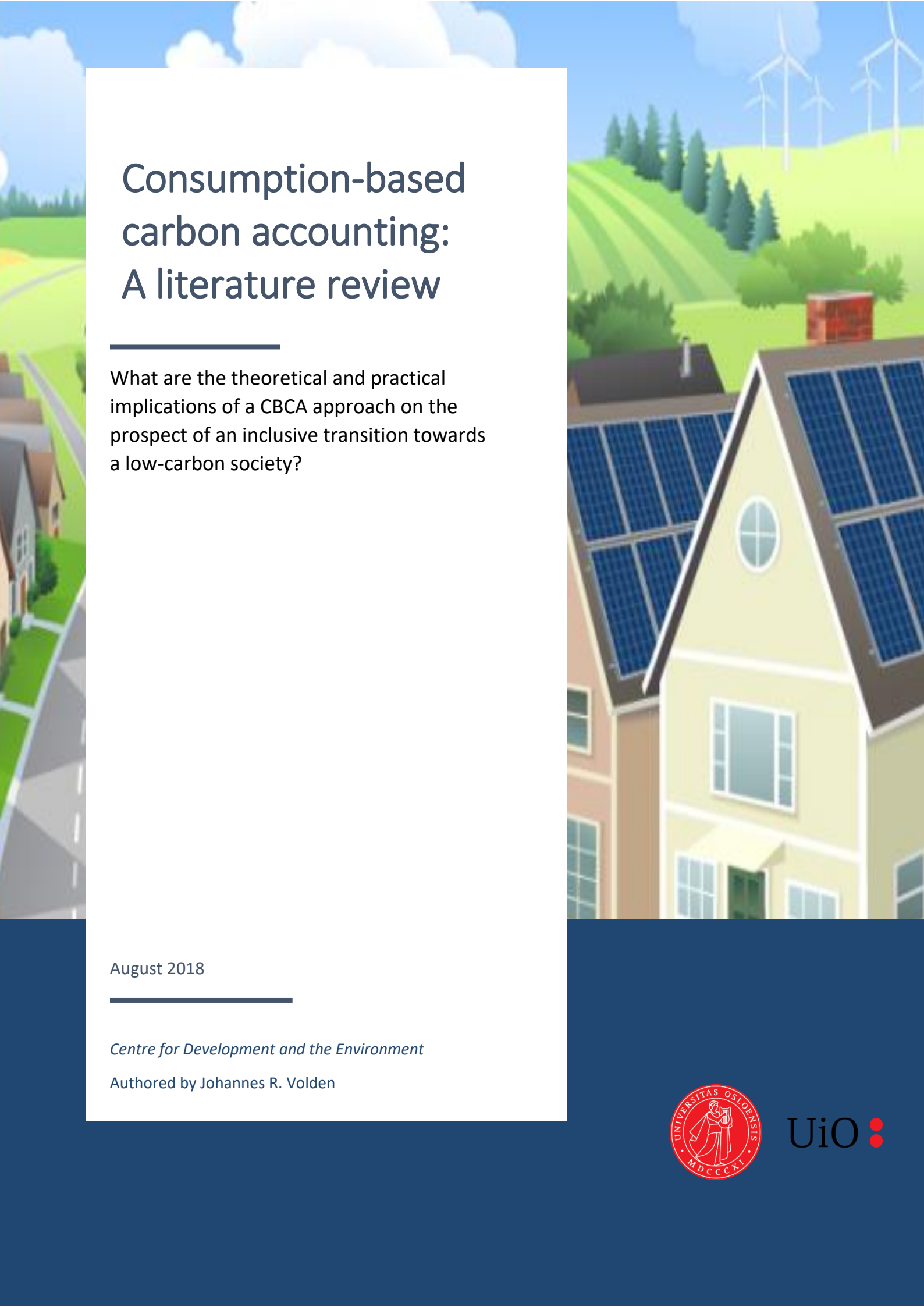




Consumption-based carbon accounting: A literature review

What are the theoretical and practical implications of a CBCA approach on the prospect of an inclusive transition towards a low-carbon society?

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1. Introduction

1.1 Consumption-based carbon accounting

As more research has pointed to final consumption among affluent consumers in the industrialised world as one of “the main drivers of the level and growth of environmental pressure” (Lenzen et al. 2007: 28), consumption-based carbon accounting (henceforth referred to as CBCA) has received increased attention. This report reviews the literature on CBCA, particularly as it relates to the Norwegian context. The purpose of the report is to make sense of what CBCA is, and what role it ought to play as we transition towards a sustainable future. What are the theoretical and practical implications of a CBCA approach on the prospect of an inclusive transition towards a low-carbon society? The report finds that the CBCA presents a more just, fair and productive theoretical understanding of the responsibility tied to emitting CO₂, which negatively affect the environment, but that the model in practice presents some pitfalls in terms of practical implementation (cf. Peters 2008; Rodrigues et al. 2018).

The report will argue that a consumption-based focus will be crucial to implement as a supplementary “shadow indicator” (Peters 2008: 20) which can help correct for skewed environmental responsibilities on different levels, and consequently serve to guide better policy for a sustainability transition. Moreover, by bringing attention to indirect emissions through embodied carbon, CBCA analysis opens for new ways of thinking about consumption at different levels. On these grounds, CBCA is a powerful tool – in both theory and practice – that ought to be used in conjunction with other/current methods; either as part of a “hybrid” approach (Schaltegger and Csutora 2012; Barrett et al. 2013) or as a gateway for an inclusive and fair assignment of responsibility tied to consumption, and in particular to emitting CO₂ (Davis and Caldeira 2012). In a Norwegian context, CBCA can arguably provide a better understanding of Norway’s total emissions, as well as to the “embodied” energy and carbon used in households.

1.2 Aims and objectives

The overarching aims of this report is to (1) make sense of the CBCA model; (2) review the carbon footprints of Norway and other economies, particularly in terms of households; (3) identify knowledge gaps and implications for further inquiry; and (4) discuss the relevance of the findings in terms of the Norwegian context. The objective is to review the literature on CBCA as a means to better understand household carbon footprints from consumption; primarily as it relates to the Norwegian context.

1.3 Outline

The report is divided into seven chapters.

- Chapter 2 presents a conceptual overview, aiming to make sense of the production-consumption continuum, carbon accounting as a framework to reduce emissions, and the role of household consumption amidst this.
- Chapter 3 reviews the literature on consumption- and production-oriented models, as well as hybrid approaches to carbon accounting; considering the benefits and pitfalls of each of these.
- Chapters 4 and 5 focus on household consumption specifically; first, through the lens of household characteristics, and second through the lens of land-use characteristics.
- Chapter 6 addresses some alternative perspectives on household consumption that came up through the CBCA literature review – situated lifestyles, rebound effects, and structure/agency.
- Finally, Chapter 7 summarises the main findings and the implications of these, in addition to addressing some limitations of the report and some ideas for future inquiry.

2. Conceptual overview

This chapter aims to provide a basic overview of the main concepts used throughout this report, as a backbone for the subsequent chapters.

2.1 Consumption and production

2.1.1 The production-consumption continuum

The existence of all goods and services results from the production initiative from the producer's side, and the demand from the consumer's side. From an environmental perspective, over-consumption is a big issue and the best way to reduce GHG emissions would be to reduce overall consumption on a global basis. Recognising that production and consumption are two parts of a continuum, or a circular process¹, it becomes fair to suggest that (1) all consumption is partly fault of producers; and (2) all production is partly fault of consumers. Once this is established, however, the challenge is to decide the extent to which these two parties are responsible, and how to allocate this relative responsibility. This is the key function of carbon accounting. While current conventional accounting is production-based – and therefore allocates all responsibility to the producer – this report investigates the premise for CBCA, which allocates all responsibility to the consumer.

2.1.2 Direct and indirect emissions

To further understand the dynamics between production and consumption, we must differentiate between direct and indirect emissions. “Direct emissions” refers to the emissions that are generated “on-site”, while “indirect emissions” are embodied into goods and services

¹ Through the lense of environmentalism, consumption can refer to more than simply consuming a product which has been produced by a producer. An alternative understanding is “consumption” as a “using up” of (natural) resources (Princen 1999). If this understanding is implied, then even producers are consumers. In this report, however, consumption will be understood in its standard economic sense, given that this is what the carbon accounting models currently operate with.

(Bin and Dowlatabadi 2005: 199). Given the large amount of emissions embodied in trade, this becomes an important distinction to make. A household good – a chair, for instance – will generate no direct emissions; yet it still has the emissions that resulted from its production embedded/embodied² into it. This means that when someone – a Norwegian household, for instance – buys, i.e. consumes, this chair, they contribute to these emissions in some way. While the consumer does not directly contribute to the emissions, they contribute indirectly by keeping up the demand for the product so that the production process will continue. The premise of CBCA is that the final consumer ought to bear the responsibility for the whole provision process. The discussion thus revolves around the relative importance of “consumptive expenditure” contra “territorial production” for determining responsibility for emissions (Lentzen et al 2006: 182).

2.1.3 Carbon leakage

The concept “carbon leakage” describes the process by which carbon emissions are displaced between territories. Kanemoto et al (2016: 10515-10516) defines carbon leakage as (1) “the shifting of emissions from countries with stringent climate policies to countries without such policies” or as (2) “developed countries reducing their carbon emissions within their territorial area but increasing their footprint in foreign countries”. In practice, transnational carbon leakage implies “decreasing production within the country’s borders and growing imports from the developing countries” (Mozner 2013: 84).

Two types of carbon leakage can be identified. “Strong carbon leakage, also known as policy-induced leakage, occurs when carbon-intensive sectors of an economy decide to relocate their manufacturing base from a developed country which may have introduced carbon price legislation, like for example an emissions trading scheme, to a developing country that is currently subject to limited emissions controls” (Afionis et al. 2017: 3). Given the conventional production-based carbon accounting method, this has become a normal and strategic method for industrialised countries to reduce their own carbon footprint on paper without hampering economic growth or giving up personal interests. “Weak” carbon leakage, however, happens

² The terms “embedded” and “embodied” are used seemingly interchangeably in the literature. In this report, I will henceforth use the term “embodied” to refer to indirect energy.

indirectly, as (1) “companies in developed ... [are] relocating to the global South” as a strategy to “reduce employment and regulatory compliance costs”; or (2) “the import of goods manufactured by native companies in foreign countries with higher competitive advantages and lower costs [increases due to increasing demand]” (Afionis et al. 2017: 3-4).

2.2 Carbon accounting

As a subset of environmental accounting, carbon accounting is used to determine how many CO₂ equivalents from GHG emissions are borne out of the provision of goods or services, and can be operationalised at different scales; national scale, project scale, organisational scale, and all the way down to product scale (Stechemesser and Guenther 2012). As such, it is a technical tool to manage emissions on a global scale. Following the 1997 Kyoto Protocol, developed countries have agreed to reduce national emissions according to targets due to “the principle of common but differentiated responsibility (CBDR), which acknowledges that countries have contributed by varying scales to the mounting problem of climate change” (Afionis et al. 2017: 1). The Paris Agreement has subsequently assigned responsibility for mitigation to all countries. However, given the flaws of the conventional production-based accounting method, which opens for carbon leakage between nations, the total global emission levels are not been curbed. As such, CBCA might be a more effective and just alternative.

2.2.1 The production-based accounting model

The conventional measure method for carbon accounting is based on producer responsibility. This means that the carbon emissions resulting from the production of goods and/or services within a geographic area are attributed strictly to the proprietor of that area, which is consequently held accountable. In simpler terms, then, it “measures emissions generated in the place where goods and services are produced” (Afionis et al. 2017: 1). The key problem is therefore whether responsibility should be put on “the actor that initiates a polluting process” (the consumer) or “the actor producing the pollution” (the producer) (Peters and Hertwich 2007: 55).

The production-based accounting model works the following way: “all emissions from different production sectors, such as agriculture, transportation, and industrial production, are summed up and allocated to the area where these sectors are physically located, regardless of who the final consumers of the produced products and services are ... emissions from production *outside* the studied area [are not] taken into account, although the production is driven by final demand *inside* the studied area” (Nilsson and Brandt 2013: no page).

2.2.2 The consumption-based accounting model

The CBCA model “accounts for emissions at the point of consumption, attributing all the emissions that occurred in the course of production and distribution to the final consumers of goods and services” (Afionis et al. 2017: 1). This way, the full life-cycle of the consumed good or service is taken into account³, making its total *carbon footprint* (CF)⁴ the responsibility of the consumer⁵ (Steen-Olsen et al. 2012). “The carbon footprint is a measure of the exclusive total amount of carbon-dioxide emissions that are directly and indirectly caused by an activity or are accumulated over the life stages of a product” (Wiedmann and Minx 2007; cited in Mozner 2013: 86)⁶. This way, all *indirect* emissions resulting from the various processes tied to the provision process are accounted for in addition to the direct emissions associated with production in itself, and ultimately attributed to the final consumer. CBCA thus accounts for “embodied emissions”, taking into account “all the emissions required producing a product ... all steps in production from raw material extraction through to final assembly and ultimately

³ However, this only includes the provision phase and use phase of the product – the post-use phase (which is relevant for recycling, re-use, and disposal) generally remains unaccounted for. This is one of the limitations of CBCA and most other carbon accounting methodologies.

⁴ As Steen-Olsen et al. (2012) emphasise, the carbon footprint (CF) is but one part of a larger “family” of environmental pressures, further consisting of ecological/land footprints (EF) and water footprints (WF). These environmental footprints have all in common that they focus on the ways in which environmental pressures become displaced through the conventional production-based method of assigning environmental responsibility. Nevertheless, these are often calculated together in terms of CO₂/carbon emission equivalents, which will henceforth be the focus of this report.

⁵ Here the “consumer” refers to the agents responsible for the “final consumption of goods and services” (Hertwich and Peters 2009).

⁶ As Mozner (2013: 86) notes, the carbon footprint concept is closely related to “the energy cost of living”, which relates to the energy requirements imbued in general household expenditures. This reports considers research on both embodied emissions and energy requirements; while these are different indicators they generally follow the same trends and will therefore not be distinguished a great deal in this report.

the final sale of the product” (Peters and Hertwich 2007: 55). This idea of the “footprint” of a product does not work well with the conventional production-based methods, given that the producer is only held accountable for its pre-exported footprint. Given that, as Afionis et al. (2017: 2) note, “20-25% of overall carbon dioxide emissions are from the production of internationally traded products”, a lot of the total emissions produced thus go lost. In addition to shift responsibility, the CBCA model seeks to correct for this.

There are several different versions of CBCA – while CBCA offers an initial approach toward carbon accounting, different methodologies to reach the most accurate data have been developed⁷. While carbon footprints can be calculated in different ways, it seems to be generally accepted that the *multiregional input-output* analysis model (MRIO) is favourable for the most accurate results (Afionis et al. 2017: 8). The basis for this is input-output analysis (I-O; IOA), a top-down macro-economic approach to “an economic modeling technique for understanding financial transactions between economic sectors, producers and consumers, within a country” (Galli et al. 2013: 814). It makes it possible to “estimate the total upstream impact in the production of an average good or service” (Larsen and Hertwich 2009: 793). MRIO adds to this the possibility to expand the scope of analysis to include multiple regions, i.e. more than one territory or nation – it “gathers domestic and import input-output tables from a number of individual nations or regions, combining them to form a single aggregated matrix, reconciled by trade statistics” (Afionis et al. 2017: 8)⁸. This matrix then represents the supply chain, while “capturing the inter-industry relationships between all the trading partners” (ibid). The model is useful both for allocating emissions to final demand and for estimating regional changes in production/emissions due to changes in final demand in other regions (ibid). It does, however, require a lot of complex information from sources that are not always readily available (ibid).

In addition to input-output-based models, carbon footprint can be calculated through life-cycle assessments (LCA)⁹. LCA “covers the production, distribution, use and disposal of individual products” (Hertwich 2011: 28). This means that while the input-output model

⁷ Explaining and discussing the soundness of the specific economic-mathematical models used will be beyond the scope of this paper; see e.g. Hertwich (2011) and Pauliuk (2018) for a more thorough explanation of I-O and LCA models.

⁸ MRIO databases with environmental accounts can be found online – e.g. <http://worldmrio.com/>.

⁹ LCA databases can also be found online – e.g. <http://www.openlca.org/lca-data/>; <https://nexus.openlca.org/databases>; <https://www.lifecycleinitiative.org/applying-lca/lca-databases-map/>

focuses on financial transactions (i.e. monetary units), LCA focuses on the products themselves (i.e. mass/energy/numbers etc.; Pauliuk 2018). Research is done to find out which products are being produced/consumed/traded, and data for each of these are gathered from an LCA database and applied to estimate carbon emissions. On a theoretical level, LCA considers all production and consumption as inputs for further production and consumption, along a continuum (Hertwich 2011). Granted, many “cycles” of production and consumption happen before a product reaches the final demand category/consumer. Moreover, a range of different inputs and outputs of goods and services contribute to each product, making for a complex web of interactive production and consumption processes. While MR/IO analysis is perhaps best suited to analyse transnational trade flows, LCA is useful to analyse household consumption patterns.

Various hybrid models also exist. Notably, the aforementioned models can be combined (MRIO-LCA)¹⁰. It should also be mentioned that none of these models are able to fully “reconstruct the actual supply chains of the commodities consumed” (see Pauliuk 2018 for more on this).

2.2.3 Shared responsibility frameworks

One drawback with both production and consumption oriented models, is that they essentially put all responsibility on one party. Indeed, assigning full responsibility from producer to consumer, the CBCA model moves from one “extreme” to another (Lenzen et al. 2007; Peters 2008). As such, some alternative “shared” frameworks have been developed, which attempt to move past this impasse by assigning a relative share of the responsibilities to each party; or, rather, by distributing responsibility along the production/consumption chain. According to the “product stewardship” concept, all parties involved in design, production, sale, and consumption/use of a product are in some way responsible given that they contribute indirectly to the emissions resulting from that product (Lenzen et al. 2007: 28). It is, however, incredibly complex to reflect this in an economic-mathematical due to the

¹⁰ Many studies combine a range of methods and data in various ways. For instance, as an example of how this is done, Wier et al. (2001) combined “input-output tables energy flow matrices, CO2 emissions factors, and national consumer survey statistics into an integrated modelling framework” (abstract) in their study of the effects of household consumption patterns on CO2 requirements.

sheer complexity of parties involved. Indeed, CBCA is complex enough in itself – the now-conventional production-based accounting model was favoured by UNFCCC in the first place given its relative simplicity and consistency compared to CBCA (Afionis et al. 2017: 7). Lenzen et al. (2007) present one example of such a shared responsibility framework (see section 3.3 of this report).

2.3 Household consumption

The household is a particularly interesting for consumption research. The household typically constitutes a final demand category – the very end of the lifecycle or provision chain of a good or service (at least if the post-use phase or disposal is taken out of the equation). From a household perspective, the “consumer” is defined as “the entity that purchases and uses products and services for the purpose of individual or household consumption” (Bin and Dowlatabadi 2005: 198). From a CBCA perspective, then, the household that buys a commodity ought to be held responsible for the sum of the indirect (embodied) emissions that have accumulated throughout its lifecycle. While a production-based accounting model typically allocates 20% of total GHG emissions to households on a global level, a CBCA model allocates more than 70% of total GHG emissions to households (Hertwich and Peters 2009; Hertwich 2011)¹¹.

2.3.1 Household emission sources

Households pollute the environment through direct and indirect emissions. While direct emissions imply fuels directly consumed in household, indirect emissions imply the hidden emissions resulting from the production of consumed goods and services (Wier et al. 2010: 260). Direct emissions result primarily from energy use in the home and personal travel, while indirect emissions result from the “operation” embodied in housing, household goods, travel, and food related consumption (Bin and Dowlatabadi 2005: 1999-200). The carbon footprint of the household is usually divided into five categories: housing, mobility, food, services, and

¹¹ Numbers from Statistics Norway (2018a) show that half of the energy is consumed through industry; while only 10-15% seems to be allocated to households. Moreover, it is stated that, in 2017, the overall export of energy was 4.5x higher than overall consumption. These data clearly reflect a production-oriented bias which could be nuanced through a CBCA perspective. (See: <https://www.ssb.no/energi-og-industri/artikler-og-publikasjoner/halvparten-av-energiforbruket-er-i-industrien>)

consumer goods (Steen-Olsen et al. 2012; Hertwich 2011) – the first three generally seeming to have the greatest impact with 80% of total emissions (Holden 2004; Norland et al. 2004; Wood and Hertwich 2016). The source categories are explained in the table below.

Household emission sources

Sources	Definition	Direct/indirect
Housing/shelter	Refers to all consumption related to one's dwelling (construction, maintenance, heating, electricity, etc.)	Direct and indirect
Transport/mobility	Refers to all modes of assisted travel (personal vehicles, public transport, air-travel, etc.)	Direct and indirect
Food/nutrition	Refers to all food and beverages privately consumed by the household (tends to exclude external provision, e.g. restaurants/café/hotels etc.)	Indirect
Services	Refers to all private services consumed by the households (but tends to exclude government/public services)	Indirect
Goods	Refers to all tangible goods consumed by the household ¹²	Indirect

2.3.2 Household emission variables

The different characteristics of a household tend to be grouped into overarching structural categories or variables – economic, demographic, socio-cultural, and so on. While different studies operate with different factors (e.g. socio-economic status, which might encompass economic factors such as income as well as socio-cultural factors such as education and employment status), they are generally variations of the four factors elaborated on in the table below¹³.

Structural factors for household characteristics

Structural factors	Components
Economic	Economic status, income, disposable income, expenditure
Demographic	Geography (location, neighbourhood, urban/rural formations), household size and composition, age, etc.
Socio-cultural	Education, employment status

¹² I am not certain as to whether intangible goods such as digital media etc. ought to count as a good or a service.

¹³ Ivanova et al. (2017) also operate with «technical» variables, which in their study relates to relative intensity of local electricity mix that affects the emissions of energy consumption in the household.

3. The carbon accounting debate

This chapter aims to provide a general overview to the debates surrounding carbon accounting; particularly as it relates to CBCA and production-consumption dichotomy.

- Section 3.1 synthesises the literature on the favourable aspects of CBCA
- Section 3.2 synthesises the literature which favours a production-oriented approach, and which sows scepticism tied to CBCA
- Section 3.3 synthesises the literature on alternative frameworks and hybrid accounting models
- Section 3.4 summarises the chapter and suggests some concluding remarks

3.1 The case for consumption-based accounting

A consumption-based model for carbon accounting allows for the operationalisation of carbon footprint analysis to shift responsibility of emissions from the provision of goods and services from producers onto consumers. There are several reasons as to why this model might be beneficial – in this section, these are grouped into two overarching categories: (1) accuracy, comprehensiveness and effectiveness, i.e. the technically oriented benefits; and (2) equity and fairness, i.e. the ethically oriented benefits.

3.1.1 Accuracy, comprehensiveness, effectiveness

There is no doubt that a production-oriented accounting method, as instantiated by the Kyoto protocol, opens for a lot of carbon leakage (i.e. transnational/transterritorial displacement of emissions; Peters and Hertwich 2007) – when using consumption rather than production data, the emissions of rich developed countries tend to rise significantly (Mozner 2013). Due to the complex nature of international trade, it is not always a straightforward task to decide who is responsible for what emissions. Leakage therefore happens as emissions become displaced between stakeholders at some point during the complex transnational flows of goods and services (Peters 2008).

There are many relevant examples of this. For instance, Peters and Hertwich (2004) found that about half of all Norwegian emissions occur externally. Peters and Hertwich (2007) further

found that 30-40% of Norway's domestic production based carbon footprint "leaked" out in 2000 due to high import factor; the carbon leakage being much higher in import than export¹⁴. Similarly, Munoz and Steininger (2015) found that Austria's emissions would, on paper, be doubled through consumption-based accounting. In a life-cycle assessment analysis, Hertwich (2011) found that USA, Japan and most of Europe have more emissions embodied in import than export (CBCA will show higher emissions) while China, India, Russia, South Africa and Australia have higher emissions embodied in exports than imports (production-based carbon accounts will show higher emissions). The data further show that, while the EU consists of only 7.6% of the global population, its carbon footprint makes up 18% of the world total – in other words, the average EU CF is twice of the global average (Steen-Olsen et al. 2012).

Moreover, carbon accounts not only suffer from "leaking" under the current production-oriented regime, but can also simply be lost. It is particularly troublesome to properly allocate responsibility for emissions resulting from international transport, given the complexity of both production and consumption factors involved. As Peters and Hertwich (2007) note, international transportation accounts for 3% of global carbon emissions, yet from the Kyoto protocol, no one is given responsibility for these. Aviation is particularly prone to this, and the UNFCCC does not allocate any responsibility for air-transport emissions due to high amounts of uncertainties in the data (Afionos et al. 2017: 3). CBCA would be a means to close "carbon loopholes" (Peters and Hertwich 2007) such as this.

A CBCA overview report presented by Deloitte (2015) suggests that, by effectively presenting an incomplete picture, production-based accounting can, in addition to carbon leakage, lead to "inefficient incentives for abatement". The report argues that if emissions occurring throughout the total life cycle of a product or service (embodied emissions) are taken into account, it should motivate drastically different policy interventions. For instance, the total emissions produced by an electric vehicle increases significantly if emissions embodied in production of the vehicle itself, as well as production of the electricity on which it runs, are taken into consideration.

While much of the literature is focused on CBCA in a global perspective, Larsen and Hertwich (2009) demonstrate that CBCA could be a good tool to measure success of local climate actions

¹⁴ This is due to the relative inter-territorial processes – less energy/emissions are required to "move" a product *out from a territory* than *into a territory*, given that import considers all emissions occurring after the export.

on the level of local governance. This, they suggest, would be an important area of implementation given that local governments have the main responsibility for localised services and infrastructure, which in turn determine the everyday practices of citizens. In their case study of the municipality of Trondheim in Norway, they found that 93% of its carbon footprint, and 19% of its total GHG emissions, were stemming from indirect emissions (i.e. from outside of the municipality) in 2005. A CBCA approach can this way lead to a more comprehensive understanding of local provision and emissions.

On the grounds of what has been discussed so far, it is evident that a wide implementation of CBCA could lead to more effective mitigation efforts at different geographical levels, in order to achieve a two-degree reduction by 2050 – first and foremost by making the connection between consumption and environmental impacts more clear and consistent (Peters 2008). Given the ever-increasing connectedness that comes with globalisation, everything is interconnected. In terms of policy-making, a CBCA approach could open new avenues for policies that yield real effects, rather than simply shifting emissions around; taking into account all the indirect and embodied energies and emissions occurring over the lifetime of a provisioning process, thereby hopefully avoiding some of the common pitfalls of rebound effects tied to conventional, production-based policy-making. An isolated focus on production further leads to a skewed understanding of the broader impacts of the produced goods and services, meaning that well-intentioned policy implementations can yield unfortunate and easily avoidable rebound effects (Bin and Dowlatabadi 2005: 206). Moreover, on the level of local-regional planning and the household, a focus on consumption can inform policy by shining new light on what factors ultimately produce the most emissions in total terms.

3.1.2 Equity and fairness

By eliminating import-related carbon leakage, a CBCA model would also improve equity and fairness when it comes to deciding who ought to be responsible for emissions. As Peters (2008) argues, it would shift some of the global emissions that today have limited participation, e.g. those associated with production processes in China and other “factories” of the world. Export-heavy developing countries already suffer from the more localised aspects of production-related emissions, so having to account for all related emissions constitutes a double burden.

Carbon leakage leads to skewed sanctions for polluting the environment – “if a pressure is displaced from country A to country B, emissions, land use, or water use occurring in country B serve the consumption in country A” (Steen-Olsen et al. 2012: 10884). This, in turn, is reflected in power relations between nations and continents: rich, industrialised countries tend to be net importers of environmental pressure, while pushing the responsibility for this pressure onto poor developing countries who tend to be net exporters of the very same environmental pressures. In general, high footprint countries are net importers, while low footprint countries are net exporters; although this is seldom reflected when only production is taken into account. The emissions embodied through trade increase the already high emissions of rich countries. Economic status of a country thus roughly correlates with per capita carbon footprint – Europe/EU, Japan, USA, South Korea are topping this list (Steen-Olsen et al. 2012).

The embodiment of emissions through trade makes for an “unbalanced flow of energy and materials within the world-system” which produces “patterns of uneven development”, making for an “ecological unequal exchange” through which “international trade blurs the responsibility for the ecological effects of production and consumption” (Mozner 2013: 84). Rich countries produce environmental degradation in poor countries through consumption; a phenomenon described by Mozner (2013: 85) as the “consumption/environmental degradation paradox”. The issue here is that a production-based accounting method does not reflect this – in Mozner’s (2013: 85) words: “because of the indirect flows embodied in traded goods, the distribution of the environmental impacts can be uneven, even if in terms of direct trade flows it seems to be equal and balanced”. The very fact of carbon leakage means that reductions in emissions of rich countries tend to result not from *actual reductions*, but from *displacement* (outsourcing; “off-shoring”) emissions to other countries. Arguably, then, a CBCA/LCA/CF approach “helps parties other than primary emitters to become involved in reducing indirect emissions” (Kanemoto et al 2016: 10515-10516).

These issues of double burdens are exacerbated by technology differences. As Peters and Hertwich (2007) note, there tends to be differences in technology levels and relative efficiency of production between export and import countries – in other words, developing countries tend to have less efficient production, so that the relative emissions produced per unit of production is higher than it would be in a developed country. The fact that rich countries under

the current production-oriented accounting regime are effectively incentivised to outsource production of goods and services to developing countries to lower own emission counts on paper, then, contributes to increased overall emissions. This is labelled the “environmental dumping hypothesis” by Lenzen et al. (2006: 184). “The accuracy when determining emissions embodied in trade is therefore “particularly important when there are significant technology differences between the domestic economy and its trading partners” (Peters and Hertwich 2007). This is demonstrated in practice by Bin and Dowlatabadi (2005: 204), who find that, if the total LCA-based consumer expenditure emissions of the US are added up, they constitute 102% of total (production-based) US carbon emissions; indicating the low efficiency and high intensity of imported products.

Norway is an interesting case study in terms of CBCA. Peters and Hertwich (2004) found that “the majority of emissions in Norwegian consumption are embodied in imports; signifying the importance of considering regional technology differences”. Indeed, a consumption-based perspective shines further light on the intricacies of Norwegian emissions – the data show that although Norway is a “net exporter of pollution”, largely due to pollution intensive exports (making up 38% of the economy but 72% of total carbon emissions) such as those occurring through the oil and gas sector, its imports are more emission intensive per unit (*ibid*). Half of Norwegian emissions occur externally; half of these in turn – i.e. 25% of total emissions – occur in developing economies, despite the fact that these make out only 10% of import (Peters and Hertwich 2004). This indicates that the emissions would have been reduced if these goods and services were produced under more efficient and technologically advanced conditions in Norway¹⁵.

As the counter-example to Norway, China – as a “factory of the world” (Pan et al. 2008) – demonstrates the ethical dilemmas tied to carbon leakage. Pan et al. (2008) found that a CBCA approach would reduce China’s responsibility for emissions mitigations by about 25% (based on 2001-2006 numbers). Similarly, Lin and Sun (2010) found that while China is the largest CO₂ emitter in the world, one third of its GDP is based on export, indicating that a substantial part of this emission is a result of external demand – in fact, they found that 3357 million tons

¹⁵ Statistics Norway show that Norway’s total GHG emissions were only 3% higher in 2016 than in 1990 (SSB 2017a). They also show that during the same period emissions from Norway’s economic activity have been reduced by 2.6% (SSB 2017b). It is evident that these numbers are heavily skewed from a production-based accounting model.

CO₂ were embodied through export, leading to 2333 million tons emissions were avoided through imports (based on 2005 numbers).

This is further problematic, since Chinese production standard is relatively inefficient in that it produces a large amount of emissions per unit (Lin and Sun 2010). On these grounds, Lin and Sun (2010: 613) call for a “new global framework to allocate emission responsibilities”, while also noting that China ought to improve energy efficiency, carry out electricity pricing reforms and increase renewable energy. The case of carbon leakage due to difference in production efficiency is further backed up by findings by Su and Ang (2014), who, exploring how inter-regional and international trade affect the regional domestic emissions in China, found that while developed regions of China are generally net importers of emissions, developing regions are net exporters (i.e. mirroring world perspective); and that this is due to the developing high-export regions having less efficient production. For this reason, Liu et al. (2015) suggests a CBCA framework for interregional carbon flows in China.

Pan et al. (2008) therefore conclude that “recent emissions reductions by developed countries may lack credibility if production has merely been displaced to countries such as China...[Therefore] in the current institutional context, production methodologies encourage leakages through trade that may do more to displace than to reduce emissions. Both equity and efficiency concerns therefore suggest that emissions embodied in trade should receive special attention in the distribution of post-Kyoto abatement burdens” (p. 354).

Put simply, then, the key issue here is that carbon leakage from Norwegian imports leads to the displacement of (a) responsibility, (b) pollution, and (c) cost onto poorer economies; in turn resulting in a higher overall carbon footprint due to less efficient production mechanisms¹⁶. This puts additional, unnecessary strain both on the production economies and the environment as a whole.

A pressing issue tied to carbon leakage is that the current regime rewards cheap, and in turn emission-intensive, production mechanisms – Annex 1 countries shift their production to non-Annex 1 countries to “reduce” own emissions while keeping costs low¹⁷. A CBCA focus would

¹⁶ This is, of course, the case with most rich economies. Indeed, it is another example of the dilemma that what is good for the economy is rarely (equally) good for the environment.

¹⁷ From the Kyoto protocol, Annex 1 refers to developed countries and economies-in-transition (EIT), while other countries are either OECD members but not EIT (referred to as Annex 2 countries) or other developing nations (referred to as Non-Annex 1 countries).

reward emission-effective production, in the sense that the final consumer would be held responsible for a lower emission total. Here Norway is an interesting example – in fact, if a CBCA system was implemented to address responsibility, then it is likely that this would be a win-win situation for Norway. This is because Norway has a large production of oil and gas, as well as a large aquaculture industry, which is *relatively “clean” compared to that of most other nations*. In general terms, Steen-Olsen (2012) suggests that due to comparative advantages in different regions, “the displacements of environmental pressures through trade” are not in themselves problematic – rather, “negative impacts depend on local conditions” (p. 10890). Peters and Hertwich (2004) thus ask whether Norway ought to be held responsible for its probable large export of oil and gas (as a net exporter of emissions) if a consumption-based inventory were to be implemented, and conclude that perhaps high exports would be a good thing in this context. They write: “Given the Norwegian energy mix is high in the use of hydropower, the emission intensities of Norway in the exporting sectors is relatively low compared to other regions. This would suggest that Norway should be encouraged to export energy intensive goods due to its low greenhouse gas emissions. This argument would favour making the consumer responsible for pollution. If the consumer is responsible, then they need to purchase goods from the country with the lowest embodied emissions intensity” (Peters and Hertwich 2004).

Moreover, a CBCA framework would enable a *decoupling* of (i) population, and (ii) emissions, in the sense that substantial emissions would be shifted from emerging economies to countries with smaller populations (Davis and Caldeira 2010). Similarly, Peters and Hertwich (2007) argue that, in terms of national territories, more attention ought to be put on *economic activity* (which could be “coupled” with emissions through consumption focus) than on *geographical territory* (which is currently “coupled” with emissions through production focus). This “coupling” of *economic activity through consumption* with *emissions*, and consequently the de-coupling of population and geography with emissions, would be important to reflect the skewed consumption patterns in the world, whereby small but rich countries – Norway being a perfect example – consume disproportionately large amount of the world’s resources, while large and populous but poor(er) countries are left to produce a substantial amount of these consumer goods and services. In essence, a consumption-orientation reflects an inequality which is statistically “hidden” through a production-orientation.

While a CBCA model would not “fix” any of these issues per se, it would at least build a *sharing of responsibility* (Davis and Caldeira 2010) into the macro-economic structure of international trade – first, by making nations acknowledge responsibility for own consumption activity; and second, by indirectly incentivising (i) more localised and (ii) more efficient production. This way, a re-modelling of the allocation of responsibility of emissions could, to an extent, make up for the shadow-side of the extensive globalised trade-flows we have grown accustomed to under late capitalism. As Liu et al. (2015) argue, choice and practice of accounting method has real socio-economic impacts given its power to determine responsibility for emissions in terms of mitigation and/or adaption. Indeed, as Bin and Dowlatabadi (2015) argue, a consumption-based perspective helps remove the false dichotomy that is “them” (the industrial polluters/producers) vs. “us” (the innocent consumers).

As a final note, it is important to remember that CBCA does not take into account the residual or “post-use” carbon of products that have been consumed but still have a carbon value; such as some building materials or any other goods that have a re-use or recycling value¹⁸. It thus shares the systemic weakness of LCA methodologies (as well as conventional production methodology) in not taking into account the total implications of the post-use phase.

3.2 The case for production-based accounting

Nevertheless, the literature also presents some justified criticism of CBCA as a concept and tool for policy-making. While it is obvious that such a radical shift in allocation of responsibility would not favour the market (create more economic growth etc.), there are some concerns from a strictly environmental standpoint as well. Given that that production-based accounts of national emissions inventories harmonise with the country’s GDP, it can easily be held accountable for its production-related emissions; while consumption-based accounts would make this equation much more complex and troublesome to manoeuvre (cf. Peters 2008). This brings forth the main criticism of CBCA – namely that it would be difficult to actually

¹⁸ For example, how should we account timber that is imported, and burned in-country after use? We have imported both embodied carbon of producing the timber product, and a stock of calorific energy – which when it is burned after use, will normally be accounted as in-country production and consumption of biomass energy. Similarly, there can be a problem if consumption is based on economic data; if a durable and re-usable item such as a battery is imported, and later reconditioned and resold, its embodied carbon may be accounted – for a second time – as an in-country product. (Thanks to Chris Butters for bringing up this point.)

implement. As such, it is promising in theory, but perhaps unrealistic as a replacement for the Kyoto-driven production-oriented approach in practice.

Indeed, discussing the potential for consumption-based national emission inventories, Peters (2008) addresses some potent issues. First, there are issues tied to the actual model itself. The fact that CBCA entails much more complex calculations with a larger dataset presents a range of “implementation obstacles” (Peters 2008: 21). Arguably, when consumers are included in the equation the policy-making process becomes much more intricate and impractical (cf. Afionis et al. 2017: 6). This could lead to higher uncertainty, wider margins of error, and general difficulties with implementation. Rodrigues et al. (2018) found that CBCA requires more “data transformation” than conventional carbon accounting, which can lead to more uncertainties and higher margins of error – for instance, he found that Chinese carbon-based emissions varied by 15% due to inconsistent measures of coal consumption. The methodological issue of double counting in life-cycle analysis has also been brought up¹⁹ (e.g. Lenzen et al. 2006). Moreover, it is likely that it would be difficult or even impossible to estimate consumption accounts in some countries due to lack of adequate data (Peters 2008).

Second, a lack of GDP consistency would hold some institutions less accountable for own production, which could potentially create a rebound effect. Production-heavy economies might be incentivised to keep up, or even increase, production as responsibility for its emissions are allocated elsewhere. This would, of course, lead to environmental setbacks. Peters and Hertwich (2007) address Norway as an example, given its production-heavy economy. Indeed, “loss of responsibility for GHG emissions in Norway’s oil and gas sector may lead to less attention to mitigation” (Peters 2008: 20). However, as discussed in the previous section, this might still be beneficial on a global scale due to Norway’s relatively environmentally efficient production. It is further likely that pressure would be put on production-heavy economies to make their production more efficient (e.g. China).

Third, and perhaps most importantly, Peters (2008) stresses the issue of potential geopolitical barriers. The central issue is that decision-making would need to be extended beyond “the standard geo-political region” (e.g. nation state), which could create conflicts of interest. Consumption-based inventories would require more collaboration among economies as “the

¹⁹ For instance in terms of re-use and recycling of various elements that go into production.

emissions from different geo-political territories are allocated to the domestic economy” (p. 20). Furthermore, if a country’s footprint manifests in another country’s activities, there is a question of what political power a country has to enforce mitigation in a trading partner. This could be very problematic, given that reducing environmental impacts by humans ought to be a globally universal goal, and not subject to unnecessary geopolitics – political barriers are already a leading cause for failed mitigation efforts after all.

In addition to these setbacks of CBCA, Steckel et al. (2010) argue that the difference between a production- and a consumption-based approach would be smaller in practice than in theory, given that neither method influence the efficiency of production or welfare distribution. They show that environmental cost is internalised into goods and services through both accounting principles, albeit in different ways. Through production-based accounting, this happens *explicitly* through consumers paying for emissions costs internalised in the price of the exported goods; while through consumption-based accounting, this happens *indirectly* through carbon-correcting market forces (Steckel et al. 2010: 781-782). When also taking into account the technical and methodological difficulties tied to implementation of CBCA, the authors reach the conclusion that “in terms of transaction costs and environmental effectiveness the current accounting based on production would be favored” (Steckel et al. 2010: 782).

3.3 The case for a hybrid accounting model

The two previous sections have demonstrated that CBCA great potential in theory, but might not play out so well in practice – at least at the macro-scale of national emissions accounting. This is widely recognised; and consequently some have sketched out models of hybrid approaches, shared-responsibility frameworks, and alternative challenges and focal points, which will be covered in this section.

Peters (2008) suggests that a “shared responsibility framework” would allow for sharing of responsibility by focusing on emissions embodied in both imports and exports, thereby putting a greater focus on the *flows* of goods and services. CBCA does not yet constitute a viable alternative to replace the production-based accounting model, he argues, but it can – and should – still serve as an important “shadow indicator” to inform future climate policy about

“how much of a country’s consumption occurs in other countries” (p. 20). Davis and Caldeira (2010), too, make the case that CBCA can work as a tool to *enable a vision* for shared responsibility. Similarly, Mozner (2013) argues that a consumption-based method makes for increased effectiveness and equity, but that measurements that are more correct are needed to inform final decision-making.

Lenzen et al. (2007) present a methodological framework for a shared producer-consumer responsibility, which avoids the double counting problem associated with full life-cycle analysis. Other “hybrid” accounting models have combined “monetary input-output analysis with physical environmental accounts to develop an estimate of emission flows” (Schaltegger and Csutora 2012: 12). These models demonstrate a potential point of departure for implementation of fair and just carbon accounting, but are very complicated and might therefore work best as policy indicators. As an answer to this issue, Weidema et al. (2008) argue that the “carbon footprint” can potentially constitute a simpler, “catchier” version of the very complicated life-cycle assessments. Carbon footprints, they argue, are easily understood and can be *put into context* by NGOs, companies, and private initiatives. Moreover, carbon footprints can easily be calculated online by the individual consumer. “Carbon footprints carry the potential of being a good entry point for increasing consumer awareness and fostering discussions about the environmental impacts of products. This, in turn, facilitates the diffusion of life cycle thinking and LCA. It may even have the potential to promote a more consistent framework for environmental assessment of products and services” (Weidema et al. 2008: 6). At micro level, then, carbon footprint analysis might be a gateway towards a CBCA orientation.

Through their UK case study, Barrett et al. (2013) suggest that consumption-based emissions need to be included as an indicator to *complement*, not replace, current approaches of production and territorial emissions; thereby expanding the basis for existing climate policies to reflect the future increase in carbon leakage the embodied carbon in consumer goods, which have been predicted for the UK (pre-Brexit, at least). There is already some developments in regards to this, as both the UK and Australia monitor consumption-based carbon accounts. Similarly, Deloitte (2015) concludes that “national production-based targets” ought to be *enhanced* using various “metrics for carbon intensity and carbon footprint”; e.g. “carbon intensity of production” (production-based CO₂/GDP), “consumption-

based emissions" (CO₂ allocated to final demand), and "carbon intensity of consumption" (consumption-based CO₂/GNE).

Pauliuk et al. (2016) argue for a practical approach based on adding a "consumption-based charge for emissions intensive materials". In their paper, they address the implications of adding a consumption charge to (1) industry, and (2) consumers, based on material flow analysis and material flow cost accounting of 4000 commodity groups containing steel, aluminium, plastics, paper, and/or cement. They found that such a charge would incentivise more sustainable consumption among both final consumers and intermediate consumers (manufacturers). This charge would imply liabilities for the whole process of provision – i.e. production, import, export, consumption – in the form of adjustments of product prices depending on their levels of embodied carbon. Similarly, Liu (2014) addresses the complexity of CBCA in terms of policy, and suggests that "it would make better sense to induce producers to invest in cleaner production practices and then simply pass extra costs to the consumers" (paraphrased in Afionis et al. 2017: 6). These strategies both emphasise the possibility of implementing consumer responsibility into the existing market structures.

Steckel et al. (2010) show that a country's *preference* for either (production- or consumption-based) accounting model cannot be determined without taking into account situational context. In a grandfathering case, for instance, "countries that are net exporters of emissions benefit from production-based accounting, because it implies a higher initial cap. Conversely, if countries' historical emissions lead to a diminution of the allocation...net exporters benefit from consumption-based accounting" (Steckel et al. 2010: 782). This demonstrates that no allocation method in itself leads to reduced overall emissions *per se*, but must be seen in conjuncture with other circumstances. Steckel et al. (2010: 782) therefore suggest that "appropriate burden sharing rules" – through "(1) on an equal per-capita basis, (2) by grandfathering, or (3) by the principle of historical responsibility" – need to be part of the emission accounting framework.

Wood and Peters (2016) suggest two policy measures building on a hybrid framework logic. First, they suggest the need to establish "a commonly accepted standard framework for environmental footprint analyses using detailed local data combined with the comprehensive global MRIO systems" (no page). In other words, they suggest the need for a consumption focus to complement a territorial or production based approach. Second, they suggest the

need for hybrid models to replace input-output models (I-O) to “greatly improve the ability to distinguish between functionally similar, but environmentally different, commodities” (no page).

Finally, Steen-Olsen et al. (2012) pose an important dilemma: if we decide to focus on carbon footprints, what are the implications for other environmental pressures such as ecological footprints and water footprints? While CO₂ emissions equivalents are usually calculated, this does not take into account the other non-emission environmentally degrading effects. This is a shortcoming of carbon accounting as a tool to counter environmental degradation in general – and consequently a more in-depth discussion of this issue is beyond the scope of this report.

3.4 Chapter summary

- Given that carbon leakage is higher in import than export, production-intensive economies are net exporters of emissions while consumption-intensive economies are net importers of emissions.
- Efficiency of production technology affect emissions. Therefore, displacing production from developed to developing countries not only hides substantial emission counts from the consumer’s production-based inventory, but increases the total amount of emissions generated.
- A conventional production-based accounting framework suffers from carbon loopholes – emissions that are not attributed to anyone and therefore not accounted for – e.g. through some international transport.
- Norway is a net exporter of emissions, although the imports are more emission-intensive per unit. Given that Norway’s production activities are relatively efficient, adaption of a CBCA-based inventory could likely be a win-win situation for Norway.
- While a CBCA approach would be fairer in its allocation of responsibility, it would also likely incentivise large industrial economies such as China to further ramp up production.
- CBCA would be difficult to implement as a replacement for conventional production-based accounting due to several factors: (1) technical and mathematical complexities and high margins of error; (2) lacking GDP consistency would to a lesser extent hold

production-intensive economies responsible for their emissions; (3) the need to increased transnational cooperation could face geopolitical challenges.

- Various alternative hybrid approaches and models have been developed to tackle the challenges with both production- and consumption-dominant models. However, these are also complex in nature.
- CBCA arguably ought to work as an additional indicator to complement existing models and to inform policy making. It can also help develop tax systems and carbon calculators.

4. Household characteristics

This chapter reviews studies on the influence of household characteristics on household emissions related to consumption.

- Section 4.2 reviews case studies that address how household characteristics influence household emissions embodied in consumption.
- Section 4.3 provides a discussion of the findings from the case studies.
- Section 4.4 summarises the findings from the chapter.

4.1 Household characteristics

The social and structural elements or variables that affect the character of a household are referred to as household characteristics. Studies on household consumption usually use some form or combination of household characteristics as a starting point. The CBCA-oriented research breathes new life into household consumption studies, in that they include the emissions embodied in indirect consumption – which seemingly account for most of household emissions.

4.2 Case-studies

Wood and Hertwich (2016) have studied the carbon footprint of Norwegian household consumption between 1999 and 2012, using data from the Norwegian consumer expenditure survey (SSB) and a global MRIO dataset. Between 1999 and 2012 they found a 26% increase in emissions, which corresponds with a 26% increase in consumption volume. Direct emissions only accounted for 16.5% of the total. Direct household emissions seem to be particularly low in Norway, given that electricity (as opposed to gas) is primarily used for cooking and heating, and hydropower is used to generate this electricity. Transport, however, was found to produce relatively large amounts of emissions, due to factors such as long distances, low population density, limited rail network, high affluence, etc. Income was found to be a crucial factor, given that the average expenditure of the most affluent decile was 4.1 times higher than the poorest decile (and conversely, the average CF was 5.1 times higher). Moreover, affluent households spent more on the three most carbon-intensive commodities; namely transport,

furniture, and clothing. Travel was characterised by high intensities and high elasticities – high-income households therefore had higher impact from travel due to e.g. air-travel. For these reasons, “CF per unit of expenditure increased with overall expenditure levels ... notably owing to the correlation between overall household expenditure and transport activities” (p. 582). Finally, Woods and Herwich (2016) found that: “A substantial share of the processing and manufacture of final and intermediate products ultimately delivered for consumption by Norwegian households has been shifted to developing countries”. In fact, in 2010, 12% of Norwegian households’ carbon footprint stemmed from activity in China.

In a comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India, and Japan, Lenzen et al. (2006) find a general positive correlation between income expenditure and per capita energy requirements. Nevertheless, equal income levels were not found to produce equal energy requirements *per se*, and there was no uniform relationship between energy requirements and household expenditure. This was due to contextual factors such “geographical conditions and population density...energy conservation and technology, and consumer lifestyles” (p. 201). Moreover, there was a positive correlation between income, urbanity, and education. Only Japan showed a positive correlation between household size and energy requirements. This was due to structural factors, such as weak insulation, and energy-related practices, such as heating rooms individually. These counteracted the otherwise persistent *economy of scale*, which predicts that per capita energy requirements go down as the household grows²⁰. In Denmark, this manifested through increased sharing of goods between members of larger households. Similar economy of scale effects have been found in other studies (see e.g. Ivanova et al. 2017). The study demonstrates that a universal Kuznets curve, which predicts that at some point increased income expenditure, reaches a “turning point” whereby energy requirements are reduced, is highly unlikely.

A study by Ivanova et al. (2017) maps the carbon footprint of EU regions using subnational household data, addressing socio-economic, geographic, and technical factors for household characteristics. In terms of socio-economic factors, they find income to be the highest

²⁰ Wier et al. (2001) found that, in Denmark, per-capita emissions decrease by 20% per additional household member. It thus becomes important to differentiate between the total household as a unit, and emissions caused per household member.

explanatory factor. They further find a weak correlation between emissions and household size, but a positive correlation between emissions and dwelling size. Little evidence for a correlation between emissions and geography, education, or social status was found. There was a strong correlation between high basic-needs spending and lower emissions – this is because necessities (such as food, shelter, and clothing) generally produce “lower emissions per unit of expenditure compared to that of transport and manufactured products” (Ivanova et al. 2017: 3). In terms of geographic factors, they found that location in areas with lower or higher temperatures correlated with higher emissions, due to cooling and heating practices (cf. Hoornweg et al. 2011: 18). They also found an ambiguous correlation between access to natural resources and relative emissions, seeing as this could both facilitate low-carbon leisure activities and depletion of natural resources. Finally, in terms of technical factors, it was found that the intensity of the electricity mix correlates with higher emissions, given that this further determines the carbon intensity of locally produced and consumed goods and services²¹. These findings seem to hold true for most other studies reviewed in this report. (An overview table is included in Appendix 1.)

Wier et al. (2001) have studied the effects of household consumption patterns on CO₂ requirements in Denmark, focusing specifically on emissions from energy consumption, which at the time of the study made up 76% of Danish GHG emissions. The study looks at three groups of variables. Socio-cultural variables (i.e. education level, employment status, and environmental knowledge) were found to make little difference in terms of emissions. In terms of demographic variables, it was found that while urban families in flats had the lowest *direct* CO₂ emissions (50% below Danish average), high income rural families had the highest (78% above Danish average). Other variables controlled for, urban families had lower emissions than “equal” rural households. Despite this, however, *indirect* emissions ultimately depended on economic factors, i.e. household income – families classified as “high-income” produced 40% more emissions than the average family regardless of other factors. Relative variance in four factors were found to produce different CO₂ requirements: (1) household expenditure, (2) accommodation type, (3) level of urbanity, and (4) age of household

²¹ Indeed, the electricity mix intensity varies throughout Europe – for instance, while Norway and France have a generally low-emission electricity due to Norwegian hydropower (Peters and Hertwich 2004; Larsen and Hertwich 2009) and French nuclear power (Wier et al 2001), respectively, Czech and Polish electricity, for instance, has a generally high intensity due to heavy coal use (Steen-Olsen et al. 2012).

members. Due to structural similarities, it is suggested that similar results would be likely for the Netherlands, Germany and Norway.

Nilsson and Brandt (2013) uses CBCA to determine the carbon footprint of households in Stockholm and Sweden in general²². They find that the majority, 58%, of emissions attributed to Swedish households occur abroad, and that 89% of total energy use was indirect. Food was the largest contributor; followed by transport, goods, housing, and services. The most import-intensive categories were goods and food, of which 86% and 65% occurred abroad, respectively. 60% of total emissions happened in the consumption category – which were also the most emissions intensive: food, goods, and services – and 70% of these, in turn, happened abroad. On these grounds, it becomes evident that a CBCA approach produces a very different picture than would a production-based accounting methodology. The study further found that Stockholm had a 5% higher carbon footprint than the rest of Sweden – while the average Swedish household had larger footprints for housing (21%) and transport (3%), Stockholm households had larger footprints for food (11%), goods (16%), and services (27%). Moreover, the average Stockholm household had 14% higher income than the average Swedish household – this could contribute to these differences in consumption footprints. Indeed, high-emission factors seemed to vary with income levels; emissions from transportation and goods with 800% and 600%, respectively, between the lowest and the highest income brackets.

Several studies have focused on the impacts of household consumption in the US. Using a consumption-based lifecycle approach, Jones and Kammen (2011) quantify carbon footprints of US households (28 cities; 6 household sizes; 12 income brackets) through emissions embodied in transportation, energy, water, waste, food, goods, and services. The study found that indirect emissions accounted for 77% of total household emissions. The findings also support the economy of scale theory: a doubling of household members was only found to increase carbon footprint by 23%, thereby decreasing per capita emissions by 60%. Low carbon footprint correlated with low transportation footprints; which, in turn, correlated with high housing footprints. Minneapolis had lowest household size (with an average of 2.2 persons) but largest carbon footprint – likely due to large living spaces, varying climate, and

²² Their sample consists of only 32 households – the study could arguably benefit from a larger sample.

so on²³. Food was only a small factor for “single-person households at high incomes” (less than 10%), but a large factor for low income households (p. 4091). While substantial differences in average income was identified in the 28 sample cities, income level in general had little effect on carbon footprint. High population density, however, strongly correlated with lower carbon footprints. Jones and Kammen (2011) estimated that US household carbon footprints can be reduced by 5-12% on a voluntary basis, i.e. without imposing structural changes.

Based on these findings, Jones and Kammen (2011) have developed a “Climate Action Planner” – an online carbon footprint management tool help households create effective behaviour change. Through “abatement cost curves”, they demonstrate how much emissions cost for households, and therefore in turn how much households can save by reducing these emissions²⁴. This way, consumer households are empowered to understand and to make changes: “While modeling techniques have become increasingly sophisticated, this research has not been translated into comprehensive carbon management tools available to households, communities, and small businesses to monitor and quantify emission reduction opportunities” (p. 4088). For Jones and Kammen (2011), then, knowledge of the ways in which household characteristics affect consumption emissions in households ought to be operationalised into actual tools that can help households reduce their carbon footprint.

Estiri (2015: 109) argues for a more nuanced understanding of household energy consumption as “a complex socio-technical phenomenon”. Taking into account both household characteristics (which he terms *household effects*) and housing attributes (which he terms *building effects*), he addresses the important indirect effects of choosing housing in the first place. He argues that the choice of housing unit characteristics affects and determines a range of other factors tied to household characteristics and lifestyle choices. He terms this the “housing choice effect” (p. 117). In essence, then, there is a mutual relationship between the housing unit as a structure and the household as an agent; so that the outcome in terms of energy required and emissions produced is co-constructed as a “derived demand” (p. 111). In other words, “household and building characteristics determine energy consumption interactively” (Estiri 2015: 111). The central argument is articulated in the following quote:

²³ For instance, the climate in Minneapolis is rather extreme, with very hot summers and very cold winters, making for two energy use “peaks” during the year. (Thanks to Chris Butters for pointing this out.)

²⁴ See Figures 5-6 in Jones and Kammen (2001: 4092-4093) in Appendix 3.

“the impact of households on per-capita energy use through choice of the housing type, size, and number of rooms is much larger than the corresponding impact through the age of building, residency status, and tenure type ... Once a given household selects a housing unit with certain characteristics, a permanent effect of that housing choice will remain embedded in their ultimate residential energy use, until they relocate” (p. 116-117). This implies that the responsibility for reducing carbon emissions should lie not only with residential owners, but also with the designer of the residence (Li et al. 2014). While this study is based on US household, the *theoretical foundation* should be universally applicable (Estiri 2015)²⁵.

Bin and Dowlatabadi (2005) have developed a “consumer lifestyle approach” (CLA) to explore the relationship between US household consumer activity and their environmental impacts in the form of carbon emissions²⁶. They find that “more than 80% of the energy used and the CO₂ emitted in the US are a consequence of consumer demands and the economic activities to support these demands” (p. 197). Moreover, they found that there was twice as much energy used indirectly as directly; and that indirect CO₂ emissions were 30% higher than direct emissions. Housing operation was found to be the most energy and carbon intensive category due to high indirect energy use. Moreover, perhaps the most interesting finding from this study is that when total emissions from consumer expenditures are calculated, they add up to 102% of total US carbon emissions. This is due to the fact that many imported products have higher emissions intensity than that which is domestically produced. In other words, there is a relative difference in production efficiency.

These findings, Bin and Dowlatabadi (2005) suggest, imply that it will be crucial for policy-makers to consider indirect emissions – not only because they are significant, but because a

²⁵ Li et al. (2014) have estimated the carbon embodied in residential buildings in China. They found that certain materials – such as concrete, metal, and masonry – had very high impacts. For this reason, the emissions produced by the building pre-occupancy accounts for 25% of its total lifecycle energy consumption. Moreover, “designer-defined” carbon emissions – i.e. structural factors imbued into the layout and/or material fabric of the residential building which will affect future consumption patterns – were found to account for at least 90% of total household emissions. This demonstrates the importance of a CBCA framework to properly make sense of the carbon footprint of buildings.

²⁶ In addition to household characteristics, they look at other factors such as “external environmental variables” (variables which indirectly inform the consumer decision process, such as cultural influences or technology development); “individual determinants” (psychologically influencing variables such as attitudes or beliefs); “consumer choices” (purchases and use of services or equipment by consumers); and “consequences” (the use of resources and the consumer activities induced environmental impacts) (p. 198-199). See Appendix 5 for an illustration of this framework.

production focus can lead to ill-informed policy choices which in turn fuel rebound effects²⁷. They further suggest that the focus on efficiency measures is ineffective due to rebounds, and that quality of both production technology and products themselves need to be the foundation for sustainable consumption. Moreover, they suggest that “target activities”, such as “services and products related to home...and personal transportation” (p. 207), ought to be identified and focused on, given that incentives related to food and clothing will have a too limited effect. They argue that initial efforts should be made to create emission inventories to differentiate between what is produced and what is consumed within US borders.

In the study “Quantifying the global and distributional aspects of American household carbon footprint”, Weber and Matthews (2008) find that (1) 30% of total US household CO₂ impact occurred outside of the US in 2004, and (2) when “global differences in production structure and emissions intensities” are accounted for, average CO₂ needed to meet household consumption levels increases by 15%. This is due to the same efficiency issues problematised by Bin and Dowlatabadi (2005). Total household income and expenditure were found to be the best predictors for both domestic and international portions of total CO₂ impact. In terms of policy options, they argue that there will be a need for policies aiming to lower consumer impacts; for instance in the form of carbon taxes. However, they emphasise that the effectiveness and fairness of such policies depend on a good understanding of the impact of income distributions, rebound effects and international trade. Finally, they sketch out three options to decrease global CO₂ emissions: (1) improve production efficiency of purchased goods²⁸; (2) change the structure of consumption towards “a more sustainable bundle of goods and services” (p. 387); and/or (3) decrease overall consumption volume. While the latter option is politically unattractive, and therefore has received little attention, it would arguably be the most effective one.

4.3 Discussion

The previous section outlined the findings from several case studies of the impact of household characteristics on consumption patterns. While there are differences in the methodologies, analyses and scopes of these studies, they paint a general picture of how

²⁷ For instance, when discussing development of speed-trains as an alternative, more environmentally friendly transport mechanism compared to air-travel, it is crucial that emissions embodied in construction and infrastructure are not omitted from the equation.

²⁸ A measure that seems relatively ineffective – at least according to Bin and Dowlatabadi (2005).

household characteristics affect consumption, and which such forms of consumption produce the most emissions.

First, it must be noted that most studies found that indirect energy requirements contributed to a larger percentage of the households' total carbon footprint than did direct energy requirements. Although the margins differed²⁹, this result was still striking in all cases. This underscores the need for a CBCA approach to understand the full impact of household consumption.

Second, another striking similarity between the studies is the finding that economic factors (income levels, disposable income, income expenditure)³⁰ are the most important driver for overall emissions, regardless of other household characteristics³¹. All studies showed that there is a general positive correlation between higher expenditure and higher energy requirements and/or emissions. In particular, higher expenditure seems to correlate with higher spending on emission-intensive goods and services. For instance, in Sweden, Nilsson and Brandt (2013) found that higher income correlated with drastically higher emissions from consumption of transportation and goods. Similarly, in Norway, Wood and Hertwich (2016) found that the most affluent household had five times higher carbon footprint than the least affluent households, with higher consumption of the three most carbon-intensive categories, namely transport, furniture, and clothing. Estiri's (2015) argument that housing choice effects effectively creates lock-ins and path dependencies for future consumption, both in terms of structural and lifestyle factors, further supports this. Conversely, in terms of EU regions, Ivanova et al. (2017) noted that high basic-needs spending correlated with lower emissions due to necessities (e.g. food, shelter, clothing) generally producing less emissions than "luxuries" afforded by high income (e.g. transport and goods). Nevertheless, it should be noted that contextual factors can override income expenditure – in

²⁹ Direct emissions made up: a "very low" amount in Norway (Wood and Hertwich 2016); less than 50% according to Bin and Dowlatabadi (2005: 197) and 23% according to Jones and Kammen (2011: 4090) in the US; 11% in Stockholm (Nilsson and Brandt 2013: 6); etc.

³⁰ Different studies operate with different economic variables – income level, disposable income, or total expenditure. Arguably, expenditure – which usually follows disposable income – is a better determinant than net income (Wier et al. 2001). Nevertheless, as these indicators seem to produce somewhat similar results, little effort has been made to differentiate between these in this report.

³¹ Wier et al. (2001) found that income factors were more important for indirect than direct emissions. In terms of direct CO₂ emissions, demographics were important; income somewhat important; and socio-cultural factors not so important. In terms of indirect CO₂ emissions, income was the primary indicator.

Lenzen's (2006) comparative analysis of Australia, Brazil, Denmark, India, and Japan, he found no uniform relationship between energy requirements and household expenditure.

The necessity-luxury dichotomy implicitly addressed by Ivanova et al. (2017) is interesting. Girod and de Haan (2010) have studied the effects of higher consumption with increased income on the relative quality and quantity of what is consumed. They argue that household consumption models should not only focus on expenditure, but on consumption of functional units, to account for differences in quantity and quality, and thus also relative environmental impact. In their study of Swiss households, Girod and de Haan (2010: 43) find that "wealthier households pay higher prices per functional unit for many consumption categories". In other words, while quantity of consumption of goods and services did increase with income, so did quality³². Quality level is defined in the study as "price level per functional unit" (p. 32); and this was found to vary by 50% between the richest and the poorest households in the sample³³. On these grounds, they address the potential for "dematerialization", that is, decoupling the causal link between materials and emissions through spending more on quality rather than quantity. This builds on the logic that products and services can be "functionally similar, but environmentally different" (Wood and Hertwich 2016: no page). The income rebound effect might thus be countered through the "potential of decoupling income and environmental impact by consuming better instead of more" (Girod and de Haan 2010: 31)³⁴. The authors suggest that these findings should be applicable to other wealthy OECD nations – such as Norway.

Third, all studies show evidence of economy-of-scale effects related to household sizes – the larger the household, the smaller the per capita carbon footprints of its members³⁵. In Denmark per-capita emissions were found to decrease by 20% per additional household

³² The notion that economic growth leads to purchase of resources with higher quality and thus lower environmental impact is one of the hypotheses used to justify the Environmental Kuznets Curve (Lenzen et al. 2006). While this has not proved to be the reality in practice, there seems to be relevant to some extent in terms of household consumption.

³³ For instance, Jones and Kammen (2001) found food to constitute only a small emission factor for "single-person households at high incomes" but a large factor for low income households – one potential reason for this could be that high-income households pay more for less emission-intensive food products than low-income households.

³⁴ Most studies reviewed in this report have not taken the quality/quantity problem into account – for instance, Heinonen et al. (2013a) cite this as a weakness of their study's analysis.

³⁵ With the notable exception of Japan, where structural-cultural factors in the household (for instance individualised/non-centralised cooling/heating practices) negated the economy-of-scale effects (Lenzen et al. 2006).

member (Wier et al. 2001). In the US, a doubling of household members was found to increase total household carbon footprint by 23% and reduce per capita emissions by 60% (Jones and Kammen 2011). The main reason for this effect is that larger households means that a substantial amount of both direct and indirect energy/emissions are “shared” by more people.

The fourth common finding between the studies is that (some of) the most energy/emission-intensive products consumed are imported from abroad. In Sweden, the most import-intensive categories were goods and food, of which 86% and 65% occurred abroad respectively. Moreover, 12% of the carbon footprint of Norwegian households were from production in China alone (Wood and Hertwich 2016). Bin and Dowlatabadi (2005) further found that the emission intensity of the production outsourced from the US was higher than it would have been if the same production had happened in the US due to relative differences in production technology efficiency. This is problematic – when production is moved from a developed to a developing nation the domestic emissions of the consumer-nation are lowered while the actual net emissions increase³⁶. Indeed, the emissions embodied in imported goods for household consumption remain unaccounted for through a production-based inventory. This is the main reason why production- and consumption-oriented accounting models allocate very different amounts of total GHG emissions to households – ~20% and ~70%, respectively (Hertwich and Peters 2009; Hertwich 2011). A CBCA approach will arguably be needed to correct for this.

Some household consumption categories seem to remain constant in terms of their relative importance – income, housing, transport, and goods in general. Three consumption categories tend to make up 80% of (in/direct) environmental impacts: housing (“energy consumption related to heating and operating housing” [direct], “material housing consumption” [indirect]), transport [private cars, air-travel], and food (Holden 2004: 46).

However, one category seems to vary considerable between the different cases; namely *food*. In Norway, food was found to be the single largest contributor to the carbon footprint per household – without accounting for food consumed in restaurants, cafes, or hotels (Wood and Hertwich 2016). In Stockholm and Sweden, too, food was found to be the largest contributor to the carbon footprint per household (although emissions from food were 11% higher in

³⁶ This has been highlighted in other studies as well (e.g. Peters and Hertwich 2004; Weber and Matthews 2007; Pan et al 2008; Lin and Sun 2010; Steen-Olsen et al. 2012; Su and Ang 2014).

Stockholm than in all of Sweden). In Denmark, different food categories make up six out of the ten variables which produce the most emissions from indirect consumption; while food as an overarching category constitutes the fifth overall most emission intensive consumption category (Wier et al. 2011: 264, 267). In the EU, food made up 17% of the overall household emissions, being the second most important category following transport.

In the US, however, Bin and Dowlatabadi (2005) found that the impacts of food and clothing were too limited to focus on in terms of policy measures. Weber and Matthews (2008) also find food to be a relatively small contributor to overall carbon footprints of American households. This is somewhat odd. While food constituted 4.9 tons CO₂e per Stockholm household in 2012 (Nilsson and Brandt 2013: 6), indirect emissions from food alone constituted 4.16 kg CO₂ per year per household in the US in 1997 (Bin and Dowlatabadi 2005: 202) – and, given the 15-year time difference between these numbers one would assume that the US numbers have risen significantly.

One reason for food being regarded as a lesser important factor in the US scenario than in the European scenarios might be that the US seems to have a drastically higher overall household carbon footprint. This is demonstrated by Hoornweg et al. (2011), who present a comprehensive table showing the GHG emissions (tons CO₂ equivalents per capita) of different countries and their major cities. While Sweden, Finland, and Norway emit 7.15, 14.81, and 11.69 tCO₂e/capita, respectively, the US number is 23.59 (numbers from 2007; Hoornweg et al. 2011: 5-6). The US thus emits more than twice as much as Norway and more than three times as much as Sweden per capita. The reason for this might be, in part, the pollution-intensive electricity mix combined with emission-inducing planning solutions and a generally consumption-oriented culture. While the contribution of food might be similar in terms of actual emissions, it is different in terms of percentage of overall emissions. However, this is only speculation.

Generally speaking, Girod and de Haan (2010) argue that emissions from food can be reduced through buying more expensive, regional, and/or organic products. Products from China, for instance, have a high environmental impact per functional unit due to low prices, inefficient production, coal-dominated electricity mix, etc. In addition comes emissions from transportation. Eco-labelling is therefore a good strategy because it allows consumers to pay

more for lower environmental impacts (Girod and de Haan 2010), making for a “positive” rebound effect given that less money is available for additional consumption.

Another interesting factor to note, which is addressed by Lenzen et al. (2006: 196), is the effect of an ageing population on emissions. They suggest the effect of an ageing will drive up residential energy demand. This might be relevant for Norway.

In general, then, seems that the early findings in this field (coupling household expenditure data with input/output energy intensities) still hold true. These were – and to a large extent still are – according to Lenzen et al. (2006: 183): “a substantial part of a household’s energy requirements is constituted by non-energy commodities”; “total energy intensity decreases with income”; “per-capita energy requirements decrease with the number of household members”; and “urban households exhibit a lower energy intensity than rural households” (see next chapter).

4.4 Chapter summary

- Indirect (embodied) energy requirements tend to make up the largest part of the total amount of household emissions. While only 20% of total emissions are typically allocated to the household, a CBCA framework would therefore increase this to more than 70%.
- Economic variables (income, disposable income, expenditure) are the most important in determining overall consumption and in turn emissions. This seems to be universal.
- Households with higher income tend not only to spend money on quantity but also quality, which reduces some of the environmental impacts of higher consumption. Arguably, this can be used to the advantage of the environment when designing policy.
- Larger households correlate with lower emissions per household member due to economy of scale effects. Larger size of dwelling, however, correlates with higher overall emissions.
- Some of the most emission-intensive household categories were imported, e.g. food and consumer goods.

- Household consumption can be attributed partially to “housing choice effects”, i.e. the long-lasting effects of choosing one’s specific dwelling on consumption patterns due to structural limitations or motivating factors.

5. Land-use characteristics

This chapter reviews studies on the influence of land-use characteristics on household emissions related to consumption. While there will be some overlap with the previous chapter, this chapter focuses more on urban planning and the structuring of society.

- Section 5.1 introduces the role of land-use and urbanisation on household consumption.
- Section 5.2 reviews case studies that address how land-use characteristics influence household emissions embodied in consumption.
- Section 5.3 provides a discussion of the findings from the case studies.
- Section 5.4 summarises the findings from the chapter.

5.1 Land-use and urbanisation

In this report, I refer to the aspects of household characteristics that relate to planning and geography as “land-use characteristics”. While these sometimes are referred to as household characteristics – alongside income status, household size, socio-cultural variables, and so on – I find it useful to separate these. Land-use characteristics are more “macro” scale in the sense that they pertain to the ways in which living arrangements are structured, urban-rural configurations, and so on. While there is some overlap between sections 4.2 and 4.3, the “urbanity” case will receive the most attention here, given that it is a contested topic within the research on sustainable societies and sustainable household consumption.

Urbanisation might be one of the most enduring trends of civilisation in human history; given that major cities are now the focal points of basically all societies, a significant counter-urbanisation trend seems very unlikely. Urbanisation and resulting emissions are contested topics, as cities have been both accused for climate change, and been deemed as the solution to climate change. Indeed, cities account for more than 80% of global GHG emissions (Hoornweg et al. 2011; Heinonen et al. 2011). What we do know, is that while urbanisation implies denser living and generally reduced direct energy use and emissions, cities also require vast amount of energy and resources imported to them. High-emitting industries are generally

located outside of cities, not within them. Arguably, however, emissions ought to be “the responsibility of the cities they serve” (Hoornweg et al. 2011).

Hoornweg et al. (2001) address the paradoxical nature of cities’ relations to climate change, arguing that they are a key driver of climate change whilst also being key sites for mitigation and adaptation potential. “Cities have the unique ability to respond to a global issue such as climate change at a local, more visceral level; they usually offer more immediate and effective communication between the public and the decision makers. Cities are credible laboratories of social change, with sufficient scale to bring about meaningful changes. Potential co-benefits of mitigation and adaptation are largest in cities” (Hoornweg et al. 2011: 2). This makes the city a crucial site for CBCA and lifecycle oriented investigation.

5.2 Case-studies

Hoornweg et al. (2011) demonstrate that average per capita GHG emissions vary dramatically between rich cities in the developed world and poorer cities in developing countries, by more than 30 times. With Toronto, Canada as a case study (which is one of the more affluent high-emitting cities), Hoornweg et al. (2011) address some ways in which urban infrastructure influence lifestyle choices and in turn emissions. They find that, in Toronto, the neighbourhood with the lowest per capita emissions was “a high-density apartment complex within walking distance of a shopping centre and public transit”; while the highest emissions were found in suburbs characterised by low-density family-homes located far from commercial activity (Hoornweg et al. 2011: 8).

Norman et al. (2006) have further compared the effects of high and low residential density on energy use and GHG emissions in Toronto using lifecycle analysis. They considered three factors: (1) “construction materials for infrastructure”; (2) “building operations; and (3) “transportation”. They found that, not surprisingly, low-density suburban development was more energy and GHG intensive than high-density urban core development on a per capita basis. However, when the functional unit of analysis was changed from “per capita” to “per unit of living space” (or: per living area, per square meter of living space) the difference

between these categories was reduced significantly³⁷. This result indicates that the choice of functional unit when doing analyses affects the results dramatically. This essentially demonstrates that the relative increase in energy use and carbon emissions with increased dwelling size is lower in less densely populated areas. In total, low-density development was associated with drastically higher (per capita) or slightly higher (per unit of living space) energy requirements and GHG emissions than high-density development (see figures in Appendix 2).

Høyer and Holden (2003) have studied the effects of urban form – as “physical/structural conditions in housing areas” – on household consumption patterns, through three Norwegian survey case-studies: Greater Oslo (big city), Storhaug (neighbourhood in mid-sized city), and Førde (small town). They address five consumption categories – food, housing, transportation, consumer goods, and services; and four housing categories – energy consumption, material housing consumption, everyday transport, and holiday/leisure travel. Food, transport, and housing were found to take up most of the households’ ecological footprint. In all cases, they found evidence for lower per capita footprint for larger households (economy of scale), higher footprint with car ownership, and increased footprint following higher income. While travel by car decreased with increased urbanity, footprints from overall travel increased due to increased air-travel. They conclude that compact urban structures are generally favourable in terms of reducing emissions, given that (1) shorter distances require less mobility; and (2) dense/concentrated housing requires less energy.

Building on the case study from Høyer and Holden (2003), Holden (2005) specifically addresses *energy* and *transport* as household consumption categories in eight residential areas in the Greater Oslo region. Four categories of energy consumption were studied: (1) heating/operation in house; (2) everyday travel; (3) long leisure travel by plane; and (4) long leisure travel by car. The study finds a clear connection between household consumption of transport and energy, and land-use characteristics. The first finding echoes that of Høyer and Holden (2003): everyday travel decreases in densely populated areas, but leisure travel by plane increases. A second finding fleshes out this dilemma – they found that leisure travel is

³⁷ The factor of difference was reduced from 2.0-2.5 to 1.0-1.5 – in other words, the difference in energy use and GHG emissions dropped by ~40-50%. Arguably, the latter category – per unit of living space – ought to be the standard when addressing total emissions, given that a per capita measurement will be relative to the population size.

reduced by access to a private garden. The study finds support for a “compensatory mechanism hypothesis”, suggesting that people who live in dense urban areas with limited need for everyday transport tend to compensate for lack of access to green/outdoor areas by going on longer leisure trips. An alternative explanation is the “hypothesis of opportunity”, suggesting that time and money saved by having reduced living space are re-invested into long-distance leisure-travel. A third finding was that the difference in energy use between single- and multi-family housing is reduced in housing built after 1980, due to efficiency gains.

Holden’s (2005) study identified high-, medium-, and low-energy-consumption areas in Greater Oslo (see table below). The land-use characteristics of these areas correspond with the research, showing that high-density, multi-family housing, proximity to a city centre, work, services, and public transport are factors that correlate to low energy use. Based on these findings, three challenges for the “compact city” are identified: (1) the correlation between higher density and more leisure air travel; (2) the correlation between having access to a private garden and doing less leisure travel by car or plane; (3) the fact that the type of housing matters less now than it did previously, with older buildings. On these grounds, a decentralised concentration city planning model is suggested as a middle-ground solution.

Characteristics of Greater Oslo areas at different energy consumption levels (Holden 2005)

Energy use	Density	Housing	Location	Services proximity	Transport proximity	Provision proximity	Areas
High	Low	Single-family	Urban fringe	Far	Far	Far	Rykkinn, Bjørndal
Medium	High	Multi-family	City centre	Close	Close	Close	Grünerløkka, Vålerenga, Silkestrå
Low	High	Multi-family	Sub-centres	Relatively close	Relatively close	Relatively close	Sandvika, Hovseter

Norland et al. (2004) studied how urban planning (i.e. land-use characteristics; structural factors) and “green consumerism” (i.e. socio-cultural/economic characteristics; lifestyle/social factors) affected consumption of energy and transport in urban households in the Greater Oslo region. The overarching conclusion of the study is that land-use characteristic are far more important – “individual attitudes towards environmental issues have considerably less

impact on behaviour than land-use characteristics...physical structures pose serious barriers for 'green consumerism'" (Norland et al. 2004: 155). In fact, the study suggests that total household energy consumption is not affected by attitudes at all; but that, ironically, structural factors contribute to environmentally minded households often having a *higher* carbon footprint. In terms of land-use characteristics, housing type, size/age of the house, housing density of the residential area, and proximity to a city-centre were found to be important factors for emissions. Four common characteristics were found to correlate with high-energy households: (1) single-family housing; (2) ownership of one or more cars; (3) few household members in the house; and (4) high household income. On these grounds, some policy implications are suggested: "economic incentives (e.g. taxes and subsidies), regulations (laws and other types of standard), physical infrastructures (e.g. the public transport system and urban layout) and information (i.e. information campaigns to increase individual awareness and attitudes)" (Norland et al. 2004: 155).

Heinonen et al. (2011) challenge the notion that urban density is crucial for climate change mitigation due to decreased living unit size and automobile dependence. In their Helsinki case study, they find that dense downtown living is in fact *more* carbon intense than suburban living due to higher overall consumption. A consumption-oriented LCA approach here demonstrates that "higher urban density might have negligible or even reverse effect on the per capita carbon emissions ... the increased consumption due to the higher standard of living increases emissions more than the higher density is able to reduce them ... life in less dense and less affluent areas is in fact less CO₂ intensive due to lower overall consumption" (Heinonen et al. 2011: 1-2)³⁸. For instance, there was little variation in food consumption, but downtown inhabitants consumed twice as much clothes and leisure mobility³⁹ as the suburban inhabitants. Moreover, Heinonen et al. (2013a) found that city dwellers had a higher level of (money and time) expenditure on housing goods, recreational/cultural activities, hotels and restaurants, and that they owned more cabins, than those who lived in more rural areas of Finland – and while there were less driving in the city, fuel efficiency was lower and there was only a 20% difference in time spent driving due to higher traffic etc. Interestingly,

³⁸ In other words, urban density might lead to an indirect rebound effect through excessive consumption. This will be more thoroughly discussed in the rebound effect section of the report.

³⁹ The downtown inhabitants consumed three times as much leisure mobility as the national average.

however, the carbon emissions per euro consumed not very different between areas, suggesting that the *structure* of consumption was similar. The difference in consumption were thus mostly due to higher income levels in the city. Much like Norland et al. (2004), Heinonen et al. (2011) found that land-use characteristics were crucial – in Helsinki, housing and ground structure accounted for 60-75% of the total carbon consumption in all areas⁴⁰. Conversely, consumption related to housing contributed to 40% of all emissions.

On the basis of these findings, the overall conclusion suggested by Heinonen et al. (2011: 7) was the following: “the socioeconomic standard of living in the city center potentially combined with the easy access and availability to goods and services seems to generate substantially higher per capita carbon loads than are generated in the suburban areas with lower standard of living. It is considered very likely that similar results would be obtained elsewhere too as long as the same condition, the dense downtown attracting wealthier residents is met ... The bottom line, however, is that all consumption causes adverse effects to the environment”. On these grounds, they suggest some policy implications. While urban planning design principles ought to build on “the four Ds” – density, diversity, design, distance to transit, and destination accessibility – a CBCA framework shows that this is not sufficient; rather, policy needs to focus on (1) energy consumption of buildings, (2) alternative energy production/distribution modes, (3) general consumption patterns and opportunities for low carbon consumption within the city. In terms of city-level management, they suggest, this could manifest through (1) requirements for greener energy modes; (2) demand better energy efficiency of buildings; and (3) implementing policies for improving competitiveness among low carbon products and services.

The trends described in the previous studies also seem to hold true in China. Næss’ (2010) study of the impact of residential location on energy use and travel emissions in the Hangzhou metropolitan area demonstrates the positive impacts that living closer to the city-centre or a sub-centre (“low order centres”) have on both emissions from travel and energy use⁴¹. Based on this finding, it is emphasised that China ought to avoid the urban sprawl tendencies seen

⁴⁰ In low-income areas these factors were even more important.

⁴¹ Synthesising findings from various other studies, Næss (2010: 51) argues that this finding has high generality, given that similar evidence has been found in case-studies of Paris, London, NYC, Melbourne, San Francisco, Oslo, Dutch urban regions, English cities, Danish cities, Copenhagen, and Santiago.

in American cities, and to some extent European cities, in order to keep overall emissions down as much as possible. This quantitative study is further backed up by a qualitative study (Næss 2013).

5.3 Discussion

This section will discuss some themes and commonalities that arose in the previous section connecting the threads between land-use characteristics and household consumption, particularly as it relates to urban planning. As Hoornweg et al. (2011: 18) found in their Toronto case-study, “there is no single factor that can explain variations in per capita emissions across cities; they are agglomerations of a variety of physical, economic and social factors specific to their unique urban life”. Nevertheless, it is useful to examine correlations between, and impacts of, various factors.

In terms of transport, which generally makes up a large part of the household carbon footprint, the literature suggests that urban households contribute to fewer emissions through everyday mobility, but more through leisure-time mobility (cf. Holden 2005). In some cases, the net total emissions from transport remain lower in the cities or high-density areas than in suburban or rural areas (e.g. Wier et al. 2001; Jones and Kammen 2011), while in other cases they are actually higher due to excessive air-travel (e.g. Holden 2005; Heinonen et al. 2011; Heinonen et al. 2013a). Holden (2005) suggests that the reason for this might be explained through either (a) the “compensatory mechanism hypothesis”, which suggests that the lack of personal space in high-density areas drive consumers to compensate through holiday/leisure travel; or (b) the “hypothesis of opportunity”, which suggests that time and money saved by having reduced living space are re-invested into long-distance leisure-travel. Both of these hypotheses constitute an indirect rebound effect. Additionally, I would argue that three equally probable explanations are (a) higher income in cities, which might enable or motivate more travel; (b) a different lifestyle in the city (see next section); and/or (3) city-dwellers being attracted to city living in the first place because they value a certain way of spending their time, space, and money. It is certainly difficult to disentangle cause-and-effect relationships here.

Several of the aforementioned studies support an alternative city planning model to the currently dominant “concentration-sprawl” or “centralised sprawl” – namely “decentralised concentration” (also referred to as “small towns within large towns” or “sustainable urban neighbourhoods”; Høyer and Holden 2003: 346-347). This model implies combining the best of both the compact city and the rural land. Rather than being constituted by a concentrated city core surrounded by sprawl or suburbs⁴², it is argued that cities ought to consist of multiple small-contained and largely self-sufficient community centres (Høyer and Holden 2003). This approach focuses on social sustainability as a key aspect of long-term environmental sustainability (Høyer and Holden 2003) – in a sense, then, it suggests an anti-globalisation approach to city planning.

Urban planners and thinkers have long referred to the city as a site of anonymity and individualism – traits in many ways favoured by late-capitalist societies. A decentralised concentration or urban sustainable neighbourhoods approach, however, could perhaps facilitate an ethos of trust, community, and participation; leading to multi-use and sharing of goods and services, thus lowering emissions through economies of scale. A growing body of literature focuses on community energy projects, for instance.

Nevertheless, it is important to differentiate between ideals of society and pragmatic solutions to real-life problems. As the literature on CBCA and embodied carbon demonstrates so well, there are vast amounts of emissions embodied in our current structures; to tear these down in favour of rebuilding society after sustainable models might not be sustainable after all. This will, of course, depend on the time-scale applied to the analysis⁴³. Despite this caveat, however, it is useful to understand how different ways of structuring society affects energy requirements and overall emissions.

⁴² American cities are good examples of cities that are built predominantly around urban sprawl and suburbs, and, as the previous section demonstrated, emissions from American households are extremely high.

⁴³ This is also a matter of perspective. To exemplify using a thought-experiment: as Holden (2005) found, housing built after 1980 is considerably more efficient than housing built prior to this – but, does this mean that we (a) ought to re-build pre-1980s houses to ensure more sustainable housing, or does it mean that (b) we ought to sustain these buildings for as long as possible to make the relatively inefficient construction processes “worth it”?

It is further clear from the literature that land-use and household characteristics are much better determinants of emissions from household consumption than socio-cultural factors such as attitudes, values, beliefs, and/or knowledge. It has been firmly established that self-perceived “greenness” through membership of environmental organisations is more likely to increase rather than decrease overall household emissions (Norland et al. 2004; Holden 2004). Structural factors such as class, socio-economic status, neighbourhood etc. have larger impacts, leading to a range of different attitude-behaviour gaps and cognitive dissonances (this is discussed more thoroughly in the next section).

It is worth noting that the role of economic status (disposable income; household expenditure) is perhaps the most important indicator also when it comes to land-use characteristics (Norland 2004; Heinonen et al. 2011). In many cases, income levels will be higher in the city, which will in turn lead to increased consumption. While Hoornweg et al. (2011: 18) found that housing type (i.e. how you live) and neighbourhood choices (i.e. where you live) matters more than consumption habits (i.e. what you buy), these factors clearly influence one another – as pointed to by Estiri’s (2015) housing choice theory; and by Høyer and Holden (2003) who argue that physical structures shape attitudes and actions.

Finally, it is important to take a couple of considerations into account. In this report, different studies are gathered from different parts of the world; which are both structurally and culturally different. Data from North America, for instance, is not necessarily applicable to the Norwegian context. Moreover, different studies operate with different variables when it comes to urban development – e.g. urban vs suburban; urban vs. rural; low-density vs. high-density; and so on. This complicates the data and makes for a somewhat skewed analysis.

5.4 Chapter summary

- A consumption-oriented focus demonstrates that urbanisation is a key driver of climate change; however, the city can (and ought) also be a key site for change.
- A CBCA/lifecycle approach to planning gives a more accurate understanding of the impacts of different living arrangements on consumption. Looking at direct emissions, demographics are important, income is somewhat important, and socio-

cultural factors are not so important; looking at indirect emissions, income becomes the primary indicator.

- All household variables being equal, urban living correlates with lower household emissions. However, because variables are usually different in cities compared to suburbs or rural areas, this is not so relevant.
- As with household characteristics in general, income seems to be the single most important variable for emissions from household consumption, regardless of land-use characteristics. A high-income household will have high emissions regardless of where or how they live (in most cases).
- Urban households contribute to fewer emissions through everyday transport, but more through leisure-time transport, e.g. through air- or holiday-travel.
- Some literature suggests that planning strategies focusing on self-contained sub-centres, as opposed to a downtown-sprawl model, have the potential to motivate more sustainable consumption.

6. Discussion: Alternative perspectives

The previous chapters have focused on household and land-use characteristics from a CBCA oriented perspective. This chapter will discuss some alternative perspectives which arise from this focus, and which shine further light on the findings gathered in the previous chapters.

- Section 6.1 discusses the role of “lifestyle factors” in generating household emissions.
- Section 6.2 addresses practice theory and discusses the role of structure and agency in mediating household consumption behaviour.
- Section 6.3 discusses how a CBCA approach influences our understandings of the rebound effect.
- Section 6.4 discusses some implications and possible policy avenues arising from these perspectives.
- Section 6.5 summarises the findings from the chapter.

6.1 Beyond the household: Situated lifestyles?

A growing body of research has focused on lifestyle factors and how these affect overall energy requirements and emissions from consumption. The premise of the lifestyle concept is that different (household and land-use) characteristics produce, and are (re)produced by, different ways-of-life, and that these need to be taken into account. In a sense, “identifiable lifestyles” reflects the intersection between “purchasing decisions” and “time allocation” (Heinonen et al. 2013a: 3). While socio-cultural factors are generally considered from an economic perspective (education, employment status, etc.) the lifestyle concept referred to here pertains to “socio-cultural factors from a sociological perspective” (i.e. more fluid variables such as attitudes, values, and identity; Wier et al. 2001: 260). The lifestyle concept extends the gaze beyond the household, making for an even more encompassing understanding of the effects of consumption on individuals’ and households’ carbon footprints.

Two twin studies of Finland and Helsinki demonstrate the ways in which lifestyle is “situated” (Heinonen et al. 2013a, 2013b). Between them, the studies find that (1) “the GHGs increase along with the level of income due to increased consumption activity” [study 1]; and (2) “at

equal income levels there are complementary effects for the majority of the low-carbon lifestyle choices” [study 2] (Heinonen et al. 2013b: 9).

The first study analyses the relationship between (a) urban forms (metropolitan, urban, semi-urban, rural) and (b) lifestyle – and their resulting GHG emissions – in Finland. They find that indirect emissions from consumption practices *embodied through lifestyle* in the city override the reduction in direct emissions from transportation and housing energy. They found that this largely happened through “parallel consumption” – that is, “concurrent consumption of service spaces in different locations ... consumption of space can multiply and extend beyond the apparent limit of time budgets or the spatial constraint imposed by the home or even the surrounding settlement” (p. 10). While the city can enable sharing of spaces, it makes it also possible for a “double” use of spaces. This way, “the lifestyles especially in more urbanized areas lead to multiplication of consumption outside of the limits of time budget and the living environment” (p. 1). In the authors’ words: “the urban form affects the lifestyles and thus the GHGs on a much wider scale than traditionally assumed. The urban form affects housing types, commuting distances, availability of different goods and services, social contracts and emulation, and the alternatives for pastimes, meaning that lifestyles are actually situated instead of personal projects” (Heinonen et al. 2013a: 1). To gain a full understanding of indirect and embodied emissions from consumption, it is crucial to focus on the ways in which “structural determinants” restrict or motivate various forms of consumption (Heinonen et al. 2013a: 2). For instance, urban dwellers were found to have more cabins⁴⁴ (something that tended to require having a car as well – and even if the car is not used very often, the embodied emissions in production, storage, etc. are considerable).

Lifestyle is without doubt heavily influenced by income. As other studies have shown, income is in general the most important predictor for carbon footprint. To correct for this, another study by Heinonen et al. (2013b), using the same data, looks at how lifestyle differs when budgets/expenditure/disposable income are similar, focusing on the middle-income population segment. They find that carbon footprints vary little among the same income

⁴⁴ As Norland et al. (2004) found in Oslo, having a private garden reduced time spend traveling away on holiday. This is an example of a structural factors which affect consumption behavior. The lack of private space in the city might drive households to acquire cabins or summer houses elsewhere, which must be taken into account when assessing emissions from household consumption. Statistics show that energy consumption tied to Norwegian cabins have increased threefold in the period 1993-2017 (SSB 2018b).

segment due to the “complementary effects” (i.e. rebounds) of environmentally friendly choices. In contrast to the first study, urban lifestyles seemed to produce slightly less emissions due to less driving. While the carbon intensity was lower for the city, more time and money was allocated to overall consumption (rebound). While city-dwellers travelled more by air, “increased air travel of city dwellers seems not to undo the benefits of denser living in an income neutral situation” (cf. Ornetzeder et al 2008; Holden and Norland 2005).

The study also looked at lifestyle factors tied to high- and low-rise housing. High and low rise housing were found to produce similar amounts of emissions with similar income base; in fact high-rise led to slightly higher emissions. “Active leisure” was found to be similar between the two categories. While high-rise households spend more total time at home, low-rise households spend more time at work and school – but in turn sleep less and thus contribute to a similar amount of home-related energy use.

The study found three main explanations for the emissions being similar for the different lifestyles within the same income bracket. First, similar income leads to similar time consumption, in other words “equal income levels the consumption choices are mostly trade-offs between allocation of time and money to one type of consumption and some other” (Heinonen et al. 2013b: 4), i.e. rebound effect leads to re-allocations. Second, the per capita focus skews the results somewhat as households with cars are twice as big as those without, meaning that the emissions from the car is divided on several consumers. Finally, fewer people share the high-rise spaces, cancelling out its potential emission-reducing effects.

Heinonen et al. (2013b) conclude that there is little reason to believe that urban high-rise is more environmentally friendly than suburban low-rise; in fact, the truth is closer to the opposite. Larger families activate economies-of-scale effects, i.e. through sharing of goods and services – “larger family sizes and the economies-of-scale effects in the less dense areas offset the advantages of more dense living when the emissions are assessed on per capita basis” (p. 9). Basically, the reason for this finding is the rebound effect which is apparent on all levels and scales, making income the single most important factor for overall production of emissions by households and consumers.

In terms of policy, Heinonen et al (2013b) reach two conclusions: policy-makers ought to pay attention to (1) situations where families accept dense urban settings, and how decreased

family sizes in urban settings lead to potential GHG implications; and (2) on how to share resources beyond the family boundary in cities to take advantage of economy-of-scale effects. Moreover, they state that: “It is of key importance to probe whether, and to what extent, the trade-offs are due directly to density. If so, there is little scope for promoting low-carbon lifestyles with urban planning” (p. 9).

The importance of income is further backed up by an urban-rural comparison by Heinonen and Junnila (2011). They argue that “when a change from rural to urban area type leads to upgrade in the income level, and thus in the consumption volume, urbanization might lead to significantly higher carbon emissions instead of diminishing of the emissions” (p. 1235). In their study they found several factors made urban living producing higher overall carbon footprints - “growth of the urban density, change in the dominant type of habitation from detached houses to apartment buildings, and growth in the income level”.

Some studies have explored the correlation between perceived lifestyle and environmental impacts. In a case-study of Stavanger, Holden (2004) demonstrated that “green” households⁴⁵ have a smaller ecological footprint than “ordinary” households only because of structural factors – such as the typical “green” household being larger than average, thus reaping the benefits of economies of scale. The study “found no indication that green households seek conditions such as small houses, avoiding car occupancy and having low income. Rather the opposite seems to be the case. We must therefore conclude that green households are no greener than ordinary households. Being green simply doesn’t seem to matter” (Holden 2004: 54). This conclusion is similar to the one reached by Norland et al. (2004), who, based on a case-study of eight residential areas in Greater Oslo, argue that urban planning is more important than “green consumerism”⁴⁶. Their study found that environmental attitudes in general – measured through affiliations with pro-environmental organisations – had “considerably less impact on behaviour than land-use characteristics”, which in turn implies that “physical structures pose serious barriers for ‘green consumerism’” (Norland et al. 2004: 155; see also previous section on land-use characteristics)⁴⁷. These findings are backed up by

⁴⁵ «Green households» here refer to households affiliated with pro-environmental organisations; i.e. it is measured by ideological orientation and not actual “greenness”.

⁴⁶ «Green consumerism» here loosely refers to consumption habits informed by environmental engagement.

⁴⁷ It is important to note, however, that there are many ways of quantifying “green” lifestyles – it might be that the indicator employed by these studies, i.e. affiliations with pro-environmental organisations, is not a good one. However, when seeing the results from these studies in light of other studies in the same field, it is at least

a growing body of research suggesting that there exist various attitude-behaviour gaps among environmentally conscious consumers⁴⁸. It seems that positive behaviour change will not be motivated by appealing to the environment alone, but needs to be structurally and economically incentivised; as this report demonstrates, the relations between behaviour, consumption and carbon emissions are so complex that a consumer cause-effect understanding of carbon emissions will very useful in practice⁴⁹.

The lifestyle perspective is interesting because it puts attention on the ways in which various factors come together to mediate a “way of life”, both symbolically and in practice. While lifestyle has long been considered within consumption research, the new focus on the “situatedness” (or embeddedness) of lifestyle – how it affects and is affected by physical structures – deepens our contextual base for understanding household consumption in relation to other factors. Lifestyle, then, is predicated on a perceived understanding of the environmental impacts of various consumer choices, habits, and practices. However, as the focus on CBCA and embodied carbon demonstrates, this understanding is complicated by a lack of simple cause-effect relationships, largely due to rebound effects. Moreover, it becomes evident that lifestyle is as much, if not more, a product of structural determinants than ideological orientations.

6.2 Beyond the consumer: Structure and agency

Social practice theory is concerned with the omnipresent tension between structure and agency, which governs the processes by which social beings transform their lifeworlds through their practices (Bourdieu 1977; Giddens 1984). The ‘practice’ concept is defined by Reckwitz (2002: 249) as “a routinised type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, ‘things’

obvious that there exists a widespread dissonance between attitudes or values and actual behaviours, and that this applies to so-called “green” households and consumers *in general*.

⁴⁸ Godbolt (2015: 28) argues that “people tend to interpret knowledge in ways that fit their everyday life choices; they domesticate facts and knowledge in ways that easily integrate into their everyday lives”. Wier (2001) found that neither education level nor environmental knowledge bore any direct relation to carbon emissions produced in Danish households. Blake (1999), McDonald et al. (2015), Stoknes (2015), Holden (2005), Norgaard (2001), Davidson et al. (2014), Barr et al. (2010) all find cognitive dissonances and attitude-behaviour gaps when it comes to “green” lifestyles and carbon footprints.

⁴⁹ This point is elaborated on in the *rebound effect* and *practice* sections.

and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge”. For the purpose of this report, I refer to practice as this routinized type of behaviours, which is mediated through the relationship between structure (societal structures) and agency (the consumer/household).

Practice theories build on the notion of “structuration” suggested by Giddens (1984), which in essence implies that the omnipresent push-and-pull forces of agency and structures mediate all human action. Put differently, in some cases structural factors have the most power to determine actions, whilst in other cases the same can be said for human agency. The CBCA-oriented research on household consumption, and on carbon emissions in general, seem to suggest that structure tends to override agency: society is structured in such a way that almost any call to action has only moderate effects, if any – largely due to the prevalence of direct and indirect rebounds. Arguably, such practice-oriented insight is useful to determine what to focus on; which mitigation strategies have real implications for reducing carbon footprints, and which ones only have imaginary implications⁵⁰?

Spaargaren (2003) argues that a focus on practice and structuration allows for a contextual approach to consumption behaviour and lifestyle, which will be necessary to create knowledge around “the social conditions and circumstances that frame the green or sustainable alternatives” (p. 691). To understand the underlying mechanisms and drives for consumption, he argues, lifestyle groups ought to be mapped: “The lifestyle of each individual is constructed from a series of building blocks—corresponding to the set of social practices an individual invokes when pursuing his or her daily life. The lifestyle of an individual human agent is ... [defined as] the set of social practices that an individual embraces, together with the storytelling that goes along with it” (Spaargaren 2003: 689).

⁵⁰ When I write «imaginary implications», I refer to that which has gained status as pro-environmental choices or behaviours due to a cause-effect understanding of mitigation actions, and thus has become normative in society – but might not *necessarily* reduce overall emissions. There are many examples of this – moving to the city, downsizing one’s dwelling, eating “green”, installing heat pumps, buying a new and more efficient car, etc.

Building on this, the carbon footprint calculator solution suggested by Jones and Kammen (2011) might be a step in the right direction in terms of changing practices. They argue that households need to be empowered to make actual change, which has positive impact (also when rebound effects are accounted for). The carbon calculator allows households and other societal institutions to quantify and understand their total carbon impact, and therefore ought to help them “pick the right battle”, so to say. This could make mitigation efforts more effective. However, while this seems like a good idea theoretically, it is difficult to predict how it would turn out in practice. Nevertheless, there is need for more such concrete policy ideas which takes the contextual influences of practice into account.

Drawing on Ritzer's consumption theory, Høyer and Holden (2003: 329) argue that physical structures shape "human attitude and actions". Moreover, all human-made objects – "artefacts", e.g. houses, cars, phones – influence behaviour. Given that materials and artefacts are always distributed in space, they produce "socio-spatial structures" and "socio-spatial fields of action", with which there is always a correspondence with humans (p. 329)⁵¹. Through this correspondence, a normalisation has led to "requirements" of behaviour and consumption within and between households. These requirements shape, and are shaped by, attitudes and lifestyles, which in turn are tied to socio-economic and socio-demographic contexts. This argument is similar to that of Verbeek (2006: 361), who suggests that technologies gain the power to answer "the ethical question of how to act" through their materiality, thus effectively transforming the practitioners' perceptions of reality. This theoretical understanding of consumption helps us conceptualise some of the indirect influences on consumption behaviour in households⁵².

Ryghaug et al. (2018) argue that new energy technologies might have the power to create new energy practices, by stimulating new forms of interactions between consumers and their energy-using materials. This, they argue, is a potential avenue for the co-creation of energy citizenship ("increased engagement with and participation in low-carbon energy transitions"; Ryghaug et al. 2018: 295).

A focus on CBCA and embodied carbon makes apparent the undeniable complexity of consumption, carbon emissions, and overall environmental footprints. As Estiri (2015: 109) is right in arguing, household energy consumption is "a complex socio-technical phenomenon" – it is derived, motivated, and limited from *both* (a) "soft" social organisation of behaviour, and (2) "hard" structural, material, and technical variables. Similarly, Spaargaren (2004) argues that we need to focus on consumer practices as "the deliberate achievements of knowledgeable and capable agents who *make use of the possibilities offered to them in the context of specific systems of provision*" (p. 688; my emphasis).

⁵¹ Von Grabe (2016a, b), for instance, writes about how this correspondence works through human-building-interactions, whereby occupants of a building interact with equipment/elements in the building to optimize their local environment.

⁵² See Figure in Appendix 4 for an illustration of this theory.

According to Godbolt (2015), energy behaviours can be understood as the intersection between (1) cognitive norms, (2) material culture, and (3) energy practices. She suggests that consumers' "energy culture" revolves around specific understandings and perceptions of the energy that is used. In her study of how Norwegian consumers framed and understood their energy use, she found that they developed an "ethos of energy efficiency" – i.e. "a set of guiding beliefs or values" – that they used to determine and justify their energy behaviours. Four moral positions were found to influence this, namely: savings, merits, needs, and entitlements. The fact that the consumers perceived energy as something *more* or *other* than energy suggests the relevance of *practice* to conceptualise consumption behaviours, and that structural factors will be needed to "direct" consumer agency towards less overall consumption.

There are in particular four concepts that ought to be focused on in terms of understanding the ways in which structure influences agency when it comes to household carbon footprints.

- **Infrastructure.** This concept relates to the ways in which socio-material structures in society directs behaviours, or mediate practice by affecting agency. An "infrastructural perspective", according to Spaargaren (2003: 691-692), puts "special emphasis ... on the ways in which modes of design, production, and distribution at the providers side of the chain do or do not correspond with certain mode of access, use, and disposal at the consumer end of the chain". In other words, the focus on producers/consumers and production/consumption ought to be linked to understand the lifecycle of carbon emission processes.
- **Material agency.** Relates to the extent to which material fabric can have the power to influence human behaviour or acts. If so, this needs to be used actively to benefit the environment. The agential role of a material can also be "scripted" into it through its design. We need infrastructures that incentivise low-carbon behaviours. In terms of human-buildings interactions, for instance, von Grabe (2016a: 75) argues that "the prediction of these interactions needs to be included in optimization calculations".
- **Lock-ins and path dependencies.** We need structures which "lock in" pro-environmental behaviours, or at least avoid "lock in" of non-environmental behaviour. For instance, if there are good bike lanes and access to e.g. city bikes, chances are more people will cycle instead of driving a car. On the other hand, if there are no bike lanes,

or lacking public transport, a “lock-in” mechanisms is effectively created so that consumers will have to drive their cars to get from point A to point B. On a macro-scale, dependence on extraction of fossil fuels has led to a path dependency for Norway whereby the economy has been dependent on this high-emission activity to sustain economic growth. To reduce carbon emissions, such destructive path dependencies and lock-ins must be avoided.

- **Nudging**⁵³. This concept refers to a process by which societal structures are shaped as to motivate a certain behaviour from consumers. This can entail making a low-emission consumption choice easier to make, while making a high-emission choice more difficult.

The general conclusion here is thus that environmental choices must be easier to make; structures must direct agency in the right way.

Using the practice approach as a base, Spaargaren (2003) suggests that, in terms of policy, there is a need to develop “environmental heuristics” for different social practices. “Environmental heuristics can be regarded as rules of thumb to be used by citizen-consumers in determining ‘how to go on’ in a more sustainable way in the context of the time/space-bound daily routines they are involved in. These heuristics connect the predominantly technical rationale of environmentalism to the social rationale of the lifeworld and at the same time reduce the complexity of sustainable consumption in such a way that it fits the practical logic of daily life” (Spaargaren 2003: 690). Arguably, such heuristics would have to include different infrastructural pathways so that changes in behaviour and lifestyle would be made possible without rebound effects (see next section)⁵⁴.

Nevertheless, while it will be crucial to focus on “energy behaviour” as part of an “integrative perspective when addressing energy behaviours and designing effective behavioural change interventions and energy efficiency policies” (Lopes et al. 2015: 84), the complexity of these behaviours must be addressed. Lopes et al. (2015: 85) map out the different behaviours that comprise someone’s “management and provision of energy resources” must be accounted for in such an integrative model – “investment behaviours”, “efficiency behaviours”,

⁵³ Cass Sunstein developed, and has written extensively about, “nudge theory”, which builds on this premise.

⁵⁴ This could be combined with a consumer-oriented carbon footprint calculator of some sort (cf. Jones and Kammen 2011).

“maintenance behaviours”, “usage behaviours”, and “curtailment and conservation behaviours” (see the paper for visualised models).

In addition to (1) environmental heuristics development, Spaargaren (2003: 697-698) suggests the following practice-oriented policies for sustainable consumption: (2) identify/analyse potential “routes of innovation” within social practices, e.g. manoeuvring infrastructure via “lock-ins”, scripting, etc.; (3) analysis of style/symbolism in lifestyle groups, i.e. exploring the cultural-symbolic drivers of non/environmental trends/practices; and (4) redefine roles of governmental and non-governmental actors in policy-making depending on the individual social practices, i.e. making policy revolve around the different *practices* (and not the *practitioners*).

An open question that remains is the extent to which infra/structural elements of society that have detrimental path-dependency and lock-in mechanisms built into them, or that contribute to excessive emissions due to inefficient technology and so on, ought to be changed for something “better”. A CBCA perspective complicates our understanding of carbon footprints because it includes the emissions that are *embodied in/through production*. In other words, when we identify faults with current fabrics of society – e.g. infrastructure – will it be better to tear this down and build a new, better version; or will the carbon embodied in production override this?

Muller et al. (2013) studied the emissions embodied in the whole life-cycle of infrastructure, i.e. the construction, use, and end-of-life phase. They found that a vast amount of these indirect emissions occur in the early phases, i.e. the construction phase; and that these are often emitted decades before the use-phase begins. Infrastructure is a crucial aspect of total carbon footprints because it constitutes a form of “lock-in”. To exemplify: will building extensive speed-train infrastructure contribute to lower total emissions from long-distance travel, or will the emissions embodied in production negate this effect? What time-scales do we need to consider when thinking this way? Questions such as this, brought up by a focus on embodied emissions, need to be grappled with to avoid major rebound effects.

6.3 Beyond change: The rebound effect

Attention put on the rebound effect has been a trend throughout the literature review. CBCA and attention to embodied/indirect emissions make it clear that, rather than reducing overall emissions, mitigation efforts – whether that be through policies or behavioural changes – tend to have less than a desired effect due to rebounds⁵⁵. Arguably, when discussing how to reduce emissions at any scale, the rebound effect is the elephant in the room. If we are to transition to a low-carbon society, then, effective change without counter-intuitive rebound effects is key.

Hertwich (2005) provides a useful conceptual overview of the rebound effect from the perspective of industrial ecology, which is generally concerned with more complex rebounds than energy economics, which usually focus on energy rebounds alone. Indeed, while the energy economics rebound is concerned with behavioural and systems responses to cost reductions of energy services as a result of energy efficiency measure, industrial ecology is concerned by the notion that “Any given efficiency measure has several types of environmental impacts” (Hertwich 2005: 85). Rebound effects can be weak or strong (measured by the extent to which efficiency benefits are lower than expected), or lead to a complete backfire (i.e. cancelling out initial benefits completely). In essence, rebound effects describe *ripple effects* from change making - which can also be positive, moving in the “desired direction” (Hertwich 2005: 85). Moreover, rebounds can be direct or indirect – the table below is based on Hertwich (2005).

⁵⁵ For instance, carbon leakage tends to constitute a form of rebound effect on the global level. The data show that the UK's emissions from imports will rise in the future, while the domestic GHG emissions will sink – in other words, while the production-based inventories will make it seem like the UK is emitting less, the net environmental impact of UKs trade operations will keep rising (Barrett et al. 2013).

Overview of different rebound effects (Hertwich 2005).

Category	Rebound effect	Explanation
Direct / micro rebound effect	Substitution effect	Efficiency gains in energy service motivates to increase overall demand for the service.
	Income effect	Efficiency gains in energy service leads to price reduction; consumers then spend the money saved on other energy-consuming purchases.
Indirect / macro rebound effect	Secondary effect	Efficiency gains leads to reduced cost of a product or service; this stimulates increased overall demand.
	Economy-wide effects	Usually applies to fuel, electricity, etc. General energy efficiency reduces demand for fuel, which in turn reduces fuel prices; this stimulates increased overall consumption of fuel.
	Transformational effects	Changes in technology alters consumers' preferences, social institutions, and rearranges the organisation of production.
Alternative concepts (Hertwich 2005: 90-91)	Co-benefits	Describes a (policy) change that (directly or indirectly) also leads to positive ripple effects beyond the scope of the policy (i.e. domino effect).
	Negative side effects	Describes a (policy) measure which addresses a single issue but which negatively impacts another issue
	Spillover effects (behavioural rebound)	Describes positive, indirect behavioural effects; for instance, adopting one pro-environmental behaviour might reduce time/money for general consumption, or prompt the adoption of another.

In addition to these, Jalas (2002) suggests a time-rebound, suggesting that technical progress leads to time saving; and that this newfound time can be invested into more consumption. This builds on the premise that in present-day societies, consumption as an *activity* has become an ends in itself and not just a means – it has intrinsic value as a practice (Jalas 2002: 111). Jalas (2002) suggests that time is in fact a better indicator than money in terms of consumption.

On a national or global scale, it is evident that increased efficiency per unit of consumption can easily be undermined if there is economic growth or population growth which leads to the sum total consumption (and thus production) of these units increasing. For instance, while Norwegians used less electricity per household in 2017 compared to 1993 (although electricity use in cabins has increased threefold in the same time-period) – but overall Norwegian electricity consumption has increased due to increase in material welfare and population (SSB 2018b). Moreover, as studies by Holden (2004) and Norland et al. (2004) among others show, lifestyle choices among Norwegians (green vs non-green) can lead to rebounds through attitude-behaviour gaps⁵⁶.

Bjelle et al. (2018) addresses the potential for mitigation within Norwegian households accounting for the rebound effect, which constitutes a “re-spending” effect in practice. They find that, without accounting for rebounds, households can obtain a 58% decrease in carbon footprint; with rebound accounted for, households can obtain a 24-35% decrease⁵⁷. The first target would be sufficient to meet the reduction target set by the Paris Agreement (sub two degrees by 2050, which will require a 40%+ reduction in household emissions) – the latter would not. It is thus crucial to account for rebounds. Bjelle et al. (2018) therefore suggest that, in order to have any change of meeting the reduction goal, re-spending needs to be restricted to *specific* goods and services; in which case the rebound effect is curbed, and a 45% decrease is possible. While this process will require “moderate to large changes”, it is important to remember that “the potential reductions are larger when including future efficiency

⁵⁶ Bjelle et al. (2018: 209) cite sources finding the relative rebounds of re-spending from different behavioral actions: 49% for a vegetarian diet; 42-49% for car sharing; 5-15% for household energy improvement; 3-5% for hybrid electric car; and 238% for “green” food consumption. This demonstrates rebound effects in households in practice.

⁵⁷ For context, it has been found that behavior factors alone can produce around 20% savings in energy (Lopes et al. 2015: 84).

improvements in production and optimal collaboration between producers, consumers and policy makers” (Bjelle et al. 2018: 214).

Attention to rebound effects makes clear that (ecological) efficiency of production is worthless from an environmental perspective unless there is equal attention to (consumer) efficiency of consumption (Jalas 2002; Bjelle et al. 2018: 208). Indeed, consumption-side changes will be needed, as “technological improvements have not outweighed the growth in impacts due to increased consumption” due to increased demand due to higher standards of living and growing populations (Bjelle et al. 2018: 208).

From a policy perspective, it will be important to (1) limit negative rebound effects, side effects, and spillover effects; while (2) make use of “positive” rebound effects, spillover effects, and co-benefits as best as possible. Consumption-driven emissions must be reduced through a focus on (1) *sufficiency* (i.e. overall consumption must be reduced), and (2) *efficiency* (i.e. consumption patterns must be shifted towards less emission-intensive goods and services) (Bjelle et al. 2018). In practice, this implies that consumers ought to “re-spend saved money on goods and services that are both fulfilling and have low emission multipliers”, and/or alternatively “re-spending on higher quality goods and services” (Bjelle et al. 2018: 215). The first step towards reducing negative rebound effects must be to adopt a CBCA understanding of emissions, since this reveals a magnitude of indirect rebound effects that might not have been sufficiently taken into account otherwise. While some reduction is possible through shifting of re-spending, overall de-growth will be the only secure manner to reach the mitigation goals set forth by the Paris Agreement.

6.4 Discussion

While it is clear that solutions for reducing consumption must be developed within the context of each specific case⁵⁸, some factors will always play a part in determining overall indirect emissions from energy use and consumption. A CBCA framework makes it more intuitive to operationalise some of the more “vague” factors playing a part in this puzzle, such as the ones

⁵⁸ As Wier (2001) concludes, “characteristics of energy consumption are unique to each country, and determined by distinctive features such as resource endowment, historical events...socio-cultural norms, behaviours and present market conditions, as well as energy and environmental policy measures. Consequently, there is no one-fits-all recipe for planning for energy reduction” (p. 201).

discussed in this chapter – lifestyle, practice, and rebounds. This section addresses some policy-oriented implications arising from these themes.

The lifestyle approach to understanding consumption is important because it extends the operationalisation of “indirect” or “embodied” consumption to the more abstract realms of consumers’ ways-of-life. In other words, rather than addressing how a certain amount of emissions are embodied into a specific good or service, this focus demands attention to how emissions are effectively embodied into one’s lifestyle. Lifestyle is also about self-perception. Arguably, the lifestyle concept is useful for policy-making because it describes the intersection between structure and agency – the research seems to show that structures can influence lifestyles the way lifestyles can influence structures.

Therefore, lifestyle can be considered a more “soft” variable which nonetheless impacts on the other variables, and which can be tied to agency – both to the agency of the consumer, and to the agency of materials (if we accept the material agency premise). When a family moves into a new house, for instance, the lifestyle of that family will affect how they consume as a household (agency); but the structural elements of that house will also motivate to a certain form or extent of consumption (structure; material agency). As Hoornweg et al. (2011: 12) notes, lifestyle choices are affected by structures and policies; and as Estiri (2015) argues through his “housing choice effect” concept, these might be long-lasting due to their material embeddedness. The studies that show higher emissions in cities due to indirect emissions, effectively demonstrate the effects of lifestyle in practice (e.g. Nilsson and Brandt 2013).

In this sense, socio-economic and demographic variables cannot make full sense of household consumption patterns. As Holden (2004: 54) concluded from his findings: “A household member with a low ecological footprint does not live in a large house, has no access to a car, and lives in a low-income family with many members ... the typical high-footprint person lives alone in a large house, has daily access to a car and earns lots of money”. Similarly, Wier (2001: 273) suggested that “the explanation of the consumption patterns should be based preferably on economic variables and housing characteristics, rather than on socio-cultural variables”. These statements are, of course, true – but it is important that there needs to be some variables which makes households “arrive” at their state of being. In this sense, an attention to

lifestyle would suggest that socio-cultural variables can be equally important given their indirect effect on the other variables⁵⁹.

Michaelis (2000; paraphrased in Holden 2004: 47) has suggested that four general bundles of factors shape consumption patterns: (1) demographic/economic/technological change; (2) resources/infrastructure/time constraints; (3) motivation/habit/needs/compulsion; and (4) social structures/identities/discourse/symbols. A CBCA oriented focus, which in turn makes a focus on lifestyle, practice, and rebound effects more relevant, allows us to “tap” more into these factors.

If we broaden our understanding of household consumption this way, lifestyle, practice, and rebounds seem to operate in symbiotic relationships. Indeed, lifestyle and practice are tightly interwoven, and these work as “directing” forces for different rebound effects – for instance, as have been shown, households that emit less in terms of everyday travel emit more in terms of holiday travel, and vice-versa. If the causal relationships between structural elements – household characteristics, land-use characteristics, etc. – and lifestyle factors can be better understood, together with the rebound effects these produce, then policy makers can work on mitigating or “re-directing” these rebounds towards less emission-intensive consumption options.

One policy route is to create a deeper understanding of one’s role as a consumer or household in contributing to climate change through consumption-related emissions. While attitude-behaviour gaps are difficult to manoeuvre around, some suggestions have been made – Weidema et al. (2008) argue for making use of the carbon footprint concept as a more consumer-oriented tool to frame and understand own consumption⁶⁰; and Jones and Kammen (2011) suggest empowering households to make change through encompassing carbon footprint calculators. NGOs, companies, and private initiatives, as well as individual consumers and households, can use online carbon footprint calculators to understand and contextualise

⁵⁹ This is difficult to measure in an economic model, of course; but ought to be considered by policy-makers – if the consumption “culture” in Norwegian households can be re-oriented towards buying less and buying different (thereby “decoupling” some of the trends discovered in the research, e.g. income-consumption), there might be potentials for substantial emission reductions.

⁶⁰ “Carbon footprints carry the potential of being a good entry point for increasing consumer awareness and fostering discussions about the environmental impacts of products. This, in turn, facilitates the diffusion of life cycle thinking and LCA. It may even have the potential to promote a more consistent framework for environmental assessment of products and services” (Weidema et al. 2008: 6).

their own carbon footprints (Weidema et al. 2008). The underlying premise here is that households need to understand the impacts of their practices on a deeper level than that of the conventional production-oriented emissions logic. Only through a full understanding of the total carbon footprint can rebound effects be reduced. This, of course, has to do with changing practices, but also motivating certain lifestyles.

Mitigating negative rebound effects by shifting “re-spending” to higher-quality goods and services is an obvious policy opportunity to reduce indirect emissions from household consumption (cf. Heinonen et al. 2013a; Bjelle et al. 2018). The relative quality of what is consumed is another factor tied to lifestyle or consumption “culture”⁶¹, in the sense that it concerns *how* consumers choose to spend their time and money. Understanding the factors that contribute to the quality of a product will require a deeper understanding of how emissions become embodied into them.

Given the effect of global transportation, especially when it comes to food and consumer goods, this will likely demand increased focus on more localised provision strategies. Hoornweg et al (2011) argue that action needs to begin with “a good understanding of emissions sources” through an “inventory” of GHG emissions starting at the local level; and that this is “critical to drive municipal policies and actions” (p. 19).

One of the most crucial policy implications arising from the discussion of the literature reviewed in this report, is to adopt economies of scale beyond the current household structures. Most importantly, this will involve a focus on how to share resources beyond the family boundary in cities (Heinonen et al. 2013b). The statistics show that household sizes are decreasing in Norway, which means that the economy-of-scale effects are currently not being maximised (SSB 2012; 2018c). This will also require attention to lifestyle and practice.

The overarching implications and goals of this research however, is well articulated by Heinonen et al. (2013b: 9), who argue that it provides “a step towards discussing the impacts of directing consumption towards goods that either relatively or even absolutely reduce the

⁶¹ Such consumer “culture” can also be tied to specific consumption related practices – for instance, Høyer and Holden (2003) addresses renovation as a means of “re-enchantment” of one’s dwelling. They argue that growing housing spaces and suburbanisation have promoted a “renovation culture”. While fixing, repairing, and bettering materials ought to be an imperative for sustainable consumption, renovation tends to be tied to aesthetics and improvement.

caused emissions. It would imply considering the structural and physical constraints and enablers of the personal strategies of working, earning and consuming less or directing the earnings in a way that would reduce the emissions". A similar conclusion is reached by Bjelle et al. (2018: 215): "The focus should ... be to re-spend saved money on goods and services that are both fulfilling and have low emission multipliers", alternatively "re-spending on higher quality goods and services". These arguments both lean towards adapting a less materialistic lifestyle as the end-goal. The question is, however, how can this be *structurally* promoted into society through policy? With CBCA as a starting point, this question needs more focus.

Given the evidence suggesting the high importance of economic factors, more radical "de-growth" and "downshifting" strategies ought to receive more attention (Heinonen et al. 2013b: 9). The key point of the de-growth argument is that in order for sustainability to be achieved, not only consumption but also production needs to decrease (Nørgård 2013). Some alternative approaches focus on changes in work structures as a key aspect of such a transition. Schor (2005) argues that we will need to reduce work-time hours to achieve de-growth, given that, when productivity growth is channelled into income, it leads to more consumption and thus more emissions. Efficiency is thus lost to growing living standards and rebound effects. However, given the time-rebound sketched out by Jalas (2002), a potential issue with this reduction in work-time hours would be that more time would effectively be freed up to consume. As such, one could argue, the reduction in income would have to be parallel with the reduction in work time for this to be a viable option.

Nørgård (2013) proposes another solution for "happy degrowth", which is to transfer/shift some activity from the "professional economy" to the "amateur economy" through reducing work-time hours. She argues that a growing amateur economy could shift possible consumption time into production time while also sparking happiness and wellbeing, thus making for a win-win situation⁶². The basis for this argument is that the amateur economy is driven by people's *affective* rather than purely *economic* motivations (happiness) while also taking longer time to produce products (less time to consume), and could be part of self-sufficiency strategy within communities (less indirect emissions). While these visions for a sustainable future through de-growth will likely remain thought experiments, they are useful

⁶² The paradox here is that the total amount of work time thus would increase, although more time would be spent on an "amateur" basis and less on "professional" work.

in the sense that they question the current structures of society and how these contribute to excessive consumption. The remaining question is whether time or money are more important for consumption activity – especially when the relative quality of consumed products are taken into account⁶³.

6.5 Chapter summary

- Lifestyle factors help producing a more complete picture of household consumption by focusing on the consumption that happens outside of, or parallel to, the actual household. Cities motivate higher total consumption. The availability of consumption-oriented spaces and services lead to “parallel consumption” in cities (Heinonen et al. 2013a, 2013b). Disposable income is a better indicator of actual lived lifestyle than perceived lifestyle or attitude/knowledge/values.
- Practice theory directs attention to the ways in which consumption is jointly enabled or motivated by agency and structure. In terms of household emissions, attention ought to be put on structural factors which affect practices and in turn consumption – such as lock-in mechanisms, path dependencies, or scripting. These can work both to increase and reduce consumption, and can therefore be tools for policy-makers.
- The rebound effect is a known issue for consumption policy. A CBCA perspective shows that rebound effects are even more prevalent, given that new pathways for re-spending and “shifting” of consumption open up as embodied emissions are taken into account. In order to reduce overall consumption, policy makers will need to address ways to ensure “positive” rebound effects (win-wins).
- Insight from these alternative approaches can inform policy by extending the realms of emissions embodied through indirect consumption beyond the household, and by motivating the questioning of the impacts of some ways in which our society is generally structured.

⁶³ A possible and unfortunate scenario of a reduced work day would be that more time would be freed up for consumption activities while lower salaries would lead to consumption of lower quality products, and thus the total carbon footprint of the consumer/household would increase. More research and calculations would be needed to find out how these various factors affect overall carbon footprint.

7. Summary and implications

7.1 Summary of findings

Holden (2004: 46) lists four empirical dimensions that must be considered to achieve sustainable consumption: (1) disruptive human activities; (2) actors performing these activities; (3) forces making these disruptive; and (4) ways to change these activities. From a policy perspective, all of these must be taken into account. Corresponding to these four dimensions, the CBCA related literature reviewed in this report shows that:

- (1) Consumption of non-energy consuming goods and services still have negative effects on the environment due to the indirect emissions embodied into them;
- (2) On a macro-scale, developed economies contribute disproportionately to increased global emissions due to consumer demand and carbon leakage; on a micro-scale, households make up a substantial part of global emissions (~70%) when indirect emissions are accounted for;
- (3) The production and provision of goods and services generate emissions along their whole lifecycle, much of which is (a) “lost” through transnational transport under current accounting methodology (i.e. responsibility is unaccounted for), and (b) loaded onto developing economies whose technological production mechanisms are relatively inefficient and thus emit more, and who must suffer a double burden due to increased local pollution; and that
- (4) The more nuanced and holistic understandings of energy and emission requirements brought to the fore by CBCA related literature allows for new policy strategies, especially in terms of accounting for potential direct and indirect rebound effects.

In addition to this, the following are the most important findings from the literature reviewed in this report, summarised into a few bullet points:

- CBCA analysis demonstrates that most developed countries are net importers of emissions while most developing countries are net exporters of emissions. Attention is brought to the role of affluent consumers in facilitating this flow of goods and

services from developing to developed countries, thereby providing an alternative to the “factories of the world” narrative.

- The conventional production-based carbon accounting methodology currently employed to determine carbon budgets on a global scale is flawed, both in terms of methodological effectiveness (it is not able to properly account for all emissions) and in terms of equity and fairness (it allocates all responsibility onto producers despite the demand being driven by consumers; and it incentivises shifting of production/manufacturing to developing economies with less efficient production technologies). While CBCA offers a theoretical solution to these issues, practical implementation would be problematic due to its methodological complexity and geopolitical barriers. Hybrid approaches tend to be even more complex and suffer from similar issues.
- CBCA analysis shows that “the majority of emissions in Norwegian consumption are embodied in imports; signifying the importance of considering regional technology differences” (Peters and Hertwich 2004). Half of Norway’s emissions occurred externally, and half of these in turn in developing economies in 2004 (ibid). Due to emission-intensive exports (oil and gas), Norway is – as one of few developed economies – a net exporter of emissions. Still, given that, in relative terms, Norwegian fossil fuels are “cleaner” than those produced anywhere else in the world, the argument could be made that the production is justified as long as there is demand. Under this premise, implementation of CBCA could be a win-win scenario for Norway if the demand for oil/gas remained static, given that (1) the consumers would be held responsible for the emissions; but (2) they would nonetheless be incentivised to buy from Norway due to *relatively* low emissions.
- Indirect (embodied) energy requirements tend to make up the largest part of the total amount of household emissions. While only 20% of total emissions are typically allocated to the household, a CBCA framework would therefore increase this to more than 70%. When considering indirect as well as direct emissions from consumption, economic factors (disposable income and total expenditure) are the single most important in determining the carbon footprint of households; both in terms of household and land-use characteristics. However, more attention needs to be put on the effect of increased quality of a product on its carbon footprint. Generally,

consumption related to housing, transport, and food are the highest. Some of the most emission-intensive household categories – e.g. food and consumer goods – were largely imported.

- All household variables being equal, urban living correlates with lower household emissions. However, given the differences in structural composition and characteristics of the households in cities compared to suburbs or rural areas, CBCA analysis attributes a higher amounts of emissions to urban households. In particular, “lifestyle” factors and “parallel consumption” in cities increase indirect emissions (Heinonen et al. 2013a, 2013b).
- One of the most important findings in terms of household characteristics, in addition to the importance of income, is that larger households have lower per capita emissions due to the economy-of-scale effects that come with co-sharing space, goods, and services in almost all instances. This is also an example where social sustainability seems to be a precursor to environmental sustainability. It is important to note however, that while economies of scale definitely apply to households, they do not apply to cities – past a certain level of growth, cities become less environmentally efficient (Timmons et al. 2016: 139).
- Rebound effects are a pressing concern when it comes to mitigating emissions. CBCA analysis provide a better understanding of how rebounds occur. Values/beliefs/attitudes in terms of the environment have not been found to reduce household carbon footprint, in fact the opposite might be the case (Norland et al. 2004; Holden 2004; Godbolt 2015; Wier et al. 2001; Norgaard 2001) – this is seemingly due to rebound effects from air-travel and indirect emissions from consumption.
- CBCA also directs newfound attention to issues of temporality. It is important to consider that indirect/embodied emissions have a past and a future. Moreover, while technical efficiency can reduce emissions, time can be freed up for other forms of consumption, making for a time-rebound (Jalas 2002).

7.2 Implications of findings

While it is beyond the scope of this report to suggest specific policies, some general implications for policy and for how we ought to think about consumption are addressed in this section.

7.2.1 General implications

- While it does not seem likely that CBCA is a good alternative to replace production-based accounting due to the flaws discussed in this report, it serves as a valuable tool to better understand how indirect emissions affect the environment, and how attention to this changes our “mapping” or understanding of who are responsible for, and what drives, emissions. Consumption-based perspectives will be important to provide a full picture of current emissions at all levels, so that the sum total of global emissions can be reduced; not just shifted around. On these grounds, CBCA ought to receive more focus among policy-makers and politicians as well as consumers. On the one hand, it constitutes a useful tool that can be operationalised by policy-makers and researchers through MRIO/LCA analysis, and by consumers/households through carbon footprint calculators. This way, CBCA can work as a “shadow indicator” (Peters 2008: 20) to supplement and correct for issues occurring through conventional carbon accounting procedures. On the other hand, it has potential as a “thought experiment” which allows for a new way of thinking about consumption and responsibility which ought to be part of the public discourse.
- Attention to indirect consumption has revealed the issue of rebound effects, which seems to nearly be inescapable in any society where economic growth is the norm. We know that in order to avoid rebound effects, it is not enough to improve efficiency of production; this must be coupled with a focus on sufficiency, i.e. producing and consuming less. However, this will not happen overnight. Therefore, in order to mitigate emissions within the current growth-paradigm, rebound effects need to be *taken advantage of*. From a policy perspective, it will be important to (1) limit negative rebound effects, side effects, and spillover effects; while (2) make use of “positive” rebound effects, spillover effects, and co-benefits as best as possible. One possible avenue to make use of the rebound effect, is to promote the consumption of better

quality, more expensive goods and services. Doing so, it seems, produces a positive rebound effect in that (a) the product is less emission-intensive and lasts longer; and (b) less money is freed up to “re-spend” on other products⁶⁴.

- Policy efforts should be directed towards mimicking larger households to reap the benefits of economy-of-scale effects, particularly because the household sizes in Norway are decreasing (cf. SSB 2018c). This can likely be done indirectly in many ways through smart solutions. The key element here seems to be *sharing* – a goal for neighborhoods, then, ought to be creating more avenues for sharing rather than private ownership. Moreover, services providing renting or sharing options for cars, clothes, tools, and so on seem to gain popularity. The renting model implies spending money without buying, which could constitute a positive rebound. The same is true for the consumption of second-hand and refurbished goods. In general, more research should be done on the potentials for the sharing economy and the circular economy in terms of providing beneficial rebound effects and reduced indirect emissions from household consumption.
- Arguably, more attention needs to be put on structures and materials than facilitating pro-environmental lifestyles per se. The research shows that the latter leads to indirect rebounds through e.g. increased air-travel. Low-emission consumption choices should therefore be structurally enabled. This has been discussed in relation to urban planning (see Chapter 5) and structure-agency/practice approaches (see Chapter 6.2).
- CBCA makes clear the incentive for implementing various emission-related taxation schemes by internalising indirect emissions – which are currently externalised – into product prices (cf. Liu 2014). A more low-bar approach would be to implement carbon footprint labelling on all goods and services, making it easier for consumers to understand the environmental impact of their practices. This could be a policy option which would implement CBCA thinking into the conventional system.

⁶⁴ For instance, within the consumption category of “food”, buying local produce might be an example of this in practice – this would also have the additional effect of reducing indirect emissions from transportation. However, more research is needed to determine exactly where such positive rebound effects have the most potential.

7.2.2 Implications for the Norwegian context

Statistics Norway (SSB) offers a broad range of statistics related to Norwegian consumption and emissions. Nevertheless, no information is to be found regarding consumption-based carbon accounts. While the conventional – that is, production-oriented – statistics illustrate various trends and scenarios, it does not paint a complete picture of the global impacts of consumption. (See Appendix 6 for an overview of relevant SSB statistics available – these could arguably benefit from additional CBCA-based data). Additionally, various statistics on city areas (bydeler) and municipalities (kommuner) can be found in Statistics Norway’s statistics bank⁶⁵. There are no statistics on consumer impacts of different municipalities per se; nor are there any statistics on household consumption by municipality except for electricity. Still, a few of the statistics might be useful for contextual/illustrative purposes (see Appendix 7 for overview and links to these). To gain a better understanding of the indirect emissions from Norwegian households, more mapping and surveys ought to be done on this; statistics ought to reflect indirect as well as direct emissions. In general terms, the findings and implications listed above are also relevant to Norwegian households.

7.3 Relevance for INCLUDE

One of the key aspects of the INCLUDE project is to assess the options for total reduction of embodied emissions. CBCA analysis provides a gateway to understand how these embodied emissions work. This report has addressed the potential of CBCA on a more general basis, but also in relation to Norway. Given that income expenditure seems to be the most important factor for households’ contribution to total emissions, social inclusiveness should be possible to protect while focusing on mitigation options. Due to lifestyle-related rebounds, it is rarely those with less money who emit the most, regardless of their (consumption) practices.

⁶⁵ City areas: https://www.ssb.no/offentlig-sektor/kommunetall/bydelstabeller#Barn_familier_og_husholdninger
Municipalities: <https://www.ssb.no/offentlig-sektor/kommunetall/kommunetabeller>

7.4 Some limitations and loose threads

- This report has only reviewed the “surface” literature on the topics discussed. Future inquiry would benefit from looking more closely at the economics and the mathematical models used in the different models.
- While the Norwegian context has been considered, lack of time/scope/data availability has led to a limited focus on Norwegian municipalities. Future inquiry could benefit from looking into or doing specific case-studies on the emissions embodied in consumption in different regions and municipalities, to gain a better picture of which areas and what processes have the greatest mitigation potential and so on.
- Some of the research discussed in this report might be somewhat dated. With a longer time-frame, even more recent development within the field could have been implemented.

7.1 Some suggestions for further inquiry

- Exactly how can “positive” rebound effects be operationalised? What products/goods/services have the most potential here? How can consumers be motivated, enabled, or directed to consume these? Both qualitative and quantitative studies could be fruitful to find out more about this.
- How can we account for emissions resulting from the post-use phase of consumption? How can this be incorporated into a CBCA framework? How ought we think about post-use emissions when assessing consumption-related emissions? How can a post-use perspective influence our understanding of, and assessment of the potential for, a circular economy model? What would the implications of a post-use perspective be on the carbon footprint of Norway and Norwegian households?
- Which concrete measures could be taken to reap the environmental benefits of economy-of-scale effects seen in households without suffering the consequences seen in large cities, where the economy of scale does not seem to apply? (cf. Timmons et al. (2016))
- How can structural strategies be implemented to motivate sustainable consumption? How can “infrastructure”, “path-dependencies”, “lock-ins”, “nudging”, and similar concepts be implemented in practice?

- What is the role of ageing trends on total carbon footprints? How does indirect emissions embodied in increased individualistic solutions and hospital/medical related expenses from an ageing society impact the carbon footprint?
- How do investments, saving, and choice of banks affect indirect emissions? What is the mitigation potential of switching to a banking service with a more environmentally beneficial investment profile?
- How can CBCA illuminate the indirect emissions generated through food consumption? How can the results of this be implemented through labelling or tax mechanisms?
- Is there any potential for “gamification” strategies to reduce carbon footprints? If so, how could embodied carbon be integrated? Can the carbon calculator tools discussed in this report play a part here?

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Appendices

APPENDIX 1: Summary of findings, from Ivanova et al. (2017: 3).

Table 1. Summary of exploratory hypotheses on relevant factors for consumption-based GHG emissions per capita. The table broadly agrees with an assessment conducted by Hertwich (2005) on energy consumption and CO₂ emissions.

	Factors	Direction of effect	Reasoning	Sources
Socio-economic	Income (INC)	+	Income directly determines household capacity to consume. The direction of the effect is more difficult to predict on product level, e.g. there exist inferior goods whose consumption goes down as income rises	Wilson <i>et al</i> (2013b), Tukker <i>et al</i> (2010), Peters and Hertwich (2008), Jackson and Papathanasopoulou (2008), Lenzen <i>et al</i> (2006)
	Household size (HHSIZE)	—	Household members share electrical appliances and require less individual living space Economies of scale in different consumption domains	Tukker <i>et al</i> (2010), Lenzen <i>et al</i> (2006), Wilson <i>et al</i> (2013b), Minx <i>et al</i> (2013)
	Urban-rural typology (URBAN)	+/-	Urban typology is associated with more compact development and larger availability of public transport, but studies have also found urban inhabitants to have higher impacts associated with food, leisure travel and manufactured products	Marcotullio <i>et al</i> (2014), Tukker <i>et al</i> (2010), Lenzen <i>et al</i> (2006), Minx <i>et al</i> (2013), Wiedenhofer <i>et al</i> (2013)
	Tertiary education (EDUC)	+/-	Education and social status redesign individual preferences towards more or less emission-intensive lifestyles	Chancel and Piketty (2015)
	Basic need spending (BASIC)	—	Spending on necessities (food, shelter, clothing) may be associated with lower emissions per unit of expenditure compared to that of transport and manufactured products	Ivanova <i>et al</i> (2015), Steen-Olsen <i>et al</i> (2016)
	Dwelling size (NROOMS)	+	Housing size determines the requirements of space heating/cooling and building material use	Lenzen <i>et al</i> (2006), Newton and Meyer (2012)
Geographic	Temperature (HDD)	+/-	Lower average temperatures (north) and low-quality, poorly isolated homes (south) are associated with higher emissions. Rising temperatures may also drive energy use for cooling.	Minx <i>et al</i> (2013), Wiedenhofer <i>et al</i> (2013), Chancel and Piketty (2015)
	Landscape (FORESTAREA)	+/-	Access to forest and semi-natural area may foster low-carbon leisure activities, but also encourage the consumption of available resources	Ivanova <i>et al</i> (2015)
Technical	Electricity mix intensity (EMIX)	+	The local electricity mix directly determines the carbon intensity of products produced and consumed locally (e.g. housing emissions)	Tukker <i>et al</i> (2010)

APPENDIX 2: Figures 7-8 and Table 5 from Norman et al. (2006: 18-19)

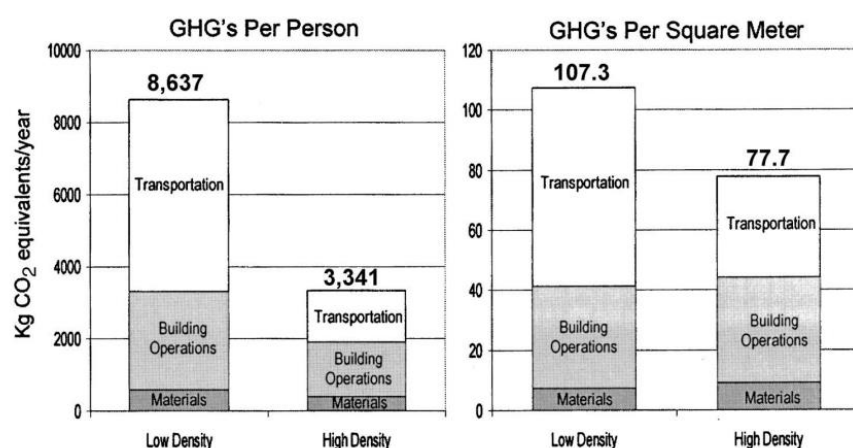


Fig. 7. Annual greenhouse gas emissions associated with low- and high-density development

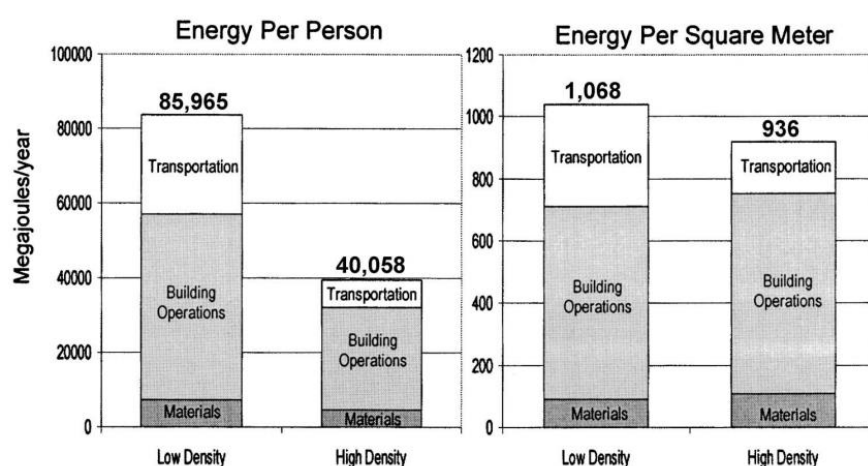


Fig. 8. Annual energy use associated with low- and high-density development

Table 5. Summary of Key Findings Pertaining to Low- and High-Density Development Case Studies Considered

Study element	Key conclusions
1. Building materials	a. Brick and Drywall in residential buildings contribute disproportionately to urban embodied energy/GHG emissions. b. Materials required for non-housing infrastructure do not contribute significantly. c. Material production overall accounts for about 10% of total life-cycle energy use/GHG emissions from residential development.
2. Building operations	a. Building operations account for 60–70% of life-cycle energy use in new residential development. b. Building operations for low-density development are 2× as energy and GHG emissions intensive as high-density development per capita. c. Building operations for low-density and high-density developments are about equal in energy and GHG emissions intensiveness per unit of living space.
3. Transportation	a. Transportation accounts for 40–60% of life-cycle GHG emissions in residential development. b. Public transit accounts for only 2–5% of total transportation energy use/GHG emissions. c. Transportation requirements for low density suburban development are nearly 4× as energy and GHG emissions intensive as high-density urban core development per capita. d. Transportation requirements for low density suburban development are 2× as energy and GHG emissions-intensive as high-density city core development per unit of living space.
4. Comparison of high and low urban density	a. Low density suburban development is 2.0–2.5× as energy and GHG emissions intensive as high-density urban core development per capita. b. Low density suburban development is 1.0–1.5× as energy and GHG emissions intensive as high-density urban core development per unit of living space. c. The choice of functional unit is highly relevant to understanding life-cycle density effects.

APPENDIX 3: Cost abatement curves from Jones and Kammen (2011: 4092-4093).

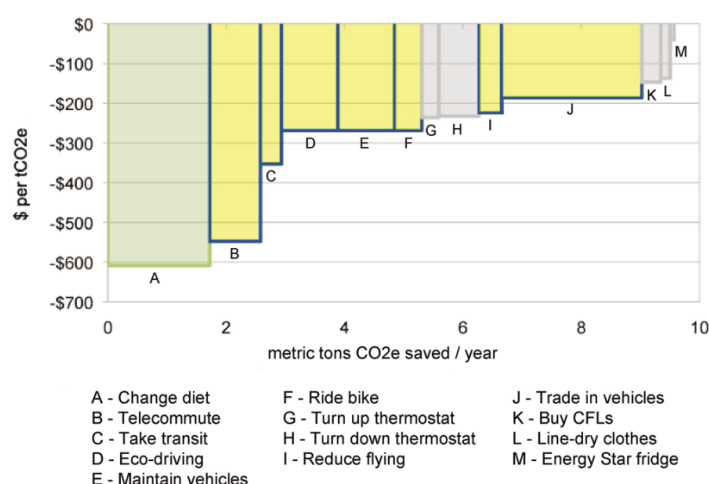


Figure 5. Greenhouse Gas (GHG) abatement curve for average U.S. household. X-axis is annual GHG savings; y-axis is levelized annual cost of mitigation measures per metric ton of CO₂e conserved. Green bars are for changing diets; yellow bars with blue outline are transportation; gray bars are household energy.

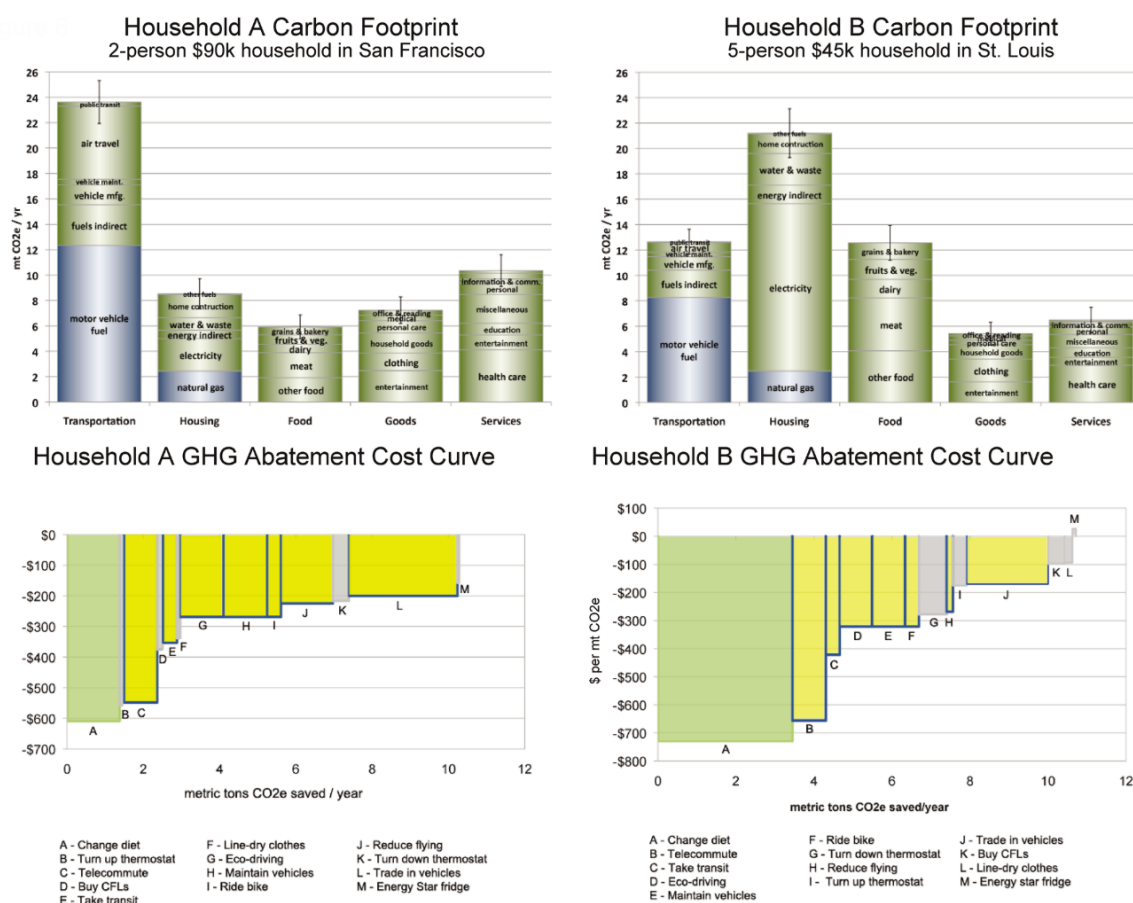


Figure 6. Carbon footprints and GHG abatement cost curves for example households. Household A is an upper income two-person household in the San Francisco Bay Area. Household B is a middle-income five-person household in St. Louis. In the upper figures, carbon footprints are shown for the major categories of emissions, with annual CO₂e emissions on the y-axis. In the lower figures, X-axis is annual GHG savings; y-axis is levelized annual cost of mitigation measures per metric ton of CO₂e conserved. Green bars are for changing diets; yellow bars with blue outline are transportation; solid gray bars are household energy.

APPENDIX 4: Figure 1 from Høyer and Holden (2003: 331)

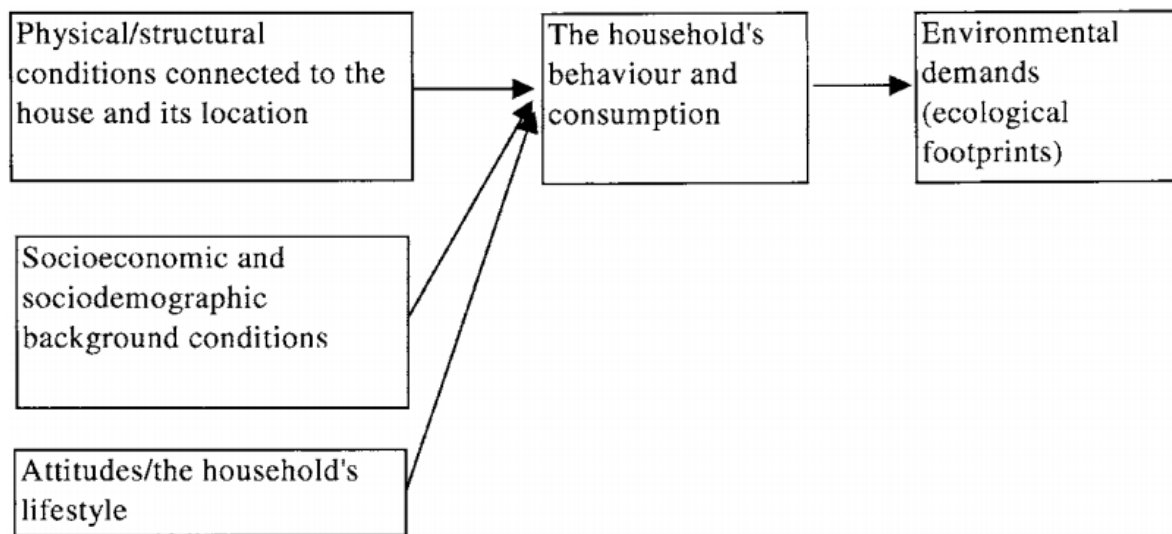
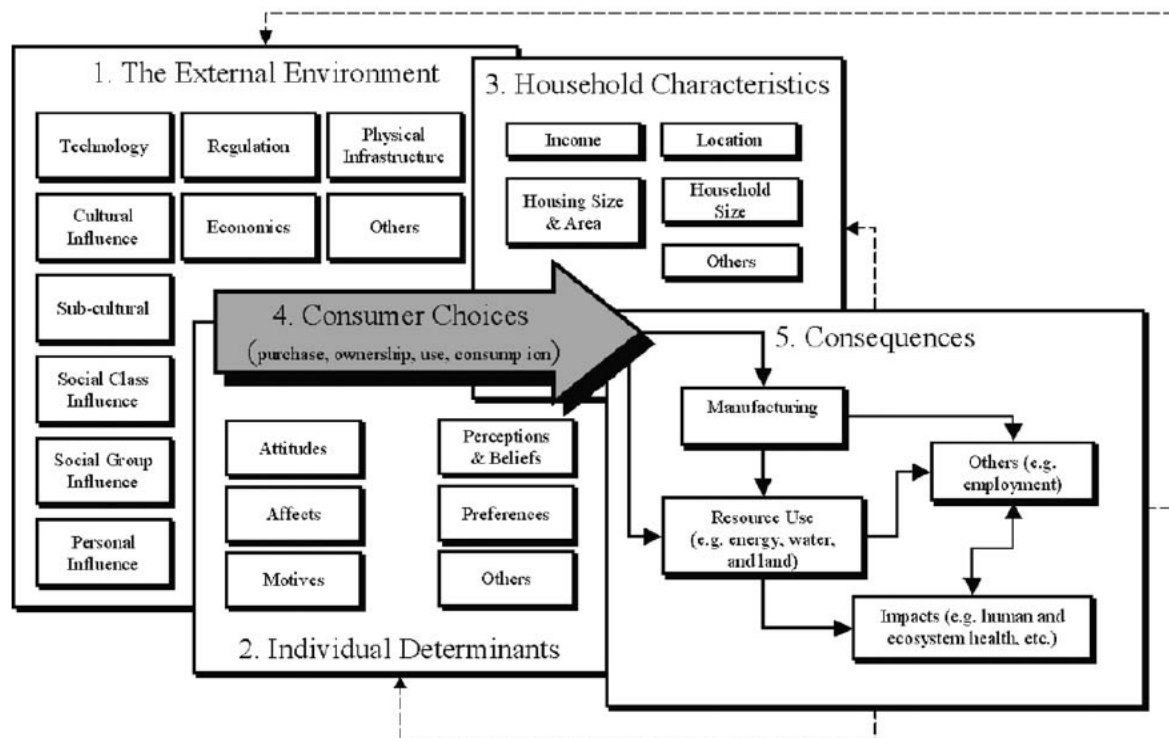


Figure 1. Simplified model illustrating causal connections between characteristics of households and their houses, behaviour, consumption, and environmental demands.

APPENDIX 5: Illustration of the CLA framework (from Bin and Dowlatabadi 2005: 198).



APPENDIX 6: Overview of relevant statistics from SSB.

Category	Statistics	Notes	URL
Consumption	The consumer survey (Forbruksundersøkelsen)	Measures household expenditures on different consumption categories.	https://www.ssb.no/inntekt-og-forbruk/statistikker/fbu/aar/2013-12-17)
Energy	Energy use in households	Measures use of different forms of energy in households.	https://www.ssb.no/energi-og-industri/statistikker/husenergi
	Energy use in industry	Measures energy use in different industries.	https://www.ssb.no/energi-og-industri/statistikker/indenergi
	Production and consumption of electricity	Measures production and consumption of electricity from different sources.	https://www.ssb.no/energi-og-industri/statistikker/elektrisitet
	Supply and consumption of electricity in various sectors (including household) 1993-2017	More detailed version of the previous source.	https://www.ssb.no/energi-og-industri/artikler-og-publikasjoner/attachment/348783?ts=1632600d5b8
	Consumption of energy in industry and households	Shows that half of energy use in Norway come from industry (production-based).	https://www.ssb.no/energi-og-industri/artikler-og-publikasjoner/halvparten-av-energiforbruket-er-i-industrien
Demographics	General demographic data		https://www.ssb.no/befolkning
	Household composition data		https://www.ssb.no/befolkning/statistikker/familie/aar
Transport/mobility	Train transport	Include individuals and freight.	https://www.ssb.no/transport-og-reiseliv/statistikker/jernbane
	Driving distances	Personal vehicles are among the variables.	https://www.ssb.no/transport-og-reiseliv/statistikker/klreg
	Air-travel (commercial flights)	Shows statistics for commercial flights at Norwegian airports.	https://www.ssb.no/transport-og-reiseliv/statistikker/luft

			reiseliv/statistikk/flytrafikk
	Travel by Norwegians	Includes consumption costs.	https://www.ssb.no/transport-og-reiseliv/statistikk/reise
	Public transport	Shows passengers and revenue from tickets for different modes of public transport.	https://www.ssb.no/transport-og-reiseliv/statistikk/kolltrans
Environment/ emissions	GHG emissions from Norway	Show only a 3% increase in GHG emissions from 1990 to 2016 – this would be different with a consumption-based perspective	https://www.ssb.no/natur-og-miljo/statistikk/klimagassn
	Emissions from total Norwegian economic activity	Shows a 2.6% reduction.	https://www.ssb.no/natur-og-miljo/statistikk/nrmiljo

APPENDIX 7: List of potential relevant statistics with municipality data included.

- Statistics on driving distances by municipality affiliation of the owner of the vehicle (<https://www.ssb.no/statbank/table/08741>)
- Statistics on households and income group, combined with *spaciousness* (<https://www.ssb.no/statbank/table/11344>), *building type* (<https://www.ssb.no/statbank/table/11034>), and *ownership status* (<https://www.ssb.no/statbank/table/11346>)
- Statistics on net consumption of electricity by consumer group (<https://www.ssb.no/statbank/table/10314>)
- Various statistics on housing (<https://www.ssb.no/statbank/list/boligstat>)
- Various statistics on household characteristics (<https://www.ssb.no/statbank/list/fobhushold>)