Consumers and energy demand in food supply chains: Synthesising insights from the social sciences

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Abstract

Food and drink is the biggest consumer spending category in the UK, accounting for over 20% of average household expenditure (Defra, 2013). In addition the food chain is responsible for approximately 18% of total UK energy use (Tassou *et al.*, 2014), and food storage and cooking for 25-30% of household electricity use (Zimmermann *et al.*, 2012). With the Climate Change Act committing the UK Government to ambitious targets of 80% reductions in emissions by 2050, identifying and achieving opportunities in the food sector poses a significant challenge. Consequently reducing energy use in food supply chains, from agriculture through to consumer preparation and waste, offers the opportunity to make substantial contributions to the UK's emission targets. As part of an interdisciplinary project examining opportunities for an 80% reduction in energy related emissions in the food sector by 2050, this work aims provides a framework to inform and evaluate potential interventions in the supply chain from the perspective of consumers.

In recent decades a significant yet fragmented body of literature has been developed that seeks to understand how resource consuming practices are formed and how these may be steered toward more sustainable levels of consumption. This review provides an overview of key developments in academic research, providing a unique and detailed means of understanding a deeply complex challenge, synthesising the key issues and highlighting potential areas for intervention. Firstly, a life cycle assessment approach is used to identify trends in consumer behaviour that are of significance to energy use in supply chains, and may present opportunities to contribute to the Government's Climate Change targets. Second, the ISM tool outlined by Southerton et al. (2011) is used to structure a multi-disciplinary review to understand existing research on the individual, social and material drivers of these trends. The implications of the insights gained, are discussed in relation to the design and evaluation of behaviour change interventions to reduce energy in food supply chains.

Key words: behaviour change, sustainable food, energy demand, interdisciplinary

Topics: New trends and directions in food consumption**;** Models of food consumption behaviour and their predictive power.

1. Introduction

The centuries old challenge of making a nutritious diet accessible and affordable has in recent years been made increasingly challenging by the sustainable consumption agenda. The environmental impact of food alongside its social and economic significance has rendered its management an increasing feature of public and political concern. The supply chains of food produced for UK consumption account for approximately 18-20% of the UK's greenhouse gas emissions (hereby referred to as GHG emissions, or emissions), even when excluding emissions resulting from land-use change (Audsley *et al.*, 2009)[1]. At this scale food is comparable to domestic energy and transport in its contribution to per capita emissions in the UK. In addition food waste, water quality and security, biodiversity and competing demands for land are but some of the environmental challenges the industry faces.

It is predicted that growing populations and the increasing impacts of climate change will increase global food production needs by 50% and with it energy demand by 45% and water demand by 30% by 2030 (Beddington, 2009). With the Climate Change Act committing the UK Government to ambitious targets of 80% reductions in emissions by 2050 (against a 1991 baseline) (HM Government, 2008), identifying and achieving opportunities for reductions in the food supply chain poses a significant challenge. In an effort to address such challenges, consumer behaviour has emerged as an essential component of policy and management. For example in the UK's *Food 2030* (HM Government, 2010), duel visions are presented in "consumers are informed, can choose and afford, healthy, sustainable food", and "food is produced, processed, and distributed, to feed a growing global population in ways which; use global natural resources sustainably; enable the continuing provision of the benefits and services a healthy natural environment provides; [etc…]" (HM Government, 2010, p. 7).

In this paper we argue that a deeper understanding of the relationship between trends in consumption behaviour and energy-use not only in consumer homes, but embodied throughout the food supply system, is essential for the design of robust policy and management activity. Research from across the social sciences provides invaluable insights however the multi-disciplinary nature of this field, with disparate aims, goals and theoretical starting points can render potential contributions confusing, often contradictory, and difficult to apply. As part of an interdisciplinary project

[1] Research estimates that the inclusion of land-use change resulting from production for UK consumption increases total emissions by approximately 50% (Audsley *et al.*, 2009)

examining opportunities for an 80% reduction in energy related emissions in the food sector by 2050, this paper provides a two stage literature review with an aim to inform efforts to mobilise consumer behaviour and reduce energy in food supply chains. Firstly, we employ a life cycle assessment approach to identify key trends in consumer behaviour that are of significance to energy use in supply chains, and may present opportunities to contribute to the Government's Climate Change targets. Second, we use the ISM tool outlined by Southerton et al. (2011, see also Darnton and Evans, 2013) to structure a multi-disciplinary literature review to understand the drivers of these trends, and gain insights as to how they may be managed in order to reduce energy use throughout the supply chain.

As part of the Centre for Sustainable Energy Use in Food Chains, we focus on energy use. As a percentage of all food related greenhouse gas emissions, 60% result from energy-use in food supply chains, from transport, heating and electricity and from manufacturing processes (Audsley *et al.*, 2009). In consumer homes the energy associated with the storage and preparation of food contributes around 30% of all electricity use in the home (Zimmermann *et al.*, 2012). Thus identifying interactions between consumer behaviours and the energy and emissions in food supply chains of food products is the primary objective. However, to contribute to a broader discussion on sustainable food and consider the implications of energy reduction focussed interventions for wider environmental impacts we have sustained a broader framing through the paper.

2. Methods and theory

This literature review proceeds in two main sections, each responding to one of the two core aims of this paper, with a discussion drawing out the implications for conceptualising and designing behaviour change interventions to reduce energy use in food supply chains. As an interdisciplinary project we combine analytical devices from engineering and the social sciences to provide identify the key trends where change may be most beneficial, and the elements upholding unsustainable behaviours that may provide useful points to target intervention.

Towards the first aim; to identify key trends in consumer behaviour that are of significance to energy use in supply chains, a life-cycle approach to energy is employed. UNEP (2014) define Life Cycle Assessment (LCA) as "a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle". Thus it is designed as a means of mapping the resource requirements of different stages of production and consumption, in order to facilitate

decision making. Typical models of food supply chains can be characterised relatively simply (see figure 1) but vary according to the specific products or processes being assessed.

Figure 1: example Life cycle flow model typical of food management

As a tool predominantly used to understand the resource requirements of different stages of production, the processes flow model typical of LCA detailed means of identifying significant spaces of environmental impact. However the linear model poorly accounts for interconnections, relegating the consumer to the end of the supply at the expense of attention paid coproduction between behavioural trends and energy use in different supply chains stages. It is precisely this separation of production and consumption that has been challenged in recent social science developments (Spaargaren, 2006, Spaargaren *et al.*, 2012, Welch and Warde, 2014) particularly where the schism between production and consumption is seen to limit the scope of management activities which are argued to have become concentrated on providing information and incentive at the expense of actions to promote the necessary social and material infrastructure to enable systemic change (Hobson, 2002, Southerton, Mcmeekin, *et al.*, 2011, Shove, 2012, Strengers, 2012, Darnton and Evans, 2013). Thus in applying a LCA perspective in this paper, we consider how trends in consumer behaviour permeate throughout the supply chain with implications for energy use at different life cycle stages.

With these observations as the starting point, Section 3 begins the task of mapping interactions between consumers, farms, transport networks and retail and thereby extending traditional analysis beyond domestic energy consumption. Rather than starting with 'consumers' as the focus for analysis, an initial literature review was carried out (see Fig 2 for details), working through the flow model presented in Figure 1, to identify key behavioural trends of significance to energy in the supply chain. The intention is to inform a more systemic approach to managing environmental impact and avoid unintended consequences of activities in one life-cycle stage for another.

In order to engage with the behavioural trends identified in this initial stage, a more nuanced view of how unsustainable trends in consumer behaviour are configured is required. The Green Food Project, a stakeholder forum coordinated by Defra to explore the issues around sustainable food, concludes that with relation to consumer behaviour "a deeper understanding of what drives consumer

purchasing and consumption decisions" (Defra, 2012, p. 30) is paramount to informing debate and future change. However it is widely recognised that consumer behaviour is, for the most part, not based on rational decision making (Defra, 2013). A wide variety of factors affect behaviour, amongst these are the availability, affordability and acceptability of food in local areas; the meaning and values associated with different food stuffs and purchasing practices; daily rhythms and pace of life in a global society; family structures and social connection as well as real and perceived notions of price, taste, quality and freshness. Furthermore the impacts associated with consumption, and the drivers of behaviour stretch far beyond the consumer, or the home. Thus the second aim is to understand the drivers of these trends, and gain insights as to how they may be managed in order to reduce energy use throughout the supply chain.

In section 4 we employ the ISM tool proposed by Southerton et al. (2011, see also Darnton and Evans, 2013) to structure a multi-disciplinary literature review of recent social science contributions to our understanding of the drivers of current (unsustainable) consumer behaviour in relation to the food system. This framework presents three 'contexts' in which behaviour occurs; 'the individual', which refers to things that shape behaviours and purchasing patterns; 'the social', which relates to shared understandings, social norms and cultural conventions that guide individual practices; and 'the material', which looks toward technologies and infrastructures that shape and constrain consumer behaviour. The initial application of this tool, to review behaviour change initiatives for the Scottish government illustrated that the most effective campaigns were those that focus on more than one of these three contexts. Thus the purpose of this review is to understand the recent social science research into these contexts and their application to managing behaviour trends of relevance to energy in food supply chains.

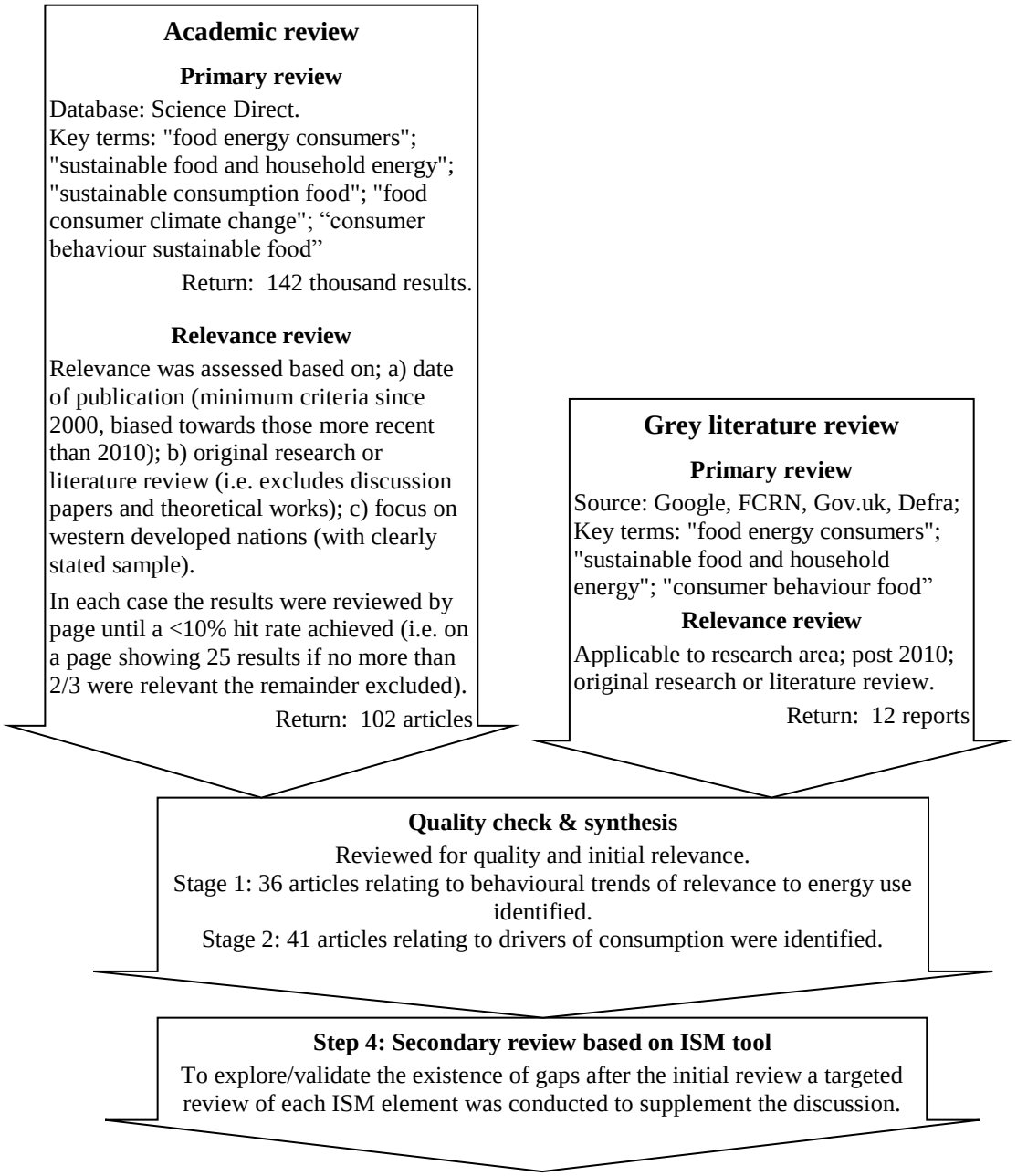

Figure 2: Literature review process

Finally, in section 5 we discuss the implications of the insights gained for the design and evaluation of behaviour change interventions to reduce energy in the supply chains.

3. Trends in consumer behaviour and their implications for energy use in the supply chain

The following section presents the first stage of findings from a literature review. The life cycle flow model presented in Figure 1 is used to map the interactions between consumers and energy in

throughout the supply chain. It should be noted from the outset there is substantial overlap between different lifecycle stages.

1.1. Farming and processing

The connection between consumers and farming and processing patterns are perhaps the most complex, particularly in a globalised food system where the relationship is indirect and mediated by a multitude of actors and processes. The clearest connection is that certain dietary trends have correspond with greater energy use on farms and in factories than others. Amidst a myriad of changes that are likely to have occurred in recent decades there are two dietary shifts that stand out in the literature, each that have implications for energy use in supply chains.

1.1.1. Trend 1: Rise in meat consumption

Meat is a staple feature of the British diet, with the average person eating at least 330 grams of meat per day[2]. However research demonstrates that meat and dairy products have greater environmental impact than non-meat alternatives (Berners-Lee et al., 2012, Masset et al., 2014). From an energy perspective there are inherent inefficiencies in the meat production system whereby significant resources are expended to grow crop and grains to provide animal feed. The production of fertiliser to support growth of feed crops is a particularly energy intensive process, requiring 30-50 gigajoules of energy per tonne and accounting for approximately 1% of global energy supply (FAO, 2006). Energy is also required to produce other inputs and to sustain on-farm operations. Sainz (2003, in FAO, 2006) estimate that a typical US farm requires around 25 mega joules (MJ) of energy per kilogram of carcass chicken, 46 MJ for pigs and 51 MJ for beef (FAO, 2006).

While energy use is substantial, arguably the more significant environmental impacts associated with meat are greenhouse gas emissions (particularly with regards to non-CO_2 emissions [3]). Subsequently interventions that support a shift towards a diet with less meat, and less animal proteins has been shown to offer significant potential to contribute towards both energy demand and emissions targets, (Berners-Lee *et al.*, 2012, Hoolohan *et al.*, 2013, Garnett, 2014, Masset *et al.*, 2014), with associated benefits for health and nutrition (Aston *et al.*, 2012, Briggs *et al.*, 2013).

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[2] Defra's Family Food survey estimates that in 2011 people were eating approximately 0.383 kg capita^{-1} annum^{-1} while the National Diets and Nutrition Survey for the same period estimates 0.33 kg capita^{-1} annum^{-1}. Both of these data sets are suspected to have issues around underreporting see Hoolohan *et al.* (2013) for discussion.

[3] see Bows-Larkin *et al.*(2014) for discussion, and particularly those resulting from rumination; the digestive process of 'ruminants', a mammalian classification (including sheep and cows) with reference to a specific form of digestion which results in methane emissions.) and land use change (particularly deforestation) resulting from farming practices (Williams *et al.*, 2010, Berners-Lee *et al.*, 2012, de Boer *et al.*, 2013b, Hoolohan *et al.*, 2013).

1.1.2. Trend 2: Rise of processed products

The mechanisation of the food industry has made processing food more available and today processed products are common features of everyday diets. The energy in specific product supply chains varies, for this discussion we focus on refined grains (such as rice, bread and pasta) and fruit juices, both of which are staple features of the UK diet.

In the UK the average person is thought to overconsume refined grains despite nutritional advice to the contrary (Garnett, 2014). Processing grains is an energy consuming process, for example Espinoza-Orias *et al.*, (2011) show that white bread is 7% more energy intensive than brown, while Williams et al. (2013) demonstrate that potatoes, that require no processing, are significantly less intensive than either pasta or rice (resulting in 0.31 kg CO_2e per kg fresh weight to the point of sale compared to 1.6 for pasta, and 2.0-2.3 for rice). While accounting for only a small proportion of emissions in the food system, the refining of grains is unnecessary for their consumption and contrary to research on health and nutrition which connects refined grains to loss of dietary fibre, linked to diabetes and heart disease (Hu, 2010, Siri-tarino *et al.*, 2010).

In the UK fruit juice consumption has increased ten-fold since 1974 from 34 to 350 g person^{-1} day^{-1} in 2005 (Defra, 2008). While the energy and water required to produce concentrated juice is much higher than non-processed alternatives (Beccali *et al.*, 2010), the potential reduction in transport emissions (due to the greater volume that can be shipped), refrigeration emissions and significant reduction in waste during processing means that overall the GHG impact is positive (Foster *et al.*, 2012). While more dated forms of processing lead to loss of nutritional value in juices modern production systems can provide less energy intensive means of providing equal nutritional value (Bull *et al.*, 2004). However on balance, fruit juices are a relatively energy intensive way of accessing nutrients and there are thought to be significant dietary benefits from eating whole fruit (and vegetables) over processed forms (Masset *et al.*, 2014).

Thus while the relative difference in energy consumption between processed and non-processed alternatives may be small, the scale of the shift towards mass-consumption of processed products means there may be potential positive contributions to energy and emissions targets made by shifting towards wholefood (and wholegrain) diets.

1.2. Transport and distribution

1.2.1. Trend 3: Standardisation of diets

Globalisation has had significant impacts on the availability of food. Specifically the increased transport networks, trans-nationalisation of companies and supply chains, and a growing retail market mean that an increasing range of foods from around the world are available in UK stores year-round.

As a net importer of food (Defra, 2014) food miles are of concern in the UK, particularly the small amount of produce which is air freighted. There is evidence of rapid growth in the air-freighting of food, a particularly concerning trend especially where dedicated freight aircraft are used (Garnett *et al.*, n.d.). In addition significant road miles are incurred moving produce around the country, and the EU, where produce could otherwise be sourced locally. Between 1978 and 2002, the amount of food moved by heavy goods vehicles (HGVs) increased by 23% per annum with the average distance per trip increasing by over 50%. As a result in 2002, food transport accounted for approximately 30 billion vehicle kilometres (Smith *et al.*, 2005). While transport efficiencies continue to reduce the GHG intensity of transportation this is not sufficient to offset the general trend and shortening the supply chain is further beneficial in terms of reducing spoilage, refrigeration emissions and fuel consumption.

While the debate around the impacts of the globalisation tends to focus on locality and transport, as reflected in its positioning in this paper, it is well recognised that things are not as simple as the term 'food miles' suggests. Local food grown out of season is not necessarily any less intensive (and in some cases worse) than its imported counterparts, as it is far more energy intensive to grow out of season produce in artificial conditions (Edwards-Jones *et al.*, 2008). For example, grown outdoors UK lettuce may incur less than 0.5kg CO_2e kg^{-1} while Spanish lettuce results in approximately 0.8-1kg CO_2e kg^{-1}. In contrast grown indoors British lettuce results in approximately 5kg CO_2e kg^{-1} and Ugandan (air-freighted) lettuce in excess of 10 kg CO_2e kg^{-1} (Milà i Canals *et al.*, 2008)[4]. So while the Ugandan lettuce, air-freighted due to its short shelf-life is the most energy intensive means of producing lettuce, growing in the UK out of season also has significant environmental impacts (i.e. 5 times the emissions of seasonally grown leaves).

The greatest contribution towards energy and emissions targets would be to ensure that products are grown without climate control and without air-freighting (Hoolohan *et al.*, 2013). This is likely to require integrated management of production, distribution, retail and consumption.

[4] These are estimates from Fig 3.1f (Milà i Canals *et al.*, 2008) and appropriate caution should be applied in.

1.3. Food storage, preparation and cooking

Energy use in the home is a relatively small part of the picture in terms of energy across the supply chain, Clear et al. (2013) calculate that on average supply chain emissions up to the point of sale exceed direct emissions from cooking by a factor of 3.8. However energy in the home is nonetheless significant as an area of interest to policy makers and campaigners.

1.3.1. Trends 6: Cooking technologies and practices

Cooking accounts for approximately 14% of household electricity use (Zimmermann *et al.*, 2012)[5]. The amount of energy used for cooking is dependent on a number of factors; the efficiency of fuel production, the efficiency of appliances, and consumer cooking habits (Hager and Morawicki, 2013). Cooking habits in particular have been shown to vary substantially between individuals. In an in-depth study of student cooking practices Clear et al. (2013) demonstrate that typically between 0.2–0.4 kWh was required to prepare a single serving of pasta. However in one case, spaghetti was cooked for 20 minutes with more spaghetti then added along with more water from kettle and cooked for a further 20 minutes resulting in 0.75 kWh electricity consumed. Taken individually these are very small amounts of energy, but in the long term amount to significant differences in household energy consumption.

An additional concern is the 'peaky-ness' of cooking practices. Time series data demonstrates that notable moments of cooking are recognisable, both at household (Wood and Newborough, 2003) and societal (Southerton, Díaz-méndez, *et al.*, 2011) levels. This connects the practices of end users to the upstream production of electricity as the synchronisation of eating across the UK exacerbates peak loads, which for industries determined to supply to meet demand determines the size of the infrastructure required.

Demand for energy for cooking currently contributes to peak demand and rescheduling activities such that they occur at off-peak times is likely to be beneficial to reduce peak load. In general as an energy consuming processes changes to the way cooking and eating are done may offer positive contributions to energy and emissions targets. Efforts could focus on: matching appropriate cooking apparatus and practice to food and meals and improving efficiency (microwave versus over, appropriately sized hobs, use of lids) or establishing different approaches to how and where we eat (e.g. community level facilities).

1.3.2. Trends 7: Home refrigeration / freezing

[5] it should be noted that this omits gas consumption which is significant in terms energy used in cooking

In the 1960's only 3% of the UK population owned a freezer, a figure that had by 2000 increased to over 96% of UK households possessing one if not more (Shove and Southerton, 2000). This trend has direct implications for energy. Cold storage accounts for approximately 16% of electricity for the average household, approximately 570 kWh per annum (Zimmermann *et al.*, 2012). Given that cold storage tends to be accessed during 1700-1900h, this also adds to peak demand as the units demand energy to retain their temperature (Strengers, 2012, Zimmermann *et al.*, 2012).

In addition to the direct energy use of these appliances research describes the co-evolution of the freezer with a broader shift in patterns of food provisioning and domestic practice. Originally designed to overcome seasonal gluts and preserve food in the home, the freezer now is more commonly used to store convenience foods and plays a key role in managing busy lives (Shove and Southerton, 2000, Spurling *et al.*, 2013). See trend 8 for details.

Again, demand management may benefit energy and emissions targets and could be addressed through efficiency measures such as tightening of product standards, smart appliances that respond to energy availability information. Capacity of appliances must be considered here too as product standards tend to focus on efficiency rather than overall demand. Again, more significant changes to how we eat, prepare and store food at a community level may have implications for energy use in refrigeration.

1.4. Retail

1.4.1. Trend 4: Supermarkets over convenience stores and independents

In recent years there has been much media attention, if little academic research, to the shift from local and high street shopping towards supermarkets and out-of-town retailers. As Portas quips "The days of a high street populated simply by independent butchers, bakers and candlestick makers are, except in the most exceptional circumstances, over" (2011, p. 2). These changes to shopping practices have implications for energy in the supply chain.

The direct energy intensity of retail varies substantially depending on store type. Research by Tassou et al., (2011) demonstrates that while superstores and 'hyper-markets' use significantly more energy than convenience stores, the energy intensity per square meter is substantially lower in larger stores[6]. This is due to the efficiency of technologies and practices in stores but also related to the disproportional amount of energy required per square meter to run refrigeration in smaller stores.

[6] The largest stores use on average 770 kWh/m^2 per annum, while superstores more typical of a chain supermarket use 920 use kWh/m^2 and convenience stores (80-280m^2) average 1480 kWh/m^2 per annum

Less direct are the impacts on consumer travel. The economy of scale afforded by superstores offer opportunities for provisioning of public transport and internet shopping, however the potential of this is rarely realised, furthermore their location often necessitates travel which is an increasingly private practice (Avineri, 2012). In contrast the locality of convenience stores mean they are generally within walking distance, and have far less parking facilities compared to superstores, reducing the need and opportunity for motorised travel.

The ideal course of action is unclear in this instance, it is likely to be a balance between store types that includes support for efficient technologies in smaller retail space, and improved transport connections for larger stores.

1.4.2. Trend 5: Internet shopping

Internet shopping is a recent, yet rapidly increasing part of the way we shop. Rhodes (2014) demonstrates that since 2007 the share of internet retailing has increased from only 2.7% to 11.1% (in 2011). In 2011, around 6% of all UK grocery sales were made online, worth around £6 billion (Dawes and Nenycz-Thiel, 2014).

The energy impacts of internet retailing work both ways. On the one hand they enable greater centralisation of supply chains, requiring fewer warehouses (thereby reducing operating emissions) and more efficient distribution of products (thereby reducing transport miles and potential for spoilage). Furthermore internet shopping may reduce the number of journeys made by consumers and home delivery could be timed to avoid contributing to peak traffic. It is also suggested that internet shopping better allows supply for demand, with advanced ordering and improved data on purchasing patterns (Siikavirta *et al.*, 2003).

However Coley et al., (2009) estimate that where typical food shops incur a journey of less than 6.7 km they are likely to result in fewer emissions than the system required to replace this journey through internet shopping. Secondly the opportunity for ‘on-time’ supply increases demand for high speed logistics and thereby may increase air-freighting with implications for transport emissions (Siikavirta *et al.*, 2003). A further challenge is the energy use for refrigerated transport, given that the produce would not ordinarily be refrigerated for the journey. Finally there is no guarantee that internet shopping reduces the number of car trips, as research suggests that consumers combine food shopping with other errands (Edwards *et al.*, 2010).

Again, in terms of energy consumption it is not possible to give a simple recommendation in terms of increasing or decreasing internet shopping. The wider energy demand implications of this trend need

to be considered in specific supply chains and their potential for decarbonisation and efficiency improvements. In addition, further understanding of the extent to which the total number of trips are reduced by internet shopping is required.

1.5. Eating

One of the most significant points of consumer interaction with energy in food supply chains relates to the changing patterns of eating. Cheng et al., (2007) report an overall decline in the time devoted to not only making, but consuming food, particularly for younger people, and those who are single and/or without children (see also Daniels *et al.*, 2014). However they also note that for many the family meal remains an important feature of family life.

1.5.1. Trend 8: Convenience at home (could be in cooking)

Today the there is a vast range of convenience foods on the market; including canned meals, bread and cake mixes, pizzas, pre-prepared fruit and vegetables, and ready-meals (Daniels *et al.*, 2014). Parallel with this growth, which has occurred predominantly over the last 20 years, convenience food is an increasing feature of peoples' everyday lives (Shove, 2003, Scholderer and Grunert, 2005). In 10% of UK household reported eating ready-meals at least once a week (Garnett *et al.*, n.d.); a finding echoed by Daelman *et al.*, (2013) in a study of Belgian eating habits. Consequently in 2013 sales of ready meals in major supermarkets alone were estimated at to be worth over £2.3billion, an 8% rise on the previous year (Gibbons, 2013).

The implications of this for energy in the supply chain are complex. LCA demonstrate that ready-meals have a marginally higher environmental impact than preparing a similar meal (in this instance a chicken dinner) at home due to the increase energy used in manufacturing processes, and refrigeration throughout the supply chain. However frozen ready-meals are of significantly higher impact (Schmidt Rivera *et al.*, 2014). In addition while total wastage is broadly similar between a ready-made lasagne and a home-made lasagne, the ready-meal reduces household waste, and that managing supply chain waste may be a comparatively simple task (Jungbluth *et al.*, 2014).

Again, it is impossible to state whether a general trend toward increased consumption of convenience foods will have a positive or negative development for energy consumption due to the diversity of individual products. However, there may be potential to reduce energy use and manage waste by controlling the ingredients in these meals (e.g. by reducing meat and dairy content) and their substitution of conventional oven cooking for microwave in single person households. This potential

needs to be considered in the context of whether consumers make 'like-for-like' exchanges between cooking from scratch and ready-meals and any wider related changes in terms of their diet.

1.5.2. Trend 9: Eating out

Parallel to the rise of convenience foods in the home is a trend towards eating out, particularly for younger (18-30 years) and more affluent consumers (Cheng *et al.*, 2007). There is little peer-reviewed research regarding this trend and government statistics which rely on self-reported data sets such as food diaries are known to contain under-reporting issues (see Berners-Lee *et al.*, 2012 for discussion). Despite this, research suggests that one in six meals are now consumed outside the home (Grinnell-Wright et al. 2013), and the catering industry (which includes restaurants, cafes, canteens, etc) attracts £84bn of consumer spending per annum (Defra, 2014). Interestingly there is a suggestion that the rise in convenience foods at home may correspond to a decline in eating out, particularly since the emergence of luxury, yet comparatively cheap, ready meals (for example Marks and Spencer's 'Dine in for Two: £10') (Gibbons, 2013).

One sub-trend of the general shift towards eating out is that of on-the-go eating. Cheng *et al.*, (2007) demonstrate that one of the most significant changes between 1975 and 2000 is the increased frequency of short duration meals outside of the home. Grinnell-Wright *et al.*, (2013) give an overview showing, amongst others, a significant rise in the number of people breakfasting on-the-go with the number of coffee shops rising four-fold in a decade to nearly 15 thousand establishments in 2011. There is also evidence that conventional 'fast foods' are becoming a staple feature of British eating, with one in three people reporting to eat fast food at least once a week. Amidst this are some concerning sub-trends; in particular the dominance of 'poor fast food choices (e.g. burgers, fried chicken and pizzas) (Grinnell-Wright *et al.*, 2013).

Again the energy implications of this trend are difficult to analyse and there is very little research that attempts to do so. Some key issues are worthy of mention. Firstly evidence suggests overrepresentation of processed products and meat based meals (particularly in low income areas where the diversity of establishments is reduced) (Cullen, 1994, Cummins *et al.*, 2005). Both processed foods and meat products are of higher environmental and energy impact than their alternatives (Williams *et al.*, 2010, 2013, Berners-Lee *et al.*, 2012, Hoolohan *et al.*, 2013), see section 1.1. Secondly there are concerns around portion sizing, with eating out shown to increase the chances of over eating in the US (Kral and Rolls, 2004) but whether this is country specific is unknown, and corresponding research in Europe or the UK is lacking. Thus, while eating out offers a potential point of intervention in terms of engaging consumers with different and new ingredients

and meals, in order to understand the energy implications of such a behavioural trend further research is needed to understand whether eating out makes a difference to what is eaten (e.g. portion sizes, meat content, local and seasonal produce).

1.6. Food waste

Globally between 30 and 50% of all food produced is wasted (Institution of Mechanical Engineers, 2013). Wastage occurs for many reasons and is a systemic issue, occurring throughout the supply chain. The Waste and Resource Action Programme (WRAP) estimate that of the 15 million tonnes of food waste occurring annually in the UK, approximately half occurs in consumer homes (over 7.2 million tonnes, of which 4.4 million tonnes is avoidable), a further 3.9 million tonnes occur during manufacturing and 3.0 million tonnes in other space (including pre-factory gate). Only around 1.15 million tonnes result from retail, catering and hospitality (WRAP, 2015).

Reducing food waste is beneficial not only in terms of managing energy use, but also for reducing a wide range of environmental, social and economic impacts. There are useful applications for food waste, such as bioenergy and compost, however these are sub-optimal and the most preferable solution is prevention (WRAP, 2015). While the majority of food waste occurs in the home, this is inseparable from broader supply chain management, particularly retail practice and is likely to require action throughout the supply chain (Quested *et al.*, 2013).

4. What are the main drivers of these trends?

Given the policy relevance and focus of our work, and our desire to engage with researchers and stakeholders across the food supply chain, we adopt the ISM tool developed by Southerton et al. (2011) which aims to offer a way of combining disparate social science approaches in a way that is meaningful to policy makers. This framework presents three ‘contexts’ to understand the mechanisms of behaviour change; 1) the individual, which refers to things that shape behaviours and purchasing patterns; 2) the social, which relates to shared understandings, social norms and cultural conventions that guide individual practices; and 3) the material, which looks toward technologies and infrastructures that shape and constrain consumer behaviour. They argue that this three-fold approach provides a means of understanding behaviour, and demonstrate that the most effective behaviour change campaigns are those that focus on more than one of these contexts. This approach is used here to synthesise existing work relating to sustainable food behaviours and to consider potential future interventions across the supply chain.

1.7. The individual context

The individual context of food related behaviour is perhaps the most commonly researched across the social sciences. In particular there is a large body of literature that seeks to understand the motivations influencing uptake of organic food and genetically modified food. While we recognise the significant amount of research in these areas, they are excluded from this study due to their ambiguous relationship to energy use.

In the technical guide to the ISM tool Darnton and Evans (2013) list values and attitudes; costs and benefits; emotions; agency; skills and habits as key factors that make up the individual context.

1.7.1. Values & attitudes

In psychological theory attitudes, beliefs and values are thought to form the basis of much individual activity. The theory of planned behaviour (TPB) (Ajzen, 1991) and the theory of basic values (TBV) (Schwartz, 2012) are two of the most commonly applied models. Both use individual values and attitudes as a basis for predicting behavioural intentions, and have been applied extensively in relation to food and sustainable consumption.

Attitudes refer to the degree to which a person looks favourably on a specific product or behaviour. This has been shown to be the main predictor of behavioural intention in relation to sustainable dairy choices (Vermeir and Verbeke, 2008), alternatives to meat (de Boer *et al.*, 2009, Ruby, 2012, Vanhonacker *et al.*, 2013), farmers markets (Conner *et al.*, 2010), and fast-food (Dave *et al.*, 2009). Attitudes are context specific behavioural beliefs about desirability of the behaviour and the perceived positive outcome of action (Ajzen, 1991). In most models attitudes are one of a tri-partitive system predicting behaviour comprising of perceived behavioural control (i.e. an individual's perception of their ability see agency) and subjective social norms (see norms, under social context). It is common to see values omitted or discussed separated in research using the TPB although some research exists to draw the two together, for example Vermier and Verbeke (2008) show that while values are a weak predictor of behavioural intent, they influence attitudes and therefore remain important to discussions around sustainable behaviour.

Universalism, a term used to describe a group of values pertaining to broadmindedness, social justice, equality, unity with nonhuman species and other bigger-than-self priorities, is found to be one of the most compelling values underlying intention to make sustainable consumption decisions. Animal welfare is a specific universal value that is shown to be significant in relation to consuming less meat (de Boer *et al.*, 2007, Fox and Ward, 2008, Ruby, 2012, De Backer and Hudders, 2015),

while Seyfang (2006) describes a sympathy with local farmers and interest in supporting local economies as a universal motivation for local food purchasing. Other influential motivators include ethical beliefs about the most appropriate form of conduct, for example in not wasting food (Graham-Rowe et al., 2014), and buying local food (Kemp *et al.*, 2010).

1.7.2. Costs & benefits

Alongside values and attitudes the costs and benefits (both real and perceived) attributed to certain products and behaviours have been show to significantly influence individual motivation. Rational choice (RC) models, again present in much research on sustainable consumption, suggest that consumers are capable of calculating the relative cost-benefits of different products, and do so in order to make purchase and use decisions, for example weighing up the perceived heighted costs of local produce compared to the perceived higher quality (Chambers *et al.*, 2007, Darby *et al.*, 2008, Brunner *et al.*, 2010, Martinez *et al.*, 2010, Campbell *et al.*, 2014).

Price, health and nutrition, food safety, quality and convenience are the most commonly cited cost benefits associated with sustainable food behaviours. For example financial saving has been identified as a potential reason for consuming less meat (de Boer *et al.*, 2009) and a reason not to waste food (Quested et al., 2013, Graham-Rowe et al., 2014). Conversely the perceived high price is an obstacle to consumer uptake of local and seasonal produce (Weatherell et al., 2003, Conner et al., 2010), and cooking from scratch (Grinnell-Wright *et al.*, 2013). An increasingly powerful benefit is the convenience afforded by certain products, particularly prepared foods (Jabs *et al.*, 2007) and convenience foods (Candel, 2001, Mahon *et al.*, 2006, Dave *et al.*, 2009, Celnik *et al.*, 2012), with associated benefits for family time management. Convenience is also of significant to the frequency and type of meals consumed outside the home, shown to be one of a number of factors including access to new tastes and recipes and social value given to eating out by some sub-groups of the population (de Boer *et al.*, 2004). Finally Rohm and Swaminathan (2004) show convinience to be one of several factors including desires for variety, immediacy of possession and social interaction which influence decisions on how and where to shop.

Other influential perceived benefits include trust and transparency which are associated with cooking food from scratch (de Boer et al., 2004), buying local produce (Noble *et al.*, 2006, Kemp *et al.*, 2010), or buying from farmers markets (Seyfang, 2006) and choosing recognisable brands (Williams *et al.*, 2001) restaurants or fast-food vendors (Sahagun and Vasquez-Parraga, 2014). While freshness and nutritional value are important to choosing unprocessed products (Broad and Cavanagh, 2011, Foster et al., 2012) and cooking from scratch (de Boer et al., 2004).

1.7.3. Emotions

In psychological models emotions are usually grouped in two categories; altruistic and egoistic the former referring to emotions centred on bigger-than-self subjects and the latter to emotions relating to the individual. Empathy has been shown to be the most prevalent altruistic value relating to deliberate acts of sustainable consumption. Empathy for other people, animals and environments has been shown to lead to emotional responses to meat eating (Ruby, 2012, Rothgerber, 2014a) and local food (Seyfang, 2006) and other sustainable food consumption behaviours (Nisbet et al., 2008). As for egoistic emotions, guilt and pride are two of the most significant to sustainable consumption. Gregory-Smith et al. (2013) identify guilt from a range of emotions as one of the most powerful motivators of intention to consume ethically. Similarly Quested et al. (2013) find that food waste results in feelings of guilt and regret. Pride has been associated with many food moderation choices, such as avoiding vice foods and eating healthily and while it has not been well researched with regards to sustainable consumption Gregory-Smith et al. (2013) suggest pride should have a positive influence on consumers' desire to engage in future sustainable consumption (Antonetti and Maklan, 2014).

Several studies have demonstrated that far from intentional food waste causes consumers considerable angst with feelings of frustration, anxiety, annoyance and guilt being reported when food is wasted (Evans, 2011a, Graham-Rowe *et al.*, 2014).

In a different vein, research into socio-spatial relations looks at the emotions provoked by material conditions (see also material context), Williams et al (2001) illustrate how anxiety and stress caused by complex journeys or the (lack of) facilities available at given locations can have a significant impact on the experience of shopping and likelihood of return.

1.7.4. Agency

Agency is one of the other key factors in TPB (Ajzen, 1991), referring to an individual's confidence in their ability to behave in a specific way (see also Bandura (1977). There is little research that deals with agency in relation to sustainable food head on; instead it is usually discussed as a limiting factor in decision making, preventing decisions based on attitudes, values, emotions and cost-benefits. That said it has been shown to be a factor in managing household waste (Thogersen and Grunert-Beckmann, 1997), buying local food (Bissonnette and Contento, 2001), and changing food preparation and cooking patterns (Morin et al., 2013).

In relation to sustainability the perceived ineffectiveness of individual action in the face of global challenges is a more commonly discussed in relation to behaviour, particularly as an underlying determinant of attitudes (Barr *et al.*, 2011, Tobler *et al.*, 2011, Kneafsey *et al.*, 2012, Vanhonacker *et al.*, 2013). There is also a growing body of literature that challenges the notion of innate individual agency as presented by psychological models, instead viewing agency as something that arises from socio-technical configurations (Shove, 2010), this is reflected in research presented under social and material context.

1.7.5. Skills & habits

In partial rebuttal of the cognitive models that underpin the TPB, TBV and RC models there is growing evidence of the habitual and routinized nature of food purchasing and consumption. Consumer decision making takes place in constrained rather than idealistic conditions, in particular the limited availability of time inhibits full reasoned action (Lockie, 2002, Kalnikaitė *et al.*, 2012), consequently consumers are shown to have short-cuts to filter information and enable 'fast and frugal' decision making. De Boer et al. (2009) show how these processes may become routinized through two choice editing strategies; 'chronic promotion' whereby consumers select products that appear to best match their values from the choices on offer, and 'chronic prevention' focus where they limit the least desirable options.

Shopping, cooking and eating habits are also shaped through long-term interaction with other activities such as work, childcare and leisure time (see also 'roles & identities', 'networks & relationships', and 'times & schedules'). Consequently the time given to cooking, the likelihood of preparing food from scratch, and the frequency and type of food consumed beyond the home are all connected to daily routines (Daniels *et al.*, 2012, 2014). This in turn connects people to the structures of food provisioning available to them during the day (see 'infrastructure').

Finally, the potential de-skilling of the British public is something of growing interest to academics. With regards to cooking, there is evidence that peoples self-reported ability to cook appears to be declining (Grinnell-Wright *et al.*, 2013), and Short (2003, 2006) shows that the meaning of 'cooking' has changed over time to incorporate many pre-prepared foods (e.g. juices, soups and breads). Consequently cooking appears to be more about providing a meal than assembling fresh ingredients. Skills are also associated with food waste. While some of the population have habits and skills to plan meals, prepare and store batch meals, make use of left-overs and determine when to abide by the sell-by date, many do not and the lack of such skills and habits is thought to be significant to waste generation (Ganglbauer *et al.*, 2013, Quested *et al.*, 2013, Graham-Rowe *et al.*, 2014).

The studies presented in the sections above demonstrate the connection between individual context and sustainable behaviours, however the directness of their connection is problematic. Gregory-Smith et al. (2013) demonstrate that consumers consciously partake in behaviours they consider to be ethical and unethical in relatively short time frames, using personal compensatory mechanisms to manage emotions, and values, making the relationship between intention and action complex. Furthermore it is important to note that most studies conclude that values, attitudes and beliefs are useful predictors of behavioural intentions, not behaviour directly, and a well-developed body of literature exists that discusses the value-action gap (Kollmuss and Agyeman, 2002). There is much discussion in the social sciences about overcoming this value-action gap however Shove (2010) amongst others cautions that preoccupation with the link between attitudes, values, emotions and behaviours risks producing an analytical blind-spot that inhibits our understanding of how behaviours, along with values, attitudes and emotions are produced, within the socio-material landscape of everyday life.

1.8. The social context

While the literature on the individual context is well developed that relating to the social context is still emerging and fragmented across disciplines. The following paragraphs seek to draw out key findings grouped around the factors listed by Darnton and Evans (2013); opinion leaders, institutions, norms, identity & roles, tastes, meanings, networks & relationships. Within the constraints of a paper it is necessary to reduce the scope of enquiry and consequently 'tastes', and 'meanings' have been removed from the following discussion due to their overlaps with other categories in the ISM tool, and the limited availability of literature exploring these in relation to sustainable food.

1.8.1. Opinion leaders

Opinion leaders, or mavens (Feick and Price, 2015), are individuals who communicate information, opinions and experiences of new products and practices with other consumers, thereby increasing the likelihood of repetition by others. There is very little research into the role opinion leaders to the diffusion of food related sustainable behaviours, however celebrity chefs have been shown to act as talking labels, "knowledge intermediaries and boundary objects to connect audiences with food in multiple ways" (Barnes, 2014, p. 1). Barnes focuses on Jamie Oliver and describes how trust, credibility and popularity enable chefs to convey food information in a manner that exceeds any amount of on packet information, and can effectively introduce consumers to new foods and diets (Romero del Castillo *et al.*, 2014). The role of chefs in promoting local seasonal food in restaurant

kitchens has also been shown to be valuable, increasing consumer familiarity with local produce through signage and menus, knowledgeable staff and cookery classes (Inwood *et al.*, 2008), however the same authors acknowledge that the restaurant can be an isolated site, with chefs existing in relatively confined networks, thereby limiting diffusion of such practices. Opinion leaders have also been shown to play a role at the firm level, for example the role of The Co-operative in stimulating the diffusion of organic produce by proving it to be a high value growth area rather than a commercial risk (Elzen *et al.*, 2004)

Trendsetters have also been acknowledged in relation to food, particularly around diets. De Boer show trendsetters to play a key role in raising the profile of alternative sources of protein, such as lentils and seaweed (de Boer *et al.*, 2013a), which they demonstrate to have an impact on consumption habits, while Rothgerber (2014b) provides examples in the context of low meat diets (see also Smart, 2004).

1.8.2. Institutions

Institutions refer to formal and informal socio-political systems collectively formed over long time periods that govern individual behaviour (Darnton and Evans, 2013). These range from workplace and family life which present implicit expectations around personal conduct (see 'identity and roles' and 'time and schedules'), to government nutrition guidance in the food industry.

Labelling and certification are perhaps the most distinguishable institutional mechanisms in sustainable food. Draper and Green (2002) describe how, for many western nations, government guidance has shifted from a protectionist role, shielding consumers from potential negligence in food processing, to educational role, enabling consumers to make the best choices from the products on offer. This is supportive of a neoliberal policy model in which progress is measured in terms of individual's ability to make choices unrestrained by the state (Lang *et al.*, 2009). However Lang et al. (2009) suggest that to achieve social, environmental and nutritional health, that institutional reform towards restrained choice is likely to be required. Choice-editing is one of the more common proposed mechanisms to achieve this whereby undesirable products do not make it to the shelves in the first place. This is often perceived to be contrary to progressive policy however Lang et al (2010) demonstrate that choice editing is already common feature of current supply chains, as a result of contractual agreements and buyer-supplier relationships. Furthermore research by ASDA that consumers expect supermarkets to be making the most basic products sustainable, and removing harmful options from the shelves (ASDA, 2011). Consequently Lang (2010) advocates a systemic shift towards social, environmental and nutritional priorities in this upstream choice-editing. The

fundamental principle in choice editing is that information regarding product sustainability criteria is used for upstream product management, to govern what is available to consumers, rather than presented to the consumer in the form of a label or certificate so as to guide their judgement. This same principle may be applied to ready-meals and meals outside the home, where portion controls, calorie controls or nutritional balancing can all be used as means to ensure that the food available to consumers is more sustainable (Story *et al.*, 2008). As opposed to providing information, for example calorie information on menus, which has been shown to have an insignificant effect on consumer choices (Harnack *et al.*, 2008).

1.8.3. Norms

Norms refer both to descriptive norms, behaviours perceived to be typical of everyday conduct, and injunctive norms, based on our judgement of how others would judge our conduct against social and moral standards. In both cases normative influence is thought to be most affective within self-identified peer groups, where behaviour forms part of group identity (see also 'identity and roles') (Darnton and Evans, 2013).

Using Ajzen's theory of planned behaviour Mahon et al. (2006) demonstrate that a key influence on individuals intention, is the motivation to comply to perceived normal behaviour, particularly the views held by those they considered close to them. This was shown to influence individual's intention to eat ready-meals, yet was insignificant to individual intention to eat take-away meals. Similarly, Robinson et al. (2014) illustrate that normative appropriate information has a moderate relationship with changes in the amount of food consumed, intake of snack food, fruit and vegetables, and main meals.

At a broader level normative cues are a subtle and experiential part of everyday life. De Boer et al. (2009) discuss the notion of 'feeling right' describing how transparency in production and retail processes act as effective normative signals that sustainable behaviour is the right thing to do.

Norms are also significant beyond the immediate attachment to food. For example, the proliferation of social and cultural experience on offer to consumers in contemporary society arises in conjunction with a normative cue that participation in cultural and social activities is now part of citizenship in a globalised society (Darier, 1998, Southerton, 2006, Warde, 2006). Consequently research suggests that individuals are engaged in a wider variety of consumption practices than ever before. This has a duel outcome, firstly there is little time left for the shopping, preparation and consumption of food in

the home and food is increasingly incorporated into other activities. Second, there is an increasing range of culinary experiences that consumers may engage with (REF).

1.8.4. Identity & roles

Individuals may fulfil many different roles in their lives (e.g. parent, employer/ee) and each may have a different set of behavioural repertoires associated with it which guide individual behaviour (Valentine, n.d.). In addition identity is comprised of one's personal identity (e.g. a person's values, attitudes, opinions), but also a social identity, whereby they gain reference of how to behave from the shared representation derived from membership in social groups, which may also relate to their roles. (Abrahamse *et al.*, 2009)

Identity is thought to be a factor influencing people's attitudes and values, and in turn a factor in what people eat (Bisogni *et al.*, 2002, Abrahamse *et al.*, 2009). Meat eating in particular has been explored as an identity dependent food practice. Sparks et al. (Sparks *et al.*, 2001) found that meat-eating correlated with self-declared identity as a healthy person, however Povey et al., (2001) did not find health conscious identify to explain difference between meat eaters and vege/vegan diets. In a further study Abrahamse (2009) demonstrated that for those who do not identify as a vegetarian, pro-vegetarian branding and information can significantly reduce individuals intention to eat certain products.

There is also research to suggest that different sup-groups of the population have different tastes, eating practices and principles, all connected to identity and expressions. For example Bugge and Bahr (2011) show that fast food, even particular brands, may be a part of youth food cultures, but that in recent years this has shifted to reflect health concerns, particularly around fat and weight gain such that there is increasing scepticism from young people toward such foods. Similarly, Guthman (2003) describes how the preferred foods of young adults are shifting toward ethical and environmental produce (the specific example offered is mixed organic lettuce).

Connections have also been made between food waste and identity, with people self identifying with notions of thrift and frugality, which support the adoption of routines to minimise food waste in the home (Evans, 2011b, 2011c). Similarly identity has been shown to be rooted in notions of place and belonging, with consequences for the uptake of local food. However place is shown to be a reflexive concept, not necessarily corresponding to geographic locale, but increasingly to diverse locales across the globes (Feagan, 2007).

1.8.5. Networks & relationships

Consumers that see food as part of a social event are shown by (de Boer *et al.*, 2004) are likely to consume ready meals and take-away meals, more likely to eat out. Daelman *et al.*, (2013) note the presence of a clear bell curve with consumers aged 18-30 most likely to purchase and consume ready meals, and men to consume more frequently than women. They associate this with lifestyle and in particular working patterns of people that age. In this case ready-meals offer the freedom to partake in other things deemed important by the individual (Short, 2003). Connections are also made to eating alone, while few consumers report the desire to eat alone, busy schedules particularly for singles mean many do (Daniels *et al.*, 2014). Eating alone is shown to correlate with more frequent eating out, suggested to be as a result of different patterns of socialising for single people compared to couples and families. It is also seen to correlate with reduced cooking from raw ingredients and more frequent purchase of both ready-meals and fast food (Daniels *et al.*, 2014). Men more so that women are likely to eat alone, particularly young adults.

Research elsewhere demonstrates that the connection between eating and other activities may potentially offer explanation for this trend, with those who incorporate eating in activities with friends more likely to prepare food or eat out, while those who work are more likely to skip meals or eat on the go. Currently men remain more likely to work while women care for children, eating with children and therefore less likely to eat alone (Daniels et al., 2014; Devine et al., 2009). It is also suggested that households with more than one adult are more likely to prepare food as there is a more significant cost saving than when preparing food for one. Work by Scholderer & Grunert, (2005) support these findings, however they associate the above factors with disposable income and available time rather that lifestyles and interaction with other activities.

The sections above demonstrate that the social context is complex, often subtle and without clear ramifications for sustainability issues, however they also illustrate the significance of the social context as situating behaviour, enabling and empowering certain behaviours and facilitating the diffusion or suppression of new trends. Consequently for anyone interested in changing individual behaviours the social context in which they are embedded cannot be ignored. What is not shown in these sections, and we move onto in the following, is the significance of social context when it becomes embodied in material (and immaterial) structures that shape and constrain everyday activities.

1.9. The material context

A relatively under researched element of sustainable food is the material context in which individual behaviour takes place. In the ISM tool rules and regulations, technologies and objects, time & schedules, infrastructure are all specified as factors within this third 'context' of behavioural change (Darnton and Evans, 2013).

1.9.1. Infrastructure

Infrastructure appears in numerous social science disciplines in reference to the socio-material environment that bounds individual behaviour. Darnton and Evans (2013) refer to both hard and soft infrastructures, the former relating to the physical presence and proximity of, for example, roads and public transport networks, while the latter refers to non-concrete elements of everyday life (including 'Time & schedules', and 'Rules & regulations') that can either facilitate or impede certain actions and behaviours . Research suggests that consumers, regardless of values and intentions are most likely to partake in sustainable behaviour if the option is easily available to them (Hjelmar, 2011).

Perhaps the most developed body of literature investigating the infrastructural effect on behaviour is in the environmental justice literature where the term 'food desert' has been used to describe urban areas where residents have limited access to affordable and healthy diets for the last few decades (Beaulac et al., 2009).

There is much discussion regarding both the existence of food deserts and their significance for consumer behaviour. The findings of Pearson et al. (2005) suggest that three key elements of the food desert; prices, socio-economic deprivation and the presence of appropriate local amenities were not influential factors on fruit and vegetable intake. However other research has shown connections between local infrastructure and diet more generally. Fraser and Edwards (2010) demonstrate that the density of fast-food purveyors has been shown to correlate with obesity and various studies evaluating the impact of the establishment of a new facility on consumer behaviour have illustrated significant changes to consumer behaviour. Wrigley et al. demonstrate that despite the diversity of individual relationships to the local infrastructure, the introduction of a large supermarket lead to positive, if only modest changes to consumers' diets (Wrigley et al., 2003, 2004, 2015, Whelan et al., 2015). Similarly, Darmon and Warde (2013) found an 'infrastructure effect' in a detailed study of a greengrocers. They demonstrate changes in the store were likely to bring about changes to eating habits, particularly for customers who use 'veg boxes' schemes in which some choices are made on their behalf. The UK governments convenience store pilot programme (Health, 2010) showed that changes to the range, layout and promotion of fruit and vegetables resulted in increases sales from 6%-480% with an average increase of 143%. This is interesting in consideration of the 'explosion of

farmers markets' Seyfang observes, from none in 1997 to 450 in 2002 (Seyfang, 2006). This research suggests that proximate local food networks, such as farmers markets, promote sustainable behaviour as well as providing an enabling context for its expression. There is also suggestion that the introduction of a new infrastructure may have a ripple effect on the existing infrastructure. Larsen and Gilliland (2009) show that the introduction of a farmers market to an area previously described as a food desert resulted in a significant shift in grocery prices (12% in 3 years).

Connections have also been made between an areas socio-economic demography and the availability of healthy affordable food. Research by Cummins et al. shows a statistically significant relationship between neighbourhood deprivation and the mean number of McDonald's outlets (Cummins et al., 2005) and also that the foods most likely to be cheaper in poorer areas tended towards the high-fat, high-sugar types, the consumption of which current dietary guidelines suggest need to be reduced (Cummins and Macintyre, 2002). These findings not only support Grinnell-Wright et al. (2013) in their observation that poor fast food choices appear to prevail, but also suggesting that the presence of different outlets for food has some bearing on how frequently the food consumed, thus if a neighbourhood is rich in fast-food but poor in retail people are likely to consumer more fast food than on average.

While these studies do not research the significance of these findings in terms of energy use, they provide interesting insights as to how change to consumer behaviour may be brought about, in particular thinking about the relative ease which alternative systems of provisioning may be established (for example mass collective provisioning of food or pharmaceutical products such as nutritional pills (Bows et al., 2012, Spurling et al., 2013, Bows-Larkin et al., 2014)) but also the degree to which material infrastructures prevent and enable certain behaviours.

1.9.2. Time & schedules

Southerton (2006) illustrates how everyday life is anchored around practices that require a fixed time and place, not only of the individual but within families and social groups. Consequently those practices that are not fixed in time and space must fit the gaps between these. Warde (2006) demonstrates the significance of this in relation to convenience foods, offering two partial suggestions as to how, and why, they have become a feature of modern life. Firstly he argues that people are increasingly juggling multiple roles and commitments, resulting in what he describes as modularised, as opposed to continuous time. Consequently convenience foods are valued not simply for their time saving characteristics, but for their fit with this modular time by their improved ability to be stored, prepared and consumed in such a way that they fit with fragmented lifestyles. Secondly,

eating together is made increasingly difficult by this modularisation, resulting in a heightened scheduling processes in order to bring families and other groups together to eat, something that research indicates is still highly valued (Cheng *et al.*, 2007). As a result greater organisational power is required, something afforded by convenience foods and eating out, over and above less flexible practices such as cooking from scratch.

Southerton (2006) also describes key socio-demographic characteristics of relevance to the individual experience of fixed practices. These include age, gender, life-course and education, for example gender is significant particularly with relation to the parental role, showing the frequency, duration and tempo of practices relating to childcare to anchor others in the day. Jabs *et al.* (2007) makes similar observations and again relates these to convenience foods, showing how they are a part of time-management strategies necessitated by feelings of time scarcity and need to control temporal organisation.

Time and scheduling is also important to energy use when considering the synchronicity of practices across societies as a result of the interconnection between personal and organisational rhythms (Walker, 2014). Interestingly in a cross-comparison of synchronised eating practices in the UK and Spain, Southerton (2011) demonstrate that the level of synchronicity in the UK is far less than in Spain, with meals interspersed such that rarely are there in excess of 15-20% of the population eating at any one time.

While there is only a small body of research specifically exploring the significance of time and scheduling to sustainability, and virtually nothing written about the energy implications of temporality, ideas around flexibility and modularity can be detected in studies on convenience food (including prepared foods) (Jabs and Devine, 2006, Jabs et al., 2007) and eating out (Short, 2003, de Boer et al., 2004, Daelman et al., 2013), internet shopping (Verhoef and Langerak, 2001), shopping at convenience stores (Khaled Bachour, Jon Bird, Vaiva Kalnikaitė, Yvonne Rogers, Nicolas Villar, 2012), all of which have implications for energy use in the supply chain.

1.9.3. Technologies & objects

The role of technologies and objects in facilitating behaviours is a simple, yet under-researched element in the sustainable food agenda. In seeking to manage energy use in the home, much has been written about smart meters and other feedback mechanisms to raise awareness and change consumer behaviours. However, these technologies have been shown to have only limited impact on action as they assume that increased awareness and understanding will equate to action, and fail to account for

the socio-material context in which energy is used (Strengers, 2008, 2011). On a similar vein home automation has been discussed in a number of studies with an aim to reschedule household activities to reduce peak energy loads. A study by IBM found that while consumers considered some practices flexible, such as laundry and dishwashing, cooking was immobile, connected to other activities, people, places and practices which prevented rescheduling (Paetz *et al.*, 2011)(REF Birzle-Harder et al. 2008).

Objects and technologies have been shown to be entangled with behavioural trends and societal shifts in the way food is stored and eaten (Shove and Southerton, 2000). However missing from the literature is discussion of how everyday objects and technologies structure food related behaviours in certain ways, and produce blind-spots as to how alternative ways of doing may be contrived. There is some theoretical discussion of this in the design literature (Borja *et al.*, n.d.) but little application.

1.9.4. Rules & regulations

The rules and regulations of significance to this discussion are vast and there is not a consolidated literature on these themes, however it is useful to provide a brief example of the interrelationship between rules and regulations and consumers. The issue of cosmetic standards is one that has been picked up by food waste organisations and activists in recent years as a cause of supply chain waste, much of which is to do with very specific rules and regulations and their embedding in business practice.

The 'Big 4' food retailers in the UK represent over 60% of the market (Defra, 2014) and consequently have a large impact on the supply chains of food. One impact of this is stringent standards placed on the appearance of produce (particularly fruit and vegetables) that endure despite relaxation of both national and European standards (Bond *et al.*, 2013). In a case study of carrots on a farm in Yorkshire as many as 25-30% of all carrots were deemed out-graded, failing to meet cosmetic standards that aim to ensure "all carrots [are] straight, so customers can peel the full length in one easy stroke" (Stuart, 2009 in Gustavsson *et al.*, 2011). The obduracy of these standards is problematic. Supermarkets cite consumers displaying a preference for aesthetically perfect produce as the reason to sustain, and to remain competitive in current economic circumstances, yet a growing body of evidence suggests that consumers are ready to accept 'ugly' produce, as a result of price inflation as well as a growing understanding of sustainability issues (Bond *et al.*, 2013). However there are concerns about the disconnect between the acceptance and actual uptake of 'ugly' produce (Bentley, 2011). This issue leaves significant volumes of edible produce on farms but the weight of supermarket buying power undermines alternative infrastructures for distribution (e.g. exclusivity

rights on farmers) thus leaving managing this food waste to third parties and charities (e.g. gleaning) (Earth, 2002).

The sections above demonstrate the significance of the material context, illustrating how the social and material are heavily entangled as shared understandings, meanings and norms become embedded in the built environment. The combination of the social and material elements provide insight into behaviour, decentralising discussion from individuals by revealing the situated nature of the individual context.

5. Looking towards a framework for managing energy in food supply chains through consumer behaviour change.

In 2010 Defra published Food 2030, which identified the key challenges for the UK food industry in order to maintain resilience, profitability, sustainability and security. Amidst this was a strong call for a more integrated approach to managing the environmental impacts of food supply chains, requiring coordinated action from a range of different critical actors (consumers, food processors, food businesses, food manufacturers, and, government). However, in the main, behaviour change interventions relating to sustainable food and energy have been fragmented approaches to provide consumers with the awareness, information and incentive to take action to make sustainable purchase decisions, and reduce energy use in the home.

In the preceding sections we have outlined the insights gained from a multi-disciplinary review of the social science literature on food and behaviour change to understand what such an integrated approach might look like. In Section 3 we have provided a literature review that rather than viewing the consumer as an isolated individual at the end of the supply chain is interactive with various stages to greater or lesser degrees. In Section 4 we have demonstrated the relevance of the 3 layers of the ISM model (Individual, Social and Material) to understanding existing food behaviours and interventions to change these. This combination allows for a broader consideration of how the ‘problem’ of unsustainable consumer behaviour and potential interventions are defined and framed. In particular the inclusion of the social and material layers offers a route to thinking about the relationship between behaviour and other life cycle stages as it enables explicit reflection on how elements such as retail provision, agricultural policy and practice, social organisation, transport networks, IT, household technologies all shape and constrain the variety of choice, and scope of action available to individuals.

Darnton and Evans show that in a broad range of case studies the most effective at delivering beneficial change are those which incorporate more than just the individual context, but the most effective are those that engage in the reconfiguration of the social and material context. At present common behaviour change activities include product labelling to raise awareness of the impacts of products, information campaigns, particularly where there are associated health benefits, and smart metering and other feedback mechanisms have been explored to optimise cooking behaviour as part of broader demand management initiatives to reduce energy consumption in the home. These activities each are heavily invested in changing the elements that shape the individual context to behaviour, and while each have their own internal challenges the common problem between them is the failure to engage with the social and material context in which behaviour occurs. During the course of this review case studies have emerged that provide counter examples to these actions that may be learnt from.

Firstly the UK governments convenience store pilot programme demonstrated that changes to product availability, positioning in stores and marketing could have quite profound impact on consumer uptake of fresh fruit (Health, 2010). This draws attention to how a wide range of practices such as infrastructure development, marketing, and procurement all have a role to play in behaviour change, and may be particularly useful in thinking about how to increase uptake of unprocessed products, meat free meals, as well as seasonal and local produce. Secondly the case study of the freezer illustrates the extensive network of changes to individual behaviour, largescale systems of provisioning and everything in between providing a unique insight to the types of changes facilitated by a technological development (Shove and Southerton, 2000). Many of these changes are unlikely to have been conceived at the design stage, initially designed to manage seasonal gluts, and in order to learn from this case more nuanced systems of testing and evaluating the immediate and long term consequences (both intentional and otherwise) of technological developments are required. Thirdly, and finally within the scope of this paper, the example of how organic produce has been subsumed into foodstuffs that intersect with social identity demonstrates the fluidity of social and cultural values (Guthman, 2003). This highlights a role for proactive, rather than reactive initiatives, such that interventions are invested in producing the sustainable behaviours of the future, not confined to preventing the unsustainable trends of the present.

Thus our goal is not to identify ever more complicated ways that the consumer *should* be thinking about their environmental impact, or huge amounts of new information that may need to be provided, but rather to stress that in order to shape consumption to reduce energy use in food there are

activities both throughout and beyond the supply chain of food that may prove fruitful; from choice editing in supermarkets, to improving fast food offerings, to improving standard of ready-meals and catering, to re-evaluating patterns in working days so that lone eaters may eat with family and friends, to new technologies, to new systems of provision. These are complex activities, but a fundamental part of a long term project to reconfigure the context in which individual behaviour takes place.

In addition, it is also clear that there are many areas in which the preferred option in terms of energy consumption is unclear or highly dependent upon the specific supply chain and so those trying to manage the emissions in these cases must consider both bottom up calculations of impact, wider environmental impacts and the unintended behavioural change that may occur outside the immediate focus of specific interventions.

6. Conclusion

The scale of the emissions reductions committed to under the Climate Change Act mean that all sectors will have to make significant reductions in their GHG emissions. The intertwined nature of the various elements of the food supply chain indicates that attempts to make these reductions will directly involve or have implications for consumers. Understanding consumer interaction with food supply chains has an important role in mitigating the environmental impact of the food system and hence can make a significant contribution to the development of robust policy and management activities.

In this review we have identified key trends in consumer behaviours that are of significance to management of supply chain energy use and presented an overview of social science literature from a range of disciplines that provides insight into the drivers of these trends. In doing so we highlight the potential contribution the social sciences offer to managing environmental impact. Management actions to bring about more sustainable behaviour are often limited to providing information to enable consumers to make better choices, stopping short of engaging with broader drivers of unsustainable social trends (Shove, 2010). This review has problematised this by challenging the linearity of commonly used resource flow models that position the consumer at the end of supply chains thus limiting the scope of management activity. Instead, this review has illustrated the range of factors driving unsustainable trends in consumer behaviour, demonstrating the integrated nature of the food system.

By considering the individual, social and material contexts of consumer behaviour, we have identified various points of intervention that decision-makers may look to combine in order to achieve more sustainable patterns of consumption. Consideration of the stages of the lifecycle and the 3 contexts of consumer behaviour open up the potential for new constellations of interventions that target various elements of the consumer behaviour context and actors throughout the supply chain. Rather than increasing a sense of responsibilities of the consumer, our aim has been to highlight the range upstream and downstream activities that are likely to be needed to support the development of more sustainable patterns of consumption.

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