Behaviour change, public engagement and Net Zero

A report for the Committee on Climate Change

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Table of Contents

Executive Summary

Behaviour change in Net Zero

The IPCC Special Report on the impacts of global warming of 1.5 degrees above pre-industrial levels strengthened the case for pursuing greater efforts to reduce greenhouse gas emissions. In May 2019 the Committee on Climate Change (CCC) updated its advice to the UK Government detailing the recommended timing and scenarios for a net-zero emissions target to contribute to the global ambitions set out in the Paris Agreement. The CCC recommended a UK target of net-zero emissions by 2050 and this has now also been adopted by Government which is now legally committed to delivering it. It is in this context that this report considers the contribution of behavioural and societal shifts to delivering the long-term UK Net Zero target and how policy can support these changes. It identifies opportunities for where shifts in behaviour could deliver deep emissions reductions and recommends policies that could help to deliver them.

The UK has reduced emissions by 40% since 1990 while its economy has grown. This progress has come largely from things that have not involved consumers changing their behaviour - notably decarbonisation of electricity supply. The UK is not on course to meet the legally binding fourth and fifth carbon budgets and rising to the challenge of Net Zero scenarios will require major progress in all sectors and for behavioural shifts to play a much greater role. On a global basis, household consumption accounts for almost three-quarters of greenhouse gas emissions. The need for changes in household consumption is even more pressing in wealthy countries such as the UK and there is an urgent need to identify and implement solutions for promoting greater engagement and action from citizens and consumers.

Policy for behavioural and societal change for Net Zero scenarios may best be informed by two inter-dependent strategies:

(i) *enable consumers to take specific concrete actions that deliver large emissions reductions* and

(ii) *create a wider context that nurtures public engagement* with action on climate change

Breaking with previous messaging to households to make small and easy changes, high-impact shifts in consumer behaviours and choices are needed that are consistent with the scale of the climate challenge, build optimism and commitment, and give weight to new ambitious narratives that inspire wide public participation. These changes need not be expensive or reduce well-being and could deliver huge co-benefits to health and beyond, but they will not happen at the pace required unless policy first removes obstacles to change in markets and consumer choice. For high-income European countries, the largest contributions to household consumption footprints come from car and plane mobility, animal-based foods, and heating. The recommendations discussed in this report therefore focus on transport, aviation, heating and diet as areas where shifts in behaviour are both feasible and could deliver large reductions in emissions. Given the inherent uncertainty in predicting levels of behaviour change over the long-term, this report focuses on *how* Government can facilitate behavioural and societal shifts rather than on quantifying *how much* change can be expected.

Recommendations for transport, heating and diet

Transport and heating

Surface transport currently accounts for 27% of UK greenhouse gas (GHG) emissions, over half of which is from cars. Reducing car ownership, dependency and use through modal shift to public transport, walking and cycling will be an important part of solutions and offers the greatest co-benefits for air quality, congestion, more active and healthy lifestyles, and safer, stronger communities.

- An integrated package of measures including investment across the whole of rail and bus networks, support for car clubs and investment in cycling infrastructure are likely to deliver better benefit-to-cost ratios than single large infrastructure schemes.

Excellent progress in decarbonising UK electricity - together with sharp falls in the costs of renewables and batteries - creates a real opportunity for consumers to reduce emissions by shifting to electric vehicles, potentially cutting a third from the average household's carbon footprint if smart charging on renewable energy. Achieving targets for electric vehicle (EV) growth could also deliver important public health co-benefits through improved air quality but there is uncertainty over the rapid consumer uptake which will be required. Commercial fleet and company car purchases account for over half of new car sales and move quickly into the private market but, despite the heavy mileage of company cars, awareness of the benefits of EVs is lacking among fleet operators.

- Raising fleet operators' awareness of incentives, the lower lifetime costs of EVs and additional benefits could boost EV sales and also play a key role in growing the market in more affordable second-hand electric vehicles.

The availability of increasingly low-carbon electricity offers consumers a similar opportunity to decarbonise heating within the home. Adding a smart hybrid heat pump (HHP) to an existing gas central heating system could potentially deliver an emissions reduction of similar size to switching to an EV. However, mainstream adoption of HHPs will require policy to reduce running costs. Rebalancing the tax and regulatory costs to fall more evenly on electricity and gas would deliver lower-cost electricity and make hybrid heat pumps a more attractive proposition. Greater scope for reducing running costs for both EVs and HHPs is offered via smart controls combined with time-of-use (TOU) electricity tariffs, and other 'demand response' (DR) services, which reward flexibility in household electricity demand.

- Regulatory changes that increase the market value of residential flexibility and develop the market for domestic demand response services are needed to reduce running costs for both electric vehicles and smart heat pumps.
- Maintaining rapid rollout of second generation smart meters is also required to bring in market-wide half-hourly settlement and incentivise competition in time-of-use tariffs (TOU) and demand response (DR) offerings.

Consumer awareness of cheaper EV and HHP running costs via time-of-use electricity pricing is extremely low and tailored cost projections are not available through price comparison websites and running-cost calculators, as they are for flat-rate tariffs. This bottleneck for technology adoption and the development of services for residential flexibility (DR) should be addressed with new online digital comparison tools (DCTs).

- Action is needed to enable consumers to share their smart meter consumption data with selected third party digital comparison tools offering tailored comparisons of projected up-

front costs, running costs and pay-back periods for electric vehicles and smart hybrid heat pumps when combined with demand response services and other smart low-carbon technologies (e.g., storage, solar PV). Government support, regulation and open data for developing these digital comparison tools may also be needed.

Try-before-you-buy is not possible for home heating technologies, as it is for electric vehicles through a test-drive or rental, so additional support for the adoption of heating technologies using real-world data and ICT could prove effective in further lowering barriers to adoption.

- Require installers to provide independently-verified ex-post evaluations of the real-world performance of smart heat pump/HHP, insulation and energy storage technologies to increase consumer trust and generate real-world data for policy development.
- Fund development of a publicly-accessible online database featuring case studies of the real-world performance, running costs and customer satisfaction with smart heat pumps/HHP and associated storage, insulation, smart controls and energy services offerings. This could further increase trust in unfamiliar technologies and make adoption more visible thereby leveraging social proof and norms. Independent verification of technology performance and running costs will also require a data portability solution enabling households to share their gas and electricity smart meter data with selected third parties.

Aviation demand growth

Approaching 2050, aviation is expected make up a large share of the UK's remaining positive emissions as other sectors contract. The CCC's Net Zero scenarios allow for a growth in UK demand of up to 25% on current levels but the risk of much larger growth in demand has been forecast. Flying is a uniquely high-impact activity and is the quickest and cheapest way for a consumer to increase their carbon footprint. The emissions from one return ticket from London to New York are roughly equivalent to that of heating a typical home for a whole year. Low-carbon aviation technology is expected to remain technically unfeasible and so it is vital to restrain rising demand despite this having been considered politically difficult to address hitherto. Aviation has so far enjoyed generous tax treatment despite a large proportion of flights being taken by a small, wealthy segment of the population: an estimated 70% of UK flights are taken by just 15% of the population. Given that there is a finite budget of carbon emissions allowable if global warming is to be held below 1.5 degrees, the highly uneven distribution of emissions due to flying raises equity concerns. In contrast to an aviation fuel tax, which would increase air fares for all passengers at the same rate, research suggests a levy aimed at excessive flying by frequent flyers could have popular support.

- An Air Miles Levy which escalates with the air miles travelled by an individual within a three-year accounting period could provide strong price signals to curb some demand by less price-sensitive frequent flyers, encourage shifting from long-haul to short-haul destinations and fund research into low-carbon aviation technology, while sparing the large majority of travellers any extra cost.

Shifting to sustainable diets

Like aviation demand, diet has been neglected by climate policy. Also like aviation, UK agriculture is expected to account for approximately 30% of remaining positive emissions by 2050 under the CCC's Further Ambition net-zero scenario. The impacts of UK food consumption also extend beyond emissions currently produced by UK agriculture – both through imported foods and the potential to free-up land use for carbon sequestration through afforestation. The livestock industry is especially high-emitting and accounts for an estimated 14.5 per cent of all human greenhouse gas emissions

globally. In countries with high per-capita meat consumption, like the UK, a shift to plant-based diets would deliver up to around a 73% reduction in diet-related emissions compared to current levels and would require 70-80% less farmland. Halving the consumption of meat, dairy products and eggs in the EU would achieve a 25–40% reduction in greenhouse gas emissions from agriculture. Shifting to more sustainable diets, with reduced meat and dairy and more plant-based proteins and foods, offers a huge opportunity for consumers to reduce their personal carbon footprints with no additional cost and would also deliver large health benefits and NHS cost savings to society.

Demand for plant-based foods has grown rapidly and the retail sector is responding but shifting to sustainable diets will not happen if left to the market, individuals, or voluntary industry initiatives. Limited availability of plant-based foods in catering is a major bottleneck which restricts choice, reinforces traditional diets and impedes behaviour change. Including more plant-based options on catering menus has been found to greatly increase their sales, especially among meat-eaters.

- Broadening choice rather than introducing restrictions is an obvious first step in enabling people to shift to lower-impact and healthier eating habits. New regulation should require that all schools, hospitals and other public-sector catering outlets – which provide thirty per cent of UK meals - include at least one fully plant-based menu option that is available for everyone every day without special request. This has been implemented throughout Portugal. It would not only cater to those already willing but unable to access plant-based meals but would allow others to try these foods and help to normalise low-impact diets.
- Funding should be made available for training public-sector catering staff in more plant-based cooking to address skills gaps and win them over to champion menu changes rather than resist them.

Plant-protein based meat replacements, or ‘analogues’, have around one tenth the GHG impact of meat and a fraction of land and water use. They have further appeal on health and animal welfare grounds, both now common concerns. Strong market growth demonstrates consumer appeal and no change to meal planning or cooking skills are required for swapping from meat to meat analogues, indicating good scope for a shift in purchasing and consumption habits. Blending meat with plant ingredients to create heathier burgers with 30% lower emissions, fat and cholesterol has also already proven successful with consumers in the USA.

- Reducing meat consumption can also be approached as a technical rather than a societal challenge. In the same way that the development of technology for low-carbon electricity was financially supported, Government should fund food technology research to accelerate the development and commercialisation of low-carbon plant-based meat analogues and blended products. An opportunity for UK industry also exists through accelerating a ‘new protein economy’ with good potential for global markets and reducing dietary emissions beyond the UK.

Lower impact diets also tend to be healthier than current UK diets. Excessive consumption in the UK of high-emission livestock-derived products high in saturated fats is contributing to grave public health problems in terms of diet-related diseases and their costs to society. There is consumer demand for clear, standardised, graphical nutritional labelling to replace the confusing variety of voluntary schemes used selectively now.

- Introduce mandatory standardised ‘traffic light’ nutrition labelling on all retail food products, which evidence suggests can help consumers make more informed decisions.

Although foods from livestock have much higher GHG-emissions than plant-based foods, huge variations exist between different producers of the same type of food. High-impact beef producers emit 12 times more GHGs and have 50 times the land use of low-emitting beef producers. *Halving consumption of animal products by avoiding the highest-impact producers would achieve 73% of the GHG emissions reduction from switching to completely plant-based diets.* Significant targeted emissions reductions could be achieved by consumers making easy choices of lower-impact producers/brands of the same food.

- Almost three-quarters of UK shoppers want information on the climate impacts of their foods to help them make more informed choices. Mandatory standardised environmental impact labels for food should be developed and introduced which are based on producer-specific data. The Danish Government has recently indicated its commitment to climate food labelling and feasibility has already be demonstrated using free-to-use software. This information would enable UK consumers to make informed choices of lower-impact food types and lower-impact producers and has the potential for the UK to contribute to data-led systemic change in global food production.

While food labels are attached to individual food items, a diet is the sum of a variety of food and drink consumed habitually. Aggregating labelling data across the whole of a household's food purchasing and adjusting for product weight would give a more meaningful picture for health and environmental impacts than individual product labels alone. Over time, such personalised feedback showing patterns in food shopping and progress towards goals is more likely to influence purchasing habits.

- Introduce a requirement for supermarkets to give shoppers feedback on their overall food purchasing habits based on data from mandatory nutritional and environmental impact labels. This should be benchmarked to guidelines for healthy and sustainable diets and be provided on till receipts and online shopping sites. Supermarkets should also be required (with support from Government) to enable customers to easily access and share their food purchasing data with selected third parties offering further feedback services.

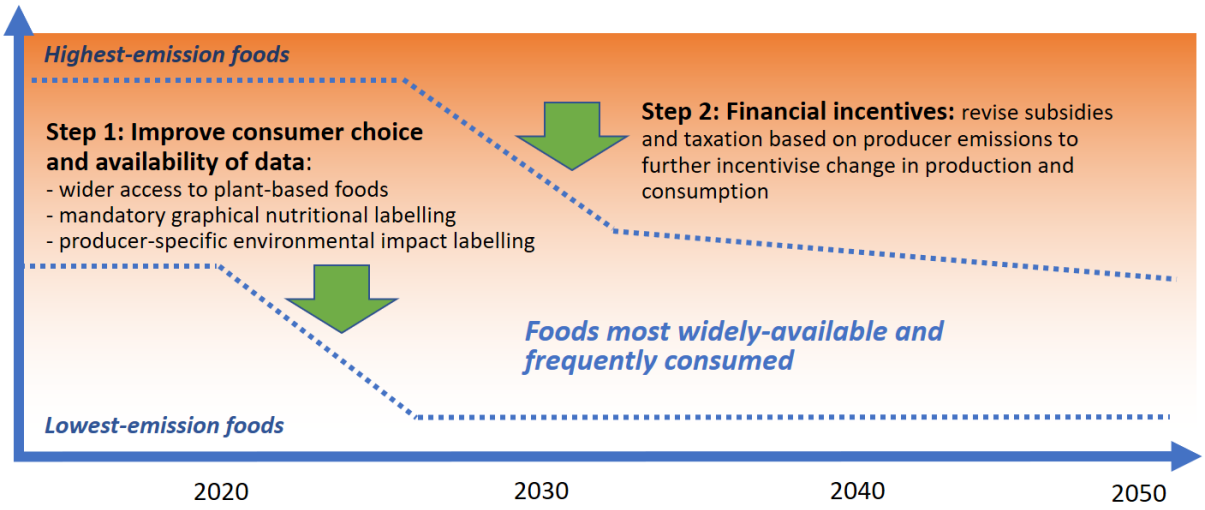
Farming subsidies through the Common Agricultural Policy (CAP) and inconsistent VAT rules for food currently make livestock products cheaper for consumers despite conflicting with Government healthy eating advice, public health crises and UK Net Zero obligations. Approximately three-quarters (€29-33 billion) of the CAP direct payments go to producers of livestock or livestock fodder - almost a fifth of the EU's total annual budget.

- The producer-specific data used for food environmental impact labelling could also be used as the basis for administering and revising financial supports, subsidies and taxation to reward lower-emission producers, filter down as price signals to consumers, and incentivise changes in product development and production methods. The Agriculture Bill has potential to deliver these changes to farming subsidies to better reflect the real price of meat and dairy but currently lacks detail.

Approximately 14% of all food purchased in the UK is thrown away. This wasted food is associated with emissions equivalent to a quarter of private car journeys on UK roads and, in addition, releases methane from landfill. Half of households in England do not have access to collection of separate food waste.

- Extend access to weekly separate food waste collections to all UK households.

- Require products to have only one date label to reduce confusion over food safety caused by 'Best before' and 'Use by' dates.
- Environmental impact food labelling and personalised feedback could raise awareness in consumers that food waste has environmental as well as financial costs and may, combined with greater visibility of waste through separating food waste for collections, reduce waste of the highest-impact foods particularly.



A two-step approach to reducing diet-related emissions:
improve choice and data availability before introducing financial incentives

Common themes

Predicting the levels of behaviour change that will be delivered by these interventions is extremely difficult. Policy to deliver rapid societal change and technology adoption for Net Zero is uncharted territory beyond the available evidence base and inherently subject to uncertainty. Government will need to take a pragmatic approach, begin now and learn by doing. Policy is needed to help redirect the flow of consumer spending away from high GHG-impact products and services and towards low-carbon alternatives. This will involve financial supports and price signals but will also mean lowering other barriers.

A common theme for shifting behaviours across both energy and food is the emerging importance of data and ICT (information and communications technology) as an important asset and tool for enabling consumers to make informed decisions about technology adoption (EVs and heating), for providing consumers with product information and feedback on purchasing habits (diet) and for redesigning financial incentives for shifts in demand and production (diet and aviation). While digitalisation is greatly increasing the role of data in energy, data is lacking in the food system. In both sectors, new infrastructure enabling consumers to share their data with third parties is needed to allow access to new services which can support low-carbon choices and habits.

A second theme across transport, heat and diet is that policies will need to work in combination and be introduced in the right order to deliver change in behaviours and markets, avoid negative outcomes and build public acceptance. Access to attractive and affordable products and services, and support for informed choices and new industry practices, should be in place wherever possible before interventions which raise prices for essential goods (*as illustrated in figure above*).

The wider policy context for public engagement and behaviour change

If the public are to become engaged with the climate challenge and contribute to Net Zero then the wider context created by policy will also need to be more supportive. New, compelling narratives could play an important role in inspiring and mobilising mainstream participation in solutions, adoption of technologies and shifts in behaviours. Policy which reinforces rather than undermines these narratives will also be required. Greater fairness, consistency and leadership in Government policy is imperative to remove reasons for cynicism, apathy and rationalisations for inaction. To a large degree this will mean removing financial and other barriers which frustrate shifts to low-carbon household choices. Greater leadership and consistency from Government could also be demonstrated through: public procurement practices; divestment of public money from high carbon-impact activities; and climate impact assessment of all new policy and regulation. More ambitiously, a gradually-increasing economy-wide carbon fee where revenue is given back to citizens as payments (already in effect in Canada) could incentivise transitions without making lower-income households worse off. New policy to tackle poverty and time-poverty, and to improve well-being could also be decisive in empowering more households with both the economic and personal resources to participate.

Finally, feedback systems should be developed for building momentum across behaviour change, policy and industry. It will be vital to capture evidence – of public participation, of progress delivered towards emissions goals, and of co-benefits accrued – and to make this evidence visible to all stakeholders (citizens, MPs, business, …) to normalise low-carbon behaviours and technologies, strengthen collective commitment and accelerate change. Co-benefits – for health, wellbeing, biodiversity, jobs and the economy – are tangible and *will be enjoyed on much shorter time horizons* than the benefits from climate change mitigation and so it will be particularly important to raise awareness of these for building and sustaining public engagement.

Surface transport and aviation - Summary of recommendations

Cycling and e-bikes

- Further cycling infrastructure investment for safer cycling and secure cycle parking.
- Introduce grants for e-bikes.

Bus and rail

- Invite and support new budget-priced intercity rail services (such as that planned for London to Edinburgh in 2021 with £25 fares) to encourage modal shift from cars and planes.
- Require introduction of reduced-price season tickets/passes for part-time workers.
- Reopen disused rail lines and withdrawn bus services where demand exists, or could develop, to reduce car dependency and ownership.
- Finance a programme of investment across the whole of rail and bus networks.

Electric Vehicles (EVs)

Charging infrastructure

- Introduce measures to improve interoperability, reliability and smart grid compatibility.

Fleets

- Raise awareness among fleet operators of incentives, lifetime costs and additional benefits of EV adoption. Company/fleet purchases account for over half of new car sales and have good potential for growing the second-hand EV market to make EVs more accessible.
- Increase funding for procurement of fully electric EVs for Government and Local Authority car fleets. This will lead by example, deliver whole-life cost savings and air quality benefits.
- Extra support for growing car-club EV fleets which reduce private car ownership and use.

Reduce up-front costs

- Reinstate the OLEV grant to the previous level but exclude high-end EV models.
- Lower or remove VAT on new EV sales (as in Norway and Iceland).

Reduce Running costs

- Introduce a 'Flexibility First' approach in new regulation which would improve access to the full market value of flexibility in household electricity demand and support the development of new demand response (DR) services for cheaper smart-charging of EVs.

Enable informed adoption of EVs, smart meters and time-of-use tariffs

- Raise awareness (e.g., via smart metering awareness campaign) of the range of benefits of smart EV-charging (bill savings, system efficiency and supporting renewable energy) and of the need to have a smart meter to give access to new products and services for flexibility.
- Improve the regulatory context and support for third parties to develop innovative digital comparison tools (DCTs) to communicate the lower EV-charging costs and payback periods possible when combined with smart tariffs, other DR services and/or solar PV.
- Support the development of a data portability solution for consumers to share their smart meter data with third-party digital comparison tools to support adoption decisions.

- **Aviation demand**

Leisure travel

- Introduce an escalating Air Miles Levy to discourage excessive flying by the 15% of the UK population estimated to be responsible for 70% of flights. Unlike a fuel tax, this would provide strong price signals for frequent flyers without raising prices for people taking an annual holiday. It would also encourage shifting from long-haul to short-haul leisure destinations while 3 or 4-year cycles would allow travellers greater flexibility for long-haul. The levy should also factor in the much larger emissions for Business and First Class tickets.
- Introduce regulation to ban frequent flyer reward schemes that stimulate demand.
- Raise awareness and encourage more responsible flying by mandating that all marketing of flights show emissions information expressed in terms that are meaningful to consumers.

Domestic heating - Summary of recommendations

Reduce up-front costs for smart Heat Pump (HP) and Hybrid Heat Pumps (HHPs)

- Extend the Renewable Heat Incentive (RHI) for HP/HHPs beyond 2021, rebalance towards a capital grant, and stipulate smart controls as a requirement. (The RHI for heat pumps in smart hybrid systems can taper off as installation costs come down and the market value of flexibility increases).
- Reduce VAT on smart HP/HHP installations (including boiler and smart controls) in all installations of hybrid retrofit, not just new-build or energy efficient homes as eligibility presently requires.
- Mandate standards for smart appliances to avoid the need for additional appliance purchases due to interoperability issues (air source heat pumps and boilers are not generally ready for smart digital control).

Reduce running costs for smart Heat Pump (HP) and Hybrid Heat Pumps (HHPs)

Reduce electricity costs

- Introduce a 'Flexibility First' approach in new regulation to improve access to the full market value of flexibility in household electricity demand ('demand response'/DR) and better support the emergence of new cost-saving DR services.
- Reduce electricity prices by rebalancing the tax and regulatory costs applied to consumer energy bills which currently fall much more heavily on increasingly low-carbon electricity (17.45%) than fossil fuel gas (1.8%).

Support load-shifting technologies to reduce running costs through demand response

- Pre-heating: Financial assistance for home insulation retrofits via low-interest loans/Variable Council Tax/Green Mortgage proposals.
- Storage: Extend the reduced 5% or zero VAT level to all thermal and electrical storage installations (as for newbuild housing). Storage options can present fewer barriers to adoption than building fabric insulation in terms of disruption and cost of installation.

Enable informed adoption decisions for heating and insulation technologies

- Implement a centrally-administered system of accreditation for smart HP/HHP suppliers and installers and funding for regional centres of excellence to maintain high levels of outcomes and consumer trust.
- Retrofit public buildings open to the public with low-carbon heating, insulation and storage technologies to raise awareness and trust to encourage uptake.
- Provide funding for showrooms on high streets to introduce consumers to smart HP/HHPs and other low-carbon smart heating, storage and insulation solutions.
- Require and support installers to provide independently-verified ex-post evaluations of the real-world performance of smart HP/HHP technology to increase consumer trust and generate real-world data for policy development.
- Support the development of a publicly-accessible online database featuring case studies of the real-world performance, running costs and customer satisfaction with smart heat pumps/HHP and associated storage, insulation, smart controls and energy service offerings. This could help to normalise, and increase trust in, unfamiliar technologies.
- Support the development (finance, regulation and open data) of a digital comparison tool offering tailored cost projections (up-front costs, running costs and payback periods) and market comparisons of smart HPs combined with smart time-of-use tariffs/DR services and other behind-the-meter low-carbon technologies such as storage, insulation and solar PV.
- Support the development of a data portability solution for consumers to share their smart meter data with third party digital comparison tools and for ex-post assessments.

Shifting to sustainable diets - Summary of recommendations

Reducing food waste

- Give all UK households access to weekly collection of food waste.
- Require products to have only one date label to reduce confusion over food safety.
- Regulation to discourage excessive portion sizing and improve portion size choice for meals eaten outside the home (co-benefits for health from reduced calorie over-consumption).

Public sector catering

- Mandate that all public-sector catering menus include at least one fully plant-based (vegan) option that is available to everyone every day to improve access to lower-impact foods.
- Fund training in plant-based cooking to address skills gaps and provide financial support for equipping kitchen facilities for additional plant-based food preparation where needed.

New product development: plant-based analogues and blended products

- Fund research and development (R&D) in food technology for plant-based meat and dairy replacements (analogues) and plant-animal blended products with a focus on sustainability, health and consumer appeal. This could accelerate a 'new protein economy' for the UK and has scope for reducing dietary emissions globally. The Industrial Strategy Challenge Fund could be suitable for pursuing such a large, fast-growing and sustainable global market.

Food labelling and feedback on shopping habits

Nutritional labelling

- Lower-impact foods strongly tend be lower in saturated fats and cholesterol. Introduce mandatory, standardised 'traffic light' nutrition labels on retailed food to replace numerous ineffective voluntary schemes and permit personalised feedback on overall shopping habits.

Producer-specific environmental impact labelling

- Introduce mandatory, standardised, graphical labelling for the environmental impact of food products based on verified producer-specific data not food type. This can incentivise shifts to lower-impact consumer purchasing choices, production practices and product innovation.

Feedback on shopping habits

- Require supermarkets to provide consumers with graphical feedback on their overall shopping habits by leveraging new mandatory, standardised labelling for nutrition and environmental impact. Feedback to be benchmarked to guidelines for globally sustainable and healthy diets and provided on till receipts and on online food shopping sites.
- Require supermarkets to enable customers to share nutritional and environmental-impact labelling data with chosen third parties offering feedback on purchasing habits.
- Government to create the technical and regulatory environment needed to enable consumers to access and share their food purchasing data with third parties offering analysis and feedback services.

Financial incentives for lower-impact food production and consumption

- Apply financial incentives to high GHG-impact foods based on producer-specific data to further incentivise shifts to lower-impact production practices, product innovation and consumer purchasing choices. Price signals should leverage validated data used for mandatory environmental impact labelling (rather than food types, e.g., beef) and should be introduced after this data and labelling infrastructure is established.
- Financial incentives should be applied in the first instance through rebalancing existing EU farm subsidies post-Brexit, 69-79% of which go to support fodder and livestock production.
- Revise VAT rules on foods to remove many existing inconsistencies and reflect the goals of healthy and sustainable diets.
- New Government support (e.g., finance and knowledge-sharing) for farmers to shift from livestock to horticulture, where land is suitable, or to other land use options.

Chapter 1: Behaviour change and Net Zero

1.1 Report Aims

Up to now, behaviour change and societal change around lifestyles and consumption have not played a significant role in progress towards meeting UK emissions reductions targets. Going forwards with greater ambition to reduce UK emissions to net zero there is an urgent need for the public, as citizens and consumers, to have a much larger role. This report aims to identify and recommend strategies for the UK Government to facilitate much greater behavioural and societal change towards net-zero emissions scenarios for the UK.

The report does not aim to be an exhaustive list of the effective actions that individuals could take to mitigate climate change impacts – one notable omission in this regard is choosing to have one less child (Wynes and Nicholas, 2017). The focus, rather, is on where UK Government policy is most needed to facilitate specific action by individuals and public engagement generally.

1.2 UK emissions targets, progress and households

Following advice from the Committee on Climate Change in May 2019 (CCC, 2019a), Parliament amended the Climate Change Act 2008 from 80 per cent to a net zero reduction target by 2050 (The Climate Change Act 2008, 2050 Target Amendment, 2019). While this was one of the shortest pieces of legislation it is one which will require ambitious and far-reaching actions to deliver this now legally-binding commitment.

UK emissions currently stand at 40% lower than 1990 levels (including international aviation and shipping). This achievement is largely attributable to shifting to lower carbon electricity over the last ten years: 75% of all UK emissions reductions since 2012 have come from progress in the power sector (CCC, 2018). There has been significant progress in the waste sector also, with a reduction of 22% from 2012 to 2017. However, progress in overall reductions conceals a lack of progress in all other sectors.

Moreover, behaviour change has played little or no part in reductions so far. Progress in the power sector has been delivered largely by replacing coal generation with gas and wind power, energy efficiency improvements and less energy-intensive UK industry. In the waste sector reductions have been driven by tax on waste going to landfill. With the notable exception of household adoption of photovoltaic solar panels, supported by the Feed-in Tariff, and the mandatory move to condensing gas boilers since 2005, there has been little contribution from households. The UK is not on course to meet the legally binding fourth and fifth carbon budgets and rising to the challenge of Net Zero will require major progress in all sectors and for behaviour change to play a much greater role. On the global level, household consumption accounts for about 72% of greenhouse gas emissions (Hertwich and Peters, 2009; Wilson, Tyedmers and Spinney, 2013). The need for major changes in household consumption is even more pressing in high income countries such as the UK. More detail is urgently needed on how shifts in household consumption and behaviour can contribute to delivering net-zero reductions and how policy and other stakeholders could support these changes.

1.3 In which sectors is behaviour change most needed and feasible?

How do households and consumers currently contribute most to UK emissions and what feasible opportunities exist for shifting to lower-carbon lifestyles? What answer should be given to the question posed by consumers and households, ‘what can I do?’.

For Western countries, transportation, housing and food make the largest contributions to household carbon footprints (Druckman and Jackson, 2016). Similarly, within high-income European countries, household consumption footprints are dominated by mobility (34%), food (30%) and housing (21%) (Dubois et al., 2019).

Transport and heating. The successful and ongoing decarbonisation of the power sector has not involved consumers changing behaviour but does now present excellent new opportunities for decarbonising transport and heat. In both cases, switching from fossil fuels to increasingly low-carbon electricity is now technically feasible through electric vehicle technology and heat pumps further facilitated by smart grid technology. This opens the door for the public to play a more active role by choosing low-carbon electric transport and heating. Surface transport is now the largest emitting sector of the UK economy, accounting for 27% of UK greenhouse gas emissions, over half of which is from cars. Vehicle emissions make up around a third of the emissions for a typical UK household and heat within the home a further 29% (CCC, 2016a).

Most UK decarbonisation scenarios for transport and domestic heat hinge on consumers purchasing EVs and heat pumps in large numbers and at a fast rate. Targets for UK adoption of electric vehicles (EVs) are ambitious but considerable uncertainty exists around actual future rates of adoption. Similarly, take-up of heat pumps has been very slow, with householders preferring familiar gas central heating. Greater clarity in how to reduce the risk that these adoption rates will not be realised is a priority.

Switching from petrol/diesel cars to EVs will also deliver considerable immediate co-benefits to health through reduced air pollution. However, modal shift from cars to public transport, walking and cycling will be an important part of solutions, offering substantial further co-benefits for air quality, congestion, more active and healthy lifestyles, and safer, stronger communities.

Aviation demand. Currently, flights make up around 12% of emissions from UK households but this is very unevenly distributed within the population and is growing. The CCC Net Zero 'Further Ambition' scenario, can accommodate a maximum growth of 25% in aviation demand from current levels by 2050, at which time, with much-reduced emissions from other sectors, it would account for about 30% of the UK's remaining positive emissions. There is a real risk that aviation demand may grow well beyond levels allowed for (Department for Transport, 2017b). While some advances in fuel efficiency are anticipated, switching to low-carbon aviation technology is expected to remain technically unfeasible and so it is vital to explore how rising demand can be restrained, despite this having been considered politically difficult to address.

Shifting to sustainable diets. Along with heating and car and plane mobility, diet makes up the other dominant component of household footprints in high-income European countries (Dubois et al., 2019). UK diet is another area which has so far been overlooked by UK climate policy. Like aviation, UK agriculture is also expected to account for approximately 30% of total positive emissions by 2050 under the CCC's Further Ambition scenario for Net Zero, though the impacts of food consumed in the UK go beyond UK agricultural emissions and much work on food emissions takes a global perspective. However, while aviation demand is growing, a proportion of the public have recently shown that they are increasingly interested in more sustainable diets and are ahead of Government action and thinking. Shifting UK diets to foods with lower greenhouse gas (GHG) emissions offers a huge opportunity for consumers to reduce their carbon footprints and enjoy important health benefits for no additional cost.

Surface transport, aviation, heating and diet are the most promising areas for reducing household emissions through behavioural and societal change and will be discussed in detail in this report as priorities for policy.

1.4 Building scenarios and behaviour change strategies in uncertainty

Sources of uncertainty

Emissions reduction scenarios routinely consider the technical feasibility of various strategies. The feasibility of behavioural and societal change is considered far less frequently, in far less depth, and is considered more uncertain in the work of the IPCC and the CCC. There are many sources of uncertainty in trying to predict or engineer shifts in behaviours, attitudes and social practices.

The evidence base for behaviour change policies to support the deep decarbonisation scenarios considered under Net Zero is sparse. There are evidence gaps and uncertainty over rates of technology adoption based on previous experience, and policy for such rapid adoption of these technologies is uncharted waters beyond the experience of any country. Adoption rates have varied widely between different end-user technologies (Hampshire, 2017) and learning curves to deliver lower prices may be highly technology-specific, as seen for electricity generation (Gross et al., 2013).

There are limits also to the applicability of the existing evidence base. A behaviour change intervention, such as a tax, implemented in one country may not inform experience in the UK due to differences in context including cultural attitudes and the priorities of taxpayers. Behavioural economics emphasises universally-applicable cognitive biases but significant behaviour change will also typically involve working with or against social and cultural norms and identities. People are, moreover, free to resist when they perceive attempts to influence them. Often, behavioural and societal change ultimately requires a more historical rather than causal explanation, suggesting the behavioural and social sciences have value for 'sensitization' rather than prediction (Gergen, 1973).

There are also limitations to the evidence available from pilots, experiments and randomised controlled trials. Even well-designed field trials are limited in duration and size, and so typically miss the potential influence of social proof, changing norms and the impact of market responses to uptake such as product development. In addition, while providing useful knowledge about technical feasibility and giving an idea of consumer engagement issues, field trials will typically investigate a single or limited aspect of the energy system or consumer environment - for example, trialling smart electricity tariffs without supportive technology and policy changes, or research on the effects of food labelling which does not consider new products and price signals. This is one expression of what could be seen as presentism – underestimating the multiple ways in which the future will be different and how these changes may interact over time in real-world market conditions.

How to build policy and behaviour change strategies in uncertainty

For these reasons, attempts to predict and quantify the level of behaviour change (e.g., adoption rates or purchasing habits) delivered by policy interventions are likely to suffer from a high degree of uncertainty. Some strategies will deliver greater impacts than expected. Real-world change can occur rapidly. The adoption of smart phones and the successful rollout of wind turbines and solar photovoltaic panels occurred at a pace beyond all expectations. Well-planned policy interventions, especially in combination over a sustained period, have the potential to outstrip the outcomes seen in pilots and research. Nor, however, is policy design working blind - the available evidence, and a sensitivity to the wide range of influences over human behaviour and social change, can inform specific strategies.

It must be accepted that we are entering uncharted territory in aiming to move rapidly towards mainstream low-carbon lifestyles, not only in the technology but the pace of social change and the policy to get there. Government will need to take a pragmatic approach, begin now and learn by doing (Chatham House, 2015a). Policy for behavioural and societal change for net-zero scenarios may best be informed by two inter-dependent strategies:

(i) *enable consumers to take specific concrete actions that deliver large emissions reductions* and
(ii) *create a wider context conducive to public engagement* with action on climate change.

Policy is needed which supports consumers to take specific, high-impact actions by lowering barriers and enabling more informed choices. Beyond delivering emissions reductions, public action and behaviour change can also signal to Government the public support that exists for low-carbon living and so build political momentum. Specific recommendations for transport, heating and diets are explored in Chapters 2, 3 and 4. Given the inherent uncertainty in predicting levels of behaviour and system change to 2050, this report focuses on *how* Government can facilitate behavioural and societal shifts rather than on quantifying *how much* change can be expected.

A wider context that is supportive of public engagement with climate action is also lacking. Social norms and everyday life work against, instead of in support of, discussing and participating in low-carbon lifestyles. The public do not feel connected to the climate challenge. Consequently, behaviour change is limited and Government and MPs do not have a sense of having a mandate from voters to champion, or act on, climate issues (Willis, 2018).

1.5 The wider context for public engagement

Bushell, Workman and Colley (2016) argue that closing the action gap between current actions and what needs to be done is primarily a social and political challenge requiring both a coordinated strategic plan and "a set of strategic narratives – a story, or system of stories, that explain this strategy in a persuasive way" (p.1). Stories can be immensely powerful for giving sense to the world and mobilising people to act (Evans, 2017). Narrative psychology emphasises the fundamentally 'storied' nature of everyday life which guides behaviour (e.g., László, 2008; Sarbin, 1986). There is an important role for narratives and policy to work together to create a context for engagement.

There has been a lack of compelling narratives for action on climate and especially for participation by the public. Reliance on market solutions and regulatory changes to decarbonise the power sector has meant that Government's actions have been largely invisible to the public (Rose, in Green Alliance, 2010). This has left UK decarbonisation 'depopulated' and removed from everyday lives and actions: change is described in terms of nouns ('energy transitions', 'decarbonisation pathways') rather than verbs which could identify actors and actions people can take. The tendency for depopulated and agentless rhetoric has been noted in the writing of the social sciences (Billig, 2013) but the stakes are much higher for public engagement with action on climate change.

When a role for households has been offered, the message has not built engagement. Instead "Government has presented climate change as a potential catastrophe ... Yet its statements about solutions, and its actual policies, do not match up to the story it tells…Mixed messages are highly damaging to public understanding, trust and sense of personal capacity to act" (Christie, in Green Alliance, 2010, p.16). This mismatch is apparent in advice to take painless, small and easy actions and the idea that these will add up to a big impact. This has been seen in the *Act on CO_2* campaign and, more recently, in the smart meter rollout awareness campaign. New stories and ways of talking

are needed which invite and inspire individuals and communities to take more ambitious actions proportionate to the climate challenge and to do it urgently.

Such narratives include *human rights and inter-generational justice* (Unicef, 2010) - backed-up by some success in legal cases against governments and corporations (Setzer and Byrnes, 2019) - and *popular rebellion* or *uprising* (Extinction Rebellion) – which offers the identity of 'rebel' but will also polarise attitudes. The recent rise of the narrative of a *climate emergency* is a promising example which may have broader appeal: in emergencies people act differently, with urgency and according to a different set of priorities. Not changing one's behaviour in response to an emergency is accepted as irrational. The point has been made before that one problem for public engagement with the climate emergency is that it is a slow emergency. The dangers posed are not *tangible, immediate or visible* and waiting for them to become so before acting will be too late (Giddens, 2011). While dangers such as extreme weather events are now becoming increasingly tangible, the timing and specifics of the action required are not clearly defined, so constantly deferring action on climate is easy to do. This is compounded by two other tendencies where solutions may be more forthcoming.

Firstly, in citizens' daily lives many other more pressing concerns crowd out climate change for immediate attention. The psychological tendency to discount longer-term costs and benefits makes it more likely that actions for the climate will remain lower down the list of priorities. Secondly, the classic study of group inhibition of bystander intervention in emergencies (Latane and Darley, 1968), which involved a room slowly filling with smoke, is not just an apt metaphor for climate change. The so-called 'Smoke-filled Room Experiment' underlines the risk of conformity with a norm of passivity such that an individual is much less likely to take action in an emergency if others do not act, especially when there is some ambiguity about the situation. Passivity breeds passivity through social proof (being influenced by others to interpret a situation), normative social influence (including a fear of being seen as overreacting) and the diffusion of responsibility.

Lower-carbon choices need to be seen not only as important and urgent but also normal, easy and in alignment with other day-to-day concerns (e.g., household budgets and social relations). New narratives by themselves are not enough and there is a need for policy that is consistent with these narratives and that supports acting on them. Moreover, rather than behaviour change strategies which focus largely on motivating people (informed by the usual assumption that motivation comes first), enabling people to act and see change happening can kick-start motivation, engagement and new narratives.

1.5.1 Make it more difficult to rationalise inaction

Policy is needed that helps to redirect the flow of household spending away from high GHG-impact products and services and towards the commercialisation and mass-adoption of low-carbon alternatives. To a large degree this will mean removing the financial and other barriers which frustrate shifts in consumer choices. More generally, policy should also avoid creating a context that makes it easy for people to justify inaction. If reasons or excuses for inaction are readily available then it will be tempting to persuade oneself and others that acting on climate change can be, or should be, left to someone else (Government, business, the better off…). Policies, individually and collectively, affect this rhetorical context for people's thinking, talking and arguing about, and participating in climate solutions.

Such arguments or rationalisations for inaction include the perception of unfairness, inconsistency or lack of leadership in Government actions and policies. Since last summer, of the 25 critical actions for emissions reductions recommended to Government by the CCC for the year ahead, only one has

been delivered in full (CCC, 2019b). The public want a comprehensive plan that is implemented consistently and want the opportunity to do their bit (Green Alliance, 2019) – more so if they know others are also doing theirs (10:10 Climate Action, 2019). The IPCC reports (with high confidence) that public acceptability of policy to limit global warming depends on the perceived fairness of policy-making and policy consequences (IPCC, 2018). Seeing individuals or businesses as polluting without penalty, or 'freeloading', can contribute powerfully to cynicism and apathy. There is potential to strengthen public engagement with climate action through Government policy that demonstrates greater consistency, leadership and 'walking the talk'. This should include all sectors and practices - from subsidies for polluting industries to tax breaks for private jets. The CCC have recommended that HM Treasury undertake a review of where the costs of the net-zero transition should fall: this is an opportunity to plan how effective support for low-carbon choices, and other costs, can be most justly distributed.

Public procurement practices. One area which could improve the perception of fairness, consistency and leadership is public-sector procurement practices. If the public are being asked to spend their money on low-carbon technologies and services then the public sector should be doing the same and setting an example in how it procures vehicles, food, energy and all other goods and services.

Investments and divestment. The investment of public money in fossil fuel companies is another area where consistency could be demonstrated through divestment and removal of subsidies to fossil fuel activities at home and abroad. This would also encourage households to reconsider their own investments – pensions, insurance, and other financial products – which may be supporting high-impact activities. In 2018 Ireland passed a bill requiring the state's national investment fund to sell all investments in coal, oil, gas and peat, likely within five years. In 2019 the Norwegian Government indicated that it will begin divesting its $1 trillion sovereign wealth fund from oil production companies.

Climate impact assessment of all new policy and regulation. Another measure which would improve consistency in policy and make this publicly visible would be to introduce a duty to prepare a climate impact assessment of all new policy and regulation in Parliament and in the public sector. This could be similar to the current requirement for Equality Impact Assessments of all new policy under the Equality Act 2010 and the Public Sector Equality Duty. This would have the effect of demonstrating Government commitment to consistency in policy and also safeguard against unexpected consequences of policies. It would also do much to keep climate and long-term perspectives on the agenda and better equip Members of Parliament to champion climate change in their day-to-day work at Westminster, who, research finds, still feel that action on climate change is outside the political mainstream and lacks a mandate from their constituents (Willis, 2018).

Carbon fee with public dividend. A fourth policy measure with potentially the greatest potential to make the context for public participation visibly fairer and more consistent is a carbon fee with public dividend. The CPLC's Report of the High-Level Commission on Carbon Prices (Stiglitz and Stern, 2017) concludes that carbon prices are an indispensable way to reduce greenhouse gas emissions. Yet globally, 85% of emissions are still not covered by carbon pricing and carbon prices are significantly lower than values the Stern-Stiglitz High-Level Commission on Carbon Prices found to be consistent with the temperature goal of the Paris Agreement (Klenert et al., 2018; Policy Exchange, 2018). Carbon-pricing initiatives are spreading at an unprecedented rate and, with the prospect of the UK leaving the EU Emissions Trading System as a result of leaving the EU, the UK Government has an opportunity to change carbon pricing, to which it is committed in principle.

Political acceptability is seen as the biggest obstacle to the introduction of ambitious carbon pricing schemes, but effective use of the substantial revenues raised offers a way of increasing public acceptance (Carattini, Carvalho and Fankhauser, 2017; Klenert et al., 2018). With the opportunity for innovation in the field of carbon pricing offered by Brexit, the option of an independent carbon tax with revenues directly returned to the populace in the form of a carbon dividend has been proposed. This combination of carbon fee and public dividend could give voters an immediate connection to, and interest in, the fight against climate change and turn "an otherwise regressive and unpopular carbon tax into a popular and even populist policy that promotes more inclusive economic growth and enables the vast majority of UK citizens to benefit financially from this new climate solution" (Policy Exchange, 2018, p.8). Klenert et al (2018) also advocate uniform lump-sum recycling of carbon revenues to citizens and observe that it is successfully employed in several real-world recycling schemes including British Columbia, Switzerland and Canada. In 2018 the Prime Minister of Ireland endorsed a carbon tax in which all funds go to a direct cash dividend with the carbon price rising from €20 per tonne to €90 per tonne by 2030. As in the Canadian policy, most households are expected to be better off after the dividend even after paying higher prices for some goods.

As levels of public dividend increase with a rising carbon fee, some of the benefits seen on universal basic income (UBI) trials may be delivered. Observed benefits from a basic citizen's income include improved health and well-being and lower associated public healthcare costs. The 1970's Mincome basic income pilot in Manitoba saw an 8.5% decline in healthcare utilization, hospitalizations and psychiatric-related doctor visits (Forget, 2011; Simpson, Mason and Godwin, 2017).

Communication and framing is important for a carbon tax and public dividend policy, as seen in Australia's experience of abandoned policy. It should have a convincing narrative and an acceptable name or label, e.g., 'fee' or 'climate contribution' rather than 'tax' (Klenert et al., 2018) that increases the visibility of the progressiveness of lump-sum transfers. Communication should also highlight: the specific expected benefits (for emissions, air quality, congestion, health, the economy and household incomes) and the expected increase in cost for goods most likely to be affected by the tax. Crucially, once in place, "government should regularly measure and report its effects, along with information on how revenues have been used" (Carattini, Carvalho and Fankhauser, 2017, p.3).

Procrastination, poverty, time-poverty and well-being. Even when consumers are not resistant to moving to low-carbon behaviours and lifestyles, and may be both willing and able to act, action may commonly be put-off until another day with the risk that action is never taken. Empirical studies have found procrastination to be a barrier to sustainability-related behaviours (Hafner, Elmes and Read, 2019; Lillemo, 2014; Malott, 2010). Specific policy and interventions can reduce the deferral of action by leveraging trigger-points (e.g., a home purchase) and by breaking down the target behaviour into smaller steps. Procrastination due to choice-overload and information-overload problems can also be addressed using strategies from behavioural economics (e.g., setting defaults). But there is a wider role for policy beyond treating procrastination as a self-regulatory problem within the individual or by engineering 'choice architectures'. Taking action on climate concerns and pursuing a low-carbon lifestyle will always be a low priority or put off till later if subjective well-being is low or households experience time-poverty in their busy daily lives. Procrastination is correlated with stress, poorer mental health and well-being (Stead, Shanahan and Neufeld, 2010) and poorer health-related behaviours (Sirois, 2007). Poverty not only reduces a household's ability to afford low-carbon technologies but there is also evidence for a causal link between poverty and an impaired ability to make financial decisions due to poverty-related concerns reducing available mental capacity (Mani, Mullainathan, Shafir and Zhao, 2013).

Insomuch as procrastination and reduced decision-making ability are barriers to behaviour change, policy which addresses poverty and promotes well-being will better support public participation in climate solutions. These links further underline co-benefits. A stronger well-being agenda in policy - such as the public commitment by the Prime Minister of New Zealand to a Living Standards Framework and Wellbeing Budget (under which all spending must improve inter-generational well-being) - would be a positive step towards a context which supports public participation and shifts in behaviours. A carbon fee and public dividend could, over time, also contribute to reducing poverty and time-poverty (through more even distribution of paid work and reduced working hours), further improving well-being. While large household carbon footprints are associated with high income they are not associated with higher levels of well-being (Wilson et al., 2013), which suggests win-win opportunities for policies which encourage low-carbon choices and lifestyles while also enhancing well-being (Druckman and Jackson, 2016).

1.5.2 Build momentum in action and policy

The last component for a context which supports engagement is the need to build momentum in action and policy. With Members of Parliament currently feeling that their mandate to champion action on climate change is very weak there is a need for policies that build engagement and public support (Willis, 2018). Section 1.5.1 has considered some ways in which this might be done. As well as a need for policy which better supports public engagement, there is a further need to consider how public engagement can be made visible to MPs to better support political will and policy change. Data collection systems are needed to measure and track public action and disseminate this to MPs (including on a regional/constituency basis). As action grows, a positive feedback loop between the public and parliamentarians could support faster more ambitious action by all stakeholders.

Of equal importance is the need for a feedback loop between citizens. There is low public awareness of popular support for low-carbon futures. Survey results have found that British adults underestimate the level of public support for the use of renewables despite findings showing that 80% of the public support this (ComRes, 2016). As highlighted in the above discussion of bystander influence in emergencies, it will be paramount going forward to make public engagement and shifts in behaviour more visible to all. This would leverage social influence and social proof to normalise participation, new behaviours and technologies, and thereby accelerate further behavioural and societal change. Seeing others' engagement, and the progress achieved in emissions reductions and co-benefits, should reinforce citizens' sense that taking action is possible and socially desirable and that everyone can, should, and is doing their part.

A visible sense of progress could also nurture ambitious narratives of positive change and provide a sense of satisfaction from being part of a collective endeavour consistent with their values. Systems are needed to collect, collate and disseminate evidence on public engagement, shifts in behaviours, progress towards targets and co-benefits accrued - for health, wellbeing, biodiversity, jobs and the economy. The co-benefits of actions to reduce emissions will be enjoyed on *much shorter time horizons* than their effects on climate and so it is politically easier to gather support for policies which deliver them (UNECE, 2016) but this also means that these tangible co-benefits are particularly valuable for building and sustaining public engagement. Annual progress reports (Shaw, Corner and Clarke, 2018) and a continually updated open access 'observatory' for evidence of UK public engagement (Chilvers, Pallett and Hargreaves, 2017) have been previously suggested; capturing and reporting co-benefits should be a part of this. This data would also support greater focus by media on public participation, progress and co-benefits to help replace the current media emphasis on reporting the science of climate change, small and easy actions, or extreme lifestyles.

Specific concrete actions delivering high-impact reductions in emissions are needed to begin building such momentum. Chapters 2, 3 and 4 explore recommendations for how policy can support such behaviour change in the areas of surface transport and aviation, heating and diets.

Chapter 2: Recommendations for behaviour change in surface transport and aviation

The CCC's 2018 Progress Report (CCC, 2018) concluded that the surface transport sector is now significantly off-track from the cost-effective path in the Committee's Fifth Carbon Budget advice. Surface transport is now the largest emitting sector of the UK economy, accounting for 27% of UK greenhouse gas emissions, over half of which is from cars. Vehicle emissions makes up around a third of the emissions for a typical UK household (CCC, 2016a).

Emissions in domestic transport have levelled off but demand for car travel continues to grow while improvements in vehicle efficiency have slowed. Reducing demand for conventional internal combustion engine (ICE) vehicular transport has many co-benefits for air quality, health, congestion and communities (Active Transport for Healthy Living Coalition, 2014) and must be pursued, in part, by reducing behavioural lock-in to car use and giving people more freedom to choose more sustainable travel alternatives including walking, cycling and public transport.

2.1 Active transport

The actual number of UK cyclists and trips taken by bicycle have not grown since 2002 (DfT, 2018b). Road safety appears to be a major barrier. In 2017 a British Social Attitudes Survey conducted by the Department for Transport reported that 62% 'agree' or 'strongly agree' that 'It is too dangerous for me to cycle on the roads' (Department for Transport, 2018a). A 2018 review warned of inadequate cycle paths across the country with 46% of the National Cycle Network considered either 'poor' or 'very poor' (Sustrans, 2018).

Recommendations:

- Further investment in cycle infrastructure (continuous cycle lanes and secure cycle parking facilities) for safe cycling is needed.
- Introducing small grants for e-bikes would bring them within reach of more consumers and would need to be just a fraction of the size of those now offered for e-motorbikes and e-cargo bikes.

2.2 Rail and bus travel

Simpler and cheaper train fares could reduce car journeys and flights on domestic routes such as Heathrow-Edinburgh (Britain's busiest domestic route with 3.4 million passengers annually). Budget high-speed intercity services, such as that planned for London-Edinburgh by FirstGroup in 2021[1] promising average fares below £25, have the intention and potential to shift travel modal choices away from cars and flights to lower-carbon rail journeys. Rail companies should offer reduced-price season tickets and passes for part-time workers to help reduce commuting by car.

The re-opening of the long-closed Borders Railway in Scotland has been a sustained success (1.5 million journeys per year) and should be replicated elsewhere where sufficient demand exists or could develop. Reopening 33 disused train lines could generate up to 20 million additional passenger journeys and bring over 500,000 people within walking distance of a station (Campaign for Better Transport, 2018) thereby reducing reliance on cars and improving access to employment, tourism and other economic benefits. Compared to HS2, a programme of investment across the whole rail

[1] https://www.firstgroupplc.com/about-firstgroup/uk-rail/eastcoast.aspx

network could have a greater emissions reduction impact and improve the travel options for a greater number of people over a wider area. Suggestions for such a programme include full electrification of the Midland and Great Western lines and much of the northern rail network, plus a Bradford Crossrail to link the two lines that terminate in the city and put it at the centre of northern rail (NEF, 2019).

Buses provide three times more passenger journeys than trains and are the main means of transport for the quarter of the population that does not own a car. There has been a decline in funding for bus services with over 3000 bus routes reduced, altered or withdrawn completely since 2011 (Campaign for Better Transport, 2018) while local bus fares in England increased by 66% on average between 2005 and 2017 and 80% in metropolitan areas (Department for Transport, 2017a). Lower, simpler fares with multi-operator ticketing schemes could encourage modal shift from cars to buses.

Recommendations:

- Invite operators to offer new low-fare, high-speed inter-city rail services to shift journeys from car and air to rail (as planned for London-Edinburgh from 2021).
- Require rail and bus companies to introduce reduced-price season tickets/passes for part-time workers.
- Reopen disused rail lines and withdrawn bus services where demand exists, or could develop, to reduce car dependency.
- Finance a programme of investment across the whole of rail and bus networks to improve services and reduce and simplify fares.

2.3 Electric vehicles

The emissions reductions needed for Net Zero will not be delivered solely through curbing demand for car travel. Research in 2018 for the RAC found that car use is rising not falling, with 33% of motorists reporting that they are more dependent on their car now than in the previous year (RAC, 2018). By 2050, car traffic is also forecast to grow between 11 per cent and 43 per cent, whilst continued growth in van traffic of between 23 per cent and 108 per cent is anticipated in all scenarios (DfT, 2018).

Privately-owned electric vehicles are not a perfect solution to mobility issues and, as with internal combustion engine vehicles, considerable emissions are associated with their manufacture, they contribute to particulate air pollution from brakes and tyres (Air Quality Expert Group, 2019; Defra, 2019) and switching to EVs will not reduce road congestion or road safety problems. In the longer-term, changes to current models of vehicle ownership and use should materialise, helped by disruption from car clubs, mobility-as-a-service (MaaS) business models (Wilson, Pettifor, Cassar, Kerr and Wilson, 2019) and developments in autonomous vehicle technology (Energy Systems Catapult, 2018; Mazur, Offer, Contestabile and Brandon, 2018).

In the short to medium term, however, adoption of electric vehicles remains the most feasible route to lowering domestic vehicle emissions and making large reductions in the transport sector. Progress in decarbonising the UK power sector now affords an excellent opportunity for low-carbon personal mobility through the adoption of fully electric plug-in vehicles (PEVs). Use of low-carbon generation and local grid management can be conveniently optimised through automated smart EV-charging, with owners being incentivised by cost savings through time-varying pricing and other 'demand response' (DR) services (which encourage flexibility in household electricity demand), such as vehicle-to-grid (V2G).

Beyond GHG emissions, EVs will deliver important co-benefits for air quality and health. Each year, 40,000 deaths in Britain are attributable to exposure to outdoor air pollution, which is linked to cancer, asthma, COPD, stroke, heart disease, diabetes, obesity and dementia (Royal College of Physicians, 2018). Over 800 schools are situated on main roads with illegal levels of pollution and 65% of the British public would support a new Clean Air Act (Royal College of Physicians, 2018). Noise from internal combustion engine road traffic is also a risk factor for cardiovascular and metabolic disease (Münzel et al., 2017) and is much reduced by electric vehicles. The total social cost to the UK of air pollution is estimated at £22.6 billion per year (Royal College of Physicians, 2018) and there are further potential co-benefits for the economy through opportunities for the UK electric vehicle industry (Ricardo Energy & Environment, 2017).

UK sales of electric vehicles increased in 2017 to 1.9% of new cars but the CCC calculates that policy needs to aim for electric vehicles to reach 100% of new car and van sales by 2030 or 2035 at the latest. This will require exponential growth in sales (Regen, 2018) and there is considerable uncertainty about whether this ambitious target will be met (Mazur et al., 2018; Napp et al., 2017). There is also a risk of rising inequality in the health effects of air pollution if adoption rates remain low in less affluent regions (Staffell, Jansen and Chase, 2018).

Under current policy, the sale of new ICE vehicles in the UK will be phased out from 2040 and EV adoption is supported by a range of fiscal incentives: OLEV grants for new vehicle purchases and home charge point installations; exemption from Vehicle Excise Duty ('road tax') for EVs valued less than £40,000; exemption from Congestion Charge and ultra-low emission zone (ULEZ) charges in central London; no Fuel Duty and reduced 5% VAT on electricity (road fuel incurs 20%) (HM Government, 2017). Drivers also enjoy a number of non-financial benefits which include: less noise and superior performance (Noel, Zarazua de Rubens, Kester and Sovacool, 2018); greater reliability and fewer breakdowns; less maintenance costs and fewer trips to the garage; and easier-to-drive automatic transmissions. Public support for renewable energy is high (ClientEarth, 2018) so the green credentials of EVs will appeal to many consumers.

Several factors help explain the continued slow growth in adoption: limited choice of models; constrained manufacturer supply leading to long wait times for orders; and buyers' concerns over costs, limited battery range and charging infrastructure. The number of available models and battery range are growing rapidly and costs are falling. The UK Government is also making a £400 million Charging Infrastructure Investment (HM Government, 2018c). However, more support is needed to accelerate adoption and avoid the risk of continued slow growth.

Recommendation:

- Policy to lower barriers to EV adoption should include further support for EV charging networks by introducing measures to deliver: improved interoperability for access and ease-of-payment; compatibility with smart grid; visibility of current operational status; and enforcement powers for reliability; as recommended by the Science and Technology Committee (2019).

Although the total cost of ownership of electric cars in the UK is typically already lower than ICE or hybrid (Palmer, Tate, Wadud and Nellthorp, 2018), affordability is still the main barrier to wider EV adoption. Scholars of the diffusion of innovation find that the perceived 'relative advantage' of an innovation is one of the strongest predictors of its rate of adoption (Rogers, 2003). Relative advantage includes non-financial aspects but reducing the upfront purchase cost and clarifying low running costs of EVs will be crucial to more rapid take-up.

2.3.1 Reducing the up-front cost: incentives, fleets and the second-hand market

Purchase incentives

Reducing the upfront cost of EV ownership through a move to a battery or vehicle leasing business model could be attractive for consumers and companies are already offering such battery leasing (e.g. Renault) and EV leasing (e.g., Octopus Energy) propositions. Otherwise, drawing on the evidence base for the effectiveness of purchase incentives for PEVs (Hardman, Chandan, Tal and Turrentine, 2017) suggests the following policy measures would be the most cost-effective for increasing EV sales in the UK.

Recommendations:

- Reinstating the OLEV grant from £3,500 to the previous level of £4,500. The value of financial incentives offered in the UK is among the lowest of countries offering support for EV sales.
- VAT exemption for EV sales (as currently applies in Norway and Iceland).
- Grants and VAT exemptions for EV purchases should exclude high-end EV models (as applies for Vehicle Excise Duty). These buyers are not as price-sensitive so these grants are not lowering a barrier to adoption and therefore provide very little additionality in EV sales.

Support for company and fleet EV purchases, the second-hand market and car clubs

Even with the OLEV grant, a new EV is still considered unaffordable for many households and the lower-cost second-hand market in electric vehicles is very small. Commercial fleet and company cars make up under 9% of registered cars but account for 57% of new car sales annually (DfT, 2019). These cars move quickly into the private market and so could be strategically important for growing the second-hand EV market, making EVs more accessible in price. More company and fleet EVs will also increase the *visibility* of EVs and help normalise the technology leading to more rapid adoption (Rogers, 2003).

Each car-club car replaces 10 privately-owned cars, encouraging a switch to public transport, walking and cycling, and offers more affordable mobility than private car ownership (Transform Scotland Trust, 2013). Across London in 2016/17, car-club members sold or disposed around 26,400 cars (Steer Davies Gleave, 2017). Car club EVs also introduce car buyers to EVs: this so-called 'trialability' of a technology is associated with more rapid adoption (Rogers, 2003) and greater exposure to EVs does appear to increase willingness to purchase (Larson, Viáfara, Parsons and Elias, 2014).

Recommendations:

- Promote greater awareness among fleet operators of grants and other financial incentives, lower lifetime costs of EVs and additional benefits which may include: benefits for corporate social responsibility (CSR); enabling workplace charging for employees and or customers; increased value of on-site power generation or potential for vehicle-to-grid services (Regen, 2018).
- Government and public sector should lead by example by setting and hitting ambitious targets for procurement of electric vehicles. Poor progress on the Government Fleet Commitment to ensuring 25% of the central Government car fleet is ultra-low emission by 2022 has been challenged by the Improving Air Quality joint committee report.
- Extra support should be made available for growing car-club EV fleets due to their additional benefits for reducing private car ownership. Support could include offering attractive locations for on-street parking bays, improved charging infrastructure, resourcing dedicated

Local Authority staff, better integration of car clubs into transport planning processes (Car Club Coalition, 2015) and support via block-booking by Local Authorities (Halden, 2016).

2.3.2 Reducing charging costs: smart charging and demand response

On a whole-life cost basis, plug-in EVs are already competitive with petrol or diesel vehicles (Palmer et al., 2018). However, running costs depend on car usage and on battery charging costs. Introducing policy enabling cheaper EV-charging would increase the attractiveness to buyers and could also deliver greater flexibility needed in the energy system.

The considerable extra load from growth in EVs poses a potential challenge for electricity supply and for the electricity distribution network but as EV loads are stored in batteries, and vehicles have a lot of downtime, there is great potential for off-peak and flexible charging made convenient by smart charging. Reductions in charging costs can be achieved with smart charging combined with time-of-use (TOU) tariffs and other demand response (DR) services (Hall, 2018; Rhys, 2018). Substantial load-shifting and cost savings have been demonstrated on such time-varying electricity tariffs. For example, average annual bill savings of £338 compared to a typical standard variable tariff (Octopus Energy, 2018). Smart charging of electric vehicles could offer savings of £1.1bn per year in whole system costs through greater renewable generation and deferred network reinforcement (OVO Energy and Imperial College London, 2018). EV batteries also have further potential for vehicle-to-grid (V2G) balancing services, potentially raising system savings to £3.5bn (Ibid) and making EVs even cheaper to own.

Since Ofgem's introduction of elective half-hourly settlement in 2017, a small number of smart time-of-use (TOU) tariffs for residential electricity have emerged on the market, including those specifically aimed at EV owners. However, the full potential of domestic demand response (DR) and consumer savings are not likely to be realised under current market conditions. Regulatory change to maximise the market value of household flexibility and improve access for residential energy systems to grid services markets could play an important role in further reducing EV running costs and payback periods (IEEFA, 2019; OVO Energy and Imperial College London, 2018). Over twenty potential flexibility providers and energy trade associations were signatories to a recent call to prioritise a 'flexibility first' approach to regulation (OVO Energy, 2018). Individual regulatory changes might have a small effect but collectively they could make a noticeable difference to charging costs and, if communicated effectively, influence adoption rates of both EVs and time-varying electricity pricing for the home.

As electricity demand from EVs and heating grows, TOU tariffs and demand response services will be increasingly required in order to limit peak loads and the need to reinforce the distribution network. In its cost-benefit analysis of the Smart Metering Implementation Programme (SMIP) the UK Government assumed that 20% of consumers will switch to a static TOU tariff by 2020, rising to 30% in 2030 (BEIS, 2016). Greater levels of engagement with flexibility services will also be crucial to permit the massive growth in wind power required to further decarbonise the power sector.

Recommendation:

- Introduce a 'Flexibility First' approach in new regulation which improves access to the full market value of flexibility in household electricity demand in order to support the development of demand response (DR) services for cheaper smart-charging of EVs.

2.3.3 Enabling informed adoption: digital comparison tools, innovation and competition

Improving the affordability of EVs is, at this stage, crucial for uptake. But it is not enough to make adoption affordable, EVs must also be *seen to be* affordable and to have a strong 'relative advantage' over ICE vehicles. Additional support will be needed to communicate the relative advantage and make the adoption decision-making process easier.

Awareness of new technologies and of incentives is key to additionality in sales, but consumer awareness of purchase incentives for EVs is low (Hardman, Chandan, Tal and Turrentine, 2017). Government incentives such as the OLEV grant should be accompanied by prominent education and awareness campaigns.

One problem for technology adoption decision-making is the tendency for consumers to put greater importance on near-term costs and benefits than on longer-term costs/benefits ('hyperbolic discounting'): the savings on running costs over the lifetime of the car are less salient than the immediate purchase cost (Brand, Anable and Tran, 2013). Clarifying charging costs and comparing these to ICE vehicle running costs to make lifetime or monthly savings more prominent will be vital. Cost comparisons should include all financial incentives that reduce running costs (such as exemptions for road tax, and congestion zone and ULEZ charges) and should also clarify charging costs on TOU tariffs. Estimating EV charging costs on TOU tariffs is an additional level of complexity creating a huge 'information overload' barrier for potential buyers in the absence of additional support.

2.3.3.1 Digital comparison tools for more informed EV adoption

Consumer awareness of time-varying electricity pricing and its potential to reduce EV charging costs is also very low. Partnerships between EV manufacturers and electricity suppliers are beginning to emerge which could help to raise awareness of low-cost charging and also introduce energy-as-a-service (EaaS) or mobility-as-as-service (MaaS) business models for EV charging. But the choices facing consumers are complex and further support for consumer awareness and decision-making is badly needed.

A prospective EV buyer currently has no access to information about EV charging costs on a TOU tariff. Running-cost calculators for EVs do exist (e.g., GoUltraLow.com, nextgreencar.com) but these do not allow users to factor-in savings on TOU tariffs and other DR services. Price comparison websites (PCWs) are used by most bill-payers shopping around for energy deals (CMA, 2017b) and consumers generally find them easy to use (CMA, 2017a). However, smart TOU tariffs are not included in the market comparisons provided on price comparison websites and this is likely to become a bottle-neck for consumer engagement with smart TOU tariffs, and therefore EVs, by obscuring the lower EV-charging costs they offer. Suppliers offering EV-tariffs may provide potential consumers with estimates based on similar consumers but these are approximate and do not offer a comparison with other products and services available on the market, which may vary in terms of the level of exposure to electricity price volatility, degree of fit with householder preferences, contract terms (He, Azevedo and Meeus, 2013) and customer satisfaction.

A more sophisticated online digital comparison tool (DCT) is needed which can show prospective EV purchasers the expected charging costs for a range of EVs and TOU tariffs (and, later, other DR offerings such as vehicle-to-grid ancillary services). Such a tool could make clear the monthly running costs and payback periods for EVs relative to the consumer's current petrol/diesel vehicle, current electricity tariff, factoring in grants and other savings. The DCT would then direct the user to the vendor and service providers which may include EVs bundled with a TOU tariff or other DR service.

Digital comparison tools should also permit consumers to explore other smart low-carbon technologies and combinations, such as an EV paired with residential solar photovoltaics, and show projections of their running costs, energy bills and payback periods – *see Figure 1*. An analysis of near-term opportunities for growth in EV, battery and solar finds that strong mutual benefits and reduced payback periods make these technologies even more disruptive together than in isolation (IEEFA, 2019). Innovations are often viewed not in isolation but as a 'cluster' of new ideas or inter-related products and the adoption of one idea or product may trigger the adoption of other related products. EVs are not yet seen by consumers as linked to TOU pricing, solar PV, smart meters, heat pumps, storage and other behind-the-meter smart-enabled energy technologies. By modelling and projecting the financial benefits of smart technology and time-varying electricity pricing, digital comparison tools could be a highly effective way of raising awareness and supporting adoption of the whole cluster of technologies and services enabling flexible electricity consumption. Adoption of smart hybrid heat pumps is discussed further in Chapter 3.

Finally, people are often held to account for their decisions (Strong, 2014) and the reactions of others may be a further barrier to adoption. The price comparison tool discussed here could provide potential buyers with credible information not only for their own peace-of-mind but also for justifying their decision to a potentially sceptical spouse or colleague, thereby also lowering social barriers.

2.3.3.2 Removing barriers to digital comparison tools, innovation and competition

A range of data would be required to offer such digital comparison tool (DCT) services. This would include some household data entered manually (such as appliance ownership, household make-up, preferences and existing ICE vehicle monthly mileage), market data (TOU tariff details, vehicle purchase costs, grants and tax exemptions) and technical performance data (vehicle and charging technology etc). As electricity bills under a TOU tariff are affected by the electricity consumption patterns of the whole household[2] it would also include the household's half-hourly consumption data from their smart meter.

Most consumers are relatively unconcerned about sharing smart meter data (Frerk, 2018; Navigator, 2012), ranking half-hourly energy consumption data as the least sensitive type of data from a range of options presented (Ofgem, 2018a). Data could also be shared anonymously by digital comparison tool users to get tailored advice about tariff and technology choices - providing such a mechanism existed. There are some technical and regulatory obstacles to such a DCT which the Government should seek to address as a priority. The chief barrier is the current lack of infrastructure enabling consumers to share, or 'port', their half-hourly smart meter consumption data to third parties (FSB, 2018) – *see Figure 1*.

Activities in the area of household energy data portability are ongoing within Midata (BIS, 2014) and the Energy Data Taskforce (HM Government, 2018b). As yet, Midata is unable to handle the half-hourly data that would be needed for Price Comparison Websites to advise on TOU offerings (Citizens Advice, 2017b). A call for evidence on implementing Midata in the energy sector proposed that the new data fields include "consumption data by time of use for those customers on Economy 7 (or other time-of use tariff) as recommended by the CMA to enable a more tailored tariff comparison for customers with non-standard tariffs" (BEIS, 2018b, p.17). All customers with smart meters, not just those currently on TOU tariffs, should be enabled to share their half-hourly usage

[2] This could change if meter splitting allows a consumer to have multiple energy providers - for example, one for EV charging and one for household appliances. See https://www.elexon.co.uk/mod-proposal/p379/

data in order for EV-buyers and others to make informed decisions about switching to a TOU tariff for the first time.

In the future, basic in-home displays which accompany smart meters may give way to consumer access devices (CADs) with advanced functionality potentially allowing highly granular consumption data to be sent from the smart meter direct to the cloud and shared (Frerk, 2019) (13 months of data is stored on the smart meter). CADs may prove to be a good route to smart energy management and tailored market comparison services but, at least in the short-term, households do not have CADs to enable them to share their data with third parties. Another option for data portability is for third parties to become registered users of the Data Communications Company secure network for accessing smart meter data but this is complex and costly (Frerk, 2019) suggesting the need for an intermediary to facilitate this.

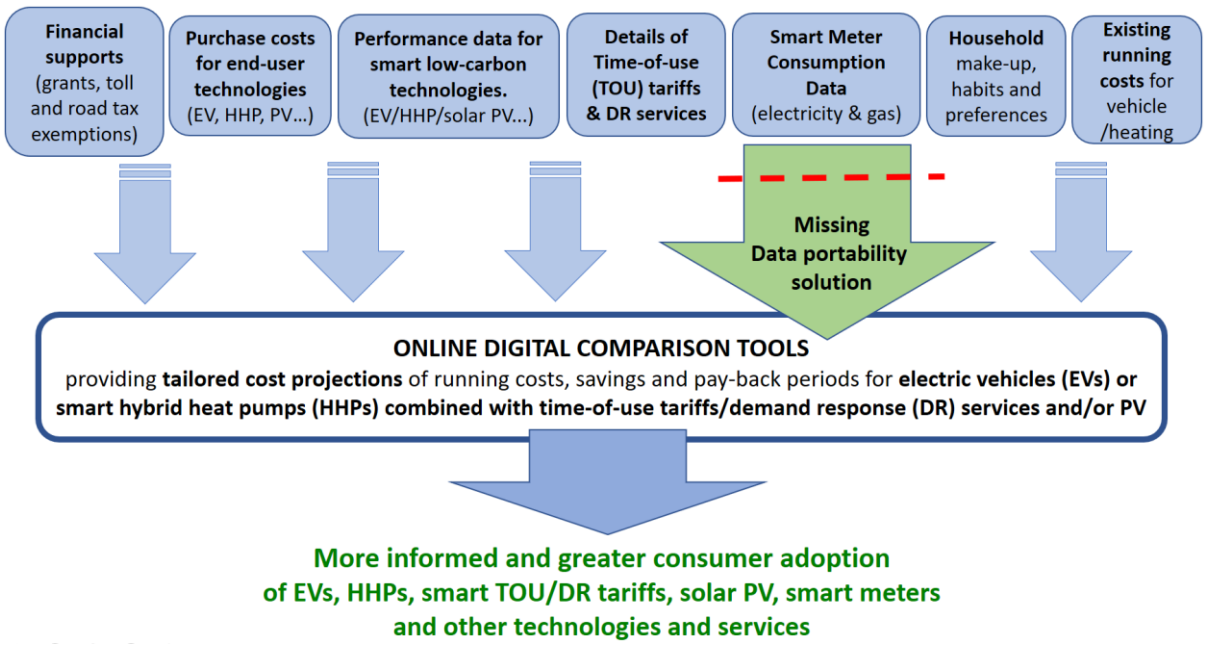


Figure 1: A solution is needed to allow households to share their smart meter data with third-party Digital Comparison Tools supporting more informed adoption of EVs and time-of-use tariffs

Developing and delivering the digital comparison tool itself could be further facilitated by Government. The modelling and market comparisons for TOU and EVs would be much more complex than current price comparisons of flat-rate electricity tariffs. The service would also need to be user-friendly and trusted by users while the added complexity would mean an important role for standards and regulation. Ofgem's Confidence Code for digital comparison tools is underpinned by four main principles: independence, transparency, accuracy and reliability (CMA, 2015). Non-price information, such as customer satisfaction, should also be included, as advocated by Citizens Advice (2017).

Regulation in data privacy and access should remove barriers to the development of such innovative digital comparison tools. The Smart Meter Data Public Interest Advisory Group, acknowledge that "it is in the public interest to support the emergence of such consumer services, because of their potential to contribute towards realising wider public benefits, such as decarbonisation" and that "to enable such services to emerge, smart meter data may need to be used in the development and

testing phase" (Hodges, 2018, p.12), including granting companies access to large anonymised smart meter data sets (Frerk, 2019). More open data – as advocated by the Energy Data Taskforce (2019) and others (FSB, 2018; Hardy, Sandys and Green, 2018) - would facilitate the inclusion of end-user technologies (EVs, HHPs, PV etc) in cost projections. Government-supported development of the technical work for a 'white label' solution, that could be used by all price comparison services, could produce greater alignment with Ofgem's Confidence Code, overcome market barriers (such as initial low consumer demand) and avoid duplication of effort.

Enabling consumers to share their consumption data with third parties would facilitate more informed consumer adoption of innovation, but smart metering infrastructure and competition in DR offerings will also be needed. Currently, electricity smart meters have been installed in approximately one in four households (BEIS, 2018e). Moreover, these are almost all first generation (SMETS1) smart meters which currently experience interoperability issues that prevent customers being able to switch with confidence to other suppliers' smart tariffs and services (BEIS, 2018d). Of the 25 million electricity meters operated by large suppliers only around one million smart meters have so far been enrolled into the Data Communications Company network (DCC, 2019a) which ensures smart functionality is maintained upon switching suppliers. This limits consumer access to smart tariffs and does not incentivise competition in DR offerings, new product development, or consumer services offering market comparisons for TOU tariffs. While a technical remedy for interoperability has now been developed to enrol SMETS1 meters into the DCC (DCC, 2019b) it will take some time to implement and to roll out second generation (SMETS2) meters to the remaining households.

Ofgem has indicated that it will introduce mandatory market-wide HHS which would provide the right 'incentive framework' for "bringing forward new products, services and business models, supporting more dynamic competition, and helping consumers to manage and shift their consumption to cheaper periods" (Ofgem, 2018b, p.69). However, the timeline for this settlement reform also depends on smart metering infrastructure being in place (Ibid, p.12). The Smart Meter Implementation Programme's (SMIP) rollout of second generation (SMETS2) smart meters should be further supported and SMETS1 meters enrolled into the DCC as a matter of urgency to resolve loss of smart functionality when switching suppliers.

Consumer engagement with the smart metering rollout could also be strengthened. Research for Citizens Advice found that only around 7% of consumers identify the potential for new products or services as a benefit of smart meters (Citizens Advice, 2018; p.8). The SMIP communication campaigns have so far focussed on households 'bringing consumption under control' (Smart Energy GB, 2017) and on households consuming *less* rather than more flexibly. The most recent SMIP campaigns introduce the idea of smart meters supporting renewable energy but do not reveal how they do this or what households can do. These campaigns should be broadened to raise awareness around smart meters as giving access to innovative products and services that are available now and deliver individual, environmental and societal benefits - as others have called for (Buchanan, Banks, Preston and Russo, 2016; Poyry/Imperial College London, 2017). This could drive greater household engagement with the smart meter rollout and greater awareness and enthusiasm for EVs, TOU and the whole cluster of associated technologies supporting flexibility, renewables, system efficiency and bill savings. A data portability solution for smart meter data and Ofgem's implementation of next-day switching would both add value to smart meters and could further improve consumer enthusiasm for the rollout.

Recommendations:

- Increase consumer awareness of all financial supports (grants and tax/toll benefits) for EVs and savings available through smart charging on time-of-use tariffs (and other demand response services such as vehicle-to-grid).
- Raise awareness of the wider benefits of more flexible electricity consumption - for renewable energy and system efficiency and the need to have a smart meter to give access to such flexibility services.
- Remove technical and regulatory barriers to innovative third-party digital comparison tools (DCTs) offering tailored market comparison of TOU (and emerging DR services) for EV buyers/owners.
- Facilitate the development of a user-friendly data portability solution allowing consumers to share their smart meter data with these third-party consumer services.

2.4 Aviation demand

The number of passengers flying, miles flown, number of flights and emissions are all rising (CCC, 2018). Forecasts indicate that demand for aviation will continue to grow in the period to 2050. Under the CCC's Further Ambition Net Zero scenario, allowing for a 60% increase in aviation demand from 2005 levels (25% from present levels), this sector will by 2050 account for around 30% of the remaining positive UK emissions. There is a risk, however, of larger increases in demand for flying, with estimates of up to 127% for long-haul (DfT, 2017). Sensitivity about pricing annual holiday-makers out of the sky has discouraged greater taxation on flights and policy has not addressed rising aviation demand. However, well-designed fiscal measures could offer effective, fair and publicly acceptable means to confront the risk of unrestrained growth in demand in the absence of alternative low-carbon aviation technologies. Fairness and how impacts are distributed are of key importance to public acceptability of policy in general (IPCC, 2018) and will be especially important for aviation.

If averaged over all households, UK aviation now makes up around 12% of a household's carbon footprint. However, emissions from flying vary enormously between households. While the average household's annual carbon footprint is approximately 8.1 tonnes (CCC, 2016a) return flights from London to Los Angeles for two people have a carbon footprint of approximately 5.7 tonnes CO_2e for Economy Class and over 9 tonnes CO_2e for Premium Economy. The emissions from one return ticket from London to New York are roughly equivalent to that of heating a typical home in the EU for a whole year (European Commission, 2019).

Seventy per cent of flights are for leisure and three quarters of this air travel is by members of the ABC1 social classes (Hopkinson, Sloman, Newson and Hiblin, 2019). While half of the UK population do not fly at all in any given year, it is estimated that 70 per cent of flights are taken by just 15 per cent of the population (DfT, 2014). There is a finite budget of carbon emissions allowable if global warming is to be held below 1.5 degrees so this highly uneven distribution of emissions due to flying raises equity concerns. The greatest beneficiaries of aviation's generous tax treatment in the UK (it is exempt from fuel duty and zero-rated for VAT) are therefore those who pollute most and could most easily afford to pay more. The norm of unlimited flying being acceptable needs to be challenged and, as a very highly-polluting luxury, it is suitable to taxation.

Suggestions have been made to replace the Air Passenger Duty with a Frequent Flyer Levy (Devlin and Bernick, 2015; Fellow Travellers, 2015; Hopkinson et al., 2019). Given the small number of frequent fliers, most of the population would be unaffected by the levy and families would not be

penalised for an annual holiday in the sun. Frequent flyers, who strongly tend to be wealthier and less price-sensitive, would incur increasingly powerful taxation to discourage additional flights. A levy which escalates in line with excessive flying behaviour would be less regressive than a simple carbon tax on flying (e.g., via aviation fuel tax) as instead of all passengers being equally exposed to the same tax per mile on all flights, those flying infrequently would pay less for the same flight than those flying frequently. At least some of the revenue from the levy could be directed towards research into lower-carbon aviation technology, further increasing the levy's acceptability and helping to tackle this hard-to-decarbonise sector. A recent UK survey found that people prefer a Frequent Flyer Levy over other potential policy options and over doing nothing: 56% agreed that a levy on frequent flyers would be fair, while only 26% felt it would be unfair (10:10 Climate Action, 2019).

However, a frequent flyer levy based on number of flights could fall more heavily on travellers who take several short-haul flights than those talking fewer but much more damaging long-haul flights: a flight from London to Melbourne Australia has approximately 15 times the impact of a London-to-Barcelona flight. An alternative replacement for the Air Passenger Duty which should be considered and explored is an Air Miles Levy which escalates with air miles travelled rather than simply the number of flights taken. It should also factor in the much larger emissions for First Class tickets which can have 7 times the emissions of an economy ticket (Murray et al., 2019) due to more spacious cabins and more unfilled seats. By factoring-in distance, the levy would be more closely linked to emissions and fall more heavily on those polluting more. It would also more effectively discourage long-haul flights: as most flying is for leisure, some shift from long-haul to short-haul destinations would be expected, delivering further emissions reductions. Averaging-out flying habits over a longer period than one year would also be fairer: a three or four-year period, for example, could mean a traveller could take a long-haul trip without incurring a substantial levy if they took few other flights during the rest of the period. Travel for work should be kept separate from personal allowances and the 3-year cycle should be based on travellers' dates of birth, rather than calendar year or tax year, to prevent distorting demand at the beginning and end of these periods.

The complexity of administering this levy need not be onerous, though would need a central database storing total miles flown in the accounting period under a passport number. Flight-booking software would need to access this database to calculate flight cost and to update the air miles total on central database once the flight is paid for. The class of passenger tickets would also need to be recorded and it would be desirable to add a calculation reflecting the carbon intensity of the flight or ticket; this could go some way towards encouraging improvements in fuel efficiency per passenger. Finally, data on the distribution within society of flying behaviour appears to be limited, so a database for an Air Miles Levy could also give Government accurate and up-to-date data for designing future policy for aviation demand and monitoring its impacts.

Flying is a uniquely high-impact activity and is the quickest and cheapest way for a consumer to increase their carbon footprint. An air miles levy is a promising option if policy objectives are to: limit rising demand for flying in a way which does not make it inaccessible to lower-income households; encourage shift in demand from flying to trains and from long-haul to short-haul; and generate funds for lower-impact aviation and improving high-speed rail networks. Given the scope for frequent flyers to have carbon footprints many times that of the average UK household, a lack of policy in this area is likely to be increasingly seen as inconsistent and unjust and risks damaging public engagement with climate action.

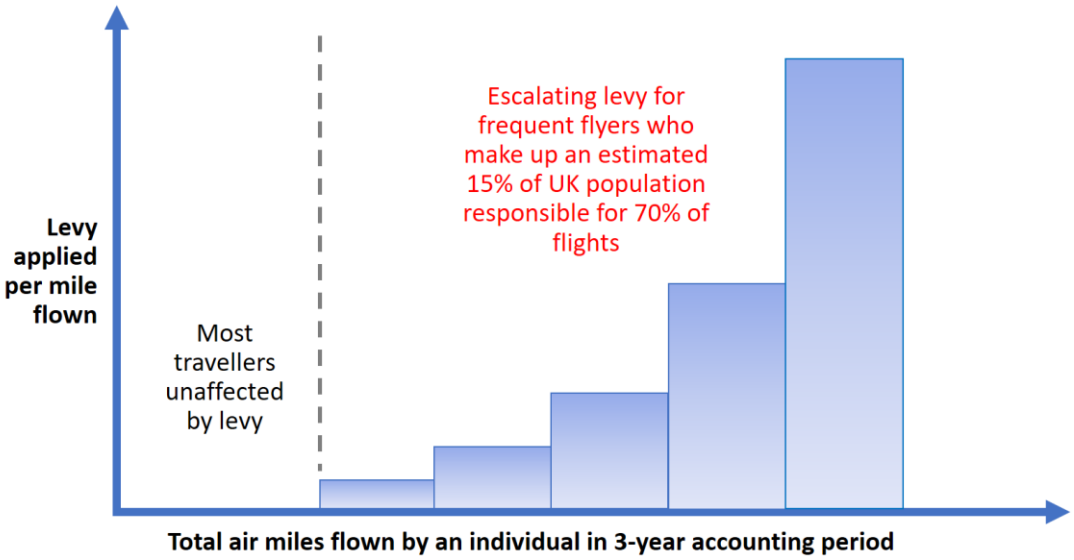


Figure 2: A progressive Air Miles Levy that escalates with air miles travelled would combine public acceptability with targeted, effective price signals for price-insensitive frequent flyers.

There is also evidence that mobility can be induced, or fulfil purposes other than transport needs. For instance, as much as 60% of Low-Cost-Carrier (LCC) demand may be stimulated by low prices. Evidence also suggests that frequent flyers engage in additional flights to maintain their privileged traveller status (so-called 'mileage runs' or 'status runs') and that frequent flying is related to status and social identity (Gössling and Cohen, 2014). Introducing restrictions to 'all-you-can-fly' passes and loyalty schemes which offer air miles would remove incentives to excessive or stimulated flying.

Advertising and marketing of holiday destinations and airlines also stimulate demand for flying and help set norms and aspirations about flying. Advertising and packaging for alcohol and tobacco has long been tightly controlled in view of their health risks, and gambling marketing must warn about irresponsible betting. More responsible flying could also be encouraged by new regulations for the marketing and promotion of flights and holiday destinations by requiring that carbon footprints of flights are stated in the advertising material. This could raise awareness and begin to change the norm of unproblematic unlimited flying.

Recommendations:

- Introduce an Air Miles Levy which escalates as a function of air miles travelled by the individual traveller and factors-in larger emissions for First Class tickets. This would provide strong price signals against excessive flying by 15% of the UK population responsible for 70% of flights without raising prices for other travellers as an aviation fuel tax would. It would also encourage shifting from long-haul to short-haul leisure destinations while using 3 or 4-year accounting periods would allow travellers greater flexibility for an occasional long-haul flight without incurring the levy.
- Introduce a ban on air miles and frequent flyer loyalty schemes that incentivise excessive flying (as was enforced in Norway 2002-13).
- Encourage more responsible flying by mandating that all marketing of flights show emissions information expressed in terms that are meaningful to consumers (e.g., as proportion of an average household's annual emissions now and under Net Zero).

2.4.1 Work-related flying

Business travel accounts for approximately 19% of flights and has declined as a proportion of flights, mostly due to growth in flights for leisure (DfT, 2017). A separate scheme to the Air Miles Levy will also be needed for business travel in order to avoid loopholes or gaming the system. Also, over a third of business passengers travel first or business class, compared with only 1 in 17 leisure (POST, 2000) and these classes of tickets are associated with much higher emissions due to the larger space taken up onboard and more unfilled seats.

Tele-conferencing and telepresence technologies offer an alternative to some work-related travelling and measures to promote these alternative ways of working and doing business could deliver economic savings and benefits for well-being as well as emissions reductions. For institutions with employees flying frequently, match-funded financial support could be provided for the installation of video-conferencing/tele-presence suites. Funding for venues to install facilities for hosting 'nodal conferences' (where a conference is distributed over numerous sites around the globe) or fully 'distributed meetings' (Le Quéré et al., 2015) could also be piloted. Such investments and new practices would contribute to shifting norms and workplace cultures towards alternatives to physical meetings and work-related travel, and should also stress other benefits, such as improved accessibility (Ibid).

It is well-established that making the positive behaviour of others more visible can increase wider engagement in low-carbon behaviour (Schultz, Nolan, Cialdini, Goldstein and Griskevicius, 2007). Among academics for example, survey data has found over 80% would support an organisation-wide policy to reduce flying (Le Quéré et al., 2015). Other surveys suggest there is an 'appetite for leadership' and that high profile individuals reducing or giving up flying appears to contribute to changing norms and a collective effort to reduce flying (Westlake, 2018). Funding could be made available for the development and introduction of ICT systems which monitor and make more transparent work-related flying behaviour, avoided flying, and the use of alternatives in order to help to make visible others' efforts to minimise flying.

Recommendations:

- Provide match-funded financial support to institutions (with employees flying frequently) for the installation of video-conferencing/tele-presence suites.
- Funding for venues to install facilities for regional hosting of nodal conferences and fully distributed meetings offering an alternative to physically attending conferences/meetings.

2.5 Surface transport and aviation - Summary of recommendations

Cycling and e-bikes

- Further cycling infrastructure investment for safer cycling and secure cycle parking.
- Introduce grants for e-bikes.

Bus and rail

- Invite and support new budget-priced intercity rail services (such as that planned for London to Edinburgh in 2021 with £25 fares) to encourage modal shift from cars and planes.
- Require introduction of reduced-price season tickets/passes for part-time workers.
- Reopen disused rail lines and withdrawn bus services where demand exists, or could develop, to reduce car dependency and ownership.
- Finance a programme of investment across the whole of rail and bus networks.

Electric Vehicles (EVs)

Charging infrastructure

- Introduce measures to improve interoperability, reliability and smart grid compatibility.

Fleets

- Raise awareness among fleet operators of incentives, lifetime costs and additional benefits of EV adoption. Company/fleet purchases account for over half of new car sales and have good potential for growing the second-hand EV market to make EVs more accessible.
- Increase funding for procurement of fully electric EVs for Government and Local Authority car fleets. This will lead by example, deliver whole-life cost savings and air quality benefits.
- Extra support for growing car-club EV fleets which reduce private car ownership and use.

Reduce up-front costs

- Reinstate the OLEV grant to the previous level but exclude high-end EV models.
- Lower or remove VAT on new EV sales (as in Norway and Iceland).

Reduce Running costs

- Introduce a 'Flexibility First' approach in new regulation which would improve access to the full market value of flexibility in household electricity demand and support the development of new demand response (DR) services for cheaper smart-charging of EVs.

Enable informed adoption of EVs, smart meters and time-of-use tariffs

- Raise awareness (e.g., via smart metering awareness campaign) of the range of benefits of smart EV-charging (bill savings, system efficiency and supporting renewable energy) and of the need to have a smart meter to give access to new products and services for flexibility.
- Improve the regulatory context for third parties to develop innovative digital comparison tools (DCTs) to communicate the lower EV-charging costs and payback periods possible when combined with smart tariffs, other DR services and/or solar PV.
- Support the development of a solution for consumers to share (or 'port') their smart meter data with chosen third-party consumer services supporting adoption decisions.

Aviation demand

Leisure travel

- Introduce an escalating Air Miles Levy to discourage excessive flying by the 15% of the UK population estimated to be responsible for 70% of flights. Unlike a fuel tax, this would provide strong price signals for frequent flyers without raising prices for people taking an annual holiday. It would also encourage shifting from long-haul to short-haul leisure destinations while 3 or 4-year cycles would allow travellers greater flexibility for long-haul. The levy should also factor in the much larger emissions for Business and First Class tickets.
- Introduce regulation to ban frequent flyer reward schemes that stimulate demand.
- Raise awareness and encourage more responsible flying by mandating that all marketing of flights show emissions information expressed in terms that are meaningful to consumers.

Chapter 3: Recommendations for behaviour change in domestic heating

3.1 Opportunities for behaviour change in domestic heating: smart hybrid heat pumps

Heating and hot water for UK homes make up 25% of total UK energy use (CCC, 2019) and 15% of our greenhouse gas emissions (CCC, 2018). Within UK homes, space heating and domestic hot water account for 79% of household energy requirements (Palmer and Cooper, 2012). This is largely provided by gas, with only 7% of households currently using electric heating (Palmer, Terry and Kane, 2013) and a similar number of homes off the gas grid using other fuels such as heating oil. Almost complete decarbonisation of domestic heating is required for net-zero ambitions. However, emissions from domestic heating are not falling at the rate needed: there has been no progress since 2014 and emissions rose by 1% in 2017 (CCC, 2019).

While there is a role for greater awareness of how to avoid wasting energy - e.g., better use of thermostats, flow temperature and hydraulic balancing (CCC, 2018) - the greatest potential for emissions reductions is not through day-to-day behaviours in heat system usage but the uptake of low-carbon heating systems and building refurbishment for improved thermal performance. Ongoing decarbonisation of UK electricity has opened the door to lower-carbon electric heat solutions, notably heat pump (HP) technologies. The government plans to introduce its Future Homes Standard by 2025, requiring new-build homes to be energy efficient and use low-carbon heating. These homes will have lower heating demands than older housing stock and so will be suitable for heat pumps and pre-heating of the home (ahead of periods of peak electricity demand) without the need for a back-up heating system.

However, three-quarters of the houses that will be in use in 2050 will have been built before 2010 (Power, 2010). Decarbonising heat in older homes with poorer thermal performance is a much greater and more pressing challenge. Smart hybrid heat pump (HHP) technology is expected to play an important role and recent evidence suggests there is a case for deployment at scale from 2020 (CCC, 2019). The Freedom Project has demonstrated that PassivSystems' hybrid heating control system can deliver both reliable comfort and benefits for the electricity grid (Freedom Project, 2018). Retrofitting to existing boilers and wet radiator systems is straightforward and it is ready for wide-scale deployment. How to increase rates of adoption for smart HHPs in older properties will be the focus of this chapter.

Retrofitting HHP technology to older homes offers the householder a number of advantages beyond lowering carbon emissions. Consumers can retain their gas central heating (GCH) system with which they are familiar and with which there is a high level of satisfaction. Retaining the boiler and radiators means installation is low-cost and low-disruption. Keeping the existing GCH system for back-up heating ensures little risk of loss of thermal comfort. When combined with time-varying pricing of electricity, running costs can be optimised through the smart controls to maximise use of low-rate electricity by preheating the home or using other thermal storage and by using the gas boiler when electricity prices are high and extra heat is needed. In the longer-term, the gas grid and households' central heating systems could incorporate more green gas or be adapted for hydrogen gas - this gives the consumer some reassurance of HHPs being relatively future-proof.

Progress in decarbonising existing homes through HHPs would benefit from greater acceptance and demand from consumers. Consumer adoption could also stimulate innovation in products and

services and accelerate commercialisation and cost reduction. There is strong interest among consumers in having more energy efficient homes (ClientEarth, 2018) but slow uptake of heat pumps to date, and barriers to adoption, underline the scale of the challenges for widespread take-up of HHPs. These barriers include aesthetic considerations of an air-source heat pump appliance being visually conspicuous externally - solutions to this are available through running pipework to an air source heat pump (ASHP) in a less visible location and more attractive product designs in the future. Cost barriers and unfamiliarity with the technology are major concerns which will need to be addressed by industry and policy. Similar to the approach advocated for electric vehicles, recommendations made here for accelerating HHP adoption cover two complementary strategies:

(i) maximising the value proposition or 'relative advantage' to consumers through lowering up-front and running costs;
(ii) increasing awareness, removing uncertainty and supporting the consumer decision-making process.

3.2 Reducing up-front costs of hybrid heat pumps

The up-front costs of a heat pump are considered unaffordable by most households at present, with 80% of consumers surveyed reporting they 'would not or could not afford' a HHP installation (Clarke, 2018). Access to funds or low-cost borrowing is a genuine problem for many households but, as with EV purchases, the up-front cost barrier is exacerbated by consumers' tendency (so-called 'hyperbolic discounting') to focus on immediate or near-term costs and put less value on longer-term savings and benefits. The industry is developing a heat-as-a-service model (HaaS) for smart hybrid heat pumps with no up-front cost, drawing on knowledge from the Freedom Project trials (Freedom Project, 2018). The initial focus of industry for smart heat pumps will also be on target markets with the largest financial savings, notably homes off the gas grid using oil-fired heating systems - a particular focus could be Northern Ireland, where around 68% of homes rely on oil-fired boilers for heating (The Consumer Council, 2013) and levels fuel poverty are around 20% (Northern Ireland Housing Executive, 2019). These early adopters will help to bring down the hardware and installation costs. Policy to lower the barrier of up-front cost in the form of up-front subsidies would support wider adoption in the short to medium term until purchase and or financing costs fall.

Recommendations:

- The Renewable Heat Incentive (RHI), due to expire April 2021, should be renewed for air-source heat pumps (ASHP) and, in line with CCC advice, be rebalanced towards a capital grant. Smart controls should be stipulated as a requirement for RHI eligibility to incentivise installations which permit smart, flexible consumption with benefits for consumer savings and the power system. For properties with the option of gas central heating a HHP system will currently still be more expensive (D. Joffe, personal communication, July 22, 2019) but the RHI could support off gas grid early adopters. The RHI for heat pumps in smart hybrid systems could taper off as installation costs come down and the value of flexibility in electricity markets increases (see discussion of running costs in Section 3.3).
- VAT is a second possible mechanism for lowering up-front costs. HHP installations currently attract VAT except for installations in new-build or energy efficient homes. A reduced or zero VAT-rating could be introduced for all retrofit installations of smart HHPs, whether with an existing boiler or a new boiler. The VAT reduction should cover the whole installation including new efficient boilers and smart controls.
- Mandate standards for smart appliances. Costs for smart HHP installations could be further minimised by ensuring the various technology components have smart functionality and are

interoperable. Neither air-source heat pumps nor gas boilers are typically smart hybrid-ready for third-party optimised control. Manufacturers need to be incentivised to provide smart functionality and open interfaces with the appropriate level of control. BEIS should introduce standards for smart appliances to enable interoperability between consumers' smart appliances thereby avoiding unnecessary extra cost to the consumer to replace incompatible appliances. Developing common standards for smart devices would also support greater adoption of other smart devices, appliances and controls (BEIS, 2018a).

3.3 Reducing running costs for hybrid heat pumps

The Freedom Project has shown that in a smart HHP system, 70-80% of heat load could be provided by the heat pump if optimising on the basis of carbon. The Freedom Project has also demonstrated that large fuel cost savings for homes using liquefied petroleum gas (LPG) boilers are achievable by switching around 80% of their heating load onto the air-source heat pump (ASHP). However, for households on the gas grid with GCH, the heat pump is hardly used if optimising on cost alone due to the much lower cost of gas per kWh of energy compared to electricity. Widespread adoption of HHPs will require policy to close the price gap between fossil fuel gas and low-carbon electricity.

Recommendation:

- Environmental and social costs on electricity bills are applied at a rate of 17.45% whereas gas incurs just 1.8% (Ofgem, 2018c). The Government could revise and rebalance these tax and regulatory costs (CCC, 2016b; Rhys, 2018). (This same measure would also further reduce EV-charging costs.)

Retail gas prices are three to four times cheaper than electricity per kWh so rebalancing gas and electricity taxes alone will not bring cost-optimisation of HHPs into alignment with carbon optimisation. There are other, larger opportunities to reduce heat pump running costs as the power sector continues to increase the contribution from renewable sources.

Load-shifting and demand response

The electrification of space heating using heat pumps could add greatly to morning and evening power system peak demand, bringing challenges for both generation and distribution network management. However, smart HHP systems can switch to gas during peak-time and can also shift electricity loads to off-peak by pre-heating the home or using other thermal storage. Shifting heating loads offers opportunities for electricity system savings even greater than those from electric vehicle charging (OVO Energy and Imperial College London, 2018). Load-shifting can also reward consumers with reduced running costs via time-of-use (TOU) tariffs and other demand response (DR) services, thereby strengthening the value proposition and attractiveness to potential HHP adopters.

Smart TOU tariffs for flexibility in household electricity demand ('demand response' or DR), have emerged on the market since 2017 following reform of the settlement regime by Ofgem. But the full potential of domestic DR from HHPs and other behind-the-meter devices (including electric vehicles) is not likely to be realised under current market conditions:

> "The biggest challenge to propagation of residential flexibility is the lack of route to market to grid balancing revenue streams from these [behind- the-meter] devices. It is currently not possible to access the full system value identified by this study via existing flexibility markets, indicating a failing. Regulatory and market changes are required in order to facilitate the adoption of these technologies." (OVO Energy and Imperial College London, 2018, p.16).

Recommendation:

- Regulatory and policy support to increase market access to the full value of flexibility could support the emergence of new TOU tariffs and demand response (DR) services with greater financial rewards for consumers running smart, flexible HPP systems. This would make HHP adoption more cost-effective for early adopters, accelerating commercialisation and cost-reduction of these technologies.

Running costs of heating systems are lower in energy efficient homes with little heat loss. Insulation retrofits would not only reduce overall heat demand but also permit greater load-shifting via pre-heating of the home using cheap off-peak electricity, thereby further reducing running costs of HHPs. Flexibility in new electricity loads for heating – whether by pre-heating the living space or other thermal stores – will also support the huge increase in renewable energy sources that the CCC (2019a) has advised are needed to decarbonise the power sector.

Recommendations:

- *Insulation retrofits.* Support should be increased for retrofit of any insulation and energy efficiency improvements to building fabric to replace the UK's current major domestic retrofit programme (Energy Company Obligation). Options include: Variable Council Tax and Green Mortgage (Miu, Wisniewska, Mazur, Hardy and Hawkes, 2018) and access to low interest loans, as advocated by a number of organisations including IPPR, ACE, SEA and the CCC (BEIS, 2017). Loans should be compatible with an integrated 'whole house' approach to heating and insulation (a feature which was lacking from the Green Deal).
- *Storage.* As an alternative to preheating the living space, load-shifting can also be achieved using other thermal or electrical storage technologies. Smart hot water storage tanks (e.g., Mixergy) or heat batteries using phase-change material (e.g., Sunamp and PCM) are likely to be less disruptive to install, and for many properties cheaper, than improvements to the building fabric and so may have fewer barriers to widespread adoption. Policy changes that reduce the costs of behind-the-meter or near-the-meter storage devices that enable load-shifting could also make HHPs more cost-effective. New support could include zero VAT rating all home energy storage (electrical or thermal), as is the case in new build housing (currently, legislation is moving towards increasing, rather than lowering, VAT for storage).

3.4 Enabling informed adoption

As with policy to support greater electric vehicle take-up, making HHP systems more cost-effective and affordable for more homes through financial support and regulatory changes will not result in higher adoption rates unless consumers have a clear and confident idea about the costs and benefits, or relative advantage, they can expect in their home. A smart HHP system is a relatively large investment and consumers' concerns will include financial risks and other issues such as potential loss of thermal comfort, reliability and ease of use.

Unfamiliar technologies are usually adopted more slowly when they are perceived as *complex*, and are adopted more rapidly when consumers can experiment with them before purchase (*trialability*) or can see them being used by others (*observability*) (Rogers, 2003). It is not possible to trial HPP technology in the home in the same way an electric vehicle might be tried through a car club, test drive or rental, so other means of reducing uncertainty about HHP technology are needed.

Recommendations:

- *Accreditation*. Consumer confidence in HHP technology, performance and installers should be supported by a centrally-administered system of accreditation for suppliers and installers and funding for regional centres of excellence to address the skills gap for HHP installation. This would help maintain high quality of outcomes and support consumer trust. The Welsh Government has expressed interest in such a centre of excellence in South Wales.
- *Showrooms.* High street showrooms (such as used to exist for British Gas) could introduce consumers to HHPs, insulation and storage technology, and smart appliances and controls. This permanent and independent source of information could increase awareness and trust in the technologies and act as a link to trusted local installers. Satisfaction with gas central heating, and the tendency for consumers to procrastinate when faced with information and choice overload (Strong, 2014), mean that there is a major risk of consumers delaying action until their boiler breaks down at which point they make a 'distress purchase' of another, familiar, replacement gas boiler. As HHPs are installed alongside, rather than as a replacement for, existing gas boilers there is no advantage in waiting until the boiler breaks down and shifting heating load from gas to the heat pump will extend the life of the boiler. Showrooms' physical presence on the high street could act as a trigger for consumers to take the first step in a more proactive adoption process. Financial support for such low-carbon smart heating solutions showrooms, and reduced premises rates, could be made available until these technologies become more familiar and trusted by consumers.
- *Public buildings*. Similarly, public uncertainty about technologies for low-carbon heating and energy efficiency could be improved by carrying out retrofits and installations in public buildings. HHP installations and improvements to building fabric on highly visible public buildings open to the public would help to raise public awareness, showcase unfamiliar technologies and local installers, and demonstrate costs and savings.

ICT: Digital comparison tools and case studies

As well as these physical locations, there is an important role for Information and Communications Technology (ICT) to make HHP technology more familiar and reach different consumer segments. The digitalisation of energy and an increasingly smart and flexible energy grid add more complexity to energy costs and home energy systems but also mean an increasingly important role for data. The quantity and quality of energy-related data is growing and is a valuable asset which can and should be used to better inform consumers about increasingly complex technology adoption choices.

Bill savings from flexible consumption may be achieved via automated smart devices so that households do not need to engage with the price fluctuations of dynamic time-varying electricity tariffs – this delegating of control is sometimes characterised as 'do it for me' or 'profitable disengagement' (Citizens Advice, 2017a). However, consumers will still need support to compare the different market offerings available and make a decision about which package of technologies and services best suits their needs and preferences. Projecting smart heat pump or HHP system running costs for a particular household is complex and requires a tailored approach drawing on household data. Supporting consumer decision-making is especially valuable given consumers' tendency to place more importance on up-front costs than lifetime savings.

Digital Comparison tools

As discussed for electric vehicle adoption, there is a good opportunity for online digital comparison tools to support consumers in their decision-making process for smart HHP adoption combined with time-of-use tariffs. Such a digital comparison tool (DCT) would essentially be a more sophisticated

energy Price Comparison Website (PCW) and would act as a virtual one-stop-shop delivering a market-comparison of the up-front costs, running costs and payback periods for hybrid heat pump technologies combined with options for time-varying pricing and other demand response services. This would be compared with the household's current gas and electricity costs to reveal long-term savings. While HHPs are not currently cost-effective for homes with gas central heating and flat-rate electricity tariffs, digital comparison tools could initially support early adopters living off the gas grid. The running costs of HHP systems are over-estimated if TOU is not taken into account but currently neither price comparison websites nor existing online HHP running cost calculators include time-of-use tariffs in their cost projections. The thermal performance of a householder's home could be inferred from gas and electricity smart meter data (perhaps combined with data from a smart thermostat).

More ambitiously, options for additional storage technologies (e.g., smart hot water tank or heat battery) or building fabric insulation could also be modelled and additional savings from the extra load-shifting they permit could be factored into cost projections. Information overload and choice overload for consumers comes from uncertainty about HHP technology and how it would work in their home but also comes from the different cost and performance of specific HHP models and accompanying energy services. As with existing price comparison services for electricity tariffs, a comparison tool for HHPs should support consumers in making a choice of a specific hardware system, or hardware and service bundle, from a specific provider and, ideally, show customer satisfaction information.

Such an approach would lower barriers to innovation adoption and technology commercialisation using detailed and clear financial projections for specific products and services tailored to an individual household using smart meter and other data. This can be contrasted with other planned activities to provide information to consumers such as updates to the Standard Assessment Procedure which "could include smart technologies appearing as recommendations on Energy Performance Certificates" (BEIS, 2018d, p.19) or the planned collaboration with the EU Commission on its Smart Readiness Indicator (Ibid, p.34) which rates a building A to E based on an average over eight impact criteria (Verbeke et al., 2018, p.16). These forms of information will likely lack the focus on tailored calculations of running costs for specific commercial offerings which can make price comparison services effective decision-support tools for consumers. Nor do they appear to address the need to combine technologies with demand response services and consider bundled offerings (e.g., hybrid heat pump and thermal storage combined with a time-of-use tariff, solar PV or a heat-as-a-service offering).

This tool would require much more advanced modelling and additional expertise and collaboration beyond that currently required for flat-rate tariff price comparison websites. As discussed for electric vehicle adoption, such a digital comparison tool (DCT) should be delivered by a trusted provider. Given the complexity, this could be a single 'white label' solution developed with support by Government. New DCTs should also be subject to improved regulation to ensure high standards, positive outcomes and protections for users (Carmichael, Gross and Rhodes, 2018).

Recommendation:

- Support the development of digital comparison tools offering tailored cost projections (up-front costs, running costs and payback periods) and market comparisons of smart heat pumps/HHPs combined with smart time-of-use tariffs/DR services and other behind-the-meter low-carbon technologies such as storage, insulation and solar PV. This may require funding, new regulation and more open data.

Case studies

As noted, 'try-before-you-buy' is not feasible for HPP technology in the same way an electric vehicle might be trialled through a car club, test drive, rental or lease. Beyond the tailored cost projections and market comparisons discussed above, further possibilities for reducing uncertainty about HHP technology performance and costs – and for supporting adopters' choices of specific offerings- are possible via ICT using real-world data from previous installations. The CCC has stressed the value of real-world performance and a 'whole-house' approach for informing policy frameworks (CCC, 2019b); such real-world performance data also has good potential for supporting technology adoption.

Calculators and cases studies currently available online for low-carbon technologies do not offer tailored cost projections which include smart TOU electricity tariffs. Neither do they show case studies that are based on detailed and independently verified ex-post assessments after installation.

As with EV and other technologies, the digital comparison tools and databases of verified case studies of previous installations would have value for increasing trust in new technology and resolving information and choice overload for the consumer. As also noted in Chapter 2, these resources could also help to overcome the more social barriers to adoption by providing a sound basis to defend adoption choices to others and increasing trust in unfamiliar technologies by making previous adoption by other more visible.

Ex-post evaluations of the actual performance of the installed HHP system, using real-world data, could be made a requirement for installers, at least while HHP systems are unfamiliar to the public. This would help maintain quality in outcomes and promote greater consumer trust in both technologies and installers. Collecting ex-post evaluations could also provide useful real-world data for policy development.

These ex-post evaluations could be collected (with consent and without personally identifying information) and made publicly accessible through a user-friendly online database of case studies. This would make visible to prospective buyers how HHP (and storage and insulation technologies) are performing for other households and levels of customer satisfaction. This could play an important role in allaying concerns about the real-world performance of these low-carbon heating technologies in comparable households and help householders choose from the array of technologies and service offerings. Such a database would also make other homeowners' adoption of HHPs more visible and so support take-up through 'social proof' - the tendency for consumers to be influenced by others when faced with complex and unfamiliar choices (Kahneman, 2003).

Recommendations:

- Require installers to provide independently-verified ex-post evaluations of the real-world performance of HHP technology to increase consumer trust and generate real-world data for policy development.
- Fund development of a publicly-accessible online database featuring case studies of the real-world performance, running costs and customer satisfaction with smart heat pumps/HHP and associated storage, insulation, smart control and energy service offerings.

Independent verification of technology performance and running costs will require infrastructure for sharing smart meter data for gas and electricity consumption plus indoor temperature readings. One barrier to both and ex-post assessments and the digital comparison tools (for market comparison) is the current lack of a means for households to share their smart meter data on electricity and gas consumption with third-parties (see Chapter 2, Figure 1 and Section 2.3.3.2).

In 2016 BIS set out the principle that "consumers should have access to their consumption or transaction data. This should be in a format that can be easily reused (e.g. midata) and they should be able to authorise third parties such as comparison sites to access their data to help them to switch" (BIS, 2016, p.30). More recently, BEIS has also stressed the importance of "realising the benefits of data portability in consumer markets […] personalisation of price and search online [and] supporting innovation in data use in consumer markets while also preserving strong privacy rights" (BEIS, 2018b, p.29). Generally, the public do not have major concerns with sharing their smart meter data with selected parties (Frerk, 2018; Navigator, 2012; Ofgem, 2018a) but any service for data portability would also need to be a user-friendly process (Sustainability First & CSE, 2018). Making data portability and price comparison simple, frictionless and accessible to all could help redress current issues around disengaged customers and tariff switching, as well as helping to enable greater engagement with TOU tariffs.

Modelling the performance of the technology would also require sharing of additional industry data covering the technical performance of hardware such as heat pumps, boilers, smart controls and other DR-related kit. Government may have a role to play in encouraging more open data. Calls to open up energy system data and models are growing, particularly when used to support innovation, commercialisation and adoption of products and services (Energy Data Taskforce, 2019; FSB, 2018; Hardy, Sandys and Green, 2018).

Recommendation:

- A data portability solution is required enabling consumers to share their smart meter data with chosen third parties offering tailored market comparisons of the costs and savings of HHPs and other technologies combined with demand response service offerings. Given the need for a whole household perspective, a single comparison tool should cover all domestic technologies including HHPs, electric vehicles, micro-generation (e.g., solar PV) and storage devices. A data-portability solution would also support the collection of data for ex-post assessments and case studies of real-world technology performance to further support adopter choices and for policy development.

A fundamental barrier to the demand for – and the therefore the development of - demand response services and digital comparison tools (and also a barrier to data-sharing for cases studies) is the progress of the smart metering implementation programme (SMIP) which has so far reached about one in four households. This is delaying Ofgem's timeline for the introduction of a market-wide half-hourly settlement regime which would stimulate competition and innovation in time-of-use tariffs and demand response services for lower HHP running costs.

Recommendation:

- Continued Government effort towards fast rollout of smart meters, and resolving interoperability issues with first generation meters, is needed. This could include raising consumer awareness about the wider benefits of smart meters in enabling access to new products and services such as smart TOU tariffs.

3.5 Domestic heating - Summary of recommendations

Reduce up-front costs for smart Heat Pump (HP) and Hybrid Heat Pumps (HHPs)

- Extend the Renewable Heat Incentive (RHI) for HP/HHPs beyond 2021, rebalance towards a capital grant, and stipulate smart controls as a requirement. (The RHI for heat pumps in smart hybrid systems can taper off as installation costs come down and the market value of flexibility increases).
- Reduce VAT on smart HP/HHP installations (including boiler and smart controls) in all installations of hybrid retrofit, not just new-build or energy efficient homes as eligibility presently requires.
- Mandate standards for smart appliances to avoid the need for additional appliance purchases due to interoperability issues (air source heat pumps and boilers are not generally ready for smart digital control).

Reduce running costs for smart Heat Pump (HP) and Hybrid Heat Pumps (HHPs)

Reduce electricity costs

- Introduce a 'Flexibility First' approach in new regulation to improve access to the full market value of flexibility in household electricity demand ('demand response'/DR) and better support the emergence of new cost-saving DR services.
- Reduce electricity prices by rebalancing the tax and regulatory costs applied to consumer energy bills which currently fall much more heavily on increasingly low-carbon electricity (17.45%) than fossil fuel gas (1.8%).

Support load-shifting technologies to reduce running costs through demand response

- Pre-heating: Financial assistance for home insulation retrofits via low-interest loans/Variable Council Tax/Green Mortgage proposals.
- Storage: Extend the reduced 5% or zero VAT level to all thermal and electrical storage installations (as for newbuild housing). Storage options can present fewer barriers to adoption than building fabric insulation in terms of disruption and cost of installation.

Enable informed adoption decisions for heating and insulation technologies

- Implement a centrally-administered system of accreditation for smart HP/HHP suppliers and installers and funding for regional centres of excellence to maintain high levels of outcomes and consumer trust.
- Retrofit public buildings, open to the public, with low-carbon heating, insulation and storage technologies to raise awareness and trust to encourage uptake.
- Provide funding for showrooms on high streets to introduce consumers to smart HP/HHPs and other low-carbon smart heating, storage and insulation solutions.
- Require and support installers to provide independently-verified ex-post evaluations of the real-world performance of smart HP/HHP technology to increase consumer trust and generate real-world data for policy development.
- Support the development of a publicly-accessible online database featuring case studies of the real-world performance, running costs and customer satisfaction with smart heat pumps/HHP and associated storage, insulation, smart controls and energy service offerings. This could help to normalise, and increase trust in, unfamiliar technologies.
- Support the development (finance, regulation and open data) of a digital comparison tool offering tailored cost projections (up-front costs, running costs and payback periods) and market comparisons of smart HPs combined with smart time-of-use tariffs/DR services and other behind-the-meter low-carbon technologies such as storage, insulation and solar PV.
- Support the development of a data portability solution for consumers to share their smart meter data with third party digital comparison tools and for ex-post assessments.

Chapter 4: Recommendations for shifting to sustainable diets

4.1 Opportunities for more sustainable and healthy diets

4.1.1 Dietary emissions

Agriculture now accounts for 10% of UK greenhouse gas emissions - a larger share of UK economy-wide emissions than at any time since 1990 (CCC, 2018). Farming also has the potential to free-up land for carbon sequestration such as afforestation - the UK is one of the least wooded EU nations in Europe (Davies, 2017). UK diets have climate impacts beyond those associated with domestic agricultural production and land use: around half of the UK's food is imported (Energy & Climate Intelligence Unit, 2018) and UK beef imports are twice the size of beef exports (Agriculture and Horticulture Development Board, 2019). UK diets highlight the difference between national emissions calculations based on production versus footprints based on consumption practices. This chapter will therefore focus primarily on policy to deliver behavioural shift in UK diets rather than UK agricultural emissions.

By 2050, with current global trends in population growth, diet and associated land-use change, emissions from the food system alone have the potential to reach almost the full emissions allowed for all sectors under a 1.5°C target (Bajželj et al, 2014). While there are large variations in the GHG emissions of the same foodstuff depending on where and how it is produced, it is abundantly clear that the foods producing by far the most emissions come from livestock farming: meat, especially beef and lamb from ruminants, and dairy produce. The livestock industry by itself accounts for an estimated 14.5% of all human-induced greenhouse gas emissions (Gerber et al., 2013). In contrast, plant-based foods are consistently much lower impact than even the most sustainable meat and dairy products. The IPCC Special Report on 1.5°C acknowledges, with 'high confidence', that emissions could be reduced through shifting to less resource-intensive diets by reducing demand for meat and dairy, particularly where consumption is higher than suggested by human health guidelines, a conclusion increasingly shared (Chatham House, 2015a; Poore and Nemecek, 2018; Ranganathan et al., 2016; Willett et al., 2019). In countries with high per-capita meat consumption, a shift to plant-based diets would deliver up to around a 73% reduction in diet-related emissions compared to current levels and would require 70-80% less farmland (Aleksandrowicz, Green, Joy, Smith and Haines, 2016; Poore and Nemecek, 2018). Other research finds that halving the consumption of meat, dairy products and eggs in the European Union would achieve a 25–40% reduction in greenhouse gas emissions from agriculture (Westhoek et al., 2014).

4.1.2 Reducing food waste

An obvious way of reducing emissions from diets would be to reduce food waste thereby reducing demand and production. In the UK each year around 10 million tonnes of food, worth around £17 billion, is wasted post-farm gate and 70% of this comes from households (WRAP, 2017b). The consumption stage within households is the most wasteful stage from farm to plate (WRAP, 2013) with approximately 14% of all food and drink taken home being discarded (WRAP, 2015). The average UK household spends £470 annually on food that could have been eaten but is thrown away; for larger households (with or without children) this is £700 per year, or almost £60 a month at 2011 food prices (WRAP, 2017a). By weight, fresh vegetables, salads and drink are the most discarded food groups making up around 36% of discarded food; by cost the largest food groups are meat, fish and home-made and pre-prepared meals, which make up 34% (Ibid).

The UK production, storage and transport of food that could have been eaten but gets thrown away is associated with 19 million tonnes of CO_2e annually, which is equivalent to the emissions generated by a quarter of private car journeys on UK roads (WRAP, 2019). Discarded food is also a drain on finite resources for food production, land use and water, and on council budgets to collect and process waste. In addition, food waste usually ends up in landfill sites where it emits methane, a greenhouse gas 25 times more powerful than CO_2 (WRAP, 2017a).

However there are grounds to believe that substantial reductions in food waste in the UK could be achieved through interventions with excellent cost-benefit ratios for local authorities, businesses and households (WRI, 2019), mostly likely through a raft of complementary actions (Reynolds et al., 2019). Between 2007 and 2012, the UK made a 21 per cent reduction in the amount of edible food thrown away by households, mostly achieved through a variety of labelling and public relations efforts (WRAP, 2013).

An effective multi-pronged approach to household food waste would be likely to include:

- *Product date labels*. Some consumers discard food because they misinterpret date labels. This could be reduced by introducing a requirement that products have a single date label ('Best Before' or, if needed for food safety, 'Use By', but not both) and prominently-placed advice on storage to maximise product life, supported by effective symbols and graphics (WRAP, 2017c).
- *Separate food waste collection.* As of 2015, only 46% of households in England had access to a food waste collection service (WRAP, 2016). The UK Government has indicated that it will introduce consistency in food collections to ensure that all households and appropriate businesses have a weekly separate food waste collection, a move supported by WRAP, though this is subject to consultation (HM Government, 2018a). Collected avoidable and unavoidable food waste can be processed to produce biogas for heating or electricity instead of otherwise producing methane escaping from landfill. Through the daily act of separating food waste into a dedicated container, food waste collections are likely to make households more conscious of the food they are throwing away. Household food waste is significantly lower in Wales where 90% of households have access to food waste collection and use it more than in the rest of the UK (WRAP, 2017b).
- *Food environmental impact labelling.* In combination with separate food waste collection, food labelling which communicates the environmental impact of foods (see Section 4.4.2) and personalised feedback using shopping data (see Section 4.4.3.1) could increase households' awareness that throwing away food has an environmental, as well as a financial, cost. This could also encourage greater attention on reducing waste of the most high-impact foods. A study of catering food waste in US campus dining found that the 'meat and protein' category represented "the largest embodiment of GHG emissions in both the pre- and post-consumer categories despite ranking fourth in total weight" and that beef made the largest contribution to post-consumer GHG emissions embodied in food waste (Costello, Birisci and McGarvey, 2016, p.191). In UK households, meat, fish and home-made and pre-prepared meals (which typically contain further meat) make up 34%, by cost, of food thrown away (WRAP, 2013) so significant cost savings are also possible to households from reducing waste of high-impact foods.
- *Sustainable food packaging*. Food packaging helps to protect food from damage and consequently being thrown away. However, consumers also appear to be very concerned about single-use plastics and food over-packaging (Ipsos MORI, 2018) but under-estimate the environmental impact of the food itself (Camilleri, Larrick, Hossain and Patino-Echeverri,

2019). More responsible and sustainable food packaging is a worthwhile goal in itself but it may also enable consumers to be less distracted or demoralised by this issue and see efforts to reduce food waste as worthwhile. As discussed in Section 1.5.1, consistency across policy and practices will be paramount to reduce consumers' sense of cynicism, unfairness, helplessness and apathy.

Food waste in catering

In the UK, thirty per cent of all meals are provided through the education, healthcare and other government funded institutions (WRAP, 2015). Worthwhile actions to reduce food waste in restaurants and catering outlets include: reducing the size of portions, plates and trays and allowing patrons to adjust portions to how hungry they are and pay accordingly (Reynolds et al., 2019). Requiring catering outlets to provide information on calorie and or nutrition for menu items could encourage caterers to move to smaller portions on menus or more choice in portion sizes. Research suggests that "in the UK eating out accounts for 20-25% of adult energy intake and that when someone dines out or eats a takeaway meal they consume, on average, 200 more calories per day than if they eat food prepared at home" (Department of Health & Social Care, 2018, p.5). It is likely, therefore, that actions to reduce food waste through portion sizing and labelling of meals outside the home could also have benefits in reducing over-consumption of calories which has health as well as environmental costs.

Recommendations:

- Require products to have only one date label per product ('Best Before', or if needed 'Use By', but not both) and prominently-placed advice on storage to maximise product life, supported by effective symbols and graphics (WRAP, 2017c).
- Give all UK households access to weekly collection of separate food waste (currently subject to consultation).
- Combined with collections, environmental impact food labels and personalised feedback on shopping habits (see Sections 4.4.2 and 4.4.3.1) could also raise awareness and contribute to reducing food waste, especially of high-impact foods.
- Introducing measures for more responsible and sustainable food packaging could also create a more consistent context for consumers to see food waste reduction as worthwhile.
- Introduction of measures to reduce excessive portion sizing, and improved choice in portion sizes and pricing, for meals eaten outside the home.

While reducing food waste is a vital and relatively uncontroversial goal, it should not be viewed as an alternative to tackling the greater challenge of shifting to lower-impact, more sustainable and healthier diets, which the remainder of this chapter will focus on.

4.1.3 Health co-benefits of sustainable diets

In the UK there is considerable overlap between lower-emission diets and healthier diets and therefore reducing diet-related emissions can also deliver major benefits to health, well-being and public health budgets. Food eaten in excess of calorific or nutritional requirements is a waste of resources and also has negative health consequences, notably obesity. Excessive consumption in the UK of high-emission livestock-derived products specifically has also created grave public health problems in terms of diet-related diseases and their costs to society. Health concerns add further urgency to the need for a shift in UK diets and can be important to building both the political will and public acceptance for measures aimed at changing eating habits.

The EAT-Lancet Commission (Willett et al., 2019) provides the first scientific targets for a healthy diet from a sustainable food production system operating within planetary boundaries and stresses that overconsumption of meat has significant health and economic costs to society.

- Much of the meat consumed in the UK is processed, contributing to over-consumption of saturated fat and salt in the diet. The UK population continues to consume too much saturated fat and not enough fruit, vegetables, and fibre (Public Health England, 2018) and it is estimated that obesity-related conditions in the UK are currently costing the NHS £6.1 billion per year (Dept. of Health and Social Care, 2019).
- The cancer agency of the World Health Organization, the International Agency for Research on Cancer (IARC), classified the consumption of processed red meat (including beef, lamb, and pork) as carcinogenic to humans, and as probably carcinogenic if eaten in unprocessed form (IARC, 2015). Comprehensive meta-analyses have found vegetarian and vegan diets to have a significant protective effect on the incidence and/or mortality from ischemic heart disease and incidence from total cancer (Dinu, Abbate, Gensini, Casini and Sofi, 2016), diabetes prevention (Olfert and Wattick, 2018), diabetes management (Toumpanakis, Turnbull and Alba-Barba, 2018), coronary heart disease, stroke and Type 2 diabetes mellitus (Micha, Wallace and Mozaffarian, 2010) and all-cause mortality (Aleksandrowicz, Green, Joy, Smith and Haines, 2016).
- In the UK, reducing average meat consumption to two to three servings per week could prevent 45,000 deaths a year and save the NHS £1.2billion per year (Scarborough, Clarke, Wickramasinghe and Rayner, 2010).
- Guidance on healthy diets in the Eatwell Guide 2016 (Public Health England, 2016), endorsed by the Department of Health and Social Care, indicates that typical UK diets contain too much livestock products and recommends the following substantial changes in national dietary habits:
  - reduction in consumption of red meat by 78%
  - reduction in consumption of processed meat by 78%
  - reduction in consumption of white meat by 86%
  - reduction in consumption of dairy products by 20%
  - increase in consumption of pulses and legumes by 86%
  - increase in consumption of fruit and vegetables by 54% (Scarborough et al., 2016).

  Higher consumption of red and processed meats and a lack of fruit and vegetables is correlated with lower income groups in the UK (Food Foundation, 2017) but it is estimated that following the Eatwell Guide recommendations to shift to more plant-based diets could be achieved at no extra cost for the consumer (Scarborough et al., 2016).

While health impacts from unhealthy diets are projected to worsen, there are additional emerging risks associated with animal-based diets and agriculture. Intensive livestock production is often the incubator of zoonotic diseases (e.g., SARS, avian flu, swine flu) and the excessive and inappropriate use of antibiotics in factory farming has been identified as one of the main drivers of a growing resistance of bacteria and other micro-organisms to antibiotics (anti-microbial resistance, or AMR). In the US, of all antibiotics medically important for humans, over 70 per cent (by weight) is given to livestock. The O'Neil commission predicted that by 2050, "without policies to stop the worrying spread of AMR, today's already large 700,000 deaths every year would become an extremely disturbing 10 million every year, more people than currently die from cancer" (O'Neill, 2016, p.1). In addition, relatively routine surgery (e.g., hip transplants, caesarean sections, gut surgery) and treatments such as chemotherapy could become life-threatening due to the risk of untreatable

infection. O'Neill recommends reduction in the use of antibiotics for livestock and transparency in farming practices for consumers purchasing meat. Fewer livestock and reduced meat consumption would also contribute directly to reducing the risks of AMR through a reduction in the use of antibiotics and their dissemination into the environment by the food chain.

4.1.4 How to shift diets

An evidence review by the Food Carbon Research Network concludes that shifting to sustainable diets will not happen if left to the market, individuals, or voluntary industry initiatives (Garnett, Mathewson, Angelides and Borthwick, 2015). This view is shared elsewhere:

> "The challenge of meeting the protein needs of a mid-century population of 10 billion people in an inclusive, sustainable, healthy and nutritious manner is enormous, but achievable. What is clear is that this will not happen on our current, business-as-usual trajectory"
>
> (World Economic Forum, 2019, p.22).

> "The market is failing […] governments must lead" (Chatham House, 2015a, p.vii).

While climate and public health crises continue to worsen, meat is cheap and awareness of the environmental impacts of the food system is low (Chatham House, 2015a). There is a need and an opportunity for policy to support wider and faster changes. Food and eating is a highly social aspect of life – we eat together and understand food through sometimes deeply felt cultural meanings. These social and cultural aspects of diet make changing eating practices more challenging but could begin to work in favour of change, instead of against it, with well-designed assistance from policy.

Although ambition to change the global food system on the scale needed is uncharted territory for policy (Willett et al., 2019) there is clarity on the changes needed and on the need for policy intervention. There may be a lack of evidence on effective policy interventions to tackle consumption (Godfray et al., 2018) but we do not need more research before acting (Bailey and Harper, 2015). There are a number of low-risk, low-cost and pragmatic steps that can and should be taken that could also deliver considerable co-benefits and secure public acceptance. After many years of sustainable diets being neglected by policy, the context in the UK now shows many signs of being favourable for intervention.

Plant-based eating is becoming increasingly popular, particularly among younger people. Recent surveys have found that 7% of respondents identified as vegan, 14% as vegetarian and 31% as eating less meat, with the number of UK vegans increasing from 0.5m to 3.5m between 2016-2018 (Comparethemarket.com, 2018). Other surveys report that a quarter of UK shoppers are looking to cut down their meat intake in the next 12 months (for 18 to 34-year-olds the figure is 35%) with almost a third of vegans having converted in the past 12 months (Harris Interactive, 2018). Sainsburys has seen an 82% increase year on year in customers searching for vegan products online and a 65% year-on-year increase in sales of plant-based products (Horton, 2019).

4.2 Public-sector catering

Supermarkets, food manufacturers and restaurants in the private sector are responding to this surge in consumer interest in plant-based foods with innovative products (Eating Better, 2017). But while consumer demand and the private sector are clearly ahead, policy and the public sector are trailing far behind. One of the barriers to shifting diets is the difficulty in finding plant-based menu options. While growing demand exists, limited availability is a major bottleneck for change which restricts choice, reinforces traditional diets and discourages shifts in behaviour.

A ‘diffusion of innovation’ perspective is valuable for informing effective policy in this area. Innovations can be products, technologies, behaviours or ideas but they tend to be more rapidly adopted when they are: seen as having a greater *relative advantage* over alternatives; are *compatible* with consumers’ values and habits; are not seen as *complex*; when they can be *trialled* and when adoption by others is *visible* (Rogers, 2003). The ability for consumers to try out a new product or behaviour (trialability) can make a crucial difference to whether it is adopted. Many plant-based foods have excellent potential for trialability – they require no major financial commitment, risk-taking, cooking skills or effort. Supermarkets placing plant-based meat-analogues in the meat aisle is an example of a strategy which facilitates meat-eaters trialling these alternatives.

In the UK, thirty per cent of all meals are provided through the education, healthcare and other government funded institutions (WRAP, 2015). But while supermarkets and restaurants are responding to growing demand, schools, hospitals, prisons and other public-sector catering outlets do not routinely offer any purely plant-based menu options. Vegan options, if they are available, are prepared if specially requested and are not available to other diners. Schools in the UK serve between 6-7 million school lunches per day. Most schools will provide a vegan meal on request but this requires submitting a ‘Special Diet Request Form’ to the catering company and the child is then restricted to only vegan options and these vegan options are not available to other pupils who might want to try them, making a ‘flexitarian’ or ‘reducetarian’ approach impossible. In addition, cow’s milk is subsidised and, like water, is included for free with school meals while fruit juices and plant milks, if available, cost the pupil extra.

A *Meat and Poultry 2017* report (YouGov UK, 2017) showed that 56 per cent of British consumers say they do not need meat to have a good meal and a third of those who report eating less meat say it is directly due to them trying out more vegetarian meals. A series of experiments at Cambridge University Catering Services has generated evidence on the effectiveness of encouraging plant-based diets without restricting consumer choice. These showed that doubling availability of vegetarian dishes increased vegetarian sales by 42-97%, especially among meat-eaters (White, 2016). This is achieved without banning or removing meat from menus.

Recommendation:

- Introduce new regulation requiring that all public-sector catering menus offer a fully plant-based (vegan) option that is available to anyone every day without special request (as suggested by the *Catering For Everyone* campaign). This has already been enacted into law in Portugal. Increasing plant-based menu options has been found to increase demand and would lower barriers to shifting to lower-impact diets without restricting choice. This measure would introduce omnivores, and the growing number of flexitarians, to readily-available, healthy, plant-based dishes with potential for spillover into their eating habits beyond the school or hospital and for social influence effects to ripple-out to wider social circles. It would also give existing vegetarians easy, accessible options to reduce dairy consumption.

There is good potential to achieve shifts in diet by broadening public sector menus. Such a strategy is consistent with the four cornerstones of the EAST framework (Service et al., 2014), used by the Behavioural Insights Team for behaviour change ‘nudges’, which advocates making a desired behaviour *easy, attractive, social* and *timely.* Moreover, the *Easy* and *Social* components are mutually supportive: seen in terms of the *individual*, *social* and *material* contexts for behaviour change within the ISM Model (Darnton and Evans, 2013), improving the *material* context (by adding a plant-based option to menus) also improves the *social* context. Firstly, diners interested in plant-

based meals will be able to dine with others without the individual or group needing to search for another more vegetarian/vegan-friendly food outlet; this makes plant-based eating a more sociable activity. Further, having plant-based food on the menu everyday will have a huge impact on normalising 'vegan' or 'plant-based' food, increasing familiarity with it, weakening prejudices and making it more socially accepted. The issue of the language used for labelling 'plant-based'/'vegan'/'meat-free' dishes is a level of detail for marketing, largely outside the policy-focus of this report, but research and best practice is developing (e.g., Bacon, Wise, Attwood and Vennard, 2018) which should be shared and implemented - though it should be added that what constitutes effective marketing of plant-based food is dependent on multiple publics or market segments (World Economic Forum, 2019), and on evolving cultural attitudes, and as such will be subject to change.

The *observability* of an innovation being adopted by others also tends to lead to more rapid diffusion through society. This is particularly valuable and relevant for plant-based eating due to the social and cultural associations around foods. Eating is a highly social aspect of life: we often share shopping, cooking and eating and there are a great many deeply-held cultural and social meanings ascribed to food and food choices (Beardsworth and Keil, 1997). The foods we choose can affect how we are seen by others and changing dietary practices can affect personal relationships. Negative stereotypes about vegetarians and vegans and cultural associations attached to eating meat and meat-avoidance linger still. These stereotypes include ideas of vegetarians/vegans being morally superior and 'preachy', being abstemious and boring, and, for men, lacking the masculinity associated with meat-eating (Fiddes, 1991; Rothgerber, 2013). Research trials on effective language for marketing plant-based food report that 'meat-free' is a poor choice for marketing to omnivore consumers as it reinforces ideas of vegetarian/vegan food as lacking something and those who eat it as missing out (Bacon et al., 2018). These cultural stereotypes and social dimensions add to the social awkwardness of choosing plant-based foods in many social situations and can make being vegetarian or vegan a more challenging choice of lifestyle and identity to adopt, maintain and manage (Carmichael, 2002). As such, this social or rhetorical context can add further 'costs' to choosing plant-based foods and present extra barriers to shifting to sustainable diets in addition to material or structural barriers. For schoolchildren, being seen to be on (and restricted to) a 'Special Diet' of vegan foods not available to others sets them apart from other children, enforces rigid identities, is potentially stigmatising and is certainly a divisive and unnecessary obstacle to shifting eating habits.

Simply getting tasty (*attractive* in the EAST framework) plant-based dishes on menus and consumers seeing people choosing these, will weaken stereotypes and social and cultural barriers. In contrast, a recent awareness campaign in the Netherlands which aimed to promote the idea that men can eat less meat runs the risk of reinforcing the perception that real men eat meat by referring directly to it. Rather than talking about it, observation of actual behaviour – in this case 'normal' men and women choosing and enjoying plant-based foods - is likely to be an effective route to changing ideas and norms of behaviour but this will require removing the material barriers first by broadening menus. A virtuous circle of feedback effects should then build momentum to grow demand and supply for plant-based foods and further reduce material and social barriers (see Figure 3). Plant-based menu options should be high quality, attractive and tasty if they are to be popular and succeed. It will be crucial to get local staff and management on board with these changes.

Recommendations:

- Support the broadening of public sector menus through state funding for training kitchen staff in plant-based cooking to address clear skills gaps. Experience on Humane Society International UK's Forward Food programme[3] has shown that resistance from staff can quickly turn to enthusiasm for gaining new skills in plant-based food catering, converting the staff into champions for menu changes (H. Harwatt, personal communication, March 21, 2019).
- Further funding should be made available for equipping kitchens and food preparation areas where these are not adequate to support the menu changes.

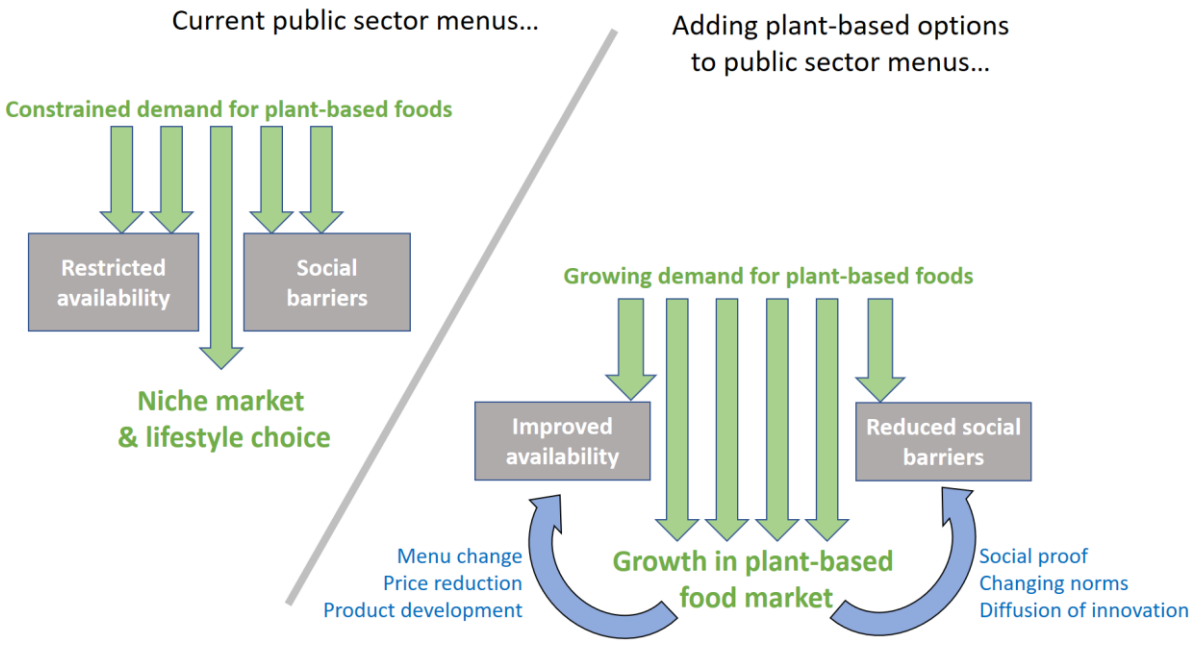


Figure 3: Improving access to plant-based menu options could lead to increased take-up, market response and a more supportive social context

[3] https://forwardfood.org/

4.3 Food technology

4.3.1 Plant-based meat analogues

Another major opportunity for shifting diets through improved choice and availability is presented by food technology in plant-based alternatives to livestock products. Meat replacement or 'meat analogue' products have approximately 10% of the GHG emissions of beef (see Table 1).

Table 1: CO_2e emissions of meat and meat analogue products

Food type	Carbon footprint
Minced beef	23.45 kg CO_2e per kg of product (Williams, Audsley and Sandars, 2006)
Plant based meat analogue or vegan burger	2.29 kg CO_2e per kg of product (Mejia, Harwatt, Jaceldo-Siegl, Soret and Sabate, 2016) See https://www.tuco.ac.uk/ghgcalculator/
Quorn mycoprotein products	Up to thirteen times lower than beef Up to 4 times lower than chicken (Carbon Trust, 2014)

Other research gives figures for meat analogues of between 1–6 kg CO_2e per kg of product, depending on whether there are any animal sourced ingredients in the product (Nijdam, Rood and Westhoek, 2012). Cow's milk has between double and five times the GHG footprint of soya milk (Poore and Nemecek, 2018).

Modelling of a range of food production and consumption scenarios has found that the 'artificial meat and dairy' and 'plant-based eating' scenarios achieved the greatest reductions in land use and GHGs and the greatest carbon sequestration potential (Röös et al., 2017). Globally, reduced livestock and animal feed crops would reduce land clearing, habitat and biodiversity loss and resultant species extinctions (Tilman and Clark, 2014; WWF, 2017). A Chatham House report on meat analogues (Chatham House, 2019) found that they have the potential to contribute to climate change mitigation and also to reduced antibiotic use (see Section 4.1.3), improved public health and sustainable resource management. A further advantage of plant-based meats is that "their precise nutritional composition can be tailored to best meet the needs of human health" (World Economic Forum, 2019, p.22).

Plant-based meat and dairy replacements or analogues have an important role to play in shifting to sustainable diets as they reduce the *complexity* of plant-based eating and are highly *compatible* with existing food habits (both associated with rapid innovation adoption). Swapping meat for meat replacement products does not require any new skills for cooking, preparation or meal planning and they are also low risk in terms of food safety. Meat analogues or substitutes, by definition and design, fit in with existing habits – a plant-based burger is still a burger not a deep-fried insect or a meal replacement drink. Similarly, plant-based milks can be used much like dairy milk. It is likely therefore to be easier to shift demand for livestock products to plant-based analogues than to reduce demand for these by other means.

In terms of the *relative advantage* to consumers, analogues have clear benefits for health, environment, and animal welfare – all now common concerns. Costs should reduce further, likely substantially, as plant-based alternative proteins and meat and dairy replacements increase their scale of production and follow the usual 'learning curves' for new technologies. Their rapid growth and success in recent years is in large part due to advances in food technology which has produced meat analogues with much-improved texture, taste and consumer appeal (for example, the *Impossible Burger*, *Beyond Burger*, the award-winning *Oumph!* range, and supermarkets' own-brand products such as Iceland's *No Bull/No Chick/No Porkies* range). In contrast, while cultured or lab-grown meat has benefits over conventional meat for animal welfare, the technology has not yet demonstrated affordability or consumer demand nor benefits for emissions or health.

There is huge potential for further growth in meat analogues. The UK has the biggest ready meal market in Europe (Euromonitor, 2018) with 9 out of 10 people eating ready meals or ready-to-cook products (Minitel, 2017). However, meat still dominates the ready meal aisles, with only 3% containing no animal ingredients (Eating Better, 2018). As with improvement to the availability of plant-based foods, further improvements in the taste and texture of meat and dairy analogues will reduce social barriers to shifting diets. The perception that a plant-based diet is extreme, weird or 'other' will diminish as these foods become easier to find and improve further in taste and texture.

4.3.2 Blended products

Another food technology route for reducing meat intake is offered by products which blend animal products with plant ingredients. There is large potential for reducing meat consumption in this way to deliver emissions and health benefits while being acceptable to a broad range of consumers.

Blended products are already showing success in the USA with the 'Blended Burger', which incorporates 30% mushroom into minced beef (see Figure 4). Meat can also be blended with plant-based meat analogues. German company Hackplus have launched a minced product consisting of 70% meat and 30% plant protein that has 30 per cent less fat and cholesterol than traditional ground meat (Ranganathan et al., 2016). Thirty-seven per cent of beef consumed in the UK is minced and so there is a significant opportunity for blending with plant-based minced beef analogues. Blending meat analogues with meat could be done widely within the ready meal market.

There is potential for advances in UK food technology to be economically important with both strong domestic demand and possibly huge global markets. This should be viewed as an industrial opportunity similar to other disruptive low-carbon technologies. The world leader in meat alternatives is UK company Quorn which has the world's largest meat-alternative factory at Billingham, County Durham. Others have called for funding to accelerate such a 'new protein economy':

> "They therefore present a strong argument for joint public-private investment and new platforms for innovation acceleration and market development, similar to how the renewables industry was 'pump-primed' by some key governments in the 1990s and 2000s, with a global public good benefit in mind. In particular, investment in technical and production methods that can be scaled in ways that maximize sustainability is critical, and may not be delivered purely by the market" (World Economic Forum, 2019, p.22).

The potential benefits of meat analogues for GHG emissions, public health, UK industry and influence on global diets should make R&D in meat analogue food technology a priority for state financial support. The £90m Industrial Strategy Challenge Fund (ISCF) could be one source of investment. Meat analogue R&D would satisfy the ISCF goals of raising UK productivity and earning

power for challenges where the UK has businesses ready to innovate and the market is large, fast-growing and sustainable.

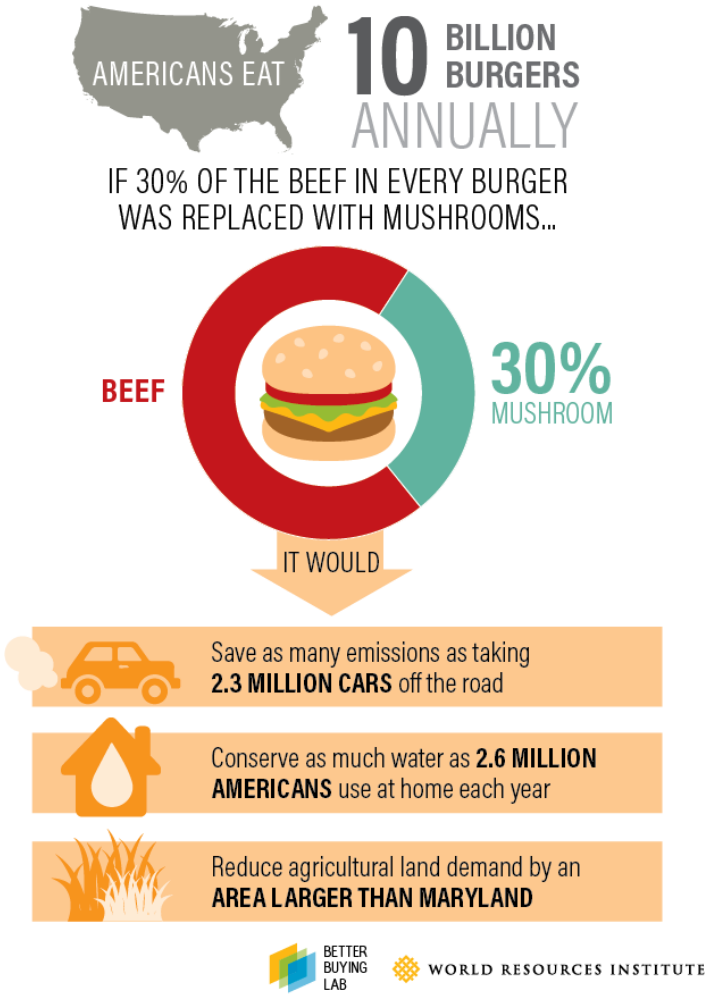


Figure 4. Blended burger with 30% mushroom
(Source: WRI at https://www.wri.org/blog/2018/02/flavor-packed-burger-saves-many-emissions-taking-2-million-cars-road)

Recommendation:

- Public funds should be invested in research, development and commercialization of plant-based meat analogues with a focus on sustainability in manufacturing processes. Research into new blended products should also be pursued. This approach has the potential to reduce uncertainty about the feasibility of shifting to more sustainable diets by turning social feasibility largely into a matter of technical feasibility.

The potential disruptive impact of meat analogues and other dietary changes on UK agriculture means that support for farmers to transition from livestock to horticulture and other land use activities is also needed. Most fruit and half of vegetables consumed in the UK are now imported (Defra, 2016). This presents a useful business case for more UK horticulture. As an idea of what is possible, the *Best Food Producer* in the BBC Food & Farming Awards 2017 was Hodmedods, who encourage and support growing more vegetables and pulses in the UK for human consumption. The

business case for more UK horticulture should be further strengthened through public-sector catering procurement sourcing more food from UK producers. The NHS has a very poor record: just 5% of fish and just two out of 150 meat contracts awarded by the NHS Supply Chain in 2008–09 involved UK sourcing (Soil Association, 2011). Menus and procurement should also have a much stronger commitment to seasonal and local produce which can result in savings to caterers, more profitability for farmers and more nutritious food as well as delivering lower emissions: Nottingham City Hospital estimates they save £6 million per year by cooking with fresh, local ingredients (Ibid). From a behaviour change and public engagement perspective, supporting UK farmers would also reduce potential consumer concerns that not buying meat is putting UK farmers out of business.

Recommendation:

- Government support for farmers to shift from livestock to horticulture, where land is suitable, or to other land use options. This could include finance and knowledge-sharing for agricultural practices, business and markets.

4.4 Food system data, labelling and feedback

Making more plant-based food products physically more available - through broader menus, plant-based analogues and blended products - will lower a major barrier to shifting diets. A second major bottleneck to shifting diets centres around awareness, informed consumer choices and availability of data.

4.4.1 Mandatory 'traffic light' nutrition labels

The UK is the most overweight nation in Western Europe. Approximately 29% of adults in England are obese (Baker, 2019) and these figures are set to climb to 60% of men and 50% of women by 2050. Twenty per cent of Year 6 children are obese (Department of Health and Social Care, 2019). The EAT-Lancet report advises a shift to unsaturated rather than saturated fats and a reduction in animal-based foods and added sugars (Willett et al., 2019). Reducing overconsumption of calories is the topmost recommendation from the World Resources Institute report on a sustainable food future (Ranganathan et al., 2016). A diet with reduced calories and saturated fats is highly consistent with reduced consumption of meat, which tends to be high in fat, and its replacement with plant-based analogues with much lower fat and cholesterol content (Bohrer, 2017; Kumar et al., 2016). Blended burgers and similar products typically offer 30 per cent less fat and cholesterol.

An evidence review found nutritional labelling to have only a modest impact at best on purchasing behaviour (Robert Wood Johnson Foundation, 2009). However, while consumers can find nutritional information in *numerical* form confusing, there is a desire for clearer information and a preference for graphical information (Cole, Peek and Cowen, 2018; Egnell et al., 2018). There is evidence that graphical 'traffic light' labelling (which indicate green, amber and red ratings for calories, fat, saturates, sugars and salt content) helps consumers make informed decisions about the food they are purchasing (Cole et al., 2018; Department of Health and Social Care, 2019; Mozaffarian, Angell, Lang and Rivera, 2018; Sánchez-García, Rodríguez-Insuasti, Martí-Parreño and Sánchez-Mena, 2018). Further, studies have found that nutritional labelling incentivises food companies to reformulate products to make them healthier (Vyth, Steenhuis, Roodenburg, Brug and Seidell, 2010). Traffic light labelling is currently voluntary and there is no standardised labelling framework or design. Some manufacturers and retailers have developed conflicting traffic light labels which allow for a product with high levels of sugar and fat to avoid a red rating based on the expected serving size. The available evidence will also tend to underestimate the potential impact on behaviour of standardised graphical labelling for nutrition as it does not reflect a wider context of supporting

changes such as new products, price signals, labels for food environmental impact (see Section 4.4.3), changing norms and the opportunities for personalised feedback that mandatory standardised labelling creates (see Section 4.4.2, below).

Recommendation:

- Introduce a standardised mandatory traffic light label applied uniformly to all food products to provide better clarity and trust. This is widely supported by the public health lobby. *Which?* have pointed to Brexit as an opportunity for better regulation of the currently confusing, and at times misleading, front-of-package (FOP) labelling (Smithers, 2018b).

4.4.2 Feedback on patterns in food shopping

Considerable further value and impact on behaviour is possible from traffic light labelling beyond the influence of individual product labels while the shopper is in-the-aisle. Although graphical labels can inform purchasing, habits can be resistant to change and some shoppers tend to make purchases quickly and as if on autopilot (Wood and Neal, 2009). Uniform and mandatory traffic light labelling opens up the possibility for supermarkets to offer shoppers feedback on patterns in their purchasing *as a whole* to influence overall purchasing habits over time. Till receipts, smart phone apps, and online shopping websites could all deliver this feedback by aggregating the traffic light labels data over all food purchases in a customer's trolley, weekly shop, or longer time-frame.

As traffic light nutritional ratings are given per kilogram of product not by product weight, the feedback would also correct for the product/package size (e.g., one apple or a large bag? a small bar of chocolate or a family-size pack?). Such weightings of data are difficult for a human but easy for ICT to perform. This would give consumers a clear, highly visible picture of their overall shopping and eating patterns, which are otherwise difficult to see, and could, over time, encourage them to take more notice of individual product labels. Survey research has demonstrated strong consumer interest in having this kind of whole basket feedback on till receipts indicating it could help inform healthier food purchases (Cole et al., 2018). An example design is shown in Figure 5. An alternative design could be to use a stacked bar-chart showing the proportion of green, amber and red products in shopping purchases.

Online shopping or third-party smart phone apps could allow users a customised level of detail and tracking over time. Importantly, this would also give consumers feedback on progress made towards improving their purchasing habits (or alert them if they drift into less healthy patterns of shopping). Goal-setting, tracking, monitoring and feedback are commonly-used strategies in digital behaviour change interventions (or DBCIs) which motivate partly through making goal-setting and progress more specific and measurable (Pinder, Vermeulen, Cowan and Beale, 2018). There should be no need for laborious inputting of shopping data into the app and sharing shopping data with these services should be as easy and frictionless as possible; app development would ideally use a participatory design approach to optimise usability (Orji and Moffatt, 2018).

Figure 5: Example design for personalised feedback on patterns of food purchases leveraging data from 'traffic light' nutritional labelling. Greater feedback on shopping habits could be offered by apps. Illustration: Hayden Peek (Peek, 2016)

Recommendations:

- Introduce regulation requiring supermarkets to provide personalised feedback to customers on their overall purchasing habits using data from standardised traffic light nutritional labels.
- This feedback should be given on all till receipts and online food shopping sites.
- In addition, Government should require, and provide support for, supermarkets to enable all consumers to access and share their food purchasing data with third parties offering data analysis and personalised feedback services. Feedback on till receipts is especially important for shoppers who will not engage with smart phone apps or online services.

4.4.3 Environmental impact labelling

Improving information to enable consumers to make better-informed food purchases should not stop at nutritional information. Research across all British supermarket chains has found concern over the environmental impact of food purchases. Thirty-eight per cent of respondents who have given up animal-based foods cite environmental reasons (Smithers, 2018a). A YouGov survey found 34% of consumers think that everyone should eat less meat in order to help the environment; among 16-24 year-olds the figure is 50% (YouGov UK, 2017).

Although some consumers are shifting their food purchasing to more environmentally-friendly products there is a lack of available information to support them and there is strong demand for better information. Surveys suggest that 72% of UK shoppers want information on the climate impacts of their foods to help them make more informed choices (Garnett, 2008). Understanding of the link between red meat consumption and climate change is low, but when made aware, respondents report willingness to reduce consumption (Chatham House, 2015a). Other research also finds awareness of the environmental footprints of foods is low and that a well-designed carbon

label has potential to be an effective intervention (Camilleri, Larrick, Hossain and Patino-Echeverri, 2019). Experience with electrical white goods indicates that eco-labelling can have far-reaching impacts: initially, 75% of fridges and freezers were rated G to D but now 98% are classed A++ or A+++. Worldwide, the energy efficiency of labelled appliances has increased three times faster than appliances without labels (International Energy Agency, 2016). After years of collaboration with the European Union to develop a climate impact label for food, in 2018 the Danish government included climate food labelling in its 38-point plan for a greener future (Food Tank, 2019). An example design for an environmental impact front-of-pack (FOP) label is shown in Figure 6. An alternative food carbon impact label design in terms of a familiar reference unit of light-bulb minutes is suggested by (Camilleri, et al., 2019).

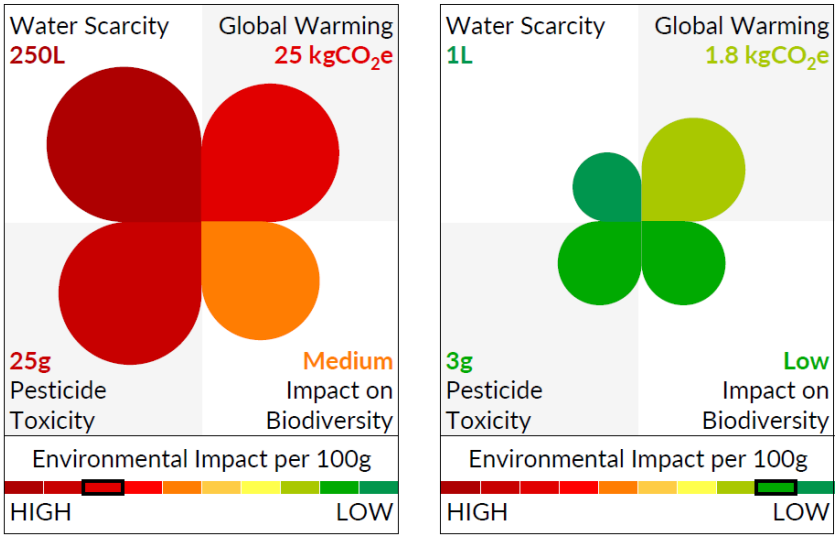


Figure 6: Example design for environmental impact front-of-pack label for food (showing a high impact and a low-impact product)
(Illustration: Joseph Poore 2018)

4.4.3.1 Personalised feedback

While food labels are attached to individual food items, a diet is the sum of all food and drink consumed habitually. As with 'traffic light' nutritional labels, personalised feedback about overall patterns in purchases in aggregate and over time would be extremely valuable to inform shoppers about the environmental impacts of their shopping and should be made available via till receipts and through third parties (as with nutrition feedback).

Environmental impacts are calculated per-kilogram of product. This feedback should therefore also account for the relative weight of products. The overall impact of food purchases should be benchmarked to a guideline of globally sustainable diets using figures informed by the Planetary Boundaries framework for food production used in the EAT-Lancet Report (Willett et al., 2019). Comparing the impacts of a household's shopping habits to other households (a 'peer proof' approach which has been used, for example, by OPower to lower household electricity consumption) is another option, but given current diets and the scale of dietary shift required, this would risk reinforcing undesirable behaviours (as highlighted in Service et al., 2014); comparison would need to be to low-impact households rather than the average UK household.

Online grocery shopping sites and smart phone apps could provide more detailed feedback on shopping habits month-on-month. Aggregating, benchmarking and tracking the environmental

impacts of food purchases in this way would make labelling information more visible and meaningful and more likely to shift shopping habits. Behaviour-change interventions based on information and awareness-raising often have limited impact. But indications are that the current lack of environmental impact information is a barrier for consumers already willing to change their consumption habits. Crucially, consumers are interested in getting this information which would be *actionable* in the sense of empowering them to make more informed purchasing decisions in daily life. As low-impact foods tend to be lower in saturated fat *there is also potential for environmental impact labelling and nutritional labelling to reinforce each other* – especially as meat analogue and blended products develop further.

Environmental impact food labelling and personalised feedback have potential to deliver an additional benefit of making people more mindful of the environmental waste of food they purchase and then throw away (see Section 4.1.2). Around 14% of food purchased by UK households, and could be eaten, is discarded (WRAP, 2015). In combination with separate weekly food waste collection, labelling which communicates the environmental impact of foods could increase households' awareness that throwing away food has an environmental as well as an economic impact and could also encourage greater attention on reducing waste of the most high-impact foods (see Section 4.1.2).

4.4.3.2 Producer-specific impact data

Calculating the GHG footprint of foods is complex, especially if incorporating co-products. However, standardised and mandatory environmental impact labelling on all retail food products would be a valuable tool to shift behaviours and this will need to be done on the basis of individual producers and manufacturers rather than simply the type of food (e.g., giving average emissions for beef). Analysis by Poore and Nemecek (2018) of over 40,000 farms found that although even the lowest-impact animal products exceed the average impacts of substitute vegetable products there is also wide variation between the most and least emitting producers. Across all products, 25% of producers create over 50% of environmental impacts. Beef and farmed crustaceans are product categories with particularly large variation between different producers (see Figure 7). High-impact beef producers (90th percentile) can emit 12 times more GHGs than low producers (10th percentile) and have nearly 50 times the land use of low-emitting beef producers. *Halving consumption of animal products by avoiding the highest-impact producers would achieve 73% of the GHG emissions reduction potential of switching to completely plant-based diets* (Ibid). Similarly, emissions from discretionary products such as alcohol can be cut significantly just by avoiding the highest-impact producers. Small, targeted changes in consumer behaviour, switching from one producer or brand to another, can therefore deliver big GHG reductions even without switching to another type of food.

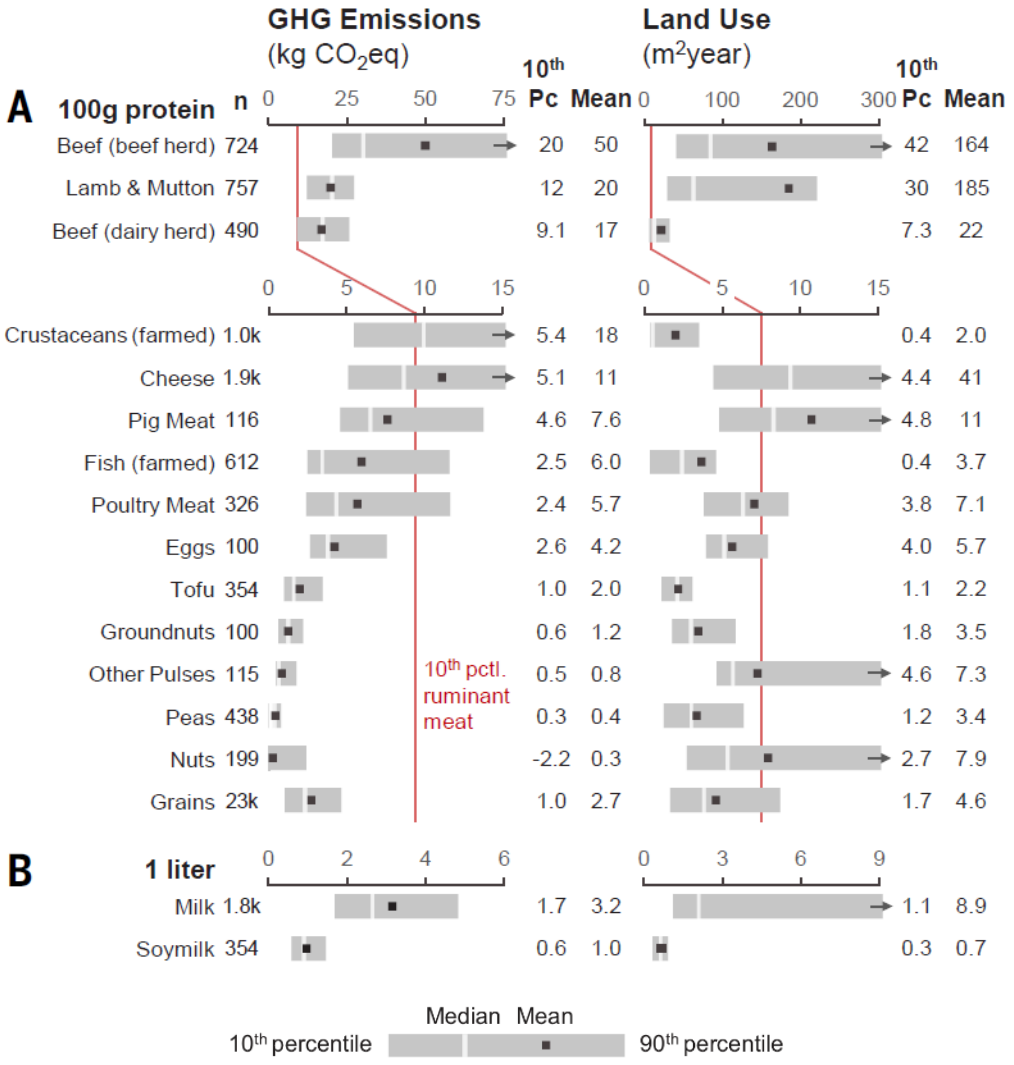


Figure 7: Estimated global variation in greenhouse gas emissions and land use within and between major foods. (Source: Poore and Nemecek, 2018)

Consumers

Currently, 96% of brands make environmental claims (Nielsen Company, 2015) and there are currently about 460 voluntary environmentally-related labels that manufacturers can choose to use. These have little impact partly because low-impact producers certify while high-impact producers do not. Standardised environmental impact labels need to be applied to high-emission producers and foods as well as low-emission ones to provide negative signals not just positive ones. This is especially important in light of research showing that negative signals affect purchasing more than positive ones: in the US, 56% of shoppers stop buying from brands if they think they are unethical (Mintel, 2015). Mandatory climate impact labels on foods based on food producer data can therefore deliver two important objectives for consumer purchasing. They would enable:

(i) a shift away from high-impact *foods* and
(ii) avoidance of high-impact *producers*.

Producers

The CCC notes that "in 2017, 44% of farmers took no action to reduce GHG emissions, and half of farmers did not think it was important to consider emissions when making decisions about farming practices. There has been little change in these percentages over the past three years" (CCC, 2018,

p.181). Poore and Nemecek (2018) propose a framework for reducing emissions from food producers which consists of three inter-related elements:

(i) environmental impact assessment and reporting;
(ii) tools for modifying production;
(iii) financial and regulatory incentives.

Under mandatory environmental impact labelling, producers would also need to communicate their impacts to suppliers and consumers, which would encourage more informed sourcing, procurement and demand throughout the supply chain. Such labelling would further support sustainable consumption by rewarding low-impact producers and encouraging higher-impact producers to change. Farmers and manufacturers would need to monitor their impacts in a uniform way and be accountable for them, encouraging better decision making and encouraging an evolution in food production methods which "multiplies the effects of smaller consumer changes", argue Poore and Nemecek (Ibid, p.991).

It is already feasible for producers to measure and monitor their impacts in a uniform way and this would not be expensive (Ibid): free-to-use digital tools already exist for the whole supply chain to measure the carbon footprint of crop and livestock products (Denef, Paustian, Archibeque, Biggar and Pape, 2012). Two examples are the award-winning *Cool Farm Tool*[4], developed at Aberdeen University, and *Fieldprint*[5]. Information from producers can be validated using on-farm checks that are already carried out for subsidy payments, plus previous data and satellite data (European Commission, 2018). Digital tools for traceability and monitoring production emissions are already in use in Africa and South Asia using 2Gmobile phones (GSMA, 2017). One of the world's largest agricultural companies, Olam, aims to expand their *AtSource* tool (which tracks the social and environmental footprint of a product from the farm all the way to its arrival at retailers) to the 4.7m farmers in its supply chain (Foodbev, 2018).

The second piece of the framework is supporting improved practices and innovation in production methods. Monitoring tools often reveal simple ways to reduce impacts (Tuomisto et al., 2015) such as a 13% cut in emissions achieved by Costco's organic egg producers (Cool Farm Tool/Costco, 2016). The huge scope for emissions reduction is indicated by a massive programme involving 21 million Chinese farmers that produced a 20% reduction in emissions (Cui et al., 2018). Assessment tools would provide producers with multiple options for impact mitigation and productivity enhancement and become platforms for best practice and knowledge-transfer among researchers and producers. Practice sharing offers a flexible and very effective way to engage producers and support innovation.

Recommendations:

- Introduce mandatory standardised, graphical labelling of food environmental impacts based on verified producer-specific data (not food type). This will be crucial to incentivising shifts to lower-impact consumer choices, production practices and product innovation.
- Introduce a requirement that supermarkets provide consumers with personalised graphical feedback on the environmental impact of their food shopping habits *as a whole*. This feedback should leverage the mandatory standardised labelling for environmental impact and be benchmarked to guidelines of globally sustainable diets. This feedback should be given on all till receipts and in online food shopping.
- Supermarkets should also be required to enable customers to easily share the environmental impact data for their food purchases with third-parties offering further analysis and feedback.

[4] https://coolfarmtool.org/
[5] https://fieldtomarket.org/our-program/fieldprint-platform/

- As for nutritional data, Government should create the technical and regulatory environment needed to enable consumers to easily share the environmental impact label data for food purchases with third-party services.

4.5 Price signals

The final element in the framework offered by Poore and Nemecek is the role of policy-makers in setting targets and incentives for food producers and manufacturers. Environmental impact labelling will influence demand from consumers thereby encouraging lower-impact production methods, product development and reformulation. Adding financial incentives will reinforce this by further affecting producer profitability and filtering down as price signals in retail and catering, further influencing demand. The monitoring data used for mandatory environmental impact labelling would address the current scarcity of information within the food system and allow financial incentives to be well-informed and optimally designed for fairness and effectiveness.

The public are more receptive to taxes than politicians often suppose, especially when seen as being in the public interest (Chatham House, 2015a; Department of Health and Social Care, 2019; McKenna, 2018). A systematic review of 38 studies found that price signals (taxes and subsidies) are consistently effective at changing consumption patterns, especially when there are 'close untaxed substitutes' (Thow, Downs and Jan, 2014). A number of other studies have similarly concluded that measures to make unhealthy foods more expensive and healthy foods less expensive are among the most effective interventions for changing consumption patterns (Chatham House, 2015a; Garnett and Finch, 2016; Springmann et al., 2018). Other research stresses that *This indicates that a combination of price signals and support for lower-impact alternatives (such as meat analogues) is likely to deliver greater shifts in diets*.

Farm subsidies

There are a number of ways in which financial incentives could be implemented. Brexit offers an opportunity to overhaul multi-annual farm support budgets to deliver GHG reduction on farms based on delivering 'public goods', as proposed in the new Agriculture Bill. Reducing and rebalancing farming subsidies to better reflect the externalised costs and negative impacts on the environment and public health is likely to be the fairest and least controversial route to financially incentivising the required shift in food production and consumption. Livestock products would not be singled-out as a special case (as with a 'meat tax') but treated under the same rules as any other producer. Good potential to use rebalancing of farming subsidies is further indicated by the fact that livestock farming currently receives much higher subsidies than horticulture through the Common Agricultural Policy (Food Foundation, 2017):

> "between 69% (€28.5 billion) and 79% (€32.6 billion) of the CAP direct payments is directed to producers of fodder for animals, or goes directly to livestock producers as coupled support. That's between 18% and 20% of the EU's €157.86 billion budget in 2017"
>
> (Greenpeace, 2019, p.15)

Another option for financial incentives for producers would be an economy-wide carbon tax which might more easily incorporate not only farms but producers of processed plant-protein products. As a first step, removing the very generous subsidies for livestock rather than applying new taxes is likely to be the lowest risk in terms of acceptability to the public and industry, although the option of linking carbon fee revenues to a public dividend has potential for securing public acceptance and support.

By supporting the development and use of data-led practices and policy for monitoring producer emissions, informing subsidies and incentivising a shift in demand and production, the UK could contribute to systemic change in global food production practices, behaviours and supply chains and thereby have a much greater impact on dietary emissions beyond UK borders.

VAT reform

Price signals could also be applied at point of sale to further reflect public health and environmental costs. Brexit also offers an opportunity to revise VAT on food to bring it more into line with policy goals, as recommended by the Department of Health and Social Care (2019). At present in the UK, meat and cake is zero-rated but cereal, protein bars and salted nuts are standard-rated at 17.5%. Milk, chocolate Nesquik powder and sweetened milk drinks are zero-rated but bottled water and meal replacement drinks are standard-rated. Unsurprisingly, a survey for Huel on consumer attitudes to VAT on foods found 95 per cent were surprised and 82 per cent were confused by how VAT is applied to different foods (Robinson, 2015). Revised food VAT rules could be based on the newly-available data supporting mandatory traffic light nutritional and environmental impact labels. Simpler and more logical VAT rules are also likely to be accepted by consumers more readily than new extra taxes on specific foods such as a 'meat tax'. As discussed in Chapter 1, bringing taxation into line with messaging about climate change should support greater public engagement by showing consistency and leadership. Price signals can not only influence purchasing financially but normatively – helping, for instance, to change the perception (in the UK) of meat as a relatively cheap and 'essential' staple food purchase. Public acceptance of food VAT reform might be further increased by ringfencing (or 'hypothecating') VAT revenues from unhealthy and high-GHG foods for additional funding to NHS budgets. This would have the additional effect of maintaining higher public awareness of dietary impacts on health and helping to change norms about unhealthy foods by clearly linking taxation to public health costs.

Recommendations:

- Apply financial incentives to high GHG-impact foods to further incentivise shifts to lower-impact consumer purchasing choices, production practices and product innovation. Due to wide variation in impacts from different producers, financial incentives should be informed by the same validated, producer-specific data used for environmental impact food labelling and should be introduced after these data and labelling practices are established.
- Financial incentives could be applied initially through a post-Brexit rebalancing of existing farm subsidies under the Common Agricultural Policy, 69-79% of which currently go to fodder and livestock production. The Agriculture Bill has potential to deliver these changes to farming subsidies to better reflect the real (less subsidised) price of meat and dairy but currently lacks detail.
- Revise VAT rules for foods to remove the many existing inconsistencies and reflect healthy and sustainable diets.

There will be a need to implement these recommendations for shifting to more sustainable diets in a way that allows them to work together as a package of complementary measures. The order in which these interventions are implemented is important for both impact and public acceptance.

As a matter of urgency, improvements are needed to consumer choice and the availability of data, delivered through:

- getting plant-based options onto public-sector menus;
- support for innovation in food technology;
- introducing mandatory standardised graphical labelling for both food nutrition and for food environmental impacts based on producer-specific data;
- enabling consumers to share food labelling data for food purchases with third-party services offering personalised feedback on shopping habits.

This will remove barriers to changing behaviours and norms and lay the groundwork for shifts in production methods.

Once these are in place, the systems used for monitoring food producers' environmental impacts can also inform well-designed subsidies and taxation to further incentivise consumers to shift to lower-emission foods and encourage producers to move to new production methods and product formulations (see Figure 8).

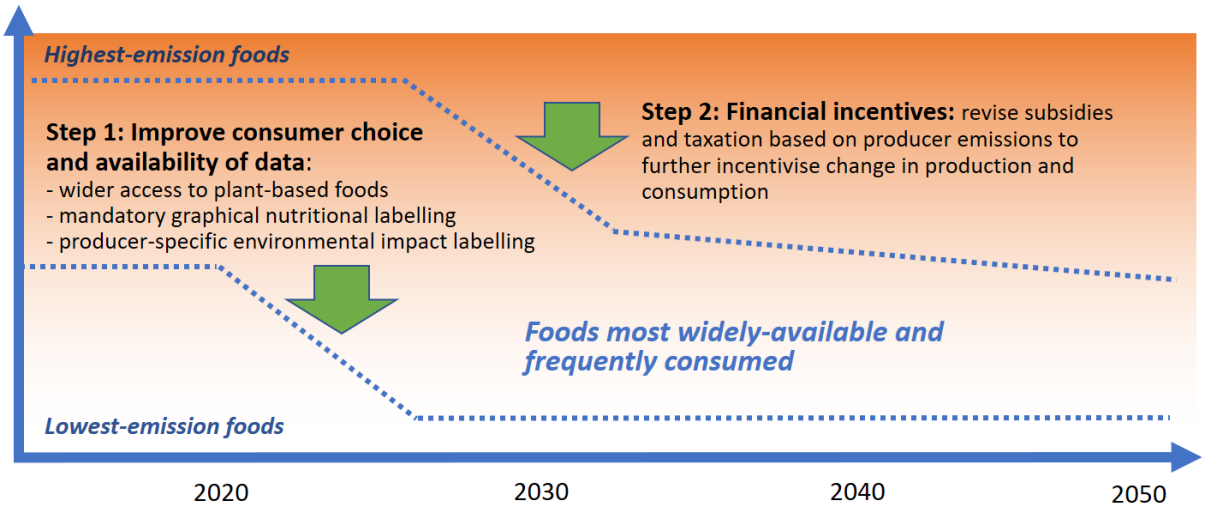


Figure 8: A two-step approach to reducing diet-related emissions: improve choice and data availability before introducing financial incentives

4.6 Shifting to sustainable diets - Summary of recommendations

Reducing food waste

- Give all UK households access to weekly collection of food waste.
- Require products to have only one date label to reduce confusion over food safety.
- Regulation to discourage excessive portion sizing and improve portion size choice for meals eaten outside the home (co-benefits for health from reduced calorie over-consumption).

Public sector catering

- Mandate that all public-sector catering menus include at least one fully plant-based (vegan) option that is available to everyone every day to improve access to lower-impact foods.
- Fund training in plant-based cooking to address skills gaps and provide financial support for equipping kitchen facilities for additional plant-based food preparation where needed.

New product development: plant-based analogues and blended products

- Fund research and development (R&D) in food technology for plant-based meat and dairy replacements (analogues) and plant-animal blended products with a focus on sustainability, health and consumer appeal. This could accelerate a 'new protein economy' for the UK and has scope for reducing dietary emissions globally. The Industrial Strategy Challenge Fund could be suitable for pursuing such a large, fast-growing and sustainable global market.

Food labelling and feedback on shopping habits

Nutritional labelling

- Lower-impact foods strongly tend be lower in saturated fats and cholesterol. Introduce mandatory, standardised 'traffic light' nutrition labels on retailed food to replace numerous ineffective voluntary schemes and permit personalised feedback on overall shopping habits.

Producer-specific environmental impact labelling

- Introduce mandatory, standardised, graphical labelling for the environmental impact of food products based on verified producer-specific data not food type. This can incentivise shifts to lower-impact consumer purchasing choices, production practices and product innovation.

Feedback on shopping habits

- Require supermarkets to provide consumers with graphical feedback on their overall shopping habits by leveraging new mandatory, standardised labelling for nutrition and environmental impact. Feedback to be benchmarked to guidelines for globally sustainable and healthy diets and provided on till receipts and on online food shopping sites.
- Require supermarkets to enable customers to share nutritional and environmental-impact labelling data with chosen third parties offering feedback on purchasing habits.
- Government to create the technical and regulatory environment needed to enable consumers to access and share their food purchasing data with third parties offering analysis and feedback services.

Financial incentives for lower-impact food production and consumption

- Apply financial incentives to high GHG-impact foods based on producer-specific data to further incentivise shifts to lower-impact production practices, product innovation and consumer purchasing choices. Price signals should leverage validated data used for mandatory environmental impact labelling (rather than food types, e.g., beef) and should be introduced after this data and labelling infrastructure is established.
- Financial incentives should be applied in the first instance through rebalancing existing EU farm subsidies post-Brexit, 69-79% of which go to support fodder and livestock production.
- Revise VAT rules on foods to remove many existing inconsistencies and reflect the goals of healthy and sustainable diets.
- New Government support (e.g., finance and knowledge-sharing) for farmers to shift from livestock to horticulture, where land is suitable, or to other land use options.

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