Mapping the co-benefits of climate change action to issues of public concern in the UK: a narrative review

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To avoid a 1·5°C rise in global temperatures above preindustrial levels, the next phase of reductions in greenhouse gas emissions will need to be comparatively rapid. Linking the co-benefits of climate action to wider issues that the public are concerned about can help decision makers to prioritise decarbonisation options that increase the chance of public support for such changes, while ensuring that a just transition is delivered. We identified key issues of concern to the UK public by use of Ipsos MORI public opinion data from 2007 to 2020 and used these data to guide a narrative review of academic and grey literature on the co-benefits of climate change action for the UK. Correspondence with civil servants, third sector organisations, and relevant academics allowed us to identify omissions and to ensure policy relevance of the recommendations. This evidence-based Review of the various co-benefits of climate change action for the UK identifies four main areas: health and the National Health Service; security; economy and unemployment; and poverty, housing, and inequality. Associated trade-offs are also discussed. City-level and regional-level governments are particularly well placed to incorporate co-benefits into their decision making because it is at this scale that co-benefits most clearly manifest, and where interventions can have the most immediate effects.

Lancet Planet Health 2020; 4: e424–33

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Introduction

In October, 2018, the Intergovernmental Panel on Climate Change published a special report on the impact of a 1·5°C rise in global temperatures above preindustrial levels.[1] The report highlighted the urgency with which greenhouse gas emissions must be reduced to avoid the worst effects of climate change. To avoid a 1·5°C rise in global temperatures, global emissions must be halved by 2030 and reach zero by 2050.[1] This report contributed to the UK government setting a target that will require the country to bring all greenhouse gas emissions to net zero by 2050, making the UK the first of the G7 nations to do so.

To avoid a rise in global temperatures above the 1·5°C threshold, governments worldwide face a considerable challenge to decarbonise their economies while meeting other key objectives, such as providing both health-care and public services, growing local and national economies, managing employment rates, maintaining security and public order, and tackling poverty. The challenge of meeting competing objectives is often exacerbated by the nature of the political cycle, in which key objectives tend to be traded off against each other, particularly around the time of elections.

Data on the amount of public concern over issues are important for many reasons, including the way in which they influence the prioritisation and allocation of public resources within a government, and how a policy can be framed and communicated in relation to issues of concern to maximise the chance that the public will be supportive of a particular course of action. However, the prioritisation of societal challenges can be treated as a zero-sum game whereby priority is given to one issue or another (eg, either health care or the environment), with insufficient consideration of how such issues interact. Considering climate change and environmental action in isolation ignores the notable benefits that such action can have on other priorities, and can lead to suboptimal policy decisions.[2] The division of priorities between different governmental departments exacerbates this challenge because departments compete for funding and there are often no direct incentives for them to collaborate where priorities intersect (ie, where there are co-benefits).

A large body of international literature exists on the co-benefits of climate action, particularly relating to public health, ecosystem services, and the economy.[3–6] The Fifth Assessment Report of the Intergovernmental Panel on Climate Change defines co-benefits as being "the positive effects that a policy or measure aimed at one objective might have on other objectives".[7] However, studies generally focus on one set of co-benefits on the basis of a specific academic discipline (eg, the co-benefits of climate mitigation for public health) and do not consider co-benefits and trade-offs within a wider context (eg, in relation to public concerns).

This narrative Review considers the issues that the UK public are most concerned about and encompasses various academic disciplines to identify key areas for

Key messages

- Climate action can provide multiple non-climate benefits that resonate with issues that the UK public are concerned about
- Co-benefits of climate action in the UK include improvements in public health, increased energy security, job creation, and reductions in poverty and inequality
- By considering the various co-benefits of climate action in the decision-making process, suboptimal policy decisions can be avoided and emission reductions can be accelerated
- The co-benefits of climate action are most clearly manifested at the local level
- City-level and regional-level governments are well placed to identify the co-benefits of climate action and to incorporate them into their decision making

co-benefits of climate change action, as well as offering recommendations to government and policy makers to better inform their decision-making processes.

Methods

Study design

To highlight the co-benefits of climate change action for various UK public priorities, we did a secondary analysis of Ipsos MORI Issues Index data, reviewed the academic and grey literature relevant to the co-benefits of climate change action for the UK, and held informal discussions with civil servants, third sector organisations, and academics with expertise in the areas identified in the literature review.

Identification of issues of concern for the UK public

Ipsos MORI is a market research company based in the UK and a member of the British Polling Council, which encourages the highest professional standards in public opinion polling. Since 1974, Ipsos MORI have conducted an Issues Index survey that identifies the main issues of concern raised by respondents to the question "What would you say is the most important issue facing Britain today?". Data for the poll come from face-to-face, in-home interviews with a representative sample of the population, and is weighted by month to match the profile of the population. Answers from members of the public are spontaneous responses; participants are not prompted with any answers and can name more than one issue of concern in their response to the question. The responses are categorised into different themes by Ipsos MORI researchers. The survey has been done monthly since 2011 and varied in its frequency before that. Other UK polling organisations do similar surveys, but we selected the Ipsos MORI poll because the open-ended nature of the survey question was deemed to be a strength in allowing respondents to provide unprompted and unlimited responses that would have the best chance of reflecting their core concerns. For example, respondents to the equivalent YouGov survey are limited in the number of issues they can cite (up to three) and select their issues of concern from a provided list.

We used publicly available data from the Ipsos MORI survey to identify the top ten issues of concern raised by the UK public from the most recent complete year (2017) at time of initial analysis (May, 2018), and we tracked such issues back to January, 2007. The data were subsequently updated to January, 2020. To see how pollution or environment compared with the top ten issues, we also tracked the amount of public concern over this issue in the Ipsos MORI poll. The period chosen encompassed the lead up to the Climate Change Act of 2008 and the Fourth and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change; therefore, it provided a unique opportunity to identify notable changes in public concern over the past five political cycles.

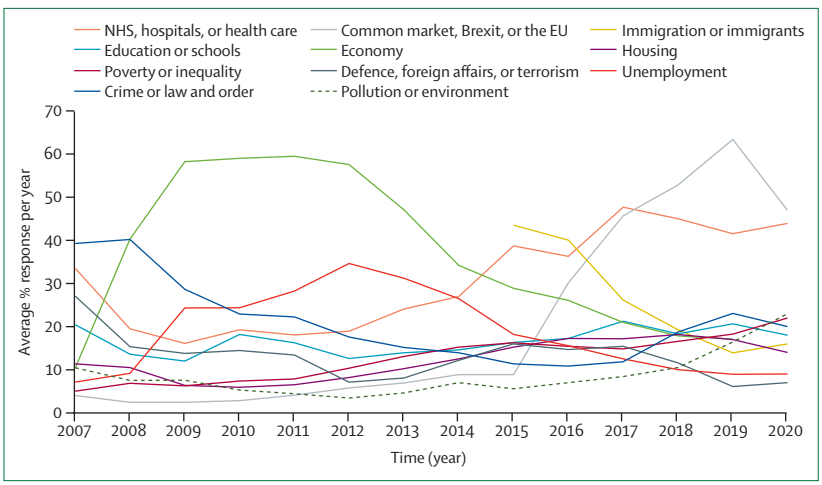

Figure 1: **Issues of concern raised by the UK public in Ipsos MORI polls, 2007–20**
Monthly data have been averaged into annual averages. Immigration was introduced in 2015 as a response category. NHS=National Health Service.

	Number of papers citing co-benefits	Number of papers citing trade-offs
National Health Service, hospitals, or health care	96	25
Education or schools	3	0
Poverty or inequality	47	34
Crime or law and order	0	0
Common market, Brexit, or the EU	0	0
Economy	61	13
Defence, foreign affairs, or terrorism	35	11
Immigration or immigrants	0	0
Housing	39	4
Unemployment	25	6

Papers identified from a Web of Science search that cited UK-focused co-benefits and trade-offs.

Table: **Number of papers citing co-benefits and trade-offs related to issues of concern in the Ipsos MORI poll, 2007–20**

Results

Between 2007 and 2020, consistently high priority areas of concern raised by the public in the UK have been the economy; unemployment; the National Health Service (NHS) and health care; and, since its introduction in 2015, immigration (figure 1). The EU and Brexit are considered in one response category and this issue has risen from a relatively minor concern in 2015 to the most important issue in 2019. For most of the period between 2007 and 2020, pollution or environment was an issue of concern for less than 10% of the population. However, since July, 2018, pollution and environment has appeared in the top ten every month and has risen steadily to be the third highest issue of concern in the January, 2020, poll.

The Web of Science search returned 497 articles, of which 199 were relevant to co-benefits for one or more of the issues of concern for the UK public (table). On the

basis of the volume of evidence and interlinkages between issues of concern, we grouped our findings into: health and the NHS; security (as a synonym for defence); economy and unemployment; and poverty, housing, and inequality.

Health and the NHS

Health and transport

Traffic-related air pollution has been linked to a range of negative health effects, including cardiovascular and respiratory diseases, lung cancer, dementia, diabetes, autism, and mental health disorders.[8] The Royal College of Physicians estimates that particulate matter and nitrogen oxides contribute to around 40 000 deaths related to air pollution per year in the UK,[9] and a WHO report[10] estimated that the economic cost to the UK economy of premature deaths from air pollution is approximately £54 billion a year. In particular, diesel vehicles are responsible for high levels of particulate matter and nitrogen oxides, which are known to cause and exacerbate respiratory-related illness.[11] Decarbonising the transport sector by improving the fuel efficiency of vehicles and transitioning from vehicles powered by petrol and diesel to electricity and hydrogen[12] have the potential to make considerable improvements to air quality across the UK,[13] consequently reducing health-care costs and NHS expenditure.

Although a move towards electric and hydrogen vehicles could have considerable benefits on local air quality,[14] it is important to note that non-exhaust emissions (eg, from break and tyre wear, road surface wear, and resuspension of road dust), are not expected to decrease for alternatively powered vehicles.[15,16] In the long term, traffic-related levels of air pollution can only be lowered in a meaningful way if car journeys are reduced and people switch to active forms of transport, such as cycling and walking. Active forms of transport have a multiplier effect in terms of benefits to public health; they help to reduce local air pollution while improving physical and mental health, and wellbeing.[17–19]

Health and housing

Poor energy efficiency in housing is having a direct effect on the physical health of UK residents. In the winter period between 2016 and 2017, there were an estimated 34 300 excess winter deaths in the UK,[20] of which approximately a third were estimated to be attributable to living in a cold home. Excess winter deaths were three times higher in the coldest quarter of homes than in the warmest quarter.[21] Children living in inadequately heated households were found to be more than twice as likely to suffer from conditions such as asthma and bronchitis than were children living in warm homes.[22] These illnesses are exacerbated or brought on by exposure to moulds and dampness that are more likely to be present in cold homes.[23] Evidence also suggests that the mental health of residents of cold homes is being negatively affected. Assessment of one of the UK government's energy efficiency schemes, Warm Front, found that increases in room temperature were associated with a reduced likelihood of having depression and anxiety.[24]

The impact of cold homes on the physical and mental health of residents has a substantial financial cost to the NHS, estimated to be £2·5 billion per year[25] including the cost of general practitioner consultations, associated treatments, hospital in days, and hospital out-day referrals. This figure compares with the annual spending of the NHS between 2016 and 2017 of £144 billion. The financial benefit to the NHS in improving the energy efficiency of housing across the UK would be considerable,[26] particularly as those savings would be made annually after energy efficiency improvements are implemented. Investing £1·00 in keeping homes warm is estimated to save the NHS £0·42 in direct health-care costs.[27] With an ageing population in the UK, the financial cost of cold homes is likely to increase in the absence of meaningful action to improve the energy efficiency of the housing sector.

Approximately 75% of the houses that will be in use in the UK by 2050 were already built in 2010,[28] which emphasises the importance of improving the energy efficiency of existing properties and the need for strong energy efficiency standards for new properties. Other health benefits from energy efficiency include reductions in noise and exposure to outdoor pollution, provided by double glazing and draught proofing.[26]

Although the health and financial benefits of increasing the energy efficiency of housing are expected to be considerable,[26,29] in some situations there are risks of negative health outcomes from installations that reduce ventilation because they can exacerbate indoor air pollution (eg, from tobacco smoke, radon, or dust mites),[26,30–32] and increase the risk of overheating in summer.[33] As such, housing retrofits need to be planned carefully to protect householders against unintentionally negative health outcomes.[34]

Health and food

The health benefits of a low-carbon diet are largely derived from a reduction in red meat consumption. Diets with relatively high amounts of beef, lamb, and pork are associated with high risks of cardiovascular disease, stroke, and particular types of cancer.[35] Worldwide, the livestock sector is responsible for approximately 14·5% of all greenhouse gas emissions,[36] and approximately half of these emissions come from cattle and sheep[37] because they ruminate and produce relatively large amounts of the potent greenhouse gas methane.

If the average dietary intake in the UK complied with the dietary recommendations of WHO, greenhouse gas emissions could decrease by 17% compared with existing diets.[38] The WHO diet in question would contain a reduced quantity of red meat, dairy products, eggs, and

sweet and savoury snacks, and an increased intake of cereals, fruit, and vegetables.[38] This diet would simultaneously increase average life expectancy at birth by over 8 months and save almost 7 million years of life lost prematurely in the UK in the next 30 years.[38] Similarly to healthy transport options, the health benefits of a low-carbon diet can also help to reduce the incidence of obesity and type 2 diabetes,[39] thereby reducing the strain on the NHS and saving public money.

Diets with low greenhouse gas emissions have considerable potential co-benefits for health;[38,40] however, the wider effects of food on the environment (eg, water consumption or plastic pollution) also need to be considered. Policy mechanisms to encourage the uptake of foods with low greenhouse gas emissions need to avoid being socially regressive[41,42] and recognise that not all of these foods are healthy (eg, sugarcane is relatively low in greenhouse gas emissions).[43] Care also needs to be taken to ensure that diets with low greenhouse gas emissions provide sufficient nutrients. For example, if not managed carefully, a vegan diet can be deficient in the micronutrients B12, choline, and calcium.[44]

Health and green space

The presence of green space, such as parks and gardens, provides multiple benefits to human health and wellbeing, particularly in urban areas.[45] It has been suggested that green spaces should be treated as a fundamental health resource[46] because they help to regulate ambient temperature and water flow, and can reduce the energy consumption of buildings, absorb carbon dioxide, and mitigate climate change.[47] Green space can also have an important role in the mental health of individuals. People living in close proximity to a green space in urban areas have been found to receive less treatment for anxiety or mood disorders than do people living farther away from a green space.[48] Furthermore, several studies have shown the link between having access to green space and reduced levels of stress.[49] Climate change is expected to increase the occurrence of extreme weather events in the UK, such as extended periods of high temperatures, increased rainfall, and possible flooding.[50] The elderly, children, and individuals with existing medical conditions are most susceptible to heat stress.[50] Therefore, the integration of green space into urban areas can have an important role in helping to reduce temperature extremes and associated admissions to the NHS, while decreasing greenhouse gas emissions.

The relationship between green space and air pollution is complex. For example, green spaces and trees are associated with low levels of air pollution.[51] However, in some situations, trees can act as a barrier to the dispersion of traffic-related air pollution.[52] Adequate consideration of any potential negative effects of urban greening is essential to maximise the overall positive health benefits that green space can bring.

Security

Increasing the proportion of energy generated by domestic and low-carbon technologies (eg, wind[53] and solar[54]), energy storage technologies (including electric vehicle batteries[55]), smart grids,[56] and improvements to the energy efficiency of domestic and commercial buildings increases the energy security of the UK by reducing the reliance on imports of oil and gas.[57–61] Given the volatility of international oil prices and the reliance on oil supplies from areas of the world that have historically been politically unstable, increasing energy security can provide a stable foundation for members of the general public and businesses in the UK to budget for their energy expenditure, while reducing vulnerability to wider geopolitical events.

Trade-offs potentially related to security include the challenge of maintaining a secure supply while incorporating an increased proportion of variable renewable energy generation in the grid.[62] Additionally, there are potentially negative effects on food cost and security in the conversion of farmland from food to biomass production for energy generation,[63,64] or to biofuels for transport.[65]

The economy and unemployment

Since 2009, annual growth of gross domestic product in the UK has been between 1·5% and 3·1%, whereas the green economy has consistently grown at around 5%.[66] In 2017, the low-carbon and renewable energy sector in the UK was worth £44·5 billion and accounted for 209 500 full-time equivalent jobs, or around 400 000 UK jobs when the full supply chain is taken into account.[66] These values represent substantial growth for this sector of the economy, which is expected to accelerate. The UK Clean Growth Strategy[67] suggests that the low-carbon sector has the potential to grow by 11% per year between 2015 and 2030.

One of the most intractable challenges for the economy highlighted by the UK Industrial Strategy[68] is that of productivity (ie, output per h per worker). Compared with the rest of the G7, the UK had a nominal productivity gap in output per worker of 16·6% in 2016[69] and this gap has been present since the financial crisis of 2008. The health co-benefits of carbon reduction could benefit the economy by helping to address some of this productivity gap. For example, poor air quality reduces the productivity of people at work.[70] Therefore, a climate-related policy focused on air pollution can simultaneously benefit the NHS and economic productivity.

The decarbonisation of the economy is expected to bring considerable aggregate benefits and job growth in some areas; however, it will also be disruptive and costly for others, at least in the short term.[71] Concerns about the adverse side-effects of action on climate change have led to a growing body of literature on just transitions.[72–74] This concept addresses the impact that climate mitigation will have on communities to identify where additional and

proactive policy support might be required to minimise any negative effects (eg, in communities reliant on jobs in the fossil fuel sector). By considering and mitigating against potential adverse side-effects early in the decision-making process, the opportunity for maximising positive co-benefits is increased and the potential for trade-offs is reduced. Managed correctly, decarbonisation of the UK economy can provide substantial benefits for job creation[75] and innovation, while improving international competitiveness, resource and economic efficiency, and productivity.

Poverty, housing, and inequality

Not being able to afford to adequately heat your own home is referred to as fuel poverty. The Hills Review[76] defines fuel poverty as individuals who have an income below the median and who spend a high proportion of their income on energy. Over 320 000 households in England live in properties with an Energy Performance Certificate rating below band E (eg, F and G ratings) and these properties cost an average of £1000 more per year to heat,[77] compared with a typical home. Therefore, increasing the energy efficiency of properties can save a considerable amount of money for people living in fuel poverty, while reducing greenhouse gas emissions.

Research suggests that low-income households in the UK are struggling to sufficiently heat their homes and provide enough food for their families.[78] This situation can have knock-on effects on nutrition and household relationships. Improving the energy efficiency of housing in the UK can address this issue and help to improve the equality of opportunities for people from low-income groups. However, it is also essential that the cost of energy efficiency measures do not fall disproportionately on individuals with low incomes.[79–81] Energy efficiency schemes in the UK are currently funded via levies applied to household energy bills and it has been argued that this is socially regressive because energy bills make up a high proportion of disposable income for the poorest households.[82] Raising money for energy efficiency via general taxation has been suggested to be a fair way to pay for such measures.[82]

Poor quality housing negatively affects the ability of young people to learn at school and study at home, leading to low educational attainment[22] that in turn increases their chance of future unemployment and poverty, and reduces their opportunities for social mobility. A household intervention programme of energy efficiency in New Zealand led to children having, on average, 21% fewer days of absence from school over the winter months and fewer visits to the family doctor than

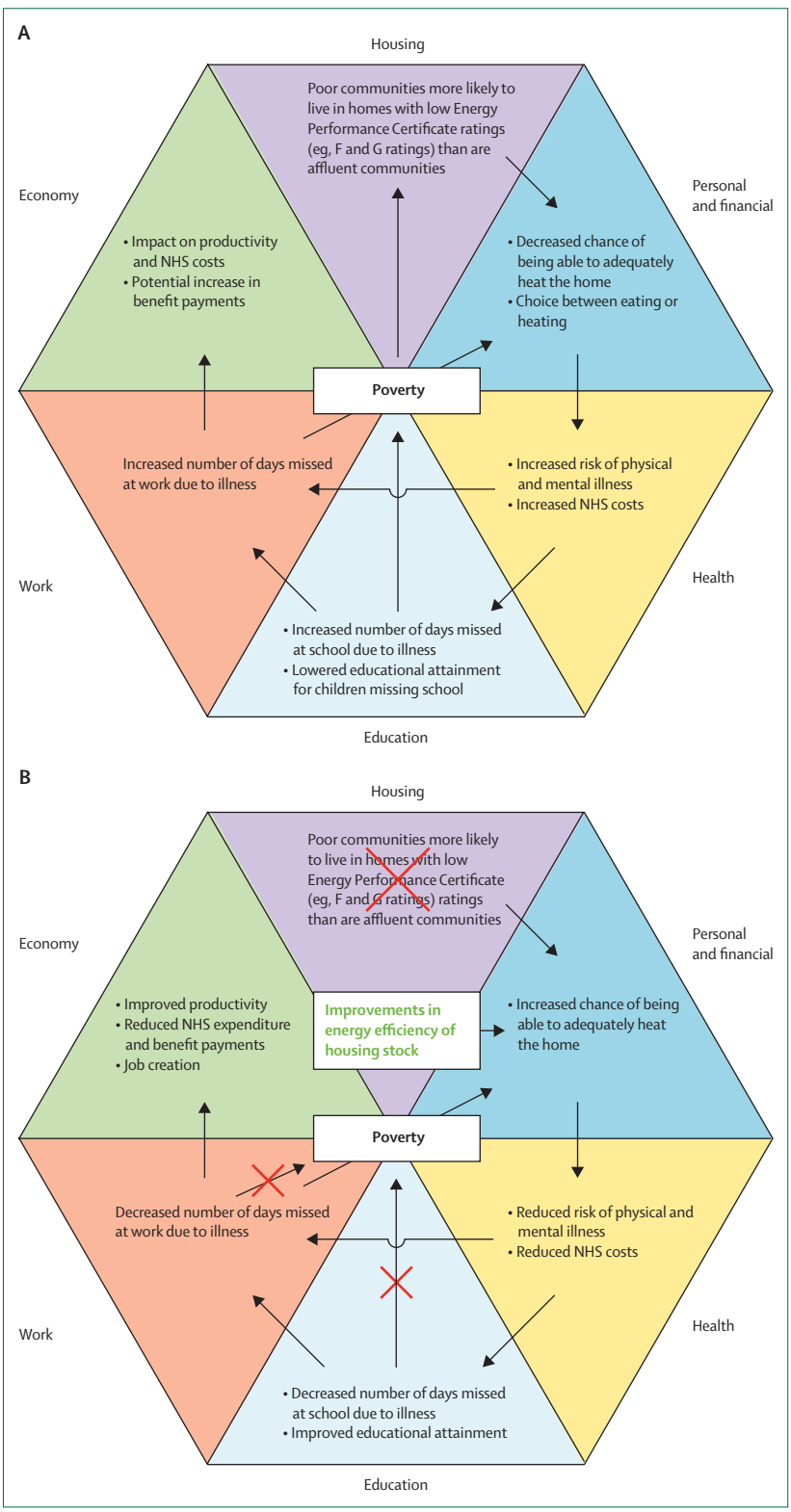

Figure 2: **The interaction between poverty, housing, health, education, work and the economy, and the potential impact of a climate change-related intervention**

(A) An illustration of how living in poverty interacts with housing, health, education, work, and the economy. (B) How a climate change-related intervention (eg, improving the energy efficiency of the housing stock) can help to break some of the pernicious cycle of poverty. NHS=National Health Service.

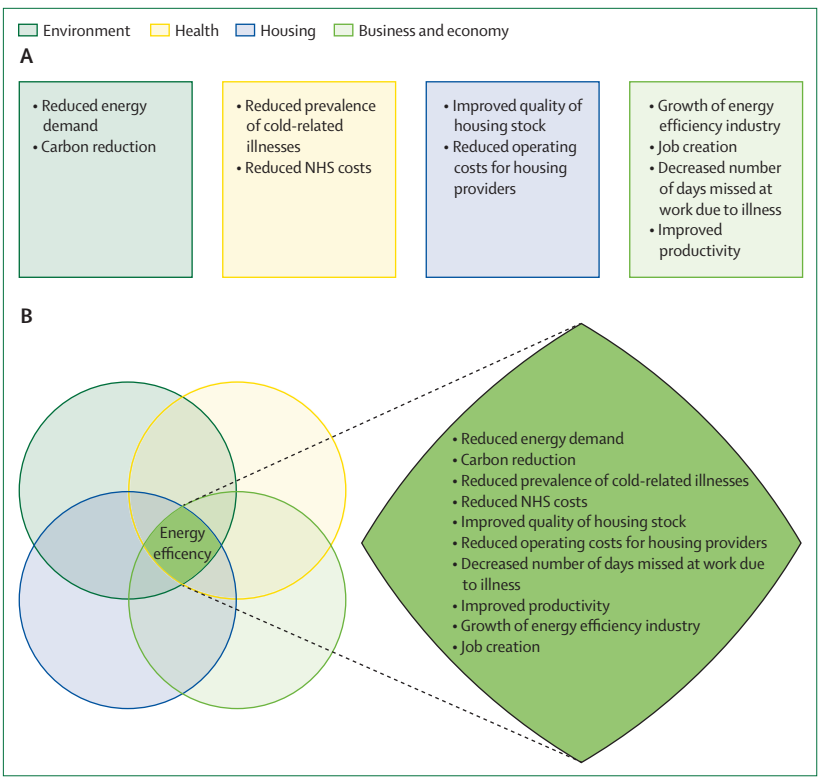

Figure 3: **Benefits of improving the energy efficiency of the housing sector to different departments**
(A) The different departments that benefit from improvements to the energy efficiency of the housing sector. (B) Consideration of the benefits of a policy (eg, domestic energy efficiency) from a cross-departmental perspective can strengthen the case for policy action. NHS=National Health Service.

did children from households that were not provided with this intervention.[83] This finding illustrates the potentially far-reaching benefits of energy efficiency, beyond addressing fuel poverty and reducing household energy expenditure.

From an asset management perspective, insufficient heating of domestic properties also poses a problem because it increases the incidence of damp and mould, which increases the frequency and cost of repairs. These costs inevitably get passed on to the tenant, thereby perpetuating the problem of unaffordability of housing and energy for the poorest members of society. Therefore, a component of the social inequality that manifests in UK housing can be addressed via energy efficiency improvements that reduce greenhouse gas emissions while providing co-benefits for job creation, economic growth, food security, poverty alleviation, educational attainment, and social mobility (figure 2).[31,84]

There is also an important link between transport, air pollution, and inequality.[85,86] Air pollution levels in the UK have been shown to have strong associations with deprivation, in which deprived neighbourhoods tend to have higher air pollution levels than do more affluent ones, and ethnic composition of neighbourhoods, whereby neighbourhoods with a large proportion of non-white residents tend to have higher air pollution levels than do predominately white neighbourhoods, particularly in urban areas.[87] The link between air pollution from transport and child cognition[88] suggests that the educational outcomes of children from deprived areas might be curtailed, potentially perpetuating the cycle of deprivation. Therefore, decarbonising the transport sector can provide health benefits that save the NHS money, and address health and educational inequalities.

Discussion

The evidence collected in this Review shows that there are considerable co-benefits of climate change mitigation for the UK, from improving public health and reducing NHS expenditure to increasing productivity, stimulating economic growth, creating jobs, improving security, and reducing poverty and inequality. The statistics on excess winter deaths due to cold homes (around 10 000 per year) and premature deaths from air pollution (around 40 000 per year) suggest that the current system is not adequately addressing issues that span across multiple departmental remits. Considering the co-benefits of a policy to multiple departments can create a much stronger case for action than considering the benefit to one department in isolation (figure 3). Figure 3 illustrates how a policy can simultaneously touch on the remit of various departments, providing combined benefits that would help to justify such a policy.

Within the policy-making community, it is essential that the co-benefits of potential policies are adequately considered to avoid suboptimal decisions being made.[89] The differentiation of expertise and areas of focus between governmental departments pose a potential barrier to decisions being made that benefit various departments simultaneously. For example, previous work at the EU level has shown that the separation of responsibility for greenhouse gas and non-greenhouse gas emissions across EU Directorate Generals has decoupled climate change and air pollution mitigation policies, consequently reducing the likelihood that health co-benefits are adequately integrated in climate mitigation policy.[90]

This Review illustrates that, despite potential organisational barriers, the advantage of adequately considering co-benefits in the decision-making process can be substantial. However, we recognise that cross-departmental collaboration is practically and politically feasible in countries, such as the UK, where one political party is responsible for all government departments. In countries where individual departments are led by different political parties, such as in Italy and Brazil, the challenge of cross-departmental collaboration is inevitably much greater because political and organisational barriers exist.

In the short term, we suggest that city-level and regional-level governments are best placed to incorporate co-benefits into the decision-making process because it is at this scale that co-benefits are most clearly manifested, and

where interventions can have the most immediate effect (eg, in identifying and addressing the effects of poor quality housing on poverty, health, and educational attainment).[91] The declaration of climate emergencies by local authorities (over 65% of UK councils at time of writing) and the setting of ambitious carbon reduction targets mean that city-level and regional-level governments are in a good position to act on the opportunities provided by the co-benefits of climate action. For example, Oxford City Council led the first climate change assembly for UK citizens in September, 2019, and subsequently released £19 million to respond to the recommendations from the representative sample of the local population invited to attend the assembly. Recommendations included improving domestic energy efficiency, reducing transport emissions, and increasing microgeneration of energy. Citizens climate assemblies are directly relevant to the framing of this Review because they show how climate action can be combined with local public priorities via the co-benefits that climate actions provide to local priorities (eg, improving public health or alleviating poverty).

The devolution of more powers (eg, health and social care, transport, housing) to local and combined authorities is also potentially relevant to the co-benefits of climate action. For example, the Mayor of Greater Manchester now oversees a £6 billion health and social care budget, so should be able to see a saving in health expenditure from investing in a transport infrastructure that improves air quality. The devolution of such power allows mayors to take a long-term view over various policy areas and budgets, and to harness the financial reward and benefit to citizens of adequately considering co-benefits.

At the national level, more needs to be done to encourage cross-departmental approaches to reduce carbon emissions while achieving other key objectives, as well as sharing best practice between councils across the country. One approach to achieving this objective could be the establishment of an Office for Public Health and the Environment, co-funded by the Department of Health and Social Care; Department for Business, Energy, and Industrial Strategy; Department for Transport; and Department for Environment, Food and Rural Affairs. Such an office could help to develop, identify, and scale up projects across the UK that both improve public health and reduce greenhouse gas emissions. An example of such a project is the Seasonal Health Intervention Network, set up by Islington Council's housing team. This project engages a network of organisations, including general practitioners and health visitors who refer vulnerable householders to the Seasonal Health Intervention Network team. This team then provide these householders with advice on energy efficiency, how to access grants for energy efficiency measures (eg, new boilers), and how to reduce their fuel bills. The project helps general practitioners to support their patients to address some of

Search strategy and selection criteria

The Ipsos MORI data provided the basis for a literature search comprising both academic and grey literature that linked the raised issues with action on climate change. The aim of the search was to provide a comprehensive picture of the key thematic areas of synergy between climate action and other public priorities in the UK. We adapted the search string used by Deng and colleagues[93] in their systematic review of the co-benefits of greenhouse gas mitigation from across the world to include articles focused on the UK only (adding in terms 'UK', 'United Kingdom', 'Great Britain', etc) and we focused on the top ten issues of concern from the Ipsos MORI poll. We did the searches between May 21, 2018, and June 14, 2018, through Web of Science (their full collection covering over 34 000 journals) for articles written in English (appendix p 1). We used the topic field tag that identifies the presence of words in the title, abstract, and keywords of articles.

We included or excluded articles from the analysis on the basis of the following criteria: whether or not the paper discussed climate mitigation (eg, papers that only focused on adaptation to climate change were excluded); whether or not the paper discussed the co-benefits of climate action for one of the issues of concern to the UK public (eg, papers that focused on the benefits of changes in public health provision for climate action were excluded); and whether or not the paper discussed co-benefits of climate action for the UK (eg, papers that were not focused on the UK were excluded). We excluded papers on the basis of their title and abstract initially and then their content, if relevance was ambiguous from the title or abstract.

Articles that passed the inclusion criteria were coded according to the Ipsos MORI issue(s) of concern covered within the paper. This strategy allowed us to identify the issues of concern to the UK public that were most relevant to the co-benefits of climate action, issues that were often featured alongside each other, and thematic areas that existed within each issue. We then used simple search strings on Google and Google Scholar (eg, "health" AND "climate change" AND "co-benefit" AND "UK") to identify grey literature relevant to the co-benefits identified in the Web of Science search that would supplement the evidence base of this narrative Review. We included literature from reports by the UK Government, university briefing papers, and non-governmental organisations whose methodological approach appeared rigorous (eg, where conclusions were drawn based on transparent research featuring sufficiently large sample sizes and suitable data analysis techniques).

The analysis was written into a draft briefing paper and used as the basis for informal discussion and correspondence with representatives from key governmental departments: Her Majesty's Treasury; Department for Business, Energy and Industrial Strategy; Office for Low Emission Vehicles; Ministry for Housing, Communities and Local Government; and Greater London Authority. Representatives from relevant third sector organisations and non-governmental organisations (eg, Ashden and their Liveable Cities Network of representatives from Combined Authorities, E3G, Clean Air Fund, Housing Associations Charitable Trust, Green Alliance) were also involved. The purpose of the discussions and correspondence was to identify any relevant omissions in our assessment of the key co-benefits of climate action for the UK and to share and discuss potential policy recommendations resulting from our analysis. Before each informal discussion, a list of key questions was compiled on the basis of the relevant person's expertise to provide a prompt to the conversation. The literature searches and stakeholder discussions were considered complete when no new co-benefits were uncovered from backward or forward reference searching, or from discussions.

The appendix provides a list of the dates and types of interactions with each organisation (p 3), and an example of the email approach to one of the stakeholders and the list of questions prepared ahead of the discussion (p 4). The Review was updated with relevant omissions following the informal discussions and its content was adapted.

For more on the **Seasonal Health Intervention Network** see https://shine-london.org.uk/

See **Online** for appendix

the root causes of their health problems, rather than dealing with the symptoms and sending them back to the home that contributed to their illness in the first place. Consequently, the initiative reduces greenhouse gas emissions, fuel poverty, and NHS costs, and improves health outcomes. The cross-departmental approach for an Office for Public Health and the Environment is similar to that used by the Office of Low Emission Vehicles, which is co-funded by the Department for Transport and the Department for Business, Energy, and Industrial Strategy.

In terms of limitations, this was a narrative review rather than a systematic review; therefore, it does not aim to be exhaustive of the entire literature. Nevertheless, the broad criteria used in the literature search, the inclusion of grey literature, public opinion polls, and stakeholder discussions make it not only comprehensive but also applicable to a real-world situation. Regarding limitations of the methods, we chose to look at the co-benefits of climate action for the top ten issues of concern in the Ipsos MORI survey from 2017. We adopted this approach to focus on issues that the public are most concerned about. However, this approach meant that we did not explicitly look for co-benefits of climate action for other issues that could rise to great prominence in the future. For example, co-benefits relating to pollution or environment were not considered (except when they were also related to another issue, such as health) because this issue of concern was not in the top ten at the time. Other categories not considered include ageing population and public services. Furthermore, there were issues of concern within the top ten (eg, migration) that are linked to climate change,[92] but whose direct effect on the UK is uncertain. Therefore, future studies that adopt a similar approach to ours might wish to look at more issues of concern and also uncover additional co-benefits and trade-offs, for which evidence is currently ambiguous.

To conclude, we suggest that widening the rationale for climate action might help to gain further traction in terms of political and public support for carbon reduction, by tapping into non-environmental priorities that resonate with public concern. The next phase of decarbonisation will need to be comparatively rapid to avoid increasingly severe consequences of climate change. A consideration of the non-climate issues that the public are concerned about and an identification of related climate co-benefits and trade-offs can help decision makers to prioritise decarbonisation options and to increase the chance that the public will be supportive of such changes, while ensuring a just transition.

Contributors

NJ conceived the idea for the Review, did the literature search, collated and analysed the Ipsos MORI survey data, held the informal discussions with experts, and produced the figures. DF and SDM contributed particularly to the health-related content of this Review and all authors contributed to the writing of the manuscript. NJ, DF, SDM approved the final version.

Declaration of interests

All authors declare no competing interests.

Acknowledgments

We thank Ajay Gambhir and Alyssa Gilbert (Grantham Institute–Climate Change and the Environment, UK), Jane Burston (Clean Air Fund, UK), Alex White (Aldersgate Group, UK), Dustin Benton (Green Alliance, UK), Rob Gould (Office of Low Emission Vehicles, UK), Jay Saggar (Housing Associations' Charitable Trust, UK), John Kolm-Murray (Greater London Authority, UK), Maria Carvalho (London School of Economics, UK), David Demeritt (King's College London, UK), Ed Mathew (E3G, UK), Tom Wells and Ben Taylor (Go-Science, UK), Alex Lim (Ministry of Housing, Communities and Local Government, UK), Mark Sinclair (University of Sheffield, UK), and Simon Brammer, Cara Jenkinson, Emma Jones from the Ashden team for their detailed and helpful comments in the development of this Review. No specific funding was received for this Review but authors are supported by the Grantham Institute at Imperial College London (NJ), the Higher Education Innovation Fund (NJ), Medical Research Council (DF), and Cagliari University and National Heart and Lung Institute at Imperial College London (SDM).

References

1 Intergovernmental Panel on Climate Change. Global warming of 1·5°C: an IPCC special report. https://www.ipcc.ch/sr15/ (accessed Nov 4, 2019).
2 Hamilton K, Brahmbhatt K, Liu J. Multiple benefits from climate change mitigation: assessing the evidence. London: Grantham Research Institute on Climate Change and the Environment, 2017.
3 Nemet GF, Holloway T, Meier P. Implications of incorporating air-quality co-benefits into climate change policymaking. *Environ Res Lett* 2010; **5:** 014007.
4 Markandya A, Sampedro J, Smith SJ, Van Dingenen R, Pizarro-Irizar C, Arto I, González-Eguino M. Health co-benefits from air pollution and mitigation costs of the Paris Agreement: a modelling study. *Lancet Planet Health* 2018; **2:** e126–33.
5 Warren R, VanDerWal J, Price J, et al. Quantifying the benefit of early climate change mitigation in avoiding biodiversity loss. *Nat Clim Chang* 2013; **3:** 678–82.
6 Burke M, Davis WM, Diffenbaugh NS. Large potential reduction in economic damages under UN mitigation targets. *Nature* 2018; **557:** 549–53.
7 Intergovernmental Panel on Climate Change. Fifth assessment report, annex II glossary. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf (accessed July 24, 2018).
8 Schraufnagel D, Balmes J, Cowl C, et al. Air pollution and noncommunicable diseases: a review by the Forum of International Respiratory Societies' Environmental Committee, part 2: air pollution and organ systems. *Chest* 2018; **155:** 417–26.
9 Royal College of Physicians. Every breath we take: the lifelong impact of air pollution. Report of a working party. London: Royal College of Physicians, 2016.
10 WHO Regional Office for Europe, OECD. Economic cost of the health impact of air pollution: clean air, health and wealth. Copenhagen: World Health Organization Regional Office for Europe, 2015.
11 Smith KR, Jerrett M, Anderson HR, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: health implications of short-lived greenhouse pollutants. *Lancet* 2009; **374:** 2091–103.
12 Chong U, Yim SHL, Barrett SRH, Boies AM. Air quality and climate impacts of alternative bus technologies in Greater London. *Environ Sci Technol* 2014; **48:** 4613–22.
13 Yim SH, Barrett SRH. Public health impacts of combustion emissions in the United Kingdom. *Environ Sci Technol* 2012; **46:** 4291–96.
14 Buekers J, Van Holderbeke M, Bierkens J, Int Panis L. Health and environmental benefits related to electric vehicle introduction in EU countries. *Transp Res Part D Transp Environ* 2014; **33:** 26–38.
15 Timmers V, Achten P. Non-exhaust PM emissions from electric vehicles. *Atmos Environ* 2016; **134:** 10–17.
16 Lott MC, Pye S, Dodds PE. Quantifying the co-impacts of energy sector decarbonisation on outdoor air pollution in the United Kingdom. *Energy Policy* 2017; **101:** 42–51.
17 Pencheon D. Making health care more sustainable: the case of the English NHS. *Public Health* 2015; **129:** 1335–43.

18 Goodman A. Walking, cycling and driving to work in the English and Welsh 2011 census: trends, socio-economic patterning and relevance to travel behaviour in general. *PLoS One* 2013; **8:** e71790.

19 Woodcock J, Givoni M, Morgan AS. Health impact modelling of active travel visions for England and Wales using an Integrated Transport and Health Impact Modelling Tool (ITHIM). *PLoS One* 2013; **8:** e51462.

20 Avila-Palencia I, Int Panis L, Dons E, et al. The effects of transport mode use on self-perceived health, mental health, and social contact measures: a cross-sectional and longitudinal study. *Environ Int* 2018; **120:** 199–206.

21 Office for National Statistics. Excess winter mortality in England and Wales. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/excesswintermortalityinenglandandwales/2016to2017provisionaland2015to2016final (accessed May 8, 2018).

22 Marmot M, Geddes I, Bloomer E, Allen J, Goldblatt P. The health impacts of cold homes and fuel poverty. London: Friends of the Earth and Marmot Review Team, 2011.

23 Caillaud D, Leynaert B, Keirsbulck M, Nadif R. Indoor mould exposure, asthma and rhinitis: findings from systematic reviews and recent longitudinal studies. *Eur Respir Rev* 2018; **27:** 170137.

24 Green G, Gilbertson J. Warm front: better health. Health impact evaluation of the warm front scheme. Sheffield: Centre for Regional Social and Economic Research at Sheffield Hallam University, 2008.

25 Friedman D. Social impact of poor housing. London: Emissions Consumption Optimization Technology, 2010.

26 Smith AC, Holland M, Korkeala O, et al. Health and environmental co-benefits and conflicts of actions to meet UK carbon targets. *Clim Policy* 2016; **16:** 253–83.

27 Department of Health. 2009 annual report of the Chief Medical Officer. http://www.sthc.co.uk/Documents/CMO_Report_2009.pdf (accessed July 19, 2018).

28 Power A. Housing and sustainability: demolition or refurbishment? *Proc Inst Civ Eng Urban Des Plan* 2010; **163:** 205–16.

29 Milner J, Chalabi Z, Vardoulakis S, Wilkinson P. Housing interventions and health: quantifying the impact of indoor particles on mortality and morbidity with disease recovery. *Environ Int* 2015; **81:** 73–79.

30 Vardoulakis S, Dear K, Wilkinson P. Challenges and opportunities for urban environmental health and sustainability: the HEALTHY-POLIS initiative. *Environ Health* 2016; **15** (suppl 1)**:** 30.

31 Shrubsole C, Macmillan A, Davies M, May N. 100 unintended consequences of policies to improve the energy efficiency of the UK housing stock. *Indoor Built Environ* 2014; **23:** 340–52.

32 Fleming LE, Haines A, Golding B, et al. Data mashups: potential contribution to decision support on climate change and health. *Int J Environ Res Public Health* 2014; **11:** 1725–46.

33 Taylor J, Mavrogianni A, Davies M, et al. Understanding and mitigating overheating and indoor $PM_{2.5}$ risks using coupled temperature and indoor air quality models. *Build Serv Eng Res Tech* 2015; **36:** 275–89.

34 Wilkinson P, Smith KR, Davies M, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: household energy. *Lancet* 2009; **374:** 1917–29.

35 Pan A, Sun Q, Bernstein AM, et al. Red meat consumption and mortality: results from 2 prospective cohort studies. *Arch Intern Med* 2012; **172:** 555–63.

36 Ripple WJ, Smith P, Haberl H, Montzka S, McAlpine C, Boucher D. Ruminants, climate change and climate policy. *Nat Clim Chang* 2014; **4:** 2–5.

37 Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. *Science* 2018; **360:** 987–92.

38 Milner J, Green R, Dangour AD, et al. Health effects of adopting low greenhouse gas emission diets in the UK. *BMJ Open* 2015; **5:** e007364.

39 Thurston GD, De Matteis S, Murray K, et al. Maximizing the public health benefits from climate action. *Environ Sci Technol* 2018; **52:** 3852–53.

40 Springmann M, Godfray HCJ, Rayner M, Scarborough P. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proc Natl Acad Sci USA* 2016; **113:** 4146–51.

41 Monsivais P, Scarborough P, Lloyd T, et al. Greater accordance with the Dietary Approaches to Stop Hypertension dietary pattern is associated with lower diet-related greenhouse gas production but higher dietary costs in the United Kingdom. *Am J Clin Nutr* 2015; **102:** 138–45.

42 Briggs ADM, Kehlbacher A, Tiffin R, Garnett T, Rayner M, Scarborough P. Assessing the impact on chronic disease of incorporating the societal cost of greenhouse gases into the price of food: an econometric and comparative risk assessment modelling study. *BMJ Open* 2013; **3:** e003543.

43 Briggs ADM, Kehlbacher A, Tiffin R, Scarborough P. Simulating the impact on health of internalising the cost of carbon in food prices combined with a tax on sugar-sweetened beverages. *BMC Public Health* 2016; **16:** 107.

44 Chen C, Chaudhary A, Mathys A. Dietary change scenarios and implications for environmental, nutrition, human health and economic dimensions of food sustainability. *Nutrients* 2019; **11:** 856.

45 Kondo MC, Fluehr JM, McKeon T, Branas CC. Urban green space and its impact on human health. *Int J Environ Res Public Health* 2018; **15:** 445.

46 Pretty J. How nature contributes to mental and physical health. *Spiritual Health Int* 2004; **5:** 68–78.

47 Llausàs A, Roe M. Green infrastructure planning: cross-national analysis between the north east of England (UK) and Catalonia (Spain). *Eur Plann Stud* 2012; **20:** 641–63.

48 Nutsford D, Pearson AL, Kingham S. An ecological study investigating the association between access to urban green space and mental health. *Public Health* 2013; **127:** 1005–11.

49 Roe JJ, Thompson CW, Aspinall PA, et al. Green space and stress: evidence from cortisol measures in deprived urban communities. *Int J Environ Res Public Health* 2013; **10:** 4086–103.

50 Department for Environment and Rural Affairs, UK Government. The UK climate change risk assessment 2012. https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-government-report (accessed Oct 31, 2019).

51 Pugh TAM, Mackenzie AR, Whyatt JDHNC, Hewitt CN. Effectiveness of green infrastructure for improvement of air quality in urban street canyons. *Environ Sci Technol* 2012; **46:** 7692–99.

52 Tong Z, Whitlow TH, MacRae PF, Landers AJ, Harada Y. Quantifying the effect of vegetation on near-road air quality using brief campaigns. *Environ Pollut* 2015; **201:** 141–49.

53 Kota S, Bayne SB, Nimmagadda S. Offshore wind energy: a comparative analysis of UK, USA and India. *Renew Sustain Energy Rev* 2015; **41:** 685–94.

54 Balta-Ozkan N, Yildirim J, Connor PM. Regional distribution of photovoltaic deployment in the UK and its determinants: a spatial econometric approach. *Energy Econ* 2015; **51:** 417–29.

55 Teng F, Mu Y, Jia H, Wu J, Zeng P, Strbac G. Challenges on primary frequency control and potential solution from EVs in the future GB electricity system. *Appl Energy* 2017; **194:** 353–62.

56 Chilvers J, Foxon TJ, Galloway S, et al. Realising transition pathways for a more electric, low-carbon energy system in the United Kingdom: challenges, insights and opportunities. *Proc Inst Mech Eng: A J Power Energy* 2017; **231:** 440–77.

57 Kerr N, Gouldson A, Barrett J. The rationale for energy efficiency policy: assessing the recognition of the multiple benefits of energy efficiency retrofit policy. *Energy Policy* 2017; **106:** 212–21.

58 Robinson M, Varga L, Allen P. An agent-based model for energy service companies. *Energy Convers Manage* 2015; **94:** 233–44.

59 Chalvatzis KJ, Hooper E. Energy security vs. climate change: theoretical framework development and experience in selected EU electricity markets. *Renew Sustain Energy Rev* 2009; **13:** 2703–09.

60 Barrett M, Lowe R, Oreszczyn T, Steadman P. How to support growth with less energy. *Energy Policy* 2008; **36:** 4592–99.

61 Neuhoff K. Large scale deployment of renewables for electricity generation. *Oxf Rev Econ Policy* 2005; **21:** 88–110.

62 Trovato G, Tindemans SH, Strbac G. Demand response contribution to effective inertia for system security in the GB 2020 gone green scenario. Lyngby, Denmark; IEEE PES ISGT Europe 2013; Oct 6–9, 2013 (abstr 14003184).

63 Feliciano D, Slee B, Smith P. The potential uptake of domestic woodfuel heating systems and its contribution to tackling climate change: a case study from the North East Scotland. *Renew Energy* 2014; **72:** 344–53.

64 Department for Transport, Department of Energy and Climate Change, Department for Environment, Food and Rural Affairs. UK bioenergy strategy. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf (accessed April 15, 2020).

65 Helliwell R, Tomei J. Practicing stewardship: EU biofuels policy and certification in the UK and Guatemala. *Agric Human Values* 2017; **34:** 473–84.

66 Office for National Statistics. Low carbon and renewable energy economy, UK: 2017. https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/finalestimates/2017 (accessed June 28, 2018).

67 Department for Business, Energy and Industrial Strategy. The clean growth strategy: leading the way to a low carbon future. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf (accessed June 28, 2018).

68 Department for Business, Energy and Industrial Strategy. Industrial strategy: building a Britain fit for the future. https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future (accessed June 28, 2018).

69 Office of National Statistics. International comparisons of UK productivity (ICP), final estimates: 2016. https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/bulletins/internationalcomparisonsofproductivityfinalestimates/2016 (accessed May 14, 2018).

70 Chang TY, Graff Zivin J, Gross T, Neidell M. The effect of pollution on worker productivity: evidence from call-center workers in China. *Am Econ J Appl Econ* 2019; **11:** 151–72.

71 Green F, Gambhir A. Transitional assistance policies for just, equitable and smooth low-carbon transitions: who, what and how? *Clim Policy* 2019; published online Aug 28. https://doi.org/10.1080/14693062.2019.1657379.

72 McCauley RJ, Darren H. What is the 'just transition'? *Geoforum* 2018; **88:** 74–77.

73 Newell P, Mulvaney D. The political economy of the 'just transition'. *Geogr J* 2013; **179:** 132–40.

74 Dimitris S, Felli R. Global labour unions and just transition to a green economy. *Int Environ Agreement Polit Law Econ* 2015; **15:** 29–43.

75 Chmutina K, Goodier CI. Alternative future energy pathways: assessment of the potential of innovative decentralised energy systems in the UK. *Energy Policy* 2014; **66:** 62–72.

76 Hills J. Getting the measure of fuel poverty: final report of the fuel poverty review. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48297/4662-getting-measure-fuel-pov-final-hills-rpt.pdf (accessed July 3, 2018).

77 HM Government. Cutting the cost of keeping warm: a fuel poverty strategy for England. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/408644/cutting_the_cost_of_keeping_warm.pdf (accessed July 3, 2018).

78 Lambie-Mumford H, Snell C. 'Heating or eating' and the impact of austerity. http://speri.dept.shef.ac.uk/wp-content/uploads/2018/11/SPERI-Brief-19-Heating-or-Eating-and-the-impact-of-austerity.pdf (accessed Oct 30, 2019).

79 Fankhauser S. A practitioner's guide to a low-carbon economy: lessons from the UK. *Clim Policy* 2013; **13:** 345–62.

80 Committee on Climate Change. Household energy bills–impacts of meeting carbon budgets. London: Committee on Climate Change, 2011.

81 Grover D, Daniels B. Social equity issues in the distribution of feed-in tariff policy benefits: a cross sectional analysis from England and Wales using spatial census and policy data. *Energy Policy* 2017; **106:** 255–65.

82 Barrett J, Owen A, Taylor P. Funding a low carbon energy system: a fairer approach? https://ukerc.ac.uk/publications/funding-a-low-carbon-energy-system/ (accessed July 20, 2018).

83 Howden-Chapman P, Pierse N, Nicholls S, et al. Effects of improved home heating on asthma in community dwelling children: randomised controlled trial. *BMJ* 2008; **337:** a1411.

84 Figus G, Turner K, McGregor P, Katris A. Making the case for supporting broad energy efficiency programmes: impacts on household incomes and other economic benefits. *Energy Policy* 2017; **111:** 157–65.

85 Wheeler BW, Ben-Shlomo Y. Environmental equity, air quality, socioeconomic status, and respiratory health: a linkage analysis of routine data from the Health Survey for England. *J Epidemiol Community Health* 2005; **59:** 948–54.

86 Woodcock J, Edwards P, Tonne C, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. *Lancet* 2009; **374:** 1930–43.

87 Fecht D, Fischer P, Fortunato L, et al. Associations between air pollution and socioeconomic characteristics, ethnicity and age profile of neighbourhoods in England and the Netherlands. *Environ Pollut* 2015; **198:** 201–10.

88 Jedrychowski WA, Perera FP, Camann D, et al. Prenatal exposure to polycyclic aromatic hydrocarbons and cognitive dysfunction in children. *Environ Sci Pollut Res Int* 2015; **22:** 3631–39.

89 Jensen HT, Keogh-Brown MR, Smith RD, et al. The importance of health co-benefits in macroeconomic assessments of UK greenhouse gas emission reduction strategies. *Clim Change* 2013; **121:** 223–37.

90 Workman A, Blashki G, Bowen KJ, Karoly DJ, Wiseman J. Health co-benefits and the development of climate change mitigation policies in the European Union. *Clim Policy* 2019; **19:** 585–97.

91 Sullivan R, Gouldson A, Webber A. Funding low carbon cities: local perspectives on opportunities and risks. *Clim Policy* 2013; **13:** 514–29.

92 Field CB, Barros VR, Mastrandrea MD, et al. Summary for policymakers. In: Field CB, Barros VR, Dokken DJ, et al, eds. Climate change 2014: impacts, adaptation, and vulnerability. Cambridge, UK, and New York, NY: Cambridge University Press, 2014: 1–32.

93 Deng HM, Liang QM, Liu LJ, Anadon LD. Co-benefits of greenhouse gas mitigation: a review and classification by type, mitigation sector, and geography. *Environ Res Lett* 2017; **12:** 123001.