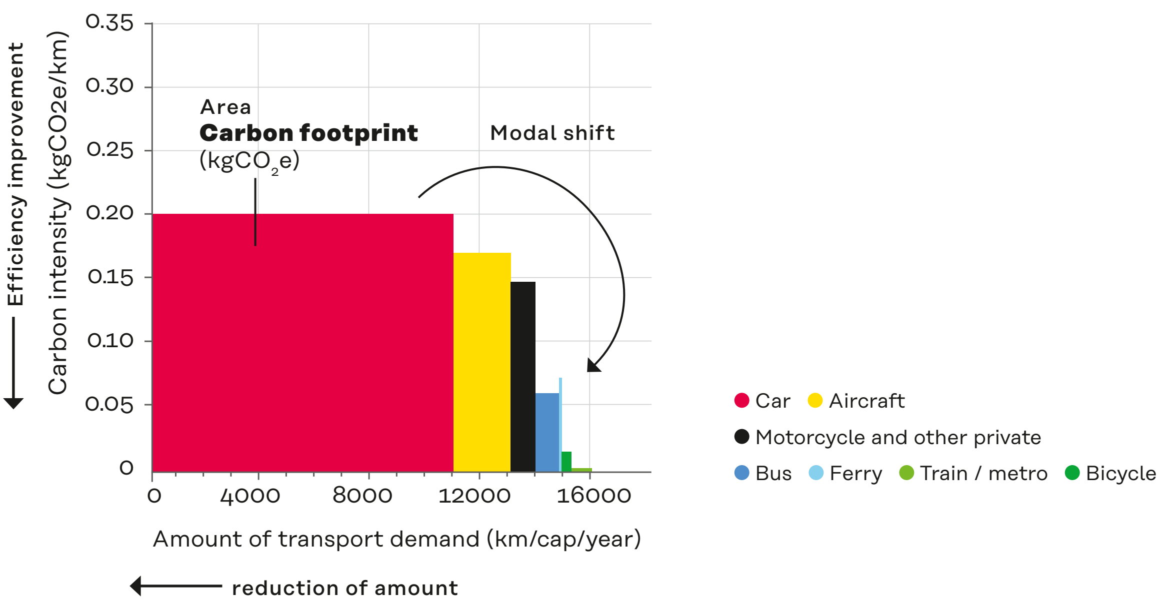
This study estimates lifestyle carbon footprints based on the amount of consumption and the carbon intensity of the categories. There are three main approaches for reducing these amounts – absolute reduction, modal shift and efficiency improvement – and these approaches are in line with the related literature (Jones and Kammen 2011; Vandenbergh, Barkenbus, and Gilligan 2008; Lacroix 2018).

• **Absolute reduction,**(Akenji et al. 2016) sometimes labelled as "sufficiency" (Figge et al. 2014) means reducing physical amounts of goods or services consumed, such as food, kilometres driven, energy use or living space, as well as avoiding unsustainable options.

• **Efficiency improvement** means decreasing emissions by replacing technologies with lower-carbon ones and not changing the amount consumed or used, such as by efficiency improvements in agriculture, vehicles or housing.

• **Modal shift** (Nelldal and Andersson 2012) initially discussed for transportation, means changing from one consumption mode to a less carbon-intensive one, such as shifting to plant-based diets, public transport or renewable energy for electricity and heating.

Figure 10. Key approaches for lifestyle carbon footprint reduction: absolute reduction, modal shift and efficiency improvement



The above is an example from Finland's mobility domain.

In the context of introducing efficient products or environmentally sound behaviours, consideration of rebound effects is essential. 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 have been discussed in the context of efficiency improvements, warning of the risk that efficiency improvements might increase total consumption and even increase emissions by making consumption cheaper (Schmidt-Bleek 1993).

The idea of a sharing economy, although it can bring about significant synergies with low-carbon lifestyles, also involves the likelihood of rebound effects (Clausen et al. 2017), depending on the options chosen; e.g. car-sharing might increase the total amount 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 thus should not raise total carbon footprints by inducing additional demand or causing unexpected adverse shifts in consumption modes.

There are three main approaches for reducing lifestyle carbon footprints – absolute reduction, modal shift and efficiency improvement.

Another important factor is the "lock-in" effect (Akenji and Chen 2016; Sanne 2002) 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, hence a stalemate leading to "carbon lock-in" of the current unsustainable industrial economy (Foxon 2002; Unruh 2000), lock-in also applies to consumer choices and lifestyles in terms of products on the market, infrastructure, the consumer's community (Akenji and Chen 2016) and economic framework conditions (Lorek and Spangenberg 2014).

Consumers in the current society are locked-in by circumstances including work-and-spend lifestyles (Sanne 2002). Considering these perspectives, the shift in lifestyles is not the sole responsibility of consumers based on their individual choices (Akenji 2014) and requires collaborative action by all stakeholders, especially the private sector and the government. The supply of low-carbon products or services by the private sector has to be improved, and a shift in infrastructure as well as national policies is needed to realise the options.

The circular economy and low-carbon lifestyles

The "circular economy" has been discussed as a strategy contributing to a low-carbon society (Material Economics 2018). It involves shifting from "a linear model of resource consumption that follows a 'take-make-dispose' pattern" to "an industrial economy that is restorative by intention; aims to rely on renewable energy; minimises, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design" (Ellen MacArthur Foundation 2013). The circular economy can also contribute to low-carbon lifestyles. The 3Rs ("reduce, reuse, recycle") can offer opportunities for low-carbon solutions through more efficient use of materials.

The circular economy can contribute to low-carbon lifestyles through the key approaches discussed above, through sharing models such as ride sharing and co-housing to promote better efficiency through the greater use of buildings and vehicles. Sharing can also enable modal shift by offering new solutions for everyday travel in the mobility sector. Reduction of food loss in both supply and consumption can also be realised via circular strategies, such as sustainable, more efficient food production chains.

Circularity can also help make low-carbon options resource-efficient; e.g. the material footprint of electric cars can be higher than that for fuel-based cars (Frieske et al. 2015) but increasing the use of recycled materials for batteries and other metals could reduce material footprints (Teubler, Kiefer, and Liedtke 2018). Yet, the low-carbon synergy of sharing options may vary depending on the types of options and the extent of rebound effects.

4.2 Impacts of low-carbon lifestyle options

In this study, the impacts of carbon footprint reduction were estimated for selected low-carbon lifestyle options in Finland and Japan. Strategically identified and promoted effective carbon reduction options are essential for addressing the Paris Agreement target, as the reductions required towards 2030 and 2050 are not incremental but drastic – over 60 and 70% reduction by 2030, for example. Given that both government and educational materials often fail to address this and instead focus on incremental or otherwise low-impact issues (Wynes and Nicholas 2017) it is important to consider lifestyle options which have large reduction potentials in each domain.

Effective carbon reduction options are essential for addressing the Paris Agreement target. We identified approximately 50 low-carbon lifestyle options.

As a result, we identified approximately 50 low-carbon lifestyle options across four domains (nutrition, housing, mobility and consumer goods). Mitigation potentials for approximately 30 options were estimated. The reviewed literature includes Project Drawdown (Hawken 2017), Capital Consumption (Hersey et al. 2009), Sitra's Green to Scale (Tynkkynen 2016, 2015), Salo and Nissinen (2017), and Sitra's 100 options for smart and sustainable living (Finnish Innovation Fund Sitra 2017) and their background materials.

The common options in both countries with the largest reduction potential of 500 to over 1,500 kg per option on average are car-free private travel,[6] renewable grid electricity, electric cars, vegetarian diets, renewable off-grid energy, hybrid cars and vehicle fuel-efficiency improvement.[7] Most options are based on a modal shift from carbon-intensive to other low-intensity consumption modes, such as car to public transport, fossil fuel to renewable energy, and meat to vegetarian nutrition sources. Efficiency improvement options such as vehicle fuel efficiency and electric and hybrid cars are also listed. The majority of these highest-impact options are from the mobility and housing domains, while food also has potential impact through the shifting of dietary habits.

Options with the next largest reduction potentials of 250 to 500 kg per option on average are ride sharing, living closer to a workplace, heat pumps for temperature control, car-free commuting, alternatives to dairy products, low-carbon protein instead of red meat and smaller living spaces.[8] The options include an absolute reduction approach, such as reducing commuting distance, and others based on modal shift, such as shifting transportation mode and dietary habits. The options cover all three major domains of mobility, housing and nutrition.

6 Shift of transportation mode from private cars to public transport for the private purpose trips such as leisure and visiting shops. Commuting is excluded from this items but included in another specific item.
7 Estimated to have more than 500 kgCO2e/capita/year reduction potential in full implementation as a mean of potentials in two case countries. Descending order by estimated mean reduction potentials.
8 Estimated to have more than 250 kgCO2e/capita/year reduction potential in full implementation as a mean of potentials in two case countries. Descending order by estimated mean reduction potentials.

Figure 11.
A comparison of the estimated per capita carbon footprint reduction impacts of low-carbon lifestyle options in Finland

Estimated by authors based on the assumptions in Annex F of the technical report (IGES et al. 2019). Achieving the 1.5 °C and 2 °C targets would require an average adoption rate of 65 and 75 per cent respectively for the options displayed in Figures 11 and 12.

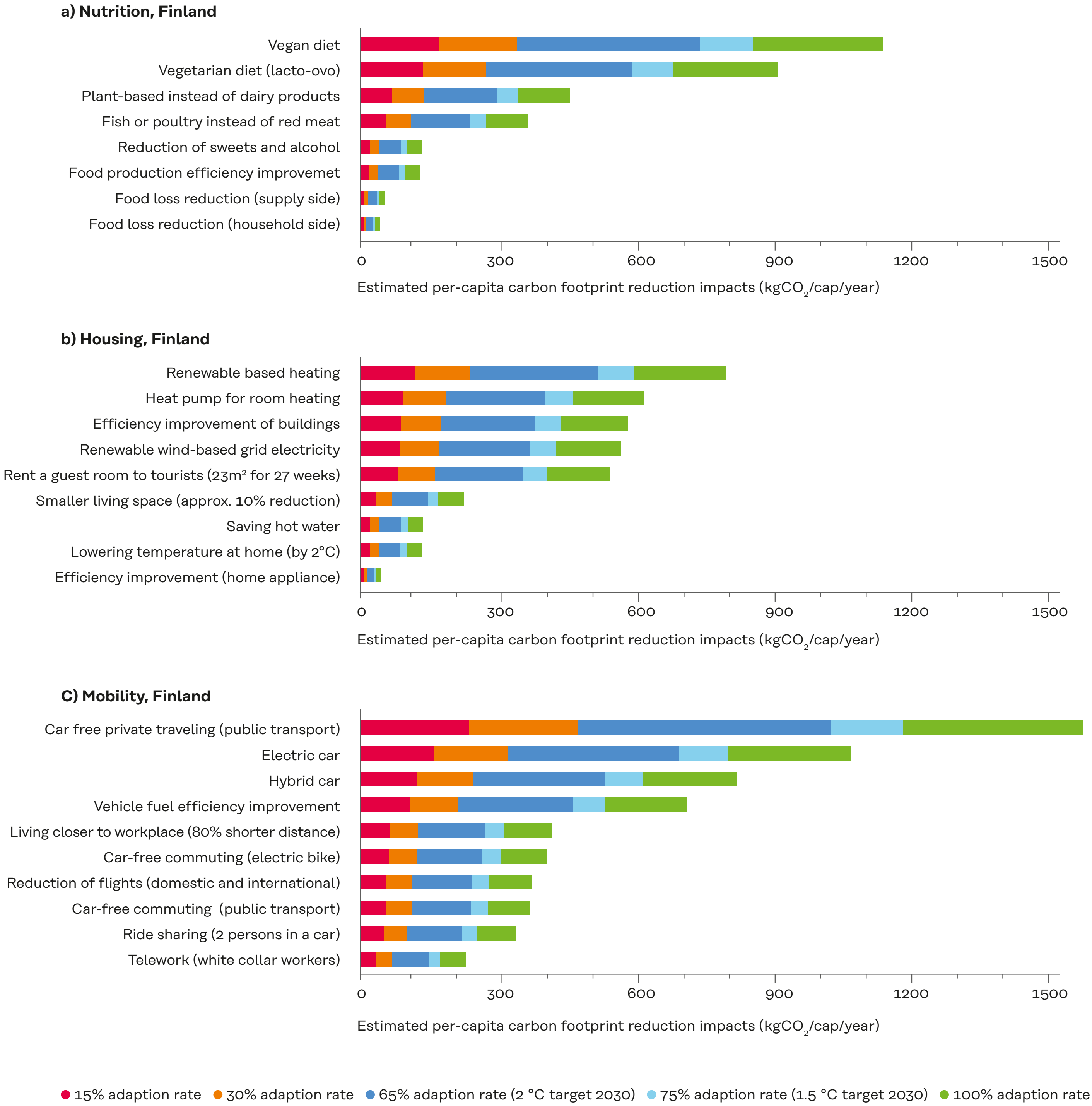
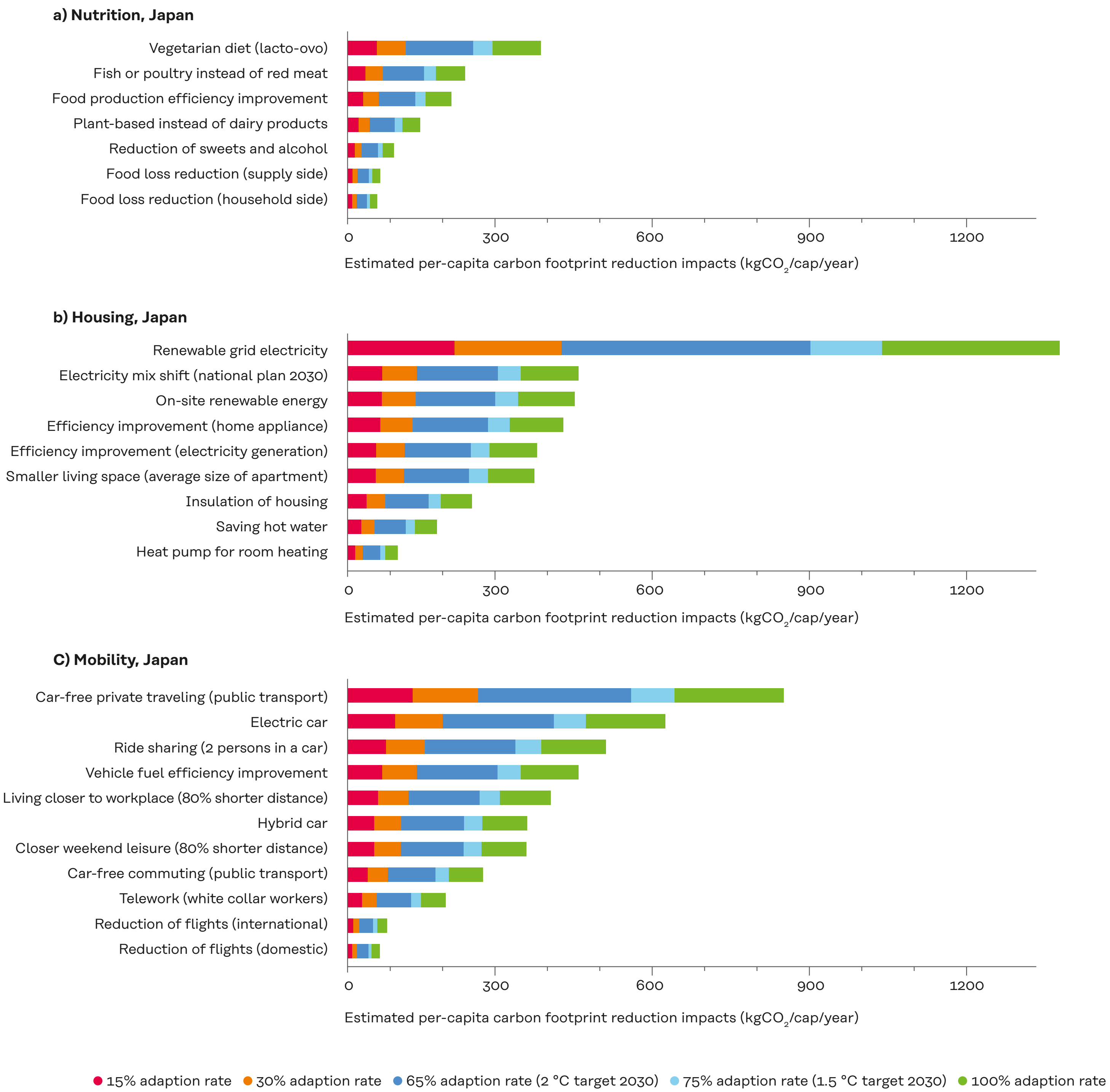


**Figure 12.
A comparison of the estimated per capita carbon footprint reduction impacts of low-carbon lifestyle options in japan**

Estimated by authors based on the assumptions in Annex F of the technical report (IGES et al. 2019). Achieving the 1.5 °C and 2 °C targets would require an average adoption rate of 65 and 75 per cent respectively for the options displayed in Figures 11 and 12.



The options with moderate impacts, less than 250 kg per option on average, are efficiency improvement of home appliances and production of food, teleworking,[9] saving of hot water, reduction of flights, and reduction of food loss and excess food;[10] i.e. options based on efficiency improvement of production and products or absolute reduction of physical consumption amounts.

Achieving the 1.5 °C and 2 °C targets would require an average adoption rate of 65 and 75 percent respectively for the options displayed in Figures 11 and 12.

These results highlight the large potential lifestyle changes required across consumption domains in order to implement the Paris Agreement, and also imply it is not an either/or question of technology or lifestyles but rather both – improvements to the energy system and technology as well as shifts in consumption patterns are required to achieve the ambitious climate targets.

These results highlight the large lifestyle changes required across consumption domains in order to implement the Paris Agreement, and imply it is not an either/ or question of technology or lifestyles but rather both.

9 Footprints caused by business operation such as energy consumption at office building is considered as part of production activities and attributed to each product or service consumed, but commuting is considered as part of household consumption. Thus, telework and shifting commuting transportation mode were included in this study as low-carbon options.

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

5. Conclusions

5.1 Long-term targets for lifestyle carbon footprints

This study proposes long-term targets for lifestyle carbon footprints comparable with the 1.5 °C aspirational target of the Paris Agreement, based on representative mitigation pathways drawn from scientific literature and assuming no or low use of negative-emission technologies. They are proposed as globally unified equitable per capita targets for the carbon footprint of household consumption at the national average level. Meeting them requires changes in lifestyles of individuals and households and, of equal importance, implies systemic changes in infrastructure and provision systems via governments, businesses and other stakeholders.

As each country has a unique culture and society, solutions should be tailored to each country's context.

In terms of inter-country differences, the five case nations revealed huge gaps. The 10.4 and 7.6 tonne carbon footprints of Finland and Japan need to be reduced by 80–93% by 2050, assuming actions for a 58–76% reduction start immediately to achieve the 2030 target. Any delays in starting actions would mean that per capita targets would increase and long terms targets would become even tighter. For developing countries, the current carbon footprints of 4.2 tonnes in China, 2.9 tonnes in Brazil and 2.0 tonnes in India need to be reduced by 23–84%, depending on the country and the scenario, by 2050. These gaps reveal the urgency of immediate and major action in developed countries, and for emerging economies to find alternative paths with low-carbon infrastructure and provision systems that enable sustainable lifestyles as the primary option.

The examination of lifestyle carbon footprints based on physical consumption units revealed several lifestyle area hotspots, such as meat and dairy consumption, fossil fuel-based energy and car use, which are currently the major causes of climate change from the perspective of household consumption. These can be effective intervention areas for activating low-carbon lifestyles compatible with the Paris Agreement.

As each country has a unique culture and society, consumption patterns and the mitigation potential from lifestyle changes are expected to vary. This implies that, despite per capita unified targets at the global level by 2030 and 2050, solutions should be tailored to each country's context while still addressing the urgent and enormous need for change.

5.2 Practical implications of the study

These low-carbon options should not be construed as merely restrictive measures, but instead as opportunities for new business, employment and improved quality of life. Many of the low-carbon options, such as reducing excess nutrition intake, use of bicycles, closer leisure destinations and telecommuting have additional knock-on benefits too, such as improved health, exercise and more free time – synergies which need to be investigated further through future research and interventions.

Actions by all related stakeholders are needed to bring about the level of reductions in footprints as projected by this study; the roles of governments and business are essential to reforming the infrastructure and ensuring product and service availability, while individuals should be better incentivised to adopt low-carbon lifestyle options as soon as possible.

Low-carbon options should not be construed as merely restrictive measures, but as opportunities for new business and improved quality of life.

National and local governments can improve public transport and promote cycling through low-carbon city planning, and facilitate switching the energy supply system to renewables. Taxation, subsidies and other policy instruments can be used to incentivise low-carbon lifestyles, e.g. modal shifts and service accessibility directed at low-carbon solutions and reductions in carbon intensity and consumption amounts for all consumption domains.

Businesses can help increase numbers and types of low-carbon options in the different domains studied, such as for teleworking, platforms for sharing and food loss reduction, alternatives to meat and dairy products, and other decarbonised product and service options. They also need to incorporate 1.5-degree business models into their strategic planning and investment decisions. To facilitate actions by governments and businesses, both the voting and purchasing power of consumers can demonstrate the urgency to initiate systemic change to bring about absolute reductions, modal shifts and efficiency improvements, especially in the domains of mobility, housing and nutrition, according to the options presented in this report.

Individuals themselves have, despite being partly locked into solutions provided by the existing infrastructure, numerous opportunities to shift their consumption habits, even in the short term – such as in mobility, by shifting to public transport, cycling and low-carbon vehicles, reducing private car use and use of air travel; in housing, by purchasing, investing or producing renewable electricity, and investing in low-carbon houses and equipment such as heat pumps and insulation; and in nutrition, by adopting plant-based diets and reducing consumption of meat and dairy products, and reducing food waste. Choosing decarbonised products and services, wherever available, is crucial for strengthening the market for low-carbon solutions, as well as for demonstrating interest in low-carbon solutions to local and national government.

5.3 Next steps

The study proposed and analysed lifestyle carbon footprints, defined as the GHG emissions directly emitted and indirectly induced from household consumption. The methodology developed for this study can be extended to analyse other elements of planetary boundaries than just climate change – looking at, for example, freshwater use and biogeochemical flows such as nitrogen from a lifestyles perspective. With further adaptation, such analysis could be carried out for the sustainable development goals, analysing, for example, resource use and waste from different lifestyles.

As further steps, the estimation of lifestyle carbon footprints and hotspot analysis can be expanded to other countries not included in this study or to sub-national levels, such as cities. Additionally, carbon footprints of governments and capital investments can also be integrated into the analysis to include other aspects of society. Such analysis can also be done at the individual level through an interactive lifestyle carbon footprint assessment tool or based on survey data or big data collected on consumer behaviour. In addition, more varieties of low-carbon lifestyle options should be included and evaluated, incorporating specific considerations of local culture, consumer behaviours and the characteristics of infrastructure and service providers. To facilitate the research and ensure comparability, methodological guidance for lifestyle carbon footprint estimation can be developed further as an addition to the present guidelines for the footprints of products and organisations.

The targets and understanding of hotspots and the mitigation potential of lifestyle-related options should be reflected in all strategies of companies and local and national governments over both the short and long term. A combination of research and experiments would further facilitate policymaking, business development and individual actions towards 1.5-degree lifestyles.

The mitigation potential of lifestyle-related options should be reflected in all strategies of companies and governments over both the short and long term.

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Appendix

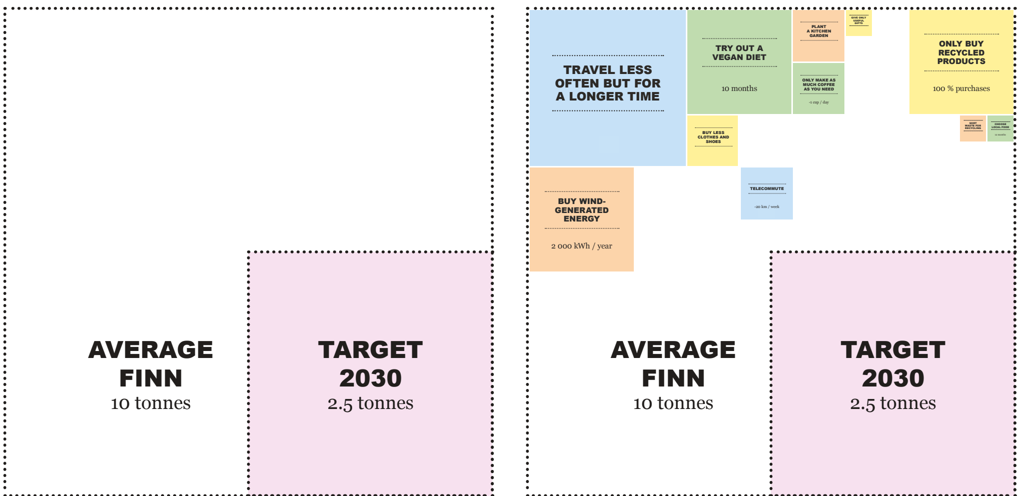
Interactive tool for households

In the context of the 1.5-degree lifestyles project, a prototype of an interactive household tool, the “1.5-degree lifestyles puzzle” has been developed. The purpose of the tool is to help households understand the idea, opportunities and challenges of 1.5-degree lifestyles, as well as to inspire and enable them to move towards low-carbon lifestyles. The tool thus intends to make the results and implications of the project approachable and understandable to both households and other stakeholders in order to foster discussion and action around the required systemic changes to enable 1.5-degree lifestyles.

In the first phase, the participants are given the size of their current carbon footprint, visualised in a square. Inside the square, there is a smaller square indicating the 2030 target (2.5 tonnes), i.e. the sustainable level of lifestyle carbon footprint in 2030. Hereafter, the participants are given a collection of “puzzle pieces”: squares in different sizes that represent different actions that the household can take in order to lower its carbon footprint. The relative sizes of the squares indicate the reduction potential in the household carbon footprint. The task is to choose relevant actions to fill the gap between the current carbon footprint and the target for 2030. Here, we are trying out an action-oriented approach where the participants’ mindset is not oriented towards reducing but towards active implementation of options according to a household’s preferences.

Figure 13. The 1.5-degree lifestyles puzzle

The puzzle illustrates the size of the participant’s current lifestyle carbon footprint compared to the 1.5 °C target for 2030 (2.5 tCO_2e). Hereafter, the participants are given a collection of “puzzle pieces”, squares of different sizes that represent different actions they can take to lower their carbon footprint. The relative sizes of the squares indicate the reduction potential for the lifestyle carbon footprint.



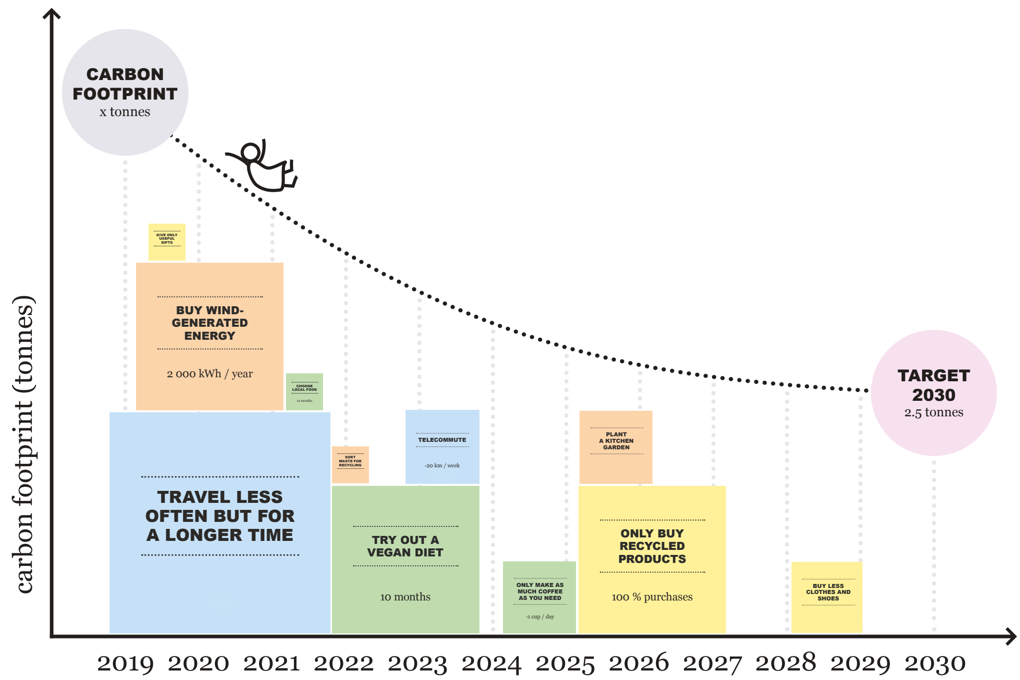
When the gap between the present footprint and the target for 2030 is filled, the participants move to the second phase. They are asked to place the options chosen on a timeline from the present until 2030. Here, the households need to go through the actions once more and think about what it would require to realise them in practice. What are the aspects that motivate or restrict certain actions? When and how they could be implemented? This reflection process helps to take a step closer to realising the actions in real life.

In the third phase, the participants are asked to think about which options they can realise themselves, and which options should be especially promoted by others in society, like the public sector or private companies.

The iterative design process makes it possible to try out and co-create prototypes with different stakeholders at an early stage, hence facilitating a transdisciplinary discussion on what is needed and desirable for mobilising action.

Figure 14. The 1.5-degree lifestyles puzzle

In the second phase of the puzzle, the participants are asked to place the chosen options on a timeline ranging from now until 2030.



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