

Chapter 9

Understanding Households as Drivers of Carbon Emissions

Angela Druckman and Tim Jackson

Abstract Households are accountable for nearly three quarters of global carbon emissions and thus understanding the drivers of these emissions is important if we are to make progress towards a low carbon future. This chapter starts by explaining the importance of using an appropriate consumption perspective accounting framework for assessing the carbon footprint of households. This contrasts from the more commonly used production perspective, as, for many Western countries in particular, once responsibility for emissions embedded in imported goods and services are taken into account, consumption emissions are often higher than production emissions.

The chapter then reviews findings concerning the determinants and composition of the carbon footprint of households, focusing on Western countries. One of the main determinants is income, with carbon footprints increasing with increasing incomes. However, other drivers, such as household size and composition, rural/urban location, diet and type of energy supply, also play a part. Studies show that the majority of an average carbon footprint arises from three domains: transportation, housing and food. Further analyses aimed at gaining a deeper understanding of the motivations behind the activities driving emissions, in particular those due to transportation and housing, show that recreation and leisure pursuits are responsible for a substantial portion of average carbon footprints. Studies indicate, for example, that activities such as spending time with friends and family in and around the home, which are generally low carbon and also enhance well-being, should be encouraged alongside the more mainstream strategies of improving systems of provision of energy, food, housing and transportation.

The finding that income is one of the principal drivers of carbon emissions is a challenging and important issue to address, as, for instance, incomes are arguably the driver of the rebound effect – a phenomenon that confounds attempts to reduce carbon footprints, making reducing emissions more of an uphill task than often acknowledged. This challenge leads us to a wider, whole-systems approach in which we view households as an integral part of the system of production and consumption.

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In summary, industrial ecology, with its wide ranging systems approach as shown in this chapter, has a great deal to contribute to the quest to devise strategies to move towards lower carbon, fulfilling lifestyles.

Keywords Carbon footprint • Consumption-based accounting • Environmental input-output analysis • Household carbon-footprint • Personal carbon-footprint • Rebound effect • Time use • Work-time reductions

1 Introduction

Adam Smith stated that “consumption is the sole end and purpose of all production” (Smith 1904) thus putting consumption firmly in the field of industrial ecology. In this chapter we specifically focus on the carbon emissions caused by household consumption, as these have been estimated to be accountable for around 72 % of carbon emissions on a global basis (Hertwich and Peters 2009; Wilson et al. 2013). Thus the study of households¹ and how the environmental impacts for which they are responsible may be reduced is key to achieving a low carbon future.

Accordingly, in this chapter, we first examine the accounting perspective required to scrutinise the carbon emissions for which household consumption is responsible (Sect. 2). Section 3 reviews the evidence concerning the determinants of household carbon emissions. In Sect. 4, we introduce the ‘rebound effect’ – a phenomenon that confounds attempts to reduce carbon footprints, making reducing emissions more of an uphill task than often acknowledged. In the final section (Sect. 5), we broaden the focus to look at households in the wider context of systems of production and consumption, and possibilities of win-win solutions that offer potential to reduce carbon while at the same time enhancing well-being.

Household consumption is a wide ranging topic and inevitably there are many limitations to this chapter. One of these is that we focus here on consumption by Western households. A second is that we do not review the prolific literature on the driving forces behind household consumption or the ways that household consumption may be reduced.² And a third limitation is our focus on ‘carbon’ emissions. However carbon is defined (see Sect. 2), use of carbon emissions as a single indicator can lead to policies that, while beneficial in terms of reducing global warming, may lead to unexpected and unintended detrimental consequences in terms of other environmental impacts. For example, Benders et al. (2012) analysed five environmental impact categories: global warming potential, acidification, eutrophication,

¹We focus here on household carbon footprints as much of the consumption that gives rise to carbon emissions, such as energy use for space heating, arises at a household level. Estimation of per capita (personal) carbon footprints requires division by the number of people in a household with appropriate apportioning to children. Apportioning to children is generally done using equivalence scales (OECD 2015).

²For an overview of these literatures see Jackson (2005, 2006, 2009).

summer smog and land use. Combined analysis of the five impact categories found that food has the largest environmental impact,³ whereas analysis of greenhouse gas emissions alone indicated that housing has the largest impact. Nevertheless, climate change caused by anthropogenic carbon emissions is currently accepted as the most urgent environmental threat (IPCC 2014) and is thus considered a useful indicator for the focus of this chapter.

2 Consumption Accounting and Carbon Footprinting

In this Section, we first set out the importance of the type of accounting framework used for exploring household carbon footprints, and explain how this is different from the default framework normally applied by governments in assessing their emissions and in international treaties. The framework is best introduced by posing the question: to what extent should Western consumers take responsibility for the things they buy? If, say, a UK consumer purchases a TV manufactured in China, which nation should take responsibility for the emissions incurred during its manufacture? This dilemma illustrates two different accounting approaches that must be untangled as we strive to devise strategies for a more sustainable future. According to accounting by the production perspective, China should take responsibility as the emissions arose on Chinese territory. This is the approach used in the Kyoto Protocol and is the most commonly used accounting approach (Bows and Barrett 2010; Wiedmann 2009). An alternative is the consumption perspective. According to this perspective, the UK should take responsibility, as export to the UK was the driving force motivating production, and a UK consumer is the primary beneficiary of the final product (Druckman et al. 2008; Peters and Hertwich 2008a; Peters et al. 2011; Lenzen 2008; Lenzen et al. 2007; Jackson et al. 2006).

The accounting perspective used is particularly important because accounting according to the production perspective shows that many Western economies are successfully reducing their carbon emissions. However, when the consumption perspective is used for accounting, not only are carbon emissions often found to be higher than compared to the production accounts, but they also tend to exhibit a rising trend (CCC 2013; Baiocchi and Minx 2010; Ahmad and Wyckoff 2003; Peters and Hertwich 2006a; Baiocchi et al. 2010). The reason for the differences shown between the two accounting perspectives is the quantity of carbon emissions embedded in trade, which is the subject of Wiedman's chapter (Chap. 8) in this book. An example of the importance of the carbon embedded in trade is given by Li and Hewitt (2008) who found that, through trade with China, the UK reduced its production based carbon dioxide emissions by approximately 11 % in 2004, compared with a non-trade scenario in which the same type and volume of goods are produced in the UK.

³They analysed 12 COICOP domains: Food, alcohol & tobacco, clothing, housing, furniture, health, transport, communication, recreation, education, restaurants, others.

Table 9.1 Recent definitions of a carbon footprint

“The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product” (Wiedmann and Minx 2007: 4)
“A carbon footprint is equal to the greenhouse gas emissions generated by a person, organization or product” (Johnson 2008: 1569)
“A measure of the total amount of CO ₂ and CH ₄ emissions of a defined population, system or activity considering all relevant sources, sinks and storage within the spatial and temporary boundary of the population, system or activity of interest. Calculated as CO ₂ e using the relevant 100-year global warming (GWP100)” (Wright et al. 2011: 69)
“Climate footprint: A measure of the total amount of CO ₂ , CH ₄ , nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride emissions of a defined population, system or activity considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. Calculated as CO ₂ equivalents using the relevant 100-year global warming potential” (Williams et al. 2012: 56)
“A measure of the amount of carbon dioxide released into the atmosphere by a single endeavour or by a company, household, or individual through day-to-day activities over a given period” (Collins English Dictionary 2012)

Source: Birmik (2013: 281)

While many studies explore the carbon emissions embedded in trade,⁴ some studies focus specifically on the role of imported goods and services and their associated emissions in the carbon footprints of households⁵ (Hertwich and Peters 2009; Lenzen et al. 2006; Munksgaard et al. 2005; Nijdam et al. 2005; Peters and Hertwich 2006b). Peters and Hertwich (2006a) put forward a general rule that countries with a high proportion of imports and relatively clean electricity generation are likely to have a significant proportion of their household carbon emissions attributed to imports. This means that, due to the supply chain emissions embedded in imported goods, households drive emissions in other countries as well as in their own country. For example, Weber and Mathews (2008) found that nearly 30 % of the carbon dioxide emitted to meet household demand in the US occurred outside the borders of the US.

Accounting according to the consumption perspective is commonly known as ‘footprinting’: this is the approach adopted in this chapter, and in particular the chapter is concerned with carbon footprinting. However, the definition of what is included in a carbon footprint is contentious, as shown in Table 9.1. In this chapter

⁴See for example: Davis and Caldeira (2010), Ahmad and Wyckoff (2003), Andrew et al. (2013), Atkinson et al. (2011), Cave and Blomquist (2008), Hertwich and Peters (2009), Lin and Sun (2010), Maenpaa and Siikavirta (2007), Munksgaard et al. (2005), Nakano et al. (2009), Peters and Hertwich (2008b), Peters et al. (2011), Shui and Hariss (2006), Weber and Peters (2009) and Knight and Schor (2014).

⁵Consumption accounting attributes carbon emissions to the ‘final demand’ of a country and is based on the UN System of National Accounts. According to this system, final demand is composed of government expenditure, capital investment, exports and household expenditure. Although there is an argument that government expenditure should be re-allocated to households, as government exists to serve households, it is generally kept as a separate category. A similar argument relates to investment (Hertwich 2011). In consumption accounting exports are excluded but imports are included.

we take a relaxed approach to what we mean by ‘carbon’ and include reviews of studies that range from assessing carbon dioxide emissions only to those that take a more comprehensive greenhouse gas approach. The main difference in results is that emissions due to food make up a larger portion of the carbon footprint of a household when the analysis is extended to a basket of greenhouse gases. What we are more stringent about in this chapter is that we take a whole supply chain, life cycle approach to assess the carbon emissions caused by households.

There are two basic categories of a household carbon footprint. First are direct emissions that arise due to direct energy use in the home (such as gas for space and water heating, and electricity for lighting and powering appliances and gadgets) and due to burning personal transportation fuels (petrol and diesel). Second is ‘embedded’ emissions, such as those that arise during our example of the manufacture of a TV made in China. Embedded emissions along supply chains (arising domestically and abroad) account for the majority (around 60–70 %) of the carbon footprints of Western households (Druckman and Jackson 2010; Dey et al. 2003; Bin and Dowlatabadi 2005; Baiocchi et al. 2010).⁶

Estimates of household carbon footprints are generally derived from expenditure data. Carbon emissions arising from expenditure on transportation fuels and energy use in the home are relatively easily estimated from information on prices, the carbon content of fuels and information from each country’s Environmental Accounts. Estimation of carbon emissions embedded in other expenditures is harder and requires information on the technologies used to manufacture all products and services purchased, wherever in the world this may occur. This is generally done using Environmentally Extended Input-Output Analysis (EE-IOA) (Hertwich 2011; Munksgaard et al. 2005; Baiocchi et al. 2010; Weber and Matthews 2008; Weber and Perrels 2000; Lenzen et al. 2004; Wiedmann 2009). EE-IOA is a top-down methodology that combines information on the structure of the economy with environmental data (see Miller and Blair (2009)). There are some notable exceptions to this methodology. The first is hybrid analysis which combines process-based, bottom-up Life Cycle Assessment (LCA) with top down EE-IOA (Benders et al. 2012). Another exception is the work by Girod and de Haan (2009, 2010) who use a bottom-up LCA methodology only, based on physical functional units such as kg of food, person kilometres and living square meters.

3 What Makes a Household Carbon Footprint?

In this section we first examine the major socio-economic drivers of household footprints, we then explore the composition of average carbon footprints, and the final sub-section examines carbon footprints from the perspective of time-use.

⁶Estimates include 60 % for USA (Bin and Dowlatabadi 2005), 66 % and 70 % for the UK (Druckman and Jackson 2010 and Baiocchi et al. 2010, respectively), and 70 % for Australia (Dey et al. 2003).

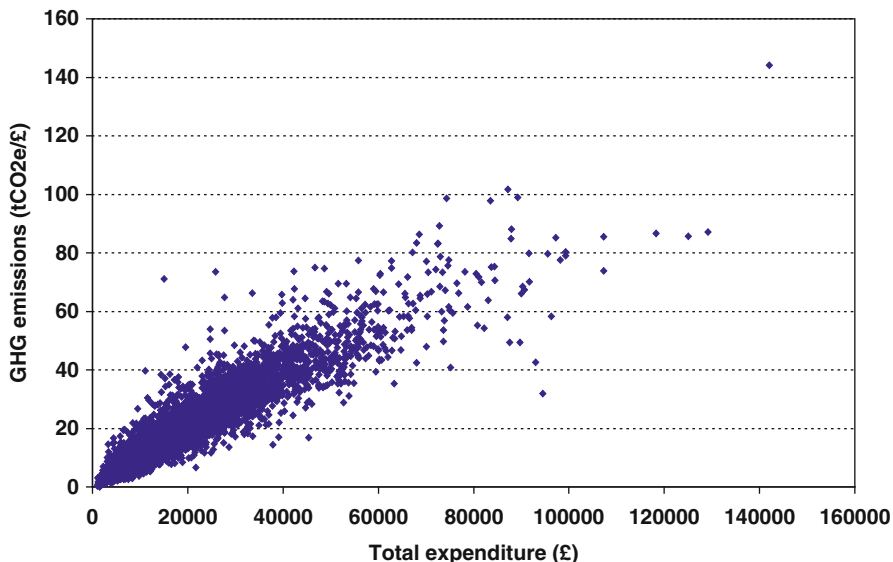


Fig. 9.1 The relationship between household carbon footprints and total household expenditure (2009) (Source: Chitnis et al. 2014, p. 21)

3.1 *The Determinants of Household Carbon Footprints*

One of the most important factors determining the carbon footprint of Western households is household income,⁷ with (as illustrated in Fig. 9.1) household footprints generally increasing with income (Wier et al. 2001; Dey et al. 2003; Weber and Matthews 2008; Buchs and Schnepf 2013; Baiocchi et al. 2010; Gough et al. 2011; Kerkhof et al. 2009; Chitnis et al. 2014). As discussed by Baiocchi et al. (2010) and Dey et al. (2003), this finding dispels the ‘Kuznets curve’ theory according to which, as nations become more developed, incomes rise and emissions are hypothesized to fall.

Whereas the relationship between income and carbon footprint is strong, studies have shown that as incomes increase consumers tend to shift their expenditures away from carbon intensive ‘necessities’ towards discretionary expenditures that are generally less carbon intensive (Buchs and Schnepf 2013; Weber and Matthews 2008; Chitnis et al. 2014; Jones and Kammen 2011). For example, Fig. 9.2b shows that lower income US households tend to incur a greater proportion of their carbon emissions from ‘necessities’ such as food and home energy, and in particular the home energy emissions tend to arise from direct energy use (gas and electricity). Additionally, Chitnis et al. (2014), in a study of UK households, showed that high income households incur a higher proportion of their carbon due to ‘Recreation and

⁷Total household expenditure is often used as a proxy for income, as total household expenditure is generally more accurately captured in surveys than income.

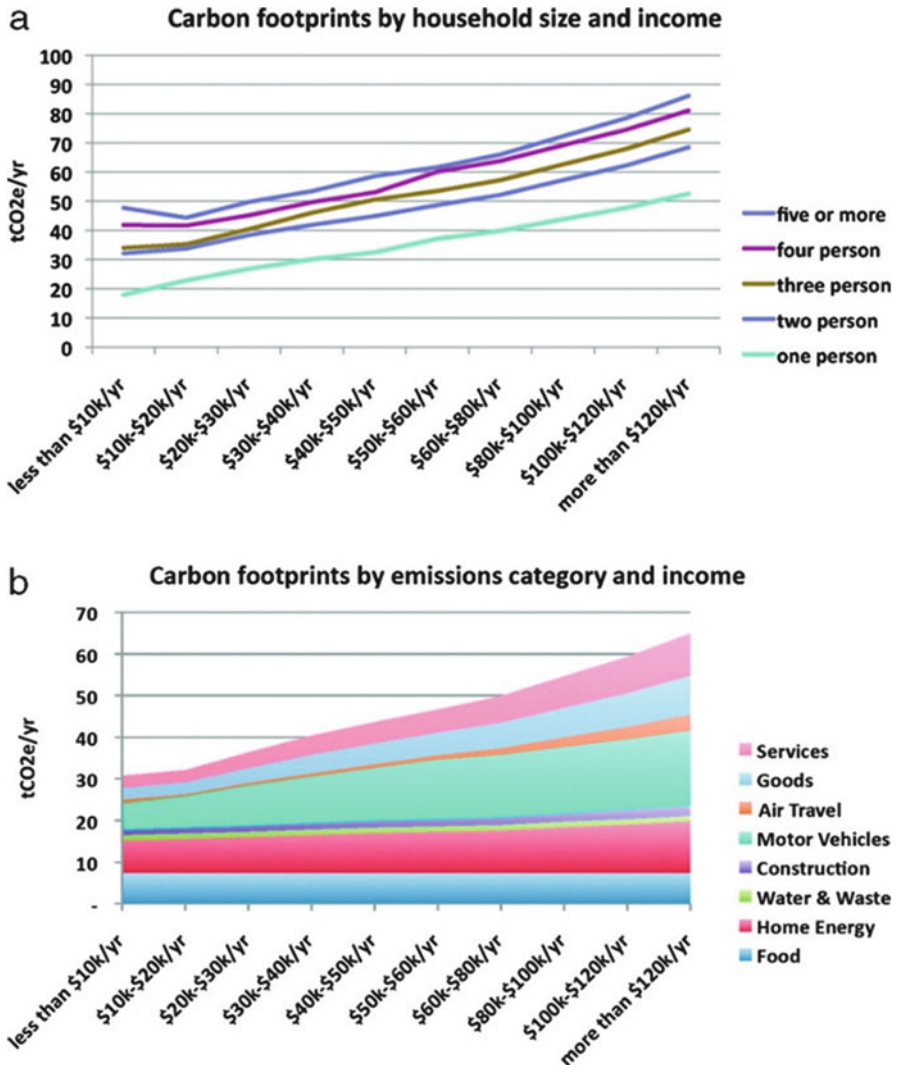


Fig. 9.2 (a) Carbon footprints by income bracket and household size; (b) Carbon footprints by category of emissions and income bracket for average household size of 2.5 persons (Source: Jones and Kammen (2011), Fig. 2, p. 4090)

Culture’ than lower income households. Weber and Mathews (2008) also point out that there tends to be a higher diversity in the carbon footprint of households with higher incomes/total household expenditure.

Exceptions to the general pattern of low income households incurring a greater proportion of their carbon emissions from direct energy use than upper income households was found by Kerkhof et al. (2009) who compared four countries. While they found this pattern for UK and The Netherlands, they found reverse trends in

Sweden and Norway and attributed this mainly to the use of district heating in Sweden and the use of low carbon intensity electricity for heating in Norway.

Household size is generally found to be an important determinant of household carbon emissions (see Fig. 9.2a), as households with more people tend to benefit from economies of scale (Dey et al. 2003; Baiocchi et al. 2010; Jones and Kammen 2011; Weber and Matthews 2008; Tukker et al. 2010; Gough et al. 2011). As Tukker et al. (2010) explain, this is because people sharing a dwelling also share energy using appliances and cohabitants tend to require less living space than single occupants: this reduces the energy required for heating and cooling. Buchs and Schnepf (2013) note that economies of scale are less important for transport and indirect emissions, and Gough et al. (2011), in their analysis of different UK household types, found that younger single person households tend to emit relatively high amounts due to transport and personal services.

Gough et al. (2011) found statistically significant differences between the emissions of UK households according to employment status, with the working households exhibiting higher emissions when income and composition are controlled for, and the unemployed and unoccupied having lower emissions. The explanation Gough puts forward is that work-rich households tend to have higher emissions due to commuting and tend to substitute purchased goods and services for 'household production'. Buchs and Schnepf (2013) added to this by noting that workless households tend to have higher emissions due to home energy use.

Urban locations are generally more efficient in terms of direct emissions than rural locations (Wier et al. 2001; Jones and Kammen 2011; Buchs and Schnepf 2013; Baiocchi et al. 2010; Glaeser and Kahn 2010; Tukker et al. 2010). One reason for this is that urban transportation distances tend to be shorter with greater availability of public transport options. Another reason is that urban dwellings tend to be smaller and therefore more efficient to heat (Tukker et al. 2010; Wier et al. 2001; Baiocchi et al. 2010). Also the 'heat island effect' lowers energy required for space heating in urban locations⁸ (EPA2014). However, as Baiocchi et al. (2010) point out, the general rule of urban households requiring less direct energy and hence having lower carbon footprints is, in some instances, counterbalanced by the fact that poorer rural households living in rural locations may not be able to afford a car or long recreational trips by aeroplane.

Households dwelling in extreme climates generally incur higher carbon emissions due to energy use for space heating and/or air conditioning (Tukker et al. 2010); however this effect is moderated by other factors, such as the type of energy supply and housing construction. For example, Kerkhof et al. (2009) attributed the higher household carbon emissions for space heating in the UK and the Netherlands than in Sweden and Norway to use of natural gas in the first two countries, district heating in Sweden and low carbon-intensity electricity in Norway. The carbon intensity of the electricity supply also effects household carbon footprints even if it is only used for powering lights, appliances and gadgets and not for heating, as intensities vary widely: for example, electricity from geothermal sources in Iceland

⁸This can reverse in hot climates, with urban locations needing more cooling.

has an intensity of just 0.00018 kg CO₂/kWh, and in Norway the intensity is 0.013 kg CO₂/kWh, compared to the EU average of 0.35 kgCO₂/kWh (DEFRA et al. 2014).

The construction of housing also, of course, affects the carbon footprint. For example, in the UK, much of the housing stock is hard to insulate adequately at reasonable costs (Hong et al. 2006) and hence occupiers of these dwellings tend to have relatively high carbon footprints. Also the control systems installed, such as thermostats, affect carbon footprints (Tukker et al. 2010).

The carbon emissions embedded in food products generally forms a substantial portion of a carbon footprint (see Sect. 3.2), in particular when analysed in terms of greenhouse gas emissions instead of carbon dioxide only (Dey et al. 2003; Nijdam et al. 2005; Tukker and Jansen 2006; Druckman and Jackson 2009, 2010). The type of diet has a high impact on this. In general, vegetarians and consumers who eat locally harvested seasonal food tend to have lower per capita environmental impacts from food consumption than individuals who rely on more traditional diets (Garnett 2013; Tukker et al. 2010).

Education has also been found to play a role in determining household carbon emissions, with high education being significant and positively related to emissions once income is controlled for (Baicocchi et al. 2010; Buchs and Schnepf 2013). Baicocchi et al. (2010) interpret this as support for justification for environmental education campaigns.

Other factors that influence household carbon footprints include social and cultural differences. This includes how people use their household control systems (Wood and Newborough 2007), whether, for example, it is the social norm to wear a jersey indoors during cold weather (Druckman et al. 2011b; Shove 2012), and the prevalence of a ‘throwaway’, consumerist culture, as opposed to a more thrifty way of living (Cooper 2010).

3.2 Composition of Household Carbon Footprints

In this sub-section, we look in more detail at the composition of average household carbon footprints of Western households. Generally the categories of transportation, housing and food make the largest contributions (Jones and Kammen 2011; Caeiro et al. 2012; Tukker 2006; Tukker and Jansen 2006). For example, Benders et al. (2012) found that these three domains account for nearly three quarters of carbon emissions and inclusion of the next largest category, recreation, accounted for around 85 % of average carbon footprints in The Netherlands. Jones and Kammen (2011) (see Fig. 9.3) assessed carbon emissions of an average US household in five main categories, with further sub-divisions and also making a distinction between direct and indirect emissions (blue and green in Fig. 9.3, respectively). While supporting the general findings that the broad categories of transportation, housing and food make up the majority of emissions, their analysis found that direct emissions from motor fuels was the largest sub-category, at around 20 % of the total, with electricity consumption coming next (15 %), followed by emissions due to meat consumption (5 %).

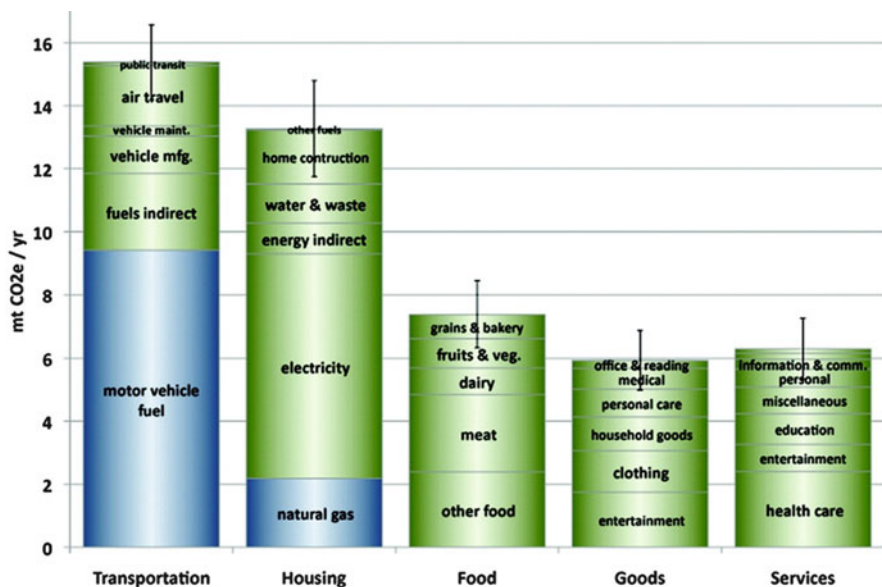


Fig. 9.3 Total carbon footprint of a typical US household (48 tCO₂e/yr) (Source: Jones and Kammen (2011), Fig. 1, p. 4090)

Studies vary in the number of categories used for analysing household carbon footprints, as shown in Table 9.2. Some studies use the top 12 categories of the Classification of Individual Consumption According to Purpose (COICOP) system which is part of the UN System of National Accounts (UN 2011).⁹ COICOP categories are, however, primarily intended for economic rather than environmental analysis and so other researchers modify the categories to reveal the carbon implications of expenditures better. For example, Weber and Mathews (2008) add an extra category of ‘Utilities/home energy’.

Travel is rarely undertaken as an end in itself, as it is generally undertaken to serve a purpose such as visiting friends, attending a football match or going to work. Similarly, water heated by gas may be used for food related activities such as washing up, or, for example, for health and hygiene purposes. Acknowledging this, and to further elucidate the activities that give rise to carbon emissions, Druckman and Jackson (2009, 2010) allocate carbon emissions to ‘functional uses’. In this approach all carbon emissions that arise due to activities related to food (for example), such as emissions due to driving to supermarkets, energy used in preparing food, cooking and washing-up, emissions embedded in the production of food, and even those

⁹The 12 top COICOP categories are: Clothing and footwear; Housing, water, electricity, gas and other fuels; Furnishings, household equipment and routine household maintenance; Health; Transport; Communication; Recreation and culture; Education; Restaurants and hotels; Miscellaneous goods and services.

Table 9.2 A summary of selected studies on the carbon footprints of households

Source	Country	Number of categories	Carbon dioxide (CO ₂) or greenhouse gases (GHG)?
Druckman and Jackson (2010)	UK	44	GHG
Jones and Kammen (2011)	USA	27	GHG
Dey et al. (2003)	Australia	17	GHG
Benders et al. (2012)	The Netherlands	12	GHG
Gough et al. (2011)	UK	5	GHG
Kerkhof et al. (2008)	The Netherlands	5	GHG
Jackson et al. (2006)	UK	27	CO ₂
Bin and Bowlatabadi (2005)	USA	18	CO ₂
Weber and Mathews (2008)	USA	13	CO ₂
Baiocchi et al. (2010)	UK	12	CO ₂
Kerkhof et al. (2009)	The Netherlands, UK, Sweden, Norway	12	CO ₂
Druckman and Jackson (2009)	UK	9	CO ₂

embedded in running the supermarkets, are attributed to the category ‘Food and Catering’. The exception to this is emissions due to space heating which are included as a separate category as they account for such a high proportion of carbon emissions (13 %). Druckman and Jackson’s (2010) analysis shows that there is an element of travel emissions in all categories apart from space heating. They find that while there are a great deal of carbon emissions tied up in the mundane activities of everyday life, such as keeping families warm (‘Space Heating’ 13 %), fed (‘Food & Catering’ 24 %), safe and secure (‘Household’¹⁰ 11 %) and clothed (‘Clothing & Footwear’ 8 %), ‘Recreation & Leisure’ is, however, the largest category at around 27 % (Druckman and Jackson 2010).

Understanding emissions due to recreation and leisure is important for a number of reasons: they arise due to ‘discretionary’ activities, and so this category may offer rich opportunities for reductions; this category accounts for a substantial proportion of the carbon footprint as described above (Druckman and Jackson 2009, 2010; Benders et al. 2012); emissions in this category are generally increasing, with energy intensive forms of leisure (such as flying on holidays) generally increasing whereas less energy intensive leisure activities, such as reading, are stable or decreasing (Aall et al. 2011). Also there has been an increasing ‘materialisation’ of leisure practices, whereby, for example there are increasing tendencies to buy specialist equipment and clothing for walking and other such pursuits (Aall et al. 2011).

¹⁰The Household category comprises the carbon emissions that are associated with constructing, occupying and running a dwelling.

In order to further understand emissions due to recreation and leisure, Druckman and Jackson (2010) divided recreation and leisure into 12 sub-categories with particular focus on holiday/non-holiday activities. They found that carbon emissions due to holidays account for around 10 % of an average UK household's entire carbon footprint. Of this, over half (52 %) of holiday emissions were found to be due to aviation, and when this was added to other holiday-related transport emissions, transportation accounted for nearly three quarters (74 %) of 'Holiday' emissions. Emissions due accommodation services in hotels were found to make up around just 16 % of 'Holiday' emissions. These figures give us an indication of how carbon emissions might be reduced, primarily in this case through reducing holiday travel emissions. Holidays are, however, a particularly difficult area to tackle: as Barr et al. (2010) said '*A holiday is a holiday*' during which people take a vacation from their environmental behaviour. Aviation emissions are, in particular, growing rapidly, and, due to political difficulties in introducing policies to restrict aviation demand, it is considered unlikely that this trend will be reversed (Macintosh and Wallace 2009).

3.3 *Looking Through the Lens of Time-Use*

How we use our time is a key determinant in the emissions for which we are responsible, in particular in the case of discretionary time-use, such as during recreation and leisure. Additionally, looking through the lens of time-use allows allocation of emissions due to space heating to functional uses.

Although researchers such as Minx and Baiocchi (2009) and Becker (1965) have laid out theoretical foundations for the relating how people use their time to sustainability, Godbey (1996) and Godbey et al. (1998) have explored the relationship between generation of municipal solid waste and time-use in USA, and Jalas (2002) have related direct and indirect energy use to use of time in Finland, to our knowledge the only study relating carbon emissions to time-use is Druckman et al. (2012). In their analysis of the 'carbon emissions per hour' of different activities for an average British household, Druckman et al. (2012) found the most carbon intensive uses of time are 'Personal Care' (which includes personal washing, clothes and care of clothing, and health care), 'Eating & Drinking' (which includes alcohol and eating out) and 'Commuting'. Apart from 'Sleep & Rest', the broad category of 'Leisure and Recreation' has the lowest intensity. However, 'Leisure and Recreation' is the second largest time-use category at 5.7 h per day on average, only exceeded by 'Sleeping and Resting' at 8.9 h per day (ONS 2006). Further analysis of leisure and recreation (see Fig. 9.4) showed clearly that activities in and around the home are the lowest in carbon emissions per hour, and that moving away from the home, thus incurring emissions due to transportation, increases emissions. Indeed, they found that emissions for 'Sports and Outdoor Activities' were nearly three times as carbon intensive as 'Spending time with family/friends at home'.

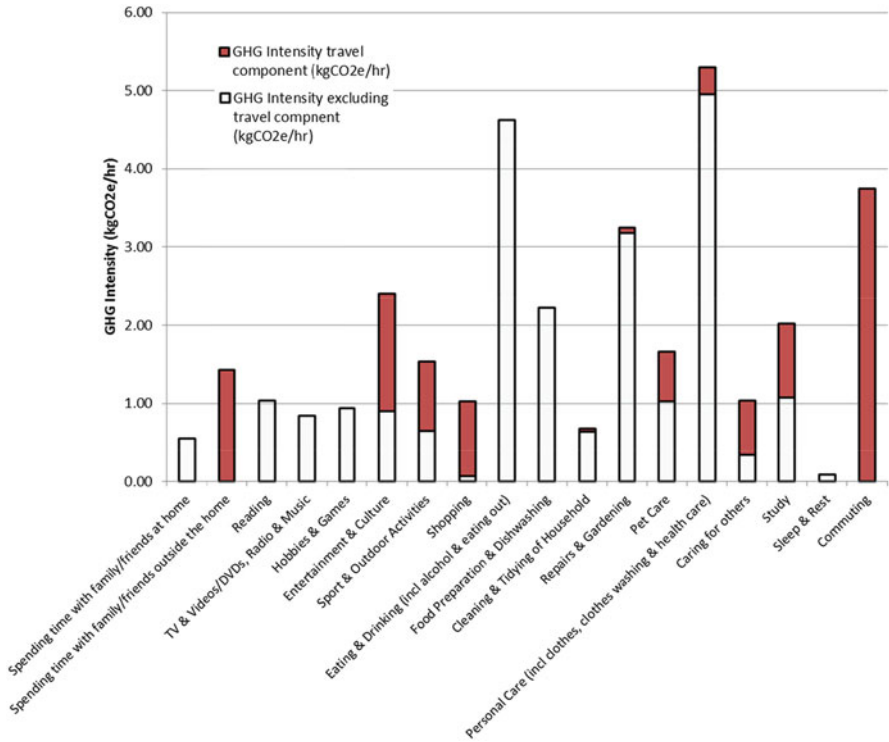


Fig. 9.4 Carbon intensity of time use for an average British household (2004) (Source: Druckman et al. (2012), Fig. 3a, p. 156)

4 The Rebound Effect

The discussions above lead to many suggestions concerning ways that the carbon footprints of households may be reduced, but this is beyond the scope of this chapter, as explained in Sect. 1. However, a systemic issue that works against many measures suggested for reducing emissions (such as installing loft insulation and travelling less) is the ‘rebound effect’. The rebound effect, in relation to households, can be explained as follows (Sorrell 2007; Maxwell et al. 2011): When an action is carried out that is intended to save energy, it will often result in saving money also. However, a household always uses its income in some way or other. For example, when purchasing a car, suppose the purchaser decides to buy one that is more fuel efficient than the average car on the market. Knowing his normal mileage, he can calculate the fuel saved, and hence by how much he will expect to reduce his carbon footprint. However, as less fuel is now used for his normal journeys, less money is spent on this fuel. This freed up money might be spent on driving further, which will result in more carbon emissions. This is called the direct rebound effect. Alternatively, the money saved might be spent on something entirely different from motor vehicle fuel, such as taking a vacation. This will also give rise to more emissions, and this

is known as the indirect rebound effect. Alternatively, he might decide, rather than to spend the money, to save it and therefore he puts it on deposit in a bank. The bank, however, then invests the money, and this investment, in turn, gives rise to carbon emissions. This is another example of the indirect rebound effect.

Another type of rebound effect that commonly arises is the ‘embodied’ rebound effect, and this is better illustrated through an example of loft insulation. In this example a person who installs loft insulation can calculate how much energy (and hence carbon emissions) will be saved through reduced fuel use. However, energy is used in the manufacture of the loft insulation, and, following the consumption accounting principle discussed in Sect. 1, carbon emissions from this energy use are the purchaser of the insulation material’s responsibility. Hence these emissions offset the expected savings, and this is known as the embodied rebound effect.

If a measure is expected to achieve a reduction of 100 kgCO₂e then a rebound effect of 30 % implies that only 70 kgCO₂e was saved, and a rebound effect of 100 % implies that no carbon was saved. A rebound effect greater than 100 % means that the measure resulted in more, not less, emissions, and, from this view, it would have been better not to have done the action at all. This is known as ‘backfire’.

Until relatively recently, although the rebound effect was a well-known phenomenon, there were few studies that had estimated to what extent it is a problem with respect to households. In the last few years, however, studies have been carried out to explore it focusing on various different countries. These include Lenzen and Dey (2002) and Murray (2013) for Australia; Alfredsson (2004) and Brännlund et al. (2007) for Sweden; Mizobuchi (2008) for Japan; Kratena and Wuger (2010) for Austria; and Thomas and Azevedo (2013) for US and Druckman et al. (2011a) and Chitnis et al. (2013, 2014) for the UK. These studies generally consider a variety of measures such as abatement actions (for example, reducing the amount of food wasted, reducing household room temperature thermostat settings and replacing short car journeys by walking or cycling) and energy efficiency measures (for example, installation of cavity wall insulation, loft insulation, condensing boiler, water tank insulation, energy efficient lighting and purchase of an efficient car). Chitnis et al. (2014), who estimated the rebound effect in terms of GHG emissions, found rebound to be around 0–32 % for measures affecting domestic energy use and around 25–65 % for measures affecting vehicle fuel. The possibility of backfire was found for measures that reduce food waste, with estimates being around 66–106 % (Chitnis et al. 2014). In general, rebound was found to be larger for lower income groups (with some exceptions) as they have a higher proportion of expenditure on direct energy (as discussed in Sect. 3.1) and this expenditure has relatively high income elasticities (Chitnis et al. 2014).

The conclusion from this rebound effect work is *not* that encouragement to carry out the abatement and energy efficiency actions should be abandoned: indeed, for all except food waste under certain conditions, considerable carbon emissions can be saved through these means and therefore it is imperative that such actions should be supported. However, it is vital that governments take into account the rebound effect when estimating reductions in carbon emissions that can be achieved, else they stand in danger of systemically missing their carbon reduction targets.

Nevertheless, efforts should be made to minimize the rebound effect wherever possible. The best way to do this is to encourage a wholesale shift in expenditure patterns towards low carbon goods and services. The rebound effect studies also highlight the importance of investment decisions, and Druckman et al. (2011a) show that in order to achieve zero rebound, the money saved through the abatement or efficiency actions should be invested in carbon neutral or reducing investments.

5 Concluding Comments

This chapter has explored the drivers and components of household carbon footprints. Evidence shows that ‘hair-shirt’ policies, particularly within the realm of recreation and leisure, are unlikely to gain enough traction to achieve the widespread changes needed (Soper 2008). The ‘holy grail’ is thus to devise low carbon lifestyles that achieve maximum happiness. However, economic growth (the policy goal of most governments¹¹) aims to increase incomes. But it is generally found that as incomes increase, carbon footprints are likely to increase while well-being levels off (Lenzen and Cummins 2013; Jackson 2009). This raises the question: which policies enhance well-being, or at least do not reduce well-being, while being environmentally beneficial? Such activities represent win-win opportunities for encouraging activities which give rise to relatively low quantities of carbon emissions while at the same time enhancing well-being and happiness.

Reviews of the literature reveal that social activities such as conversing with friends and family, making love, reading and carrying out hobbies are low carbon activities that generally make people happy (Csikszentmihalyi 2006; Holmberg et al. 2012; Kahneman et al. 2004; Caprariello and Reis 2012; Nassen and Larsson 2015). For many of the activities that generally enhance happiness, the carbon emissions depend on how they are carried out. For example, being close to nature and physical activities such as walking, exercising and sport can be relatively low carbon if carried out without the use of personal transportation. Csikszentmihalyi (2006) talks about how goal-orientated activities can induce high levels of happiness. His theory is that when a person is carrying out an activity that is all-encompassing, in that the activity requires total concentration and focus (in other words, the person is “in the flow”) then a high state of happiness can be achieved. Examples of this include playing a musical instrument or singing in a choir, both of which can be done in relatively low carbon ways, but one of Csikszentmihalyi’s examples is the state of flow achieved during downhill skiing, and, depending on where one lives, this can be a very high carbon activity. Gatersleben et al. (2008) investigated how volunteering can yield high levels of happiness and, again, this may be carried out in high or low carbon ways. Shopping is an example of an activity that generally brings happiness, but is, arguably, rarely a particularly low carbon activity.

¹¹The notable exception to this was Bhutan which has had for some years, the goal of increasing gross national happiness (Zurick 2006).

This discussion has highlighted some win-win approaches to reducing carbon emissions while increasing well-being, and these should be key components of strategies for moving towards a more sustainable future. But before closing this chapter it is worth taking stock and standing back to take a whole-systems approach.

A whole-systems approach requires looking at systems of production and consumption in which households play a central role. The economy is circular in nature: in simplistic terms, households earn wages from firms, and firms produce goods and services to sell to the households. Thus producers are consumers, and consumers are producers. Linking this understanding with the earlier discussion in which it was shown that one of the main determinants of a household's carbon footprint is income, and also that households spend or invest all their income, raises another possible win-win situation: that of working-hours reduction.

Reducing the average number of hours worked per week can have both a scale effect and a compositional effect (Gough 2013). Hypothetically, due to the scale effect of fewer hours at work, workers' incomes would be reduced, and thus expenditures and consumption would also be expected to be reduced. With each person working less, there is the possibility of increasing the number of people employed and thus reducing inequalities. High levels of inequality are associated with low levels of well-being (Wilkinson and Pickett 2009), and, furthermore, meaningful work is generally found to be a positive factor in increasing well-being (Diener and Seligman 2004). Hence sharing the work may yield multiple benefits (Hayden 1999).

The compositional effect can be explained as follows: with lower incomes but less time at work, people's use of time outside work would be expected to change, as would the composition of their expenditure baskets. For example, rather than buying ready-meals, people may be more inclined to cook from raw ingredients. Now such changes in time and expenditure budgets might result in higher or lower carbon emissions. For example, with less time pressure, people might walk and cycle for short journeys rather than drive. On the other hand, some people may drive further and more often to visit friends. But if we look back to the graph in Fig. 9.1, we see that there is good evidence that lower incomes will, in general, result in lower carbon footprints.

Reducing the working week has been shown to enhance the work-life balance (Nassen and Larsson 2015; Kasser and Sheldon 2009; Eurofund 2013). For example, Hayden (1999) records how French employees reported overall improved quality of life when their working week was reduced to 35 h. In another investigation 400 Swedish employees who had their worktime reduced to 6 h per day for 18 months reported improved life satisfaction, health and a more equal gender-balance on time spent on housework (Bildt (2007) cited in Nassen and Larsson (2015)).

The suggestion of reducing working hours must be taken with an important warning concerning low income groups. Currently many low paid workers are struggling to meet their weekly household expenses (MacInnes et al. 2014; The Living Wage Commission 2014), and therefore any initiative to reduce the working week must be accompanied by special measures to protect them. If these are put in

place, then work-time reduction offers a promising way to reduce unemployment by sharing the work, leading to reduced inequalities, while at the same time offering high prospects of increasing well-being and reducing environmental burdens (Hayden and Shandra 2009; Victor 2008; Jackson 2009; Coote et al. 2010; Knight et al. 2013; Pullinger 2014; Rosnick and Weisbrot 2007).

In conclusion, this chapter has reviewed the main determinants of Western household carbon footprints. What is clear from this body of work is that, seen from a consumption perspective, the majority of carbon impacts arise from transportation, food and housing. The need to improve systems of provision of food, energy and transportation and renovate or rebuild inefficient housing stock is therefore indisputable. However, where possible these measures should be supplemented by other approaches. For instance, through further analysis it is evident that recreation and leisure leads to the single highest proportion of household carbon emissions. Opportunities should therefore be sought for low carbon leisure activities which also enhance wellbeing. Such activities might include for instance spending time with friends and family in and around the home, or engaging in physical recreation in the local community.

One inescapable finding from this body of work is that income is one of the principal drivers of carbon emissions, with carbon footprints increasing with increasing incomes. Incomes also appear to drive the rebound effect. These understandings led us to a wider, whole-systems approach in which we view households as an integral part of the system of production and consumption. Policies on work-time reduction, with appropriate measures to safeguard low income households, can offer additional win-win opportunities that, to some extent, overcome this stumbling block. Ultimately, however, income growth is driven by economic structure. Approaches which tackle the structural implications of economic growth are also essential to a meaningful understanding of the potential to reduce carbon footprints. In summary, industrial ecology, with its wide ranging systems approach as shown in this chapter, has a great deal to contribute to the quest to devise strategies to move towards lower carbon, fulfilling lifestyles.

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